mode." That is, it becomes a like a plug-in thumb drive. If you ever need to upgrade FiFi, you can use this mode to access its memory and load new software.

FiFi isn't the top performing software defined receiver on the market, but for less than $180 US, it is hard to beat.

Distributor: Available from the FUNKAMATEUR online shop at **www.box73.com**.

See the Digital Edition of *QST* for a video overview of the FiFi Software Defined Receiver

MeterBuilder MB-1 Programmable RF Power Meter

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Let's be clear right from the start. Calling this box an RF power meter is like referring to a Lamborghini Aventador Roadster as "just another car." It may be true, but it certainly is not an adequate description! As you will see, the MB-1 is a very advanced programmable RF power meter and might be better called a programmable station monitor. There is a lot of versatility built into this instrument.

One of the first things you notice when looking at the front panel is the variety of display features. Most obvious is an analog cross-needle meter with scales for forward and reflected power, with SWR read at the intersection of the two needles. Then there are four 7-segment LED digital displays. Not visible in the photo is a bar graph display along the top of the LCD information display.

You can measure forward and reflected power as well as SWR. Would you like that to be average or peak power? Okay. Maybe you would like to subtract the reflected power from the forward power, to display the actual power delivered to the load. Okay. Your choice of peak or average power will be displayed on the cross-needle analog meter. Would you prefer a 7-segment LED digital display? You can have that, too. How about a simple bar graph for a quick visual indication of any of those parameters? The MB-1 has you covered!

But wait, there's more! What if you want to be able to display average power and PEP at the same time? Sure. The analog meter and four digital displays can all be programmed to show different information.

If that isn't enough, just add more displays! Our MB-1 included an optional Expansion Kit with two 1½ inch, high-visibility 7-segment LED displays and an LED bar graph. You can connect two of those three expansion displays at once. Seven-segment displays are available in various sizes up to 7 inches high from a number of suppliers, so you can add an even larger display.

You can add up to four more analog meters — two cross needle meters with linear or non-linear scales, as well as other linear and non-linear scale meter movements. The MB-1 provides calibration functions for just about any meter. By now you are getting the idea — this is one very fancy station accessory.

Bottom Line

The MeterBuilder MB-1 is an accurate RF power meter that can be built from a kit or purchased assembled and tested. It covers a wide range of frequencies and power levels with the standard coupler, and can be expanded with multiple couplers and displays.

Menu Control

This versatility comes with a price. There is an extensive set of menu controls to adjust the MB-1's many display parameters and features. There are 14 pushbuttons on the front panel, with most performing two or three different functions. The Expansion Kit included four gray MENU buttons and a red POWER button, to make them easier to distinguish from the black

buttons supplied with the standard kit. (Yes, I did say "kit." More about that later.)

Red, green and yellow LEDs on the switches help identify which buttons are active in the various menu modes, and they also indicate when certain meter functions are active during normal operation. The LEDs also blink to indicate whether you have held the button for a short, medium or long duration while selecting various menu functions. While there are labels printed above or below the buttons, it takes some practice to figure out the menus.

In general, green LEDs indicate normal operation, while yellow or red LEDs indicate "abnormal" or "non-standard" operating conditions. For example, if you have stumbled into the Demo mode or selected one of the virtual couplers instead of a real coupler, you will see several yellow LEDs. This may explain why the meter is not behaving as you expected.

The *User's Manual* is supplied as a 227 page PDF file downloadable from the manufacturer's website. It is a lot to print out, but I expect many owners will want a copy of this documentation for reference. I won't attempt to describe all of the parameters that you can adjust with the menu options in the MB-1, but I will touch on some that I think will interest many readers. Check out the manual for full details.

You can adjust the Peak Hold and Decay time constants for the panel meter (or another analog meter that you have connected). You can adjust the brightness of the LED and LCD displays, and you can also set the time delay for Sleep mode — or turn it off altogether.

The Averaging Filter controls the computation of average power measurements. You might think that a long averaging time is best for displaying average power, and in general that's true, especially for SSB measurements. In some circumstances, however, a short timing window is better. With the MB-1, you can turn on the "Snap" feature, so that when the circuitry detects a constant power, such as when you are adjusting an antenna tuner, it will use a shorter averaging window, but during normal SSB operation, the longer averaging time will be used.

SWR readings can change a bit, especially when you are operating SSB. To provide a stabilized reading, select display of the SWR Min or SWR Max values (or both) rather than (or in addition to) the instantaneous reading. The MB-1 calculates minimum and maximum values of power or other measurements, so you can obtain a readout of those values, too.

The Rear Panel

Figure 5 shows the MB-1 rear panel. What are all those phono jacks for? Added versatility, of course! External meters connect to jacks on the right side block. There are also six jacks in that right block for the contacts on the double-pole, double-throw relay that goes with the SWR alarms. Use these relays to control amplifiers or other external devices that you want to disable if the SWR is too high. Most transceivers have high SWR power rollback, but that isn't always the case with external power amplifiers. The MB-1 can trip an alarm and either sound an alert or activate the relays to take an amplifier offline if the SWR exceeds a preset threshold. You can also set the alarm to trip if a certain power threshold (max or min) is exceeded.

Figure 5 — Looking at the back of the MB-1, you can see lots of phono jacks for coupler inputs and external meter outputs as well as a number of test signals and auxiliary power. The pair of ICD connectors is for the external 7-segment display and bar graph. There is also an RS-232 serial port that you can connect to a computer for firmware updates.

Other jacks provide 5 V output power for external circuits. These outputs are not fuse protected, except by the fuse on the 12 V input supply, so be careful. Phono jacks at the bottom left of the left side block provide 50 μA and 200 μA test signals. You can use these to determine the full scale range of external panel meters that you might be considering for use with your MB-1.

Multiple Couplers

One power coupler is provided with the MB-1. This coupler has been calibrated over the 160 to 6 meter range and is rated to 1500 W ICAS (1000 W ICAS on 6 meters). You're not limited to the standard coupler, though. The block of phono jacks on the left side of the rear panel provides inputs for up to four couplers. If you have a coupler designed for a higher frequency range or a higher power, you can connect it to the MB-1. With the appropriate coupler, you can measure up to 30,000 W. If you have a power sensor that has been calibrated by an instrumentation laboratory, you might want to compare it to the standard coupler.

You can connect couplers other than RF sensors to your MB-1, too. For example, if you have an RF ammeter or other analog sensor, you can establish a calibration table in the MB-1 for that sensor. Just about

Figure 6 — All of the parts for the MB-1 were packaged inside the chassis. The Expansion Kit components (not shown) were included in the box with the MB-1 kit.

Table 2
MeterBuilder MB-1 Programmable RF Power Meter

Frequency range:	1.6 – 60 MHz with MB-HF1 sensor
Sensor serial number:	MB90091
Power range:	10 mW – 1500 W with MB-HF1
Power requirement:	12-15 V dc @ 800 mA max
Current consumption:	392 mA at 13.8 V dc
PEP measurement:	Active
Size (height, width, depth):	5.5 × 8.9 × 7.7 inches
Weight:	10.2 lb

Price: MB-1 kit, $599; assembled and tested, $699. Expansion kit, $149.

ARRL Lab Measurements

	Actual Forward Power MB-1 (indicated power)			
Frequency (MHz)	**2**	**14**	**28**	**50**
5 W CW	5.0	5.0	4.9	5.0
5 W 50%	5.0	5.0	4.9	5.0
100 W CW	101	100	90	94
100 W 50%	102	100	100	102
100 W Two-Tone	—	100	—	—
1 kW CW	1060	1026	1010	1044
1 kW 50%	1100	1040	1020	1150
1 kW Two-Tone	—	1040	—	—
SWR Accuracy				
50 Ω (1:1 SWR)	1.01:1	1.05:1	1.10:1	1.20:1
25 Ω (2:1 SWR)	2.14:1	2.00:1	1.84:1	—
100 Ω (2:1 SWR)	2.12:1	2.15:1	2.25:1	—

Insertion loss: < 0.1 dB throughout operating range.

— = not measured

any quantity can be measured with the appropriate sensor that generates a dc voltage in proportion to the measured quantity. RF current, temperature and pressure sensors come to mind.

I tried the coupler I built years ago as part of a digital wattmeter from *The ARRL Handbook*. Conveniently, I had used phono plugs on the leads from that coupler, so it plugs right in to the MB-1. Calibration was a simple task of measuring the coupler output voltage for several power settings from my transceiver. Just select the coupler number (2 to 4) and the calibration menu. The MB-1 walks you through the process.

It seems there is nothing this versatile box can't do. Well, not quite. With the ability to use four different sensors, my thoughts ran to a contest or Field Day station, where each transmitter could use a separate coupler to provide an input to the meter, and the remote display capabilities could be used to give each operator an indication of transmitter power, SWR or whatever other parameter they wanted to monitor. Searching the *User's Manual* I could not find any mention of how to display the measurements from different sensors simultaneously. An e-mail to the MeterBuilder tech support desk brought a quick reply indicating that it is not possible to display multiple sensors. Only one sensor can be selected at any time. When I questioned this further, the answer was that there is so much computation going on in the unit's microprocessor that there was not room in the processor for the additional computations that would be required to track more than one sensor. They did leave open the possibility that this capability could be added in the future.

Firmware Updates

Speaking of the future, the DB-9 connector on the MB-1's rear panel is a serial port, which you can connect to a computer to load new firmware as updates become available. You won't need to connect a computer to the MB-1 for any other reason, though. There is no computer control program and no interface to read data from the MB-1.

ARRL Lab Test Results

ARRL Test Engineer Bob Allison, WB1GCM, compared the MB-1 measurements with the transmitter output power as measured by the Lab's calibrated HP-437B power meter with appropriate calibrated power attenuator and cables. Results are shown in Table 1.

As you can see, the worst measured case is for 100 W continuous carrier on 28 MHz, where the measurement is low by 10% compared to the HP-437B. In all other cases, the power is within a few percent of the value measured by the Lab's equipment. The measured SWR values are also very close to the theoretical values using resistive loads of 25, 50 and 100 Ω.

The MB-HF 1 coupler that comes with the MB-1 has been calibrated at the factory, and a calibration table has been stored in the MB-1 memory. The calibration table uses reference frequencies on 80, 20, 10 and 6 meters.

To perform the initial setup of the meter, I used my digital VOM to measure the output voltage from the coupler, and used the calibration voltage printed on the coupler to fine tune my transmitter output. Then, with the coupler plugged in to the MB-1, I adjusted the FWD trimpot on the side of the meter to set the appropriate power reading on the MB-1. I had to swap the cables from the coupler to the MB-1 and adjust the REFL trimpot in the same way. I checked the settings for several transmit power levels, but that's about it for calibrating the MB-1.

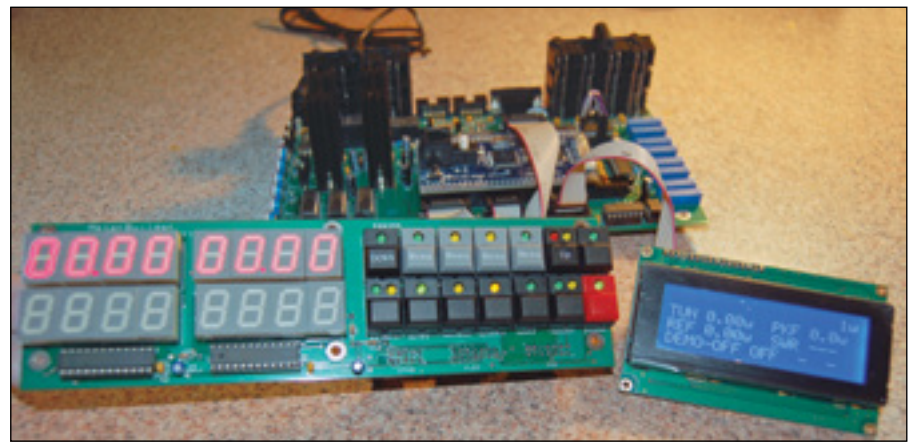

Figure 7 — The assembled circuitry, ready for the initial checkout and testing.

With a lab grade (calibrated) voltmeter to make those measurements, it may be possible to obtain even better accuracy. You could also perform the adjustment using a calibrated wattmeter connected in series with the MB-1 coupler.

Our test engineer was quite impressed with the accuracy of this meter considering that I built it from a kit and calibrated it with a common VOM similar to what most amateurs might have at home. Of course we could have adjusted the MB-1 to exactly match power and SWR measurements from the Lab's test setup.

In reviewing the Lab numbers again as I complete this review, I wonder if we might have activated the Band Correction feature for the 10 meter test. Information from the manufacturer indicates that their tests with an NIST certified power sensor shows the MB-1 coupler to be essentially flat across the entire HF range, including 6 meters. So they say there is no need to activate that feature.

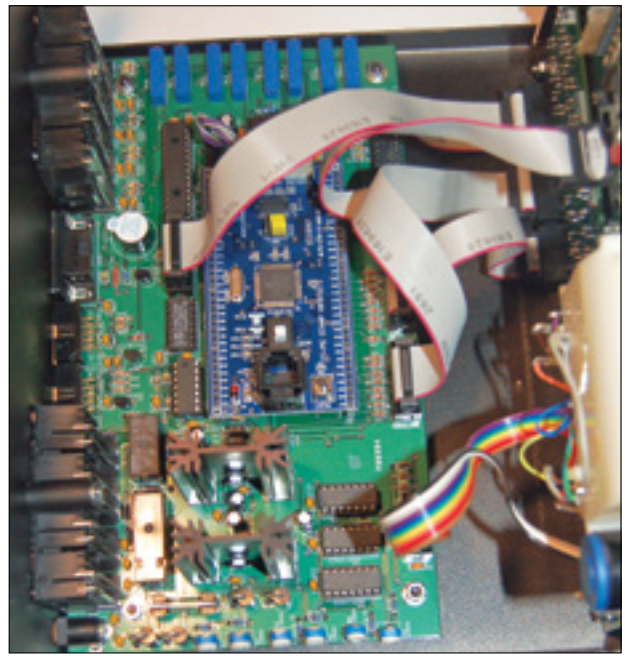

Figure 8 — Looking inside the MB-1 enclosure, you can see that there is plenty of space inside.

Building the Kit

When we purchased the MB-1 for this review, the meter was available only as a kit. The manufacturer now offers the MB-1 assembled and tested as well.

When I received the MB-1, it was like Christmas, opening one package after another to see what was inside (see Figure 6). I had already printed out the *Assembly Manual* (a 54 page document) from the MeterBuilder website.

One of my personal rules for kit building is to read through the assembly instructions and do a careful parts inventory. In this case, it quickly became apparent that this kit is for experienced builders. The *Assembly Manual* gives some good general guidelines, but you are not led step by step through the process. There is a Display Board and a Controller Board, with some suggestions about what components to install first. Beyond that, you populate the boards as you see fit.

All of the components you will install are through hole parts. You will not have to solder any surface mount devices. The MB-1 uses a surface mount microprocessor, but it's on a daughter board that comes assembled. The Microchip PIC18F8722 microprocessor and various surface mount components are already soldered in place. The LCD board also comes as a small, fully assembled daughter card that plugs into the display board.

I did not need any special tools to build the MB-1. I have a temperature controlled soldering station with a fine tip, assorted hand tools and a magnifier lamp on an extension arm that I find increasingly handy for reading color codes and component values. These are all standard fare for any builder, I believe. In addition I kept my digital VOM handy to double check the occasional resistor or capacitor value. The meter also helped with the final adjustments to the meter display circuits.

I spent about four hours reading through the *Assembly Manual*, taking inventory and sorting the components into a couple of plastic boxes with adjustable compartments. With resistors and capacitors sorted into separate bins by component value, it's easy to pick out the correct value part as you work your way across the circuit boards. (Of course I still verified each component value again before installing it on the board!)

The actual assembly time was about another six to eight hours. I work very slowly on a project like this, double and triple checking each component and board location. It is much easier to put the correct part in each location than it is to have to go back and unsolder and remove parts later.

During assembly I installed the gray switch caps and other components supplied with the Expansion Kit. I also selected the blue LED backlit cover for the cross-needle panel meter. The standard kit comes with a white LED backlit cover. Note that you could also choose to install LEDs of any other color, but I think the blue backlight gives the meter a nice soft glow in my shack.

After all of the components are installed, the *Assembly Manual* walks you through the initial checkout and meter self-tests. There is much more detail here than there is in the actual assembly section. Figure 7 shows the various circuit boards and display modules during the initial checkout. Figure 8 is a peek inside the completed MB-1 chassis. There is plenty of room to work inside the cabinet.

For the final adjustments I turned to the MB-1 *Quick Start Guide*, written by Phil Salas, AD5X, and available for download from the manufacturer's website. Phil's review of the MB-1 is also available there, and is another five pages of good information. The website has a lot of information and ideas for using the MB-1 and is worth a look.

Manufacturer: FullWave LLC, 48 Eastwood Blvd, Manalapan, NJ 07726, **www.meterbuilder.com**.

See the Digital Edition of *QST* for a video overview of the MeterBuilder MB-1 Programmable RF Power Meter