# LDG AT-1000 1KW
# Automatic Memory
# Antenna Tuner


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# LDG AT-1000 1KW Automatic Antenna Tuner

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## Introduction

Congratulations on selecting the LDG AT-1000 tuner. The AT-1000 is a breakthrough product, providing fully automatic antenna tuning with memories for high power amplifiers. The AT-1000 is intended for use with most tube or transistor amplifiers outputting up to 1,000 watts SSB. It will tune dipoles, verticals, Yagis or virtually any coax-fed antenna.

LDG pioneered the automatic, wide-range switched-L tuner in 1995. From its laboratories in St. Leonard, Maryland LDG continues to define the state of the art in this field with innovative automatic tuners for every amateur need.

**IMPORTANT SAFETY WARNINGS**

Like all high power antenna tuners, your AT-1000 handles a great deal of RF energy. Very large RF currents flow through the tuner, and very high RF voltages are sometimes present. Your AT-1000 is designed to safely handle this RF energy ***within its specifications***, with a reasonable margin of safety. However, some amateur amplifiers are capable of outputting RF levels in excess, sometimes *far* in excess, of the specified maximums. Operating significantly above specifications will definitely damage or destroy your AT-1000. Operating above specifications can cause catastrophic failure of internal components; under extreme overload, components could actually explode. You must observe the stated specifications of your AT-1000, just as you do with your amplifier or any conventional tuner operating at this power level. Never operate your AT-1000 with the cover removed; lethal RF voltages may be present during operation.

**Jumpstart,** ***or*** **"Real hams don't read manuals!"**

Ok, but at least read this one section before you transmit:

Safety Warning: Never operate your AT-1000 with the cover removed; lethal RF voltages may be present during operation. Never exceed specifications.

1. Connect your AT-1000 to a source of 11 – 15-volt DC power capable of supplying at least 1 Amp, red lead positive; the pilot will flash once. Press the Power button to turn on the tuner.
2. Connect your amplifier output to the AT-1000 input socket labeled "Transmitter" using 50-ohm coaxial cables. Connect the coax lead to your antenna to the AT-1000 output socket labeled "Antenna".
3. Set your amplifier to "Standby" mode so it will NOT operate when you transmit.
4. Transmit a carrier from your <u>exciter</u> of 20 watts CW, FM or AM.
5. Momentarily press the "Tune" button on your AT-1000. An automatic tuning cycle will begin, then stop. Check the meter to ensure an SWR of 2 or less before using your amplifier.
6. Tune your amplifier if needed; you're ready to transmit.

## Specifications

- Microprocessor controlled
- 200 non-volatile memories
- Switched L tuning network
- Back-lit cross needle meters
- Continuous coverage 1.8 to 54 MHz
- Power rating HF (1.8 to 30 MHz):
  - 1000 Watts Single Side Band
  - 750 Watts CW
  - 500 Watts Digital (RTTY, Packet, etc.)
- Power rating 6 meters:
  - 100 Watts
- Capacitor / Inductor fine tune controls
- Tuning time: 1 to 8 seconds, 4 average. Memory tune time: less than 0.5 seconds.
- Antenna impedance: 6 to 800 Ohms (approximately up to 10:1 SWR)
- Tuning power: 20 to 125 watts maximum, constant carrier
- Relay protection software prevents tuning:
  - Greater than 125 watts into a 1:1 SWR load
  - Greater than 75 watts into a 3:1 SWR load
- Soft touch buttons
- Includes 6 foot power cable
- Power requirements: 11 to 15 volts DC @ 1 Amp (user supplies power source)
- Enclosure sizes: 9 x 13 x 3 (measured in inches)
- Weight: 6 pounds

## Operating Instructions

**Getting to know your AT-1000**

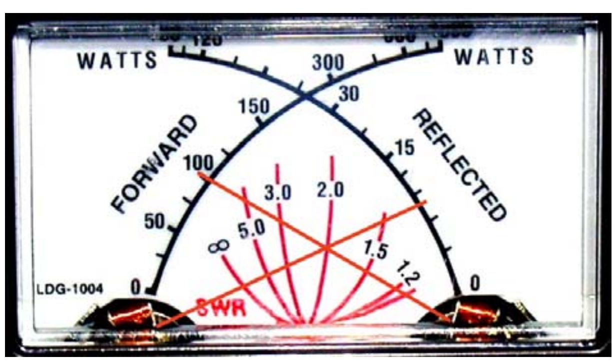
Your AT-1000 is a quality, precision instrument that will give you many years of outstanding service; take a few minutes to get to know it. On the front panel, there are six pushbutton switches:

- Power: turns your AT-1000 on and off
- Manual capacity and inductance adjustments (rarely needed)
  - Ind Up: adds inductance
  - Ind Dn: subtracts inductance
  - Cap Up: adds capacity
  - Cap Dn: subtracts capacity
- Tune: begins a tuning cycle, places the tuner in bypass mode


The Power switch does not turn the tuner completely off. It places it in a low-current "sleep" mode. In the Off mode, the tuner is in bypass, routing RF directly from your amplifier to the antenna with no matching. On power-up, the tuner is automatically restored to the last tuned setting. If DC power is interrupted, the tuner will revert to bypass mode on power-up.

In addition to the pushbuttons, there is a cross-needle meter. This meter indicates forward power up to 1,000 watts, reflected power up to 180 watts and SWR (see Theory of Operation, below). Power readings are accurate to +/- 5% of full scale across the entire range (this may very well be the most accurate wattmeter you own!). This meter also indicates various operational states, as described later in this section.

Forward and reflected power are indicted on individual scales. SWR is read at the intersection of the two needles, on the curved red scales across the center of the meter face. In the picture below, the meter is indicating forward power of 100 watts, reflected power of 11 watts and an SWR of 2.0.



On the back panel, there are four connectors:

- DC power input (2.5 x 5.5 mm coaxial power connector, center pin positive)
- RF in (marked “Transmitter”, standard SO-239 socket)
- RF out (marked “Antenna”, standard SO-239 socket)
- Ground (wingnut)


“What’s the deal with the hole?” Sharp-eyed users will note an empty cutout labeled “Control” on the back panel. Future versions of the AT-1000 may feature remote control and monitoring via a DB-9 connector in this position. This feature may also be offered as an upgrade for present users, but is not available at this time. In this version, the cutout serves no function. Never insert anything into this cutout, especially when transmitting.

**Installation**

Your AT-1000 is intended for indoor use only; it is not water-resistant. If you use it outdoors (Field Day, for example) you must protect it from rain. Place your AT-1000 as near as practical to your exciter (your transceiver or transmitter) and your amplifier, keeping free access to the front panel controls. You should avoid placing other equipment on top of your AT-1000 if possible to aid in cooling.

Grounding will significantly improve the safety and performance of your tuner. Attach the ground connection on the back panel to a suitable ground using heavy-gauge wire or metal braid. A dedicated outside ground rod is best, but a nearby cold water pipe is usually satisfactory. If no other ground is available, the screw holding the cover on a power outlet is a usable ground.

Connect the socket marked “Transmitter” on the back of your AT-1000 to your amplifier output using high-quality 50-ohm coaxial cable and PL-259 plugs. Do not use crimp-on plugs for this connection; only properly soldered plugs will be safe and provide satisfactory performance. The coaxial cable should be rated for the maximum output of your amplifier. Keep the cable as short as practical.

Attach your antenna lead-in coax to the socket marked “Antenna” on the rear of the tuner with a soldered PL-259 plug. Your AT-1000 is intended for use with coax-fed (unbalanced) antennas only. If you wish to use it with antennas fed with ladder-line, or with longwire antennas you must provide a suitable balun to adapt your AT-1000 to the balanced load. LDG does not presently sell a balun that handles 1,000 watts, but they are readily available from many ham radio vendors.

Your AT-1000 requires 11 – 15 volts DC at 1 Amp. If your exciter runs on 12 volts DC, you can use the same power supply for your AT-1000 if it can provide the necessary 1 Amp current; otherwise, you will need a separate power supply. We recommend a regulated supply, but an unregulated one may be used with satisfactory results. Connect the power supply to the DC power jack on the back of your AT-1000 using the provided 2.5 x 5.5 mm coaxial power plug. Be sure to observe proper polarity; the center pin, and the red lead are positive. When you connect to DC power, the power LED will flash once, and the tuner will remain in the off state.

## Operation

### *Meter bounce codes*

In addition to displaying power and SWR, the power meters also indicate several important tuner states. The meters are used as a kind of digital output device; they "bounce" to indicate information. While bouncing, they do not indicate power levels.

There are three levels of bounce (100 {Low}, 300 {Mid} and 1,000 {High} watt marks on the forward power meter) and two speeds (fast and slow). For example, when you press [Ind Dn + Cap Dn] to place the tuner into bypass, the meter bounces to the 100 watt mark at the slow rate until you release the buttons. Some functions are indicated by one or two discrete bounces, other by steady bouncing until a key is released.

### *Power-Up Options*

There are two power-up options, selected by holding down one ore more buttons while applying DC power (typically by plugging in the DC power connector).

Version Display: press and hold the Power button while applying DC power to the tuner. The meter will "bounce" to indicate the software version number. The REFLECTED meter will first bounce out the whole number part of the version number, then the FORWARD meter will bounce the fractional part. For example, if the version number is 2.4, the REFLECTED meter will bounce twice, then the FORWARD meter will bounce 4 times. This is only an example; your tuner may have a different software version.

Status and Tune Memory Clear: Press and hold the Power and Tune button while applying DC power. This clears all tune memories, and is indicated by three meter bounces in a REFLECTED - FORWARD sequence. To clear the memories, you must continue to hold both buttons down until the three bounce sequence has completed. If you release either or both buttons before the bounce sequence has completed, the memory clear command is aborted and the memories are not cleared.

### *Button Functions and Meter Indications*

Power: The Power button turns the tuner on and off. In the off state, the tuner is in bypass mode, routing RF from your transmitter or amplifier directly to your antenna with no matching. The meter light is off, but the meters still indicate forward and reverse power.

Pressing the Power button toggles the tuner between off and on states. When toggled to the on state, the tuner resets to the last tuned setting before the previous power-down.

Tune: The Tune button begins a semi-automatic tuning cycle, a memory tuning cycle, or places the tuner in bypass mode. A momentary press (< 0.3 seconds) toggles the tuner between bypass and its last tuned setting. Bypass is indicated by two Low meter bounces, while previous setting restore is indicated by one Low meter bounce.

A medium press (0.3 - 2.5 seconds, indicated by both meters steady at the 300 Watt mark) begins a memory tune; the 200 memories will be scanned for a match. A long press (> 2.5 seconds), indicated by both meters steady at full scale) begins a full tuning cycle.

Cap Up: The Cap Up button adds capacitance; holding the button down auto-repeats the add. Both meters bounce fast at the Low mark when you reach the upper capacitance limit.

Cap Dn: The Cap Dn button subtracts capacitance; holding the button down auto-repeats the subtract. Both meters bounce fast at the Low mark when you reach the lower capacitance limit.

Ind Up: The Ind Up button adds inductance; holding the button down auto-repeats the add. Both meters bounce fast at the Low mark when you reach the upper inductance limit.

Ind Dn: The Ind Dn button subtracts inductance; holding the button down auto-repeats the subtract. Both meters bounce fast at the Low mark when you reach the lower inductance limit.

Cap Up + Ind Up: Manually stores the current tuning settings. The REVERSE meter will bounce High, followed by the FORWARD meter High to indicate a successful save. If the FORWARD meter bounces twice, it indicates that a new set of tuning parameters has been saved. A single FORWARD bounce indicates that the current tuning settings are the same as the most recently saved settings, and no new memory usage is needed.

Cap Dn + Ind Dn: Places the tuner in bypass mode; RF is routed directly to the antenna with no matching. The meter bounces slowly at the Low mark to indicate bypass mode. If the tuner is bypassed in this manner, pressing the Tune button will *not* restore the most recent setting; the tuner will remain bypassed until a new tuning cycle, either memory or full, is executed.

Cap Up + Cap Dn: Sets all capacitors to the Antenna side. The FORWARD meter bounces fast at the High mark. This is typically never used as the tuner will always over ride any setting the user selects on the next tuning cycle.

Ind Up + Ind Dn: Sets all capacitors to the Transmitter side. The REVERSE meter bounces fast at the High mark. This is typically never used as the tuner will always over ride any setting the user selects on the next tuning cycle.

***Normal Operation***

When you first apply DC power, with or without power-up options, the tuner defaults to its Off state, in which the tuner is in Bypass mode; RF goes directly to your antenna with no matching. The Power LED will flash once to indicate successful DC power connection.

To prepare the tuner for use, press the “Power” button on the front panel. The red LED above the button, and the meter lights come on, indicating that your AT-1000 has powered up and successfully completed a self-test. The tuner resets to the last tuned setting before the previous power-down.

Set your amplifier to standby, so it will not operate when you transmit; tune with your exciter only. Set your exciter to transmit 20 watts (without rollback; see below), or up to 100 watts (with rollback) on the frequency you plan to use. CW is usually the most convenient mode, but you can also use FM or an AM carrier.

While transmitting 20 – 100 watts, press and release the “Tune” button on the tuner front panel; an automatic tuning cycle will begin. You will hear the relays in your AT-1000 operate as they switch inductors and capacitors in and out seeking a match; they make a fairly loud buzzing noise. You can observe the present reflected power and SWR on the meter during the tuning process—but watch closely; it happens fast! The tuning cycle will automatically end in a few seconds, with the meter indicating the final achieved SWR, usually 1.7 or less. Check for an SWR of 2 or less. If the SWR is greater than 2, use the manual adjustment buttons to adjust the SWR to level less than 2. Unkey your exciter.

The meters may indicate several error and status states:

Power too low: your AT-1000 requires at least 5 watts to tune. If the power is too low, the FORWARD meter will bounce once to the High mark. In this case, increase power and begin a new tuning cycle.

Power too high: if the power exceeds 125 watts, a tuning cycle will not begin, both meters bounce fast at the High mark. They will continue to bounce until the RF is removed. In this case, reduce power and begin a new tuning cycle.

SWR too high for the power level: if power exceeds 100 Watts while the SWR is greater than 3, or if power exceeds 75 watts while the SWR is greater than 5, a tuning cycle will not begin, and both meters will bounce slowly to the High mark. They will continue to bounce until RF is removed. In this case, reduce power and begin a new tuning cycle.

Loss of power during tune: if RF power is removed before a tuning cycle has ended, the FORWARD meter will bounce once to the High mark. In this case, the tune is not stored; restore RF and begin a new tuning cycle.

Final SWR over 3: in rare cases, your AT-1000 will not be able to achieve an SWR lower than 3. This is most often due to attempting a tune very far from the resonant frequency of your antenna. The REVERSE meter will bounce once to the High mark, and the resultant tune will not be stored in memory.

Successful tune: When a tuning cycle ends with an SWR below 1.7, The REVERSE meter bounces once then FORWARD meters bounce twice to the High mark, and the tuning results are stored in memory[1]. If the tuning settings are the same as the last saved settings, the FORWARD meter will bounce only once, and no additional memory will be used.

After tuning is completed, set your amplifier to operate, key your exciter and tune your amplifier as usual (if needed). Good practice dictates tuning your amplifier into a 50-ohm dummy load with a suitable power rating. You may tune your amplifier into the antenna through your AT-1000 providing it has tuned the antenna to a low SWR, and also providing you do not exceed the specified ratings of either your amplifier or your AT-1000. Never press the Tune button while transmitting more than 100 watts. Unkey when done; you are ready to transmit.

***Memory Operation***

At the end of each successful tuning cycle (SWR < 1.7), the tuning parameters are stored in non-volatile memory. There are 200 memory locations forming a stack of the 200 most recent successful tunes. Each time a tuning cycle is started, the tuner very quickly tries these 200 stored values. If one of them gives an SWR of 1.7 or less, the tuning cycle ends. If not, a full tuning cycle begins automatically, with the new tuning parameters stored automatically upon successful completion of the cycle. Meter bounce codes indicating a successful memory tune are the same as those for a manually executed tune cycle (see above).

The memory storage and tuning process is completely automatic, with no impact on your operation of the tuner. The effect is much faster overall tuning once the tuner has "learned" your most common bands and frequencies. You will probably want to use memory tuning most of the time.

***A word about “roll-back” circuits***

Modern amateur exciters with solid state finals usually employ a “rollback” circuit to protect the final amplifier transistors from high SWR, which can damage or destroy them. A rollback circuit senses the SWR at the antenna terminal during transmit, and reduces the output power as the SWR rises above a preset level, often 2:1. The higher the SWR, the lower the power is set to prevent damage.

If your solid state or tube-type exciter has a rollback circuit, you can simply key down and tune as described above at any power level from 20 to 100 watts. If your exciter lacks a rollback circuit, you must manually set the power level for tuning to 20 watts. At higher power levels, the reflected power encountered during the tuning cycle could damage your exciter. Check your exciter owner’s manual to determine if yours has a rollback circuit.

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***Fine-tuning the tuner***

In rare circumstances, the automatic tuning cycle will end with a relative high SWR, perhaps 1.8 or 2. This is usually due to operation far from the antenna's natural resonant frequency. You can manually adjust the match using the Ind and Cap Up and Dn buttons on the front panel. While still transmitting with your exciter after the automatic tuning cycle ends, press these buttons and observe the effect on SWR on the meter.

Since you don't know how the automatic tuning cycle set the inductors and capacitors, you will have to make manual adjustments by trial and error. Press the Cap or Ind Up button three times and observe the change in SWR. If it gets worse, tap the Dn button three times to return to your starting place, then try three taps of the Dn button. Once you've gone through this process a few times, you will get a better feel for matching certain antennas or frequencies.

Frankly, you won't use the Cap and Ind buttons very often; your AT-1000 is very good at finding a match. These buttons are included only to provide you with maximum flexibility and utility.

The following table summarizes the various meter bounce codes:

| Function | Meter Bounce Code |
|---|---|
| Version | Rev.Fwd |
| Memory Clear | Rev-Fwd |
| Bypass Mode | 2 Low |
| Memory Tune | Both Steady Mid |
| Full Tune | Both Steady High |
| Cap Limit Up/Down | Fast - Low |
| Ind Limit Up/Down | Fast - Low |
| Manual memory store | Rev then Fwd Full |
| Caps to antenna side | Fwd Fast-High |
| Caps to Transmitter Side | Rev Fast-High |
| RF too low | Fwd-High Once |
| RF too high | Both Fast-High |
| SWR too high for Pwr | Both Slow-High |
| Pwr loss during tune | Fwd High-Once |
| Final SWR > 3 | Rev High-Once |
| Final SWR < 1.7 | Rev-Fwd-Fwd |
| Final SWR < 1.8 Not Stored | Rev-Fwd |

Low=100 Watt mark, Mid=300 Watt mark, High = 1,000 Watt mark

## Theory of Operation

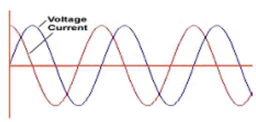
Some basic ideas about impedance

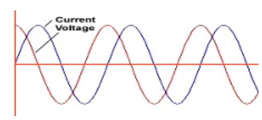
The theory underlying antennas and transmission lines is fairly complex, and in fact employs a mathematical notation called "complex numbers" that have "real" and "imaginary" parts[2]. It is beyond the scope of this manual to present a tutorial on this subject, but a little background will help you understand what your AT-1000 is doing, and how it does it.

In simple DC circuits, the wire resists the current flow, converting some of it into heat. The relationship between voltage, current and resistance is described by the elegant and well-known "Ohm's Law", named for Sir George Simon Ohm of England, who first described it in 1826. In RF circuits, an analogous but far more complicated relationship exists.

RF circuits also resist the flow of electricity. However, the presence of capacitive and inductive elements cause the voltage in the circuit to lead or lag the current, respectively. In RF circuits this resistance to the flow of electricity is called "impedance", and can include all three elements: resistive, capacitive, and inductive.

Capacitive Reactance




Inductive Reactance

The output circuit of your amplifier consists of inductors and capacitors, usually in a series/parallel configuration called a "pi network". The transmission line can be thought of as a long string of capacitors and inductors in series/parallel, and the antenna is a kind of resonant circuit. At any given RF frequency, each of these can exhibit resistance, and impedance in the form of capacitive or inductive "reactance".

Transmitters, transmission lines, antennas and impedance

The output circuit of your amplifier, the transmission line, and the antenna all have a characteristic impedance. For reasons too complicated to go into here, the standard impedance is about 50 ohms resistive, with zero capacitive and inductive components. When all three parts of the system have the same impedance, the system is said to be "matched", and maximum transfer of power from the amplifier to the antenna occurs. While the output circuit and transmission line are of fixed, carefully designed impedance, the antenna presents a 50 ohm, non-reactive load only at its natural resonant frequencies. At other frequencies, it will exhibit capacitive or inductive reactance, causing it to have an impedance different from 50 ohms.

When the impedance of the antenna is different from that of the amplifier and transmission line, a "mismatch" is said to exist. In this case, some of the RF energy from the amplifier is reflected from the antenna back down the transmission line, and into the amplifier. If this reflected energy is strong enough it can damage the amplifier's output circuits.

The ratio of transmitted to reflected energy is called the "standing wave ratio", or SWR. An SWR of 1 (sometimes written 1:1) indicates a perfect match. As more energy is reflected, the SWR rises to 2, 3 or higher. As a general rule, modern solid state amplifiers must operate with an SWR of 3 or less. Tube exciters are more tolerant of high SWR. If your 50 ohm antenna is resonant at your operating frequency, it will show an SWR of 1. However, this is usually not the case; operators often need to transmit at frequencies other than resonance, resulting in a reactive antenna and a higher SWR.

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[2] For a very complete treatment of this subject, see any edition of the ARRL Radio Amateur's Handbook

$$SWR = \frac{1+\sqrt{R/F}}{1-\sqrt{R/F}}$$ where F = Forward power (watts), R = Reflected power (watts)

SWR is measured using a device called an “SWR bridge”, inserted in the transmission line between the amplifier and antenna. This circuit measures forward and reverse power from which SWR may be calculated (some meters calculate SWR for you). More advanced units can measure forward and reverse power simultaneously, and show these values and SWR at the same time.

An antenna tuner is a device used to cancel out the effects of antenna reactance. Tuners add capacitance to cancel out inductive reactance in the antenna, and vice versa. Simple tuners use variable capacitors and inductors. The operator adjusts the them by hand while observing reflected power on the SWR meter until a minimum SWR is reached. Your LDG AT-1000 automates this process.

No tuner will fix a bad antenna. If your antenna is far from resonance, the inefficiencies inherent in such operation are inescapable; it’s simple physics. Much of your transmitted power may be dissipated as heat in the tuner, never reaching the antenna at all. A tuner simply “fools” your amplifier into behaving as though the antenna were resonant, avoiding any damage that might otherwise be caused by high reflected power. Your antenna should always be as close to resonance as practical.

| Reflected Power (Watts) | Forward Power (Watts) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
| 2 | 1.92 | 1.70 | 1.58 | 1.50 | 1.45 | 1.41 | 1.38 | 1.35 | 1.33 |
| 4 | 2.62 | 2.15 | 1.92 | 1.79 | 1.70 | 1.63 | 1.58 | 1.53 | 1.50 |
| 6 | 3.42 | 2.62 | 2.26 | 2.06 | 1.92 | 1.83 | 1.75 | 1.70 | 1.65 |
| 8 | 4.44 | 3.14 | 2.62 | 2.33 | 2.15 | 2.02 | 1.92 | 1.85 | 1.79 |
| 10 | 5.83 | 3.73 | 3.00 | 2.62 | 2.38 | 2.22 | 2.09 | 2.00 | 1.92 |
| 12 | 7.87 | 4.44 | 3.42 | 2.92 | 2.62 | 2.41 | 2.26 | 2.15 | 2.06 |
| 14 | 11.24 | 5.31 | 3.90 | 3.25 | 2.87 | 2.62 | 2.44 | 2.30 | 2.20 |
| 16 | 17.94 | 6.42 | 4.44 | 3.60 | 3.14 | 2.83 | 2.62 | 2.46 | 2.33 |
| 18 | 37.97 | 7.87 | 5.08 | 4.00 | 3.42 | 3.06 | 2.80 | 2.62 | 2.47 |
| 20 | - | 9.90 | 5.83 | 4.44 | 3.73 | 3.30 | 3.00 | 2.78 | 2.62 |
| 22 | - | 12.92 | 6.74 | 4.94 | 4.07 | 3.55 | 3.21 | 2.96 | 2.77 |
| 24 | - | 17.94 | 7.87 | 5.51 | 4.44 | 3.83 | 3.42 | 3.14 | 2.92 |
| 26 | - | 27.96 | 9.32 | 6.17 | 4.85 | 4.12 | 3.65 | 3.32 | 3.08 |
| 28 | - | 57.98 | 11.24 | 6.95 | 5.31 | 4.44 | 3.90 | 3.52 | 3.25 |
| 30 | - | - | 13.93 | 7.87 | 5.83 | 4.79 | 4.16 | 3.73 | 3.42 |
| 32 | - | - | 17.94 | 9.00 | 6.42 | 5.18 | 4.44 | 3.95 | 3.60 |
| 34 | - | - | 24.63 | 10.40 | 7.09 | 5.60 | 4.75 | 4.19 | 3.80 |
| 36 | - | - | 37.97 | 12.20 | 7.87 | 6.07 | 5.08 | 4.44 | 4.00 |
| 38 | - | - | 77.99 | 14.60 | 8.80 | 6.60 | 5.44 | 4.71 | 4.21 |
| 40 | - | - | - | 17.94 | 9.90 | 7.19 | 5.83 | 5.00 | 4.44 |
| 42 | - | - | - | 22.96 | 11.24 | 7.87 | 6.26 | 5.31 | 4.68 |
| 44 | - | - | - | 31.30 | 12.92 | 8.65 | 6.74 | 5.65 | 4.94 |
| 46 | - | - | - | 47.98 | 15.08 | 9.56 | 7.27 | 6.02 | 5.22 |
| 48 | - | - | - | 97.99 | 17.94 | 10.63 | 7.87 | 6.42 | 5.51 |
| 50 | - | - | - | - | 21.95 | 11.92 | 8.55 | 6.85 | 5.83 |

SWR Lookup Table

Find SWR at intersection of
forward power column and
reflected power row.

The LDG AT-1000

In 1995 LDG pioneered a new type of automatic antenna tuner. The LDG design uses banks of fixed capacitors and inductors, switched in and out of the circuit by relays under microprocessor control. A built-in SWR sensor provides feedback; the microprocessor searches the capacitor and inductor banks, seeking the lowest possible SWR.

The tuner is a “Switched L” network consisting of series inductors and parallel capacitors. LDG chose the L network for its minimum number of parts and its ability to tune unbalanced loads, such as coax-fed dipoles, verticals, Yagis; in fact, virtually any coax-fed antenna. Using seven toroidal inductors, the total inductance ranges from 0 to 10 µH. Each inductor’s value is selected to provide 128 different combinations, with a resolution of 0.08 µH. The inductors are switched in and out of the circuit by relays controlled by the microprocessor. An additional relay switches between high and low impedance ranges.

The inductors are wound with #16 wire on 2” toroid forms. Using seven 2,500 volt capacitors, the total capacitance ranges from 0 to 1250 pF. Each capacitor’s value is selected to provide 128 combinations, with a resolution of 10 pF. The capacitors are connected to ground with the seven inductor relays. Another relay switches the entire capacitor bank to the input or output side of the inductor. This switching allows the AT-1000 to automatically handle loads that are greater than 50 ohms (high setting) and less than 50 (low setting). All of the relays are SPDT types sized to handle up to 1,000 watts SSB (500 watts key down).

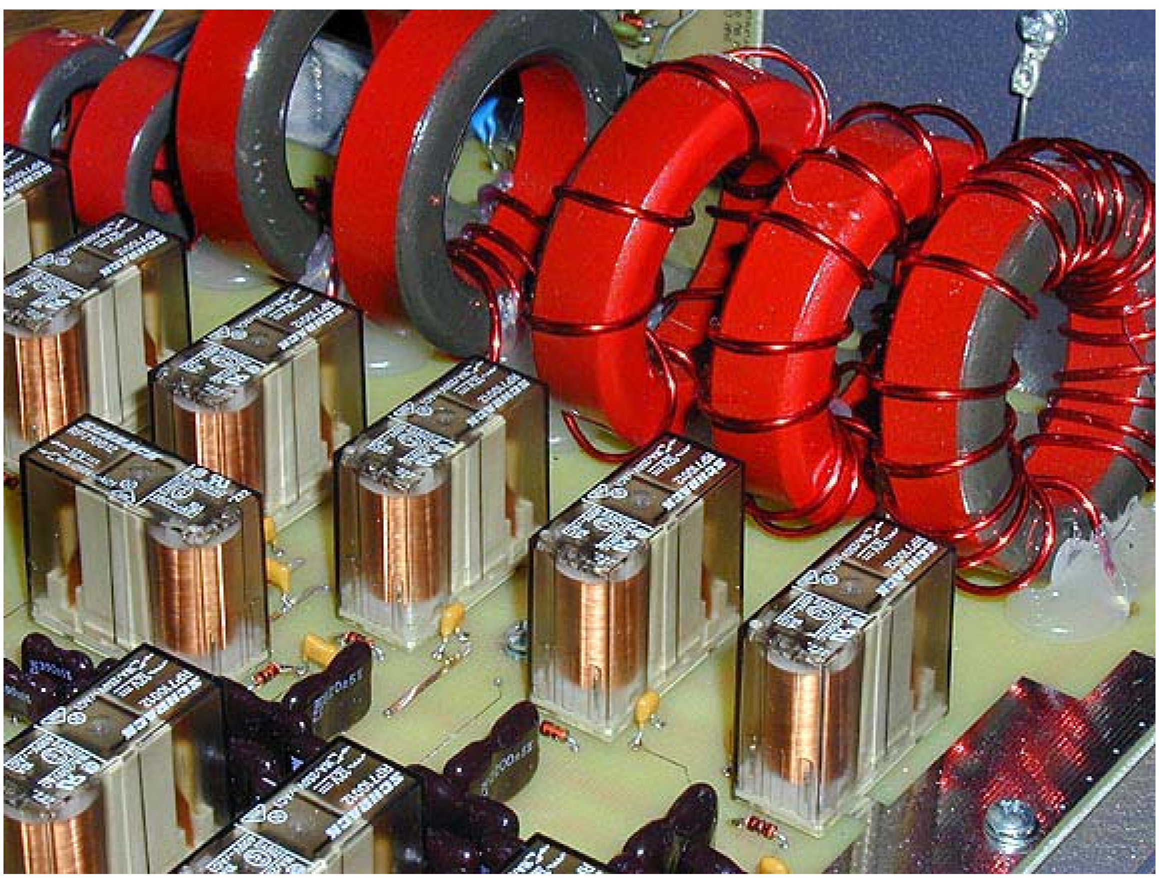
The SWR sensor is a variation of the Bruene circuit.  This SWR measuring technique is used in most dual-meter and direct-reading SWR meters. Slight modifications were made to the circuit to provide voltages (instead of currents) for the analog-to-digital converters (ADCs) that provide signals proportional to the forward and reverse power levels. The single-lead primary through the center of the sensor transformer provides RF current sampling. Diodes rectify the sample and provide a dc voltage proportional to RF power. Variable resistors calibrate the FORWARD and REVERSE power levels. Once adjusted, the forward and reverse power sensors produce a calibrated DC voltage proportional to the forward and reverse RF power levels. These two voltages are read by the ADCs in the microprocessor. Once in a digital format, the they are used to calculate SWR in real time.

The relays operate from an external 12 volt DC power supply. The total current drawn by the AT-1000 depends primarily on the number of energized relays, with the maximum current drain being approximately 1 Amp. The microprocessor also needs a power supervisory circuit (U2, the 34064 IC) to provide a proper power-on sequence and to place the microprocessor in a known reset mode while powering down.

Although the microprocessor's oscillator runs at 8 MHz, its internal bus speed is on one-fourth that, or 2 MHz. This means that one instruction cycle executes in 0.9 ms. The main tuning routine takes about 75 cycles to make a tuner adjustment and take a new SWR measurement, or 67.5 ms per tuner adjustment. If running at maximum speed, the microprocessor can try all inductor-capacitor combinations in just 8.8 seconds. Unfortunately, the mechanical relays can't react as quickly as the microprocessor, and the tuning speed must be slowed down to compensate for relay settling time.

The tuning routine, written in assembly language, uses an algorithm to minimize the number of tuner adjustments. The routine first de-energizes the high/low impedance relay if necessary, then individually steps through the inductors to find a coarse match. With the best inductor selected, the tuner then steps through the individual capacitors to find the best coarse match. If no match is found, the routine repeats the coarse tuning with the high/low impedance relay energized. The routine then fine tunes the capacitors and inductors. The program checks LC combination to see if a 1.5 or lower SWR can be obtained, and stops when it finds a good match.

The number of tuner adjustments is between 10 and 288. There are 1 to 16 checks for the coarse inductor tuning, 1 to 16 for the coarse capacitor and between 2 and 256 for the inductor and capacitor fine tuning. With the speed reduced to 10 ms per selection to compensate for relay settling, the maximum tuning time is 6.1 seconds and the minimum tuning time is 0.1 second. Generally, the farther away from resonance an antenna is from the exciter's operating frequency, the longer it takes the tuner to find a match. Test results show that a 40-meter half-wave dipole tunes to any frequency in the band in about a second.



## Care and Maintenance

Your AT-1000 tuner is essentially maintenance-free; just be sure to observe the power limits discussed in this manual. The outer case may be cleaned as needed with a soft cloth slightly dampened in household cleaning solution. As with any modern electronic device, your AT-1000 can be damaged by temperature extremes, water, impact or static discharge. LDG strongly recommends that you ground your AT-1000, and use a good quality, properly installed lightning arrestor in the antenna lead.

### Technical Support

We are happy to help you with your product. For detailed tech support, submit our Tech Support form on our web site under Support/Manuals, then Tech Support. You can find us at **www.ldgelectronics.com**.

### Warranty and Service

Your product is warranted against defects in parts or workmanship for two years from purchase. The warranty does not cover damage due to abuse or exceeding specifications. This warranty applies to the original purchaser only; it is not transferable. A copy of the receipt showing the purchaser's name and the date of purchase must accompany units returned for warranty service. All returns must be shipped to us pre-paid; we will not accept units with postage due. Please fill out and print the return form from our web site under Support/Manual, then Tech Support-Warranty.

If you need to return your unit to us for service, package it carefully, keeping in mind that we will re-use your packaging to return the unit to you. Include a full description of the problem, along with your name, address and a phone number or e-mail address on the web form. Repairs average about 3 to 6 weeks.

We will be glad to service your unit after the warranty period has ended. We will notify you of repair charges by phone or e-mail, and bill you after repairs are completed.

## Firmware upgrades

From time to time LDG may release upgraded firmware for the AT-1000, refining operation and adding features. Your AT-1000 is not field programmable; you will have to remove the present chip and replace it with the upgrade chip. To remove the chip you will need an appropriate tool. A PLCC extraction tool is ideal, but if you don't have one you can fashion a satisfactory substitute from an ordinary paperclip. Straighten the paper clip, then bend it into a "U" shape. Use pliers to bend the last 1/8" of each end toward the center (see illustration).

The extraction tool fits into opposite corners of the 68HC11 socket; the bent ends will lift the chip from beneath. Unplug the tuner, touch a ground point to avoid static discharge damage, and remove the cabinet cover. Insert the tool and pull gently and evenly on both sides to extract the chip. Press the upgrade chip into the socket, observing the small diagonal corner key. Replace the cabinet cover; your upgraded AT-1000 is ready to use.

Upgrades are expected to cost about $10-$20 and will be announced on our web site when available.

## Feedback

If you have an idea to improve our software or hardware, please send us a description. If we incorporate your idea in the AT-1000, we'll send you a free upgrade as a “thank you”.

We encourage everyone who uses the AT-1000 to contact us (card, letter or e-mail preferred) telling us how well it works for you. We are also always looking for photographs of our products in use; we frequently place such pictures on our Web site (www.ldgelectronics.com).