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QST Compares: Peak-Reading MF/HF Wattmeters
(Coaxial Dynamics 83000-A; Comet CD-160H; Daiwa NS-660PA; Diamond SX-100; Heath HM-2140-A; MFJ 815B; Mirage MP1; Nye-Viking RFM-003; Yaesu YS-60)

Conducted By James W. Healy, NJ2L
Assistant Technical Editor

QST Compares: Peak-Reading MF/HF Wattmeters

By James W. ("Rus") Healy, NJ2L

The popularity of peak-reading wattmeters has risen greatly in the last couple of years; a number of manufacturers, foreign and domestic, have responded by introducing such devices. Rather than reviewing each individually, we've taken a new approach to certain kinds of reviews, starting with this one: a comparison of features and performance of products in a distinct class. Tell us what you think; your feedback will help us decide what classes of products to review this way in the future.

Each of the peak-reading wattmeters reviewed here was selected based on ready availability, coverage of at least 1.8 through 30 MHz, and the ability to display forward power to at least 1.5 kW. Some of the meters reviewed cover broader frequency and power ranges, but all meet these basic criteria. All but one of the reviewed meters feature direct SWR-measurement capability.

Peak-reading wattmeters can be divided into two classes: active and passive. The active variety sample peak power electronically, then amplify and display forward power. The peak-reading circuitry in such meters requires a dc power source to operate. Passive models use unamplified meter-damping circuits for peak-power readings, and require no power to operate. The performance differences are apparent in the test results of Table 1. All the wattmeters tested here indicate average power (and SWR, for those that display it directly) without requiring an external power supply. In Table 1, note that some meters calculate and display SWR directly, and others require calibration before SWR readings can be made.

We developed a set of tests for these meters that would yield results allowing qualitative comparison of the performances of each one with respect to the others. These tests are briefly described below the test results in the table.

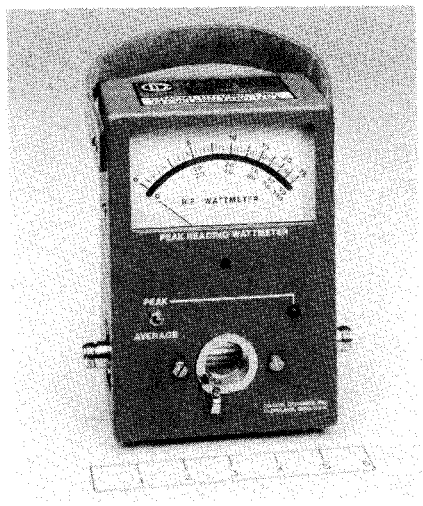
The Contenders

The meters reviewed here include the Coaxial Dynamics 83000-A, Comet CD-160H, Daiwa NS-660PA, Diamond Antenna SX-100, Heath HM-2140-A, Mirage MP1, MFJ 815B, Nye Viking RFM-003 and Yaesu YS-60. Not included here, but also meeting the stated criteria, are the Autek WM1 and the Bird 43P; these meters were reviewed in the November 1989 and December 1989 issues of *QST*, respectively. At least two wattmeters that otherwise meet the review criteria were released too late for this review.[1]

Here are the results of the individual evaluations.

Coaxial Dynamics 83000-A

Manufacturer: Coaxial Dynamics, Inc, 15210 Industrial Pkwy, Cleveland, OH 44135, tel 800-262-9425 or 216-267-2233.



The 83000-A bears a strong resemblance in function and accuracy to the Bird 43P. In fact, the 83000-A works with Bird's power-measurement elements. Able to store two spare elements and equipped with a large (4.5-inch-wide), mirrored scale and a detachable line section (coupler/element holder), the 83000-A is flexible and rugged. A single 9-V battery powers the peak-reading circuitry. An external-power receptacle is not included; Coaxial Dynamics specifies average battery life as "at least 90 days," although the original battery has lasted more than nine months in intermittent service. A rechargeable battery is optional. The instruction sheet provided with the 83000-A is adequate, if sparse.

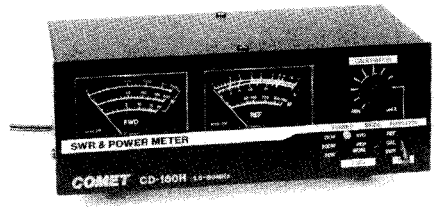
The 83000-A, like Bird's analog wattmeters, allows separate measurement of forward and reflected power (not at the same time). SWR must be calculated based on these readings. Coaxial Dynamics has achieved excellent peak-power-measurement accuracy, as shown in Table 1.

Power-measurement elements for the 83000-A are optional, and are available for full-scale power levels ranging from 5 W to 10 kW and frequency ranges of 2-30, 25-60, 50-125, 100-250, 200-500, 500-1000 and 950-1300 MHz. Prices (as of mid-December, 1990) range from $52 each for the 25- to 1000-MHz elements to $104 for the 900- to 1300-MHz units, and most 2- to 30-MHz elements are $61 each. A variety of connectors (N, UHF, BNC, TNC, etc) is also available.

All things considered, the 83000-A is well-suited to heavy-duty use where good accuracy is required, such as installation and maintenance applications. A long meter-hold time constant, the need to calculate SWR from power readings, and the expense of power-measurement elements make the 83000-A less appropriate for everyday ham-shack use than most of the other meters reviewed here.

Comet CD-160H

Manufacturer: NCG Co, Ltd, 1275 N Grove St, Anaheim, CA 92806, tel 714-630-4541.



The CD-160H is a sturdily built, dual-meter unit that uses a passive PEP-indication circuit. Its controls have a smooth feel and the meter scales are easy to read, even in low-light situations. Reading the meters can be confusing, however, because separate scale markings are used for each of the meter's three power ranges.

Of the meters we tested, only the Comet displays reflected power as a percentage of forward power. An absolute reflected-power scale is also included, but is of little value at forward-power levels of less than 1 kW or so. A brief Japanese/English instruction sheet, complete with schematic diagram and parts list, is included with the CD-160H.

Daiwa NS-660PA

Manufacturer: Daiwa Electronics Corp, 1908-A Del Ammo Blvd, Torrance, CA 90501-1303, tel 714-895-6645.

A solidly made, attractive and flexible unit, the sloped-front NS-660PA is one of two cross-needle wattmeters we tested. Its flexibility lies mainly in its ability to accept external directional couplers for VHF and UHF. This meter comes with a 9-V battery

[1]Those just released include AEA's cross-needle wattmeter and the Palomar Engineers LED-bargraph meter.

Table 1
Wattmeter Features and Performance

	Coaxial Dynamics			Comet			Daiwa			Diamond Antenna		
Manufacturer												
Model	83000-A			CD-160H			NS-660PA			SX-100		
Mfr's Suggested List Price	$275			$159			$199.95			$149.95		
Frequency Range	Element-dependent			1.6-60 MHz			1.8-150 MHz‡			1.6-60 MHz		
Power Range(s)	Element-dependent			20/200/2000			30/300/3000 W			30/300/3000 W		
Auto-Ranging	No			No			No			No		
Active PEP Circuit	Yes			No			Yes			No		
Automatic SWR Calculation	No			No			Yes			No		
Remote Dir Cplr Capability	Yes			No			Yes*			No		
Cable Length	36 in.			—			*			—		
Connector Type	N*			UHF			UHF			UHF		
Illuminated Meter(s)	No			Yes			Yes			Yes		
Power Requirement	9 V†			13.8 V dc			9-14 V dc†			13.8 V dc		
Int/Ext/Both	I			E			B			E		
Power Cable	N/A			36 in.			36 in.			None		
	Average/Peak			*Average/Peak*			*Average/Peak and Hold*			*Average/Peak*		
Actual Forward Power	*2 MHz*	*14 MHz*	*28 MHz*	*2 MHz*	*14 MHz*	*28 MHz*	*2 MHz*	*14 MHz*	*28 MHz*	*2 MHz*	*14 MHz*	*28 MHz*
5 W CW	5/5	5/5	5/5	5.2/5.2	5/5	5/5	4.3/4.3	4.3/4.3	4.3/4.3	5.2/5.2	5.2/5.2	5.2/5.2
5 W 50%	—/4	—/4	—/4	—/3	—/3	—/3	—/3.7	—/3.8	—/3.8	—/4	—4.1	—/4
100 W CW	97/100	98/102	96/98	112/112	108/108	105/105	98/95	98/95	98/95	120/120	110/110	110/108
100 W 50%	—/84	—/90	—/91	—/88	—/86	—/85	—/80	—/85	—/90	—/94	—/90	—/95
100 W Two-Tone	—/93	—/92	—/88	—/78	—/72	—/72	—/82	—/83	—/85	—/90	—/80	—/80
100 W Voice	—/—	—/90	—/—	—/—	—/50	—/—	—/—	—/80	—/—	—/—	—/60	—/—
1 kW CW	900/940	980/1000	960/990	950/950	980/980	990/990	910/900	995/990	995/990	1040/1040	1050/1050	1080/1080
1 kW 50%	—/900	—/940	—/1020	—/880	—/880	—/920	—/800	—/900	—/920	—/975	—/1000	—/1040
1 kW Two-Tone	—/930	—/930	—/860	—/880	—/800	—/810	—/950	—/950	—/980	—/1000	—/800	—/1020
1.5 kW Voice	—/—	—/1300	—/—	—/—	—/800	—/—	—/—	—/1300	—/—	—/—	—/1150	—/—
SWR Accuracy												
1:1 SWR	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1:1	1.1:1	1.1:1	1.1:1
2:1 SWR	2.3:1	2.3:1	2.3:1	2:1	2:1	2:1	1.9:1	1.9:1	1.9:1	2.3:1	2.3:1	2.4:1

*Optional. †9-V battery included. ‡Other ranges available with optional directional couplers. ††Ac-operated supply included.

Lab Notes

Each of the wattmeters was tested at three frequencies (2, 14 and 28 MHz), with test signals generated by the same transmitter and, where applicable, a legal-limit amplifier. No speech processing was used for any of the tests. The power standard on CW was an EIA-standard-calibrated Hewlett-Packard 453B/8482A micro power meter used with suitable attenuation (specified accuracy: +3/−5%). The peak-power standard was the Lab's calibrated Bird 4381 digital computing SWR/wattmeter (specified accuracy: ±5% of full scale). We also used the peak-detection capability of one of our Hewlett-Packard spectrum analyzers to confirm the accuracy of these measurements. Other specifics:

- The 50%-duty-cycle signals were generated by the CW-keying generator usually used in ARRL Lab testing of transceiver keying characteristics. Equivalent keying speed was approximately 20 WPM.
- The two-tone tests were made using the test-signal generator usually used in measuring SSB-transmitter two-tone intermodulation-distortion (IMD) performance.
- The voice signal, which was applied to each wattmeter at 100 W and 1.5 kW at 14 MHz, was a brief tape-recorded message spoken by the test engineer.
- For the SWR tests, we used a noninductive 25-Ω load.

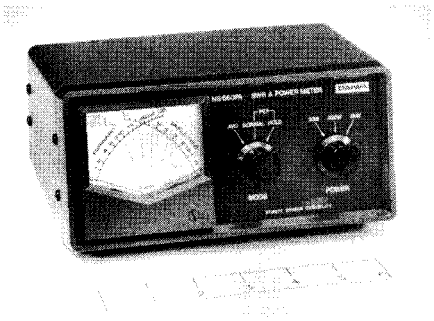
We initially had some difficulty determining whether the Bird 4381 was a suitable standard for peak-power measurements. At the time, we were also using a Bird 43P for comparison purposes. Here's a snippet from ARRL Lab Engineer Ed Hare's test-results report:

> The Bird 4381 and Bird 43P were not in agreement on voice signals. The 43P would typically indicate 1250 W for a signal that was metered as 1500 W by the 4381. ARRL Lab Engineer Zack Lau, KH6CP, performed a test of the Birds versus the peak detector in the spectrum analyzer to try to quantify the problem. Consultation between the lab engineers [following this test] yielded the conclusion that we could use the HP 453B to accurately measure a CW level of 1500 W, then use an analog oscilloscope to determine when an envelope peak was at or greater than this level in order to accurately measure peak SSB power. The fact that we need to rely on test equipment worth thousands of dollars and spend hours of engineering time just to get a go/no-go test of actual voice power speaks volumes about the techniques currently used for SSB peak-power measurement by Amateur Radio operators.

Indeed. In addition to the power tests, we tested each wattmeter for insertion loss and swept return loss (a measure of input SWR). All of the meters had insertion losses of less than 0.1 dB and input SWRs of less than 1.1:1 across their specified frequency ranges.—*NJ2L*

and a battery clip that's wired to a coaxial power plug; an external-power cable is also included.

Except for one humorous gaffe in which actual forward power is referred to as "effective radiated power," the four-page Japanese/English instruction sheet is adequate. It includes good pictorial connection diagrams and information on the two optional directional couplers (300 W, 140-525 MHz, N or UHF connectors; 60 W, 1.2-2.5 GHz, N connectors).



The NS-660PA has a quirk that limits the usefulness of its peak-reading mode: It doesn't indicate reflected power in this mode. So, when you're using the meter in its peak or peak-and-hold mode, the SWR always appears to be 1:1. Only in average-reading mode does the reflected-power needle deflect. The '660PA is more accurate in its peak-and-hold mode than in its peak/no hold mode.

The NS-660PA is nicely made and, even with its marginal illumination and sub-

Heath	MFJ	Mirage	Nye-Viking	Yaesu
HM-2140-A	815B	MP1	RFM-003	YS-60
$129.95	$69.95	$188	$300	$127
1.8-30 MHz	1.8-30 MHz	1.8-30 MHz	1.8-30 MHz‡	1.6-60 MHz
200/2000 W	200/2000 W	25/200/2000	300/3000 W	20/200/2000 W
No	No	No	Yes	No
Yes	No	Yes	Yes	Yes
No	Yes	No	Yes	No
Yes	No	Yes	Yes	No
36 in.	—	48 in.	36 in.	—
UHF	UHF	UHF	UHF	UHF
No	Yes	No	Yes	Yes
9 V dc	12 V dc	9-12 V dc†	13.8 V dc	13.8 V dc
B	E	I	B	E
*	None	N/A	††	36 in.

Heath			MFJ			Mirage			Nye-Viking			Yaesu		
Average/Peak			*Average/Peak*			*Average/Peak*			*Average/Peak and Hold*			*Average/Peak*		
2 MHz	*14 MHz*	*28 MHz*	*2 MHz*	*14 MHz*	*28 MHz*	*2 MHz*	*14 MHz*	*28 MHz*	*2 MHz*	*14 MHz*	*28 MHz*	*2 MHz*	*14 MHz*	*28 MHz*
6/5	7/5.5	6.5/5	9.5/9.5	9.5/9.5	9.5/9.5	4.5/4.5	4.2/4.2	3.8/3.8	4.5/5.5	4/5	4/4.8	6/6	5.3/5.3	5.1/5.1
—/4.5	—/4.5	—/4.5	—/6.5	—/7	—/7	—/3.5	—/3.5	—/3.2	—/4	—/4	—/4	—/4	—/4	—/4
83/82	90/90	82/85	105/105	102/102	105/105	90/90	90/90	82/82	98/104	96/102	90/95	120/120	107/107	100/100
—/70	—/82	—/95	—/81	—/83	—/89	—/75	—/81	—/75	—/85	—/92	—/90	—/88	—/90	—/90
—/98	—/90	—/78	—/85	—/73	—/78	—/70	—/62	—/75	—/80	—/72	—/70	—/105	—/92	—/85
—/—	—/75	—/—	—/—	—/45	—/—	—/—	—/60	—/—	—/—	—/85	—/—	—/—	—/75	—/—
950/1000	1020/1050	980/1000	930/930	920/920	975/975	1020/1020	1000/1000	950/950	1050/1060	1050/1060	950/1000	1200/1200	1150/1150	1100/1100
—/900	—/980	—/1000	—/830	—/820	—/900	—/860	—/900	—/900	—/960	—/1050	—/1000	—/1050	—/1020	—/1050
—/1050	—/1000	—/920	—/840	—/780	—/820	—/840	—/750	—/750	—/920	—/850	—/780	—/1280	—/1180	—/1150
—/—	—/1200	—/—	—/—	—/850	—/—	—/—	—/1200	—/—	—/—	—/1480	—/—	—/—	—/1500	—/—
1.2:1	1.2:1	1.3:1	1:1	1.1:1	1:1	1.2:1	1.1:1	1.1:1	1:1	1:1	1.2:1	1:1	1:1	1.2:1
2.3:1	2.3:1	2.7:1	2.4:1	2.4:1	2.3:1	2:1	2:1	2.3:1	2:1	2:1	2.3:1	2.4:1	2.4:1	2.5:1

optimal contrast between the SWR markings and the meter face, is one of the easiest to read of the bunch. Only one reviewer disliked the cross-needle metering function; all the others appreciated the amount of information you can gather at a glance from such a meter. The NS-660PA was quite popular among the group of reviewers.

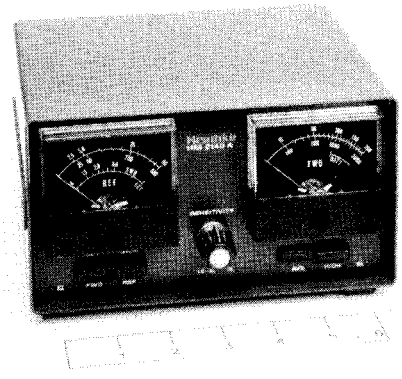
Diamond Antenna SX-100

Manufacturer: Diamond Antenna, imported by RF Parts, 1320 Grand Ave, San Marcos, CA 92069, tel 619-744-0728.

The $149.95 SX-100 uses a single wide-deflection meter movement to indicate forward and reflected power in three ranges (30, 300 and 3000 W). One of the most attractive meters in the bunch, this one uses no active circuitry for peak-power measurements, so its accuracy suffers on low-duty-cycle signals. A four-page instruction sheet explains the meter's installation and use in reasonable detail.

In some cases, the SX-100's SWR readings change with variations in applied power. In one case, the SX-100 indicated an SWR of 1.8:1 on a 40-meter dipole with 100 W applied; when power was increased to 1 kW, the indicated SWR rose to 2.4:1. (The problem wasn't in the antenna; other meters in series with the SX-100 indicated the same SWR at both power levels.)

In general, the SX-100 is nice to use; the cabinet is sturdy, the well-illuminated meter is easy to read, and, with the exception of the somewhat vague **AVG/PEP MONI** switch, the controls have a smooth, solid feel.



Heath HM-2140-A

Manufacturer: Heath Co, Benton Harbor, MI, tel 800-444-3284.

Heath has a long history of making good kits, and the HM-2140-A is no exception. An easy evening construction project, this wattmeter is the only kit in the group reviewed here. As such, its documentation is excellent, and contains complete, straightforward alignment instructions. Heath's calibration procedure yields good power-measurement accuracy in the finished kit, and the '2140 is quite sturdy.

A complaint voiced by more than one reviewer is the meter's open back (where the detachable directional coupler is usually stored); it's easy for things such as the ends of coaxial cables or tools to sneak into the meter's workings, possibly coming into contact with the active electronics. Also, the cabinet is a clamshell affair that's held together only by four sets of screws, nuts and washers; it's made such that, if the hardware isn't tight, the meter can come apart when you pick it up by the top cover. Operationally, the meter is a bit clunky; two sets of push-button switches set the power and SWR functions, but their operation isn't quite intuitive. Fortunately, Heath provides a sticker for the cabinet top (or bottom) containing condensed operation instructions.

On the plus side, the HM-2140-A's two meters give useful indications that are easily readable at arm's length (although this is one of only three wattmeters in the batch that don't have illuminated scales). This meter is relatively inexpensive and hefty enough to stay put on a desktop; cables won't pull it around the surface. For those interested in having a hand in building what

goes into their stations, the HM-2140-A is a good value.

MFJ-815B

Manufacturer: MFJ Enterprises, PO Box 494, Mississippi State, MS 39762, tel 601-323-5869.

The 815B is the only sub-$100 wattmeter we tested. For $69.95, you get a lightweight box with a large, easy-to-read cross-needle meter. The red SWR markings stand out well against the meter face's white background, and the meter illumination is effective in low-light conditions. An adequate instruction sheet accompanies the meter.

The '815B isn't without flaws. Made of lightweight materials, the meter is easily pulled across a tabletop by attached RG-8 cables, and its passive peak-indicating circuitry makes it one of the least accurate meters in the group. The feel of its controls is not particularly solid, and the front-panel finish is easily scratched.

If you're looking for an inexpensive cross-needle wattmeter with plenty of room inside for modification, the MFJ 815B is certainly one to consider.

Mirage MP1

Manufacturer: Mirage Communications Equipment, Inc, PO Box 1000, Morgan Hill, CA 95037, tel 408-779-7363.

The MP1 is a nice meter to use, but its accuracy isn't great, even though it features an active PEP-indication circuit. Its good features include a flashing low-battery indicator, a large, easy-to-read meter, and a choice of internal or external power sources. The meter comes with a schematic diagram, but its readability is poor; the diagram looks like a photocopy of a photocopy. The instruction manual is informative and complete.

The MP1's internal 9-V battery isn't conveniently accessible for replacement, and if you forget to turn off the meter when you're done using it, you'll be replacing the battery often. The meter's power rating is 1 kW continuous, 2 kW intermittent. According to a technician at Mirage, they've received no reports of problems resulting from applying 1.5 kW CW signals to the MP1 for extended periods (such as contests).

Nye-Viking RFM-003

Manufacturer: William M. Nye Corp, 12031 Northrup Wy, #101, Bellevue, WA 98005, tel 206-454-4524, fax 206-453-5704.

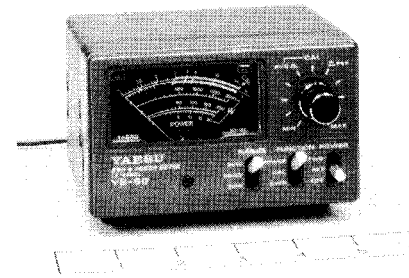
In describing the $300 RFM-003, the reviewers used words and phrases like *rugged, professional, smooth* and *nicely engineered.* This meter has more features than any of the others we tested (and perhaps more features than any other wattmeter aimed at the Amateur Radio market), and no performance compromises are evident in the test results. In fact, the Nye is one of the most accurate meters we tested.

Its list of nifty features is long; those not listed in the table include: a detachable directional coupler that uses a 4-pin connector (TS-520/820-style mike connector); meter illumination and peak-circuit operation that come on when RF is applied and go off five minutes after RF is removed; a removable swivel mount; adjustable-threshold high-SWR lock-out for amplifiers; peak-and-hold operation; an internal NiCd battery that charges from applied RF or from the supplied ac-operated adapter; and optional directional couplers (1.8-30 MHz, 500 W; and 10-160 MHz, 500 W). Add to that a sturdy, attractive design with easy-to-read meters and complete documentation, and you've got a winner. Another nice touch: a schematic diagram and parts list are supplied, and there are no unidentified "black boxes" in the RFM-003. If you're of a mind to troubleshoot your RFM-003, you can do so relatively easily with the supplied diagram, and common parts are used throughout.

Although its $300 price tag was daunting to some, the RFM-003 was the clear crowd pleaser in the lineup. The amplifier-lock-out feature alone makes it worthwhile to those who use fragile amplifiers and want the peace of mind that comes with knowing that, even if the antenna falls off, the wattmeter will keep the amplifier from blowing up!

Yaesu YS-60

Manufacturer: Yaesu USA, Inc, 17210 Edwards Rd, Cerritos, CA 90701, tel 800-999-2070.



In terms of sheer value, the YS-60 is high on the list. Its list of standard features isn't long, but this meter isn't Spartan, either. The least expensive wattmeter with active peak-power-indicating circuitry that we tested, this easy-to-read unit provides better accuracy than you might expect from a $127 wattmeter. Ergonomically, the YS-60 is pleasant, although one reviewer had trouble reading the scale at arm's length. A two-page instruction sheet, including a schematic diagram and parts list, explains meter operation. This sheet cautions you to reduce power to 1 kW for CW or RTTY transmissions of more than 10 minutes.

Red LEDs in the upper corners of the meter tell you at a glance whether the meter is in average or PEP mode, and the cabinet is sturdy and the controls are smooth and positive. The YS-60's size and its use of a 13.8-V dc supply make it a good candidate for mobile operation, too.

Summary

The wattmeters that use passive peak-measurement schemes are generally weakest in accuracy on low-duty-cycle signals (such as SSB), although all the meters we tested were fairly accurate with CW signals at the 100-W and 1-kW levels. Note the frequency dependency of the readings of some of these meters; different readings over a range of frequencies with the same input signal level indicate directional-coupler response that varies with frequency.

Based on our test results and individual evaluations, there's a wide range in quality, accuracy and usefulness between the $69.95 MFJ 815B and the $300 Nye RFM-003. For the most part, the players between these extremes have performance commensurate with their prices, with one notable exception: The $127 Yaesu YS-60 provides good accuracy, is solidly made, attractive, and easy and pleasant to use; it's an excellent value. Of all these meters, if

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Product Review

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you're looking for one that's small, inexpensive and accurate, it's the one to consider first. In terms of accuracy, ruggedness and low price, the Heath HM-2140-A is also one to consider strongly.

As in just about everything else, when you buy a peak-reading wattmeter, you get what you pay for.

Contributors

This review is a compilation of ARRL Laboratory test results and the observations of active hams on the ARRL Technical Department and Production Department staffs. Thanks to Ed Hare, KA1CV; Dave Newkirk, WJ1Z; Paul Pagel, N1FB; Larry Wolfgang, WA3VIL; Chuck Hutchinson, K8CH; Kirk Kleinschmidt, NTØZ; and Mike Gruber, WA1SVF, for participating. QST

Feedback

☐ Please refer to the parts-ordering information in footnote 2 of "The CMOS Super Keyer II," *QST*, Nov 1990, pp 18-21. The speed control pot (R13) is *not* included in the parts kit. R13 is a ¼-W, 100-kΩ linear-taper pot and is available at Radio Shack® stores (RS 271-092) and other electronic parts suppliers. When ordering CMOS Super Keyer II parts or kits, Illinois residents must include 7% state sales tax with their order.

A couple of builders reported failures that were traced to incorrect (backward) installation of the two transistors. If the transistors are installed incorrectly, the keyer will operate, but the sidetone level will be low and the current drain high. Double-check your work!

☐ Ground symbols were inadvertently left off the FL2, FL3 and FL4 sections in Fig 1 of "A Diode-Switched Band-Pass Filter" (Jan 1991 *QST*, p 25). All three filter sections should have a connection to ground from terminal 4 of the input transformers (T6, T8 and T10).

☐ The source for Kent Powloski's QRP transmitter kit in "Kayaking QRP" (*QST*, Jan 1991, p 16, footnote 1) was incorrectly identified as RF Communications. The correct source is Oak Hills Research, 20879 Madison St, Big Rapids, MI 49307. QST