

**LDG AT-1000 Pro
1000-Watt Automatic
Memory Antenna Tuner**



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INTRODUCTION

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 and related products for every amateur need.

Congratulations on selecting the AT-1000 Pro 1000-watt automatic tuner. The AT-1000 Pro provides semi-automatic and fully automatic antenna tuning across the entire HF spectrum plus 6 meters, at power levels up to 1000 watts (SSB). It will tune dipoles, verticals, Yagis, or virtually any coax-fed antenna. It will match an amazing range of antennas and impedances, far greater than some other tuners you may have considered, including the built-in tuners on many radios.

The AT-1000 Pro is an upgrade from LDG's previous AT-1000 kilowatt tuner, in that it now supports fully automatic tuning (Just talk and it tunes!) with frequency-based memories for high power amplifier applications.

TUNER SAFETY WARNING

The AT-1000 Pro internally switches a very large amount of radio frequency energy. Tremendous RF currents flow through the tuner, and sometimes very high RF voltages are present during operation. The AT-1000 Pro is designed to handle this RF energy safely *within its specifications*, with a reasonable margin of safety.

However, be warned that some amateur amplifiers are capable of transmitting RF energy in excess of the AT-1000 Pro's maximum specifications. Some are capable of levels *far* in excess of these specified maximum levels.

Operation under conditions exceeding the maximum specified ratings of the AT-1000 Pro will cause damage to or destroy the AT-1000 Pro. Operation in significant excess of the maximum specified power levels can actually cause explosion of internal components. For this reason, and because of the lethal RF voltages present during normal operation, **never operate the AT-1000 Pro with the cover removed.**

IMPORTANT ANTENNA SAFETY WARNING

Never install antennas or transmission lines over or near power lines. You can be seriously injured or killed if any part of the antenna, support or transmission line touches a power line. Always follow this antenna safety rule: the distance to the nearest power line should be at least twice the length of the longest antenna, transmission line or support dimension.

JUMPSTART, OR “REAL HAMS DON’T READ MANUALS!”

Ok, but at least read this one section before operating the AT-1000 Pro:

SAFETY WARNING: Never operate the AT-1000 Pro with the cover removed. Lethal RF voltages are present during operation. Also, never exceed the rated specifications.

Turn off power to your radio and amplifier.

Connect the antenna jack on your amplifier to the “**Transmitter**” jack on the AT-1000 Pro, using a 50 ohm coax cable jumper. Be sure that the coax jumper can handle the RF power level from the amplifier. Connect a 50 ohm coax antenna feedline to the “**ANT1**” jack on the AT-1000 Pro.

Connect the AT-1000 Pro to a source of 11 to 15 volts DC, 1A, using the supplied coaxial DC power plug. Press the “**Power**” button on the front of the AT-1000 Pro to turn on the tuner. The “**Power**” LED and meter backlight will come on.

Turn on power to your transceiver and amplifier and select the desired operating frequency and mode. **Place the amplifier in Standby mode** so that it does not operate when transmitting.

Press the “**Auto**” button on the AT-1000 Pro to turn off fully-automatic mode. The **Auto** LED will go off.

Transmit a carrier from the exciter of approximately 30 watts CW, FM, or AM.

While transmitting the carrier, momentarily press the “**Tune**” button on the AT-1000 Pro. Continue transmitting the carrier until the tuning cycle stops.

Check the meter to see that the SWR is below 2:1 before using the amplifier.

Switch the amplifier to active mode; you are ready to transmit!

SPECIFICATIONS

Continuous frequency coverage 1.8 to 54 MHz (Including MARS, CAP, etc).

Transmit Power Rating, 1.8 to 30 MHz:

Single Side Band: 1000 watts

CW: 750 Watts

Digital (RTTY/Packet/PSK31, etc): 500 Watts

Transmit Power Rating, 50-54 MHz: 250 watts, all modes.

Minimum power required for tuning: 5 Watts

Maximum power while tuning: 125W

Built-in relay protection will prevent relay operation when:

Greater than 200 watts input power under any load.

Greater than 150 watts input power when load is 3:1 SWR or greater.

Built-in two position antenna switch.

3" cross-needle illuminated Power/SWR meter with dual power scales, 0-100 and 0-1000 watts. Selectable Peak and Average power display.

2000 memories per antenna port for instantaneous band changing.

Microprocessor-controlled Switched L tuning network.

Fine tune controls for manually adjusting capacitance and inductance.

Time required for tuning: 200 ms for memory recall; 10 seconds average full tune; 30 seconds maximum full tune time.

Built-in frequency sensor allows instant recall of previously-tuned frequencies.

Tunes 6 to 1000 ohm loads (About 10:1 SWR), or 16 to 150 ohm loads on 6M (3:1 SWR)

For Dipoles, Verticals, Vees, Beams or any Coax Fed Antenna.

Includes 6 foot DC power cable.

Optional interface cables available.

Power Requirements: 11 to 15 VDC, 1.0A

Dimensions: 9.5"W x 13"L x 3.5"H.

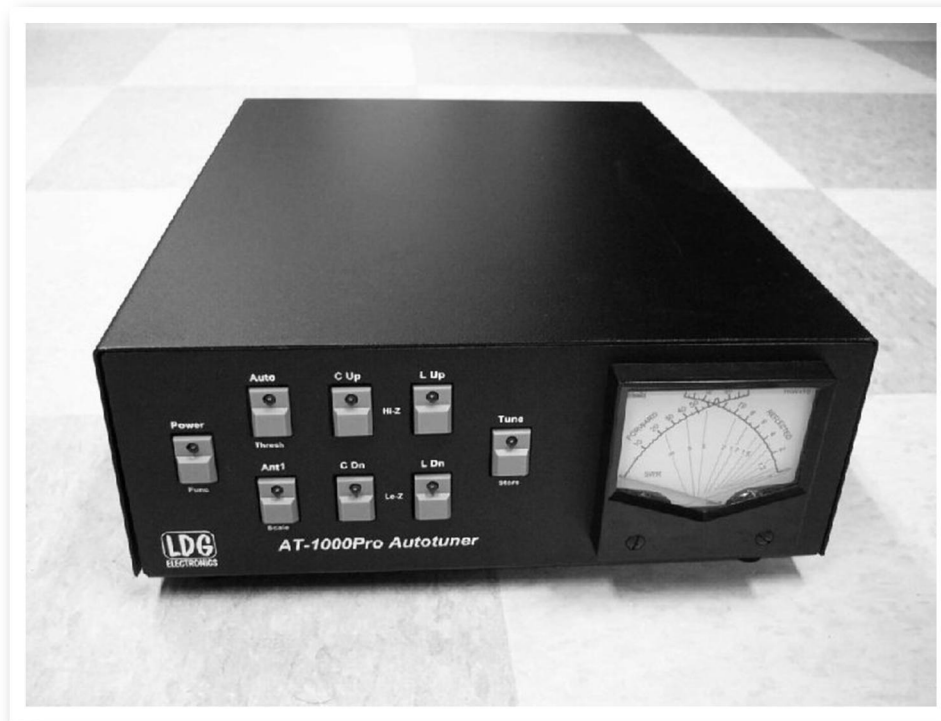
Weight: 5.2 pounds

GETTING TO KNOW YOUR AT-1000 PRO

Your AT-1000 Pro is a quality, precision instrument that will give you many years of outstanding service; take a few minutes to get to know it.

Front Panel

The front panel of the AT-1000 Pro sports eight pushbutton switches and a 3" illuminated cross-needle meter.



The front panel pushbuttons are as follows:

Power: Turns the unit on/off. Also serves as the **Function** button.

ANT1: Toggle antenna selection.

Auto: Turn fully automatic tuning on/off.

C Up: Increase capacitance.

C Dn: Decrease capacitance.

L Up: Increase inductance.

L Dn: Decrease inductance.

Tune: Initiates memory or full tuning cycle. Momentary push toggles bypass.

The **Power** switch on the AT-1000 Pro toggles between the “Off” and “On” modes. Note that even in “Off” mode, the AT-1000 is not completely “off”, but rather in a very low power sleep mode. In “Off” mode, the AT-1000 relays are completely de-energized, placing the tuner in bypass, selecting the **ANT 2** antenna, and no LEDs are illuminated. When the **Power** button is pressed, to turn the AT-1000 Pro “On”, the previous relay settings are restored, including antenna selection. The **Power** button must be pressed and held for 3 seconds to turn the AT-1000 Pro “off.”

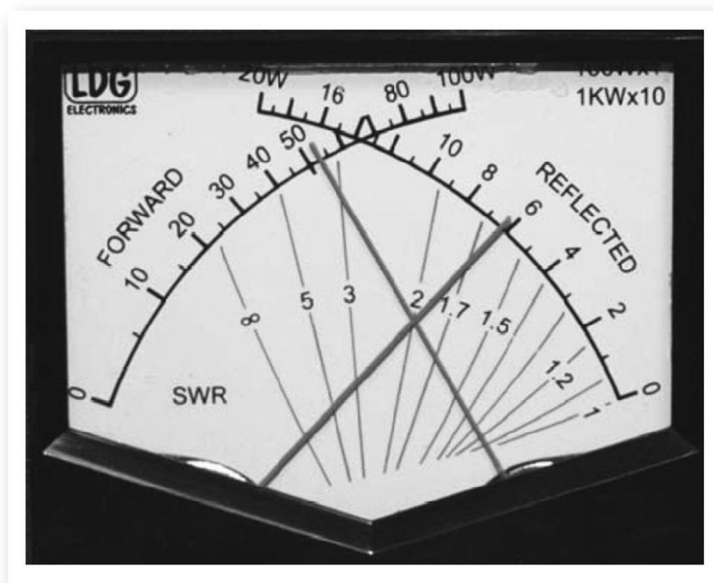
Each pushbutton contains an integrated LED that indicates the status of that button’s function. Other tuner status may also be indicated on the LEDs; see the section “Operation - LED Blink Codes” for more detail.

Most pushbuttons on the AT-1000 Pro also have a secondary function, which is activated when the button is pushed while in Function (**FUNC**) mode. The button’s secondary function is listed under the button. Function mode is entered by pushing and holding the **Power** button for 1 second, until all the panel LEDs light up, and then releasing.

The illuminated cross-needle meter indicates forward and reflected power, as well as SWR, all at once. Forward power is indicated in two ranges; 0-100W and 0-1000W. If the 1000W range is selected, multiply the indicated power by 10 to give the actual power.

Readings are accurate to $\pm 10\%$ across the full scale. Forward power is indicated in “Peak Hold” mode or average power mode. In Peak Hold mode, the peak power is indicated, then held for a moment before dropping to a lower indicated level. Power indicated is the true peak reading. Average power mode displays instantaneous average power.

The cross-needle meter displays SWR as the intersection of the Forward and Reflected power indications. For example, in the photograph at the right, the indicated SWR is 2.0:1. The forward power is 52 watts, the reflected power is 6 watts, and the two needles intersect on the red line which indicates 2.0:1 SWR.



Rear Panel

The rear panel of the AT-1000 Pro features six connectors.



ANT 1 connector: Connect a 50-ohm coax antenna feedline to this standard SO-239 connector.

ANT 2 connector: Connect a second 50-ohm coax antenna feedline to this SO-239 connector, if you have a second antenna system.

GND connector (wing nut): Connect to antenna system ground.

Transmitter connector: Connect a 50-ohm coax jumper cable from this standard SO-239 connector to the ANT jack on the back of the amplifier.

Radio Interface connector: This 1/8" stereo jack connects to the optional radio interface cable, which connects to the tuner port on the transceiver.

DC Power jack: Connect the 12V DC power cable to the 2.5mm x 5.5mm coaxial power jack. Center pin is positive, 12V 1A.

INSTALLATION

The AT-1000 Pro tuner is designed for indoor operation only; it is not water resistant. If you use it outdoors (Field Day, for example), you must protect it from the rain. The AT-1000 Pro is designed for use with coax-fed antennas. If use with longwires or ladder-line-fed antennas is desired, an external balun is required. Be sure the balun is rated for 1000 watts or greater.

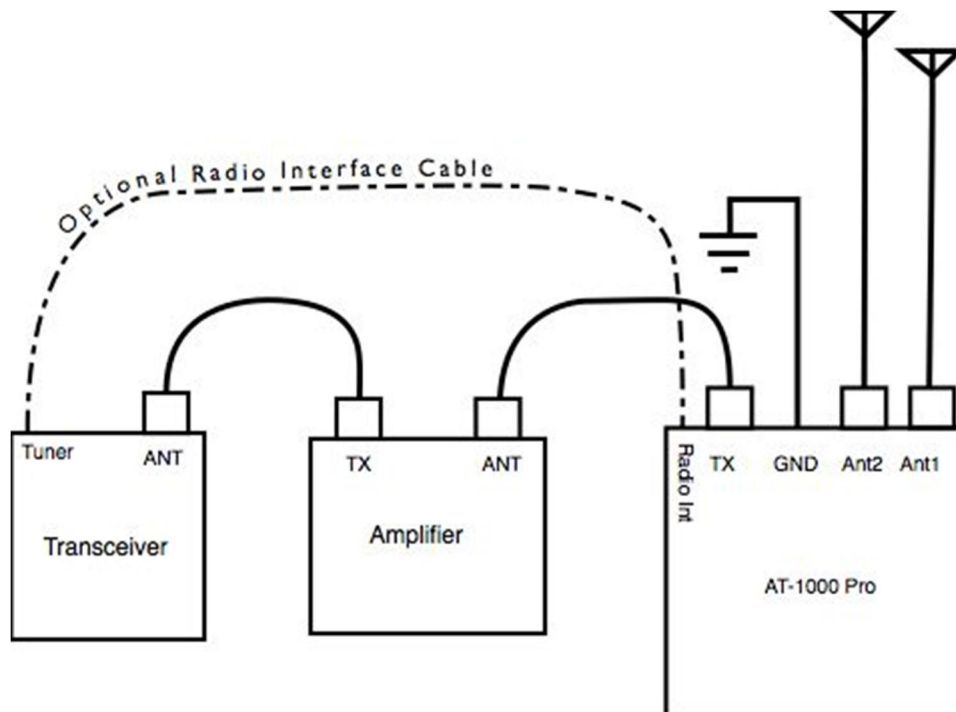
Always turn your radio off before plugging or unplugging anything. The radio may be damaged if cables are connected or disconnected while the power is on.

Connect the **Transmitter** jack on the rear of the AT-1000 Pro to the amplifier output, using high-quality 50 ohm coaxial cable terminated in a PL-259 plug. Crimp-on PL-259's should not be used in this application; only properly soldered plugs will provide safe and reliable performance. The coaxial cable should be rated for the maximum power output capacity of the amplifier, and kept as short as is practical.

Connect the antenna system to the **ANT 1** jack on the rear of the AT-1000 Pro, also using 50-ohm coaxial cable rated at the maximum power output capacity of the amplifier. If a second antenna system is used, connect that antenna system to the **ANT 2** jack.

Attach the supplied DC power cable to the **DC Power 12V 1A** jack on the rear of the AT-1000 Pro. Connect the other end of this cable to an 11-15V DC power source capable of supplying 1A of current. The center pin and the red lead are positive.

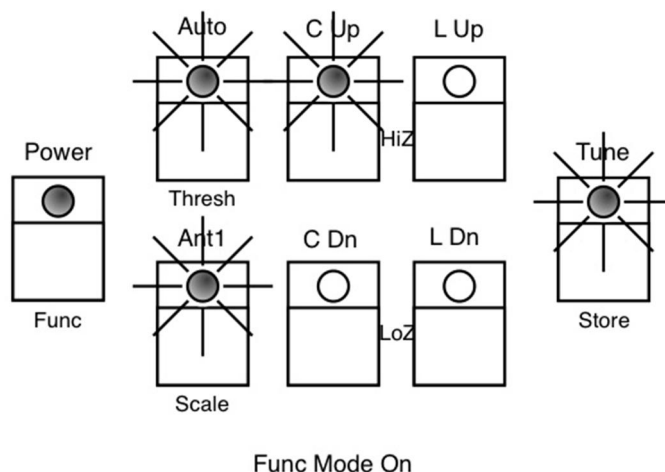
Grounding the AT-1000 Pro tuner will enhance its performance and safety. LDG recommends that you connect your tuner to a suitable ground using heavy gauge wire or metal braid. A dedicated outdoor ground rod is best, but a nearby cold water pipe is sometimes satisfactory. LDG strongly recommends the use of a properly installed, high quality lightning arrestor on all antenna cable



FRONT PANEL BUTTON DESCRIPTION

The AT-1000 Pro is controlled mainly from the front panel buttons. Tuning requests may also be made via the front panel TUNE/CALL button of a connected Icom transceiver, if the optional transceiver interface cable is installed.

Each AT-1000 Pro button has a dedicated primary function, which is activated whenever the button is pushed. In addition, some buttons have additional secondary functions that are activated after first putting the AT-1000 Pro into **FUNC** mode. **FUNC** mode is activated by pressing and holding the **Power/Func** button until all the front panel LEDs light up, then releasing it. The **Auto**, **Ant1**, **C Up**, and **Tune** LEDs will begin flashing to indicate they are ready to accept a command in **FUNC** mode.



Pressing **Auto**, **Ant1**, **C Up**, or **Tune**, while in **FUNC** mode, will actuate that button's secondary function. If no buttons are pressed within a few seconds, **FUNC** mode is automatically cancelled.

Power / Func Button

The **Power/Func** button's primary use is to turn the AT-1000 Pro "on" or "off". "Off" is really just an ultra-low-power standby mode. To turn the AT-1000 Pro on, simply press the **Power/Func** button momentarily. To turn the AT-1000 Pro off, press and hold the **Power/Func** button three seconds until the AT-1000 Pro turns off. All front panel LEDs and the meter backlight will turn off. Press the Power button momentarily to turn the AT-1000 Pro on.

The **Power/Func** button also is used to enter **FUNC** mode, as described above. Press and hold the **Power/Func** button until all the front panel LEDs light up, and then release.

Auto / Thresh Button

The **Auto/Thresh** button is used to switch between fully automatic tuning and semi-automatic tuning modes. If the **Auto** LED is lit, the tuner is in fully automatic tuning mode. This means that any time the SWR exceeds the pre-set SWR threshold, a memory tuning cycle will begin. If the **Auto** LED is extinguished, then the AT-1000 Pro is in semiautomatic tuning mode, which means that the **Tune** button must be pressed in order to request a tuning cycle.

The AT-1000 Pro uses its SWR Threshold to determine when to begin an automatic tuning cycle. If fully automatic tuning mode is on, then any time that the SWR exceeds this level during transmit, the AT-1000 Pro will begin an automatic tuning cycle.

The SWR Threshold can be set by putting the AT-1000 Pro into **FUNC** mode and then pressing the **Auto/Thresh** button. The cross-needle meter will display the current SWR threshold above which an automatic tuning cycle will begin, and the **Auto/Thresh** LED will begin blinking to indicate that the AT-1000 Pro is now in SWR Threshold Set mode.

If the currently displayed SWR Threshold level is acceptable, simply press the **Power/Func** button again to exit SWR Threshold Set mode. Otherwise, press the **Auto/Thresh** button repeatedly to cycle through the available choices of SWR Threshold level. The available levels are 1.5:1, 1.7:1, 2.0:1, 2.5:1, and 3.0:1. Repeatedly pressing the button will cycle through all the choices, and then back to the beginning again. Once the desired level is displayed on the cross-needle meter, press the **Power/Func** button to select the displayed level and exit SWR Threshold Set mode.

Ant1 / Scale Button

The **Ant1/Scale** button is used to choose which connected antenna is active. If the **ANT1** LED is lit, then Antenna 1 is selected. Otherwise, Antenna 2 is selected. Pressing the **Ant1/Scale** button repeatedly will toggle the selected antenna.

The AT-1000 Pro's cross-needle meter can display forward power up to 1000 watts, but sometimes it is handy to be able to see lower-powered transmission levels with greater detail. Pressing the **Ant1/Scale** button, while the AT-1000 Pro is in **FUNC** mode, will enter into the Meter Scale Selection mode. Put the AT-1000 Pro into **FUNC** mode as described above, and then press the **Ant1/Scale** button. The **Ant1** LED will begin blinking, and the forward power meter will display the current meter scale setting.

A display of **10** indicates the meter is in the 0-100W scale. A display of **100** indicates that the meter is in 0-1000W scale. Pressing the **Ant1/Scale** button repeatedly will toggle between these two scales. Once the desired meter scale is displayed, press the **Power/Func** button again, to exit Meter Scale Selection mode.

C Up / Peak Button¹

Pressing the **C Up** button will increase the capacitance in parallel with the load by one unit. Pressing and holding the **C Up** button will rapidly increase the capacitance. If the maximum capacitance value is met, the **C Up** button will blink.

The secondary function of the **C Up / Peak** button is to toggle between average power reading and peak power reading on the cross-needle meter. To select the metering mode, first press and hold the **Power/Func** button until the front panel LEDs light up, then release, to enter into **FUNC** mode. Then press the **C Up / Peak** button to select whether average or peak power is displayed. When average mode is selected, the Forward power needle will bounce quickly. When Peak mode is selected, the Forward power needle will go to full scale and stay there for a moment, fall back to zero and repeat. Pressing **C Up / Peak** repeatedly will toggle between these two modes. Press **Power / Func** again to set and exit.

¹ *The front panel of the AT-1000 Pro does not have a "Peak" label on the C Up button, as the peak reading feature was introduced after the initial release of the AT-1000 Pro hardware.*

C Dn Button

Pressing the **C Dn** button will decrease the capacitance in parallel with the load by one unit. Pressing and holding the **C Dn** button will rapidly decrease the capacitance. If the minimum capacitance value is met, the **C Dn** button will blink.

L Up

Pressing the **L Up** button will increase the inductance in series with the load by one unit. Pressing and holding the **L Up** button will rapidly increase the inductance. If the maximum inductance value is met, the **L Up** button will blink.

L Dn Button

Pressing the **L Dn** button will decrease the inductance in series with the load by one unit. Pressing and holding the **L Dn** button will rapidly decrease the inductance. If the minimum inductance value is met, the **L Dn** button will blink.

The **L Dn** button has no secondary function.

Tune/Store Button

The **Tune/Store** button is used for three functions: selecting bypass/active mode, requesting a tuning cycle, and manually storing tuning settings in the tuner memory.

Bypass/Active Mode: Press the **Tune/Store** button momentarily to toggle between bypass and active mode. In bypass mode, all inductance and capacitance is removed from the circuit. Active mode restores the previous inductor and capacitor settings. The **Tune/Store** LED blinks once to indicate active mode, and blinks three times to indicate bypass mode.

Request a Tuning Cycle: Press and hold the **Tune/Store** button to initiate a tuning cycle. There are two types of tuning cycles available, a memory tune and a full tune. Hold the **Tune/Store** button until the **Tune** LED comes on in order to select a memory tune cycle. Hold the **Tune/Store** button until the **Tune** LED comes on, and continue holding until the **Tune** LED goes out again in order to select a full tuning cycle. See the section on “Operation” for more details.

Manually Store Tuning Settings: Press and hold the **Power/Func** button until the front panel LEDs light up to put the tuner in **FUNC** mode, then press the **Tune/Status** button to manually store the current inductor and capacitor settings in the memory associated with the last transmitted frequency.

OPERATION - BASIC

Tuning

The AT-1000 Pro uses two different tuning cycles. The **memory tuning cycle** attempts to tune quickly based on having previously tuned on the present frequency selection. If the tuner previously was successful in tuning on the currently selected frequency, the settings for that match will be loaded into the tuner relays, and checked to see that an acceptable SWR match is found. This makes memory tuning almost instantaneous.

A **full tuning cycle** “starts from scratch” and begins a fixed tuning sequence where the AT-1000 Pro rapidly tries varying combinations of inductance and capacitance values, and then zeroes-in on the best match possible. When the tuning cycle is complete, if an acceptable match was found, the inductance and capacitance settings are saved in a memory associated with the selected frequency, so that they may be recalled quickly in the future via a memory tuning cycle.

In this manner, the AT-1000 Pro “learns”; the longer you use it, the more closely it adapts itself to the bands and frequencies you use. Most users will probably use memory tuning most of the time; it takes advantage of any saved tuning settings, but automatically defaults to a full tuning cycle if no stored data is available.

In both cases, at the end of the tuning cycle, the carrier is held for 1.5 seconds after tuning is complete, so that the final SWR may be read on the transceiver’s internal SWR meter and the built-in cross-needle SWR meter, and the front panel LEDs will indicate the status of the tuning cycle.

A Word About Roll-Back Circuits

Most modern amateur radio exciters with solid-state finals normally employ an automatic “roll-back” circuit, which protects the final amplifier transistors from high SWR. This circuit automatically reduces the output power as the SWR level rises above a preset level; often 2:1. The higher the SWR, the more the roll-back circuit reduces output power in order to prevent damage to the final transistors in the exciter.

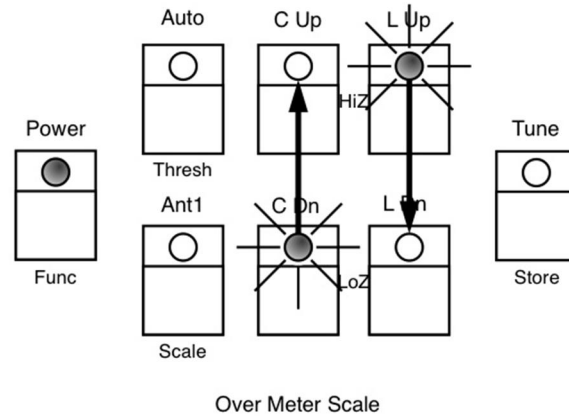
If your exciter employs a roll-back circuit, you need not worry about damaging your exciter while tuning, at any power level between 5 and 125 watts. However, if your exciter lacks a roll-back circuit, the power level **must** be set manually to 30 watts or less before tuning, in order to avoid damage to the exciter or the tuner. The exciter’s owner’s manual is a great place to check to see if the exciter employs a roll-back circuit.

Fully Automatic Mode

If the tuner is in Fully Automatic tuning mode, ensuring that the minimum SWR condition is met is simple. When changing operating frequency, simply bypass your amplifier, and transmit a carrier. If the SWR exceeds the SWR Threshold, an automatic tuning cycle will begin. Once the tuning cycle is complete, it is then okay to switch your amplifier back on and transmit at full power.

The AT-1000 Pro has built-in relay protection, so that tuning will not be permitted if conditions exceed those allowed for tuning. If tuning is attempted while transmitting more than 150 watts when the SWR is over 3:1, or if transmitting over 200 watts at any SWR, the AT-1000 Pro will abort the current tuning cycle, so as to avoid relay arcing.

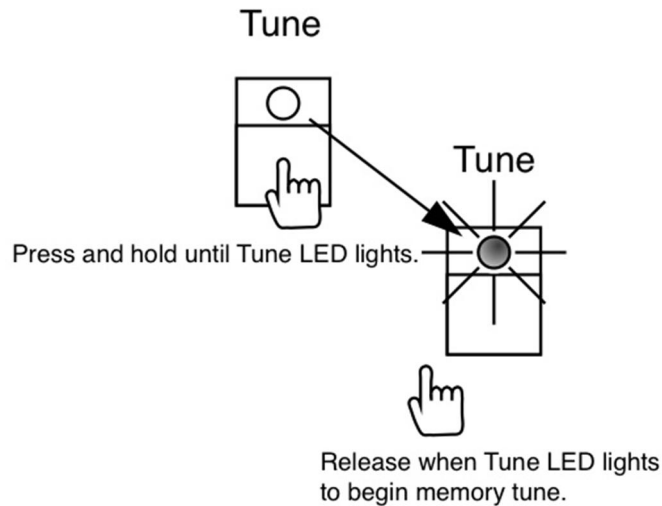
When not tuning, the cross-needle meter on the AT-1000 Pro will display peak forward power and instantaneous reflected power. If the 100W meter scale is selected, and more than 125 watts of forward power are present, the front panel LEDs will blink to indicate the over-range condition.



Semi-Automatic Tuning: Request Memory Tune Cycle

To request a memory tuning cycle, press and hold the **Tune/Store** button until the **Tune** LED lights, then release. Begin transmitting a carrier of less than 75 watts (bypass the amplifier).

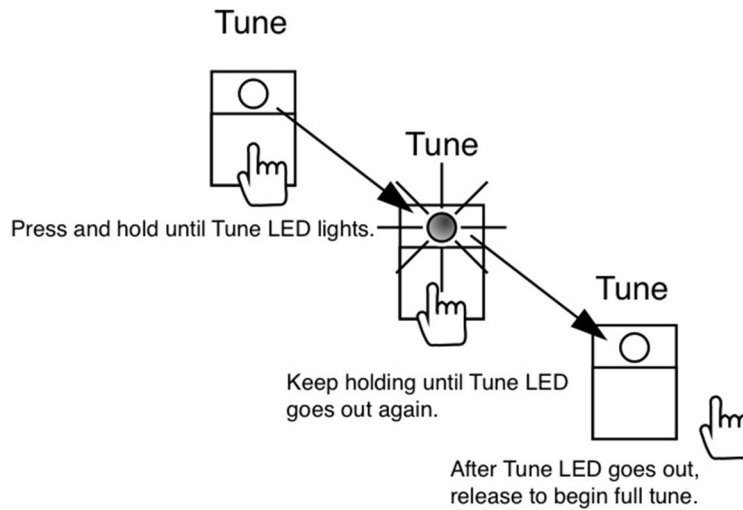
When the tuning cycle is complete, the front panel LEDs will blink to show the status of the tune, and the cross-needle display will show the final SWR. If a satisfactory match is not found in memory, a full tuning cycle will begin.



Semi-Automatic Tuning: Request Full Tune Cycle

To request a full tuning cycle, press and hold the **Tune/Store** button until the **Tune** LED lights, then keep holding until the **Tune** LED extinguishes again, then release. Begin transmitting a carrier of less than 75 watts.

When the tuning cycle is complete, the front panel LEDs will blink to show the status of the tune, and the cross-needle display will show the final SWR. If a satisfactory match is not found, a full tuning cycle will begin.



OPERATION - FINE TUNING

Although the AT-1000 Pro attempts to achieve the lowest possible SWR, there are times when it might be desirable to manually tweak the tuning parameters to arrive at a better match. Fortunately, the AT-1000 Pro provides complete manual control over all the tuning parameters, and allows the user to store a manually tweaked tuning to memory for later recall.

Manually Adjusting Tuning Parameters

Use the **L Up**, **L Dn**, **C Up**, and **C Dn** buttons to increment or decrement the amount of inductance or capacitance used to match the antenna. Press each button momentarily to increase or decrease by one step, or hold the button to continuously increase or decrease inductance or capacitance rapidly. The setting will change slowly at first, then rapidly as the button is held longer. The button's LED will blink when the limit of inductance or capacitance is reached.

The AT-1000 Pro uses an L-network for tuning. In order that a broader range of antenna loads may be matched, a relay allows switching the capacitance arm of the L from the transmitter side of the inductor bank to the antenna side of the inductor bank. This selection, too, may be manually controlled.

To select the setting which corresponds to higher impedance antennas, press the **C Up** and **L Up** buttons simultaneously, then release. The **C Up** and **L Up** LEDs will blink to confirm.

To select the setting which corresponds to lower impedance antennas, press the **C Dn** and **L Dn** buttons simultaneously, then release. The **C Dn** and **L Dn** LEDs will blink to confirm.

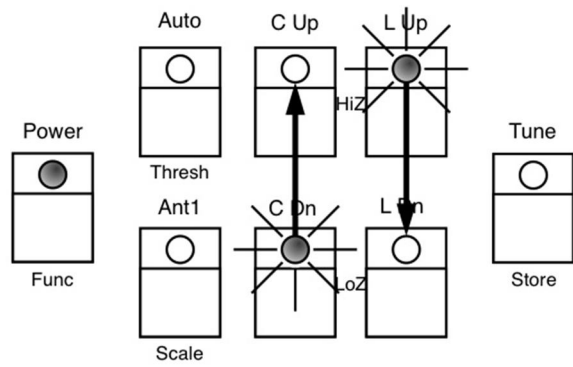
SWR can be checked while making fine adjustments. Be sure to bypass the amplifier first, then begin transmitting a carrier. Watch the cross-needle meter while making adjustments, and observe the SWR.

Storing Manually Adjusted Tuning Parameters

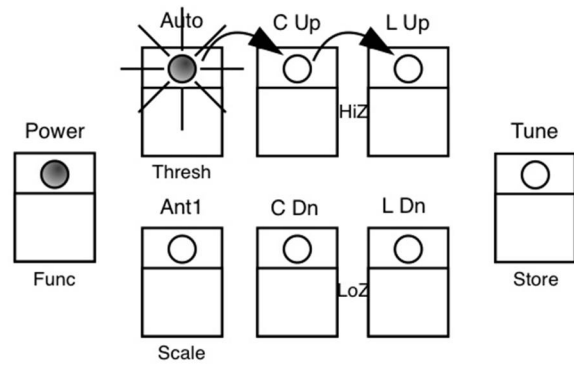
Once the tuning parameters are adjusted as desired, these settings can be stored in a memory location associated with the last transmitted frequency. To store the tuning parameters, put the AT-1000 Pro into **FUNC** mode by pressing and holding the **Power/Func** button until front panel LEDs light up, then release. While in **FUNC** mode, press the **Tune/Store** button. The **Tune** LED will blink to confirm the storage of the parameters.

OPERATION - LED BLINK CODES

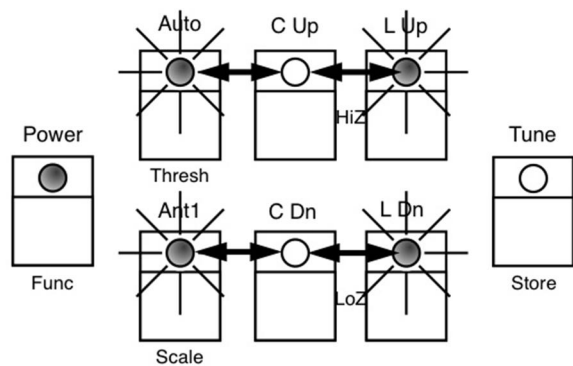
Various error or warning conditions are indicated by the front panel LEDs.



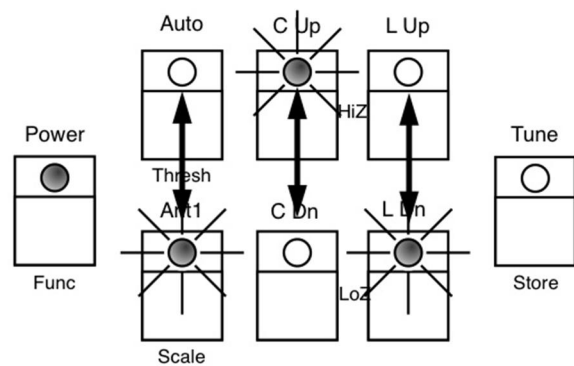
Over Meter Scale



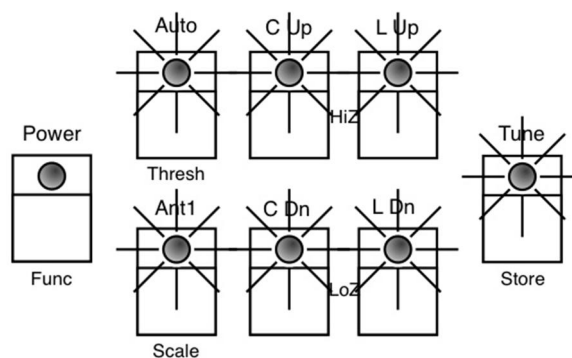
Unable to determine frequency: Top LEDs cycle left to right and back.



Relay Protect: Over
3:1 SWR and over
150W



Relay Protect: Over
200W



No RF Present: All LEDs flash once.
RF Lost during tune: All LEDs flash twice.
Unable to find good match: All LEDs flash 10
times quickly.

APPLICATION HINTS

MARS/CAP Coverage

The AT-1000 Pro provides continuous tuning coverage over its specified range; not just in the ham bands. This makes it useful for MARS or CAP operation, or any other legal HF operation.

Icom Radio Interface

The AT-1000 Pro offers integration with many Icom transceivers, including the IC-7000 and IC-706. Simply plug the 1/8" plug of the optional Icom interface cable into the **Radio Interface** jack on the back of the AT-1000 Pro, and plug the 4-pin Molex plug into the matching jack on the back of the radio.

Tuning can then be performed by first bypassing the amplifier, and then pressing and holding the **TUNE/CALL** button on the Icom radio for 1 second. When tuning is complete, the amplifier may be placed in active mode again. Momentarily pressing the **TUNE/CALL** button on the radio after the AT-1000 Pro has tuned will place the AT-1000 Pro in bypass mode.

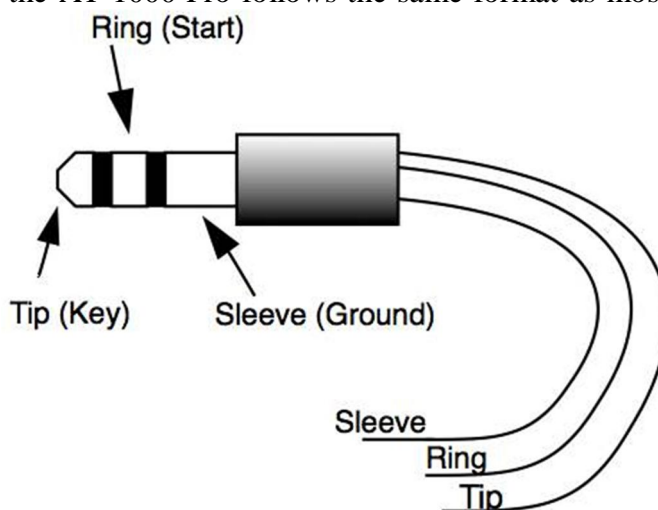
Optional Yaesu Radio Interface

The AT-1000 Pro also offers integration with Yaesu FT-857, and FT-897 transceivers. Plug the black end (marked "Tuner") of the optional Yaesu interface cable into the **Radio Interface** jack on the back of the AT-1000 Pro, and plug the red end (marked "Radio") into the **ACC** jack on the back of the FT-857 or FT-897.

Tuning operation is the same as described in the section on Basic Tuning, except that when a manual memory tune or full tune is requested, the AT-1000 Pro will send a signal to the FT-857 or FT-897 requesting that the radio begin transmitting a low level carrier. Once again, be sure to bypass the amplifier before requesting a tuning cycle in this case, and then re-activate the amplifier once the tuning cycle is complete.

Build-Your-Own Interface

The **Radio Interface** jack on the rear of the AT-1000 Pro follows the same format as most Icom transceivers' Tuner interface. The 1/8" stereo jack features a **Start** input, which requests that the AT-1000 Pro begin a tuning cycle when this input is grounded momentarily (450-600 ms). It also features an open-collector **Key** output, which the AT-1000 Pro shorts to ground when it is requesting that the radio should key up and transmit a carrier.



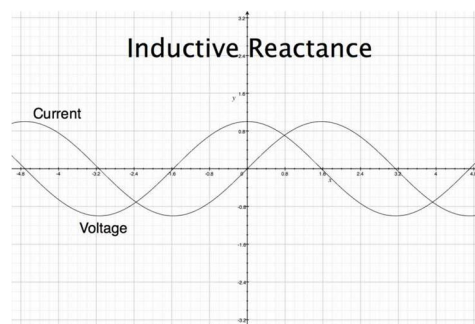
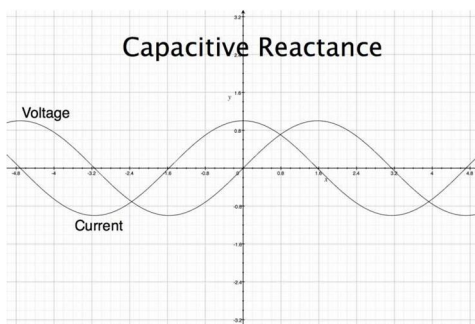
THEORY OF OPERATION

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. It is beyond the scope of this manual to present a tutorial on this subject², but a little background will help in understanding what the AT-1000 Pro is doing, and how it does it.

In simple DC circuits, the wire resists 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 Georg Simon Ohm of Germany, who first discovered the principle in 1826. In RF circuits, an analogous but more complicated relationship exists.

RF circuits also resist the flow of electricity. However, the presence of capacitive and inductive elements causes the voltage 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.



The output circuit of a transmitter 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 a transmitter, the transmission line, and the antenna, all have a characteristic impedance. For reasons beyond the scope of this document, the standard impedance is nominally 50 ohms resistive, with zero capacitive and zero 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 transmitter to the antenna occurs. While the transmitter output circuit and transmission line are of fixed, carefully designed impedance, the antenna presents 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 other than 50 ohms.

² For a very complete treatment of this subject, see any edition of the ARRL Handbook for Radio Communications (previously the Handbook For Radio Amateurs).

When the impedance of the antenna is different from that of the transmitter and transmission line, a “mismatch” is said to exist. In this case, some of the RF energy from the transmitter is reflected from the antenna back down the transmission line and into the transmitter. If this reflected energy is strong enough, it can damage the transmitter’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 increases to 2, 3, or higher. As a general rule, modern solid state transmitters must operate with an SWR of 2 or less. Tube excitors are somewhat more tolerant of high SWR. If a 50 ohm antenna is resonant at the operating frequency, it will show an SWR close to 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.

$$SWR = \frac{1 + \sqrt{\frac{R}{F}}}{1 - \sqrt{\frac{R}{F}}}$$

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 transmitter and the antenna. This circuit measures forward and reflected power from which SWR may be calculated (some meters calculate SWR for you). More advanced units can measure forward and reflected 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 them by hand while observing reflected power on the SWR meter until a minimum SWR is reached. The LDG Electronics AT-1000 Pro automates this process.

REV	FWD 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

No tuner will fix a bad antenna. If the antenna is far from resonance, the inefficiencies inherent in such operation are inescapable; it’s simple physics. Much of the transmitted power may be dissipated in the tuner as heat, never reaching the antenna at all. A tuner simply “fools” the transmitter into behaving as though the antenna were resonant, avoiding any damage that

might otherwise be caused by high reflected power. For best performance, the antenna used should always be as close to resonance as is practical.

THE LDG AT-1000 PRO

In 1995, LDG Electronics 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. An additional relay switches between high and low impedance ranges. 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, and, in fact, virtually any coax-fed antenna.

The series inductors are switched in and out of the circuit, and the parallel capacitors are switched to ground under microprocessor control. The high/low impedance relay switches the capacitor bank either to the transmitter side of the inductor bank, or to the antenna side. This allows the AT-1000 Pro to handle loads that are either greater than or less than 50 ohms. All relays are sized to carry 125 watts continuously.

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 that provide signals proportional to the forward and reflected 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. These two voltages are read by the ADCs in the microprocessor, and are used to compute SWR in real time.

The relays are powered by the 12VDC input provided by the optional radio interface cable. This power is supplied by the transceiver itself. The relays are a latching type, and so they consume no current when not actively switching.

Although the microprocessor’s oscillator runs at 32 MHz, which allows the main tuning routine to execute in only a few milliseconds, the relays require several milliseconds of settling time for every combination of inductors and capacitors. Thus, it may take several seconds before all relay combinations are exhausted, in the case of a difficult tune.

The tuning routine 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 inductors and capacitors. The program checks LC combinations to see if a 1.5:1 or lower SWR can be obtained, and stops when it finds a good match.

The microprocessor runs a fine tune routine just after the tuner finds a match of 1.5:1 or less. This fine tune routine now tries to the the SWR as low as possible (not just to 1.5); it takes about half a second to run.

A WORD ABOUT TUNING ETIQUETTE

Be sure to use a vacant frequency when tuning. With today's crowded ham bands, this is often difficult. However, causing interference to other hams should be avoided as much as possible. The AT-1000 Pro's very short tuning cycle, as little as a fraction of a second, minimizes the impact of tuning transmissions.

CARE AND MAINTENANCE

The AT-1000 Pro tuner is essentially maintenance-free. Power limits in this manual should be strictly adhered to. The outer case may be cleaned as needed with a soft cloth slightly dampened with household cleaning solution. As with any modern electronic device, the AT-1000 Pro can be damaged by temperature extremes, water, impact, or static discharge. LDG strongly recommends the use of a good quality, properly installed lightning arrestor in the antenna lead.

TECHNICAL SUPPORT

The LDG customer support staff is ready to answer your product question by telephone and by e-mail. We know that you will enjoy your product even more knowing LDG is ready to answer your questions as the need arises.

LDG regularly updates on-line information so the best on-line support information is available all day and every day.

The LDG website provides links to product manuals, just in case you lose this one! When you are thinking about the purchase of other LDG products our website also has complete product specifications and photographs you can use to help make your purchase decision. Don't forget the links to all of the quality LDG Dealers also ready to help you make that purchase decision.

TWO-YEAR TRANSFERRABLE WARRANTY

Your product is warranted against manufacturer defects in parts and labor for two full years from the date of purchase. This two-year warranty is also transferable. When you sell or give away your LDG product, give the new owner a copy of the original sales receipt and the two-year warranty goes with the new owner.

There is no need to complete a warranty card or to register an LDG product. Your product receipt establishes eligibility for warranty service, so save that receipt. Send your receipt with the product whenever you send your product to LDG for repair. Products sent to LDG without a receipt are considered requests for out-of-warranty repair.

LDG does not warranty against product damage or abuse. This means that a product failure, as determined by LDG, to be caused by the customer or by other natural calamity (e.g. lightning) is not covered under the two-year warranty. Damage can be caused by failure to heed the product's published limitations and specifications or by not following good Amateur practice.

OUT OF WARRANTY SERVICE

If a product fails after the warranty period, LDG wants to help you get it fixed. Send the product to us for repair any time you like. We will determine what needs to be done and based on your instructions, either contact you with an estimate or fix it and contact you with a request to pay any repair charges.

RETURNING YOUR PRODUCT FOR SERVICE

Returning a product to LDG is easy. We do not require a return merchandise authorization, and there is no need to contact LDG to return your product. Visit the LDG web site and download the LDG Product Repair Form. On the Repair Form tell the LDG technicians exactly what happened or didn't happen and why you believe the product needs servicing. The technician attempts to duplicate the problem(s) you had based on how well you describe it so take the time to be accurate and complete.

Ask your shipper for a tracking number or a delivery verification receipt. This way you know the product arrived safely at LDG. Be sure to give us your email address so our shipper can alert you online when your product is en-route back to you. Please be assured that our staff makes every effort to complete repairs ahead of our published wait time. Your patience is appreciated.

Repairs can take six to eight weeks, but are usually faster. The most recent information on returning products for service is found on the LDG website under Support, then Tech Support. Send your carefully packaged unit with the Repair Form to:

LDG Electronics, Inc.
Attn: Repair Department
1445 Parran Rd
St. Leonard, MD 20685

PRODUCT FEEDBACK

We encourage product feedback! Tell us what you really think of your LDG product. In a card, letter, or email (preferred) tell us how you used the product and how well it worked in your application. Send along a photo or even a schematic or drawing to illustrate your narrative. We like to share your comments with our staff, our dealers, and even other customers at the LDG website.

<http://www.ldgelectronics.com/>

