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MFJ-249 and MFJ-207 SWR Analyzers

Reviewed by Mike Gruber, WA1SVF

It was late last fall when we finally moved into our new home in the country. Its big yard and many tall trees meant lots of antenna potential—the kind I could only dream about as an apartment dweller. My enthusiasm was quickly chilled by what seemed to be an eternity of winter snowfalls and bad weather.

Not being one to admit to procrastination, I simply passed it off as rotten luck. As winter dragged on, though, strange visions of dipoles and rhombics continued to grow and dance in my head. "This springtime," I vowed, "the land will yield a particularly fine crop of new antennas."

As my upcoming antenna projects grew more and more ambitious, I began to consider the purchase of a new MFJ SWR Analyzer. Such a device can be a big timesaver when pruning a new antenna crop. For example, it can be used to determine an antenna's SWR, resonant frequency, or feed-point impedance at a particular frequency. For years I'd used my transmitter and SWR bridge to cut antennas to length, but an SWR analyzer is a lot more convenient to use. Besides, why transmit annoying test signals if you don't have to? (The SWR Analyzers transmit a signal, but it's only a few milliwatts.) And the analyzer solves the age-old problem of tuning a new antenna that initially appears to resonate outside the ham bands.

Fortunately, as they say, nothing lasts forever, and even my luck changed when the Product Review editor dropped by my office about a week later. Without hesitation I accepted his invitation to evaluate two MFJ SWR Analyzers!

The SWR Analyzers

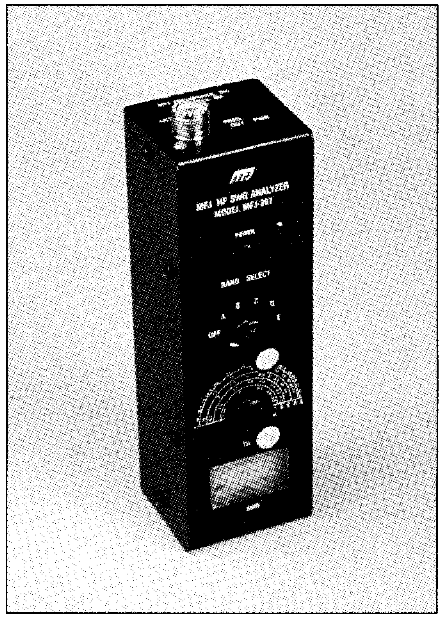
A number of such products are currently available on the market from several manufacturers. There are many different models to choose from, with a wide range of specifications and prices.

For this review, we chose two products from the MFJ line—the top-of-the-line MFJ-249 and the low-end MFJ-207. The '207 covers 1.8 to 30 MHz, and the '249 offers extended coverage to 170 MHz. Their small size, minimal weight and battery-powered circuitry make them ideal take-anywhere instruments for use on rooftops, towers, Field Day or backpacking. On the minus side, I didn't particularly like having to disassemble the cabinet (eight screws) to install or change the batteries.

When Put to Work

I installed two dipoles, one for 20 meters and one for 6 meters, as my first two test antennas. They had been intentionally made too long, resonating well below 14 and 50 MHz. Using the '249 and '207, I attempted to trim the 20-meter antenna for the CW portion of the band to a point just above 14.025 MHz. I used the MFJ-249 to trim the 6-meter dipole for final resonance at about 50.4 MHz. Table 1 shows the results.

MFJ-249 SWR Analyzer



MFJ-207 SWR Analyzer

The SWR Analyzers helped tremendously in trimming my test dipoles. Although there are differences in features and operation between the units tested, the basic drill goes like this: Connect your feed line to the SWR Analyzer's antenna input (an SO-239 connector). Set the Analyzer's band switch to the right range. Adjust the Analyzer's tuning control to the desired frequency, and read the SWR from the built-in meter. You can tune the SWR Analyzer's frequency up and down to determine your antenna's SWR-versus-frequency curve and then shorten (or lengthen) the antenna until the SWR is minimal at the desired frequency.

In adjusting the test dipoles, I was able to quickly determine the SWR at my target frequency. Next, I quickly determined the antenna's resonant frequency as well—even when that frequency occurred *outside* an amateur band. This feature was helpful in estimating the length of wire to trim from the antenna for the next pass.

The MFJ-249

The top-of-the-line MFJ-249 quickly became my favorite. It differs from the '207 in that it incorporates a frequency counter with an LCD display, and offers VHF coverage to 170 MHz. I found the counter to be a real time saver when reading or setting the '249's frequency. As an added bonus, the counter has an input jack for measuring external signals as well. (The MFJ-207 requires the use of your receiver or an external counter to accurately determine its frequency, but more about this later.)

The MFJ-249 covers 1.8 to 170 MHz continuously in six bands. The **RANGE** control selects the band; the **TUNE** control adjusts the oscillator to the desired frequency. I found the **TUNE** control somewhat touchy: Small changes in the knob's position result in relatively large frequency changes. When setting specific frequencies, several tries are usually required, and setting a frequency to within 10 kHz or so is not possible. The MFJ-207 shares this characteristic. A reduction drive might help.

The '249's counter made the task of taking measurements much easier than with the MFJ-207. I was able to immediately determine where I was relative to the target frequency. The effects of frequency drift could be negated by observing the counter's display.

The '249's manual is an 18-page booklet. It includes instructions for using of the analyzer and frequency counter and step-by-step procedures to:

- Measure an antenna's SWR at a specified frequency and find the frequency at which the antenna has the lowest SWR.
- Adjust an antenna for minimum SWR.
- Measure the feedpoint resistance of an antenna.

The Bottom Line

MFJ's 249 and 207 SWR Analyzers are handy devices for hams who like to play with antennas. With its built-in frequency counter, the versatile MFJ-249 is a particularly good investment.

Table 1
Dipole Test Results

20-Meter Dipole

Length per leg	MFJ-249 Resonant freq	MFJ-249 SWR at 14.025	MFJ-207 Resonant freq	MFJ-207 SWR at 14.025	Bird 43 SWR at 14.025
16' 4.25"	13.315	2.9	13.360	2.7	1.99
16' 2.00"	13.505	2.0	13.523	2.2	1.79
15' 11.25"	13.703	1.6	13.719	1.6	1.46
15' 8.00"	13.911	1.5	13.937	1.1	1.15
15' 6.00"	14.108	1.1	14.106	1.1	1.15

6-Meter Dipole

Length per leg	MFJ-249 Resonant freq	MFJ-249 SWR at 50.400	Bird 43 SWR at 50.400
57' 6"	47.220	3.0	2.49
55' 6"	49.080	1.8	2.04
54' 6"	49.838	1.6	1.63
53' 8"	50.552	1.4	1.51

All frequencies are in MHz.

Table 2
MFJ-249 SWR Analyzer

Manufacturer's claimed specifications	*Measured in the ARRL Lab*
Band ranges (MHz): 1.8-4, 4-10, 10-26.2, 26.2-62.5, 62.5-113, 113-170.	Ranges measured with external frequency counter: 1.733-4.021 MHz, 3.903-9.982 MHz, 9.633-26.108 MHz, 25.711-62.740 MHz, 61.422-113.838 MHz, 112.761-172.932 MHz
Warm-up drift: Not specified.	–14.6 kHz after 15 minutes from a cold start at room temperature (72 °F) at 14 MHz.
Frequency drift with temperature: Not specified.	After adjustment to 14.0 MHz at 72 °F room temperature, the MFJ-249 moved to: 14.057 MHz at 40 °F, 13.993 MHz at 90 °F
Output power: Not specified	3.4 mW (max)
Power requirements: 8 to 18 V at 200 mA. MFJ-1312B power supply (optional) or 8 AA alkaline batteries.	190 mA with battery supply

Size: (height, width, depth) 2⅜ × 4 × 6¾ inches; weight, 1.75 lb.

- Test and tune stubs and transmission lines.
- Determine the velocity factor of a transmission line.
- Determine the characteristic impedance of a transmission line.
- Adjust an antenna tuner.
- Adjust amplifier matching networks.
- Test RF transformers.
- Measure inductance and capacitance.
- Measure the resonant frequency of tuned circuits.
- Test RF chokes.

At first glance, the MFJ-249 seemed to have more functions and features than a Swiss Army knife. All of these procedures, however, are actually creative applications of the '249's SWR measurement capability. I found they can be performed easily with a minimum of additional components. Here are some of my impressions of these procedures:

Testing and tuning transmission-line stubs requires only the use of a 50-ohm noninductive resistor in series with the coax center conductor. The stub's resonant frequencies are determined by tuning the '249 for dips in SWR. If the stub is open at the far end, dips will occur at odd multiples of ¼ wavelength (¼, ¾ etc); if the stub is terminated (shorted), dips will occur at even multiples (½, 1, 1½ etc). I used an unterminated length of RG-8 approximately 22 feet long as my stub. I found a pronounced dip at 7.319 MHz and approximately at odd multiples of that frequency (22.170, 37.039, 51.933 MHz).

You can use other techniques to determine a coaxial cable's velocity factor and characteristic impedance. Following the instructions in the manual, I obtained a velocity factor of 0.65 for a sample of RG-8, which compares very favorably with the published figure of 0.66. (I did find an error in the manual, though. Velocity factor testing with the '249 involves a quarter-wavelength section of transmission line. The equation at the bottom of page 9 is shown as: Velocity Factor = Free space ¼ wavelength ÷ Actual feed line length. It should be Velocity Factor = Actual feedline length ÷ Free space ¼ wavelength.) Using the procedure described for finding characteristic impedance of coaxial cable, my test length of RG-8 measured 54.3 ohms—very close to the published value.

Measuring inductance and capacitance with the MFJ-249 requires the use of known component values. The unknown component is resonated with one of the known values, and the resonant frequency of the resulting L-C circuit is then determined by a 50-ohm resistor and the '249. Although a calculation is required for this procedure, I nonetheless found it fairly simple, easy and quick to perform. Values measured with the MFJ-249 and the ARRL Lab's Q meter agreed closely.

Adjusting an antenna tuner with the MFJ-249 is a real snap. Using a 25-ohm dummy load, I was able to quickly tune a typical commercially available antenna tuner for minimum SWR. Because the MFJ-249 transmits only a low-level signal, this is a great way to reduce unnecessary interference and QRM. You can use the '249 to make a chart of tuner control settings for a variety of frequencies for quicker on-the-air tune-ups.

According to the manual, the '249 can also be used to estimate the loss of 50-ohm feed lines if the losses are between 3 and 10 dB. I tried some line-loss measurements with RG-8 and RG-213. The measurement is simple to perform and results were reasonably close to what I expected from the published figures.

Although it's not described in the manual, you can add a few external parts and use the MFJ-249 as a dip meter. Dave Barton, AF6S, describes how to do it elsewhere in this issue.

The frequency counter in the MFJ-249 is surprisingly good, and MFJ provides an external input so you can use the counter independent of the SWR Analyzer. ARRL Lab testing revealed that its frequency range is 1 Hz to approximately 230 MHz, with a 1-Hz resolution possible. Sensitivity is 200 mV at HF. Its accuracy ranges from 10 Hz at 2 MHz to 700 Hz at 146 MHz, which is more than adequate for most amateur applications.

The MFJ-207

The MFJ-207 is the lowest-priced MFJ SWR Analyzer. It does not include a frequency counter, and it covers 1.75 to 30 MHz in five bands. Coverage is not quite continuous (see Table 3). The **BAND SELECT** switch sets the frequency range, and its **TUNE** control sets the oscillator to the desired frequency.

The **TUNE** control, although calibrated, only serves to provide a rough approximation of the actual frequency. The '207 lacks an integral frequency counter, so the manual describes two options to achieve useful accuracy: 1) Connect an external frequency counter to the phono jack provided for this

Table 3
MFJ-207 SWR Analyzer

Manufacturer's claimed specifications	*Measured in the ARRL Lab*
Band ranges (MHz): A, 1.75-3; B, 3-5; C, 6.5-11.7; D, 11.65-20; E, 18-30.	Ranges measured with external frequency counter: A, 1.735-3.044 MHz B, 2.984-5.342 MHz C, 6.402-11.501 MHz D, 12.019-21.903 MHz E, 17.393-32.118 MHz
Dial calibration (front-panel markings): 1.75-2.9 MHz (lowest range); 6.5-11 MHz (middle range); 18-33.5 MHz (highest range).	Approximately as specified: 1.771-2.835 MHz (lowest range) 6.445-10.731 MHz (mid range) 17.495-31.766 MHz (highest range)
Warm-up drift: Not specified.	+2.6 kHz after 15 minutes from a cold start at room temperature (72 °F) at 14 MHz.
Frequency drift with temperature: Not specified.	After adjustment to 14.0 MHz at 72 °F room temperature, the MFJ-207 moved to: 14.111 MHz at 40 °F 14.018 MHz at 90 °F
Output power: Not specified	2.5 mW (max)
Power requirements: MFJ-1312B power supply adapter (optional) or 9-V alkaline battery	36 mA with 9-V battery supply

Size: (height, width, depth) $2\frac{3}{8} \times 2\frac{3}{16} \times 7\frac{1}{2}$ inches; weight, 14 oz.

Table 4
SWR Accuracy of MFJ-249 and MFJ-207

Load	*Frequency*	*MFJ-207*	*MFJ-249*
50 ohms resistive	3.5 MHz	1.0:1	1.0:1
(Calculated SWR 1:1)	14.0 MHz	1.0:1	1.0:1
	28.0 MHz	1.0:1	1.0:1
	50.0 MHz	n/a	1.1:1
	144.0 MHz	n/a	1.4:1
25 ohms resistive	3.5 MHz	1.7:1	2.0:1
(Calculated SWR 2:1)	14.0 MHz	1.7:1	2.0:1
	28.0 MHz	1.7:1	2.1:1
	50.0 MHz	n/a	2.2:1
	144.0 MHz	n/a	2.4:1
100 ohms resistive	3.5 MHz	2.0:1	2.0:1
(Calculated SWR 2:1)	14.0 MHz	2.0:1	2.0:1
	28.0 MHz	1.9:1	2.0:1
	50.0 MHz	n/a	2.0:1
	144.0 MHz	n/a	2.0:1
Reactive load,	3.5 MHz	2.5:1	2.6:1
50 ohms − *j*50	14.0 MHz	2.4:1	2.5:1
(Calculated SWR, 2.6:1)	28.0 MHz	2.1:1	2.3:1
	50.0 MHz	n/a	2.3:1
	144.0 MHz	n/a	1.7:1
Reactive load,	3.5 MHz	2.4:1	2.5:1
50 ohms + *j*50	14.0 MHz	2.2:1	2.3:1
(Calculated SWR, 2.6:1)	28.0 MHz	2.1:1	2.3:1
	50.0 MHz	n/a	2.5:1
	144.0 MHz	n/a	2.4:1

purpose, or 2) zero beat the analyzer's signal with an MF/HF receiver. A general-coverage receiver is advantageous if you need to locate resonance outside the ham bands.

I found tuning the '207 to a specific frequency to be somewhat tricky. Like the '249, relatively small changes in the **TUNE** control produce large changes in the analyzer's frequency. Setting this critical adjustment almost always took several tries. Retuning was frequently required when the '207 drifted outside the receiver's passband or the beat note became a high-pitched squeal.

There are some definite advantages to the MFJ-249, with its built-in counter. I found that locating the '207's signal on my receiver (a Sony ICF-2010) was more time consuming than the using '249 with its built-in frequency counter. With the '207, SWR measurements on the roof or on a tower are more difficult because you need to bring a receiver or frequency counter along. If your receiver or counter aren't portable, you must set the frequency before leaving for the antenna site—and once there, you don't have an accurate way of changing the frequency. You may also suffer errors caused by vibration and drift.

The MFJ-207's eight-page manual is adequate. It describes how to measure an antenna's SWR at a particular frequency, find the frequency at which an antenna has the lowest SWR, adjust an antenna for lowest SWR, and adjust an antenna tuner.

Conclusion

An SWR Analyzer is very handy when working with antennas. I especially like the ability to measure the resonant frequency of an antenna without having to transmit a high-power signal into it. This feature minimizes interference within the amateur bands and provides a noninterfering means to measure SWR outside the amateur bands. The latter can be extremely helpful when estimating the length that must be trimmed from an antenna.

On the minus side, I would prefer less touchy tuning controls and better oscillator stability in each of the units I reviewed. Controlled testing in the ARRL Lab's temperature chamber confirmed that both SWR Analyzers tend to drift in frequency with temperature, particularly as the temperature falls. For example, if you set our MFJ-207 to 14.0 MHz at room temperature in your station and then brought it outside for antenna measurements on a crisp 40° fall day, the frequency would be off by about 100 kHz. The MFJ-249 suffers from temperature drift as well, but it's not as important because you can compensate for drift with the '249's internal frequency counter. See Tables 2 and 3.

Table 4 shows the results of SWR measurements with both units using controlled resistive and reactive loads. The MFJ-249 SWR readings tended to be slightly closer to the calculated SWR values, but both units were easily close enough for useful work.

My favorite is the MFJ-249. I found its built-in frequency counter and extended frequency coverage to be a real plus. In addition, its external counter input and other functions make the '249 a versatile piece of test equipment with many uses around the shack. Although the MFJ-207 does not have a counter, it's a handy, low-cost device for testing and adjusting MF/HF antennas.

As my antenna farm continues to grow, I wonder how I've gotten by without an analyzer for so long. The bottom line is that I have found them to be a big help when working with antennas.

Manufacturer: MFJ Enterprises, Inc, PO Box 494, Mississippi State, MS 39762, tel 1-800-647-1800, fax 601-323-6551. Manufacturer's suggested retail price: MFJ-249, $200; MFJ-207, $80; MFJ-1312B power supply, $13.

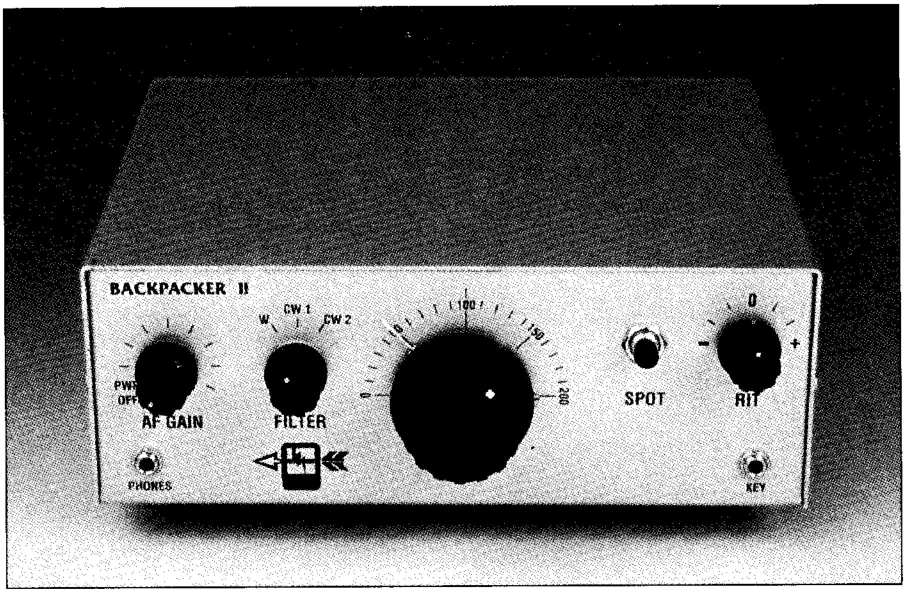
Tejas RF Technology Backpacker II Model TRFT-550 Single-Band CW Transceiver

Reviewed by Jeff Bauer, WA1MBK

Getting on HF and having fun does *not* have to cost a lot of money. I know, I know...this is contrary to what the slick ad copy in amateur magazines sometimes implies. And I can almost hear someone muttering "you get what you pay for." Fair enough!

That said, the Backpacker II delivers more than what you'd expect from just checking the price tag. Although it's not loaded with features—a zillion memory channels, microprocessor-controlled this, computer-interfaced that, and dc-to-daylight scanning—what it does, it does well.

And there's a certain joy in its simplicity...



The Package

The Backpacker II is a single-band 1.5-watt CW transceiver based on "An Optimized QRP Transceiver" designed by veteran home-brewer and RF designer Roy Lewallen, W7EL. (Roy's original design is described in August 1980 *QST*, recent editions of *The ARRL Handbook* and *QRP Classics*.) The transceiver is available in kit form only, and you have your choice of bands: 40, 30, 20, 17 or 15 meters. We reviewed a 40-meter unit. Tejas RF Technology offers optional component kits to make the transceiver work on any of the five bands. To change bands, you need to change only a handful of components. (The review transceiver is a factory assembled and tested unit. Factory-built units are no longer available.)

There have been some updates to W7EL's original design, including use of low-noise op amps instead of transistors in the audio-preamp circuit, and some changes to the VFO scheme for stable operation and easy modification for using the rig on different bands.

The Backpacker II is small and light, making it an easy stowaway. Its front panel sports key and headphone jacks (⅛-inch mini size), a power switch/volume control, a filter-selection switch, VFO tuning, a spot switch and an RIT control. The rear panel is home for the 2.1-mm coaxial power jack and phono antenna jack. The layout, both front and rear, is symmetrical and uncrowded. I particularly liked the quality knobs used.

The rigid, anodized aluminum enclosure is *incredibly* solid. The manual mentions an "exclusive design" being "very sturdy" and "will not flex." When manufacturers boast about something being heavy duty, bullet-proof or otherwise super-duper, I immediately toggle into obsession-mode to see just how sturdy the thingamajig really is. While wearing headphones and monitoring a signal, I firmly grasped the Backpacker II on each end and tried my darndest to "flex" the unit. "Hmm, no flex or shift in frequency," I mused. The next logical step was to beat on the top of the unit with my fist. That surely would make the frequency wobble. Wrong again.

As a matter of fact, the only way I could get the frequency to jump was by dropping the unit from about three or four inches onto the table top. That borders on abusive handling of equipment. Oh, all right...it's *clearly* abusive handling of equipment. But it was done in the purest scientific interest of seeing just how much of a "tough guy" this radio is (its name suggests use in rugged outdoor settings, after all). It passed the test—well done, Tejas Technology!

The Receiver

Received signals take an interesting route in this direct-conversion receiver. The path involves going "in reverse" through the *transmitter's* low-pass filter. This is not unusual for radios of this class, and it's a handy way to keep the parts count (and price) down.

Received signals go to a passive double balanced diode ring mixer circuit, where they mix with the output of the VFO circuitry. In this mixing process, the received signals are *directly converted* to audio, hence the moniker *direct conversion*. There are no intermediate-frequency (IF) amplifiers to amplify the signal, so all the gain in this receiver takes place in the audio stages.

Speaking of audio, the Backpacker II can drive a small speaker adequately for most low-noise environments. It might be a good idea to pad the headphone output with a resistor network, though, as there is *plenty* of audio.

Receiver sensitivity is more than adequate for this class of radio. Selectivity is provided by a passive, low-pass filter that follows the audio preamp stage and a two-pole active bandpass filter centered on 750 Hz. The front-panel filter choices are W, CW1 and CW2. We measured these filter bandwidths at 1088, 304 and 277 Hz respectively. According to the manual, CW1 should have been 180 Hz, and CW2 should have been 110 Hz. Tejas RF Technology researched this discrepancy and discovered that a batch of 1.8-megohm resistors used in the audio filter actually measured 1.08 megohms, resulting in wider bandwidths. The problem is corrected in current kits and replacement parts are available free to anyone with an older kit. I found the wider bandwidth to my liking, though, and elected not to replace the parts.

An RIT circuit allows for ±1.5 kHz shift from zero beat. Tejas RF Technology supplies a center-detent control for this function—a nice touch indeed, considering that my kilobuck SSB transceiver doesn't even have a detent-type pot for RIT/XIT.

Early in the review process, the receiver was found to motorboat (that putt-putt-putt sound) even at low audio volume levels. A trip back to the factory with a *fast* turnaround time provided us with a repaired unit. Tejas RF Technology made a few component changes (included in current units), and the repaired radio worked fine. Again, parts for this modification are available free to owners of older kits.

VFO Circuitry

A major departure from W7EL's original design is in the VFO circuitry. Roy's trans-

The Bottom Line

Tejas RF Technology's Backpacker II is a solid implementation of a proven QRP CW transceiver design. If you're looking for a basic radio with good performance and enjoy building your own equipment, this kit is a good choice.

Table 5
Texas RF Technology Backpacker II Model TRFT-550 40-Meter CW Transceiver

Manufacturer's Claimed Specifications	*Measured in the ARRL Lab*
Frequency coverage: 7.0-7.2 MHz.	7.003 MHz (dial at 0) to 7.206 MHz (dial at 200)
Mode of operation: CW	As specified.
Power requirement: 12-14 V dc, 300 mA max (TX), 65 mA max (RX).	At 13.8 V, 228 mA max (TX), 53 mA max (RX)
Receiver	*Receiver Dynamic Testing*
CW receiver sensitivity (bandwidth not specified, 10 dB S+N/N): 0.5 µV (−113 dBm).	Minimum discernible signal (with CW2 narrow filter), −119 dBm
Blocking dynamic range: Not specified.	Blocking dynamic range:† with CW2 narrow filter, 100 dB
Two-tone, third-order intermodulation distortion dynamic range: Not specified.	Two-tone IMD dynamic range:† with CW2 narrow filter, 81 dB
Third-order input intercept: Not specified.	with CW2 narrow filter, +2.5 dBm
Receiver audio output: 600 mW into 8 ohms	1.05 W at 10% THD into 8 ohms.
Receiver IF/audio response: Not specified.	At −6 dB: wide filter, 1088 Hz centered at 684 Hz; CW1 filter, 304 Hz centered at 768 Hz; CW2 filter, 277 Hz centered at 773 Hz.
Transmitter	*Transmitter Dynamic Testing*
Transmitter power output: Variable, up to 2 W max, 1.5 W nominal.	1.6 W at 13.8 V dc, 1.1 W at 12 V dc.
Spurious-signal and harmonic suppression: not specified.	Spurs and harmonics down by 42 dB or more.The Backpacker II meets FCC spectral-purity specifications for equipment in its power-output class and frequency range.
CW-keying characteristics: Not specified.	See Fig 1.
Transmit-receive turnaround time (PTT release to 50% audio output): Not specified.	120 ms.
Size (height, width, depth): 2.5 × 7 × 6 inches; weight, 1.4 lb.	

†Dynamic-range measurements were made at the ARRL Lab standard signal spacing of 20 kHz.

ceiver was designed for 40-meter operation, and the VFO tunes 7.0 to 7.15 MHz. The Backpacker II uses a 6.0 to 6.2-MHz VFO. The 6-MHz signal mixes with the output of a fixed oscillator (called a heterodyne frequency oscillator, or HFO), and the sum or difference signal is selected through filtering to produce the right tuning range for the band of interest. For example, on 20 meters the 6.0-6.2 MHz VFO signal mixes with an 8.0-MHz HFO signal, and the sum (8 + 6 = 14) is selected to produce a tuning range of 14 to 14.2 MHz.

The Backpacker II covers 200 kHz of each band. The 6:1 tuning ratio makes for adequate bandspread. The VFO tuning knob is centered on the front panel and has a positive feel with virtually no backlash or slop. The tuning is so sure and solid that I was able to monitor Baudot, ASCII, AMTOR, packet and PACTOR transmissions with ease.

The Transmitter

The transmitter uses the same VFO, HFO and mixer stages as the receiver. The RF output transistor, a 2SC799, is plenty rugged for this application. "Just in case," there is a 36-volt Zener diode and 10-ohm resistor from the collector of the output transistor to ground, providing some margin of safety for the transistor in the event of transmitting into an open or shorted load.

The Backpacker II employs QSK, or full break-in keying. Two diodes in a passive limiter configuration (anode to cathode and cathode to anode) provide quasi-TR switching. The keying system is called sequential keying. This is a three step procedure that involves muting the receiver, shifting the VFO to the transmit frequency (which stays the same regardless of the receiver's RIT offset), and keying the transmitter. It's all automatic, yet it happens *sequentially* each time the key is tapped. A switching (keying) transistor and associated components shape the transmitter keying, which aids in providing crisp, clean signals.

Lab testing disclosed a mild key click during TR changeover. Tejas RF Technology eliminated this problem with a slight modification, included in all current kits.

The Manual

There are 32 pages in the Backpacker II manual. Someone put a lot of work into it, and it shows. The "Theory of Operation" section takes you through the entire transceiver and is peppered with some design philosophy.

The hand-drawn schematic diagrams are

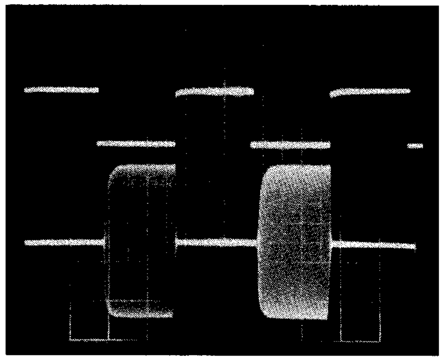


Fig 1—CW-keying waveform for the Tejas RF Technology Backpacker II after modification to reduce key clicks. The upper traces are the actual key closures; the lower traces are the RF envelopes. Horizontal divisions are 10 ms. The transceiver was being operated at 1.5 W output at 7 MHz.

individually easy to read, but there are five separate circuit schematics and one pictorial on an 11 × 17-inch page. Some of the interconnections between these circuits are not clearly labeled and may cause confusion for builders of the kit version. An "interconnecting wiring chart" spread over pages 17, 18 and 19 of the manual does define these connections, but I would have preferred to see a better schematic than the "chart."

Circuit-board parts layouts are adequate. A section with tips and other information about QRP operating is a nice addition. The construction section is fairly sparse, except for the parts lists, which are well done.

Although the manual is well written and reasonably well laid out, it is not detailed. For this reason, neophyte builders might want to have a more experienced builder available to answer the inevitable questions. Tejas RF Technology is up-front about the skill level required to complete the kit. According to the catalog, "We do suggest that this kit requires some previous building experience. It should not be considered for a beginning first-time kit."

Operation

Operating the Backpacker II is straightforward. Set the RIT to the center detent position, then tune the receiver. When you hear a station you would like to call, you zero-beat with the main tuning control and then rock the RIT up or down for best copy. If there is QRM on both sides of zero beat, the active bandpass filter comes in handy. Switch it in and rock the RIT so the desired signal peaks in the headphones.

Because the Backpacker II is a QSK (full break-in) rig, you simply tap out code on the key and the transmit/receive function is automatic. You don't have to fool with TR switch or VOX controls.

I found the sidetone a tad harsh for my ears, although simple multivibrator sidetone circuits are commonly used in similar rigs. These tone oscillators usually produce sawtooth or triangle waves, which sound harsher than sine waves. Adjusting the sidetone to a lower level made this bearable.

When turning on the transceiver, there is a sometimes painful pop in the headphones. This malady is not uncommon with radios of such simple design. Barring a redesign of the audio stages, you can simply plug in your headphones *after* power is applied.

Summary

This compact rig easily fits into a suitcase, backpack or nearly anywhere on the operating bench. Although it's in the bare-bones category of amateur equipment, it's a good performer. The Backpacker II starts with a proven, popular design and adds some intelligent and worthwhile improvements. With an average antenna, above average patience and persistence, and the desire to try something different, plenty of enjoyable contacts, even DX, are possible with this little radio.

Manufacturer: Tejas RF Technology, PO Box 720331, Houston, TX 77272-0331, tel 713-879-9300, fax 713-879-9494. Manufacturer's suggested retail price: Backpacker II kit, $160; component kits for additional bands, $10 each.

SGC Inc Model SG-230 "Smartuner" Automatic Antenna Tuner

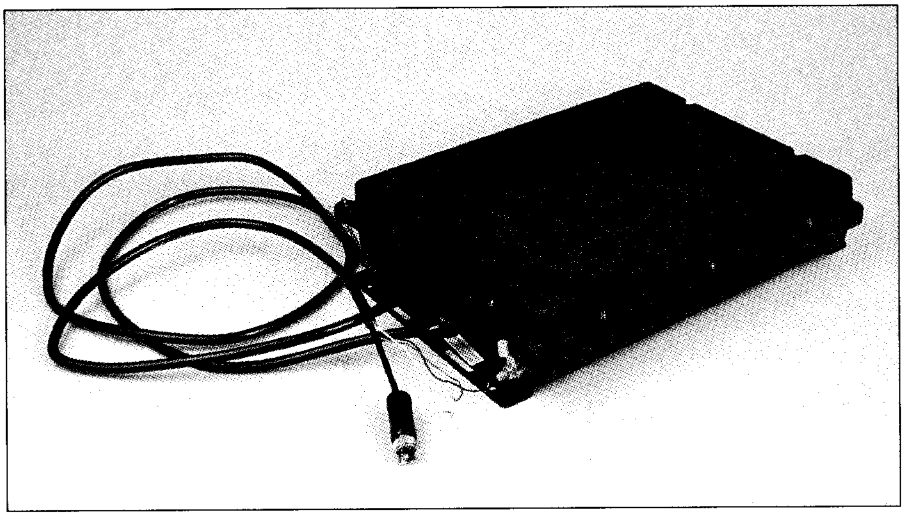
Reviewed by Jeff Bauer, WA1MBK

Way back when I was in technical school, there was a man who put forth the proposition that you could tune an antenna, but you couldn't tune a fish. Or was that tuna fish? Anyway, that was back in 1969, or so...a time when there was a *lot* of strange preaching going on. Bell-bottom pants were hip, hip-huggers often ripped, and Woodstock was an event—*not* one of Charles Schulz's Peanuts characters.

It was also before Al LaPlaca, W2WW (then K2DKK), and Lew McCoy, W1ICP, had graced the pages of *QST* with the "Ultimate Transmatch"—the most popular antenna matching device to hit the Amateur Radio scene since the famous Johnson Kilowatt Matchbox tuners.

Yet by today's standards, even the Ultimate Transmatch is a dated unit that is sometimes cumbersome to use. Some 20 years later, we revel in the luxury of automatic, remote-control, microprocessor-based technology in every aspect of our lives. Cars have computers, kilowatt audio systems and electronic *everything*. Kitchen toasters have *memories*. Coffee makers and ovens can be programmed. Will it ever end? Probably not.

Here we review the SGC Model SG-230 Smartuner, a modern successor to the Ultimate Transmatch. It's an outboard microprocessor-controlled antenna tuner for radios in the 150-watt class. Its main application is for end-fed, unbalanced antennas such as random wires or whips. The manual recommends a radiator at least ¼ wavelength long, and shows a number of mobile, marine and fixed-station applications. Hook a random wire to the output terminal, apply at least 10 watts of RF, and the Smartuner automatically finds the best match.



The SGC-230 Smartuner is the proverbial black box. The cable carries wires for RF input and dc power, and for connecting a remote LED the lights when the tuner finds a match.

Description

The Smartuner is literally and figuratively the proverbial "black box" many of us read about while studying for our licenses. The enclosure is made of ABS plastic, which is rugged and provides all-weather protection for the internal circuitry.

Inside is a virtual grab-bag of high-tech digital circuitry and some perhaps more-familiar RF and analog components. A shock-mount option is available for "military applications," as is 24-volt operation. The stock unit runs on 12 volts and should be fine for everything other than the most torturous amateur installations.

The Tuner Circuit

Stripped of its computer brain, the Smartuner turns out to be a regular antenna tuner after all. What a surprise! The circuit configuration can be configured as a classic pi network or a series L network (the computer figures out which is needed to match a given antenna). Six input capacitors, eight inductors and five output capacitors are switched in or out of the tuner circuit by relays. There are no knobs, turns counters or band switches to deal with.

Depending upon the configuration of the various relays, capacitors and inductors, up to "about a half-million different pi or L configurations" are provided, so states the manual. I didn't bother to draw out and count the various individual component configurations and do the math to verify the number. Let's just say there are a lot of combinations!

> **The Bottom Line**
>
> SGC's Smartuner applies modern microprocessor technology to a classic problem and comes up a winner. Although it's a bit pricey, the SGC-230 will match a variety of random-length radiators and is a good choice for mobile, marine or "stealth" home antenna systems.

How it Works

Using the Smartuner couldn't be simpler. Simply talk into your mike or key a CW carrier. The reflected power measured in the tuner's directional coupler is shunted across terminating resistors and rectified by diodes. The rectified voltages (dc) are fed to a resistive voltage divider, and on to a voltage comparator, which sends digital data to the CPU, the tuner's computer brain. A phase detector circuit tells the CPU whether the load (antenna) impedance presented is capacitive or inductive; more CPU data in.

An MC146805E2 CMOS microprocessor comprises the tuner's brain. Sensor, comparator and detector data provides the CPU with information the built-in software needs to choose the correct combination of capacitors and inductors to achieve a 1:1 SWR (or close to it). Then the antenna is matched. According to the manual, this process typically takes two seconds or less, and the microprocessor will stop hunting if it can't find a match in 20 seconds (time to check the antenna...).

When the tuning procedure is complete,

the CPU creates a table in nonvolatile memory that stores tuner settings and frequency information. This becomes important data for the SGC's tune-up algorithm: The more frequencies tuned, the more frequencies the SG-230 remembers and the faster it can tune up in the future. Retuning time is specified at 10 *milliseconds*, and although we didn't measure this specification, it's *fast*.

Table 6
SGC SG-230 Smartuner 1.8 to 30 MHz Antenna Tuner, Serial no. 65815174

Manufacturer's Claimed Specifications	*Measured in the ARRL Lab*
Frequency range: 1.8 to 30 MHz.	Tested on 160 through 10-meter amateur bands.
RF power input range: 10 to 150 W PEP.	As specified.
Power requirement: 10-15 V dc (13.8 V typ), 900 mA.	At 13.8 V with no RF present, 470 ma; with RF present, 880 mA.
Size (height, width, depth): 3 × 5 × 11 inches; weight, 8 lb.	

The Manual

The manual for the SG-230 is a lot more than I expected for an antenna tuner. It's a well-produced document with nine chapters: general information, specifications, a parts list, antenna types, typical installations, general parameters, installation procedures, electrical check-out and a general description. There are plenty of figures (more than 14!) that clarify almost any type of installation you could encounter.

Operation

Using the SG-230 couldn't be much easier. Simply attach an antenna and a decent RF ground to the tuner, connect the supplied coax to your transceiver, wire up the optional remote tune indicator LED, apply 13.8 V dc and apply RF. The SG-230 senses the RF, figures the SWR and goes through the process of reducing the SWR to match your rig's 50-ohm output to whatever impedance the attached radiator may present. Relays click and before you know it, the remote-tune LED is lit and you're ready to make QSOs.

At least 10 watts of RF is required for the Smartuner's sensing circuitry to function properly. This can be a problem with some solid-state transceivers that have sensitive circuitry to reduce output power in case of high SWR. The transmitter may not put out 10 watts until the Smartuner finds a reasonable match. This was problematic when using my Kenwood TS-440S on SSB: At times, the tuner didn't seem to sense any RF coming down the line. Switching the '440 to CW and sending a few dits kicked the SG-230 into gear. The manual shows how to modify the Smartuner so that its sensing circuitry responds to signals of 6 W or 3 W. I didn't try this during the review.

The specifications call for a 23 to 80-foot antenna for operation on 160 meters, but I was able to tune a haphazardly strung 15-foot length of wire on that band. For frequencies above 3.3 MHz, as little as eight feet of antenna may be used, making a garden variety 102-inch CB whip antenna more than sufficient for multiband mobile use.

One point to remember is that the use of certain antenna lengths on some frequencies can cause extremely high RF voltages to appear at the feedpoint. SGC provides a high-voltage porcelain feed-through for connecting the tuner to the antenna, so care should be exercised in maintaining high-voltage insulation for the antenna lead-in wire. High-voltage anode wire from a defunct color TV set (or a TV repair shop) works fine. The center conductor from RG-213 coaxial cable is rated at 5000 volts and should suffice for most applications unless your radiator is *very* short.

We tried some 150-watt 10-minute key-down tests in the ARRL Lab on a variety of frequencies and with a variety of loads. Although the SGC-230 became slightly warm to the touch, we observed no problems or signs of stress. When SGC says 150 watts, they mean it.

The Finale

Readers may ask, "My rig already has an internal antenna tuner. Why would I want this one?" That's a fair question.

The internal antenna tuners in most transceivers can usually handle only a rather limited range of impedances. The SG-230 will tune a wider range of impedances, and it can be located *at or near the antenna*. This is important in providing the maximum transfer of power directly to the radiator.

Although expensive, the SC-230 is a wonderful unit for the serious mobile or marine operator who prefers to keep rolling instead of stopping to change band elements or coil taps when band hopping. The SG-230 would also be a welcome helper for the amateur interested in operating undercover HF in "stealth Mode" from an apartment or condo with a minimum of gadgetry to adjust.

Come to think of it, with this SG tuner, maybe you *can* tune a fish! Or is that *can tuna fish*?

Manufacturer: SGC, Inc, 13737 SE 26th St, Bellevue, WA 98005, tel 206-746-6310, fax 206-746-6384. Manufacturer's suggested retail price: $595.

SOLICITATION FOR PRODUCT REVIEW EQUIPMENT BIDS

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The ARRL-purchased Product Review equipment listed below is for sale to the highest bidder. Prices quoted are minimum acceptable bids, and are discounted from the purchase prices. All equipment is sold without warranty.

Kenwood TS-50S MF/HF transceiver with YK-107C 500-Hz CW filter and MB-13 mounting bracket (see Product Review, September 1993 *QST*). Sold as a package only. Minimum bid: $753.

Japan Radio Company JST-135HP transceiver with power supply (see Product Review, March 1992 *QST*). Sold as a package only. Minimum bid: $1200.

SSB Electronic SP-70 mast-mount 70-cm preamplifier (see Product Review, March 1993 *QST*). Minimum bid: $100.

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Sealed bids must be submitted by mail and must be postmarked on or before November 27, 1993. Bids postmarked after the closing date will not be considered. Bids will be opened seven days after the closing postmark date. In the case of equal high bids, the high bid bearing the earliest postmark will be declared the successful bidder.

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

Please send bids to Bob Boucher, Product Review Bids, ARRL, 225 Main St, Newington, CT 06111-1494. QST

Feedback

◊ There's a numerical error in a table in "A Unified Approach to the Design Of Crystal Ladder Filters," by Wes Hayward, W7ZOI, *QST*, May 1982. (This error is repeated in W1FB's *Design Notebook.*) In Table 1, *Normalized k and q Values for a Butterworth Response Without Predistortion,* contains an error. The table entry for N=4, k23 is given as 0.4512. This is wrong. It should be 0.5412. The correct number is given in Zverev's *Handbook of Filter Synthesis,* and I have confirmed this also from Table 3, Chapter 8, in *Reference Data for Radio Engineers.* —*Dan Halbert, KB1RT*