AT-200PC
Automatic PC-Controlled
Antenna Tuner

Manual Version 1.1

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LDG AT-200PC
Automatic Antenna Tuner

Introduction

Congratulations on selecting the LDG AT-200PC tuner. The PC-controlled AT-200PC provides fully automatic, any mode antenna tuning across the entire HF range plus 6 meters at power levels to 250 watts. 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. There are no controls or indicators on the tuner itself -- all functions are controlled by software via a serial or USB connection from a PC.

The AT-200PC represents a quantum leap in features and performance. Enhanced tuning algorithms provide much faster, precise and consistent tuning. Automatic tuning is now available *during* transmission, even SSB, and many user-settable options are accessible from the front panel. LDG's 3-D memory design provides instant memory tuning for up to four different antennas on each of the two antenna ports.

LDG pioneered the automatic, wide-range switched-L tuner in 1995. From its laboratories near the nation's capitol, LDG continues to define the state of the art in this field with innovative automatic tuners and related products for every amateur need.

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

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

1. **Connect the antenna jack on your transceiver to the "Tx" jack on your AT-200PC tuner using a 50 Ohm coaxial cable jumper of appropriate power handling capability.**

2. **Connect your 50 Ohm antenna coax lead to the "Ant 1" jack on the back of your AT-200PC.**

3. **Connect your AT-200PC to a source of 11 - 16 volts DC @ 750mA via the 2.5 by 5.5 mm power jack on the back (center positive).**

4. **Connect the AT-200PC to your PC via an available serial data port.**

5. **Power up your transceiver and select the desired operating frequency.**

6. **Run your PC tuner control software and select the appropriate COM port.**

7. **Begin transmitting, any mode[1].**

8. **Click the Tune button on the PC tuner control software.**

9. **Wait for the tuning cycle to end; stop transmitting.**

10. **You're now ready to operate.**

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[1] If using SSB mode, simply speak into the microphone. You can tune while transmitting up to 125 watts if your transceiver has a "roll-back circuit" to protect it from high SWR. If it does not have a roll-back circuit, limit power when tuning to 25 watts to avoid damage to your transmitter or transceiver.

Specifications

- 5 to 250 watts SSB and CW. (100 watts on 6M)
- Two position antenna switch with memories for four antennas on each position
- Tuning time: 0.5 to 6 seconds full tune, < 0.1 second memory tune
- Built in frequency counter for memory operation
- Frequency coverage: 1.8 to 54.0 MHz.
- Tunes 6 to 1000 ohm loads (16 to 150 ohms on 6M), 6 to 4000 ohms with optional 4:1 Balun (LDG RBA 4-1)
- For Dipoles, Verticals, Vs, Beams or and Coax Fed Antenna
- Optional external Balun allows tuning of random length, long wire or ladder line fed antennas
- Flash upgradeable via software download
- Power requirements: 11 to 16 volts DC at 750 mA max during tuning
- Enclosure: 8.5 x 6.0 x 2.0 inches
- Weight: 2 pounds

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IMPORTANT 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.

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Getting To Know Your AT-200PC

Your AT-200PC is a quality, precision instrument that will give you many years of outstanding service; take a few minutes to get to know it.

Your AT-200PC can be used with any transceiver or transmitter with coax output operating in the HF and six meter range at no more than 250 watts output (100 watts on six meters). You can set the unit to tune automatically whenever the SWR exceeds a set value, or to tune semi-automatically when you start a tuning cycle by pressing the **Tune** button on the PC user interface.

The front panel has no controls or readouts. All functions are controlled from a personal computer interface. You can use any PC and operating system that supports a standard serial or USB port, including Windows, Linux, Mac OS and others.

The tuner is controlled by third party rig control software not provided by LDG. Several companies have already added support for the AT-200PC and many more are planned to be added. Check the LDG web site often to see what third party rig control software companies have added AT-200PC support.

Current AT-200PC software providers:
N4PY: www.n4py.com
SuperControl: www.supercontrol.de
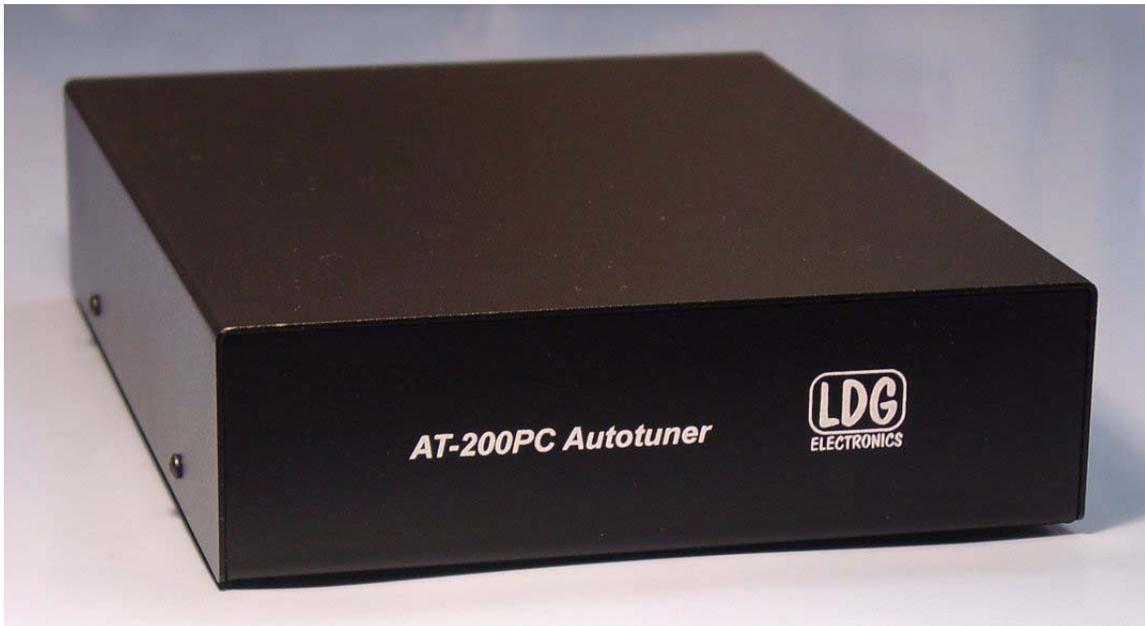
The AT-200PC has a total of 16,000 frequency memories. There are 8,000 memories for each of the two antenna ports, 2,000 tuning settings for each of four separate antennas on each port. When you transmit near a previously tuned frequency, you can use "Memory Tune" to reset the tuner in only a fraction of a second. The process of storing tuning data in memory is completely automatic; your AT-200PC "learns" as you use it, adapting itself to all of the bands and frequencies you use.

On the back panel, there are six connectors:

RF input (marked "Tx", standard SO-239 socket)
Antenna connector 1 (marked "Ant 1", standard SO-239 socket)
Antenna connector 2 (marked "Ant 2", standard SO-239 socket)
DC power in (2.5 by 5.5 mm power jack marked "Power", center positive)
DB-9 serial data port marked "Serial" for connecting a control cable to a PC
Ground connector (wing nut)

Installation

Your AT-200PC tuner 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. The AT-200PC is designed for use with coax-fed antennas. If you wish to use it with longwires or antennas fed with a balanced transmission line (e.g., ladder line) that are outside the tuning range of the tuner, an external balun is required; either the LDG RBA-4:1 or RBA-1:1 is ideal, depending on the antenna and transmission line used.

Hardware Installation

Connect the power supply to the tuner using the provided 2.5 by 5.5 mm coaxial connector. The power supply must supply 11 - 16 vdc at 750 ma minimum. Best practice is a regulated power supply, but an unregulated supply can be used if it remains with the specified voltage range under load.

Connect the HF antenna jack on your transmitter or transceiver to the Tx jack on the back of your AT-200PC tuner using a coax jumper with standard PL-259 plugs (not provided). Properly soldered connectors will be far more satisfactory and reliable than crimp-on or "solderless" connectors. Attach your antenna lead-in coax to either the Ant 1 or Ant 2 jack on the back of your AT-200PC tuner. You will select the appropriate antenna from the PC control software (see Operating Instructions).

Grounding your tuner will enhance its performance and safety. LDG recommends that you connect your tuner to a suitable ground; a common ground rod connected to buried radials is preferred, but a single ground rod, a cold water pipe can provide a serviceable ground. LDG strongly recommends that you use a properly installed, high quality lightning arrestor on all antenna cables.

Your AT-200PC can interface directly with most popular PCs. Use a suitable 9-conductor serial data cable to connect the AT-200PC to an available serial port on your PC. You can also connect the serial cable to a USB jack on your PC by using the provided adapter. RTS and CTS lines are required.

If you are using rig control software such as that offered by N4PY or SuperControl, for example, you will make two serial connections to your PC: one for the radio and one for the tuner. Your AT-200PC is designed to use a serial port, but in case you don't have a free port, LDG provides you with a serial-to-USB adapter. This will allow you to connect your AT-200PC to a USB port instead of a serial port.

In Windows 98 or XP, the USB adapter is a plug-and-play device. Place the included driver CD in your drive, then plug the adapter into any available USB port on your PC. Follow the instructions in the New Hardware dialog.

Select "Search for driver"; Windows will find the driver on the CD and install it automatically. If a security panel informs you that the driver is not certified, select Continue to complete the installation.

The USB adapter will install itself as the next available COM port. For example, if your PC is already set for COM1 and COM2, the adapter will be installed as COM3. Thereafter, you can use it as you would any COM port.

To set serial port parameters for the USB adapter in Windows, select **Start** > **Control Panel** > **System**, then select the **Hardware** tab. Select **Device Manager**, then click on **Ports**. Double click on the USB-to-Serial Bridge, then click on the port settings tab. On that panel, you can set port speed, number of data bits, number stop bits, parity, flow control and other serial parameters. Set the parameters to 9600 baud, 8 data bits, no parity, 1 stop bit and no flow control. Click OK to save your settings.
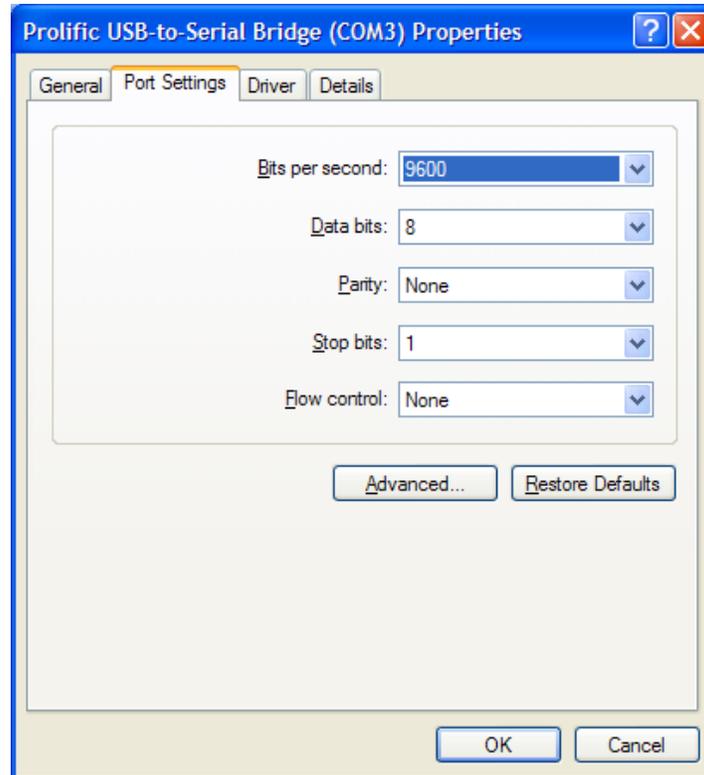
Software Installation

Your AT-200PC is compatible with several popular rig control programs. Simply follow the installation instructions that come with the software.

N4PY Rig control software.

All N4PY rig control programs support the AT-200PC. N4PY publishes software for the following rigs:

- Most Icom transceivers
- Most Kenwood transceivers
- TenTec Orion, Orion II, Pegasus, Jupiter, Argonaut V
- Elecraft K2

See the N4PY web page at www.n4py.com for more details.

SuperControl Rig control software.

SuperControl rig control programs support the AT-200PC. SuperControl publishes software for the following rigs:

- FT-1000MP/MV
- FT-847
- FT-100/100D
- FT-857/857D
- FT-897/897D
- FT-817-817ND

SuperControl also has a stand-alone software program that is downloadable for free for use with any brand standard HF radio.

See the SuperControl web page at www.supercontrol.de for more details.

MARS-ALE

The AT-200PC has been used with the MARS Automatic Link Establishment (ALE) program. While this is limited to MARS members, some information on ALE and PC controlled autotuners is available.

See the MARS-ALE web page at www.n2ckh.com/MARS_ALE_FORUM for more details.

Operation

All tuner functions are controlled through the PC interface. The details of the interface vary among software products; see your software's documentation for details. An overview of the basic modes are provided below.

Auto and Semi-Auto Modes
In Auto mode the tuner will begin a tuning cycle whenever the SWR exceeds the value you set (see section on setting autotune threshold in the PC interface). In Semi mode a tuning cycle begins only when you start one by pressing the **Tune** button on the PC interface, regardless of SWR. You can also start a Semi tuning cycle while the tuner is in Auto mode. Your personal operating practices will determine which mode is best for you.

Auto mode tuning works well while you are transmitting in SSB, AM, CW or any digital mode. Recent advances in LDG's tuning algorithms allow your AT-200PC to tune effectively even with a varying RF signal. This means that as you change frequencies, antennas or bands, you don't have to make a separate tuning transmission; just start talking and your AT-200PC will match up in as little as 0.2 seconds.

Memory Tuning
Your AT-200PC has frequency memories for four antennas on *each* antenna port. They store the tuning parameters for each frequency as you tune. You can use a wide variety of antennas, connecting them to the two antenna ports as needed. Think of it; you could be using a Yagi, Quad, Loop or Vee on the Ant A port, and a Dipole, Vertical, Longwire or J-Pole on the Ant B port, connecting them as needed (or switching them through an external coax switch), and *each of them* will have dedicated memories. When you transmit on or near a memorized frequency again, the tuner finds the best match for that port and antenna and sets those parameters in a fraction of a second, much faster than a full tuning cycle. This will work best if you always use a particular antenna on the same antenna port each time.

When you tune, you can select between a Memory tune and a Full tune. If you select Memory tune and there is no appropriate memory data, the tuner will automatically begin a full tuning cycle. Tuning parameters are stored in EEPROM memory, and are retained indefinitely, even if power is removed.

Operation with the N4PY Rig Control Software

N4PY publishes rig control software that is compatible with the AT-200PC[2]. Operation with this software is shown here as an example of this class of program. To use the software with the tuner, you will connect your rig to your PC via one serial port (COM1 for example), and the tuner to a second serial port (COM2 for example). After launching the software, select the **Settings** menu, then go to the **Preferences 3** menu. Check the box labeled "Using LDG AT-200PC Autotuner", and select the appropriate COM port from the list.


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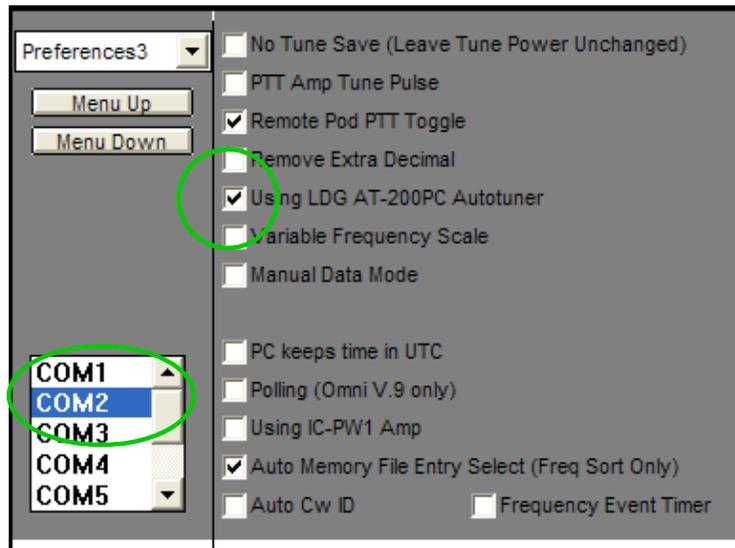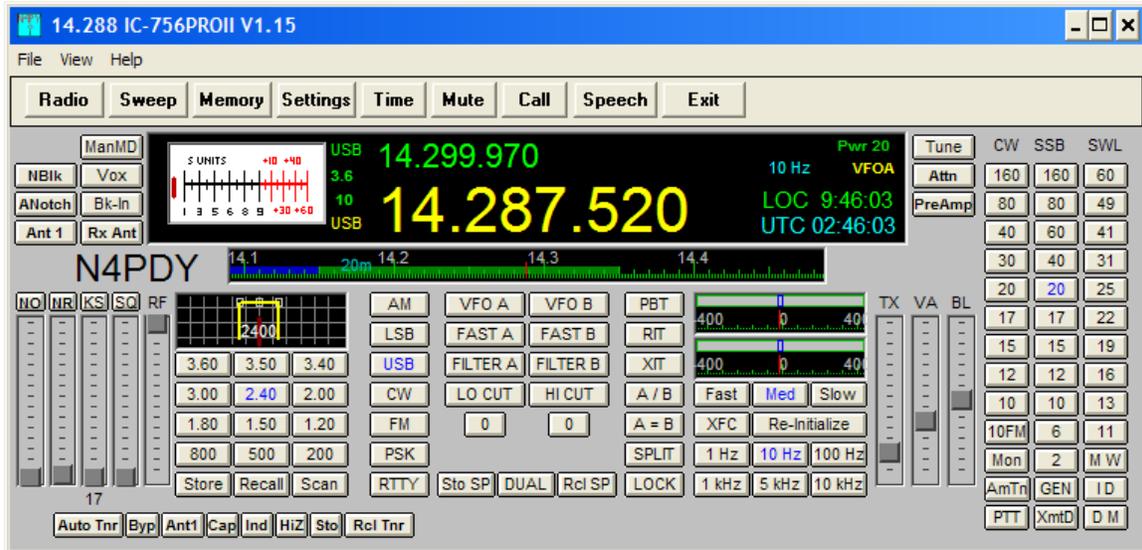
[2] This information is provided as a convenience to our users. LDG does not provide support for the N4PY or other third-party software.

On the radio control panel, the tuner controls appear at the lower left.:

1. **Auto Tnr**: Enables the tuner
2. **Byp**: Puts the tuner in bypass mode
3. **Ant1**: Toggles between the two antenna ports on the tuner
4. **Cap**: Manually adjusts the capacitor setting
5. **Ind**: Manually adjusts the inductor setting
6. **HiZ**: Manually toggles between Hi and Low Z setting
7. **Sto**: Manually stores the present tuning settings
8. **Rcl Tnr**: Initiates a memory tune

To tune manually, click the Tune button on the N4PY interface while transmitting.
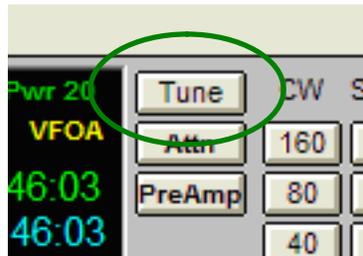
For more information on using the N4PY control program, consult the program's documentation and help files.

Application Notes

When to use Auto mode

Auto mode is most useful when you are often changing frequencies and bands (a contest, for example). With memory operation, Auto mode will retune almost instantly whenever you transmit on a new frequency. On the other hand, if your antenna SWR is fairly flat across the band of frequencies you're using, retuning might not be necessary, and semi-automatic mode would be preferable.

MARS/CAP coverage

Your AT-200PC provides continuous tuning 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.

Data Interface

The following information describes the digital dialog that takes place between the PC and tuner. It is included to allow you to write your own software to control the tuner. A more complete interface specification document is available from the LDG website.

Your AT-200PC communicates with your PC via a serial data interface with the following parameters:

8 data bits, 1 stop bit, no parity, no flow control, data speed 9600 baud

The Transmit Data, Receive Data, Clear To Send and Ready To Send lines must be connected. The RTS line must be asserted (positive going) for 3 milliseconds and then de-asserted for 1 millisecond before sending each command; this "wakes up" the tuner to receive the command.

Your AT-200PC is capable of accepting 37 different commands, and responding with 19 data replies. Each command is in the following four-byte format:

Preamble	Command	Parameter 1	Parameter 2

Each part is one byte long. The Preamble byte is always 165 decimal ($A5 hex). The Command byte specifies which of the 37 commands is being sent. Most commands have no parameters; two have one parameter, and one command uses both parameters. Even when not used, the parameters must be sent to the tuner; values are ignored but must be present -- zero works fine in these cases. Unused parameters are omitted from the definitions below, but must always be present as zeros in the data.

Responses from the tuner are in the same format. Unused parameters may in fact contain non-zero data, but it is meaningless and the PC application should ignore it. If a parameter is not listed in for a response code, its content should be ignored.

The following descriptions provide a brief summary of commands and responses. A more complete and detailed description of the protocol is available for download from the LDG web site.

No Operation, Command code 0. This is a dummy command that produces no change in the tuner.

Inductor Up, Command code 1. Increases inductance value by one unit.

Inductor down, Command code 2. Decreases inductance value by one unit.

Capacitor Up, Command code 3. Increases capacitance value by one unit.

Capacitor Down, Command code 4. Decreases capacitance value by one unit.

Memory Tune, Command code 5. Starts a memory tuning cycle. Automatically defaults to full tune if no stored tuning parameters are available.

Full Tune, Command code 6. Starts a full tuning cycle even if stored tuning parameters are available.

Set impedance range relay to High, Command code 8. Sets the Hi-Low Z range relay to the High setting.

Set impedance range relay to Low, Command code 9. Sets the Hi-Low Z range relay to Low.

Select Antenna 1, Command code 10. Selects Antenna 1 on the internal antenna switch.

Select Antenna 2, Command code 11. Selects Antenna 2 on the internal antenna switch.

Update setting data, Command code 40. Requests the tuner to send updated data on the current state of all tuning relays.

Request version number, Command code 41. Requests the tuner to send its product ID and firmware version number

Arm memory clear, Command code 42. Enables clearing memory if the next command is Clear Memory.

Clear memory, Command code 43. Clears EEPROM memory if the previous command was Arm Memory Clear

Standby, Command code 44. Places the tuner in standby mode.

Activate, Command code 45. Takes tuner out of standby mode.

Store tuning parameters, Command Code 46. Stores the current tuning parameters for the present frequency.

Set SWR threshold, Command code 50 - 56. Set the threshold for a "good" tune to SWR values between 1.1 and 3.0. Tunes ending at SWR values above the threshold will not be saved to memory.

Command Code	SWR Threshold
50	1.1
51	1.3
52	1.5
53	1.7
54	2.0
55	2.5
56	3.0

Reset relays, Command code 57. Resets all L, C and the Hi/Lo Z relays.

Automatic tuning on, Command code 58. Sets automatic tuning on.

Automatic tuning off, Command code 59. Sets automatic tuning off.

Request forward power, Command code 60. Requests tuner to report the forward RF power.

Request reflected power, Command code 61. Requests tuner to report the reflected RF power.

Request SWR, Command code 62. Requests tuner to report the SWR.

Turn live updates on, Command code 63. Turns live updates on if previous turned off.

Turn live updates off, Command code 64. Disable live updates of forward and reflected power, SWR and frequency (defaults to On at power up).

Set inductor value, Command code 65. Parameter 1: inductor value 0 - 127. Manually sets inductor values.

Set capacitor value, Command code 66. Parameter 1: capacitor value 0 - 127. Manually sets capacitor values.

Request tuner settings for a specified frequency, Command code 67. Parameter 1: frequency, most significant digit, Parameter 2: frequency, least significant digit. Requests the tuner to return the tuner parameters for a specified frequency. Frequency expressed as period in "tick" units of 0.8 μSec. Valid values of period range from 370 ticks (55.3 MHz) to 11593 ticks (1.76 MHz).

A shortcut for determining the period value from the desired operating frequency in MHz is

$$\text{Period} = 20{,}480 \text{ / Freq}$$

So, for example to set 14.230 MHz:

$$\text{Period} = 20{,}480 \text{ / } 14.230 = 1439$$

Most significant byte (1439) = 0x05
Least significant byte (1439) = 0x9F

So, the command would be sent as: 0x43 0x05 0x9F

Request memory dump, Command code 68. Requests the tuner to dump all EEPROM settings. See application notes for details.

AT-200PC responses

No operation, Response code 00. No Operation. Also sent to indicate AT200PC has woken up

Inductor value, Response code 01. Parameter 1: Value 0-127. Present inductor value.

Capacitor value, Response code 02. Parameter 1: Value 0-127. Present capacitor value.

Hi/Lo relay setting, Response code 03. Parameter 1: 0 or 1. Present Hi/Lo relay setting.

Antenna port setting, Response code 04. Parameter 1: 0 or 1, showing present antenna selection. 0 indicates port 1, 1 indicates port 2.

Forward power, Response code 05. Parameter 1: most significant digit, Parameter 2: least significant digit. Forward in hundredths of watts, I.e. a value of 1000 indicates 10.0 watts

Reverse power, Response code 18. Parameter 1: most significant digit, Parameter 2: least significant digit. Reflected Power, in hundredths of watts.

SWR, Response code 06. Parameter 1: none, Parameter 2: SWR, as $256\rho^2$, where ρ is the factor in the classic SWR equation:

$$SWR = \frac{(1+\rho)}{(1-\rho)|}$$

To calculate the SWR value from response code 06, simply divide the value in the second parameter by 256, take the square root of the quotient, then compute the SWR from the above equation

Tuned frequency, Response code 07. Parameter 1: most significant byte, Parameter 2: least significant byte. The two parameters form a 16 bit word that represents one half of the period of the transmitted frequency, divided by 32,768, in units of 0.8 μSec. No, really.

For example, if the value reported is 471, then Period = $471 \times 0.8\mu Sec$ = 3.768×10^{-4} Sec. But this is the half-period, so the actual period is: 3.768×10^{-4} Sec $\times 2 = 7.536 \times 10^{-4}$ Sec. Thus, the frequency is:

Freq = $1 / 7.536 \times 10^{-4}$ = 1326.9 Hz.

However, the frequency counter on the AT200PC internally divides the incoming frequency by 32,768 before measuring it, so you must then multiply the result by 32,768 to get the actual frequency value. Thus Freq = $1326.9 \times 32,768 = 43,481,953$ Hz = 43.481953 MHz.

Tune succeeded, Response code 09. Indicates that the requested tuning operation succeeded.

Tune failed, Response code 10. Parameter 1: Reason 0-2. Indicates that the requested tuning operation failed.

> Parameter 1 Value: Failure Reason:
> > 00 No RF was detected.
> > 01 RF Carrier was lost before the tune completed.
> > 02 The tuner was unable to bring the SWR down
> > > below the SWR Threshold.

Version information, Response code 11. Parameter 1: Produce ID, Parameter 2: Major/Minor version number.

Clear done, Response code 12. Indicates that the EEPROM erase operation has completed.

In standby mode, Response code 13. Indicates that the tuner has been placed in standby mode.

In active mode, Response code 14. Indicates that the tuner has restored the settings that were saved prior to entering standby mode.

Store OK, Response code 15. Indicates that the requested store to memory operation has completed. Note that this will be indicated whether the store operation failed or succeeded.

SWR threshold, Response code 16. Parameter 1: Threshold 0-6. Indicates the currently active SWR threshold used for tuning.

> Byte 2, SWR Threshold value
> > 0 = 1.1:1
> > 1 = 1.3:1
> > 2 = 1.5:1
> > 3 = 1.7:1
> > 4 = 2.0:1
> > 5 = 2.5:1
> > 6 = 3.0:1

Auto status, Response code 17. Parameter 1: 0 or 1Report Auto Tune setting. 0 = disabled, 1 = enabled.

Live update status, Response code 19. Parameter 1: 0 or 1. Indicates Live Update on or off. 0 = disabled, 1 = enabled.

Updating your tuner

The firmware in your tuner can be updated by running an update utility provided by LDG. This will give you access to the latest features and performance enhancements. You will download two files from the LDG web site: the updater program, and the update hex file.

1. Download the updater program from the LDG web site. Unzip the file to your desktop (or any other convenient folder), and run the setup program. Follow the installation instructions. The default install file is:
   c:\ldgelectronics,Inc\AT200OPCFirmwareDownloader

2. Download the update file; these have a .hex file type.

3. Run the updater program.

4. Click the "COM?" button to select the COM port
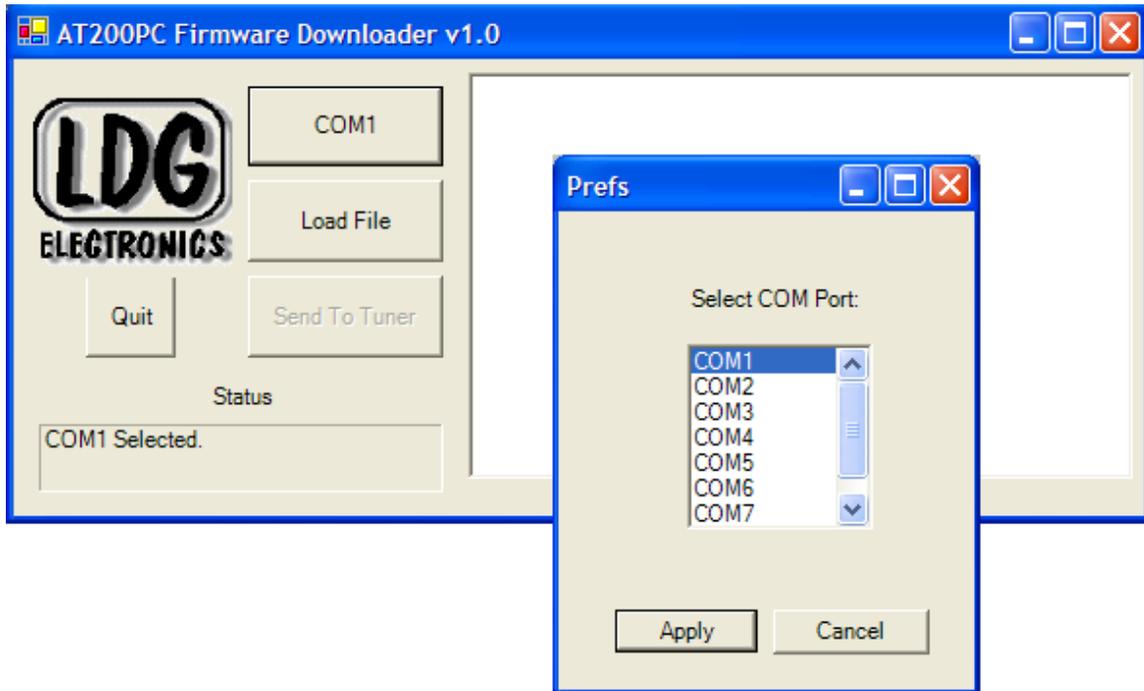
5. Click the "Load File" button, then navigate to the .hex file you downloaded, and select it.

6. Click "Send To Tuner" to load the file into the tuner.

Troubleshooting

There are two LEDs inside the tuner that can be helpful in troubleshooting. Remove the screws on the sides of the tuner, and carefully remove the top.

Exercise extreme caution when using the tuner with the cover removed: high RF voltages may be present during operation. Touch no part inside the tuner while transmitting!
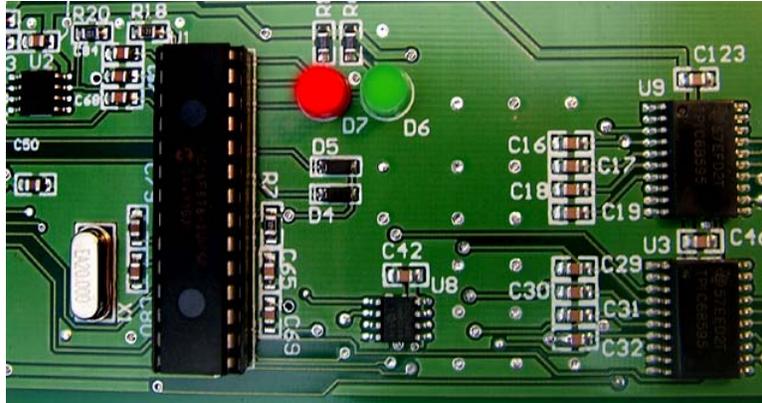
On reset, the LEDs blink green - red - green. In normal operation you should see this only at power-up.

The green LED lights when the unit receives a serial interrupt and "wakes up", then goes off when the unit goes back to "sleep". In normal operation, the green LED will blink on, then off with each serial command.

The red LED lights when RF is present. It goes off when the unit goes back to sleep.

The green LED pulses on and off during a memory clear.

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 subject[3], but a little background will help you understand what your AT-200PC 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 Georg Simon Ohm of Germany, who first discovered 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 causes 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.

The output circuit of your 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 your transmitter, 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 transmitter to the antenna occurs. While the transmitter 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 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

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

rises to 2, 3 or higher. As a general rule, modern solid state transmitters must operate with an SWR of 2 or less. Tube exciters are somewhat more tolerant of high SWR. If your 50 ohm antenna is resonant at your 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.

$$SWR = \frac{1+\sqrt{R/F}}{1-\sqrt{R/F}}$$ 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 transmitter 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 them by hand while observing reflected power on the SWR meter until a minimum SWR is reached. Your LDG AT-200PC 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 in the tuner as heat, never reaching the antenna at all. A tuner simply "fools" your transmitter 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.

Forward Power (Watts)

Reflected 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-200PC

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. 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 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-200PC to automatically handle loads that are greater than 50 ohms (high setting) and less than 50 (low setting). All of the relays are sized to handle over 300 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 (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.

Although the microprocessor's oscillator runs at 20 MHz. The main tuning routine takes about 75 cycles to make a tuner adjustment and take a new SWR measurement, or 7 milliseconds per tuner adjustment. If running at maximum speed, the microprocessor can try all inductor-capacitor combinations in under 3 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 microprocessor runs a fine tune routine just after the tuner finds a match at an SWR of 1.5 or less. This routine tries to get the SWR as low as possible (not just 1.5); it takes about a half second to run. There is also a quick tune mode. If the swr is below 2.0 when you press the tune button to start a tuning cycle, the tuner will first try a memory tune routine to see if it can achieve a low swr without a complete re-tune. This also takes about a half second to run. If it does not find a good match, then it runs a full tuning routine.

About Memory Tuning

The tuning range of the AT-200PC is divided into 2,000 frequency steps. The steps are smaller at lower frequencies where antennas are usually more reactive and frequency sensitive, and larger at higher frequencies. Each time you transmit, the tuner measures the frequency and selects the appropriate frequency step. There are four memories for each frequency step on each antenna port. If the tuning parameters are the same as one of the four existing memories for that frequency and port, they are not stored. If different, they replace one of the existing sets of parameters. In this way, up to four different antennas can be used on each of the two ports.

When you transmit on a new frequency, the tuner tries all four sets of tuning parameters for that frequency and port. If it finds a match among the four, it sets those parameters. If not, the tuner completes a full tuning cycle, storing the new parameters for that frequency and port. As you use your tuner, it literally learns the performance of up to four antennas on each of the two ports, storing their tuning parameters for virtually instant re-use.

A word about tuning etiquette

Be sure to use a vacant frequency to tune. With today's crowded ham bands, this is often difficult. However, do your best to avoid interfering with other hams as you tune. Your AT-200PC's very short tuning cycle, often only a fraction of a second, minimizes the impact of your tuning transmissions. Tune at reduced power whenever possible; one or two watts is plenty.

Care and Maintenance

Your AT-200PC 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-200PC can be damaged by temperature extremes, water, impact or static discharge. LDG strongly recommends that you 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.

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-200PC, we'll send you a free upgrade as a "thank you".

We encourage everyone who uses the AT-200PC 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).

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