Automatic Antenna Tuner KT-005

The world's smallest QRP automatic antenna tuner
Latched relays capable of zero-power operation after tuning
Ultra-compact design: 54 x 55 x 24 mm housed in a lightweight and durable aluminum enclosure

Features

- The world's smallest QRP Automatic Antenna Tuner (ATU) available on the market
- ATU can works with any type of radio in any mode (CW, WSPR, SSB, PSK, FT-8 and others)
- Auto Power Off function for zero current consumption when tuned
- High grade (Fujitsu) reliable mechanical latch type relays
- Durable lightweight aluminum housing: black anodised with laser-engraved symbols
- SMA female sockets for maximum miniaturization
- LED indicators for monitoring RF power level, SWR and battery voltage
- Low-battery detection when operating on 9 V battery
- Two control buttons for easy operation
- Reverse polarity protection

Specifications

- Matching impedance range: 5 ~ 500 R to 50 R*
- Matching accuracy (VSWR): 1.5:1 or less**
- Network type: L-network with series L and shunt C
- C shunt is switched between the TRX and ANT side
- 32 768 possible matching states due to 15 relays inside
- Minimum operating power: 0.5 W for tuning
- Maxiumum operating power: 5.0 W (in CW mode)
- Frequency range: 1.8–30 MHz
- Input impedance: 50 R
- Tuning time: 7 seconds typical (15 seconds maximum)
- Dimensions: 54x55x24 mm; 2.1x2.2x0.9 in (WxHxD)***
- Weight: 0.107 kg (3.77 oz)
- IP (Ingress Protection) rating: 20
- Connectors type: SMA female (50 R)
- DC input: 5.5/2.1 male (positive polarity)
- Power supply requirement: 8…18 VDC
- No built-in battery (no restriction on air transport)
- Operatable temperature: -25°C to +60°C; -13°F to +140°F

*) when operating on the 160 m or 80 m bands the matching range is smaller
**) except for half-wavelength or multiple-half-wavelength antennas
***) without connectors

Applications

- Designed for full electrical and mechanical compatibility with QRP Labs® QCX-mini® and QMX-mini® transceivers
- Suitable for use with other low-power (QRP) transceivers, including the ICOM IC-705, Yaesu FT-817 and the MTR series (at power levels up to 5 W)
- Ideal for portable and field operations such as POTA, SOTA, IOTA and similar activities

Introduction

Congratulations on purchasing the KRAIT Technologies KT-005 Automatic Antenna Tuner! This manual contains the information you need for the proper operation, maintenance and care of your ATU.

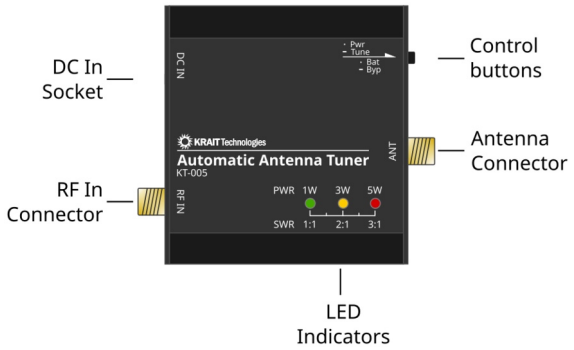


FIGURE 1. Overview of the KT-005 Automatic Antenna Tuner

Theory of Operation

An antenna tuner is a passive electronic device installed in the feed line between a radio transmitter and its antenna. Antenna tuners are especially important when used with transmitters. Their purpose is to optimize power transfer by matching the impedance of the transmitter to the impedance presented at the end of the feed line connected to the antenna. Transmitters are typically designed to deliver power into a purely resistive, non-reactive load — typically 50 R.

However, the impedance of any antenna typically varies depending on frequency and other factors. As a result, the impedance seen at the transmitter end of the feed line also changes. An impedance mismatch not only reduces the power radiated by the antenna but can also distort the signal.

The ATU shown in **Fig. 1** is based on an L-network topology. Thanks to the switched capacitor branch, it supports two possible configurations, as illustrated in **Fig. 2**.

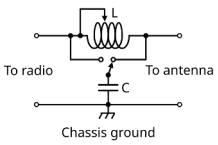


FIGURE 2. Matching network topology used in ATU KT-005

The configuration with the shunt capacitor placed after the series inductor is generally better suited for matching inductive loads, while the configuration with the shunt capacitor placed before the series inductor is more effective for matching capacitive loads (see **Fig. 3**). The ATU automatically selects the optimal configuration without the need to cycle through all possible relay states.

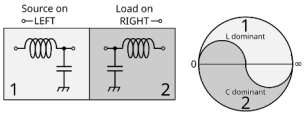


FIGURE 3. Available two ATU topologies and their corresponding Smith Chart coverage

Operation Modes

The ATU features two buttons located on the right side of the device. Each button provides access to two distinct functions. A three-LED display (see **Fig. 4**) indicated the selected mode using Morse code (refer to **Table 4**) followed by the measured value corresponding to the active operating mode.

Top button:
1. **PWR** (•) – short click to measure RF output power
2. **TUNE** (–) – long click to start tuning process

Bottom button:
3. **BAT** (•) – short click to check battery voltage
4. **BYP** (–) – long click to bypass antenna tuner

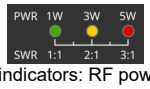


FIGURE 4. Three LED indicators: RF power and SWR meter

The ATU remains active for five minutes (300 seconds) following the last mode activation. After this time, it enters a full sleep mode, resulting in zero current draw from the power supply and eliminating any potential interference with the receiver. The last selected configuration remains active due to the use of latching relays.

► Note that the top button only wakes the ATU from sleep mode. To start tuning immediately, press and hold the top button. The ATU will begin tuning in TUNE mode immediately.

1. PWR mode

A short press of the top button activates the RF forward power measurement function. First, all LEDs will light up to indicate the “P” mode (see **Table 4**). Then, the current RF forward power is displayed using the three LEDs (see **Table 1**). The power value is sampled 60 times per second. The display allows for real-time monitoring of characters transmitted in CW mode.

► RF power reading are accuracte when the ATU is matched.
►► If the measured input power exceeds 6.0 W, all LEDs will light up, indicating that the ATU is overloaded. Reduce the transmitter power immediately!

Table 1. PWR Mode – LED Status as a Function of RF Forward Power

Power range [W]	LED status
0.0…0.1	I – I – I – I
0.1…2.0	I O I – I – I
2.0…4.0	I – I O I – I
4.0…6.0	I – I – I O I
> 6.0 (OVLD)	I O I O I O I

'–' – LED off, 'O' – LED on

2. TUNE mode

To activate the tuning function immediately, press the top button for more than 1/3 second. A good practice is to start transmitting in CW mode on the selected frequency, then press and hold the top button to begin the tuning process. First, all LEDs will light up to indicate “T” mode (see **Table 4**). Please maintain a steady carrier transmission until the tuning process is complete.

Depending on the tuning result, a message will be displayed: “S” for successful tuning or “E E E E” for no match. The LED indicator will then show the current VSWR value (see **Table 2**).

If the match without ATU is better than 1.5:1, the system will not begin the tuning procedure. Under typical conditions, the ATU considers the match acceptable if the VSWR is below 1.5:1 (96% of the transmitted power reaches the antenna). If the ATU does not find a good match within 15 seconds, it will stop the tuning process and retain the best match found so far. If the match is worse than 3.5:1 (only 69% of the transmitted power reaches the antenna), the ATU will indicate an error (no match) by lighting up three LEDs.

The algorithm selects several rough matches, then evaluates and identifies best ones, performing fine-tuning in two resolution steps. Each fine-tuning process follows a slightly different pattern to avoid local SWR minima.

► If the Pi value (incident power) is lower than 0.1 W, the ATU will not start tuning. This will be indicated by all LEDs flashing (code “L” for RF Power Too **L**ow).
►► Before starting tuning, the ATU checks the actual RF power level. If the measured RF forward power exceeds 6.5 W, tuning will not begin to avoid overloading the relays during switching. This will be indicated by all LEDs flashing (code “V” for o**V**erload).

Table 2. TUNE Mode – LED Status as a Function of VSWR Coefficient

SWR value	LED status
Pi too low	I – I – I – I
1.0…1.5	I O I – I – I
1.5…2.5	I – I O I – I
2.5…3.5	I – I – I O I
> 3.5	I O I O I O I

'–' – LED off, 'O' – LED on

3. BAT mode

In this mode, you can check the voltage of the power source. The voltage measurement is calibrated for use with a 9V battery (e.g. 6F22).

The voltage indicator uses three LEDs and distinguishes six states (see **Table 3**).

► Please note that the BAT mode can only be activated if PWR mode has been pressed to wake up the ATU or if the device was already in this mode. The BAT button does not wake up the ATU.

Table 3. BAT Mode – LED Status as a Function of Supply Voltage

Voltage range [V]	LED status
< 7.5	I – I – I – I
7.5…8.0	I O I – I – I
8.0…8.5	I – I O I – I
8.5…9.0	I – I – I O I
9.0…9.5	I – I O I O I
> 9.5	I O I O I O I

'–' – LED off, 'O' – LED on

4. BYP mode

In bypass mode the ATU does not perform impedance transformation. If the bypass function is activated again, the ATU will return to the previously succesful match without retuning. This allows you to quickly check the operation of the transciver by bypassing the ATU.

In this mode, the VSWR value is displayed, but only if the transmitted power is at least 100 mW. At lower RF power levels, the LED indicator will be off. The scale is the same as in TUNE mode.

Power Off Function

The ATU enters sleep mode five minutes after being turned on or after changing the operating mode. A short message („O”) will be displayed on LEDs just before entering into Power Off mode. The ATU then goes into full sleep mode and consumes no power. There is no need to disconnect the ATU from the battery power source. The relays will remain in their last set state.

LED Codes

Each selected operating mode is confirmed visually by three LEDs flashing in Morse code, as shown in **Table 4**. This provides visual confirmation of the selected operating mode. The LED indicator then switches to display power, VSWR or voltage, depending on the selected operating mode.

Table 4. LED Codes – Description

Letter	Morse code	Description
P	• – – •	ATU works in **P**WR meter mode
T	–	ATU started **T**uning (TUNE mode)
S	• • •	ATU **S**uccesfully matched antenna
EEEE	• • • •	ATU matching was unsuccesfull (**E**rror)
L	• – • •	RF power too **L**ow during ATU tuning
V	• • • –	ATU o**V**erloaded (Pi >6.5 W)
B	– • • •	ATU works in **B**ATerry meter mode
Y	– • – –	ATU is B**Y**Passed
R	• – •	ATU **R**eturned to the last known match
O	– – –	ATU goes into sleep mode (**O**FF)

Circuit Description

▪ The main goals of the design process were:

- achieving the smallest possible form factor while maintaining a wide tuning range and high resolution,
- full coverage of the Smith Chart, as seen in other designs of this type,
- due to maximum miniaturization, this version does not contain additional circuits such as phase and impedance measurement circuits or an internal attenuator; these will be available in the ATU PRO version,
- as a result of the above design choices, this is not the fastest ATU available,though it remains equally effective.

▪ The main part of the ATU is the latching relays. Once set they do not draw any electrical power.

▪ The ATmega8A microcontroller is used to control the entire circuit. It directly controls relays, process voltage from SWR bridge (Pi and Pr values), controls LED indicators, sense buttons and controls the power off circuit.

▪ The ATU is equipped with a voltage regulator (78L05) preceded by a protection diode. This makes the ATU protected against reverse polarity and accepts standard power sources: 9.0 V from a 6F22 battery, 11.1 V from a Li-Pol or a typical 13.8 V DC from a car battery.

▪ The KT-005 ATU source code and machine code are not public. The actual firmware uses 99.5% of the 8 kB of program memory and 44.0% of the 1 kB of RAM.

▪ The latest available firmware version is preloaded into the microcontroller before shipping (in the kit or assembled ATU). If needed, firmware updates are provided free of charge. The customer is only responsible for covering the shipping costs (both way).

▪ Extensive testing has shown that the ATU operates correctly on battery power and when using a linear power supply. Using a switching power supply (e.g. a small plug-in power supply) can significantly degrade the accuracy of SWR measurements and is not recommended. In extreme cases, this may lead to improper operation of the ATU.

Using ATU with QCX®/QMX® TRX

► The KT-005 ATU is based on mechanical relays. The tuning process is based on an algorithm to find the lowest reflected power in the fewest steps by switching relays under RF power conditions.

► During the tuning process, the transmitter stage is subjected to various load conditions: from near short circuit to open circuit.

► Since the tuning process takes only a few seconds, there is no risk of overloading the output stage built on BS170 transistors due to excessive power losses.

► The only risk is the possibility of damaging the power stage by too high a voltage during tuning. When the class-E transmitter is not nominally loaded, this will cause higher voltage spikes on the MOSFETs (the absolute maximum voltage for the BS170 transistor is 60 V).

► Please note that QCX transceivers do not have over-voltage protection.

► If you are not sure about the actual load impedance (e.g. field antenna) or you are runing TRX at Pi = 5 W it is good practice to add a 50 R attenuator in series (before the ATU) and then start tuning. If the ATU matches correctly, remove the attenuator and connect the TRX directly to ATU for maximum RF power. Press the BYPass button twice to activate the display of the current SWR level.

► Another simpler approach is to lower the TRX input voltage to e.g. 9 VDC to reduce the RF output power and then perform tuning. The lower voltage will reduce voltage spikes on the BS170 transistors during the matching process.

Safety Considerations

Do not overload the ATU! The maximum RF power provided to the RF input is 5.0 W (+37 dBm).

The ATU is built on **discrete relays**. This means that it switches different loads during tuning. Make sure that your transmitter can handle such load spikes.

Do not use ATU for frequencies higher than 30 MHz! Despite the apparent operation, the system may not adjust properly. Power losses in components may permanently damage the device!

Remember that the tuner **cannot** tune all possible load impedances. Some antenna lengths cannot be tuned and this is due to physical reasons, not the tuner design.

Never touch the antenna element while tuning or transmitting! Despite the low QRP transmitter power, the ATU can increase the output voltage several times. Risk of electric shock!

Do not reverse the ATU in connection! The RF IN connector must always be connected to the transceiver output (50 R).

This product is **NOT** designed for use in wet/damp locations and should **NOT** be used near water or exposed to rain. Do **NOT** use it if high humidity has caused water condensation.

Whenever possible, consider **grounding** the radio to improve safety and system performance.

Disconnect the ATU from the antenna when not in use. Do this especially if a storm is approaching or the radio station will not to be used for an extended period of time.

ATU Operational Hints

1. ATU is a kind of impedance transformer. Due to some physical limitations it is not possible to efficently match all possible load conditions (antenna impedance).

2. Note that for certain load conditions (e.g. R > 500 R) the ATU has to transform the voltage several times. For Pi = 5 W at 50 R it is 15.8 Vrms, but for 500 R (i.e. long wire anntenna connected directly to the ATU) the required voltage is 50 Vrms (70.5 Vpeak !) to achieve matching. Do not touch conductive elements! It is also worth considering grounding the TRX.

3. If you are considering using a Long Wire antenna (450 R), consider adding 1:9 Unun before ATU. This is not absolutely necessary, but it can improve overall transmitting efficiency.

4. Running the ATU without any load (with the ANT connector open), should be avoided as this may generate excessive voltage inside the ATU and can lead to an internal arc.

5. If you are not sure about the load impedance connected to the ATU, it is a good practise to add a series attenuator (-6 dB, 50 R) before the ATU and then tune the antenna. In case of high mismatch the TRX output stage will not see the high mismatch conditition, at most VSWR 2:1.

6. This ATU does not have a built-in frequency counter measurement circuit, therefore changing the band significantly increases the mismatch level. In this case, it is necessary to retune the ATU each time.

7. Retuning may be necessary within a given band if the frequency has been changed only a few kilohertz and the antenna is narrowband type. Each time monitor the current VSWR value on ATU LEDs. Click short PWR to wake up the ATU. Then long double-click BYP button (–) to activate real time VSWR measurement mode.

8. If you have trouble tuning your antenna with ATU, change its geometric configuration slightly. This may help the ATU to find the correct match. Please note that the border between 1 and 2 impedances area on **Fig. 3** are critical. This requires the use of extremely low capacitance and maximum inductance. This is not the optimal operating point of the ATU.

9. A small random component has been added to the search algorithm. This causes the search path to be slightly different each time. For antenna with very ultra-narrow charactersitics, this ATU feature allows to override suboptimum matching. However, if the match level is unsatisfactory (SWR greater than 1.5) it is worth trying to run ATU matching again.

10. There are no “peak & hold” circuits in SWR measurement circuit. This means that CW mode is the only appropriate mode for tuning procedure.

11. The LED display (in PWR and SWR mode) is optimized for CW operation. The internal algorithm, despite filtering, provides immediate and stable values, which allows convenient visual monitoring of transmitted characters.

12. Make sure the TRX does not reduce output power (ALC circuit) when a large mismatch condition occurs during the tuning process. However most portable QRP TRXs use a simple Class-E amplifier without advanced protection circuitry, which is the best choice for this ATU.

13. The ATU’s internal algorithm calculates the actual VSWR, rather than only monitoring the Pr value. In case of ALC circuit response it may return false feedback for the ATU. Therefore, ATU is in most cases insensitive to ALC effects.

14. The ATU uses latching type relays. If you do not use the tuning for a long time and the ATU experiences mechanical shocks, the previously set relays state may not be maintained. In this case, retuning ATU is required. The algorithm initializes all relays at the beginning of the tuning procedure.

15. The ATU has an internal EEPROM memory that is used to store the last succesfully matched configuration. If you power on the device again (PWR mode) and then click BYP button twice, the device will return to the previous relay configuration.

16. To minimize the interference level, it is best to limit the transmiter power to 1.0 W when tuning. Before tuning, check if the frequency is not occupied!

17. To improve the overall tranmission efficiency consider: a) adding 1:1 un-bal if using a dipole antenna; b) adding 1:4 or 1:9 Unun if using a long wire antenna.

18. Please note that the power meter (PWR mode) only works with good accuracy with a matched load. If there is a mismatch, the power readings may have an error of more than 50%.

19. Bypass mode does not provide a perfect 1:1 impedance transfer. This is due to the parasitic capacitance of the disconnected relays (they create ground capacitors) and the slight inductance of the paths. However, during operation the ATU compensates this effect during tuning.

Mechanical Specification

ATU dimensions: 54 x 55 x 24 mm (W x D x H) measured without RF connectors

Ingress Protection (IP) rating: 20 (the ATU is not waterproof)

PCBs specification: FR 4, 35 um layers, HAL, two-layer, 1.5 mm

At the top side there are:
- three LED indicators (green, yellow, red)

On the left side there are:
- DC input connector (5.1/2.5 mm)
- RF input connector (SMA female)

On the right side there are:
- Two TACT buttons
- RF output connector (SMA female)

At the bottom side there are:
- four rubber feet

FIGURE 5. Power cable voltage polarity

Connecting the Power Supply to ATU

To achieve the smallest possible size, the ATU does not have a built-in power source. Power is needed for a short time during tuning, so it makes sense to use the power source that powers the TRX. There is no need to remember about an additional power source.

The ATU can be powered by any DC voltage in the range of 8...18 V. The device is protected against reverse voltage polarity.

Please note that when the ATU goes into sleep mode, it does not draw any current. Therefore, there is no need to disconnect it.

To connect everything easily, use a special power splitter, shown in **Fig. 6** (available for purchase separately as KT-005C). The adapter is supplied with angled DC plugs. This allows the QCX to be directly connected to the ATU using an RF adapter, as shown in **Fig. 11**.

FIGURE 6. Power distribution cable (KT-005C

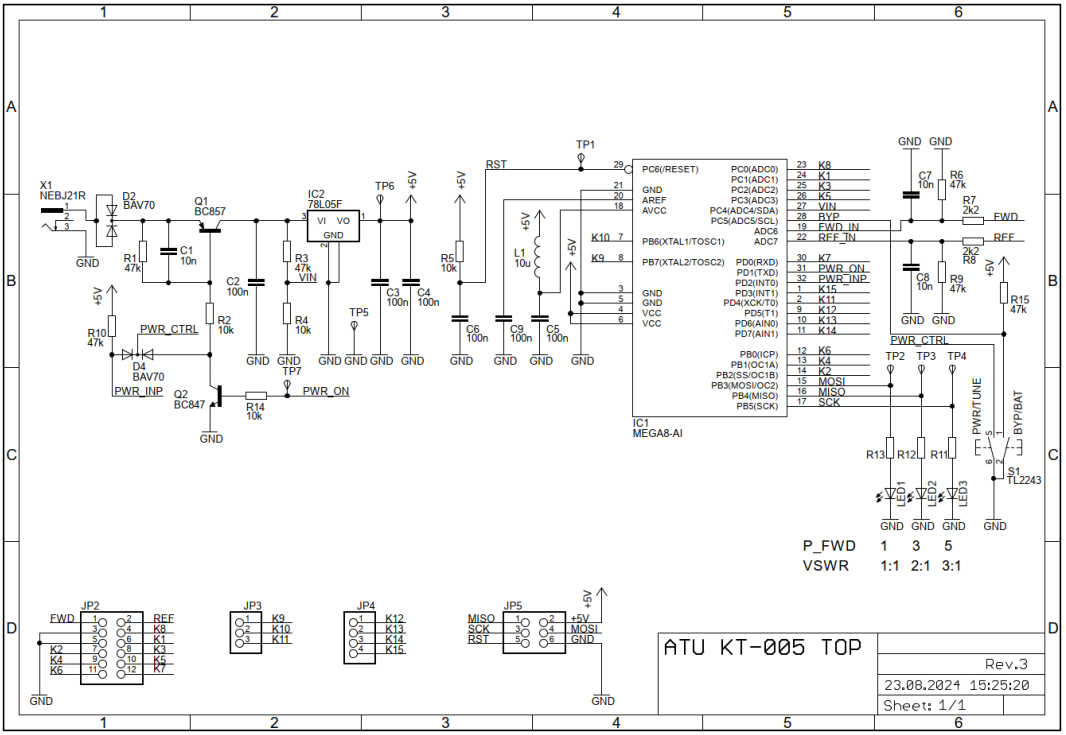


FIGURE 7. KT-005t – Automatic Antenna Tuner schematic diagram – top board

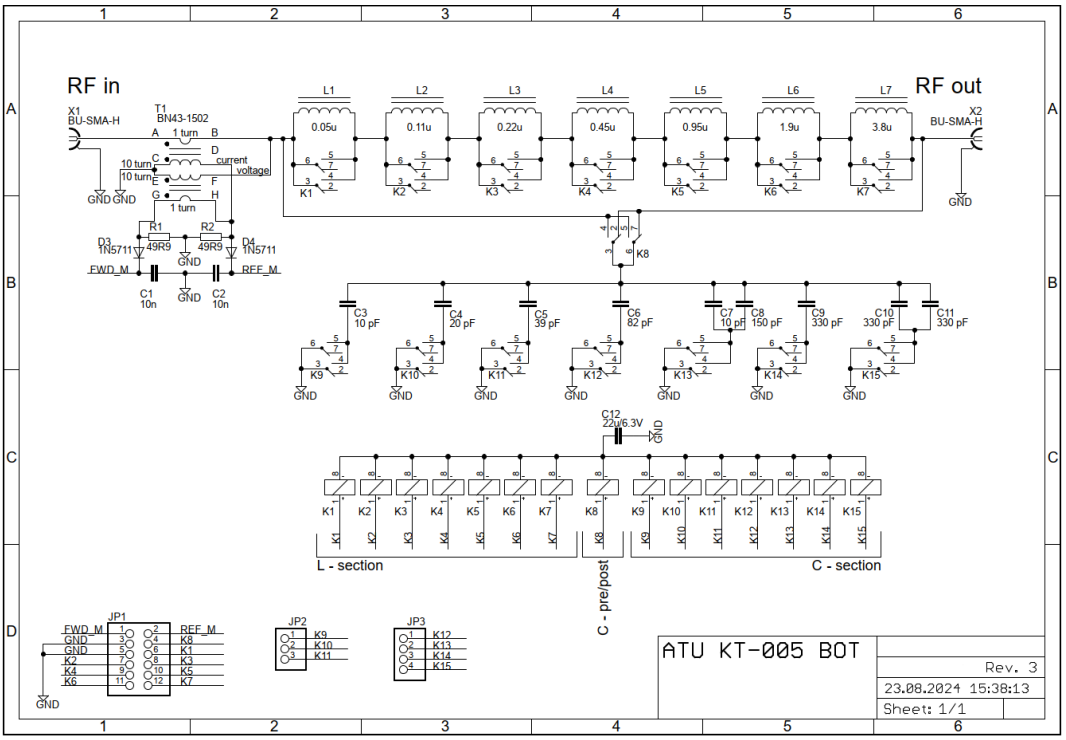


FIGURE 8. KT-005b – Automatic Antenna Tuner schematic diagram – bottom board

Printed Circuit Boards

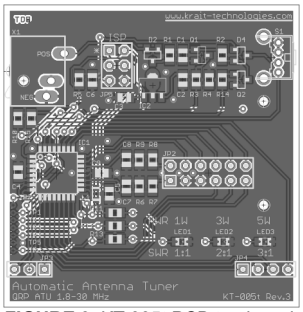


FIGURE 9. KT-005t PCB top board

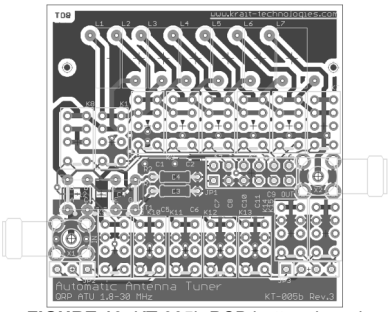


FIGURE 10. KT-005b PCB bottom board

THT components requiring assembly (applies to the kit version)

Table 5. Components list for TOP board

No.	DESIGNATOR	DESCRIPTION	QTY	PART NUMBER	VALUE
1	X1	DC input 2.1/5.5	1		
2	S1	Double TACT button THT	1		
3	JP2	2x6 pins socket (1 pc.) or 1x6 pins socket (2 pcs)	1 or 2		
4	JP3	1x3 pins socket	1		
5	JP4	1x4 pins socket	1		
6	JP5	Not assembled	-		

Table 6. Components list for BOTTOM board

No.	DESIGNATOR	DESCRIPTION	QTY	PART NUMBER	VALUE
1	X1, X2	Angle SMA(f) THT connector female	2		
2	T1	Binocular transformer BN43-1502 with winding	1		
3	K1...K15	Latched relay	15		
4	R1, R2	49R9/0,6 W THT resistor	2		49R9
5	JP1	2x6 pins goldpin	1		
6	JP2	1x3 pins goldpin	1		
7	JP3	1x4 pins goldpin	1		
8	L1	Air coil on fi 2.0 mm, 8 cm wire, 7 turns on 9 mm length	1		
9	L2	Air coil on fi 2.0 mm, 12 cm wire, 12 turns on 9 mm length	1		
10	L3	T50-2 core (yellow) – 13 cm wire fi 0,32 mm – 7 turns	1		
11	L4	T50-2 core (yellow) – 17 cm wire fi 0,32 mm – 11 turns	1		
12	L5	T50-2 core (yellow) – 25 cm wire fi 0,32 mm – 18 turns	1		
13	L6	T50-6 core (red) – 29 cm wire fi 0,32 mm – 22 turns	1		
14	L7	T50-6 core (red) – 39 cm wire fi 0,32 mm – 31 turns	1		

Table 7. Components list – mechanical parts

No.	DESIGNATOR	DESCRIPTION	QTY	PART NUMBER	VALUE
1	-	Housing (customized version with laser engraving)	1		
2	-	Rubber feet	4		
3	-	Light pipes fi 2.0 mm	3		
4	-	Foam separator (12 x 9 x 2 mm)	1		
5	-	Kapton tape (width 20 mm)	10 cm		

Assembly Instruction

► Due to the high degree of miniaturization, assembly is **not the easiest**. If you have doubts about whether you will be able to debug the system later if something does not work after assembly, consider purchasing an assembled and ready to use ATU.

►► Attention! Electrostatic sensitive components! Observe precautions for handling.

ESD damage may not cause complete system failure. However, the device may sometimes work incorrectly. This type of damage is very difficult to find.

Therefore, during assembly, take precautions:
1. Remove the microcontroller board from its ESD packaging only when necessary.
3. Use a soldering iron that has a grounded tip.
4. Use a grounded antistatic mat.
5. Use an ESD wrist strap when working on the microcontroller board. The wristband must be properly grounded.

Required tools for assembly and startup
❑ soldering iron, ❑ tin and flux, ❑ tweezers, ❑ side cutters, ❑ digital multimerer, ❑ screwdriver PH1, ❑ 9V battery with 5.1/2.5 plug or laboratory power supply, ❑ magnifier, ❑ sharp knife (e.g. OLFA CK-1)

► Soldering the coil windings requires first mechanical removal of the varnish from the wires. **Do not** do this by burning the tip for a long time, as the wire is resistant to high temperatures. This approach risks damaging the delicate paths on the board.
►► Once the choke is in place, pull the wire to the other side of the board, bend the end of the wire and scrape off the enamel with a sharp knife. The exposed wire can be easily tinned and soldered to the board.

Part #1 – KT-005t board assembly (TOP board)
► The KT-005t board can be easily identified because it contains the main microcontroller.
►► Please note that all components must be soldered on the bottom side of this PCB! The layers are described in the upper left corner of the board. an inscription was made in the corner of the plate for easy identification of the side.

Recommended assembly order
❑ Solder DC connector X1 on the **>bottom<** side.
❑ Solder S1 tact switch on the >**bottom<** side (the footprint here is symmetrical, so you can solder it wrong).
► Do it with high precision, because the buttons must fit into the cutouts in the enclosure.
❑ Solder JP3 3-pin socket on the **>bottom<** side.
❑ Solder JP4 4-pin socket on the **>bottom<** side.
❑ Solder JP2 as four 3-pin or two 6-pin connectors on the **>bottom<** (depending on what is included in the kit).
❑ Glue the foam mechanical separator on the DC socket.
❑ Stick the kapton tape as shown in the picture below.
► This tape protects the coils from the BOTTOM board from shorting to the power socket, the pads on the laminate and the TACT switch.

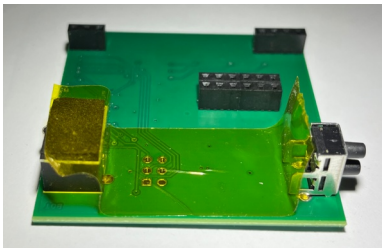


FIGURE 11. Assembled KT-005b board

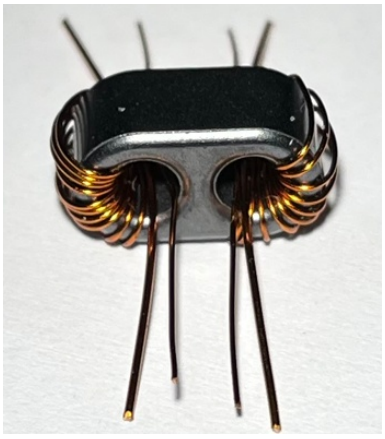
Part #2 – KT-005b board assembly (BOTTOM board)
► Before starting the assembly, you need to prepare the coils.
►► Do not start assembly by soldering the relays, as this will make assembly of the remaining components very difficult.
►►► Be careful when installing the winding and removing insulation from the wires. Ceramic capacitors are easy to damage!

Recommended assembly order
❑ The BOT board assembly should be started by preparing the T1 transformer. Transformer T1 requires special attention. It consists of four separate windings. Two wire diameters are used.

Table 8. List of T1 transformer windings

Winding No.	Required wire length	Turns	Core type
A-B	10 cm	1 (through hole) 0.45 mm	BN43-1502
C-D	22 cm	10 turns of 0.32 mm	
E-F	22 cm	10 turns of 0.32 mm	
G-H	10 cm	1 (through hole) 0.45 mm	

B | D | F | H



A | C | E | G

FIGURE 12. The method of making windings on T1

❑ Install the T1 transformer into the appropriate fields on the board (on the TOP side). The letters are printed next to the holes on the PCB. Cut off the excess wire.

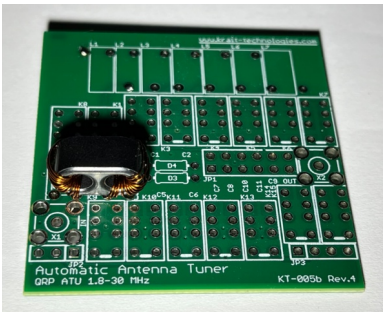


FIGURE 13. Transformer T1 mounted on the board

❑ All coils (L1...L7) should be made using 0.32 mm or #AWG 28 wire.
❑ The smallest coils L1 and L2 does not require cores. To make winding easier use a 2.0 mm drill bit as a reference point for the coil diameter.
►► Do not glue the coils to the board. This may change the electrical characteristics. The leads themselves are sufficient to hold the coil.

❑ L1 wind as 7 turns using 0.32 mm wire on 2.0 mm drill that it as shown on the right. Stretch the coils to obtain a coil length of 9.0 mm.
❑ L2 wind as 12 turns using 0.32 mm wire on 2.0 mm drill than it as shown on the right. Individual turns will give a compact winding, also 9 mm long.
► Remember that 1 cm of 0.32 mm wire is 10 nH => 0.010 uH. It may be important when you are doing the smallest coils (0.050 uH and 0.100 uH).
►► Please note that L1 and L2 should be assembled on the BOT side of KT-005B board. Assembly them as the **>last components< !**
❑ Coils L3...L7 are typical toroidal core type chokes. The lengths given are extra to allow for easy insertion and soldering. A thinner wire should be used here (fi 0.32 mm).
❑ Note that coils L3...L7 will not fit vertically between the boards: here is 10.0 mm distance and the cores are 12.7 mm. Therefore, they must be tilted slightly as shown in the photo below. Additionally, space is limited by the housing as shown in the drawing below. However, everything is designed so that all five coils on the toroids fit correctly.
► Before soldering the coils, you can measure their inductance adding e.g. 470 pF capacitor in parallel and calculate the inductance from the measured resonant frequency. VNA may be required here.
►► Wind it so that there are no turns on the toroid base, which will prevent the core from lift.

Table 9. List of coil parameters on the KT-005b board (BOTTOM)

Coil No.	Required wire length	Turns	Inductance	Core type
L1	8 cm	7	0.05 uH	Air coil, fi 2.0 mm
L2	12 cm	12	0.11 uH	Air coil, fi 2.0 mm
L3	13 cm	7	0.22 uH	T37-6
L4	17 cm	11	0.45 uH	T37-6
L5	23 cm	16	0.95 uH	T37-6
L6	29 cm	20	1.90 uH	T37-2
L7	38 cm	29	3.80 uH	T37-2

FIGURE 14. Coils ready to be mounted on the board (from left: L1 to L7)

❑ Before mounting the L3...L7 coils (those wound on cores) solder K2...K6 relays on TOP side. This will help you align the coils correctly before soldering. Don't mix up the holes when inserting the coil windings.
► Notice the photos below for their expected location.

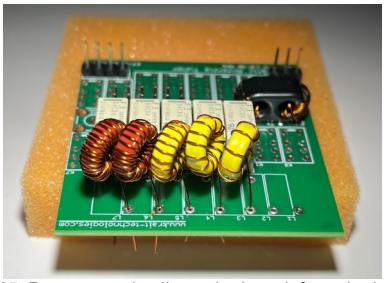


FIGURE 15. Pre-mounted coils on the board, from the left: L7...L3

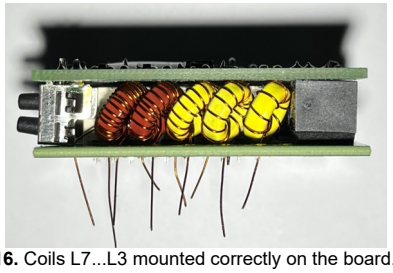


FIGURE 16. Coils L7...L3 mounted correctly on the board. There is enough space for five coils

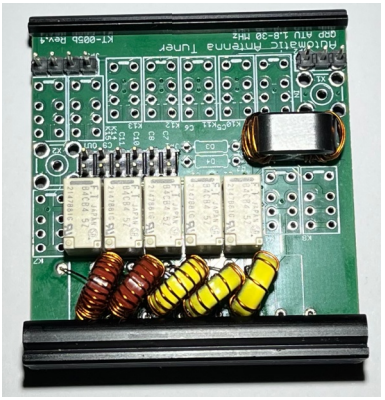


FIGURE 17. Top view of bottom board when installed into bottom part of the enclosure

❑ Solder the pins: JP2 (1x3 pins), JP3 (1x4 pins), JP1 (2x6 pins) on the TOP side of the PCB.
❑ Solder the next relays: K1, K7 and K8.
► Make sure the relay does not protrude beyond the board outline!
❑ Solder the R1 and R2 resistors (49R9) on the TOP side. Both resistors should lie flat on the board.

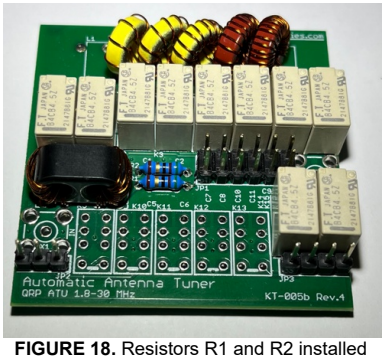


FIGURE 18. Resistors R1 and R2 installed

❑ Solder the remaining relays: K9...K15
❑ Solder SMA connectors on the top side. When preparing sockets, be sure to verify the position of the socket relative to the cutouts in the housing. If everything is correct, solder the five pins of the socket.

❑ Solder the coils L1 and L2 as shown below. These coils should be soldered on the BOT side. The 12-turn coil (L2) should be mounted on the left side. The 7-turn coil (L1) should be mounted on the right side as shown in the photo below. Both coils should be soldered flat (no gap to the PCB). The distance between the holes on the board is 10.5 mm for both coils.

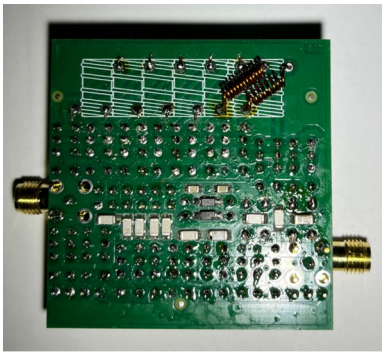


FIGURE 19. Coil L2 (0.10 uH) soldered on the left, coil L1 (0.05 uH) soldered on the right side

❑ Stick a strip of kapton tape over the coils where they will meet the housing. Bend the excess at the top flat. This tape will protect the coil insulation from damage when sliding the boards into the housing.

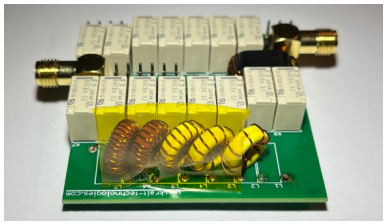


FIGURE 20. Protective kapton tape glued to coils

❑ Install the previously prepared TOP board into the BOTTOM board. Check again the position of the cores in relation to the TACT buttons and the power socket.
❑ Check both sides of the PCBs that none of the legs stick out more than 1 mm. Use side cutters to make adjustments.
❑ Before inserting the board into the case, there is some mechanical work to be done on the case. Press the three light-pipes into the top cover of the housing into three fi 2.0 holes. Press them all the way down with a wooden stick.
❑ Screw the top and bottom halves of the case together by adding the right panel and securing it with two screws.
❑ Insert gently the prepared electronics kit into the cutouts in the enclosure. The enclosure has two cutouts into which the PCB boards should be inserted. Do it very slowly, monitoring that everything fits properly.
► When mounting the boards into the housing, the position of the cores is critical here. Everything must fit precisely. If the boards cannot be inserted, check what is blocking them.

FIGURE 21. KT-005 just before closing the housing

❑ Add the second side cover and tighten the last two screws.
❑ Glue the four rubber feet to the corners of the bottom case.

Startup Procedure

❑ Connect the ATU to a current-limited 9 VDC (laboratory power supply or just a 9V battery). The positive pin is on the inner pin of the socket.
❑ To enable “PWR” mode, short click the top button. The LED indicators should flash like “P” letter (**• – – •**).
❑ Measure the current draw. With no diode lit, the current consumption should be about 15 mA at 9 VDC.
❑ Connect TRX to RF IN connector, 50 R dummy load to ANT connector and set CW mode (e.g. Pi = 2 W). Long click the bottom button to enable BYPass mode. Observe the LED indicators to confirm that the ATU is measuring the RF power in watts correctly.
❑ To confirm that the ATU is working correctly, a special load is needed, e.g. 25 R and 100 R. This can be made using 50 R/2 W resistors. Both of these resistors will allow for preliminary testing of the two possible ATU configurations (C shunt before and after series L).
❑ Connect a 25 R test load, set CW operation and click long the top button to activate TUNE mode. The ATU should find the optimal match within a few seconds. This will be indicated by the LEDs (S letter “**• • •**”). In this mode tha current VSWR ratio will be displayed. When RF power is present, only the green LED should light.
❑ Repeat the procedure described above for the 100 R test load. The behaviour should be the same.
❑ A detailed description of the ATU functionality can be found at the beginning of the document. All operating modes can be tested on the test load.

► KT-005 ATU is now ready for operation! We wish you many successful contacts during your most exotic radio expeditions!

Electrical Characteristics

Current consuption @ 9 Vin DC:	up to 45.0 mA (tuning)
Current consuption @ 9 Vin DC:	15.0 mA (ON, no LED)
Current consuption @ 9 Vin DC:	0.0 uA (Power Off state)
Maximum installed inductance:	7.48 uH
Maximum installed capacity:	1.301 nF

Absolute Maximum Ratings

Maximum Input Voltage:	18.0 VDC
Operating Temperature Range:	-20...+60°C
Maximum RF Power:	5.0 W (+37 dBm)

ATU Size Comparison

FIGURE 22. QCX-mini® and ATU (KT-005A) size comparison with BNC(m) to SMA(m) adapter (KT-005R) and power cord (KT-005C)

Ordering Information

Table 10. Ordering information

Description	Version	Ordering Code	QTY
Assembled ATU in black aluminum enclosure - ready for use	Assembled	KT-005A	1
Kit for self assembly (SMT components populated) with programmed microcontroller with aluminum enclosure	Kit	KT-005KE	1
Kit for self assembly (SMT components populated) with programmed microcontroller without enclosure	Kit	KT-005K	1
Black anodized aluminum enclosure with engraved symbols for KT-005	-	KT-005E	1
BNC(m) to SMA(m) adapter	-	KT-005R	1
Power cord (5.5/2.1): one in(m) into two out(f) connectors	-	KT-005C	1

A – assembled version ready for use, KE – self-assembly kit version with included enclosure, K – self-assembly kit version without enclosure, E – enclosure,

Warranty Terms

1. Each assembled ATU KT-005 device is supplied with a unique warranty card. In the event of a complaint, this document must be completed and sent along with the device.

2. KRAIT Technologies warrants this product (sold as assembled units) to be free from defects in materials or workmanship for a specified period of time. The manufacturer will replace or repair parts found to be defective and return the equipment or parts to the owner.

3. The above-stated warranty repair does not apply to KRAIT Technologies that, in the sole judgement of KRAIT Technologies has failed due to damage, misuse, corrosion, accident, natural disaster, alteration, unauthorized or improper installation, repair or modification.

4. The Owner is responsible for the cost of transportation of the equipment to the manufacturer in the event of warranty repairs as defined above.

5. Devices sold as kits are not covered by a warranty for operation. The warranty against defects covers the delivered components only.

6. If you have any difficulties, please contact us (email) before sending the device!

Remark:
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