Product Review: The Array Solutions PowerMaster VSWR/RF Power Meter
By Phil Salas – AD5X

Introduction

Probably the most common and most used piece of equipment in the ham shack is the SWR/Power meter. Unfortunately, many hams rely on inexpensive SWR/Power meters for accurate indications of what is really going on in their stations. Now one thing you can generally be sure of is the SWR indication – as this is really just computed from differences between the forward and reflected power which can be relative power levels. However, for making transmit power measurements you do need an accurate indication. So how accurate is your power meter? What was it calibrated against, and what was the accuracy of the test equipment? And how stable is the power level calibration after the manufacturing adjustments have been made? All of these uncertainties have bee n resolved by Array Solutions with their PowerMaster SWR/RF Power Meter.

Array Solutions

Array Solutions is located in Sunnyvale, Texa s – only 18 miles from my home. So it was easy for me to drive over and pick up a PowerMaster. Array Solutions is owned and operated by Jay Terleski WX0B. Jay started his company in 1993 as a hobby-type company, but it turned into a full-time business within a few years. Jay's team includes his wife Sharon N5CK, Bob Naumann W5OV, David Banks, David Kinsell KD4UDY, John Beckerich KE5JUF, Ken Brown WB9AJJ, and Karen Swope. An ALMOST all-ham company! After the products are designed, most are then built by contract manufacturers. However, Jay and his team do all the final product tests. And besides the products shown on the Array Solutions website (www.arraysolutions.com), Jay and his team also do custom engineering designs for both individuals and large companies.

Any ham will find the Array Solutions engineering/test lab to be very impressive. Some of the "test equipment" employed includes a Ten Tec Orion, IC-781, Amp Supply LK-800A, TS-850, ACOM-1000, and the primary PowerMaster test generator – an Icom IC-756PRO3. According to Jay, product testing comes to a halt on contest weekends!

One test station – which is ***not*** used for testing during contests!

Bob W5OV is not making a QSO with the IC-756PROIII. He's calibrating a coupler for AD5X.

The PowerMaster Design

The PowerMaster accurately displays VSWR and RF power from 1-3005 watts in one-watt steps. It consists of two separate units: a processor-controlled display unit, and an external 160-6 meter coupling unit. Array Solutions also makes couplers for the VHF and UHF ranges, but this review will focus on the basic 160-6 meter version.

In order to achieve high accuracy, Jay chose a tandem-coupled dual-transformer directional coupler design which has a very tight coupling factor variation from 160-6 meters as well as a directivity of 25 dB or greater over this entire range. Array Solutions currently makes two HF/6 meter couplers – a 3KW model, and a 10KW model. Both models look very similar, but there are less obvious cable and other electrical and software differences.

PowerMaster HF/6 Meter 3KW coupler

10KW coupler. Note the coax differences from the 3KW coupler. Other differences are less obvious.

Most HF power meters on the market typically require that two potentiometers and one or two trimmer capacitors be adjusted during the calibration process. Generally, more adjustments mean you introduce more uncertainty into the calibration. Plus there is also the possibility of variable component drift with time, temperature, and humidity. Conversely, there are NO adjustments necessary in the PowerMaster calibration process due to the minimal frequency response and coupling factor variations from unit-to-unit. Differences really only occur due to manufacturing lot variations in the toroids used. Therefore Jay's team measures the variation from the coupler under test to a precision calibrated HP-436A/attenuator set-up which has a calibration uncertainty of ±3%. The measured variation, or "Trim Factor", is recorded on each coupler for both the HF frequency range and 6-meters. This trim factor is then entered into the PowerMaster display unit when it is first powered up. Jay also did a great job in temperature compensating the coupler. He demonstrated this by directing a heat-gun across both a PowerMaster coupler, and a popular and expensive in-line wattmeter. There was no observable change in the PowerMaster reading, whereas the other wattmeter displayed about a 10% change while I watched.

Using the PowerMaster

Normally you'll want to measure power right at your transmitter output or the immediate output of your amplifier if you have one. Since the coupler and display are separate units, both can be optimally positioned in your station. The PowerMaster comes with a 6-foot cable, but much longer separation distances between the coupler and display unit

can be accommodated. If you want more separation, you'll need to provide your own shielded stereo cable with 1/4" stereo phone plugs on each end. In my case, both the coupler and display unit mount nicely just under my ALS -600 amplifier, which is also convenient for viewing from my normal operating position.

PowerMaster and ALS-600 set-up

Author's HF station - The PowerMaster is conveniently located for viewing

Once the coupler and display are mounted and interconnected, and DC power applied to the display unit, the fun really starts. First of all you'll notice that there is no power switch. The PowerMaster display comes on as soon as DC power is applied. If there is no RF activity for two minutes, the display dims to half brightness. After 10 minutes, the display unit turns itself off. However, as soon as RF power is detected, the PowerMaster turns back on automatically and is ready to go.

The PowerMaster powers up in the normal Power/VSWR mode. The first thing you need to do is to punch the "Menu" button to cycle through the menus until you find the "Forward Power" and "Reverse Power" trim menus. It is here where you enter the trim values from the coupler using the "Mode Select" button. The PowerMaster automatically selects any one of three ranges, with 1024 A/D steps per range, based on your transmit power in order to give maximum resolution. Therefore the next thing you may want to do is to scroll to the "Bargraph Range" menu and select the range most appropriate to your expected transmit power. I like to operate QRP with an IG703, up to 200 watts with my Yaesu FT-1000MP MKV, and up to 600 watts with my Ameritron ALS-600 amplifier. Therefore I chose the lowest power range of 50/250/1250 watts so as to give best resolution for my particular set-up.

Normal PowerMaster power-on view

First things first – Set the trim values

Now it is time to start using the PowerMaster. First of all, I'm not going to give accuracy information, as the PowerMaster is undoubtedly the most accurate power meter I have. How do I know this? While I was at Array Solutions, I observed the calibrated HP set-up in action – and actually watched the determination of the calibration "trim" factors for my particular coupler! As I mentioned earlier, the HP test set-up uncertainty is ±3%. Since the PowerMaster coupler response tracks effectively dead-on with the HP 436A set-up, Array Systems specs the final accuracy of the PowerMaster at the same ±3% once the trim factors are entered.

As I began to use the PowerMaster, I found myself changing the power hold time from the fastest (0.2 seconds) for CW operation, to the slowest (2 seconds) during SSB operation so I could read my peak power accurately. However, the long peak hold time also gave me some interesting information on my transceivers. The PowerMaster detector has a very fast response – so much so that it can catch transmit output power overshoot on your first "dit" before your ALC takes hold. I found that there was a 4-watt overshoot on my Yaesu MKV at the 200-watt level, about a 3-watt overshoot at 150-watts output, and a 2-watt overshoot at 100 watts or less. On my IG706MKIIG, I found virtually no overshoot at 100 watts, 2-watts overshoot at 75-watts out, and 3-watts overshoot at 60 watts output. However, below 60-watts output, the overshoot increased to 8-10 watts on the first "dit", down to about 20-watts output. Below 20 watts, the overshoot decreased to 2-3 watts.

I also found the VSWR bargraph fascinating to watch during tuning of my antenna system. I have a MFJ-994B auto-tuner in-line with the amplifier output. When I punch the "TUNE" button on the MFJ-994B, the VSWR bargraph in the PowerMaster instantly follows the tuning progress.

There are also several PowerMaster alarm features that are very useful. You can set thresholds for VSWR alarms, and high- and low-power alarms. The low-power alarm can be used to indicate that your amplifier is not in-line or has tripped out for some reason. And the VSWR and high-power alarms can be used to trip relays within the PowerMaster to protect your amplifier. As an example, you can simply pass the amplifier enable line throu gh the "PTT In" and "PTT Out" phono jacks on the back of the display unit. To get around the typical 10-20ms amplifier relay operation time, for maximum speed you can use the PowerMaster relays to enable the transceiver inhibit input for those radios with this feature, or you can apply a fixed voltage through the relays to your transceiver's ALC input to turn down power.

The Software

The PowerMaster is truly a software-defined unit. There is an RS232 port on the back for connecting the PowerMaster to your computer. Through their supplied PowerMaster Lite software, you can download firmware updates. Additionally, the PowerMaster Lite software permits you to do everything (and more) directly through your PC. I didn't immediately connect my PowerMaster to my PC, as I'd been told that PowerMaster Lite V3.0 would be released within a few days (the CD supplied with my unit contained V2.0). But I had plenty to play with in the intervening days anyway.

When I received the V3.0 update notification via email, I grabbed an RS232 cable and went to plug it into the back of my HP Pavilion desktop. And guess what? This computer doesn't have an RS232 port! Array Solutions has tested, and therefore recommends using a KeySpan USA-19HS USB/Serial adapter. I ran outto my local Fry's Electronics store, but the only USB/Serial adapter they had was a $20 Cables Unlimited unit. However, within 30 minutes I had returned home, connected the cables, installed the USB/Serial driver – and had complete communications and cont rol of the PowerMaster through my PC. Downloading the new V3.0 software was trivial, and I was up and running in minutes. And man, the software display and functionality is great!

First of all, with just a click of your mouse you can easily change any o f your settings – including VSWR and Power Alarm thresholds, and PTT In/Out relay operation. And, you can set up and easily select HF and 6 meter trim groups (and more if you have more couplers) by clicking on the "HF" button on the lower right of the display. Finally, you can read return loss in dB, and transmit power in dBm. Figure 1 is a screen capture of the normal PowerMaster computer display in action.

Figure 1 – PowerMaster Lite V3.0 normal computer screen display

I was transmitting with 72 watts (upper bargraph and upper right-hand small box) into my Butternut vertical on 20 meters. The reflected power was 5-watts (lower bargraph and right hand adjacent small box) and the SWR was 1.71:1 (lower right-hand box). As you can also see, the antenna return loss was 11.63 dB, and the power is also displayed as 48.57 dBm.

You can also double-click on the display to give you a more compact view, for more convenient ly displaying the PowerMaster screen along with other applications. In the condens ed display (Figure 2) I'm transmitting with 496 watts forward power, and I have an SWR of 1.32:1. Notice thatthe bargraph simultaneously display s forward power (blue bars) and reflected power (red bars)!

Figure 2: Condensed display - but all important information is still available!

Pretty slick! Once you start using PowerMaster Lite, you'll probably always have your computer on when you are operating.

Upcoming Features

Array Solutions continues to improve the product, and makes these improvements free through their software/firmware download capability. There are two new features that should be available soon.

The first new feature will be an AM modulation meter. This will allow AM operators to "teach" the PowerMaster the un-modulated carrier, and then the bargraph will display the percentage modulation based on that. Also the peak power will be displayed. What Jay has demonstrated with his beta program is that sometimes your AM transmitter may not have a stiff B+ supply on the finals. And the modulation transformers have loss too. So you really get a true picture that an oscilloscope doesn't show. Jay demo'd the Beta version to me, which showed that the 20W AM carrier of his ICOM 756Pro III resulted in about an 80W peak signal at 100% modulation – just like it should.

The second new feature will be an "automatic coupler scanner" capability. When this feature is implemented, you will be able to add multiple couplers to your PowerMaster. The PowerMaster will scan them and find the active one, and then automatically use the appropriate trim factors for the active coupler.

Conclusion

Array Solutions' PowerMaster VSWR/RF Power Meter is a reasonably priced lab-grade power meter that will forever keep you from wondering what your true transmit power is. It integrates nicely into any station, and is particularly nice to use with your station computer. And for those of you with amplifiers, the PowerMaster will also provide high SWR amplifier protection if something goes suddenly wrong with your feed system or antenna. Finally, with its easy on-line firmware and software upgrade capability, you never have to worry about product obsolescence!