

**LDG AT-600ProII  
600W Automatic  
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 LDG Electronics AT-600ProII 600 watt automatic tuner. The AT-600ProII provides fully- and semi-automatic antenna tuning across the entire HF spectrum plus 6 meters, at power levels up to 600 watts (250W on 6m). 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 tuners you may have considered, including the built-in tuners on many transceivers.

The AT-600ProII is designed to handle 600 watts of output power, and is ideal for use with small outboard linear amplifiers rated up to 600 watts, or even newer high power transceivers.

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

Ok, but at least read this one section before operating the AT-600ProII:

1. Connect a 50-ohm coax jumper cable from the antenna jack on your amplifier to the **TX** jack on the back of the AT-600ProII. (This cable must be rated to 600 watts.)
2. Connect your antenna’s 50-ohm coax feedline to the **ANT 1** jack on the rear of the AT-600ProII.
3. Connect the supplied DC coax cable to the jack marked **12 VDC**. Connect this cable to a DC source between 11 and 16 volts DC, 1000 mA. The jack center tip is positive.
4. Power up the transceiver, and select the desired operating frequency and mode.
5. Bypass the amplifier.
6. Make sure Antenna 1 is selected (**ANT 2** LED is off). Press **ANT** to toggle.
7. Begin transmitting, any mode<sup>1</sup>.
8. When the tuning cycle completes, activate the amplifier, and you’re ready to operate!

**Note:** With the amplifier active, it is suggested to place the AT-600ProII in semi-automatic tuning mode to avoid re-tuning at high power levels.

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*1 In SSB mode, simply speak into the microphone while transmitting. Tuning may be performed at up to 125 watts of input power, provided that the transceiver employs a “roll-back” circuit to protect it from high SWR. For transceivers without roll-back circuits, power should be limited to 25 watts when tuning, to avoid damage to the transmitter or tuner.*

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## SPECIFICATIONS

- 1 to 600 watt power range (SSB and CW), 250 watts PSK and digital modes, and 250 watts on 6 meters.
- Silver-teflon SO-239 connectors.
- Over 4,000 memories for instantaneous band changing.
- Built-in 2-port antenna switch, with 2,000 memories each.
- Tuning time 0.2 to 15 seconds full tune, 0.2 seconds memory tune.
- 1.8 to 54.0 MHz coverage. Built-in frequency sensor.
- Tunes 6 to 1,000 ohm loads (16 to 150 on 6m).
- LED bargraph displays power level, SWR, and status.
- Antenna Indicator LED shows the currently selected antenna.
- Bypass LED shows when tuner is in pass-thru.
- User-selectable operating parameters: Auto/Semi mode, 600W/60W scale, and more.
- Optional radio interface cables available. See web site for details.
- Optional large-display external analog panel meter.
- Power requirements: 11 to 16 VDC @ 1A max. 7mA when idle.
- Dimensions: 10.5”L x 8.5”W x 2.75H”; Weight 3 pounds, 6 oz.

## AN IMPORTANT WORD ABOUT POWER LEVELS

The AT-600ProII is rated at 700 watts maximum power input *at most*. Many amplifiers output well over 750 watts. Power levels that significantly exceed specifications will definitely damage or destroy your AT-600ProII. If the tuner fails during overload, it could also damage your transmitter, amplifier, or transceiver. Be sure to observe the specified power limitations.

### 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.**

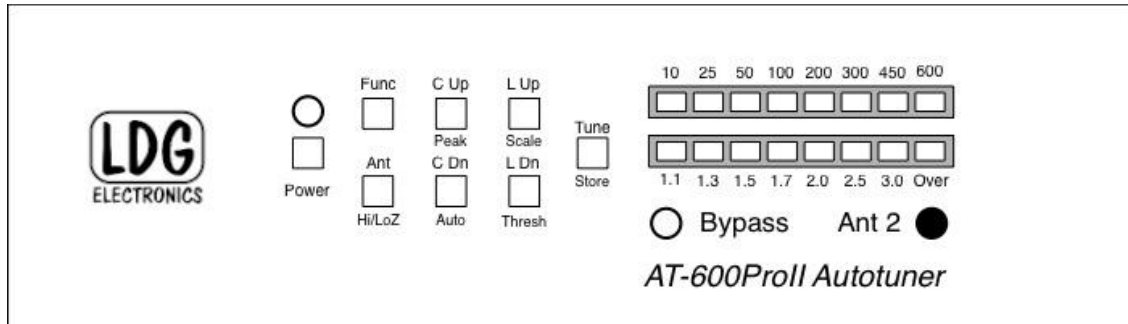
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## GETTING TO KNOW YOUR AT-600PROII

Your AT-600ProII 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-600ProII features eight pushbuttons, two LED bargraph scales, and three indicator LEDs:



- **Power:** Turns the unit on or off. The Power LED glows when the power is on.
- **Func:** Activates secondary function of other buttons.
- **Ant:** Selects the active antenna port.
- **C Up:** Manually increase capacitance.
- **C Dn:** Manually decrease capacitance.
- **L Up:** Manually increase inductance.
- **L Dn:** Manually decrease inductance.
- **Tune:** Initiates memory or full tuning cycle. Momentary push places tuner in bypass.
- **PWR Meter:** Bargraph display indicates forward power in 0-60 and 0-600 watt ranges.
- **SWR Meter:** Bargraph display indicates SWR during tuning or transmission.
- **Bypass LED:** Indicates Bypass mode is active.
- **ANT 2 LED:** Lights when Antenna 2 is selected. Off when Antenna 1 is selected.

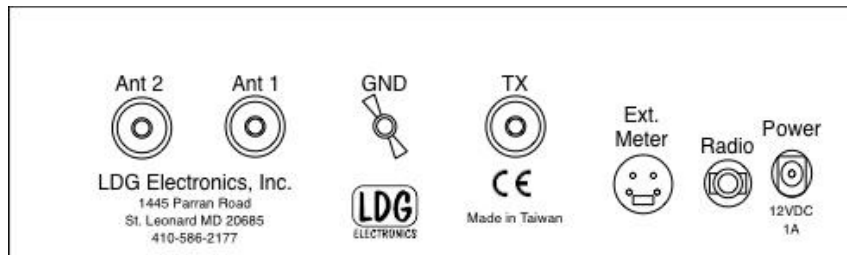
Each of the pushbuttons has the primary function listed above when pushed. Additionally, pressing the **FUNC** button before pressing any other button will activate that button's secondary function.

The power button on the AT-600ProII actually places the tuner in bypass and enters a low-power sleep mode, rather than turning the unit fully off. Press the Power button for 1 second to turn off, or momentarily to turn on.

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### Back Panel

The rear panel of the AT-600ProII has seven jacks.



- **Ant 1:** Connect a 50 ohm antenna coax feedline to this SO-239 connector. This jack is automatically disconnected when the AT-600ProII is turned off.
- **Ant 2:** Connect a second 50 ohm antenna coax feedline to this SO-239 connector. This is the antenna jack that is active when the **ANT 2** LED is lit on the front panel. Also, this jack is active when the AT-600ProII is turned off.
- **Gnd (wing nut):** Connect to the antenna system ground.
- **Tx:** Connect a 50 ohm jumper coax from this jack to the ANT jack on the rear of the amplifier.
- **Ext. Meter:** Connect the LDG M-600 External Meter to this jack, or use for remote control via PC.
- **Radio:** (optional) Connect the optional IC-PAC (Icom), Y-ACC (Yaesu), IC-2000 (Yaesu FT-2000), or AL-PAC (Alinco) radio interface cable.
- **Power:** Connect the supplied DC coaxial power cable to this connector, and connect to a source of 11-16 VDC @ 1A. Center pin is positive.

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## INSTALLATION

The AT-600ProII 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-600ProII is designed for use with coax-fed antennas. If use with longwires or ladder-line-fed antennas is desired, an external balun rated to 600 watts is required.

Place the AT-600ProII in a convenient location near the transceiver and amplifier. Always turn your radio and amplifier off before plugging or unplugging anything. The radio may be damaged if cables are connected or disconnected while the power is on.

Connect the HF antenna jack on the amplifier to the **TX** jack on the back of the AT-600ProII, using a 50 ohm coax cable rated 600 watts or higher.

Connect a 50-ohm antenna feedline coax to the **ANT 2** jack on the back of the AT-600ProII, and optionally connect a second antenna feedline to the **ANT 1** jack. **NOTE:** *ANT 2 is automatically selected when no DC power is present.* This way, if you only have one antenna, it is automatically disconnected from your radio when the power is off.

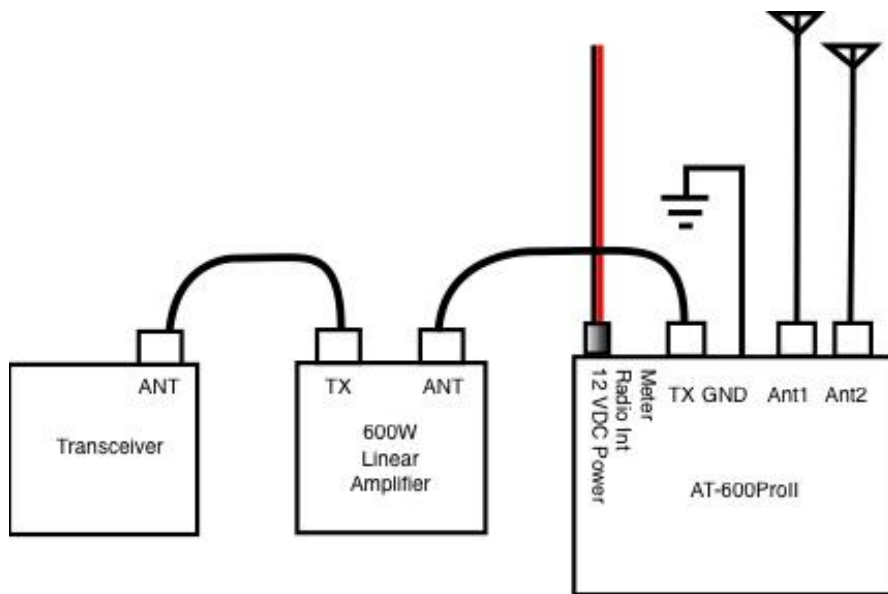
The AT-600ProII is designed to interface directly with many popular ICOM and Yaesu transceivers, enabling one button tuning. In the case of ICOM radios, the supplied interface cable also powers the tuner.

For ICOM radios supporting the AH-3 or AH-4 external tuner, connect the 4-pin Molex connector of the optional IC-PAC ICOM interface cable to the radio's Tuner port. Then connect the 1/8" stereo plug on the other end of the ICOM interface cable to the jack marked **Radio** on the rear of the AT-600ProII. Connect the coaxial DC power plug of the ICOM interface cable to the **12V DC Power** jack.

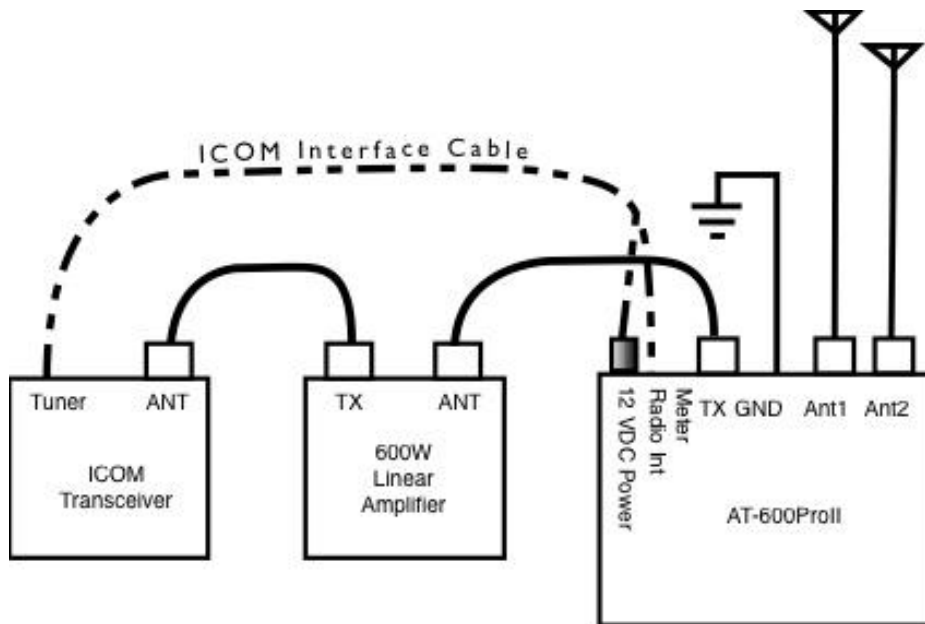
For Yaesu FT-857 and FT-897, use the optional Y-ACC cable and plug the red end marked **Radio** into the transceiver's ACC port. Plug the black end of the Y-ACC cable into the jack marked **Radio** on the rear of the AT-600ProII.

Unless the AT-600ProII is being powered by the ICOM radio interface cable as above, you'll also need to plug in the supplied DC coaxial power cable. This cable has a 2.5x5.5mm coaxial plug on the end. Plug the coaxial plug into the **12V DC Power** jack on the rear of the AT-600ProII, and connect the other end to a DC power source between 11 and 16 volts DC, capable of supplying up to 1A.

Grounding the AT-600ProII 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 ideal, but a single ground rod can provide a serviceable ground. LDG strongly recommends the use of a properly installed, high quality lightning arrestor on all antenna cables.

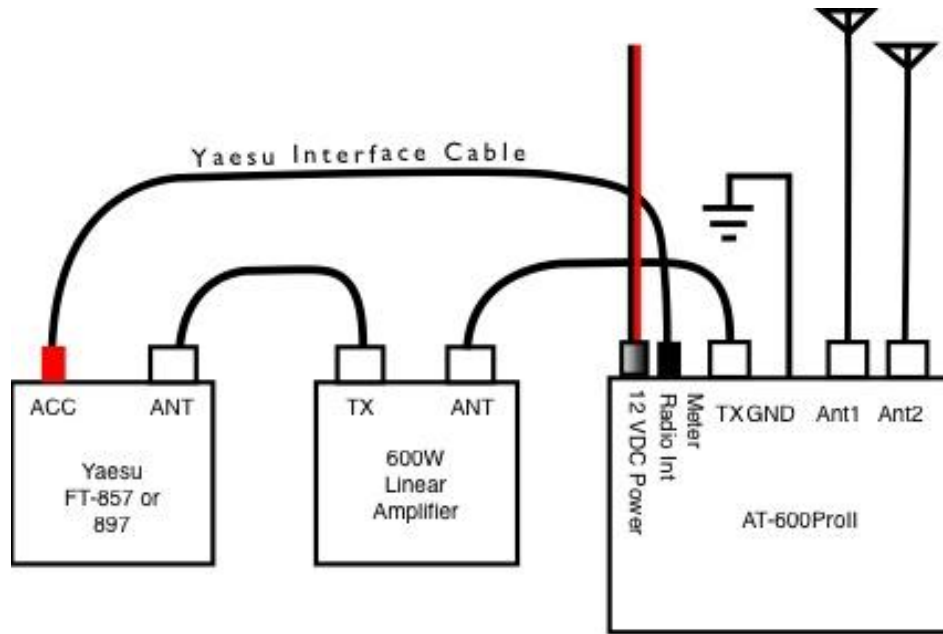


Typical Installation



ICOM Installation





FT-857/897 Installation

*Note: Optional Y-ACC cable has a red plug on the radio end of the cable, and a black plug on the tuner end.*

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## BASIC OPERATION

### *Using the Front Panel Buttons*

All operations of the AT-600ProII are controlled via the front panel buttons. Although there are a total of eight buttons on the front panel, there are more than eight functions that can be carried out on the AT-600ProII. In order to accommodate the many functions of the AT-600ProII, the operation performed by pressing a particular button is determined by the manner in which the button is pressed, and no operation begins until the button is actually released.

The various types of button presses are described here:

**Momentary or short press:** The button is pressed and released immediately.

**Medium Press:** The button is held for one-half to 2.5 seconds, and then released.

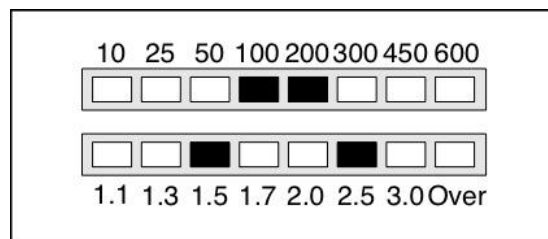
**Long Press:** The button is held for more than 2.5 seconds, and then is released.

**FUNC -> Button:** The **FUNC** button is pressed first, and then the button is pressed momentarily and released. e.g.: **FUNC -> Ant** means “Press the **Func** button and release, and then press the **Ant** button and release.”

### *User Configuration Options*

The AT-600ProII offers several user-settable options that allow the behavior of the tuner to adapt to many different operating circumstances. Most of these options are accessed by placing the tuner in **Function** mode, which is done by pressing and releasing the **Func** button, and then pressing the desired button to activate the particular configuration option while in function mode.

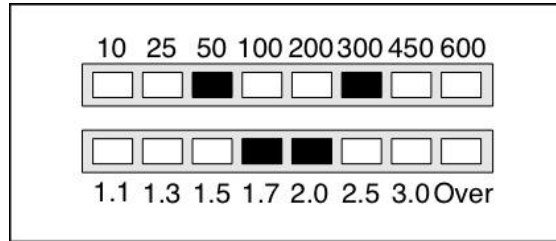
To confirm entry into **Function** mode, the AT-600ProII will flash an “up arrow” on the LED display after the **Func** button is pressed.



Function Mode On

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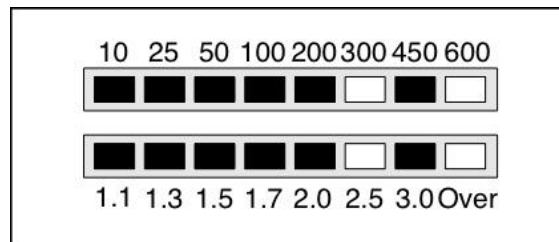
Function mode times-out after a few seconds if no other button is pushed. Alternately, function mode can be cancelled by pressing the **Func** button again. In either case, when Function mode is exited, a “down arrow” is displayed on the LED display:



Function Mode Off

**Peak Mode On/Off:** The Power display on the LED bargraph can display either average power or peak forward power, in watts. Average mode is suitable for 100% duty cycle modes such as FM, RTTY, or PSK. Peak mode is more useful on modes with varying duty cycle such as SSB or AM. The factory default is average mode.

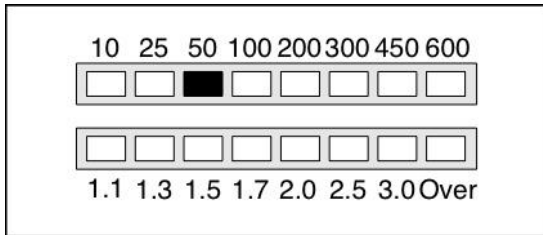
To toggle between power display modes, press **Func -> C Up** (Press and release **Func**, then press and release **C Up**). Peak mode is indicated by a falling meter display, with the highest power shown as a steady LED while the remaining LEDs fall back to zero. Average mode shows the same display, but without the steady LED showing. Press **Func -> C Up** repeatedly to toggle between Peak and Average modes.



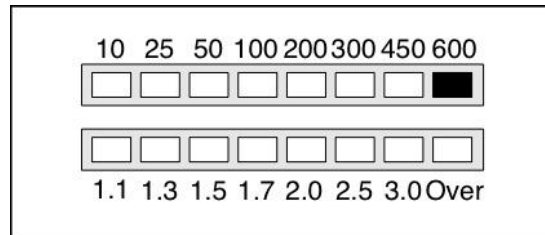
Peak Mode

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**Wattmeter Scale:** The Power LED bargraph displays either 0 to 60 watts or 0 to 600 watts full scale. To toggle between these two scales, press **Func -> L Up**. The LED marked “50” or “600” will light momentarily to indicate the newly selected scale.



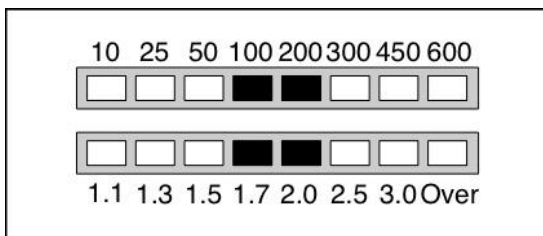
60 Watt Scale



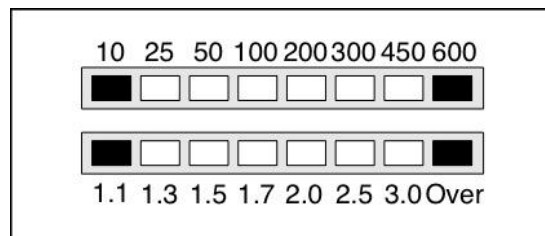
600 Watt Scale

**Automatic Tuning Mode:** The AT-600ProII may be set for either semi-automatic tuning or fully automatic tuning. In semi-automatic tuning mode, a tuning cycle will not begin unless specifically requested by pressing the **Tune** button. In fully automatic tuning mode, a tuning cycle will begin any time there is RF present and the SWR exceeds a pre-set level. The default setting is fully automatic tuning mode.

To toggle between semi- and fully automatic modes, press **Func -> C Dn**. The LED display will show one of the two patterns to indicate which mode has been selected:



Auto Mode

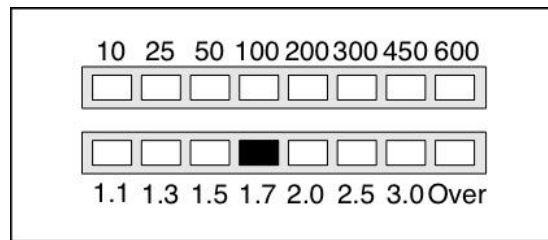


Semi Mode

**Automatic Tune SWR Threshold:** When the AT-600ProII is in fully automatic tuning mode, an automatic tuning cycle will begin any time RF is present and the SWR has exceeded a set threshold. This threshold is user-programmable to any value between 1.7:1 and 3.0:1. To set the automatic tune SWR threshold, press **Func -> L Dn** repeatedly (press **Func**, then **L Dn**; **Func**, then **L Dn**, and so on...) to cycle through all the options. The SWR threshold will be displayed on the SWR scale momentarily.

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The default value of SWR threshold is 2.0:1. The following example shows setting the SWR threshold to 1.7:1.



Auto Threshold

**Antenna Selection:** Press the **Ant** button momentarily to toggle which antenna port is currently active. The **ANT 2** LED will light when Antenna 2 is selected, and is off when Antenna 1 is selected. When toggling the antenna selection, the previous tuning settings for the newly selected antenna are also recalled. This is useful when comparing antenna performance on the same frequency.

*Transmitting and Receiving*

During receive operation, only the antenna and bypass indicator LEDs are lit on the AT-600ProII. During transmit, the forward RF power level is displayed on the PWR bargraph, and the SWR is displayed on the SWR bargraph. Each PWR bargraph LED lights from halfway between the previous value and the next higher value. For example, the 100W LED lights from 75 watts to 150 watts. If the power is 151 watts, then the 200W LED lights, as well.

When reading the SWR bargraph, an illuminated LED on the graph means “The SWR is at least this much.” In other words, if the 1.3 LED is lit, it means that the SWR is between 1.3 and 1.5:1. No LEDs lit means the SWR is less than 1.1:1.

The **Bypass** LED lights any time that all the internal relays are in their de-energized state, meaning that no inductance or capacitance is being added to the antenna system by the tuner.

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## TUNING

### *Basic Tuning Operation*

A tuning cycle on the AT-600ProII is initiated from either the **Tune** button on the front of the AT-600ProII, an over-SWR condition when in fully automatic tuning mode, or from pressing the **TUNER/CALL** button on the front of an ICOM radio connected using the ICOM interface cable. Two types of tuning cycles are available.

A **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 from that match will be loaded into the tuner relays, and checked to see if an acceptable SWR level is found using these memorized settings.

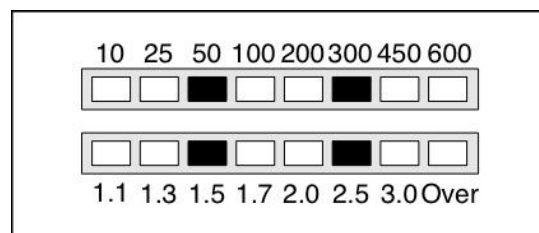
Memory frequency step sizes vary with the selected band. Steps are very close together on the lower bands, to accommodate the typically higher-Q antennas for those bands, while step size is somewhat larger on the higher (17 meters and up) bands, where antenna Q is typically lower.

A **full tuning cycle** “starts from scratch,” and begins a fixed tuning sequence, where the AT-600ProII 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 and antenna, so that they may be recalled quickly in the future via a memory tuning cycle.

In this manner, the AT-600ProII “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.

### *Manual Memory Tune*

To initiate a memory tuning cycle at any time, first, bypass the amplifier<sup>2</sup>. Press and hold the **Tune** button for 0.5 to 2.5 seconds (medium button press) and release. The LED bargraph display will show the following pattern to indicate a memory tune cycle is selected:



Medium Press > 0.5 sec

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<sup>2</sup> Note that, while the AT-600ProII employs software that prevents it from tuning while transmitting over 150 watts, it is still a good idea to bypass your amplifier while tuning, as further protection against damage to the tuner.

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If you are using the optional ICOM or Yaesu interface cable, your radio will automatically reduce power, switch to CW mode, and transmit for as long as is needed to complete the tuning cycle, and then will return to the previous operating mode and power level when done.

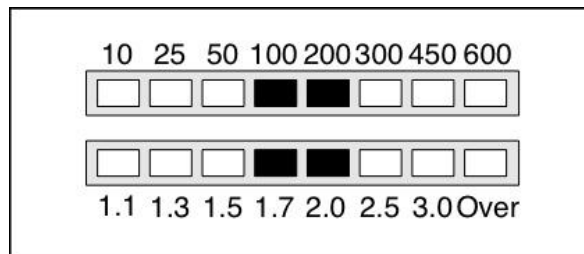
If you are not using the optional ICOM or Yaesu radio interface cable, you will need to key the radio manually in AM, SSB, or CW mode. Note that if your radio does not incorporate an SWR rollback circuit<sup>3</sup>, you will first need to reduce power to 25 watts or less. In no case should you transmit more than 150 watts during tuning.

If the memory tune is not successful, the AT-600ProII falls through to full tuning cycle. At the end of a tuning cycle, the LEDs cycle inwards to indicate a successful tune. You may then activate the amplifier, and begin transmitting.

If using the AT-600ProII with an ICOM transceiver connected with the ICOM interface cable, pressing the **TUNER/CALL** button on the transceiver initiates a memory tuning cycle. Again, bypass the amplifier while tuning. The AT-600ProII will not tune if the transmit power is over 150 watts, or if the transmit power exceeds 100 watts during high SWR conditions, in order to protect the switching relays.

#### *Manual Full Tune*

As with the memory tuning cycle, if your radio is not equipped with a rollback circuit, reduce power to 25 watts or less before tuning. To explicitly initiate a full tuning cycle, press and hold the **Tune** button on the AT-600ProII front panel for more than 2.5 seconds. The LEDs will display the following pattern to confirm a full tuning cycle is requested:



**Long Press > 2.5 sec**

If you are using one of the optional radio interface cables, the radio will automatically reduce power, switch to CW mode, and begin transmitting while the full tuning cycle is in progress. If not, key the radio (Talk into the mic on SSB or AM, close the key on CW) until the tuning cycle is complete. As with the memory tuning cycle, when the tuning cycle is complete, the LEDs will scan inward to indicate a successful tune.

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<sup>3</sup> An SWR rollback circuit automatically reduces the output power level when high SWR is present. Check your radio's manual to see if your radio uses a rollback circuit.

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### *Bypass Mode*

The AT-600ProII may be placed in Bypass Mode by pressing the **Tune** button momentarily (less than 0.5 second). Bypass places the tuner in a pass-thru configuration, where the tuner behaves like a coax jumper, not affecting the antenna match. When placed in Bypass Mode, the Bypass LED will light and the AT-600ProII is automatically put into Semi-Automatic Tuning Mode. Bypass may be useful for comparing the effect of the AT-600ProII's tuning versus the unmatched antenna system. Pressing **Tune** momentarily again will take the unit out of Bypass Mode (the LED will no longer be lit), and the relay settings of the previous match will be restored. The tuner will still be in Semi-Automatic Tuning Mode until you reset it to Automatic Tuning mode.

When the tuner is placed in Bypass mode, it will remain in bypass mode until either:

- a.) You re-enable Full Automatic Tuning mode.
- b.) You manually increment or decrement the inductor / capacitor settings.

If an ICOM radio and interface cable is used, the AT-600ProII may also be bypassed by pressing the **TUNER/CALL** button momentarily. On some models of ICOM radios, changing bands will also automatically bypass the tuner.

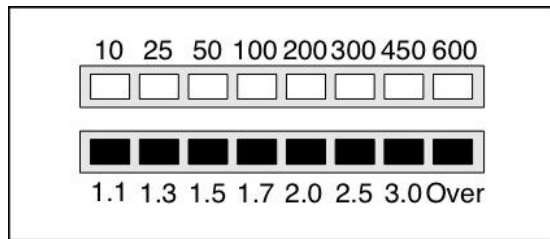
### *Error Indication*

When performing a tuning cycle, there are several conditions that may occur that cause the tune to fail. All are reported as an error, via blinking the front panel LEDs in a particular fashion. The following errors are reported:

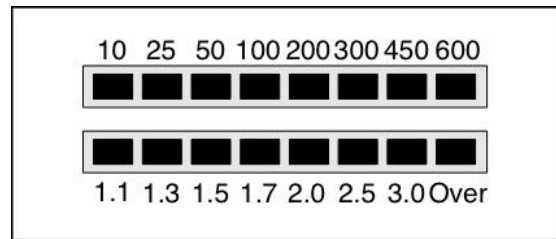
- **ERR\_NO\_MATCH:** Unable to find a suitable match. Upon completing an entire full tuning cycle, no combination of inductors and capacitors was able to bring the SWR below 3.5:1.
- **ERR\_NO\_RF:** No RF power was present at the beginning of a tuning cycle. In other words, the **Tune** button was pressed to request a tune cycle, but the transmitter was not keyed up.
- **ERR\_LOST\_RF:** RF power disappeared before the tuning cycle completed. You must continue to key the radio until the tuning cycle completes.
- **ERR\_NO\_FREQ:** Unable to determine operating frequency. In order to store a memory match, the frequency of the transmitted RF must be known.
- **ERR\_OVER\_PWR / ERR\_SWR\_PWR:** Relay protection activated. Because the relays may be damaged if they are switching during high power operation, software prevents the relays from toggling under certain conditions. Relays will not toggle if the SWR is over 3.0:1 and the power is over 100 watts, and will not toggle if the power is over 150 watts regardless of the SWR.

The diagrams on the next page show what the various error indications look like.

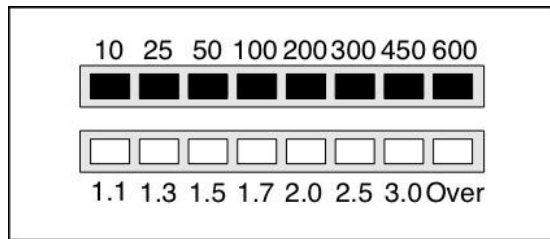




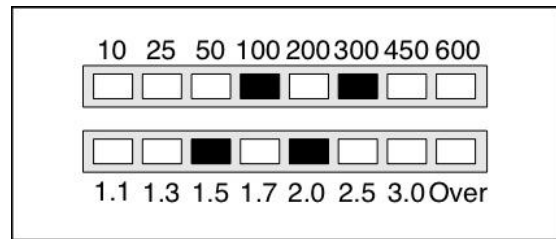
**ERR\_NO\_MATCH: SWR**  
LEDs blink twice



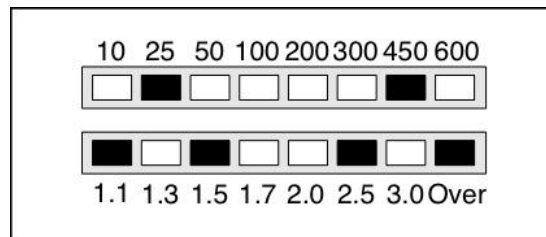
**ERR\_NO\_FREQ: All LEDs**  
blink twice



**ERR\_NO\_RF: Blink once**  
**ERR\_LOST\_RF: Blink twice**

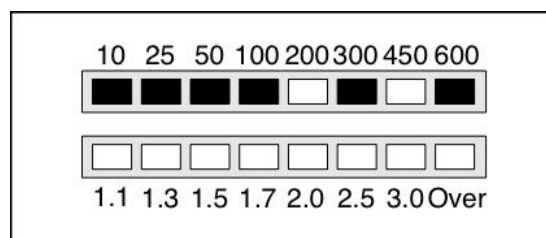


**ERR\_OVER\_PWR:**  
Center LEDs toggle



**ERR\_SWR\_PWR:**  
Outer LEDs toggle

Additionally, if the forward power exceeds the maximum value selected for the meter scale, the PWR LEDs will blink an over-range condition. The four right-most LEDs of the PWR bargraph will cycle during over-range.



**Meter Over-scale:**  
Rightmost 4 LEDs toggle

---

## ADVANCED OPERATION

### *Manual Inductor/Capacitor Adjustments*

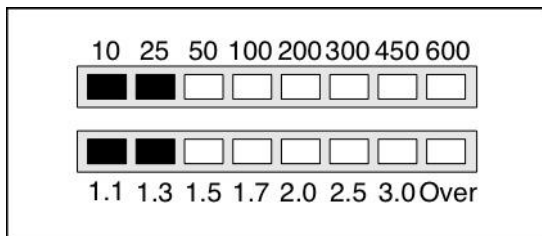
In some rare cases, after tuning, it may be desirable to adjust the inductance and capacitance settings that the AT-600ProII came up with during the tuning process. This is more likely to occur when attempting to tune an antenna far from its resonant frequency.

The **C Up**, **C Dn**, **L Up**, and **L Dn** buttons may be used to increase or decrease the amount of capacitance or inductance, respectively. A momentary press of any of these buttons increases or decreases the value by one unit, and displays the resulting value on the bargraph meter. Capacitance value is displayed on the SWR bargraph, and inductance on the PWR bargraph. These values are displayed in binary, left justified. The lowest-order relay is displayed on the leftmost LED. The rightmost LED on the PWR bargraph displays the state of the High/Low Impedance relay.

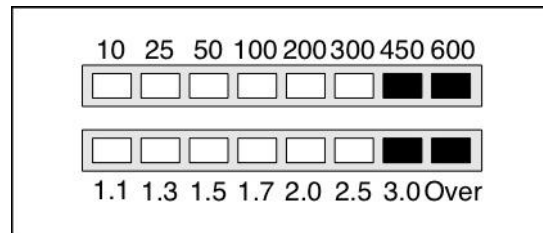
Repeatedly press one of these buttons to increase or decrease multiple times, or simply hold the button and the button will auto-repeat. You may also transmit while increasing or decreasing, so that the SWR value is displayed, but the capacitor and inductor values will not be displayed during transmit; instead, the power and SWR levels are displayed.

### *High/Low Relay Adjustment*

In addition to being able to manually control the inductor and capacitor value of the AT-600ProII, it is also possible to manually set the high/low impedance relay, which determines whether the tuner is an L-C configuration or a C-L configuration. To toggle the state of the high/low impedance relay, press **Func -> Ant**. The LED display will show one of two patterns to confirm the setting.



Low Impedance



High Impedance

### *Manual Memory Store*

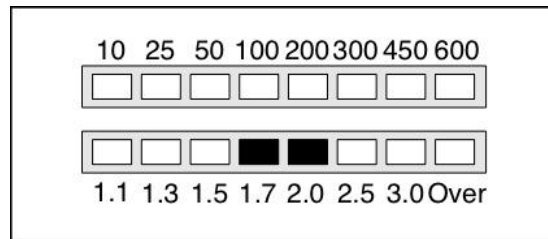
Once manual adjustments are complete, press **Func -> Tune** (that is, press **Func** momentarily, then **Tune** momentarily) to store the current relay settings in the memory associated with the frequency last transmitted upon.

---

### Status Check

The status of most user settings can be checked by pushing and *holding* the **Func** button while pressing the relevant button for that setting. For example, to check to see what the current SWR threshold value is, without changing the value, press and hold the **Func** button, and while still holding the **Func** button, press the **L Dn** (Thresh) button. The display will show the currently selected SWR threshold value.

While holding the **Func** button, the bargraph display will show the following pattern, to indicate that the AT-600ProII is waiting for you to push a button to check its status:



Function Hold

The following status items can be checked:

<i>Func Hold + This button</i>	<i>Status check</i>
<b>C Up / Peak</b>	Display Peak/Avg setting
<b>C Dn / Auto</b>	Display Auto/Semi setting
<b>L Up / Scale</b>	Display Power meter scale
<b>L Dn / Thresh</b>	Display SWR tuning threshold
<b>ANT / HiLoZ</b>	Display High / Low Impedance

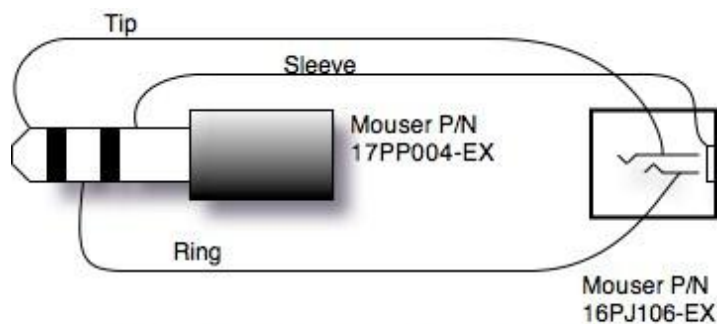
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## APPLICATION NOTES

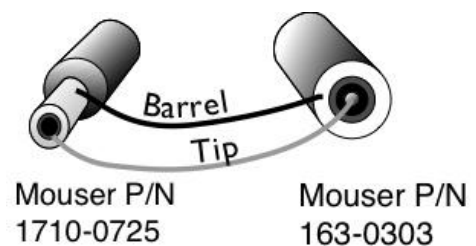
### *Mobile Operation*

The AT-600ProII is perfectly suited to mobile operation. It can be installed under the dashboard along with the transceiver, or mounted remotely. The only requirements are that the tuner remains dry, and that the power source is fused appropriately. A 2 amp “fast blow” fuse is recommended.

If the ICOM or Yaesu radio interface cable is needed for a remote installation, the optional cables can be extended in two ways. The original cable can be cut, and jumper wires soldered between all the connections, or new connectors can be purchased and a pair of homebrew extender cables made with the new connectors.



**Radio Interface Extender Cable**



**DC Power Extender  
For ICOM Interface**

With the AT-600ProII mounted, for example, in the trunk, simply set the AT-600ProII for fully automatic mode. It will automatically tune any time the SWR exceeds the preprogrammed threshold. Although the LED display will not be visible in the trunk of the car, your transceiver’s built-in SWR meter will show the tuner’s progress. Remember to keep your eyes on the road, however! In most cases, a match will be recalled from memory, so the SWR will snap to a low value as soon as you begin to transmit.

### *Internally Generated RF Noise*

The AT-600ProII is microprocessor controlled, and as such, generates a small amount of RF noise when the processor is active. Normally, the processor is only active during transmit operation, so the noise is not normally heard; however, if Peak mode is selected, the processor remains active for a moment after key-up, to allow the LEDs to settle back down to zero. You may briefly hear some noise in your receiver during this time. This is normal, and is noticeable the most when using CW in full break-in, with Peak mode selected. In practice, this should not be much of a problem, as Peak mode is not very useful when using CW.

### *MARS/CAP Coverage*

The AT-600ProII provides continuous tuning coverage from 1.8 MHz to 54.0 MHz, not just inside the ham bands. This makes it useful for MARS or CAP operation, or any other legal HF operation.

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### *Operation with LDG Electronics M-600 External Meter*

The AT-600ProII has an external meter jack on the rear panel, which supports use of the M-600 External Meter. The M-600 External Meter is an optional accessory for the AT-600ProII that provides a large analog meter movement, and can be used to display Forward Power, Reflected Power, and SWR.

Be sure to turn off your AT-600ProII before plugging in or unplugging the M-600 External Meter.

The metered parameter displayed on the external meter need not be the same as the parameter selected for viewing on the AT-600ProII's built-in LED bargraphs, so it is possible to watch two parameters at once! Consult the M-600 External Meter user manual for more details.

### *Tuning Hints*

1.) The AT-600ProII is designed to allow fully automatic tuning, which causes a tuning cycle to begin any time the SWR exceeds the user-selected threshold. However, tuning is not allowed when the forward power exceeds a level that could damage the relays. If the AT-600ProII is left in fully automatic mode with the amplifier active, it is possible to begin a tuning cycle while transmitting high power in some circumstances, such as SSB transmission, where the power level begins at a low level and then increases with voice peaks.

Once the power level exceeds the relay protection threshold, the tuning cycle will stop, leaving the tuner in an un-tuned state. Because of this, LDG recommends switching the amplifier off before tuning, and then once tuning is complete, the AT-600ProII should be switched to semi-automatic mode (**FUNC -> Auto**) for as long as the amplifier is active, to prevent re-tuning under high power.

2.) Some transceivers employ a fairly aggressive SWR roll-back circuit, which reduces transmit power under high SWR conditions. It is possible, on a particularly mismatched antenna, for the transmit power of the transceiver to be reduced so low that the frequency counter circuitry of the AT-600ProII does not provide accurate information. For this reason, LDG suggests that you tune with 20 to 50 watts of transmit power if tuning seems erratic when transmitting with lower power levels. For many transceivers, this is a simple matter of switching the radio to AM or RTTY mode and keying the mic.

## **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<sup>4</sup>, but a little background will help in understanding what the AT-600ProII is doing, and how it does it.

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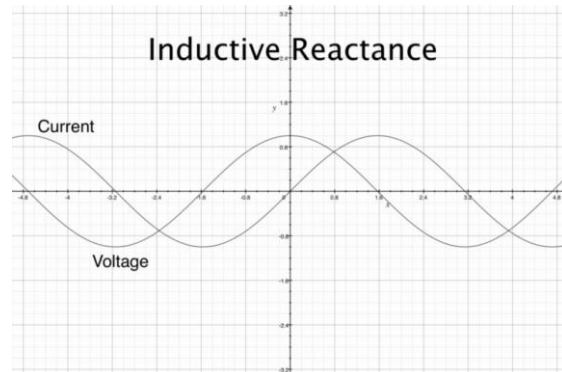
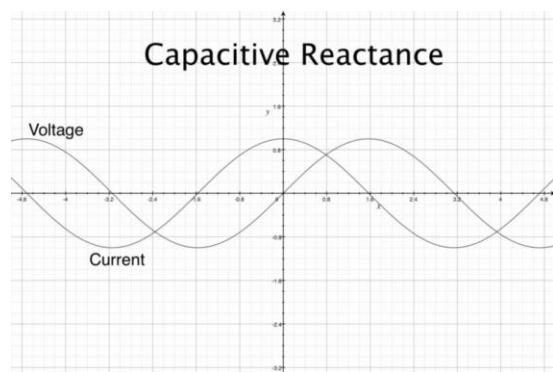
<sup>4</sup> For a very complete treatment of this subject, see any edition of the ARRL Handbook for Radio Communications (previously the Handbook For Radio Amateurs).

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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.

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.

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

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-600ProII automates this process.

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.

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

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## THE LDG AT-600PROII

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-600ProII to handle loads that are either greater than or less than 50 ohms. All relays are sized to carry 600 watts PEP.

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.

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, and 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 make the SWR as low as possible (not just to 1.5); it takes about half a second to run.



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## **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-600ProII's very short tuning cycle, as little as a fraction of a second, minimizes the impact of tuning transmissions.

## **CARE AND MAINTENANCE**

The AT-600ProII 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-600ProII 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.

## QUICK REFERENCE

<i>Button</i>	<i>Primary Function</i>	<i>Func -&gt; Button</i>	<i>Status Check (Func Hold + Button)</i>
<b>Tune</b>	Full Tune (Long Press) Memory Tune (Medium Press) Bypass (Short Press)	Manually Store Tuning Parameters	Display Relay Settings
<b>Ant</b>	Toggle Antenna Selection	Toggle High/Low Impedance	Display High/Low Impedance
<b>C Up</b>	Increase Capacitance	Toggle Peak / Average Power	Display PWR Meter Mode
<b>C Dn</b>	Decrease Capacitance	Toggle Auto / Semi Mode	Display Auto / Semi Selection
<b>L Up</b>	Increase Inductance	Set PWR Meter Scale	Display PWR Meter Scale
<b>L Dn</b>	Decrease Inductance	Set Auto Tuning SWR Threshold	Display Auto Tuning SWR Threshold
<b>Func</b>	Select Secondary Button Functions		

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## **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

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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/>



**LDG Electronics  
External Meter Serial  
Communications  
Protocol Specification**



**LDG Electronics**

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[www.ldgelectronics.com](http://www.ldgelectronics.com)

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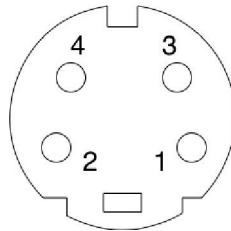
## INTRODUCTION

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 an LDG Electronics automatic tuner with external meter jack. The AT-1000ProII and AT-600ProII tuners<sup>1</sup> feature a 4-pin mini-DIN jack for connection to the LDG Electronics M1000 or M600 external meter. The tuner communicates with the meter via a TTL-level serial link. The external meter, in turn, sends requests to the tuner over this serial link. Some additional commands are built into the command protocol that allow you to build your own tuner-to-PC interface, and will allow your PC to control the AT-1000ProII or AT-600ProII tuner.

## HARDWARE INTERFACE

The AT-1000ProII and AT-600ProII tuners have a 4-pin DIN jack on the rear panel, which normally connects to the M-1000 or M-600 external meter. This jack supplies 12VDC and ground, and also provides TTL-level serial communications at 38,400 bits per second. The pinout of the jack is as follows (looking into the jack on the rear of the panel):



	<i>Name</i>	<i>Description</i>
1	+12VDC	Power to the meter
2	GND	Ground
3	METERRX	RX from meter
4	METERTX	TX to meter

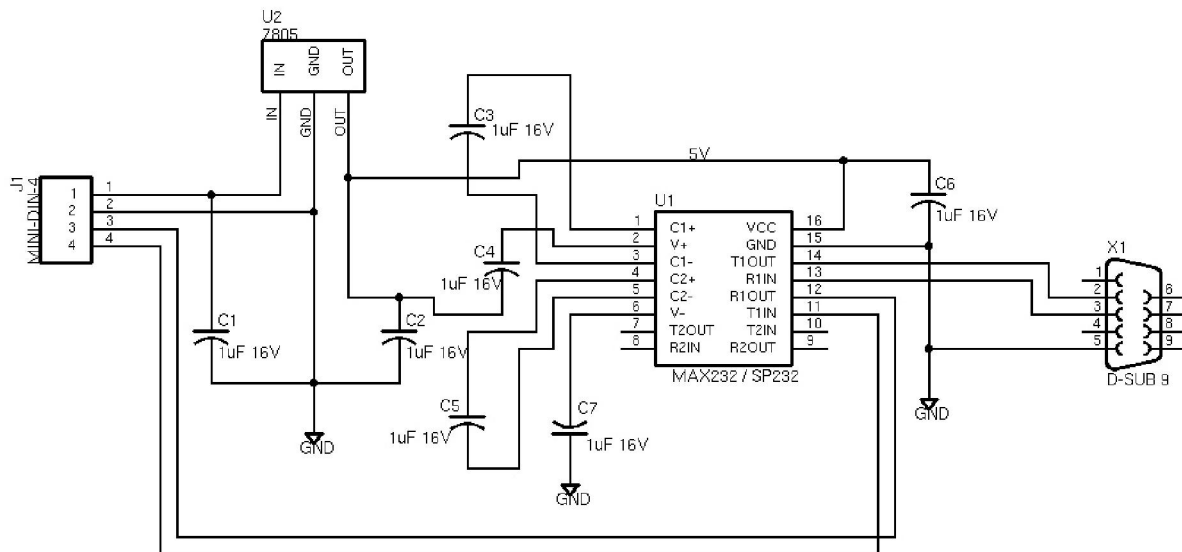
The serial data protocol over the METERRX and METERTX lines is 38,400 bits per second, 8 data bits, one stop bit, no parity. However, the signal level on these lines is TTL (0 to 5VDC), and if operation with a standard PC is required, the levels must be converted to RS232 (+/- 9VDC) first. Typically, a Maxim MAX232 or Exar SP232 level conversion chip can be used. A

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<sup>1</sup> Additional LDG Electronics tuners may include this feature in the future. This document serves to describe the protocol used in all 4-pin meter cable equipped LDG tuners.

sample schematic diagram is included here to show how to build a tuner to PC interface. LDG Electronics does not supply this interface, but may do so in the future.

The schematic below is an example of how to build a TTL to RS232 interface for communicating with the AT1000ProII via its external meter jack. Construction may be done in any way, including breadboards, PCB, point-to-point wiring, etc. The only somewhat critical construction detail is that the capacitors should be placed as close as practical to the MAX232 chip, and be sure to observe capacitor polarity if using polarized capacitors. Use whatever D-sub connector is appropriate for your application, and note that pins 2 and 3 of the D-sub may need to be swapped, depending on application. A 78L05 may be substituted for the 7805 if a smaller footprint is desired. The 4-pin mini DIN connector is Radio Shack part no. 278-0451, or DigiKey part no. CP-2040-ND



## SOFTWARE PROTOCOL

The tuner communicates with the external meter via a set of commands over the serial interface. While most of the commands are related to displaying the correct information on the external meter, LDG added some additional commands to allow the meter jack to be used for remote control of the tuner.

All commands sent to the tuner are single-byte commands. These are simple requests for such things as “Begin tuning cycle”, “Toggle Antenna”, etc. However, because the tuner’s CPU is in “sleep” mode most of the time, each single byte command should be preceded by a dummy “wakeup” character or two, to get the CPU out of sleep mode and ready for reception. The Space character or NULL character are good choices to use for the wakeup character, as they are not recognized as commands by the tuner, and will be ignored.



Upon being woken up, and having received a valid command byte, the tuner, in return, will respond with a single byte acknowledgement of the command when the command is complete, with the exception of the SYNC command, which sends a multi-byte synchronization string.

The list of commands and their responses is given in the following table.

<i>Command Character</i>	<i>Name</i>	<i>Description</i>	<i>Response(s)</i>	<i>Meaning</i>
A	Toggle Antenna	Toggle between Ant1 and Ant2	1 2	Antenna 1 is selected Antenna 2 is selected
T	Memory Tune	Begin a memory tuning cycle	T M F	<ul style="list-style-type: none"> <li>• Good tune (&lt;1.5:1)</li> <li>• Tune OK (1.5-3:1)</li> <li>• Tune Failed</li> </ul>
F	Full Tune	Begin a full tuning cycle	T M F	<ul style="list-style-type: none"> <li>• Good tune (&lt;1.5:1)</li> <li>• Tune OK (1.5-3:1)</li> <li>• Tune Failed</li> </ul>
P	Pass thru	Bypass the tuner	P	• Tuner is in bypass
C	CPU-controlled Tuning	Enter fully automatic tuning mode	A	Automatic Tuning Selected
M	Manually-controlled Tuning	Enter manual (semi-auto) tuning mode	M	Manual Tuning Selected
Z	Sync	Request that the AT1000ProII send a Sync string	Sync String (See text)	The sync string can be used by the PC software to ensure that the receive buffer is in sync with the transmissions from the tuner.

The tuner listens for commands on the meter port, and responds to them when received. All commands are single characters, but must be preceded by a wakeup character, in order to bring the tuner's CPU out of sleep. For example, to toggle the selected antenna, send a space (ASCII code 32), followed by the letter "A" (ASCII code 65). The currently selected antenna will toggle, and the newly selected antenna selection will be returned.

In the case of memory tuning, for example, send a space followed by the letter "T", and the tuner will begin a tuning cycle. When the tuning cycle is complete, one of three letters will be sent in response. The letter "T" means tuning succeeded, and the match was less than 1.5:1

---

SWR. The letter “M” means that tuning succeeded, but the match was between 1.5 and 3.0:1 SWR. The letter “F” means tuning failed for some reason, either failure to find a good match, or perhaps because RF was lost before the tuning cycle could complete.

The **Sync** request (Space followed by “Z”), asks the tuner to transmit a specific string of characters. This can be used by a PC program to determine when it is in sync with the characters coming from the tuner’s meter port. The specific string sent is “000000000000000AzAz”. That’s fifteen zeroes followed by “AzAz”.

## **TIMING**

Be sure to allow at least 200 milliseconds after the receipt of any acknowledgement from the tuner before sending another command from the PC.

## **SOFTWARE**

LDG Electronics does not provide any software for controlling the AT-1000ProII or AT-600ProII via the meter port. This manual is provided as a guide for writing your own control software.

However, it is possible to control these tuners without having to write a single line of code. Because all the commands are single characters of plain ASCII, it is possible to use a simple serial terminal emulator package, such as HyperTerminal<sup>2</sup> or Indigo<sup>3</sup>, to control the tuner. Simply connect at 38,400 baud, 8 data bits, no parity, one stop bit, no handshaking, and just type a space, followed by the desired character on the keyboard you wish to send. For example, to toggle antennas, simply hit spacebar, followed by the capital A key, and the antenna relay should click, and the tuner should respond with either “1” or “2”, depending on which antenna becomes selected. Note that the tuner’s CPU returns to sleep in a short period of time, so you may need to hit the space bar and the letter “A” more quickly, so that the “A” is received while the CPU is still awake.

## **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/>

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<sup>2</sup> *HyperTerminal* and *HyperACCESS* are available from <http://www.hilgraeve.com/>

<sup>3</sup> *Indigo* is available from <http://www.shadeblue.com/>



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**Future Technology Devices International Ltd**

**TTL-232R**    **CE** **FC**

# **TTL to USB Serial Converter Range of Cables Datasheet**

**Document Reference No.: FT\_000054**

**Version 2.03**

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## 1 Description

The **TTL-232R** cables are a family of USB to TTL serial UART converter cables incorporating FTDI's FT232RQ USB to Serial UART interface IC device which handles all the USB signalling and protocols. The cables provide a fast, simple way to connect devices with a TTL level serial interface to USB.

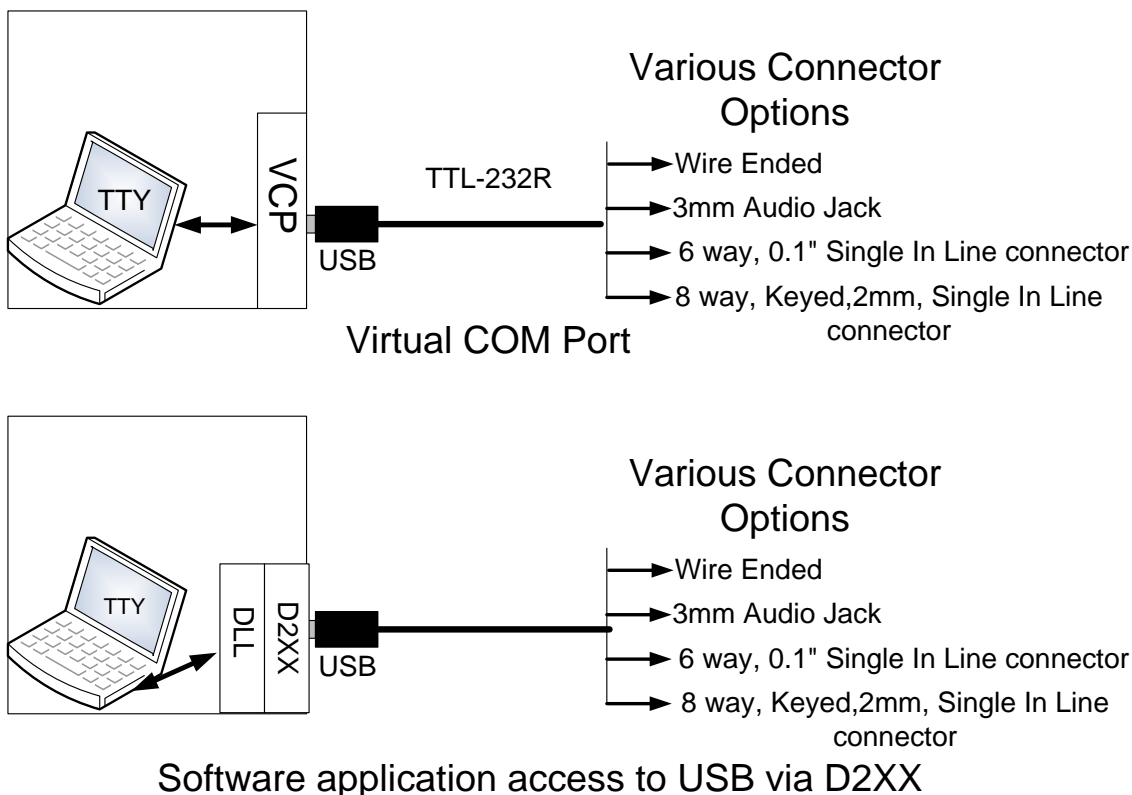
Each TTL-232R cable contains a small internal electronic circuit board, utilising the FT232R, which is encapsulated into the USB connector end of the cable. The FT232R datasheet, [DS\\_FT232R](http://www.ftdichip.com), is available at <http://www.ftdichip.com>. The other end of the cable comes with a selection of different connectors supporting various applications – see Table 1.1

Cables are FCC, CE, RoHS compliant and are available at TTL levels of +5V and +3.3V.

Cables are available with either a 6-way SIL,0.1" pitch connector, a 3.5mm Audio Jack, an 8 way, keyed 2mm pitch connector (intended for use with VMUSIC2 or VDRIVE2) or bare, tinned wire ended connections (see Table 1.1)

The USB side of the cable is USB powered and USB 2.0 full speed compatible. Each cable is 1.8m long and supports a data transfer rate up to 3 Mbaud. Each cable supports the FTDIChip-ID™, with a unique USB serial number programmed into the FT232R. This feature can be used to create a security or password protected file transfer access using the cable. Further information and examples on this feature are available at <http://www.ftdichip.com> under [FTDIChip-ID Projects](#).

The TTL-232R cables require USB drivers, available free from <http://www.ftdichip.com>, which are used to make the FT232R in the cable appear as a virtual COM port (VCP). This then allows the user to communicate with the USB interface via a standard PC serial emulation port (for example TTY). Another FTDI USB driver, the D2XX driver, can also be used with application software to directly access the FT232R on the cable through a DLL. This is illustrated in the Figure 1.1



**Figure 1.1 Using the TTL-232R Cable**

## 1.1 Available Cables and Part Numbers

The following Table 1.1 gives details of the available TTL-232R cables.

Part Number	Description	End Connector*	Cable details
TTL-232R-5V**	USB to UART cable with +5V TTL level UART signals.	6 pin SIL, 0.1" pitch	6 core, UL2464 24 AWG, diam=5mm
TTL-232R-3V3	USB to UART cable with +3.3V TTL level UART signals.	6 pin SIL, 0.1" pitch	6 core, UL2464 24 AWG, diam=5mm
TTL-232R-5V-WE**	USB to UART cable with +5V TTL level UART signals.	Wire Ended (no connector)	6 core, UL2464 24 AWG, diam=5mm
TTL-232R-3V3-WE	USB to UART cable with +3.3V TTL level UART signals.	Wire Ended (no connector)	6 core, UL2464 24 AWG, diam=5mm
TTL-232R-5V-AJ**	USB to UART cable with +5V TTL level UART signals.	3.5mm Audio Jack	2 core and spiral, 24 AWG diam=5mm
TTL-232R-3V3-AJ	USB to UART cable with +3.3V TTL level UART signals.	3.5mm Audio Jack	2 core and spiral, 24 AWG diam=5mm
TTL-232R-3V3-2mm	USB to UART cable with +3.3V TTL level UART signals.	8 way, keyed, 2mm connector for use with FTDI VDRIVE2 or VMUSIC2 modules	7 core, UL2464 26 AWG, diam=5mm

**Table 1.1 TTL-232R Cables Descriptions and Part Numbers**

\* FTDI supports customised end connector designs. For more information, please contact FTDI Sales Team (sales1@ftdichip.com)

\*\* These cables are identical to cables which do not have the "5V" in the part number. The 5V was added to the part number for clarity.

## 1.2 Certifications

FTDI TTL-232R range of cables are fully RoHs compliant as well as CE and FCC certified (with the exception of the TTL-232R-XX-WE cables which have not yet completed FCC and CE testing).



## 1.3 USB Compliant

The TTL-232R cables are fully compliant with the USB 2.0 specification.



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TTL-232R TTL TO USB SERIAL CONVERTER RANGE OF CABLES Datasheet Version 2.03  
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## 2 Typical Applications

- USB to Serial TTL Level Converter
- Upgrading Legacy Peripherals to USB
- Interface Microcontroller UART or I/O to USB
- Interface FPGA / PLD to USB
- Interface to FTDI VDRIVE2 or VMUSIC2 modules.
- Replace MAX232 type level shifters allowing for direct connection of products to PC via USB
- USB Instrumentation PC interface
- USB Industrial Control
- USB Software / Hardware Encryption Dongles

### 2.1 Driver Support

#### Royalty free VIRTUAL COM PORT (VCP) DRIVERS for...

- Windows 10 32,64-bit
- Windows 8/8.1 32,64-bit
- Windows 7 32,64-bit
- Windows Vista and Vista 64-bit
- Windows XP and XP 64-bit
- Windows 98, 98SE, ME, 2000, Server 2003, XP, Server 2008 and server 2012 R2
- Windows XP Embedded
- Windows CE 4.2, 5.0 and 6.0
- Mac OS 8/9, OS-X
- Linux 2.4 and greater

#### Royalty free D2XX Direct Drivers (USB Drivers + DLL S/W Interface)

- Windows 10 32,64-bit
- Windows 8/8.1 32,64-bit
- Windows 7 32,64-bit
- Windows Vista and Vista 64-bit
- Windows XP and XP 64-bit
- Windows 98, 98SE, ME, 2000, Server 2003, XP, Server 2008 and server 2012 R2
- Windows XP Embedded
- Windows CE 4.2, 5.0 and 6.0
- Linux 2.4 and greater
- Android (J2xx)

The drivers listed above are all available to download for free from [www.ftdichip.com](http://www.ftdichip.com). Various 3rd Party Drivers are also available for various other operating systems - see [www.ftdichip.com](http://www.ftdichip.com) for details.

## 2.2 Features

- TTL-232R Converter Cable provides a USB to TTL Serial interface with various end connectors.
- On board FT232RQ provides single chip USB to asynchronous serial data transfer interface.
- Entire USB protocol handled by the electronics in the cable USB.
- Connect directly to a microcontroller UART or I/O pins.
- UART interface support for 7 or 8 data bits, 1 or 2 stop bits and odd / even / mark / space / no parity.
- Fully assisted hardware (RTS#/CTS#) or X-On / X-Off software handshaking.
- Data transfer rates from 300 baud to 3 Mbaud at TTL levels.
- Internal EEPROM with user writeable area.
- 5V CMOS drive outputs and 5V safe TTL inputs makes the TTL-232R easy to interface to 5V MCU's.
- FTDI's royalty-free VCP allow for communication as a standard emulated COM port and D2XX 'direct' drivers provide DLL application programming interface.
- Support for FT232R FTDIChip-ID™ feature for improved security.
- +5V or +3.3V output allows external logic to be powered from the USB port.
- 6 way outputs provide Tx, Rx, RTS#, CTS#, VCC and GND (except Audio Jack which provides only TX,RX and GND).
- 8 way, keyed connector to support FTDI VDRIVE2 and VMUSIC2.
- 3 way Audio Jack connector provides Tx, Rx and GND.
- Low USB bandwidth consumption.
- UHCI / OHCI / EHCI host controller compatible.
- USB 2.0 Full Speed compatible.
- -40°C to +85°C operating temperature range.
- Cable length is 1.80m (6 feet).
- FCC and CE compliant.
- Custom versions also available (subject to MOQ).

### 3 Features of FT232R applicable to TTL-232R Cables

The TTL-232R cables use FTDI's FT232RQ USB to serial IC device. This section summarises the key features of the FT232RQ which apply to the TTL-232R USB to serial TTL converter cables. For further details, and a full features and enhancements description consult the FT232R datasheet, this is available from [www.ftdichip.com](http://www.ftdichip.com).

**Internal EEPROM.** The internal EEPROM in each cable is used to store USB Vendor ID (VID), Product ID (PID), device serial number, product description string and various other USB configuration descriptors. Each cable is supplied with the internal EEPROM pre-programmed as described in **Contact Information**

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#### Distributor and Sales Representatives

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**Appendix A - Cable EEPROM Configuration.** A user area of the internal EEPROM is available to system designers to allow storing additional data. The internal EEPROM descriptors can be programmed in circuit, over USB without any additional voltage requirement. It can be programmed using the FTDI utility software called [FT\\_PROG](#), which can be downloaded from FTDI Utilities on the FTDI website ([www.ftdichip.com](http://www.ftdichip.com)).

**Lower Operating and Suspend Current.** The FT232R has a low 15mA operating supply current and a very low USB suspend current of approximately 70µA. (Note that during suspend mode, the current drawn by application should not exceed 2.5mA to remain USB compliant)

**Low USB Bandwidth Consumption.** The USB interface of the FT232R, and therefore the TTL-232R cables has been designed to use as little as possible of the total USB bandwidth available from the USB host controller.

**High Output Drive Option.** The UART interface I/O pins on the TTL-232R cables (RXD, TXD, RTS#, and CTS#) can be configured to use the FT232R's high output drive option. This option allows the FT232R I/O pins to drive up to three times the standard signal drive level. This allows multiple devices to be driven, or devices that require a greater signal drive strength to be interfaced to the cables. This option is enabled in the internal EEPROM.

**UART Pin Signal Inversion.** The sense of each of the eight UART signals can be individually inverted by configuring options in the internal EEPROM. For example CTS# (active low) can be changed to CTS (active high), or TXD can be changed to TXD#.

**FTDICHIP-ID™.** The FT232R includes the new FTDICHIP-ID™ security dongle feature. This FTDICHIP-ID™ feature allows a unique number to be burnt into each cable during manufacture. This number cannot be reprogrammed. This number is only readable over USB can be used to form the basis of a security dongle which can be used to protect any customer application software being copied. This allows the possibility of using the TTL-232R cables as a dongle for software licensing. Further to this, a renewable license scheme can be implemented based on the FTDICHIP-ID™ number when encrypted with other information. This encrypted number can be stored in the user area of the FT232R internal EEPROM, and can be decrypted, then compared with the protected FTDICHIP-ID™ to verify that a license is valid. Web based applications can be used to maintain product licensing this way. An application note, AN232R-02, available from FTDI website ([www.ftdichip.com](http://www.ftdichip.com)) describes this feature.

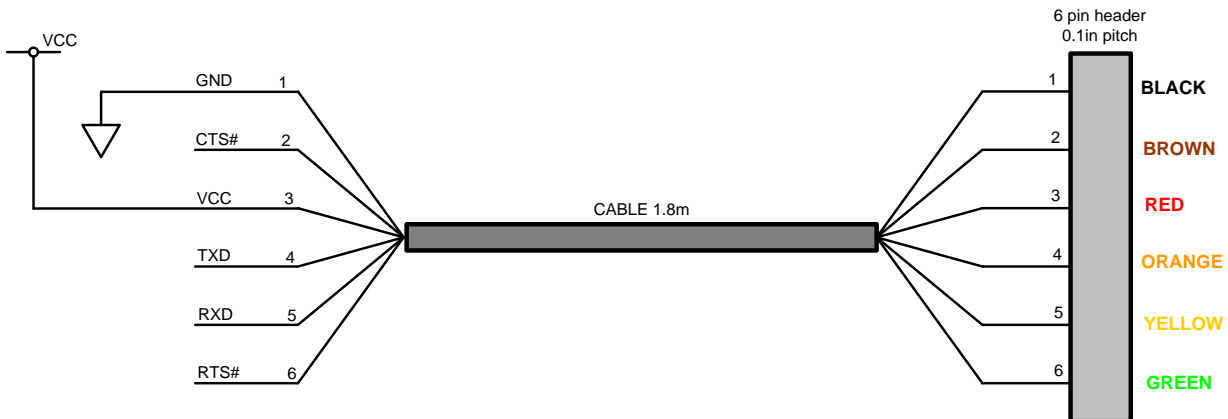
**Improved EMI Performance.** The TTL-232R cables are FCC and CE certified.

**Extended Operating Temperature Range -** The TTL-232R cables are capable of operating over an extended temperature range of -40° to +85° C thus allowing them to be used in automotive or industrial applications.

## 4 TTL-232R-5V and TTL-232R-3V3 Cables

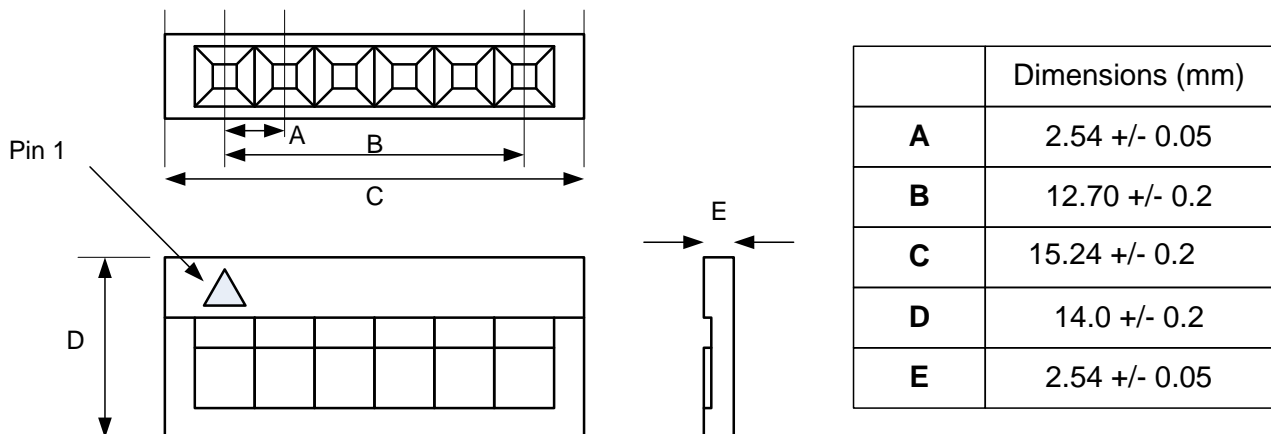
The TTL-232R-5V and TTL-232R-3V3 cables are both terminated by a 6 way, 0.1", Single-In-Line (SIL) connector. The difference between the two cables is that the TTL-232R-5V operates at +5V levels (signals and power supply) and the TTL-232R-3V3 operates at +3.3V levels (signals only, VCC= +5V).

### 4.1 TTL-232R-5V, TTL-232R-3V3 Connector Pin Out and Mechanical details



**Figure 4.1 TTL-232R-5V and TTL-232R-3V3, 6 Way Header Pin Out**

The mechanical details of the 6 way connector are shown in the following diagram



**Figure 4.2 TTL-232R-5V TTL-232R-3V3, 6 Way Header Mechanical Details**

### 4.2 TTL-232R-5V and TTL-232R-3V3 Cable Signal Descriptions

Header Pin Number	Name	Type	Colour	Description
1	GND	GND	Black	Device ground supply pin.
2	CTS#	Input	Brown	Clear to Send Control input / Handshake signal.
3	VCC	Output	Red	+5V output,

Header Pin Number	Name	Type	Colour	Description
4	TXD	Output	Orange	Transmit Asynchronous Data output.
5	RXD	Input	Yellow	Receive Asynchronous Data input.
6	RTS#	Output	Green	Request To Send Control Output / Handshake signal.

**Table 4.1 TTL-232R-5V and TTL-232R-3V3 Cable Signal Descriptions**

### 4.3 TTL-232R-5V and TTL-232R-3V3 Electrical Parameters

#### 4.3.1 TTL-232R-5V Electrical Parameters

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
VCC	Output Power Voltage	4.25	5.0	5.25	V	Dependant on the USB port that the TTL-232R-5V is connected to
I <sub>o</sub>	Output Power Current	-	-	75	mA	Must be less than 2.5mA during suspend.
T	Operating Temperature Range	-40	-	+85	°C	

**Table 4.2 TTL-232R-5V I/O Operating Parameters**

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
V <sub>oh</sub>	Output Voltage High	3.2	4.1	4.9	V	I source = 2mA
V <sub>ol</sub>	Output Voltage Low	0.3	0.4	0.6	V	I sink = 2mA
V <sub>in</sub>	Input Switching Threshold	1.0	1.2	1.5	V	
V <sub>Hys</sub>	Input Switching Hysteresis	20	25	30	mV	

**Table 4.3 TTL-232R-5V I/O Pin Characteristics**

#### 4.3.2 TTL-232R-3V3 Electrical Parameters

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
VCC	Output Power Voltage	4.25	5.0	5.25	V	Dependant on the USB port that the TTL-232R-3V3 is connected to
I <sub>o</sub>	Output Power Current	-	-	75	mA	Must be less than 2.5mA during suspend.
T	Operating Temperature Range	-40	-	+85	°C	

**Table 4.4 TTL-232R-3V3 I/O Operating Parameters**

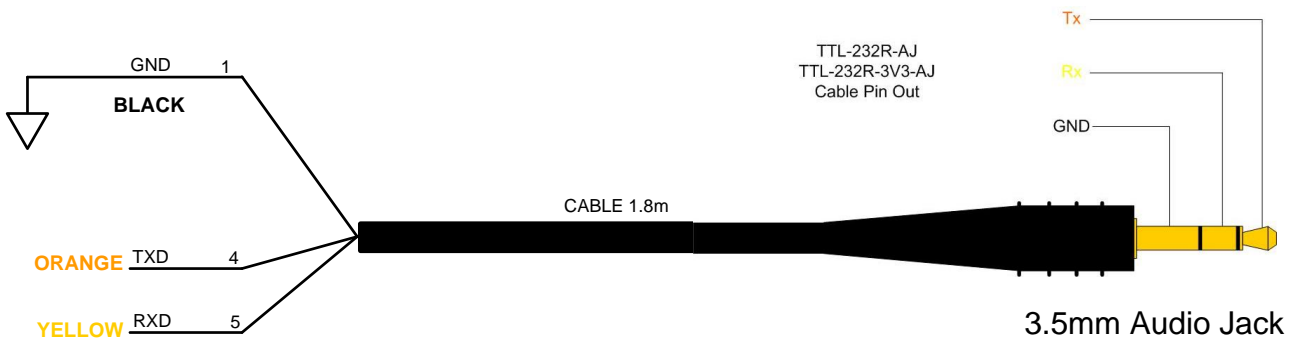
Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
Voh	Output Voltage High	2.2	2.8	3.2	V	I source = 3mA
Vol	Output Voltage Low	0.3	0.4	0.6	V	I sink = 8mA
Vin	Input Switching Threshold	1.0	1.2	1.5	V	
VHys	Input Switching Hysteresis	20	25	30	mV	

**Table 4.5 TTL-232R-3V3 I/O Pin Characteristics**

## 5 TTL-232R-5V-AJ and TTL-232R-3V3-AJ

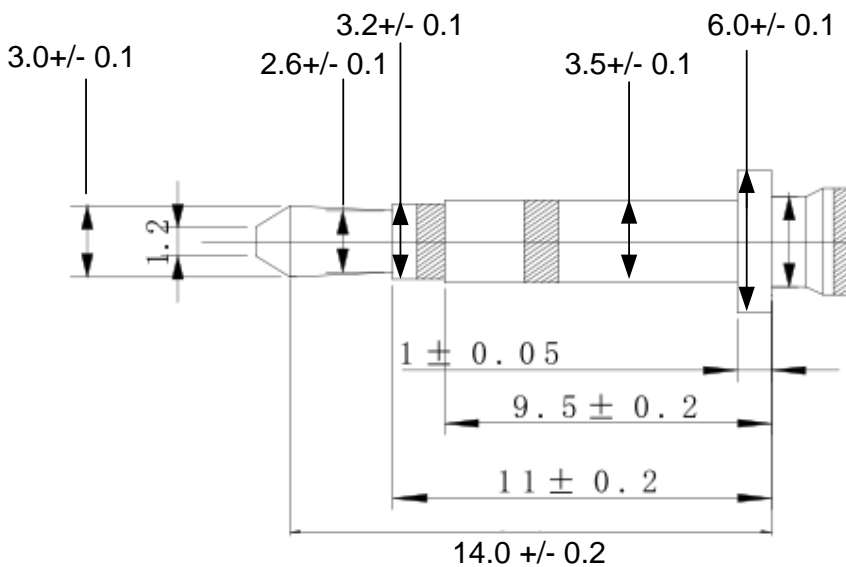
The TTL-232R-5V-AJ and TTL-232R-3V3-AJ cables are both terminated by a standard 3.5mm Audio Jack (AJ) connector. The difference between the two cables is that the TTL-232R-5V-AJ operates at +5V levels (signals and power supply) and the TTL-232R-3V3-AJ operates at +3.3V levels (signals and power supply). On these cables the VCC power is not transferred.

### 5.1 TTL-232R-5V-AJ, TTL-232R-3V3-AJ Connector Pin Out and Mechanical details



**Figure 5.1 TTL-232R-5V and TTL-232R-3V3, 6 Way Header Pin Out**

The mechanical details of the Audio Jack connector are shown in the following **Figure 5.2**.



Dimensions in mm

**Figure 5.2 TTL-232R-5V-AJ and TTL-232R-3V3-AJ Audio Jack Mechanical Details**



## 5.2 TTL-232R-5V-AJ and TTL-232R-3V3-AJ Cable Signal Descriptions

Header Pin Number	Name	Type	Colour	Description
TIP	TXD	GND	Black	Transmit Asynchronous Data output.
RING	RXD	Input	Brown	Receive Asynchronous Data input.
SLEEVE	GND	Output	Red	GND

**Table 5.1 TTL-232R-5V-AJ and TTL-232R-3V3-AJ Cable Signal Descriptions**

## 5.3 TTL-232R-5V-AJ and TTL-232R-3V3-AJ Electrical Parameters

### 5.3.1 TTL-232R-5V-AJ Electrical Parameters

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
$I_o$	Output Power Current	-		75	mA	Must be less than 2.5mA during suspend.
T	Operating Temperature Range	-40		+85	°C	

**Table 5.2 TTL-232R-5V-AJ I/O Operating Parameters**

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
Voh	Output Voltage High	3.2	4.1	4.9	V	I source = 6mA
Vol	Output Voltage Low	0.3	0.4	0.6	V	I sink = 6mA
Vin	Input Switching Threshold	1.0	1.2	1.5	V	
VHys	Input Switching Hysteresis	20	25	30	mV	

**Table 5.3 TTL-232R-5V-AJ I/O Pin Characteristics**

### 5.3.2 TTL-232R-3V3-AJ Electrical Parameters

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
I <sub>o</sub>	Output Power Current	-		75	mA	Must be less than 2.5mA during suspend.
T	Operating Temperature Range	-40		+85	°C	

**Table 5.4 TTL-232R-3V3-AJ I/O Operating Parameters**

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
V <sub>oh</sub>	Output Voltage High	2.2	2.8	3.2	V	I source = 3mA
V <sub>ol</sub>	Output Voltage Low	0.3	0.4	0.6	V	I sink = 8mA
V <sub>in</sub>	Input Switching Threshold	1.0	1.2	1.5	V	
V <sub>Hys</sub>	Input Switching Hysteresis	20	25	30	mV	

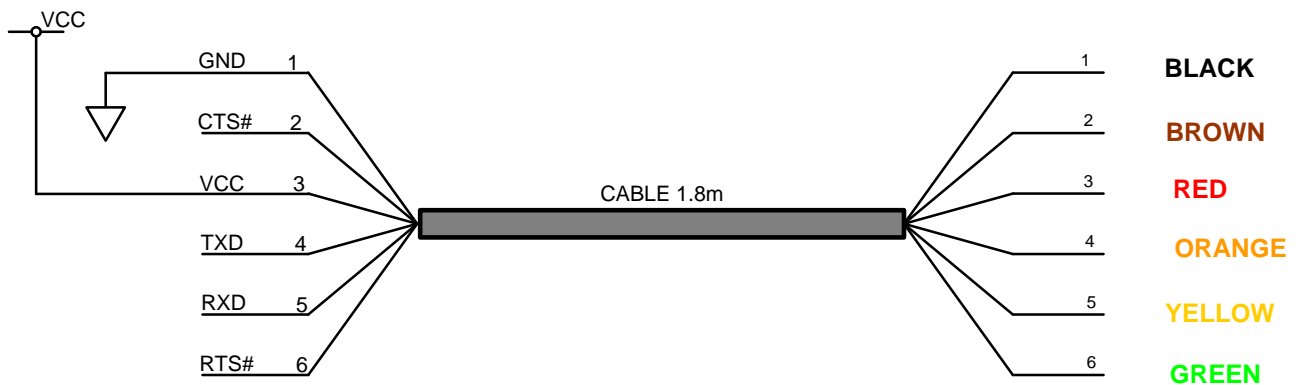
**Table 5.5 TTL-232R-3V3-AJ I/O Pin Characteristics**

## 6 TTL-232R-5V-WE and TTL-232R-3V3-WE Cables

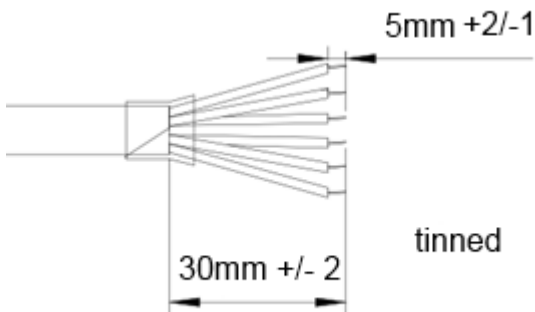
The TTL-232R-5V-WE and TTL-232R-3V3-WE cables are both un-terminated; they are bare and tinned wires. The difference between the two cables is that the TTL-232R-5V-WE operates at +5V levels (signals and power supply) and the TTL-232R-3V3-WE operates at +3.3V levels (signals only, VCC=+5V).

### 6.1 TTL-232R-5V-WE, TTL-232R-3V3-WE Connections and Mechanical Details

The following Figure 6.1 shows the cable signals and the wire colours for these signals on the TTL-232R-5V-WE and TTL-232R-3V3-WE cables.



**Figure 6.1 TTL-232R-5V-WE and TTL-232R-3V3-WE Connections**



**Figure 6.2 TTL-232R-5V-WE and TTL-232R-3V3-WE Mechanical Details (dimensions in mm)**

### 6.2 TTL-232R-5V-WE and TTL-232R-3V3-WE Cable Signal Descriptions

Colour	Name	Type	Description
Black	GND	GND	Device ground supply pin.
Brown	CTS#	Input	Clear to Send Control input / Handshake signal.
Red	VCC	Output	+5V output
Orange	TXD	Output	Transmit Asynchronous Data output.
Yellow	RXD	Input	Receive Asynchronous Data input.
Green	RTS#	Output	Request To Send Control Output / Handshake signal.

**Table 6.1 TTL-232R-5V-WE and TTL-232R-3V3-WE Cable Signal Descriptions**

### 6.3 TTL-232R-5V-WE and TTL-232R-3V3-WE Electrical Parameters

### 6.3.1 TTL-232R-5V-WE Electrical Parameters

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
VCC	Output Power Voltage	4.25	5.0	5.25	V	Dependant on the USB port that the TTL-232R-5V-WE is connected to
I <sub>o</sub>	Output Power Current	-		75	mA	Must be less that 2.5mA during suspend.
T	Operating Temperature Range	-40		+85	°C	

**Table 6.2 TTL-232R-5V-WE I/O Operating Parameters**

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
V <sub>oh</sub>	Output Voltage High	3.2	4.1	4.9	V	I source = 6mA
V <sub>ol</sub>	Output Voltage Low	0.3	0.4	0.6	V	I sink = 6mA
V <sub>in</sub>	Input Switching Threshold	1.0	1.2	1.5	V	
V <sub>Hys</sub>	Input Switching Hysteresis	20	25	30	mV	

**Table 6.3 TTL-232R-5V-WE I/O Pin Characteristics**

### 6.3.2 TTL-232R-3V3-WE Electrical Parameters

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
VCC	Output Power Voltage	4.25	5.0	5.25	V	Dependant on the USB port that the TTL-232R-3V3-WE is connected to
I <sub>o</sub>	Output Power Current	-		75	mA	Must be less that 2.5mA during suspend.
T	Operating Temperature Range	-40		+85	°C	

**Table 6.4 TTL-232R-3V3-WE I/O Operating Parameters**

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
V <sub>oh</sub>	Output Voltage High	2.2	2.8	3.2	V	I source = 3mA
V <sub>ol</sub>	Output Voltage Low	0.3	0.4	0.6	V	I sink = 8mA
V <sub>in</sub>	Input Switching Threshold	1.0	1.2	1.5	V	
V <sub>Hys</sub>	Input Switching Hysteresis	20	25	30	mV	

**Table 6.5 TTL-232R-3V3-WE I/O Pin Characteristics**

## 7 TTL-232R-3V3-2mm Cables

The TTL-232R-3V3-2mm cable is terminated by a 8 way, 2mm pitch, Single-In-Line (SIL) keyed connector. The TTL-232R-3V3-2mm operates at +3.3V levels (signals and power supply). These cables are primarily intended for interfacing the FTDI VDRIVE2 and VMUSIC2 modules.

Note that when connected to VDRIVE2 or VMUSIC2 module, the TTL-232R-3V3-2mm cable 8-way connector pin 1 connects to pin 8 of the module, and pin 8 of the cable connects to pin 1 of the cable.

### 7.1 TTL-232R-3V3-2mm Connector Pin Out and Mechanical details

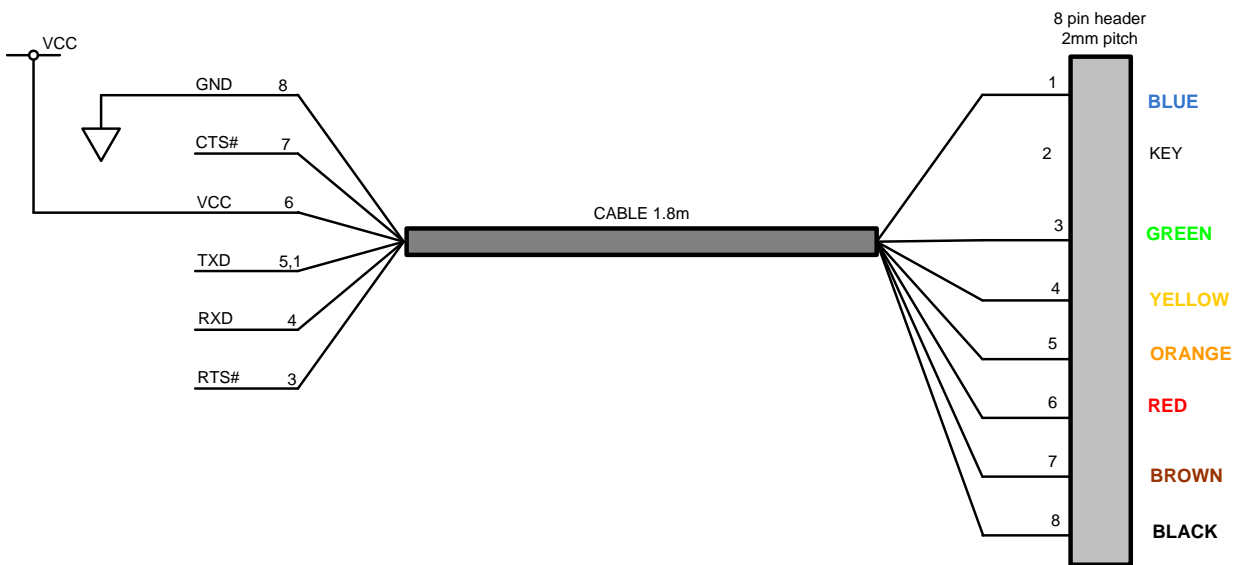


Figure 7.1 TTL-232R-3V3-2mm, 8 Way Header Pin Out

The mechanical details of the 2mm pitch 8 way, keyed, connector are shown in the following diagram

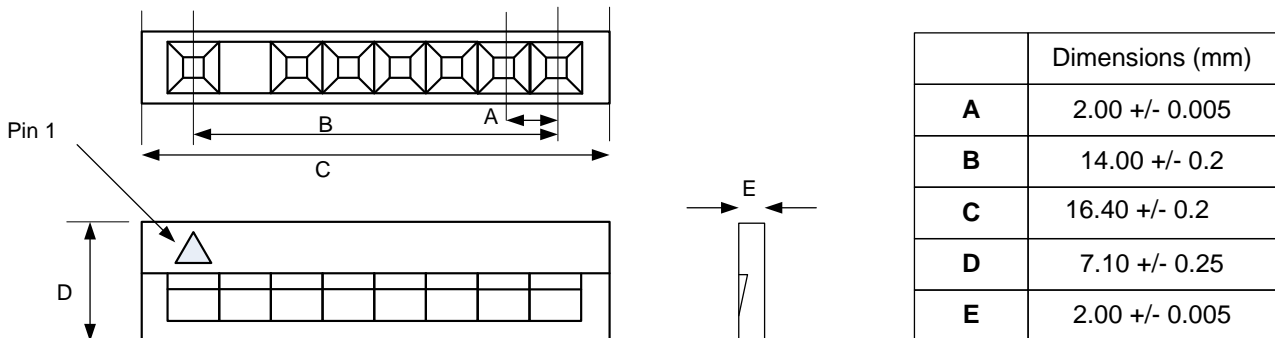


Figure 7.2 TTL-232R-3V3-2mm, 2mm pitch, Keyed, 8 way Header Mechanical Details

## 7.2 TTL-232R-3V3-2mm Cable Signal Descriptions

Header Pin Number	Name	Type	Colour	Description
1	RI#	Output	Blue	Ring Indicator Control Input. When remote wake up is enabled taking RI# low (20ms active low pulse) can be used to resume the VMUSIC2 or VDRIVE2 host controller from suspend. Connected to TXD.
2	KEY	KEY	KEY	This connection is keyed to connect to the VRDIVE2 or the VMUSIC2 modules
3	RTS#	Output	Green	Request To Send Control Output / Handshake signal.
4	RXD	Input	Yellow	Receive Asynchronous Data input.
5	TXD	Output	Orange	Transmit Asynchronous Data output.
6	VCC	Output	Red	+5V output,
7	CTS#	Input	Brown	Clear to Send Control input / Handshake signal.
8	GND	GND	Black	Device ground supply pin.

**Table 7.1 TTL-232R-3V3-2mm Cable Signal Descriptions**

## 7.3 TTL-232R-3V3-2mm Electrical Parameters

Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
VCC	Output Power Voltage	4.25	5.0	5.25	V	Dependant on the USB port that the TTL-232R-3V3-2mm is connected to
I <sub>o</sub>	Output Power Current	-		75	mA	Must be less that 2.5mA during suspend.
T	Operating Temperature Range	-40		+85	°C	

**Table 7.2 TTL-232R-3V3-2mm I/O Operating Parameters**

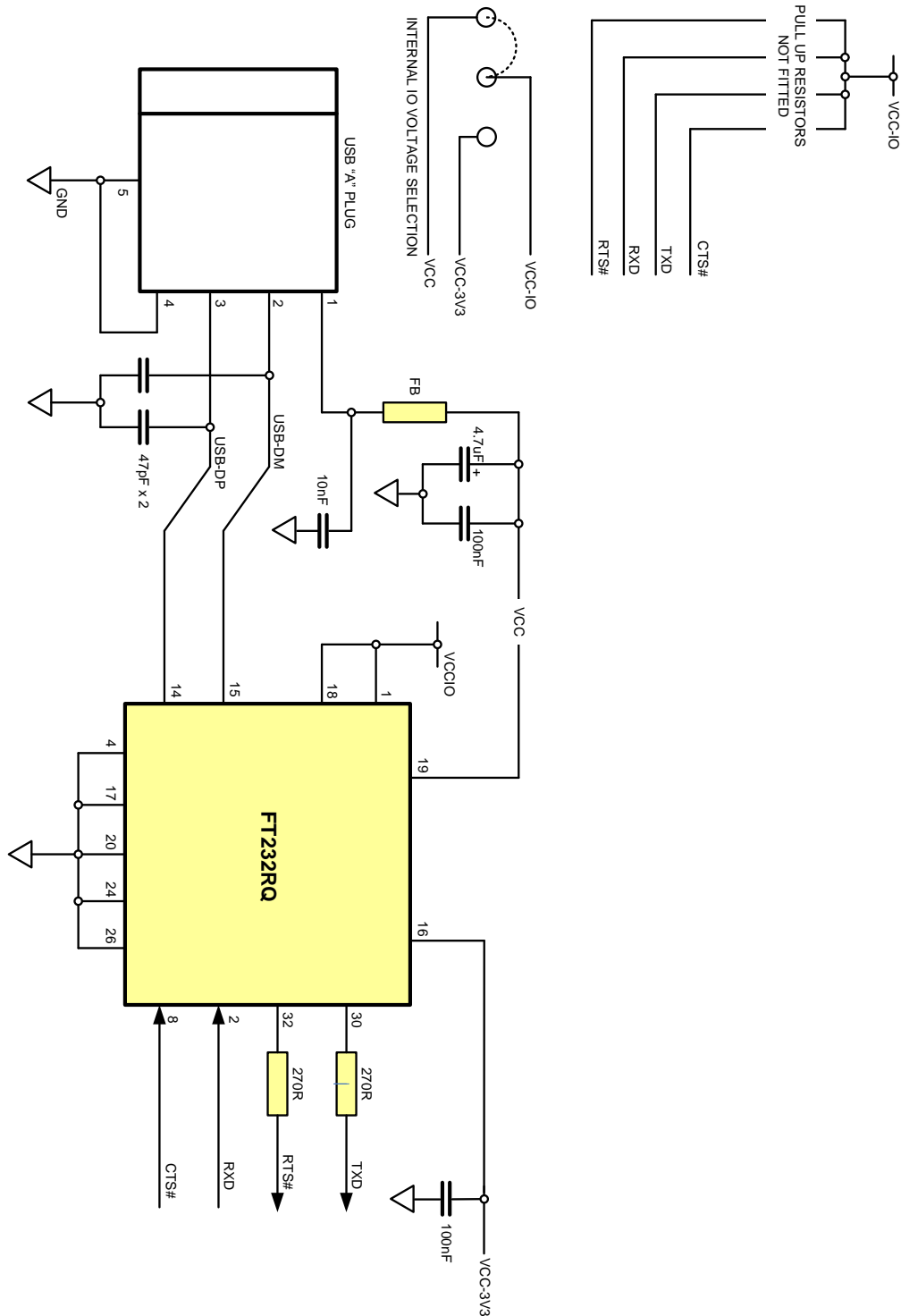
Parameter	Description	Minimum	Typical	Maximum	Units	Conditions
V <sub>oh</sub>	Output Voltage High	2.2	2.8	3.2	V	I source = 3mA
V <sub>ol</sub>	Output Voltage Low	0.3	0.4	0.6	V	I sink = 8mA
V <sub>in</sub>	Input Switching Threshold	1.0	1.2	1.5	V	
V <sub>Hys</sub>	Input Switching Hysteresis	20	25	30	mV	

**Table 7.3 TTL-232R-3V3-2mm I/O Pin Characteristics**

## 8 Cable PCB Circuit Schematic

The circuit schematic for the small internal electronic circuit board, utilising the FTDI FT232R, which is encapsulated into the USB connector end of the cable, is shown in Figure 8.1.

Customised versions of these cables are also available. Users interested in customised versions of these cables should contact FTDI sales (sales1@ftdichip.com).



**Figure 8.1 Circuit Schematic of PCB Used in the TTL to USB Serial Converter Cables**

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## Appendix A - Cable EEPROM Configuration

Each TTL-232R cable is controlled by the FTDI FT232R IC. This FT232R device contains an EEPROM which contains the USB configuration descriptors for that device. When the cable is plugged into a PC or a USB reset is performed, the PC will read these descriptors. The default values stored into the internal EEPROM are defined in Table 0.1

Parameter	Value	Notes
USB Vendor ID (VID)	0403h	FTDI default VID (hex)
USB Product ID (PID)	6001h	FTDI default PID (hex)
Serial Number Enabled?	Yes	
Serial Number	See Note	A unique serial number is generated and programmed into the EEPROM during device final test.
Pull down I/O Pins in USB Suspend	Disabled	Enabling this option will make the device pull down on the UART interface lines when the power is shut off (PWREN# is high).
Manufacturer Name	FTDI	
Product Description	See note	Product description depends on the cable. The following lists the Product description for each different cable. TTL-232R-5V TTL-232R-3V3 TTL-232R-5V-AJ TTL-232R-AJ-3V3 TTL-232R-5V-WE TTL-232R-3V3-WE TTL-232R-3V3-2mm = USB <-> Serial Cable
Max Bus Power Current	90mA	
Power Source	Bus Powered	
Device Type	FT232R	
USB Version	0200	Returns USB 2.0 device description to the host. Note: The device is be a USB 2.0 Full Speed device (12Mb/s) as opposed to a USB 2.0 High Speed device (480Mb/s).
Remote Wake Up	Disabled	
High Current I/Os	Enabled	Enables the high drive level on the UART and CBUS I/O pins.
Load VCP Driver	Enabled	Makes the device load the VCP driver interface for the device.
Invert TXD	Disabled	Signal on this pin becomes TXD# if enable.
Invert RXD	Disabled	Signal on this pin becomes RXD# if enable.
Invert RTS#	Disabled	Signal on this pin becomes RTS if enable.
Invert CTS#	Disabled	Signal on this pin becomes CTS if enable.

**Table 0.1 Default Internal EEPROM Configuration**



The internal EEPROM in the cable can be re-programmed over USB using the utility program [FT\\_PROG](#). [FT\\_PROG](#) can be downloaded from the [www.ftdichip.com](http://www.ftdichip.com). Version 2.8a or later is required for the FT232R chip. Users who do not have their own USB Vendor ID but who would like to use a unique Product ID in their design can apply to FTDI for a free block of unique PIDs. Contact FTDI support for this service.

## Appendix B - List of Figures and Tables

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## Appendix C - Revision History

Document Title: TTL to USB Serial Converter Range of Cables  
 Document Reference No.: FT\_000054  
 Clearance No.: FTDI# 53  
 Driver Page: <http://www.ftdichip.com/FTDrivers.htm>  
 Document Feedback: [Send Feedback](#)

Revision	Changes	Date
1.0	Initial Release	May 2006
2.0	Consolidated all TTL-232R variants into one datasheet. Changed part numbers for +5V cables.	July 2008
2.01	Corrected Table 6.1, RED wire VCC description	September 2008
2.02	Corrected Table 4.3, I source and I sink values Added section 1.3 USB Compliant Logo Updated contact details  Replaced reference MProg with FT_Prog	September 2010
2.03	Updated driver list 2.1 Changed tolerance of wire length in 6.2 Updated contact details and Append C format	May 2016

# Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

[FTDI:](#)

[TTL-232R-5V-WE](#) [TTL-232R-5V](#)

**Power PCB Relay RZL**

- 1 pole 12/16 A, 1 form C (CO) or 1 form A (NO) contact
- DC coil 530 mW
- 5kV/10mm coil-contact, reinforced insulation
- Ambient temperature 70°C (special applications 85°C)



Typical applications  
Household appliances, boiler control, timers, garage door control



F0305-A

**Approvals in process**

VDE Cert. No. 40023970, UL E214025, CQC 14001114367, CQC 14002113865

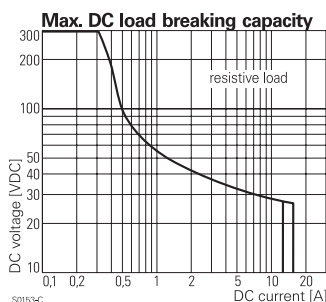
Technical data of approved types on request

Contact Data	12A	16A
Contact arrangement	1 form C (CO) or 1 form A (NO)	
Rated voltage	250VAC	
Max. switching voltage	400VAC	
Rated current	12A	16A
Limiting making current (form A contact) max. 4s, duty factor 10%	30A	
Breaking capacity max.	3000VA	4000VA
Contact material	AgNi 90/10	
Contact style	single contact	
Frequency of operation, with/without load	360/72000h <sup>-1</sup>	
Operate/release time max.	8/6ms	
Bounce time max., form A/form B	4/6ms	

**Contact ratings**

Type	Contact	Load	Cycles
<b>IEC 61810<sup>1)</sup></b>			
RZL3-1A4.	A (NO)	16A, 250VAC, 85°C	50x10 <sup>3</sup>
RZL3-1C4.	C (CO)	16A, 250VAC, 85°C	10x10 <sup>3</sup>
RZL3-1A4.	A (NO)	16A, 250VAC, 70°C	100x10 <sup>3</sup>
RZL1-1A4	A (NO)	12A, 250VAC, 85°C	100x10 <sup>3</sup>
RZL1-1A4	A (NO)	16A, 250VAC, 70°C	100x10 <sup>3</sup>
RZL3-1A4.	A (NO)	8A, cosφ=0.4, 250VAC, 25°C	100x10 <sup>3</sup>
RZL3-1C4.	B (NC)	8A, 250VAC, 25°C	100x10 <sup>3</sup>
<b>UL 508</b>			
RZL3-1A4.	A (NO)	16A, 250VAC, 85°C	50x10 <sup>3</sup>
RZL3-1C4.	C (CO)	16A, 250VAC, 85°C	10x10 <sup>3</sup>
RZL3-1A4.	A (NO)	16A, 250VAC, 70°C	100x10 <sup>3</sup>
RZL1-1A4	A (NO)	12A, 250VAC, 85°C	100x10 <sup>3</sup>
RZL1-1A4	A (NO)	16A, 250VAC, 70°C	100x10 <sup>3</sup>
RZL1/3-1A4.	A (NO)	1hp, 240VAC, 25°C	6x10 <sup>3</sup>
RZL1/3-1A4.	A (NO)	1/2hp, 120VAC, 70°C	6x10 <sup>3</sup>

1) ratings in progress



50153-c

**Coil Data**

Coil voltage range	5 to 48VDC
Operative range, IEC 61810	2
Coil insulation system according UL1446	class F

**Coil versions, DC coil**

Coil code	Rated voltage VDC	Operate voltage VDC	Release voltage VDC	Coil resistance Ω±10%	Rated coil power mW
L005	5	3,5	0,5	47	530
L006	6	4,2	0,6	67	530
L009	9	6,3	0,9	153	530
L012	12	8,4	1,2	272	530
L024	24	16,8	2,4	1086	530
L048	48	33,6	4,8	4347	530

All figures are given for coil without pre-energization, at ambient temperature +23°C. Other coil voltages on request.

**Insulation Data**

Initial dielectric strength	
between open contacts	1000V <sub>rms</sub>
between contact and coil	5000V <sub>rms</sub>
Clearance/creepage	
between contact and coil	≥10/10mm
Material group of insulation parts	IIIa
Tracking index of relay base	PTI250V

**Other Data**

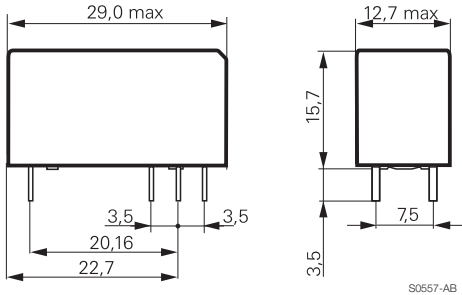
Material compliance: EU RoHS/ELV, China RoHS compliance,	
Ambient temperature	
standard version	-40 to 70°C
special applications	-40 to 85°C
Category of environmental protection	
IEC 61810	RTII - flux proof; RTIII wash tight
Vibration resistance (functional), 30 to 500Hz	
closing form A contact	>15g
opening form A contact	>20g
opening form B contact	>5g
Shock resistance (destructive)	100g
Terminal type	PCB-THT
Mounting distance	
standard version	≥0mm
Weight	10g
Resistance to soldering heat THT	
IEC 60068-2-20	260°C/10s <sup>2)</sup>
Packaging/unit	tube/20 pcs., box/500 pcs.

2) The use of foaming flux is not permitted.

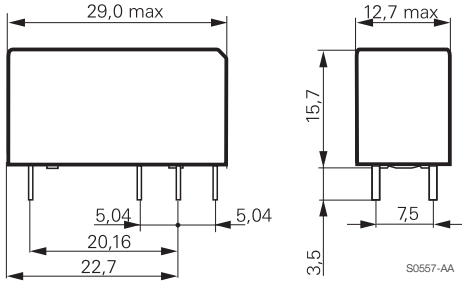
**Power PCB Relay RZL (Continued)**

**Dimensions**

12A/16A, pinning 3.5mm <sup>2)</sup>



12A, 16A, pinning 5mm <sup>2)</sup>



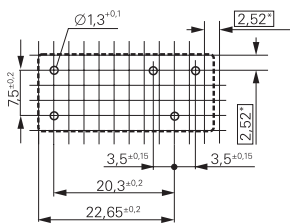
**PCB layout / terminal assignment**

Bottom view on solder pins

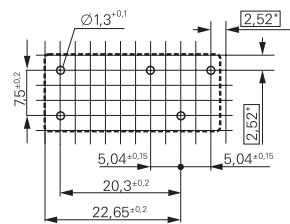
Recommended pcb hole for manual mounting:  
Ø1.3mm

For automated mounting please ask for  
detailed drawing.

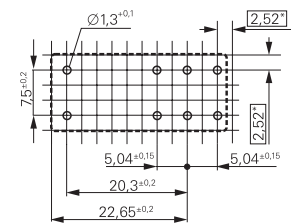
12A/16A, pinning 3.5mm <sup>2)</sup>



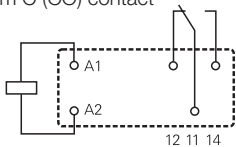
16A, pinning 5mm



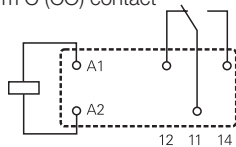
16A, pinning 5mm



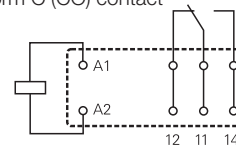
1 form C (CO) contact



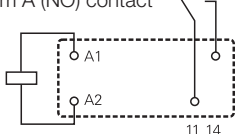
1 form C (CO) contact



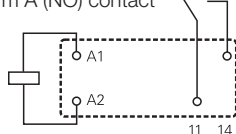
1 form C (CO) contact



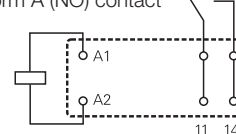
1 form A (NO) contact



1 form A (NO) contact



1 form A (NO) contact



<sup>2)</sup> For 1 Form C type, subject to develop as market requirement

**Power PCB Relay RZL** (Continued)

<b>Product code structure</b>		Typical product code		<b>RZ</b>	<b>L</b>	<b>3</b>	<b>-1C</b>	<b>4</b>	<b>-L012</b>
<b>Type</b>		RZ Power PCB Relay RZ							
<b>Version</b>		L Black Cover							
<b>Version</b>		1 3.5mm pinning, 12A/16A		3 5mm double pinning, 16A					
<b>Contact configuration</b>		1A 1 form A (1 NO) contact		1C 1 form C (1 CO) contact					
<b>Contact material</b>		4 AgNi 90/10							
<b>Coil version</b>		Coil code: please refer to coil versions table							
<b>Sealing Level</b>		R flux proof		W wash tight					

Product code	Version	Contacts	Contact material	Coil	Part number
RZL1-1A4-L012-R	12A/16A, pinning 3.5mm, flux proof	1 form A (NO)	AgNi 90/10	12VDC	2158100-4
RZL3-1A4-L012-R	16A, pinning 5mm, flux proof	1 form A (NO)		12VDC	1-2158100-6
RZL3-1A4-L024-R		1 form A (NO)		24VDC	1-2158100-7
RZL3-1C4-L012-R		1 form C (CO)		12VDC	2-2158100-2
RZL3-1C4-L024-R		1 form C (CO)		24VDC	2-2158100-3
RZL3-1A4-L012-W	16A, pinning 5mm, wash tight	1 form A (NO)		12VDC	4-2158100-0
RZL3-1C4-L024-W		1 form C (CO)		24VDC	4-2158100-7

This list represents the most common types and does not show all variants covered by this datasheet.  
Other types on request





## MINI/CIRCULAR DINs: KMDLAX Series Snap and Lock Cable Mount Plug

### Product Features

Audio, Video, Lap Top Computer and Other Portable Digital Equipment Applications  
Snap and Lock Feature Helps Prevent Accidental Disconnects  
Supplied in Kits Ready for Assembly  
Gold Plating Available Upon Request

### Performance Specifications

#### Materials and Finish

##### Insert

Nylon, Black Color, ULHB Rated

##### Plastic Shell

ABS, UL 94HB Rated

##### Contact Material

Brass, Silver Plated

##### Shield

Iron Steel, Nickel Plated

### Mechanical Characteristics

#### Suggested Wire Gauge

26-30 Awg.

#### Insertion Force

4.5kg Max.

#### Extraction Force

0.5kg - 3.0kg

#### Durability

1500 Cycles

### Electrical Characteristics

#### Contact Current Rating

2.0A Max. @12V DC and 30°C

1.25A Max. @32V DC and 30°C

1.0A Max. @32V DC and 45°C

#### Insulation Resistance

50 Megohm Min. at 250V DC

#### Dielectric Withstanding Voltage

250V AC for 1 Minute

#### Operating Temperature

-25°C to + 80°C

2D Drawing	IGES	STEP	3D PDF
Solder Profile	CofC RoHS Compliant	CofC REACH Compliant	UL Plastic File
Certificate of Origin	Check Stock	Request a Sample	Send Us An Email

### Generated Part Number

### Part Number Builder

<input type="text"/>	-	<input type="text"/>	<input type="text"/>	<input type="text"/>
Series		Number of Contacts	Contact Type	Strain Relief Diameters

#### Series

**KMDLAX** - Snap and Lock Plug

#### Number of Contacts

3 Contacts

4 Contacts

5 Contacts

6 Contacts

7 Contacts

8 Contacts

#### Contact Type

P - Plug

#### Strain Relief Diameters

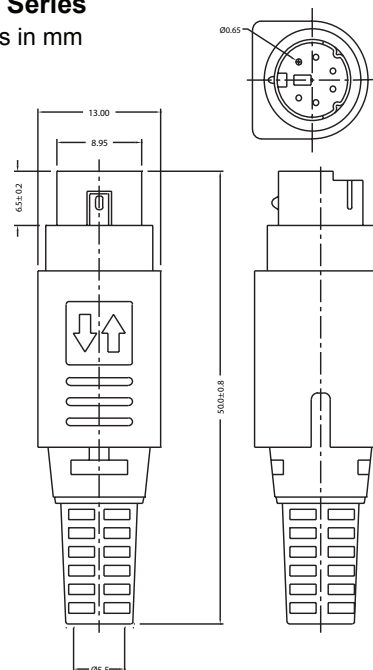
Blank - Ø5.5mm (Standard)

KPPSR - Ø6.35mm

Contact Kycon Other Options

### KMDLAX Series

Dimensions in mm



[Click here for our assembly videos](#)

# Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

[Kycon:](#)

[KMDLAX-8P](#) [KMDLAX-4P](#) [KMDLAX-6P](#) [KMDLAX-3P](#) [KMDLAX-7P](#) [KMDLAX-5P](#) [KMDLAX-8P-KPPSR](#) [KMDLAX-6P-KPPSR](#) [KMDLAX-7P-KPPSR](#) [KMDLAX-5P-KPPSR](#) [KMDLAX-4P-KPPSR](#) [KMDLAX-8P-G30](#) [KMDLAX-H](#)  
[KMDLAX-F](#) [KMDLAX-I](#) [KMDLAX-C](#) [KMDLAX-3P-KPPSR](#)

## Press Release

LDG Electronics  
1445 Parran Rd  
St. Leonard MD 20685  
(410) 586-2177  
[ldg@legelectronics.com](mailto:ldg@legelectronics.com)



## For Immediate Release

### **LDG introduces PC-controlled automatic antenna tuners**

This is the next step in the evolution of the automatic antenna tuner

St. Leonard MD, June 2019 – LDG is proud introduce the next step in the evolution of the automatic antenna tuner: PC control. With the addition of a low-cost USB cable, radio amateurs can control their AT-600ProII and AT-1000ProII tuners from their PCs, without any upgrades to the tuner. Many of the tuner’s front panel functions can be controlled via the free LDG GUI software. Use the internet and remote desktop on your computer to control your tuner from anywhere. Functions available in the free GUI are:

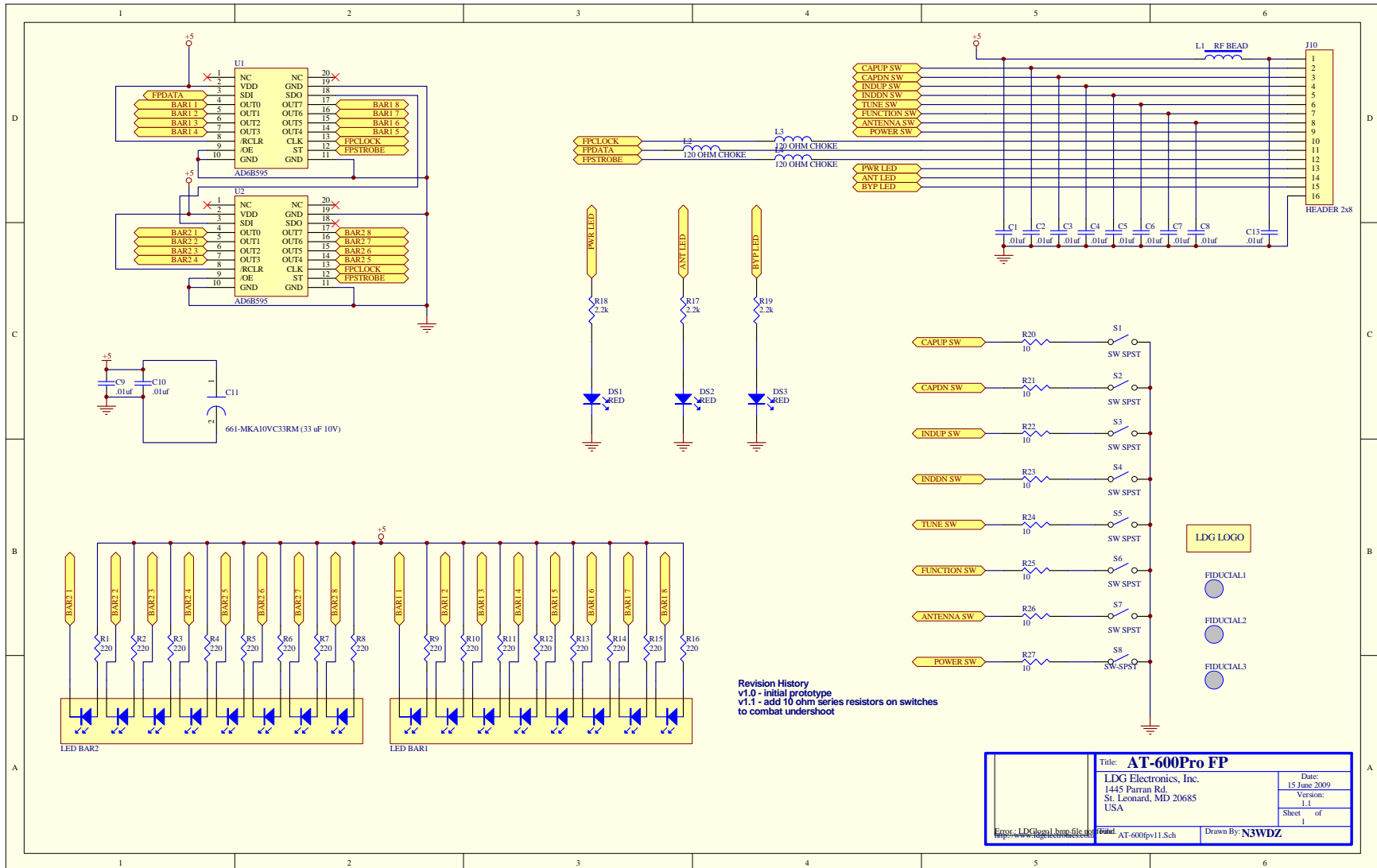
- Start Tune
- Select Ant1/Ant2
- Select Bypass
- Choose Auto/Manual modes
- SWR Result Indicator
- Tune In process Indicator

A custom USB cable connects the PC to the tuner via the tuner’s Meter port. Information for making the USB interface cable for the AT-600ProII or AT-1000ProII. Owners of these tuners can and download the free app and cable information from the LDG web site.

LDG continues to set new standards for autotuners and accessories in amateur radio service. Visit the LDG website at [www.ldgelectronics.com](http://www.ldgelectronics.com) for more information.

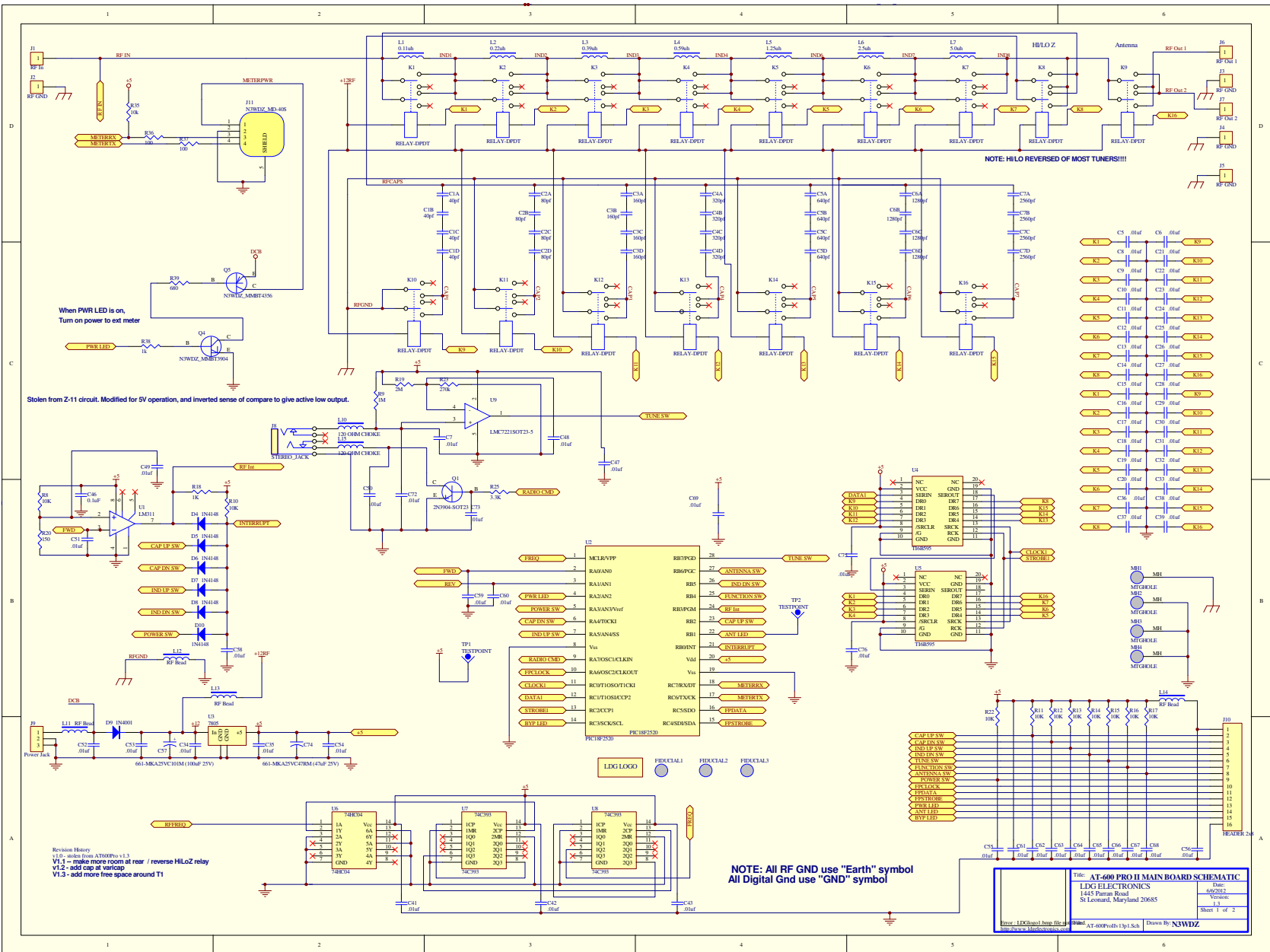
LDG Electronics is a family-owned and operated company dedicated to bringing innovative, quality products to the amateur market. Our focus is on anticipating and meeting our customer’s needs, and providing them with world-class support as they install and use our products.

###



Revision History  
v1.0 - initial prototype  
v1.1 - add 10 ohm series resistors on switches  
to combat undershoot

Title: <b>AT-600Pro FP</b>	
LDG Electronics, Inc. 1445 Parran Rd. St. Leonard, MD 20685 USA	
Date: 15 June 2009	Version: 1.1
Sheet of 1	
Drawn By: <b>N3WDZ</b>	File: AT-600fpv1.1.Sch



When PWR LED is on, Turn on power to ext meter.

Stolen from Z-11 circuit. Modified for 5V operation, and inverted sense of compare to give active low output.

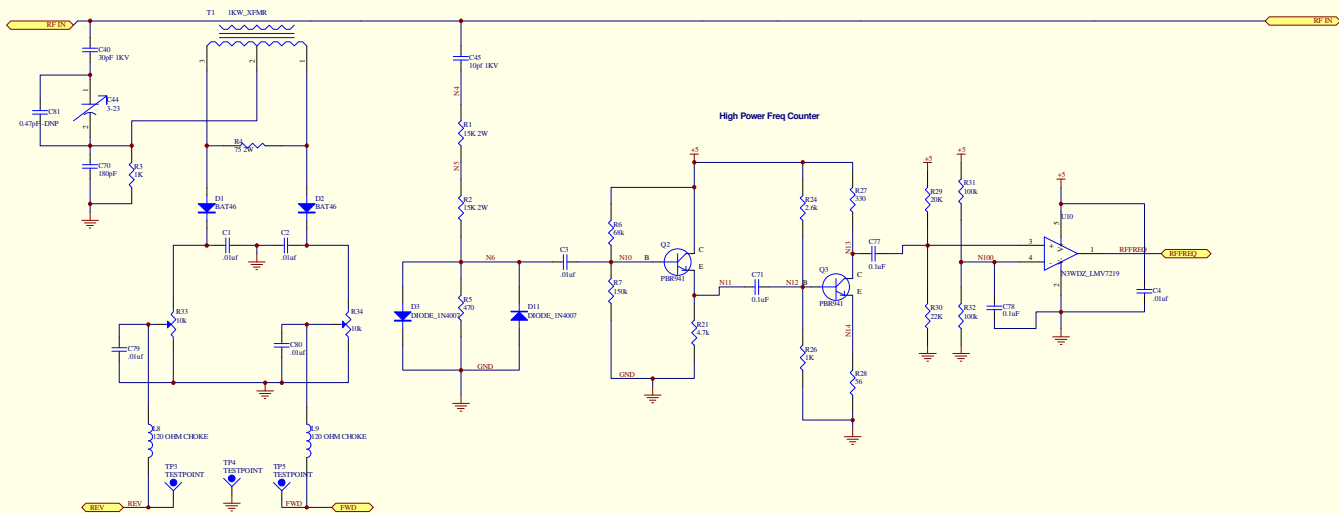
NOTE: HILoZ REVERSED OF MOST TUNERS!!!

NOTE: All RF GND use "Earth" symbol  
All Digital Gnd use "GND" symbol

Revision History  
 V1.0 - initial design  
 V1.1 - make more room at rear / reverse HILoZ relay  
 V1.2 - add cap at voltage  
 V1.3 - add more free space around T1

Title: AT-600 PRO II MAIN BOARD SCHEMATIC	
LDG ELECTRONICS	Date: 06/20/12
1445 Parra Road	Version: 1.3
St Leonard, Maryland 20685	Sheet 1 of 2
Drawn By: NSWDZ	

SWR Freq comp values updated 6/5/2012



Title			
Size	Number	Revision	
1	1		
Date:	6-Jun-2012	Sheet of	1
File:	C:\Contracting\LDGAT00\FcHn01.dwg		

Antenna 1

Bypass

Antenna 2

**In Line**

Automatic Start

Manual Start

Start Tune



1.1 - 1.7



1.7 - 3.0



Fail

Idle

Radio Sync



Select COM port

- COM 1
- COM 2
- COM 3
- COM 4
- COM 5
- COM 6
- COM 7
- COM 8
- COM 9
- COM 10
- COM 11
- COM 12
- COM 13
- COM 14
- COM 15
- COM 16

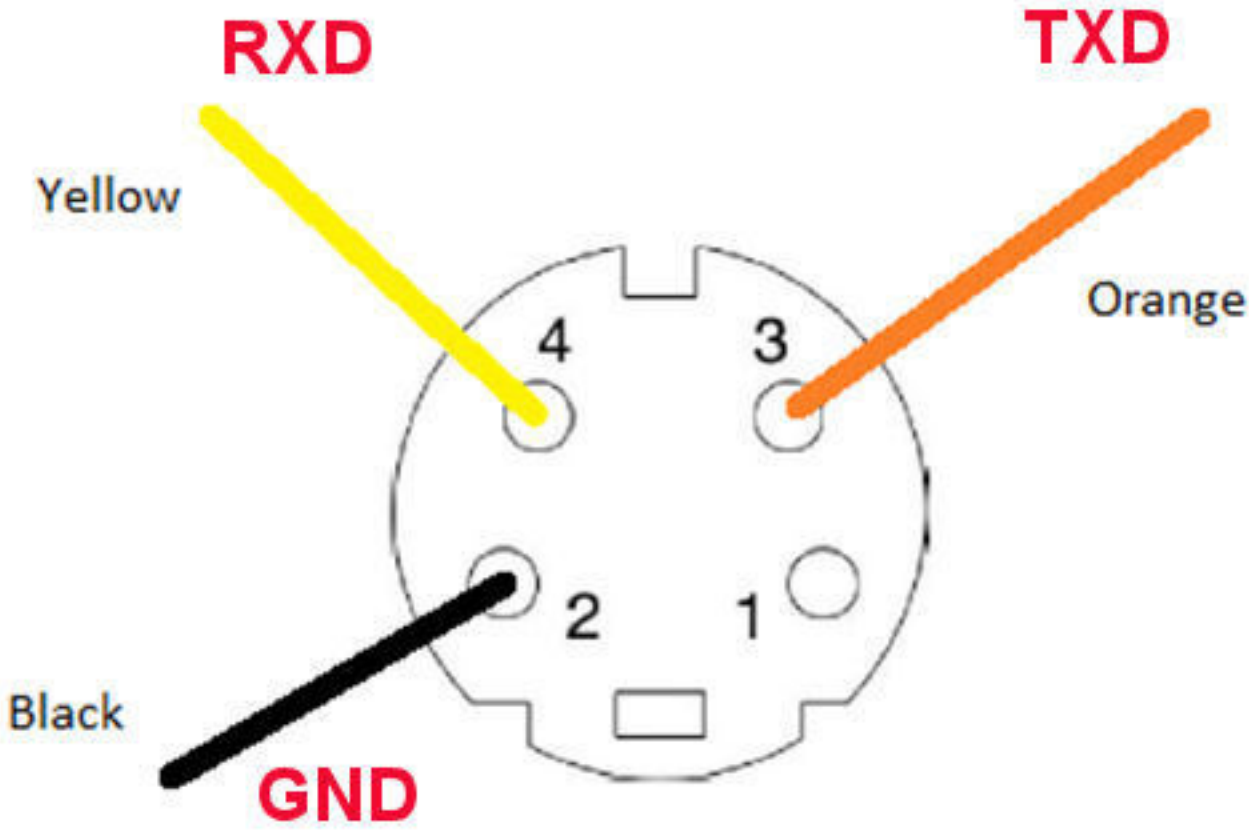
Auto Detect

Exit

PART: 768-1029-ND

DESC: CABLE USB EMBD UART 5V WIRED

MFG : FTDI, Future Technology Devices International Lt / TTL-232R-5V-WE



PART: CP-2040-ND

DESC: CONN PLUG MALE MINI DIN 4P SLDR

MFG : CUI Inc. / MD-40





Antenna 1 Bypass

Antenna 2 In Line

Automatic Start

Manual Start

- Select COM port
- COM 1
  - COM 2
  - COM 3
  - COM 4
  - COM 5
  - COM 6
  - COM 7
  - COM 8
  - COM 9
  - COM 10
  - COM 11
  - COM 12
  - COM 13
  - COM 14
  - COM 15
  - COM 16

Start Tune

1.1 - 1.7      1.7 - 3.0      Fail

Idle Radio Sync

Auto Detect

Exit