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BT1500A 1500 Watt Balanced Antenna Tuner

Specifications Summary

- 1500 Watts PEP
- 160m to 15m
- Custom variable capacitors and inductor
- Dual movement cross needle meter
- 13 1/4" x 6 1/2" x 16 7/8"

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BT1500A Balanced Antenna Tuner Technical Manual



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BT1500A SPECIFICATIONS

- **METERING:** Dual movement cross-needle power and frequency compensated coupler
- **INPUT & ANTENNA TUNING:** Variable capacitor 960pF & 65pF, 4.5 kV Peak, 6:1 Vernier Drive
- **INDUCTANCE:** 15 μ H roller inductor, 12 ga. wire wound on steatite ceramic core, silver plated bar and wheel
- **POWER RANGE SWITCH:** 2 position 300 W / 3000 W
- **REAR PANEL CONNECTORS:**
 - SO-239: RF Input
 - END FED WIRE: High Voltage Nylon66™ terminal/ground posts for Balanced Line
 - 12 VDC INPUT: 14mm connector, 2.1mm ID, 5.5mm OD, center positive, 200 ma
- **FREQUENCY COVERAGE:** 1.8 - 29.5 MHz
- **POWER MAXIMUM:** 1500 W PEP SSB, 1000 W single tone
- **IMPEDANCE RANGE:** 2500 +/- j2500 160m to 20m
1000 +/- j1000 17m to 10m
- **INPUT BALUN:** 1:1 current type balun
- **DIMENSIONS:** 6/5"H x 13.25"W x 16.875"D (incl. terminals)
- **WEIGHT:** 17 LBS, 8 Kg
- **CHASSIS & COVER:** 11 ga., .090 gold Iridite treated Aluminium

BT1500A DESCRIPTION



The Palstar BT1500A Antenna Tuner is an American-made impedance matching network.

The BT1500A optimizes the performance of your antenna and transmitter by providing adjustable impedance matching using balanced dual tandem roller inductors with a shunt capacitor that can be switched to the input (transmitter) side or the output (antenna) side.

The BT1500A also measures the power and Voltage Standing Wave Ratio (VSWR or SWR), which allows you to tune the SWR to the lowest ratio possible for the selected transmission frequency.

A switch allows the user to choose Average or Peak metering. Also, a Peak Hold function holds the peak reading for approximately 2 seconds for easier reading.

Front panel controls allow for selection between two ranges of variable capacitance, and allow the shunt capacitor to be switched between the input (transmitter) side (low Z, high pass) and the output (antenna) side (high Z, low pass).

Tuning is achieved with the front panel controls. The Vernier capacitor dial allows for fine tuning with precision and accuracy, while the Inductor crank handle provides coarse adjustments.

The range of the power meter (300W/3000W) is selected by a push button switch located on the front panel.



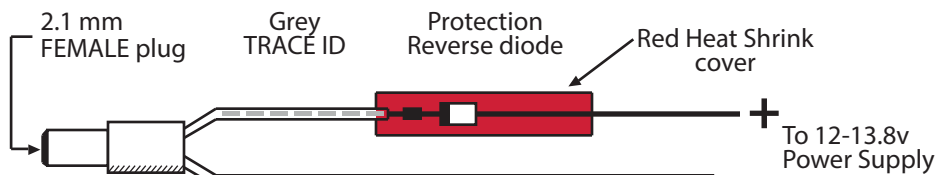
INSTALLATION

UNPACKING

Carefully remove the BT1500A from the shipping carton and inspect it for signs of damage. If any damage is apparent, notify the transportation carrier or dealer immediately. **KEEP THE PACKING CARTON for moving, storing, or reshipping the tuner to us for repair if required.**

LOCATION

Select a location for the BT1500A that allows the connectors to be free from any possible contact with people, pets, or objects during operation and with unrestricted air flow for cooling.



BT1500A DC POWER CORD

INSTALLATION PROCEDURE

Connect a coax cable from your transmitter to the RF INPUT connector on the rear panel. Keep the cable as short as possible. If you use a linear amplifier, connect your transmitter to the linear amplifier input and the linear amplifier output to the BT1500A.

DO NOT USE MORE THAN 1000 WATTS (single tone continuous; 1500 W PEP SSB) through the tuner.

REAR PANEL

BALANCED OUTPUT

Two Nylon High Voltage post connectors for output to RF balanced transmission lines. Balanced line of any impedance (300Ω , 450Ω , 600Ω) can be used.



RF INPUT coaxial connector for input from transmitter or amplifier

GROUND post/wing nut ground connector

12 VDC INPUT
(2.1 mm plug, center pin +)
12 VDC adapter 500 mA to power the metering, lamp, relay, and fan.

FRONT PANEL DESCRIPTION



1. **TUNE.** Dual section variable capacitor (960 & 65pF). Can be switched from output to input side of network using switch #4.
2. **POWER/SWR METER.** Dual needle meter displays FORWARD and REFLECTED power in watts. SWR is measured where the two needles intersect on the red scale. Metering works only if the unit is provided with 12VDC at the rear power jack.
3. **Hi-Lo PASS.** Two position switch selects Low Pass (High Z, capacitor on input side). The switching is performed with a 40 amp contact relay. **This function only works if the unit is provided with 12VDC at the rear power jack.**
4. **Hi-Lo CAPACITOR.** Two position switch selects the low value variable capacitor section of 65pf, or parallels the two sections for a total of 1025pf. The switching is performed with a 40 amp contact relay. This function only works if the unit is provided with 12 VDC at the power jack.
5. **PEAK HOLD.** Select to read Peak Hold on the SWR meter. Peak switch (Button #6 above) must be in PEAK position.

6. **PEAK** Selects between PEAK and AVERAGE power metering display.

7. **RANGE.** Two-position switch selects the range of FORWARD and REFLECTED power displayed on the power meter.

When the RANGE button is OUT, the FORWARD meter scale reads 300 watts full scale and the REFLECTED meter reads 60 watts full scale.

When the RANGE button is IN, the FORWARD meter scale reads 3000 watts full scale and the REFLECTED meter reads 600 watts full scale.

8. **POWER.** A two position button. When in the IN position, turns on meter illumination and powers the Hi-Lo Pass and Hi-Lo Capacitor switch functions and the metering functions. The unit must be provided with 12VDC at the rear power jack.

9. **INDUCTOR** 15 μ H roller inductors mounted in tandem controlled by turns counter.

UNDERSTANDING YOUR TUNER

Your Antenna and Feedline: the balanced L-network can be used with any antenna fed with parallel feedline. Parallel feedlines may range from 300 Ohm TV twin lead, to "windowed" lines in the 400-450 Ohm range, to 600 Ohm (and higher) ladder lines. The applicable types of antennas include flat-top and Vee'd all-band doublets, horizontally or vertically oriented loops, end-fed wires, and arrays such as the lazy-H and the 8JK. There are also a number of designs for wire Yagis and quad beams that employ parallel transmission lines.

At any given operating frequency, the antenna has a certain feedpoint impedance. For most multi-band antennas, the feedpoint impedance will change with the operating frequency. On most bands, the impedance will be complex, that is, a combination of resistance and reactance. However, unless your feedline happens to be an exact multiple of a half wavelength (accounting for the line's velocity factor) or unless the feedpoint impedance is identical to the characteristic impedance of the feedline, your antenna tuner will not encounter the antenna feedpoint impedance.

For any condition where the feedpoint impedance does not exactly match the characteristic impedance of the feedline, the impedance will vary continuously along the feedline, returning to the feedpoint value at every half wavelength along the line. The precise values that you will encounter at some specific point along the line depend upon the characteristic impedance of the line, its velocity factor, and the feedline impedance itself. The range of variation in both resistance and reactance is a function of the degree of difference between the feedpoint impedance and the characteristic impedance of the feedline.

Many users of multi-band antennas are surprised to learn that even very high feedpoint impedances can result in very low impedances at certain regions along the feedline. An end-fed wire at any frequency, or a center-fed wire that is close to a multiple of a wavelength long will present a very high impedance. If your feedline is the right length, you may find that the impedance at the antenna terminals is very low. Alternatively, at other lengths, you may discover that the reactance at the antenna terminals is outside the range for which the output capacitor can compensate. Without careful computation, you may not know which condition applies. You may only know that the tuner seems unable to provide 1:1 SWR for the line to the transmitter.

A Simple Work-Around: There are many ways to correct the problem of being unable to effect a good match on one or more bands of operation when using a feedline into the length from the tuner of the antenna. Since the losses on the parallel line are very low, a few extra feet of transmission line will not be detectable

UNDERSTANDING YOUR TUNER

transmitter, the tuner places a 1:1 choke (current) balun between the input side of the network and the transmitter coax connector.

The balun converts the unbalanced input from the transmitter to a balanced condition for the network. As well, it suppresses currents that might otherwise appear on the braid of the transmitter cable.

Limitations: Every antenna tuner, no matter what the type, has limits to the range of impedances that it will match to the 50 Ohm input. The balanced L-network is no exception. Understanding those limitations will help you to effect a match on every band.

The impedance presented to the tuner antenna terminals is usually expressed as a series combination of resistance and reactance, that is, $R \pm jZ$ Ohms. The L-network that places its shunt capacitor on the antenna side is normally an up converter. The limiting lower end impedance is in the vicinity of 60 to 100 Ohms resistive for a 50 Ohm input. The upper limit of impedance that the network will match is a complex function of frequency, the component values, and the amount of reactance that is part of the impedance at the tuner terminals. For most of the HF Amateur bands, the upper impedance limit of the balanced L-network in the Palstar BT1500A tuner is about 2500 \pm j2500 Ohms. This upper limit descends slowly with rising frequency so that at 30 MHz the upper limit is about 400 \pm j400 Ohms. The decrease in range results from the unavoidable minimum capacitance of the output variable capacitor.

The impedance presented to the antenna terminals may be any value of R and any value of X. For a given R component, the tuner will require a certain setting of the coil and also the capacitor. If there is reactance at the antenna terminals, then the network requires a lower value of C if the reactance is capacitive, and a higher value of C if the reactance is inductive. The network compensates for the reactance by increasing or reducing the capacitive reactance required for a purely resistive load with only small changes in the required inductance. The amount of compensation available is a function of the maximum and minimum values of shunt capacitance and the resulting reactance of this component. With finite components, the range of reactance for which the network can compensate is always limited.

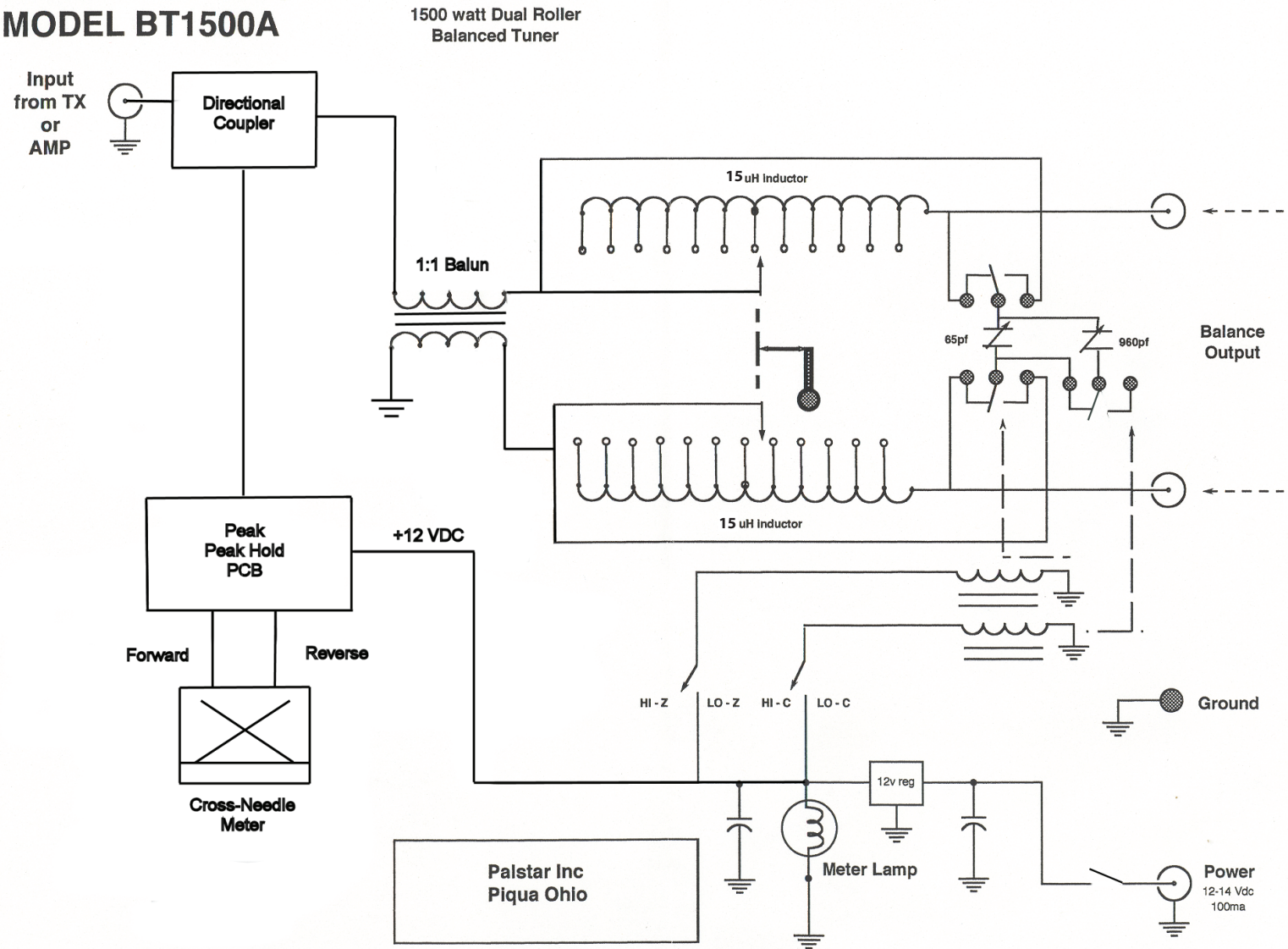
As well, every matching network incurs losses within the network, mostly as a function of the Q of the inductor and the ratio of the antenna terminal impedance to the input impedance. For the balanced L-network with a shunt output capacitor, the higher the impedance to be matched, the higher the losses. The losses will be lower if the reactance at the antenna terminals is purely resistive.



BT1500A SCHEMATIC

Schematic Diagram

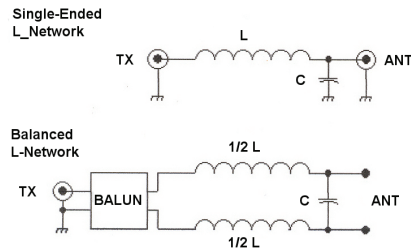
MODEL BT1500A



UNDERSTANDING YOUR TUNER

The Palstar BT1500A antenna tuner is a highly flexible matching device intended for use with antennas that use balanced or parallel transmission lines. To obtain the best performance from the tuner, you should understand how the tuner works and how it relates to your antenna and feedline.

Basic operation: Examine the schematic diagram of your tuner to see all of the electronic features. In this discussion, we shall focus only upon the matching network itself. The basic circuit under discussion is a balanced L-network with the shunt capacitor on the output side.



A single-ended L-network - the most common variety - uses a certain value of inductance (L) and a certain value of capacitance (C) to effect a match at a particular frequency for a particular antenna feedline impedance and length. For coaxial cable systems, the single-ended L-network provides the lowest loss of any network matching system. However, one limitation is that with the capacitor on the antenna side of the coil, the system is limited to antenna terminal impedances greater than about 50 Ohms. If we wish to use the single-ended network with a balanced feedline, we have to add a balun on the output side of the network. Baluns work best with very low values of reactance on their output terminals, a condition that is difficult to obtain with most antennas that use parallel feedlines.

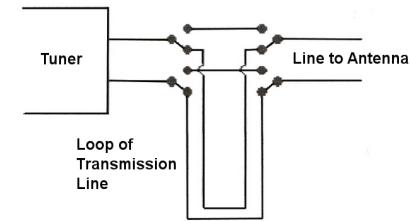
The balanced version of the L-network overcomes this limitation by providing a true balanced output directly from the network. For a particular antenna, operating frequency, and transmission line impedance and length, the matching circuit requires the same total circuit inductance and the same output capacitance as the single-ended network. However, the balanced circuit divides the inductance into two equal series portions, one in each leg of the network. The shunt capacitor has the same value in both versions of the L-network.

Unlike the single-ended L-network, the legs of the balanced L-network are both above the ground potential. Hence, both the input and antenna sides of the network are balanced. In order to accommodate the single-ended transmission line from the

UNDERSTANDING YOUR TUNER

by the station you are working.

The sketch shows the general idea. You can insert the loop manually or with a system of switches. Knife switches work very well for parallel transmission line,



since they will handle the high voltages that may be present on parallel transmission lines. As with any run of parallel transmission line, you must keep the line free and clear of metallic objects. As well, do not coil the line itself. Instead, make a single large loop.

The size of the loop depends on the frequency of operation and how much further along the line you must go to obtain an impedance value that falls within the tuner limits.

It is possible to calculate favorable line lengths for each band for any combination of antenna and feedline. The very large variety of antennas and the many types of feedlines used by amateur operators place such calculations outside the scope of these notes. Most operators find it quicker to experiment with various line lengths until the uncover the right combinations for each band.

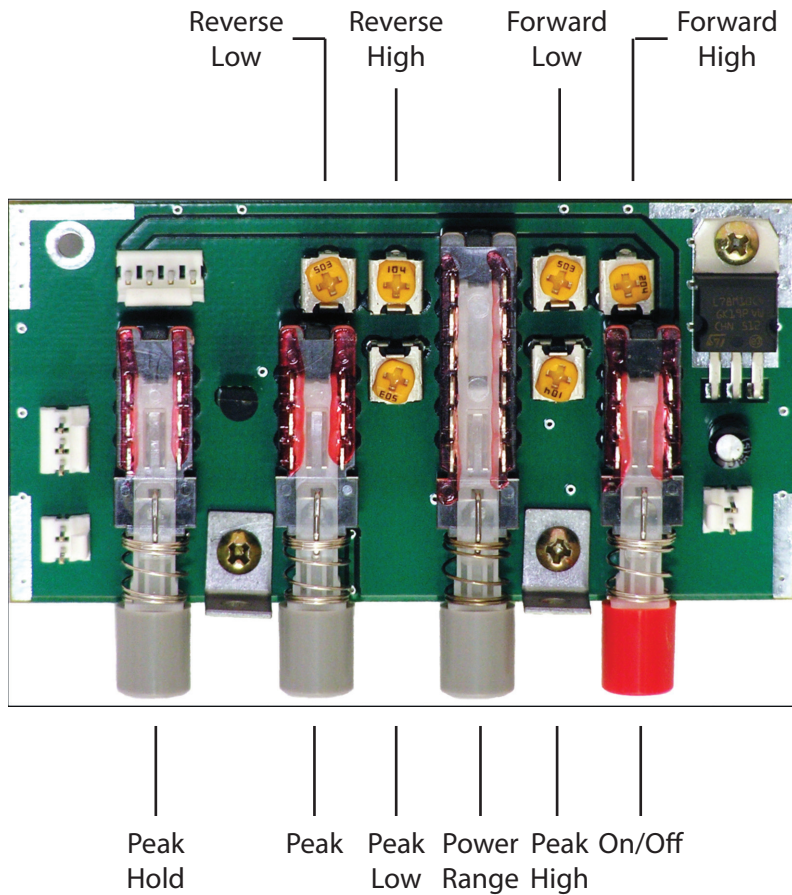
The balanced L-network, the transmission line, and the antenna form a total system that is very flexible. The initial inability to find a 1:1 SWR match for the system is not a fault of any of the three major components. Instead, the situation is a normal function of the dynamics of the antenna feedpoint impedance and its transformation along the transmission line. You may alter any of the three components of the system to arrive at an impedance at the antenna terminals that the tuner can match. In most cases, but not all, modifying the transmission line length is the easiest technique. Alternatively, you may alter the antenna length as well.

There are many resources available for learning more about your antenna and feedline system. The ARRL Antenna Book is a good place to start. In addition, there are numerous aids to making calculations of what is occurring in the system.

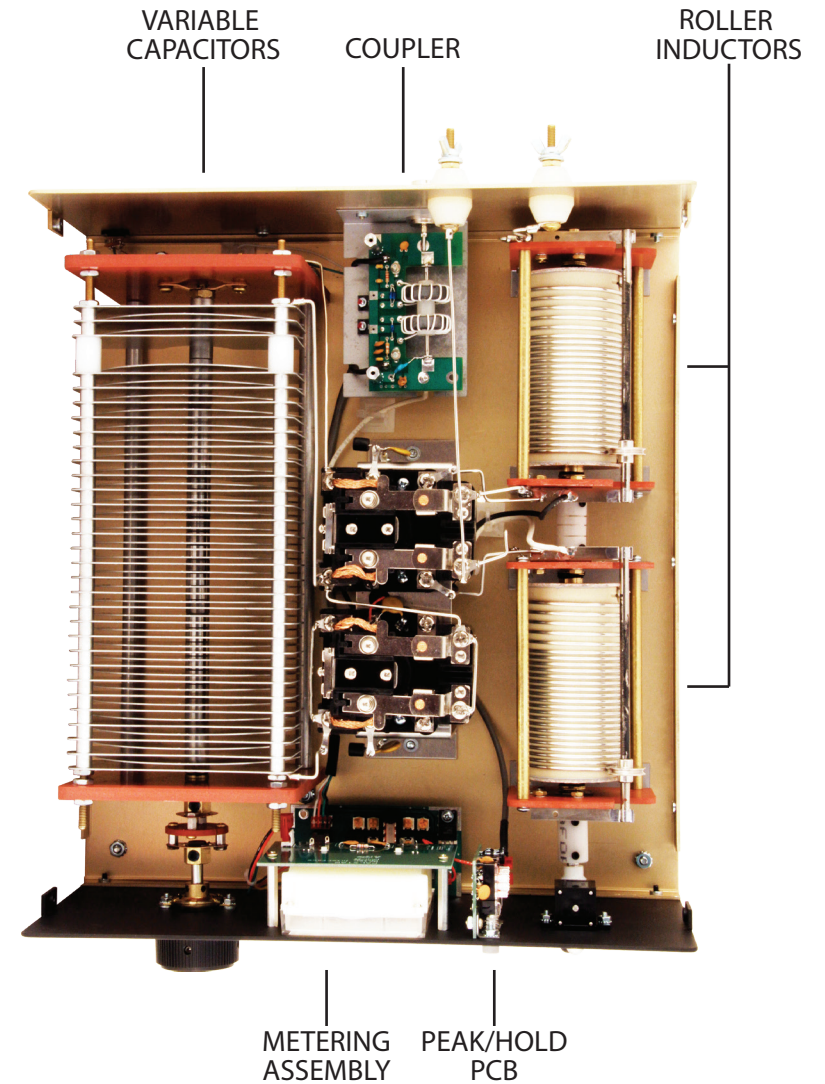
The more that you know about your antenna and feedline system, the more effective you will be able to use your Palstar BT1500A antenna tuner.



METER BOARD ADJUSTMENTS



INSIDE VIEW



OPERATING YOUR BT1500A

BEFORE OPERATING

1. To avoid possible damage to the BT1500A set INPUT, OUTPUT, INDUCTOR, and POWER RANGE switches as outlined in the chart below before applying transmitter power.
2. Begin tuning with your transmitter/amp feeding the tuner set at a low output power setting (50-100 Watts max).

WARNING: DO NOT OPERATE THE BT1500A WITH THE COVER OFF.

TUNING

1. Select the band and frequency of desired operation.
2. Set TUNE and INDUCTOR controls to the suggested setting before applying transmitter power (see chart). Actual settings will vary from antenna to antenna.
3. Set your transmitter/amplifier to 100-150 watts LOW output. If your transmitter has a TUNE position, select that position.
4. Preset the INPUT, OUTPUT, and INDUCTOR values shown in the chart. Select type of antenna feed, BALANCED or COAX.

NOTE: MINIMUM INDUCTANCE is **229** (max turns clockwise).
MAXIMUM INDUCTANCE is **0 (ZERO)** on the turns counter.

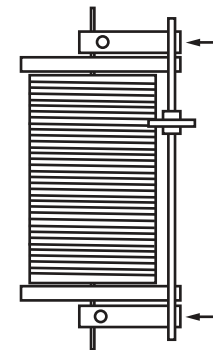
BAND	INPUT		SWITCH SETTING		INDUCTOR	
	SUGGESTED	ACTUAL	HI-C/LO-C	HI-Z/LO-Z	SUGGESTED	ACTUAL
160 M	66		HI-C	HI-Z	156	
80 M	35		HI-C	HI-Z	184	
40 M	20		HI-C	HI-Z	215	
20 M	11		HI-C	HI-Z	231	
15 M	35		HI-C	HI-Z	237	
12 M	18		HI-C	HI-Z	238	
10 M	15		HI-C	HI-Z	240	

OPERATING YOUR BT1500A

5. Set **POWER RANGE** switch to 300 W (button out).
6. **Key your transmitter** and adjust the power level for a reading of 50-100 watts on the FORWARD scale. Adjust the INPUT, OUPUT, and INDUCTOR controls for a minimum REFLECTED reading while maintaining a FORWARD reading of 50-100 watts using your transmitter power control. Use the supplied chart of approximate tuning control locations for the different bands located at the back of the manual.
7. **Read the SWR** on the red scale at the point where the two needles intersect. Repeat TUNING the input and antenna controls until the lowest SWR reading is obtained.

This procedure takes patience the first time. The input and antenna controls vary the capacitors and provide fine adjustments, while the roller inductor crank provides coarse adjustment.

When approaching the end stops of the roller inductor (readings of Zero or 279) **SLOW DOWN**. Slamming the roller wheel into the mechanical end stops on either end of the roller inductor *will decrease the pressure of the wheel* against the wire wound on the ceramic form.



To RESTORE wheel pressure on the inductor push down on the *flat springs* soldered to the wheel shaft located on each end of the shaft.

OPERATING YOUR BT1500A

NOTES:

9. When you have tuned your antenna to the best SWR, record the settings of the INPUT, ANTENNA, and INDUCTANCE controls on the chart above for future reference. When you retune, use these settings as your starting point.

Notes:

1. A SWR of 1:1 is best, but an SWR as high as 2:1 may be acceptable. Check your transmitter/amplifier manual for details.
2. If you cannot get an acceptable SWR, lengthen or shorten your antenna and/or feedlines and retune.
3. If you get low SWR readings at more than one setting, use the setting that gives:
 - highest FORWARD power reading
 - lowest REFLECTED power reading
 - uses the largest capacitance (highest number) on the INPUT and ANTENNA controls.
4. Any time a new or different antenna is connected, it is necessary to repeat the turning procedure for each antenna.
5. Once every 4-6 months clean the roller coil with Deoxit D5 contact cleaner and a clean cotton cloth. Do not remove the conducting grease on the rod that guides the roller wheel. Do not transfer any of the conducting grease from the rod to the roller coil body, as this will contaminate the windings.