User's Manual

P-3000

Digital RF Power/
V.S.W.R. Indicator

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Manufactured in the U.S.A.
Part Number 96A05801
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INTRODUCTION

Thank you very much for purchasing the RF Applications, Inc. P-3000 Digital RF Power/V.S.W.R. Indicator. The P-3000 represents a breakthrough in flexibility for measurement of the performance of your HF station. CMOS microprocessor control insures fast capture time and low power dissipation. With the ability to monitor your V.S.W.R. at all times, you will know that your antenna system is performing within its design specifications.

IMPORTANT

The P-3000 is designed to operate from a 12 to 16 volt DC power source. Do not connect it to AC (especially line voltage). As with all electronic equipment, keep the P-3000 out of direct sunlight and keep it dry.

IF YOU HAVE PROBLEMS

We want you to be satisfied with your purchase. If you have any type of problem, please check the Trouble Shooting section of this manual. If your problem persists, call our Customer Service Department at 440.974.1961. Please have the P-3000 and this manual at hand when you call.

DISCLOSURE REQUIRED BY THE
FEDERAL COMMUNICATIONS COMMISSION

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. The equipment generates, uses, and can radiate radio frequency energy, and if not installed and used in accordance with the instructions, might cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

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UNPACKING AND SETUP

INITIAL SETUP

Unpack the P-3000. The box should contain:

- ❑ One Display Head
- ❑ One Directional Coupler
- ❑ One BNC to 3.5mm Connector "Y" Cable
- ❑ One RCA-to-RCA Cable
- ❑ One 12VDC Power Cable or Optional Power Pack
- ❑ One Warranty Card
- ❑ This Manual

If anything is missing, give us a call and we'll take care of you. Please take a few moments now to send in your Warranty Card.

The P-3000 consists of two major components: the Display Unit and the Directional Coupler. The Directional Coupler is installed in series with the output of your transmitter and antenna. One BNC to 3.5mm "Y" cable is provided for connection between the Display Head and the Directional Coupler. You may use longer cables if you wish (consult the Special Applications section later in this manual).

Most users want to see how the unit works as quickly as possible after receiving it. If you want to do this, read on. If you would prefer to install the P-3000 permanently now, move ahead to the Installation section of this manual.

If you are currently using a wattmeter in your setup, you have everything you need for a test. If you are not using a wattmeter, then you will need a suitable jumper to connect the Directional Coupler to your station. Connect the Directional Coupler as follows:

Using RG-8 or RG-58 cables:

· RF SOURCE goes to your transmitter (directly)
· ANTENNA goes to your antenna (or tuner)

Using the "Y" cable:

· REF (unmarked BNC) goes to bottom connector on Display Head
· FOR (RED marked BNC) goes to top connector on Display Head
· 3.5mm plug goes to Coupler

Don't worry about the RCA cable at this time. Connect 12VDC to the power cable provided. The black wire goes to ground, and the wire with the white stripe goes to plus.

The P-3000 is protected against polarity reversals, but be careful just the same. Insure that the 12VDC is on, then turn on the P-3000 (the power switch is on the right side of the Display Head). You should observe all the lamps on the Display Head come on, then the display will show that the 120W range is selected, forward power is to be displayed, and the V.S.W.R. display goes to "- -" after the firmware version number is displayed. You are now ready for a test.

Simply use your normal procedure to transmit. The P-3000 will give you an instant indication of your current status. If you reversed the REF and FOR cables, you'll probably see a V.S.W.R. of 19 and zero forward watts. No problem--just reverse the cables.

If your transmitter has an internal tuner, you might want to turn it off. The internal tuner will cause a 50 ohm impedance to be presented to the finals of your transmitter, thereby changing the characteristic impedance present at the antenna jack on the transmitter. This will affect the accuracy of the P-3000 (just as it would any other measuring device).

If you are having other problems, refer to the Trouble Shooting section of this manual. Otherwise, you are now ready for a permanent installation.

INSTALLATION

DISPLAY HEAD AND COUPLER LOCATION

The Display Head is designed to be either table-top or wall-mounted. The cables exit from the left side of the unit. Once the position is chosen, mount the Display Head. Choose a suitable location for the Directional Coupler and mount it as well. You can either screw the Directional Coupler down or leave it free hanging. If you are using the factory cable, be sure the Display Head and Coupler are close enough to each other to route the BNC cable. If you want to use longer cables, this is fine--consult the Special Applications section of this manual for more information.

CABLE INSTALLATION

Install the two BNC connectors to the Display Head. The connector with the red band goes to the FOR input, the top BNC connector. The REV input goes to the lower BNC connector. Route the cable in a neat manner to the location of the Directional Coupler.

If you plan to use the amplifier relay inhibit feature, unplug the RCA cable from your amplifier, and plug it into the top RCA connector of the Display Head. Using the RCA cable provided, reconnect your amplifier “RELAY” input to the bottom RCA connector on the Display Head.

Connect the 12VDC cable to the Display Head. If you purchased the optional power pack, go ahead and plug it in now. If you are using the power cable, connect the black lead to ground and the white striped lead to plus. The Display Head is protected against polarity reversal; try to get the polarity right anyway.

If you would like to have remote control of the display mode, a 1/8" jack is provided on the Display Head for this purpose. Simply run a cable to a normally open push button and plug it into the jack. This feature is normally used by those who have mounted the Display Head on the wall.

DIRECTIONAL COUPLER WIRING

Since the purpose of the P-3000 is to provide an indication of the match of your antenna system to your transmitter, it is critical that the Directional Coupler be installed as the first element after the antenna jack on your transmitter (or

amplifier if you are using one). If you install it after your tuner, you will be quite frustrated by your inability to change the V.S.W.R. readings on the P-3000. With this in mind, run a suitable jumper cable from your transmitter's antenna jack to the RF SOURCE connector on the Directional Coupler. The standard Directional Coupler comes with SO-239 connectors. You can order optional "N" connectors if you prefer.

If you are using an amplifier, you want to install the Directional Coupler after your amplifier. Connect the cable that goes to your antenna system to the ANTENNA jack on the Directional Coupler. Plug the 3.5mm connector from the Display Head into the Directional Coupler.

You may ground the Directional Coupler to your station grounding system if you desire. There is a further discussion on this in the Technical Discussion section of this manual.

Recheck all your cables, and fasten them down appropriately. Turn on the power to the Display Head (the switch is on the right side of the enclosure). You should see a lamp test, then the P-3000 will go to its idle state.

You are now ready to use the P-3000. Have fun!

TECHNICAL DISCUSSION

RF POWER AND V.S.W.R. MEASUREMENT

The purpose of this section of the manual is certainly not to go into great detail on the theory of the measurement of RF power and voltage standing wave ratio (V.S.W.R.). There are many more publications on the subject dating back 50 or more years. But we do want to discuss the most important issues pertaining to this matter.

For the purpose of this discussion, RF power refers to the peak voltage measured on the line, multiplied by itself, and divided by 50 (voltage squared divided by the impedance of the load, which is watts).

V.S.W.R. is calculated by finding the sum of the forward and reflected voltages on the line and dividing by the difference of the forward and reflected voltages on the line:

$$\frac{\text{Forward Voltage + Reflected Voltage}}{\text{Forward Voltage - Reflected Voltage}} = \text{V.S.W.R.}$$

You can see that if there is no reflected voltage, you will be dividing the forward voltage by the forward voltage, which is 1.0. A V.S.W.R. of 1.0 is ideal (and actually

unobtainable because there is always a small amount of reflected voltage on the line). A V.S.W.R. of 2.0 indicates a power loss of about 10%, at 3.0 the loss is about 25%, and it gets worse from there. By loss, we mean that, for example, a transmitter looking into a 3.0 to 1 V.S.W.R. will only be able to deliver 75% of its output power to the load (the antenna). To summarize, the transmitter must see an exact impedance match (50 ohms in this case) to deliver full power to the load.

Again, to achieve maximum power transfer from the transmitter to the antenna, an impedance match between the antenna system and the transmitter is required. Normally, the desired impedance is 50 ohms. Antennas need to be designed and built to match this impedance.

In any antenna system, the object is to get the most power delivered to the actual antenna. Feedlines, antenna switches, connectors, and yes, wattmeters all contribute to losses between an RF source and an antenna. You can conclude from all this that the best place to make a power or V.S.W.R. measurement is actually at the antenna, and this is indeed the best place. In most installations, however, power and V.S.W.R. measurements are made in the shack near the transmitter. This is generally not a problem, as long as the user realizes that the readings that are being taken represent those of the entire antenna system,

not just the antenna. And in some cases, the readings can be misleading.

For example, you might have a perfectly resonant (50 ohm) antenna running on 10 meters. You connect it with 150 feet of RG-58 cable. Your station-mounted wattmeter shows that you are delivering 100 watts from your transmitter into this antenna system.

Here's the problem: the RG-58 cable exhibits a loss of 2.0 dB per one hundred feet at 30 MHz. This means that if you mounted your wattmeter at the antenna, you would read only 50 watts!

Your V.S.W.R. measurements can be affected, because losses in the feedline reduce the level of the reflected voltages as well. Therefore, you can be lulled into a sense of security about your V.S.W.R.; when, in fact, it is higher at your antenna than you see on your meter.

Wattmeters like the P-3000 allow you to mount the Directional Coupler at the antenna (or at least near it, with some restrictions). By doing this, you can see what is happening near the antenna. However, additional installation costs are incurred, because you must bring the sensing cables back to the shack.

In most installations, it is still most practical to install the measurement equipment in the shack. The best solution to the above problem is to use high quality feedlines, connectors, etc. to make your installation. By high quality, we mean components that are rated for the power, frequencies, and distances you will be using. Then, use a 50 ohm dummy load to test each feedline system after you have installed it. You can verify that your feedlines have the predicted losses and low V.S.W.R. readings. With this knowledge in mind, you can now use the information your shack-mounted power and V.S.W.R. meter gives you.

As mentioned above, each element in the connection system between the transmitter and the antenna introduces some amount of loss and increased V.S.W.R. The goal of any design is to minimize the losses and V.S.W.R., while maximizing instrument accuracy over the specified frequency range.

As in any engineering exercise, tradeoffs must be made between performance and cost. You will find that most commercially available instruments do not introduce significant losses or V.S.W.R. However, you can find wide variations in accuracy among several watt/V.S.W.R. meters. Therefore, you have to be cautious in comparing readings between various meters.

In addition, your station grounding might affect your power and V.S.W.R. measurements. When you connect all of your equipment together, you introduce new paths for RF energy to flow (in addition to your coax shields).

As an interesting point, however, many users find that the absolute value of the displays on their meters doesn't really matter that much. For power, the idea is to maximize it. For V.S.W.R., the idea is to come as close to 1.0 as possible (below a certain minimum, of course).

Most measurement systems for high frequency (HF) power and V.S.W.R. measurement consist of two major components. The first is the sensing system (Directional Coupler), the other is the display system. There are commercially available systems that integrate both of these components into one package (a conventional watt/V.S.W.R. meter) and some that separate the two (such as the P-3000).

USING THE P-3000

GENERAL OPERATION

There are three major functional units that make up the P-3000. These are:

- ❑ The power display
- ❑ The V.S.W.R. display
- ❑ The autoranging bargraph display

Each of these units function separately to present you with a great deal of information about your station. In normal operation, you don't need to make any adjustments at all. There is no need to calibrate for V.S.W.R. readings, and the ranging is taken care of by the onboard computer.

THE POWER DISPLAY

The power display gives you a peak reading in watts (or kilowatts) of your transmitted signal. There are three digits, along with a decimal point. Powers from 0 to 999 watts are displayed directly. When the power exceeds 1,000 watts, the kW LED is illuminated, and the display will indicate power in kilowatts. For example, 1,200 watts will be displayed as 1.20, and the kW light will be illuminated. The power display is updated approximately

once per second, although internal readings are taken much more quickly than that. There is a Mode Switch that you can use to observe other aspects of your transmitted signal. Four LEDs on the right side of the display tell you which mode you are in. To change modes, simply press the Mode Switch. You can select Forward Power (which is the power on default), Reflected Power, True Power, and Forward Volts. The Reflected Power display simply indicates the measured Reflected Power on your transmission line.

The True Power display indicates the Forward Power minus the Reflected Power. This display mode is used to see what the effective power being delivered to your antenna system is.

The Forward Volts display mode gives you an indication of the forward peak voltage being delivered to your transmission line. At 100 watts, you will see a display of about 70 volts.

In order to provide a pleasing display regardless of CW or SSB operation, we have carefully selected the update interval for the Forward Power display mode. This can be a problem, however, when you are trying to set an antenna tuner. For this reason, the display update interval is much faster (about three times faster) when you are displaying Reflected or True Power.

IMPORTANT

If you are displaying Reflected or True Power during normal station operation, you might find that the display indicates a number of intermediate powers (especially on SSB). You can solve this problem by returning to the Forward display mode.

In any case, the display will occasionally indicate a small wattage at the end of a transmission (even when Forward Power is displayed). This occurs when the sampling interval coincides with the end of your transmission. This is normal.

The maximum Forward Power that will be displayed is 1.50 kW. If you would like to display powers higher than this (for testing purposes), there is an internal jumper you can remove. See the Special Applications section of this manual.

The data capture time is fast. One dit (or whistle) will provide enough signal for you to get a reading. This is a nice feature that helps to reduce QRM, too.

THE V.S.W.R. DISPLAY

The V.S.W.R. display gives you continuous readout of your V.S.W.R. The display indicates V.S.W.R. from 1.0 to 9.9, then from 10 to 19. The internal arithmetic of the P-3000 is carried out to tenths and rounding is applied. It is possible for you to read a V.S.W.R. of 1.0 (a theoretically impossible number). If you see a display of 1.0, it means that your V.S.W.R. is below 1.05 (or that you have not connected the reflected power cable from the Directional Coupler!).

When your V.S.W.R. is at or below 1.5, a green LED is illuminated. When it is at 3.0 or above, a red LED is illuminated. Neither LED is illuminated when the V.S.W.R. is between these values.

In addition, the amplifier relay is opened when the V.S.W.R. is at or above 3.0. It will not close again until RF is removed from the P-3000 for three seconds, or the V.S.W.R. is brought below 3.0.

As noted above, you can set the display on reflected power to speed up the V.S.W.R. update for sweeping antennas.

THE AUTORANGING BARGRAPH

The P-3000 incorporates a unique bargraph display. This display answers one of the major complaints about digital wattmeters. Many users are used to and feel most comfortable with analog meters, because they can "see what they are sending." Digital displays remove this feature (who wants to see a bunch of meaningless numbers bouncing around?). The P-3000 updates the bargraph much more quickly than the numeric displays. The resulting display is pleasing and quite useful. In order to reduce the number of LEDs required for a meaningful display, the P-3000 incorporates an autoranging feature.

There are three ranges, which are 120 watts, 1,200 watts, and 2,000 watts. To display the power in these ranges, there are ten LEDs labeled 10% through 100%. To interpret the display, simply apply the percentage of the highest LED to the range that has been selected. For example, if the 10% through 50% LEDs are on and the 1,200 watt range light is on, your power is about 600 watts.

In normal use, however, you can use the digital display to find out what your actual power is. The bargraph is very handy for a relative indication of what your station is doing, and you can "see what you are sending."

The bargraph is particularly useful for tuning up amplifiers. Simply adjust your amplifier for the most percentage LEDs on the highest range.

The P-3000 picks the range by analyzing the most recent peak power. You will sometimes notice that it will autorange down at the end of a transmission, particularly on SSB transmissions. This is normal, and the range will be updated on your next transmission.

As shipped, the ranges are 120, 1,200, and 2,000 watts. In some installations, a different set of ranges is needed. There is an internal jumper you can remove to change the ranges to 200, 1,200, and 3,000 watts. However, we haven't provided a means to easily mark this change on the front panel. You could use a stick-on label if you want, but remember, the bargraph is really used as a relative display, so the absolute values don't really matter that much. See the Special Applications section of this manual if you want to make this change.

SPECIAL APPLICATIONS AND CALIBRATION

CONFIGURATION JUMPERS

As mentioned earlier in this manual, there are two configuration jumpers in the P-3000. One controls the maximum forward power display, and the other selects a different set of ranges for the autoranging bargraph.

To access the jumpers, disconnect the Display Head and remove the four screws holding the back cover on. Separate the back cover from the unit. The jumpers are located at the lower right hand corner of the microprocessor.

If you would like your P-3000 to display forward power to 3kW (actually 2.95kW), you need to remove the jumper labeled JB. JB is the lower jumper. You can just hang the jumper on one of the pins to keep from losing it.

If you would like to use the 200/1,200/3,000 watt bargraph ranges, you need to remove jumper JA. This is the upper jumper. You can just hang the jumper on one of the pins to keep from losing it.

ACCURACY AND CALIBRATION

The P-3000 uses an eight-bit analog to digital converter. This results in a display that cannot indicate every single power value from zero to 3,000 (there are only 256 codes available from the analog to digital converter). You will notice that this display will indicate power in steps; for example, 100, 104, 109, 113 watts, etc. The general specifications for the P-3000 call for accuracy that is plus or minus ten percent; plus or minus the analog to digital converter resolution (which is one power step increment).

We calibrate the P-3000 at 14.100MHz and then verify its operation on 1.8 and 28MHz. If your application calls for better accuracy on a certain band, you can easily recalibrate the unit to suit your needs. In this case, you can enjoy plus or minus five percent (or better); plus or minus the resolution accuracy.

You will be adjusting the potentiometers located at the top right of the PC board. Do not adjust potentiometer R8 (located near the microprocessor). Be careful not to blast the board with static electricity.

The calibration procedure is as follows:

1. Open the P-3000.
2. Select the forward power display.
3. Apply a known power to the Directional Coupler.
4. Set potentiometer R9 to display the correct power.
5. Reverse the BNC cables.
6. Select reverse power to be displayed (mode switch).
7. Apply a known power to the Directional Coupler.
8. Set potentiometer R10 to display the correct power.
9. Reverse the BNC cables back to normal.
10. Reassemble the P-3000.

You should not need to adjust the internal reference for the analog to digital converter. Test point TP1 (near the microprocessor) should measure 5.00 volts. If it does not, you can adjust potentiometer R8.

The most accurate V.S.W.R. readings are made with at least 25 watts of forward power. You will sometimes notice a small change in V.S.W.R. as you change power levels. This is normal. Cables, connectors, traps, and other items can respond differently under high power conditions. Variations of 0.2 in V.S.W.R. are not uncommon. If your variation is higher, you might have a problem with one or more of the items mentioned above. If you are having problems, give us a call.

REMOTE COUPLER MOUNTING

There is no reason that you cannot mount the Directional Coupler remotely. However, you will need longer cables terminated with BNC connectors and two BNC couplers. In addition, the Directional Coupler is not designed for outdoor use, so you will have to put it in another enclosure.

You can expect changes in accuracy with extremely low temperature. We have tested to -10 degrees C, and the changes are minimal at that temperature.

We have tested the Directional Coupler with 500 feet of cable, and it performs well. Be aware though, you will be reading power at the other end of a feedline. Maybe you don't really want to know what's out there!

SPECIAL DIRECTIONAL COUPLER CONNECTORS

If you like to use “N” type connectors, contact the factory. “N” connectors are available.

IN CASE OF TROUBLE

The P-3000 is well designed and should give you many years of trouble free service. Most of the problems you will encounter usually occur during installation and startup. If the items below aren't sufficient to help you solve your problem, please give us a call.

Unit will not come on

Check power connections. Is the unit on? The power switch is on the lower right side of the enclosure.

High V.S.W.R. displayed; no forward power displayed

Check that the BNC cables are not reversed. Also, be sure that the RF SOURCE input to the Directional Coupler goes to your transmitter (or amplifier).

V.S.W.R. doesn't change when adjusting a tuner

Be sure that you have installed the Directional Coupler **AHEAD OF** the tuner. If your rig has an internal tuner, you should turn it off to make your measurements.

Display won't go above 1.50kW

Remove jumper JB.

Bargraph percentages wrong on 120/2,000 scales

Jumper JA has been removed. Put it back in.

Power display grossly inaccurate

Someone might have recalibrated the unit. Perform the calibration procedure in this manual.

If you are experiencing other problems, give us a call. We'll help you out as quickly as possible.

SPECIFICATIONS

Frequency range:	1.8 to 30MHz (see Accuracy)	
Line impedance:	50 ohms nominal, <1.1 V.S.W.R. insertion	
Line connections:	SO-239 female (N connectors optional)	
Range:	15 to 2950 watts, 1.0 to 19 V.S.W.R.	
Accuracy:	±10%, ±resolution	
Capture time:	Less than 100 milliseconds	
Bargraph response:	Greater than 10Hz	
Bargraph ranges:	120/1,200/2,000 200/1,200/3,000 (jumper)	
Power required:	12VDC, 75mA idle 150mA normal use 250mA lamp test	
Display modes:	Forward power Reflected power True power (forward-reflected)	Forward volts All readings peak
Resolution:	256 steps over 2.95kW	
Regulatory:	Exceeds FCC Class B (tested)	
Dimensions:	Display 6.5"x5.25"x2.25" (16.5x13.3x5.7cm)	Coupler 4.5"x3.75"x2.25" (11.4x9.5x5.7cm)
Shipping weight:	6 lbs. (2.7Kg) nominal	

Specifications subject to change without notice.

LIMITED WARRANTY

Your P-3000 is warranted by RF Applications, Inc. to be free of defects for two years from the date of purchase. **THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, INCLUDING IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS.** In no event will RF Applications, Inc. be liable for consequential damages.

If you must return the unit to the factory, you must obtain authorization from the factory. Be sure to provide a copy of your original purchase receipt to validate your warranty. We will repair the P-3000 during the warranty period at no charge. We will not honor the warranty, if in our opinion, the product has been damaged due to misuse or subjected to adverse environmental conditions. We might elect not to honor the warranty on units modified by you.

After the warranty has expired, you may return the unit to the factory for repair (after receiving authorization to do so). We will repair the unit at a flat fee of US$60.00 plus shipping. Please enclose a check, money order, or credit card information to cover repair costs and shipping.

Any information you can provide regarding the problem you are having would be very helpful. Please be sure to give us a daytime telephone number in case our service technicians have any questions for you.

Please call for shipping instructions if you are returning the P-3000 to us. Ship the unit (make sure it is insured) to:

RF Applications, Inc.
7345 Production Drive
Mentor, OH 44060

ATTN: Repair

Some states might allow you additional rights under this warranty.

Thank you very much for purchasing this product. Please give us your feedback.

RF Applications, Inc.

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