

**ACOM**



## **ACOM 04AT**

Remote Automatic  
Antenna Tuner and Switch

User's Manual

Installation, Operation  
and Maintenance

**OUTSTANDING HF POWER PRODUCTS**

May 2021

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**Title of Documentation** ACOM 04AT Remote Automatic Antenna Tuner and Switch  
User's Manual  
Installation, Operation and Maintenance

**Type of Documentation** User's Manual

**Purpose of Documentation** This manual explains Installation, Operation and Maintenance of the ACOM 04AT Remote Automatic Antenna Tuner and Switch.

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## 1. GENERAL INFORMATION

Congratulations on purchasing one of the finest antenna tuners in the world today.

ACOM is pleased that you have chosen one of our products, and we will endeavor to provide you with the information and support you need to enjoy your purchase for many years.

We urge you to read all of the following materials before you embark on operating your new antenna tuner.

### 1.1. Introduction and Description

This manual explains:

- Installation
- Operation and
- Maintenance

of the ACOM 04AT remote automatic antenna tuner for HF + 6 m with integrated four-way antenna switch.

The ACOM 04AT tuner is specifically designed and developed to work exclusively with the ACOM series of solid state (transistor) amplifiers, e.g., ACOM 700S or ACOM 1200S.

It automatically selects one of four available antenna outputs (as assigned in bands by the operator) and matches the impedance of the chosen antenna output by transforming it to 50 Ohm with SWR below 1.5:1 at the tuner input (typically below 1.3), providing an optimum load impedance for the amplifier.

Any necessary readjustments are swift, following the frequency changes and antenna selections.

The tuner matches all load impedances presenting a SWR below 3:1, regardless of phase angle, in a continuous frequency range of 1.8-30 MHz and 50-54 MHz. In many cases, the tuner will match loads with higher SWR (up to 10:1) as well, however a reduction in power may be necessary if the protective functions of the tuner activate due to high values of SWR, current, voltage, forward or reflected power at the antenna output.

Provided the SWR of the feedline/antenna system is up to 3:1, the tuner can handle input power levels up to 1200 W (PEP, mean or continuous carrier), regardless of the operating communication mode. For feedline/antenna system SWRs between 3:1 and 10:1, the maximum permissible power at the tuner input is gradually reduced down to 200 W at SWR=10:1 (see [Table 8-1 Maximum input power of the tuner as function of the antenna SWR](#)), allowing for operation within tuner component specifications.

The tuner can be installed both in the shack and in a remote location, e.g., in a separate room, in a sheltered location outdoors or even out in the open, close to the antennas, so that any feedlines from the unit to the antennas, working in mismatched conditions, are kept as short as practically possible to avoid unnecessary losses.

Generally, a remote installation of the tuner is preferable to a local one, because it reduces RF losses in most of the feedline's length. Thanks to the built-in automatic antenna switch, a significant reduction in both installation effort and required cable length can be achieved (up to three times the feedline length with four antennas and in-shack tuner installation).

A single cable connects the tuner to the radio station - the main coaxial feedline, which is often already pre-installed. Tuner power supply, control and RF signals are combined on the feedline, easing remote installation, lowering costs and uncluttering the shack.

Provided a low loss hi-quality cable is used (e.g., RG213), the distance between the tuner and the shack can be up to 100 m (330 ft). However, the length of the cable should be kept at minimum to avoid any unnecessary losses, which exist in any cable even in matched conditions.

The wide operating temperature range of the tuner (-40 to +65 °C), the single cable to the shack, and the included accessories - all make for an easy outdoor installation.

However, if you have a choice of installation locations, you should always prefer one that is sheltered from the elements. It will prolong the operational life of the tuner and reduce material wear.

Regardless the choice of installation location, the operator is able to control and monitor the tuner's work via the amplifier front panel using simplified and intuitive menus in the original style of the ACOM transistor amplifier series.

## 1.2. Owner Assistance

If assistance is needed, you should contact your local dealer first. If necessary, your dealer will contact ACOM for additional guidance.

If you still have an issue you need to discuss with one of ACOM's specialists, the contact information is as follows:

ACOM Ltd.

E-mail: [support@acom-bg.com](mailto:support@acom-bg.com)

Bulgaria | Bozhurishte 2227

Sofia-Bozhurishte Economic Zone | 6 Valeri Petrov Str.

GPS coordinates: 42.748616° | 23.209801°

## 1.3. Equipment Supplied

The ACOM 04AT antenna tuner is shipped as package, consisting of:

Nr.	PACKAGE CONTENTS	Pcs.
1	Antenna tuner ACOM 04AT (unit only)	1
2	Weather Protection Hood ACOM 04-WP	1
3	Installation accessories set ACOM 04-DT (for desk mounting)	1
4	Installation accessories set ACOM 04-WM (for wall mounting)	1
5	Installation accessories set ACOM 04-MM (for mast mounting)	1
6	Fuse replacement set	2
7	User's Manual	1

Table 1-1 Package contents

## 1.4. Features

- **Easy set-up of user tuning presets**  
For a CAT transceiver a single press of the TUNE button on the amplifier front panel is all you need.
- **Transparent (invisible) operation**  
After setting up the user presets (auto tune) for the frequency segments and antennas, the operator will not be involved with tuner operation.
- **Three kinds of frequency segments, according to antenna bandwidth**  
The operator can choose according to the nature of each of the four antennas (narrow band - Sharp, normal - Regular, and broad band - Wide).
- **Capability of operation at fixed frequencies (Fixed)**
- **Non-volatile memory**  
Non-volatile memory for user presets (auto tune), independent for the four antennas, the three types of segment width, and more than 1000 random fixed frequencies for each antenna.
- **User presets**  
The user presets are automatically loaded, following frequency and antenna selection changes.
- **Export (backup) of preset memory**  
Backup of preset memory to a computer file, import of previously made backup files from a computer to the tuner memory.
- **Helpful information**  
Information about the setting age, and alerts for settings that reach a certain age, defined by the operator in 4 possible age levels.
- **Power supply and control to the tuner**  
Power supply and control to the tuner, as well as status return from the tuner are facilitated over the coaxial cable between the amplifier and tuner, no need for additional cables or special control signals from the transceiver (the availability of CAT control from the transceiver will give further advantages to the setup).
- **Improved electromagnetic compatibility**  
Full tuning can be completed within 5 seconds (typically 2-3 seconds), at 25 W at the tuner input and less than 6 W at the antenna output; quick tuning (from nonvolatile-memory presets) is completed in less than 0.05 seconds with zero emitted signals.
- **Input SWR during full tuning cycles**  
Input SWR during full tuning cycles - below 2:1, preventing activation of transceiver PA protection.
- **Input SWR after completing a tuning cycle**  
Input SWR after completing a tuning cycle - below 1.5:1 (typically below 1.3:1).
- **Relays with gold-plated contacts**  
Relays with gold-plated contacts for excellent receive characteristics.
- **Relay switching**  
Relay switching will only take place when no RF current is flowing, preventing contact arcing critical for preventing contact oxidation, surface melting and material transfer (otherwise resulting in poor receiving performance) and to avoid any unwanted widening of the spectrum of signals, emitted during the tuning cycle.
- **Air-core coils and high-quality ceramic capacitors**  
Air-core coils (no magnetic materials) and high-quality NPO (COG) ceramic capacitors usage throughout the matching circuit.

- **Harmonic suppression**  
Improves harmonic suppression - the matching network is a low-pass L filter.
- **Saves space on the operating position**  
ACOM 04AT can be located up to 100 m (330 ft) away from the shack.
- **Remote installation**  
Allows remote installation, including outdoors, close to the antenna feed point, minimizing losses.
- **Integrated antenna switch**  
Integrated four-way antenna switch - less coaxial cable, shorter unmatched sections, less losses.
- **Automatically and manually antenna switching**  
Antennas can be automatically and manually switched from the amplifier front panel. The last used antenna selection is memorized.
- **Customized antennas names and types**  
Indication and editing of names and types of antennas in editable freeform.
- **Protection mechanisms**  
Various protection mechanisms, including: antenna overvoltage, antenna overcurrent, excessive power during operation and tuning, extreme temperatures and power supply voltages, as well as relay hot-switching.
- **Safe power supply**  
Safe power supply voltage (26 VDC).
- **BYPASS mode**  
BYPASS mode - all components of the matching network are excluded, allowing direct operation of broadband antennas.
- **SERVICE menu**  
This menu allowing analysis of the tuner status and review of the used resource of coils and capacitors for all memorized and current tuning presets.
- **Lightning arrestor and bleeder resistor**  
Integrated lightning arrestor and bleeder resistor for protection against static discharges; automatic grounding of antennas on powering down.

### 1.5. Safety Considerations, Explicit Definitions

The ACOM 04AT is designed to meet international safety standards and complies with CE safety and electromagnetic compatibility requirements, as well as FCC regulations.

This User's Manual contains information, warnings (signal words **Danger**, **Warning**, **Caution** and **Notice**) and instructions, related to hazards, that should be followed by the user in order to ensure safe operation and to keep the tuner in a safe working condition at all times.

The EXPLICIT DEFINITIONS described below apply to this User's Manual:

#### **DANGER**

*These notes call attention to a procedure or instructions which, if not correctly performed, will result in serious personal injuries and even death.*

#### **WARNING**

*These notes call attention to a procedure or instructions which, if not correctly performed, could result in serious personal injuries and even death.*

#### **CAUTION**

*These notes call attention to a procedure or instructions which, if not correctly performed, could result in minor or moderate personal injuries.*

#### **NOTICE**

*These notes call attention to a procedure or instructions which, if not correctly performed, could result in property damage or equipment damage not exclusively to the tuner but also to connected equipment.*

Information notes described below apply to this User's Manual:



*These notes highlight operating procedures or practices that may improve equipment reliability and/or personnel performance, or to emphasize a concept.*

**ORANGE TEXT as LINKS**

*marks all internal links in the document between Sections, Figures, Tables, etc. for your convenience.*



The safety instructions contained in this User's Manual feature specific signal words (**Danger, Warning, Caution** or **Notice**) and, where required, a safety alert symbol, in accordance with actual standards ISO 3864 or ANSI Z535.

## PRECAUTIONS:

### DANGER

For details about lightning protection see [APPENDIX 1 | Lightning Protection](#) at the end of this manual.

### DANGER

For safe tuner operation, the tuner's grounding terminal labeled **GROUND** should be connected according to the applicable standards and local regulations for electric safety, fire safety and lightning protection, in all cases the radio station is equipped with outdoor antenna/s!

### DANGER

Never run cables into the radio station directly from outside (through a wall or window), whether from antennas, tuners, groundings, telephone or network lines, etc. The cables should first pass through the foundation of the building where they should be secured in a way that is standard for your region (observe the recommendations stated in [APPENDIX 1 | Lightning Protection](#) at the end of this manual, if no other data is available), in order to avoid conduction of a lightning strike with all resulting consequences - death, injury, fire, equipment damage, destruction, etc. (see Point **8**) in Appendix 1).

### DANGER

Regardless of the recommendations herein, it is your responsibility to consult a professional electrician for advice on installing your grounding system, and to refer to, together with the electrician, the applicable standards and local regulations for electric safety, fire safety and lightning protection, in all cases the radio station is equipped with outdoor antenna/s, in order to ensure that your installation complies with all applicable requirements. The applicable standards and local regulations shall prevail if there is a difference in the requirements, and if they contain more or stricter requirements than the minimum for installation stated in [APPENDIX 1 | Lightning Protection](#). NEVER underestimate the danger of lightning!

### 1.5.1. Lightning protection when the tuner is installed in a building

#### DANGER

For details about lightning protection see [APPENDIX 1 | Lightning Protection](#) at the end of this manual.

- a) **The tuner's terminal labeled GROUND** should be connected through a low-impedance connection with a cross section of no less than 20 sq. mm (preferably flat-shaped and solid - band or plate, rather than with a flexible multistrand cable), to the main grounding plate of the radio station (see Point [9](#)) in Appendix 1).
- b) **The antennas** should be connected by coaxial cables buried in the ground (when coming in from the field) or securely attached to the wall of the building (when coming down from the roof), all along the route from the antennas to the foundation of the building where, before entering, are discharged from the lightning charges in a safe way - directly into the ground. For this purpose, the braids of the coaxial cables should be securely grounded by a low-impedance connection to the main grounding plate of the building (see Point [8](#)) in Appendix 1).
- c) **From a low point close to the foundation of the building**, before going up to the radio station, the wires of the antenna cables should be equipped with pulse overvoltage limiters (surge arresters), the grounding terminals of which should be connected through a low-impedance connection to the main grounding plate of the building (see Point [8](#)) in Appendix 1).

#### DANGER

When installing the tuner in the shack, do not connect antenna cables to the tuner if they are entering the building directly, without being grounded through a low-impedance connection to the main grounding plate of the building! Properly grounded antennas shall be guided to the shack from the inside and from below, from the foundation of the building and its main grounding plate rather than directly from outside! (see Point [8](#)) in Appendix 1).



### 1.5.2. Lightning protection when the tuner is installed outdoor

#### DANGER

For details about lightning protection see [APPENDIX 1 | Lightning Protection](#) at the end of this manual.

When installed on a roof or in the field, the tuner and antennas, if not provided with a separate lightning protection, should be within the protection range of an existing **lightning protection system**.

Checking the efficiency range of a lightning rod is performed using the method known as "**rolling sphere**".

If the tuner and/or the antennas are not protected by an existing lightning protection system, the system should be extended, its range of action should be increased or a new lightning protection system should be built, with a sufficient range of action and in compliance with all requirements of the local standards and regulations for electric safety, fire safety, and lightning protection.

- a) **The tuner's terminal labeled GROUND** should be connected through a low-impedance connection (preferably flat-shaped) with a solid cross section of no less than 20 sq. mm to the closest (at a distance less than 6m) main conductor from an existing grounding system for lightning protection, and where there is no such system, to a purpose-built individual low-impedance grounding system for lightning protection, driven or buried directly in the ground and in compliance with all requirements of the local standards and regulations for electric safety, fire safety, and lightning protection (see Point **7**) in Appendix 1).
- b) **The braids of the antenna coax cables** should be connected through a low-impedance connection (preferably flat-shaped) with a solid cross section of no less than 20 sq. mm to the same grounding system for lightning protection, to which the tuner is connected, but with independent connections, i.e., the connections of the coaxial braids to the grounding system for lightning protection should not be broken in case the tuner is temporarily removed (e.g., for maintenance).
- c) **Before the antenna cables are laid to the tuner**, they should be equipped with pulse overvoltage limiters (surge arresters), the grounding terminals of which should be connected in the same manner as the braids in section b) above.
- d) **The feed line between the shack and a remotely located tuner** should be coaxial cable buried in the ground (when coming from the field) or securely attached to the wall of the building (when coming down from the roof), all along the route from the antennas to the foundation of the building. At the foundation, the braid of this cable should be securely grounded at ground level and just before entering the building, through a low-impedance connection (preferably flat-shaped) with solid section of no less than 20 sq. mm to the main grounding plate of the building (see Point **8**) in Appendix 1).

- e) **At the place of entering the building**, before going further to the radio station, the feedline between the amplifier and tuner input should be equipped with a pulse overvoltage limiter (surge arrester), the grounding terminal of which should be connected through a low-impedance connection to the main grounding plate of the building (see Point **8**) in Appendix 1).

### 1.5.3. Electric Safety Precautions

#### **WARNING**

The electronics inside the tuner operate under high direct-current voltage up to 200 V, which is fatal! Never allow anyone, especially children, to insert any object into box holes - this may cause electric shock. Disconnect all cables from the tuner and every time wait at least 1 minute before opening it!

#### **WARNING**

RF voltage at antenna feed point and elements may exceed several thousand volts! Never touch the antenna or antenna isolators during transmission and tuning - this may cause deep RF burns as well as indirect traumas, such as falling!

### 1.5.4. General Safety Precautions

#### **WARNING**

Do not undertake on your own repairs or changes in hardware or software of the tuner in order not to endanger your or other's health and life and not to damage the tuner and the equipment connected with it, not covered by warranty. The manufacturer is not liable for another's actions and responsibility shall be assumed by the doer.

#### **DANGER**

To avoid damage (not covered under warranty) read the Section **2 INSTALLATION** of this User's Manual carefully. If you have any doubts about the installation, operation or safety of the tuner, please consult your dealer.

## 2. INSTALLATION

The tuner can be installed at a fixed site (in a room), under a shelter or outdoors - with a special set of installation accessories for desks, walls or masts (see Section **1.3 Equipment Supplied**).

### ⚠ CAUTION

Never operate the tuner with its cover removed! Touching the components inside the tuner while transmitting may result in RF burns and injury.

Mount/place the tuner so that the antenna terminals are not accessible during operation.

Do not mount the tuner in a position that will put it under water at any time.

Do not mount the tuner in a place that will allow sprinklers or water hoses to spray the weather seals or connectors.

### NOTICE

Do not try to additional weather sealing to the tuner. It should be installed in an airy location in order to cool down during operation and to dry up after rain or morning dew!

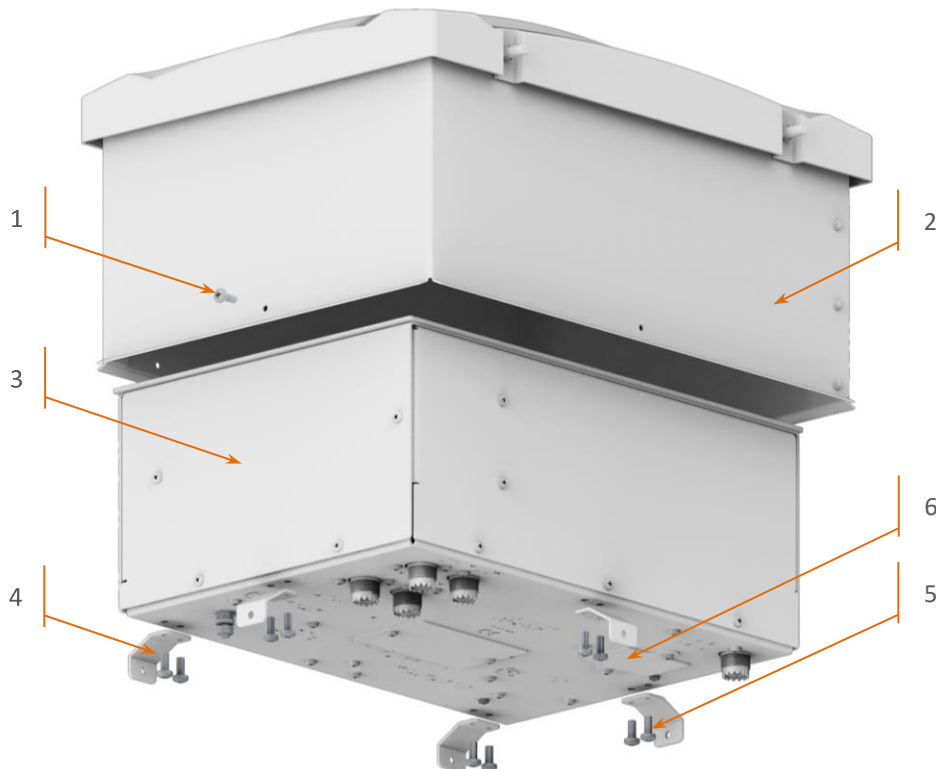


Figure 2-1 ACOM 04AT tuner with ACOM 04-WP weather protection cover removed, and without installation accessories

Your new ACOM 04AT is shipped with the protective cover mounted. Regardless of which mounting option will be chosen (desk, wall or mast), in order to mount the selected bracket, the weather protection cover must be removed (see [Figure 2-1 ACOM 04AT tuner](#), Pos. (2)).

The cover (Pos. 2) is fixed to the tuner body (Pos. 3) with 5 mounting brackets (Pos. 4). Place the tuner on a flat leveled surface with connectors facing down. Unscrew the 5 bolts (Pos. 1) and carefully lift the weather protection cover off the tuner body. If the tuner will be desk mounted, the weather cover (Pos. 2) and mounting brackets (Pos. 4) should be safely stored.

The mounting brackets (Pos. 4) are removed by placing the tuner with the connectors facing up and unscrewing the 10 bolts (Pos. 5), holding the brackets. If the tuner will be mast or wall mounted, the weather protective cover (Pos. 2) will be reassembled after mounting the selected mast or wall bracket.

## 2.1. Unpacking and Initial Inspection



Before you install your antenna tuner, thoroughly read this manual.

First, carefully inspect the cardboard cartons and its contents for physical damage. ACOM ships antenna tuners in highly protected containers, but it cannot assure that mistreatment by shippers will not occur. If damage is evident, notify your dealer immediately. Delay may void the carrier's warranty.

Remove all contents from the cartons and inspect the tuner chassis and all installation accessories for any missing items according to the order. If you notice anything missing, immediately notify your ACOM dealer. Delay may void the carrier's warranty.

Store safely the unused accessories.

Keep all packing materials for possible future antenna tuner shipment (see Section [8.3.4 Returning to the Service Provider](#)).

## 2.2. Power Supply Voltage

The tuner is powered by direct-current voltage +26 VDC +10/-15%, supplied through the coaxial cable from the ACOM amplifier RF output to the RF input of the tuner, labeled **50Ω RF +26 VDC POWER & CONTROL**.

### NOTICE

In order to avoid any damage (not covered by the warranty), never connect the input jack of the tuner, labeled **50Ω RF +26 VDC POWER & CONTROL** to any power source except the output of an amplifier from the ACOM transistor series.

### 2.3. Installation and Connection for Indoor Operation



For installation and connection for remote/outdoor operation see Section [2.4 Installation and Connection for Outdoor Operation](#).

If the desk mounting option is chosen, the tuner is placed on the desk with the connectors facing to the back, rubber feet facing down and secured in place with the provided desk bracket (see [Figure 2-2 Desk installation bracket](#)). The decorative black anodized aluminum faceplate provides an aesthetic look, matching any high-end ham radio setup.

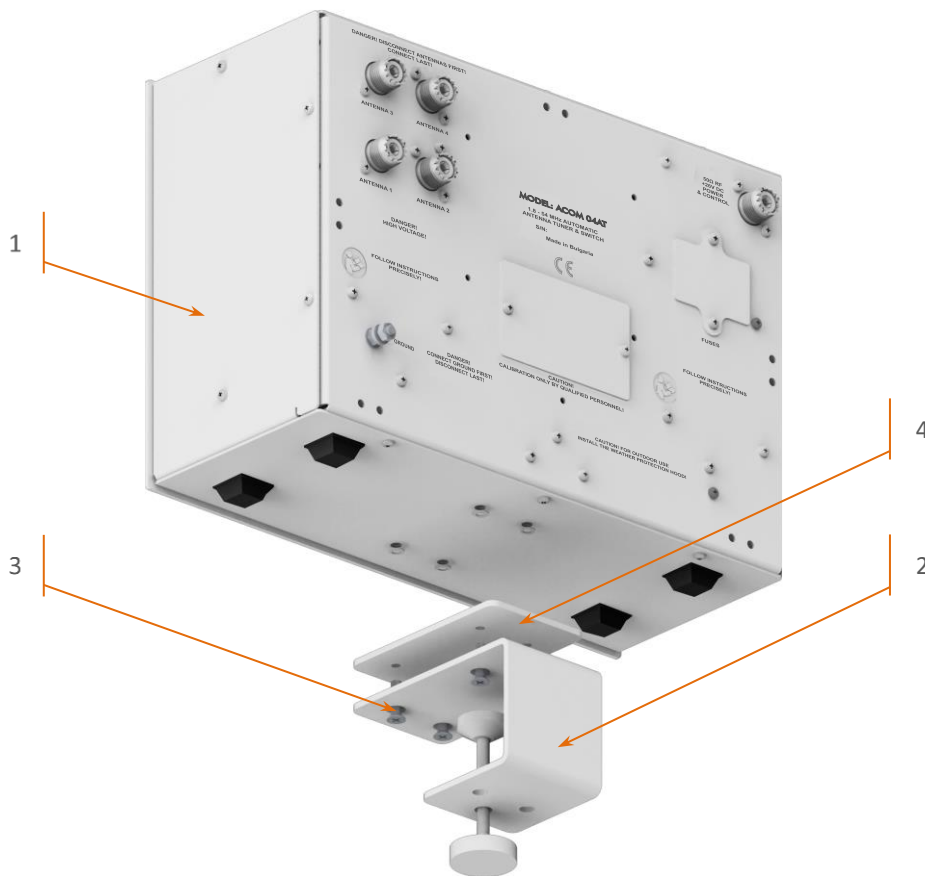


Figure 2-2 Desk installation bracket

Please, see [Figure 2-2 Desk installation bracket](#)).

The desk bracket (Pos. 2) is secured to the tuner body (Pos. 1) via 4 flat-head bolts (Pos. 3).

Be sure to place the provided metal spacer plate (Pos. 4) between the bracket and the tuner body. The bracket is finished off with black polymer paint, reducing the possibility of accidental scratching of the desk surface.

After mounting and securing the tuner to the desk, the only contact surfaces are the rubber feet and rubber protector of the bracket bolt, ensuring scratch-free desk surface.

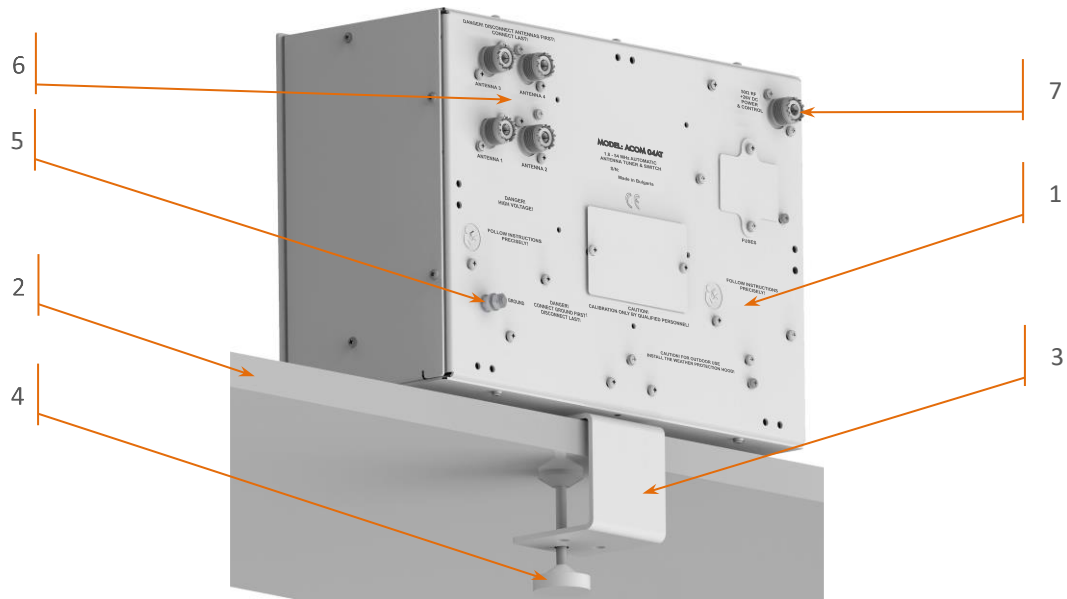


Figure 2-3 Securing the tuner to a desk

After securing the tuner body (Pos. 1) on the desk (Pos. 2) by fastening the bracket bolt (Pos. 4), the bracket (Pos. 3) remains hidden from sight (see **Figure 2-3 Securing the tuner to a desk**). This ensures both a tidy workspace and the necessary stability of the tuner body together with up to 5 heavy coaxial cables connected to the back side.

**⚠ DANGER**

For INDOOR tuner operation, the grounding terminal of the tuner labeled **GROUND** and the antenna feeders should be connected as described in Section **1.5.1 Lightning protection when the tuner is installed in a building.**

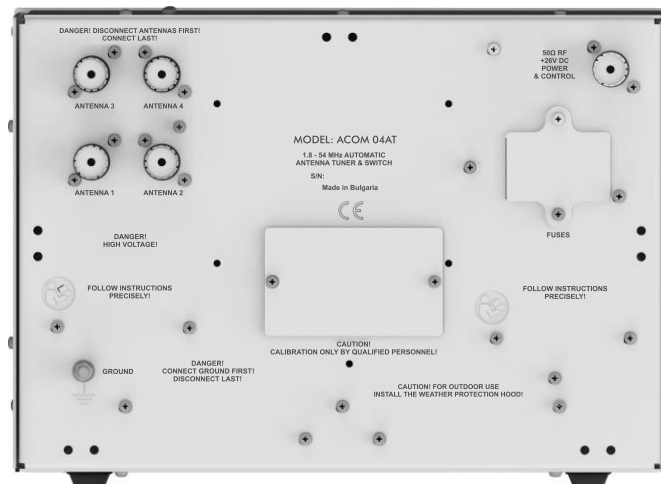


Figure 2-4 Tuner rear view with connectors

Check if the antenna cables and grounding system of your radio station are installed as described in Section **1.5.1 Lightning protection when the tuner is installed in a building**. Next, connect the grounding terminal (Pos. 5) of the tuner labeled **GROUND** (see **Figure 2-3 Securing the tuner to a desk** and **Figure 2-4 Tuner rear view with connectors**) to the main grounding plate of the radio station (see Point **9**) in Appendix 1).

After connecting the grounding terminal, connect the antenna feeders (up to 4 coaxial cables) to the respective connectors (Pos. 6) **ANTENNA 1** through **ANTENNA 4** on the tuner (see **Figure 2-3 Securing the tuner to a desk** and **Figure 2-4 Tuner rear view with connectors**).

Without powering up the amplifier, use a coaxial cable to connect the tuner input (Pos. 7) labeled **50Ω RF +26 VDC POWER & CONTROL** (see **Figure 2-3 Securing the tuner to a desk** and **Figure 2-4 Tuner rear view with connectors**) to the ACOM transistor amplifiers output labeled **RF OUTPUT**.

## 2.4. Installation and Connection for Outdoor Operation

The wall and tower mounting brackets, provided with your tuner, allow the tuner to be remotely mounted, reducing losses, installation costs and installation complexity. This option should always be preferred if applicable. Remote operation drastically reduces feedline losses, resulting from operating a mismatched coaxial line, leaving only the inherent losses of the cable, operated in a source-feedline-load matched mode.



For installation and connection for indoor operation see Section **2.3 Installation and Connection for Indoor Operation**.



Before commencing tuner installation, carefully consider and map out the way the coaxial cables run from the amplifier to the tuner and from the tuner to the antennas, as well as the manner in which they will enter the shack.

### **DANGER**

To prevent accidents, tuner installation and connection to the grounding and antennas should only be carried out in clear, quiet and sunny weather, when there is no danger of lightning and static discharges.

Life threatening voltages and electrostatic charges may occur in the antenna and the cables you install, both as a result of a direct lightning strike or by induction after a lightning strike on adjacent objects, and may also be statically induced by charged clouds or energized by dust storms!

**⚠ DANGER**

Do not commence tuner installation if you don't have a secure lightning protection grounding system as per Section **1.5.2 Lightning protection when the tuner is installed outdoor**.

Do not use grounding systems that are not built to regulations - this may lead to fire, gas explosion, other incidents or death, including that of other persons. Never use the tuner, unless it is properly grounded!

At first, lay out the cables along the route to the radio station and antennas, and protect them from mechanical damage, in case they move in the wind, snow or ice. When the end of the cable is inserted in the foundation of the building, take precautions to seal against wetting the connecting terminals, main grounding plate of the building (see Point **8**) in Appendix 1) or other connections thereof. As a minimum, leave a sufficient U-shaped slack before cable insertion to facilitate water drip off.

At the selected location install an appropriate set of installation accessories (ACOM 04-WM for walls or ACOM 04-MM for masts), as described hereafter. Do not install the protection cover at this point.

The tuner should be mounted strictly horizontally, with the connectors facing downwards and at a height of no less than 1 m above base level (ground or roof).

The installation height above the base is essential in order to install cables with a sufficient U-shaped slack under the tuner bottom level, so that any rain, dew and other precipitation or sprays reflected from base will not wet the tuner and will safely drip off.

Also, in the case of heavy snowfall, the snow will not reach the tuner connectors.

**2.4.1. If the wall mounting option is chosen**

Please, see **Figure 2-5 Wall installation bracket**.

The protective cover (Pos. 1) is removed by unscrewing the five bolts (Pos. 2). The five cover holding brackets (Pos. 7) are left in place, attached to the tuner body. Using the provided in the mounting kit four flat-head bolts (Pos. 5), the wall bracket (Pos. 4) is secured to the tuner body (Pos. 3) and then the protective cover (Pos. 1) is secured back in place with the five bolts (Pos. 2).

Please, see **Figure 2-6 Tuner installed on a wall**.

The whole assembly (Pos. 1 & 2) is then secured to a wall with 6 bolts (Pos. 3) with the weather protective cover facing up. Although the weather protective cover (Pos. 1) provides the necessary shielding from the elements, whenever it's possible, the tuner should be mounted under a shed. This way maximum protection and minimum material wear both from water and sunlight and heat will be provided, extending the tuner's operational lifespan. When installing the system outdoors always select a location, free from any possible loose cables or other objects that might fall on or hit the tuner assembly.



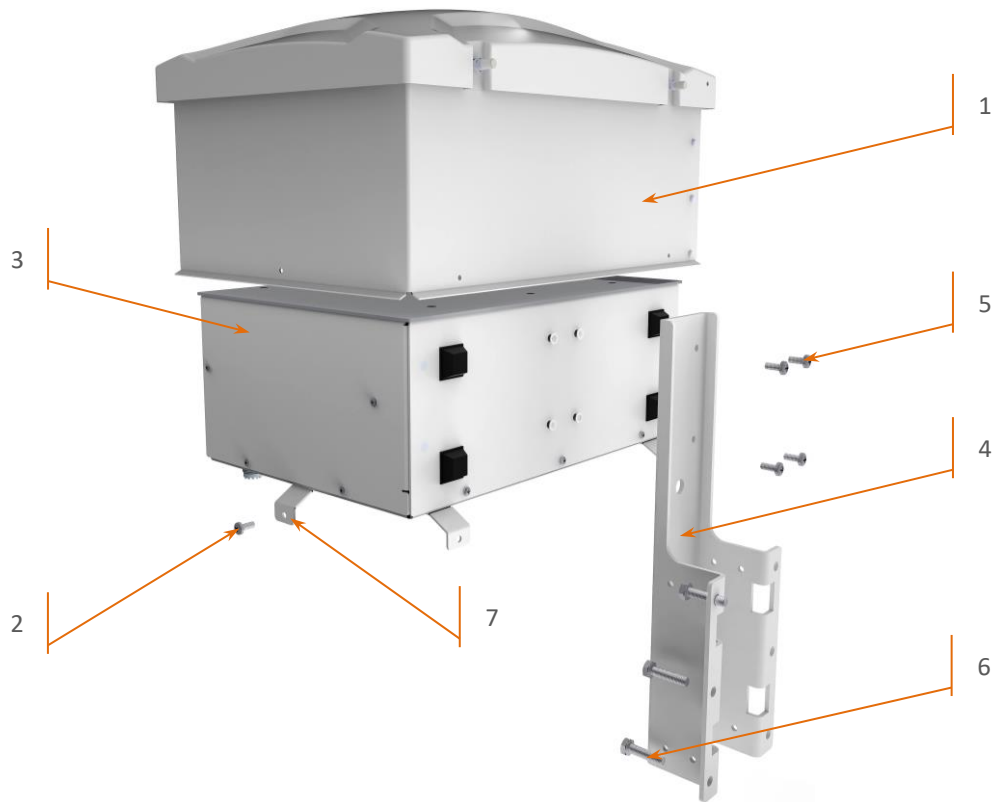


Figure 2-5 Wall installation bracket

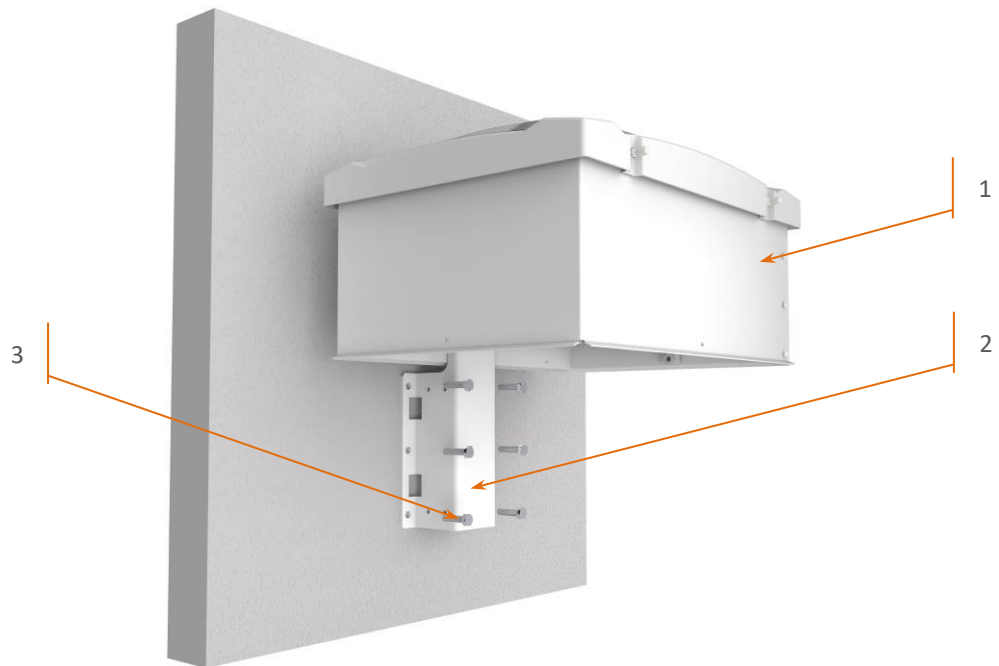


Figure 2-6 Tuner installed on a wall

**2.4.2. If the mast mounting option is chosen**

Please, see **Figure 2-7 Mast installation bracket** and **Figure 2-8 Securing the tuner to a mast**.

The weather protective cover (Pos. 1) is removed by unscrewing the five bolts (Pos. 2). The five cover holding brackets (Pos. 6) are left in place, attached to the tuner body. Using the provided in the mounting kit four flat-head bolts (Pos. 4), the mast bracket (Pos. 3) is secured to the tuner body and then the weather protective cover (Pos. 1) is secured back in place with the five bolts (Pos. 2).

Thread the three hose clamps (Pos. 5), provided with the mounting kit, through their respective rectangle opening pairs in the mast bracket (Pos. 3).

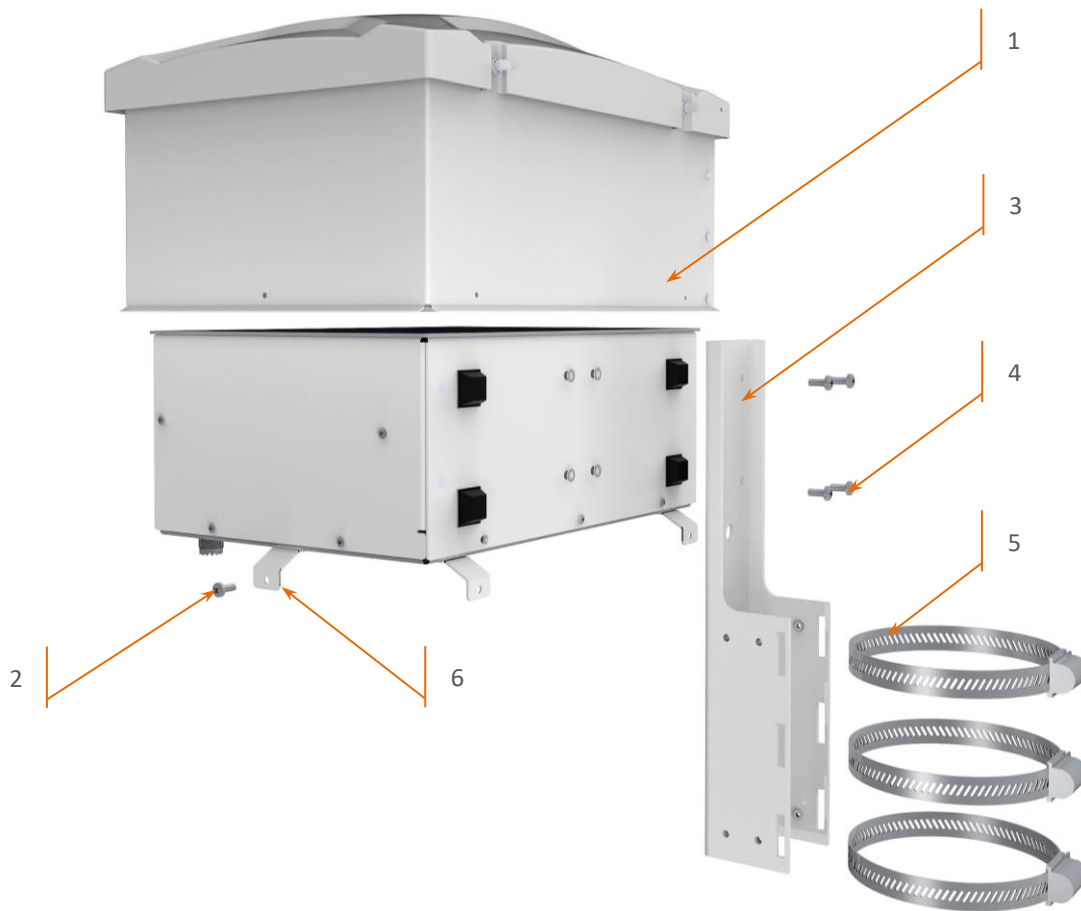


Figure 2-7 Mast installation bracket

The whole assembly (see **Figure 2-8 Securing the tuner to a mast**, Pos. 1 & 2) is then secured to the mast with the connectors facing down using three hose clamps (Pos. 3). Always secure any loose cables, guy wires or any other object that might fall on or hit the tuner assembly.

Both mast and wall brackets have mounting holes for securing cables with the provided cable clamps (Pos. 3 in the **Table 2-1 Accessories list**). The cable clamps are mounted with bolts (Pos. 11) and a combination of 2 washers (Pos. 10 and 13).

Finally, slip the Weather Protection Cover ACOM 04-WP over the tuner (see [Figure 2-5 Wall installation bracket](#), [Figure 2-6 Tuner installed on a wall](#), [Figure 2-7 Mast installation bracket](#), and [Figure 2-8 Securing the tuner to a mast](#)), (Pos. 1) - directing it with the protruding part (marked with ACOM) up. Place it over the provided four carrying pins protruding from the tuner chassis. Carefully align the protection hood until the pins fit into the respective holes. The cover will go down a bit and will rest on the five carrying plates in the tuner base.

Check whether all walls of the protection hood are equidistant from the tuner chassis and whether their bottom edges are parallel.

Use the provided fixing elements in the installation kit to fix the protection hood securely in place. Loosely screw all nuts and screws at first, then fasten them tightly.

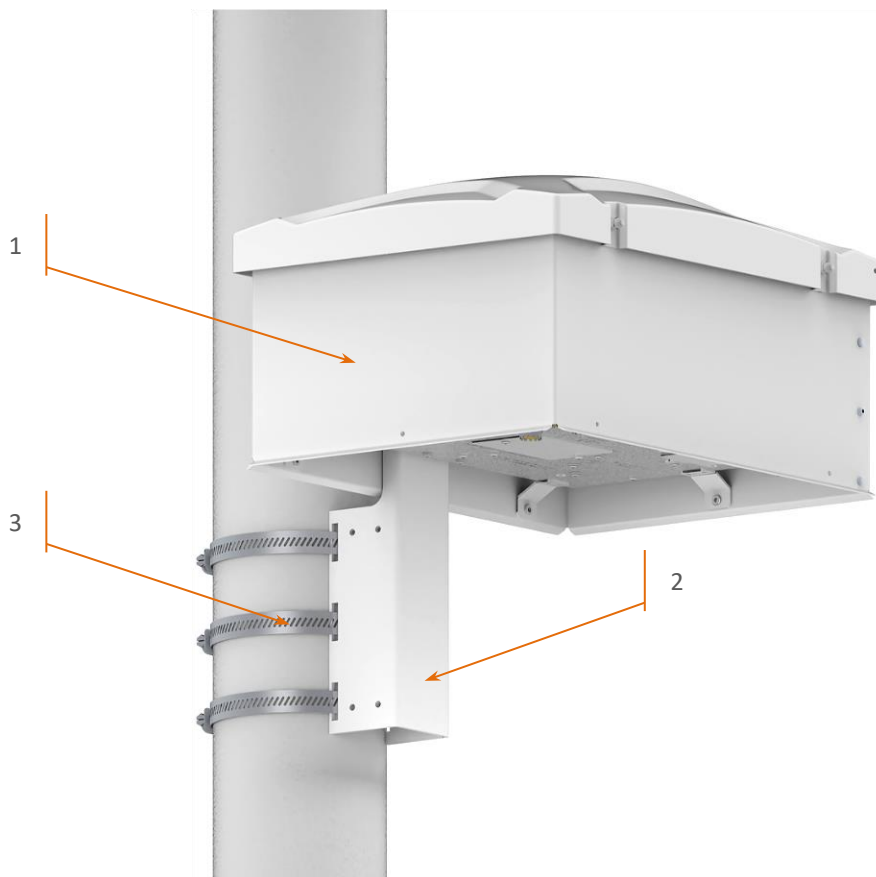


Figure 2-8 Securing the tuner to a mast

### NOTICE

When mounting in the open, never install the tuner in a slanted position neither with protection hood down, to avoid contaminating the inside of the assembly, and to prevent precipitation from seeping into it. This may cause damage that is not covered by the warranty!

**⚠ DANGER**

For remote/outdoor tuner operation, the grounding terminal of the tuner marked **GROUND**, and the antenna feeders should be connected as described in Section **1.5.2 Lightning protection when the tuner is installed outdoor**.

**⚠ DANGER**

After completing the tuner installation, attaching, and connecting the cables, check the reliability of all fixtures and fasten again, if necessary. Apply mineral jelly or another suitable lubricant to the connectors, grounding terminal, and assembling nuts and screws to prevent jamming/clinching or damage to the threads in a future disassembly.

Nr.	ACCESSORIES LIST	Pcs.
1	Mast bracket	1
2	Desk bracket	1
3	Cable clamps	5
4	Desk bracket bolt	1
5	Desk bracket bolt threaded pad	1
6	Hose clamp - small	3
7	Desk bracket spacer plate	1
8	Wall bracket	1
9	Hose clamp - large	3
10	Washer (DIN6798-A4.3-A2) - mounting Pos. 1, 8 and 3 (together with 13)	10
11	Bolt (DIN7985-M4x10-A2) - mounting Pos. 1, 8 and 3 (together with 13)	10
12	Flat-head bolt (DIN965-M4x12-A2)	4
13	Washer (DIN9021-M4-A2) - mounting Pos. 3 (together with 10 and 11)	5

Table 2-1 Accessories list

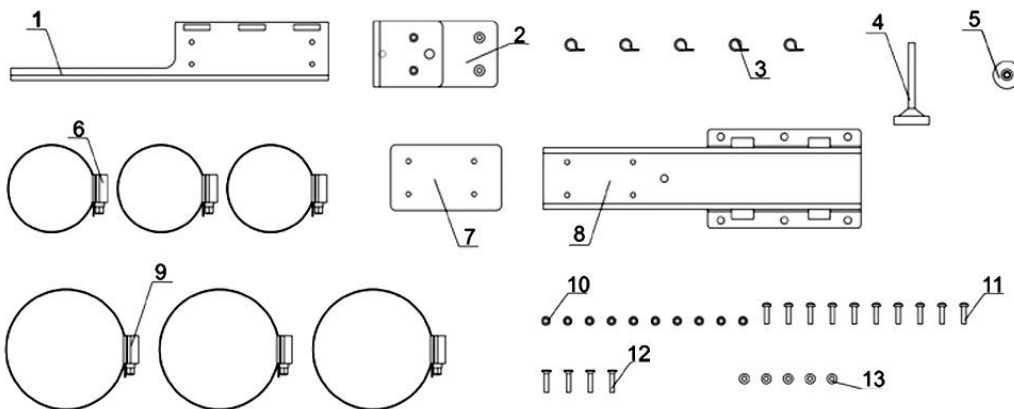


Figure 2-9 Accessories

## 2.5. Grounding, Additional Information

Ground the tuner and install the cables from the antennas and from the tuner obeying safety requirements in Section **1.5 Safety Considerations, Explicit Definitions**. You need to distinguish between different kinds of grounding according to its function!

### 2.5.1. Lightning Protection Grounding

See the instructions provided in Section **1.5 Safety Considerations, Explicit Definitions** and in **APPENDIX 1 | Lightning Protection**. This kind of grounding is used for lightning protection of people, buildings and equipment, but does not protect you from voltages or currents with mains frequency or emitted/induced RF signals.

### 2.5.2. Grounding for Protection from Electric Shock

This grounding (or neutralizing in some cases) is used for protection from electric shock from currents with mains frequency. It will not protect you from a possible lightning or emitted/induced RF signals.

To ensure that your installation complies with the requirements consult a qualified electrician to find out if simultaneous grounding and neutralizing, according to the recommendations of Section **1.5 Safety Considerations, Explicit Definitions**, is allowed by the applicable standards and local regulations for electric shock protection.

### 2.5.3. Radio Frequency Grounding or Counterpoise

This grounding is used for protection from transmitted/induced RF signals, and possible radio frequency interferences. It will not protect you from a possible lightning strike or currents with mains frequency.

These may be e.g., RF counterpoises (radials), which, in particular, could even be isolated from the ground. When they are placed at the required height and have the proper length, they can resonate and be much more effective for RF emission and protection than a direct connection to the ground.

However, this only applies to radio frequencies. They **have no protective functions** against electric shock from currents with mains frequency, or lightning.

## 2.6. Connecting RF Cables, Additional Information

All connections between the tuner and the radio station should be executed in the sequence described below, before the tuner is powered from the amplifier.

**⚠ WARNING**

Before you start connecting the coaxial cable from the radio station to the tuner, ensure that its two ends are not connected to anything and take all necessary precautions that no one has access to them! Place warning signs at both ends reading:

**WARNING! DO NOT TURN ON - PEOPLE WORKING!**

- a) Before doing anything else, connect the tuner's grounding terminal.

**⚠ DANGER**

Do not proceed with the installation, unless you have connected the tuner grounding terminal marked **GROUND** to the lightning protection grounding or the radio station grounding system, according to tuner installation location, see Section [1.5 Safety Considerations, Explicit Definitions](#).

**⚠ WARNING**

Before connecting any cable to the tuner, use a voltmeter to make sure there is no AC or DC voltage above 12 V from the pin of the cable connector to the grounding terminal of the tuner, from the ring of the cable connector to the grounding terminal of the tuner, and between the connector pin and ring!

- b) Assign the antenna numbers (1 to 4) in advance. After verifying that there is no dangerous voltage, connect, one at a time, all available antenna cables to the respective antenna sockets, **ANTENNA 1** to **ANTENNA 4** of the tuner, without fastening the connector rings at first, so that the cables may still be axially turned and adjusted.

Lay out the cables in the necessary directions and attach them to the provided holes in the supporting bracket. Finally, fasten the rings of the coaxial connectors so that swinging and vibrations from the wind will not loosen them. If you need additional binding points besides the holes in the supporting bracket, affix the cables further, e.g., up the mast or to other surrounding objects and walls. Use only UV-resistant materials!

**NOTICE**

Always leave a sufficient U-shaped slack in the cabling below the tuner's bottom level, so that any water would drip off and not enter the tuner.

- c) Connect the RF coax from the radio station to the tuner socket labeled **50Ω RF +26 VDC Power & Control** in a similar way. If the distance to the radio station exceeds 30 m (100 ft), we recommend using a RG213 type, an equivalent or a better cable. Lay out and attach the input cable and fasten the connector ring.

### 3. GETTING STARTED

#### NOTICE

Never exceed tuner specifications! Do not transmit with a high SWR!

#### 3.1. Turning ON and OFF

After you complete the tuner installation instructions (see Section [2 INSTALLATION](#)), verify that the amplifier master power ON/OFF switch on the back panel is in the OFF position, and the plug is pulled out of the mains socket.

#### ⚠ DANGER

Before connecting the coaxial cable from the tuner to the amplifier output, make sure that the cable and amplifier are securely grounded to the grounding system of the radio station. Using a voltmeter, check the cable coming from the tuner to verify there is no AC or DC voltage above 12 V from the pin and the ring of the cable connector to the grounding terminal of the amplifier and between the connector pin and ring!

Connect the tuner coaxial cable to the **RF OUTPUT** of the amplifier. Besides RF power, the tuner will be supplied with DC power from the amplifier (+26 VDC with consumption up to 25 W), and bidirectional control data (60 kHz FSK), all combined on the same cable.

The tuner is turned on together with the amplifier. Connect the power cable of the amplifier to the wall mains socket and turn it on from the front panel. To access and operate the menus related to the tuner, you should explicitly specify that it has been installed. To do that, enter the USER PREFERENCES menu (see Section [4.2 Tuner Assignment and Unassignment](#)) and select:

**ANTENNA TUNER / SWITCH INSTALLED: [YES].**

The amplifier will assign the connected tuner and will then start taking care of its control and indications. At the assignment and at any subsequent turning on, the tuner will perform a quick tuning to retrieve from its memory the last saved tuning for the current frequency of the amplifier.

The tuner is also turned off together with the amplifier. Thus, the four antennas are automatically turned off and grounded. There is no need to assign the tuner from the menu at any subsequent powering on/off. The amplifier will remember the tuner is installed and will continue to take care of it.

If, for any reason, you decide to operate the amplifier without the tuner, enter the USER PREFERENCES menu again and select:

**ANTENNA TUNER / SWITCH INSTALLED: [NO].**

After unassigning the tuner, you will have to connect a matched antenna operating at the respective frequencies to the amplifier output. Also, when the tuner is unassigned, you will not be able to use its antenna switch.

### 3.2. Indication, controls and menus

#### 3.2.1. Tuner Information Area on the Amplifier Screen

After the operator specifies in the USER PREFERENCES that a tuner is installed, the amplifier indication changes:

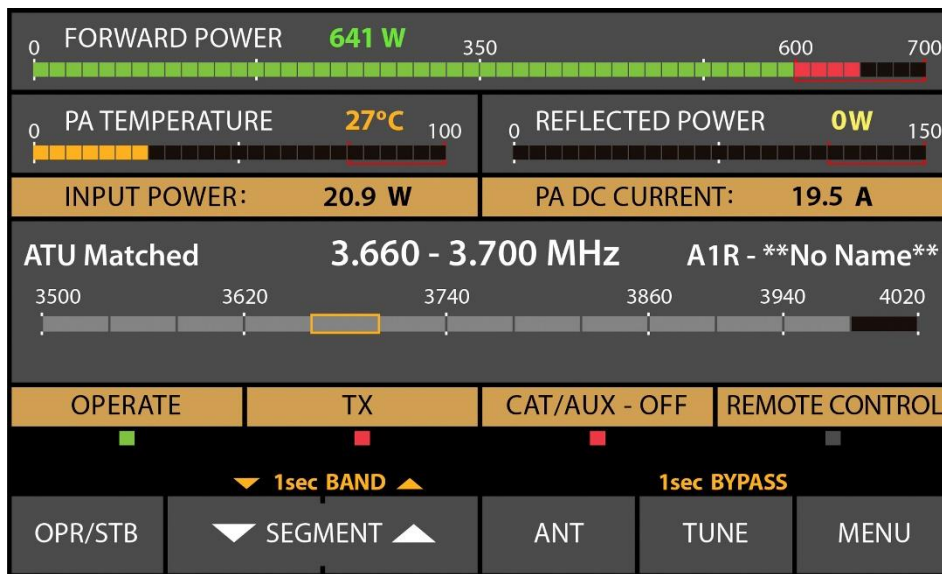


Figure 3-1 Amplifier screen with tuner installed

- The screen displays a frequency range showing the availability or absence of tuner settings for all frequency segments in the current band, to which the amplifier is tuned. The light gray segments have a user tuning stored in the tuner memory, and the black segments do not have one. The current operating segment, which contains the working frequency of the transceiver, is enclosed in a thin orange frame, which moves as the transceiver frequency moves from segment to segment.

- The numerical values displayed above the frequency range now show the boundaries of the current operating frequency segment (rather than of the entire band, if no tuner is present). In front of the values, there is a label reading "ATU Matched", "Memory Settings" or "ATU in Bypass", according to the tuner mode at that time. After the values are displayed the number, the selectivity type and the name of the currently connected antenna (see Section 6.1 ANTENNA ASSIGNMENT Menu). For example, "A2R" indicates the antenna Nr. 2 with Regular degree of selectivity is selected. The antenna number may be from 1 to 4 and each antenna may have different type, specified by the operator (up to four degrees of selectivity). The antenna names after the number may also be edited (see Section 6.1 ANTENNA ASSIGNMENT Menu).



When a tuner is assigned (see Section [4.2 Tuner Assignment and Unassignment](#)):

- The information area above the buttons is reserved for messages concerning the tuner;
- The **BAND** buttons (up and down) become **SEGMENT**;
- The **TUNE** and **ANT** buttons become available and can be used.

The tuner performs a quick tune-up using memorized data for the current operating frequency and antenna. If there is no suitable setting in the tuner memory, the tuner stays in BYPASS mode.

### 3.2.2. Segment UP/DWN buttons (Second Function - BAND)

The two **SEGMENT** buttons with second function **BAND** only appear if no CAT interface is connected to the transceiver.

- Pressing briefly either of the two buttons selects the next frequency segment in the respective direction;
- Pressing and holding either of the two buttons for 1 second selects the next band in the respective direction;

Simultaneously pressing the two buttons has no function.

When there is a CAT interface connected to transceiver, the buttons do not appear, because the segments and bands are changed via CAT automatically, following the transceiver frequency.

### 3.2.3. TUNE button (Second Function - BYPASS)

- Pressing the button briefly starts the full tuning cycle of the tuner (see Section [4.3 Tuning Modes: FULL, QUICK and BYPASS](#)). The button operates in both OPER and STBY mode, i.e., the tuner can be used with the transceiver in STANDBY mode;

- Pressing and holding the **TUNE** button for 1 second alternatively executes the BYPASS mode (see Section [4.3 Tuning Modes: FULL, QUICK and BYPASS](#)) of the tuner with the current antenna or reverts from BYPASS mode by returning the tuner setting (Use ATU);

- While the tuner is in BYPASS mode, it does not retune when frequencies and bands are changed, and the antenna change rules are retained as assigned by bands in the table of the ANTENNA ASSIGNMENTS menu (see Section [6.1 ANTENNA ASSIGNMENT Menu](#));

- When the tuner reverts from BYPASS mode, it responds to the actual frequency and antenna at the time of return. If there is a memorized setting for the current frequency segment and antenna stored in the tuner memory, it is executed and the segment range is displayed again, with the numerical values of the boundaries for the frequency segment;

- If there is no setting for the actual frequency segment and antenna stored in the memory at the time of return from BYPASS mode, the tuner stays in BYPASS mode until the operator starts a full tuning cycle, using the TUNE button or until the antenna and/or frequency are changed with ones with a tuning stored in the nonvolatile tuner memory.

### 3.2.4. ANT Button (Change of Antennas)

Antenna outputs are switched automatically, along with the change of frequency band to the values assigned to bands by the operator in the table of the ANTENNA ASSIGNMENTS menu (see Section **6.1 ANTENNA ASSIGNMENT Menu**).

The **ANT** button is only available if two or more antennas for the selected band are assigned in the table. E.g., if Antenna 2 and Antenna 4 have been assigned, the **ANT** button will switch between them in a "A2-A4-A2-A4..." loop at each button press, and the unassigned numbers (A1 and A3 in the case) will be skipped. At each antenna change, the frequency segment indication and tuning setting is refreshed as well (see Section **3.2.1 Tuner Information Area on the Amplifier Screen**).

### 3.2.5. Tuner Related Menus

When a tuner is assigned (see Section **4.2 Tuner Assignment and Unassignment**), the main menu of the amplifier MENU SELECTION makes available four additional tuner related menus:

- ANTENNA ASSIGNMENTS
- ATU MEASURE
- ATU SERVICE
- ATU TUNING SETTINGS LOOK UP/ERASE.

Each of these four menus will be reviewed in detail in Section **6 ADVANCED FUNCTIONS AND OPTIONS**.

## 4. STARTING UP AND MAIN FUNCTIONS

Operating the tuner is straightforward and intuitive due to the high degree of automation.

You may start operating right after installation. However, in order to make a better use of the tuner features, and to fully adapt it to your particular environment, we recommend reading through the following information.

### 4.1. What is tuning type / Rate (Selectivity Degree, Sharpness)

This tuning feature indicates how significant are the changes in the quality of impedance matching between the antenna and amplifier as a result of small changes of the operating frequency. This determines the necessary width of the frequency segments required in a band, so that a sufficient degree of matching is retained within any particular frequency segment. Accordingly, the tuning settings made and stored in the tuner memory will be usable in a specific frequency segment, narrower or wider, depending on the nature of the antenna used to do the settings.

In addition to narrowing the frequency segments and, respectively, increasing their number per band, the high sharpness of tuning generally leads to higher heat losses and greater instability of the settings in time or due to environmental changes.

It is clear that, by all criteria listed above, it is preferable that the tuning rate (sharpness) be as low as possible, in order to have a few wide frequency segments, with low heat losses and stable (to external impacts) state of tuning.

Unfortunately, the tuning sharpness cannot be chosen in a random manner. The specific frequency-impedance characteristics of each antenna determine a minimum of the tuning sharpness (minimum Q-factor of the tuned antenna circuit in the tuner), which cannot be further reduced, unless heat loss is introduced by design (which, however, would lead to lower efficiency).

E.g., antennas with reduced dimensions, often used for 160 m and 80 m, or at higher frequencies, recently, which are "loaded" with coils close to the maximum current or with "capacitive hats / caps" at the maximum voltage across the length of the antenna, are normally tuned critically, or "sharply".

The higher the degree of physical reduction of the antenna size, compared to its full-size version, the steeper, more frequency-dependent, narrow-band and unstable its settings are, in comparison with, e.g., the settings of a regular dipole. Typical examples include physically short verticals or small-size loops. A poor grounding of the vertical or the proximity of the loops to the ground may in part reduce tuning steepness, but this is caused by additionally induced heat losses, and is compensated by reduced efficiency of the emitter.

On the contrary, a full-size, "thick" emitter, or an emitter with a custom-designed shape, such as a Nadenenko (cage) dipole, an exponential ground-plane or log-periodic structure, will have a much wider usable frequency band of settings than a regular dipole.

Because of the wide variety of antennas used, the ANTENNA ASSIGNMENTS menu allows setting a "type" (selectivity degree) of tuning when they are assigned by bands. This can be done in four different selectivity ranges, separately and independently for the four antennas (see Section **6.1 ANTENNA ASSIGNMENT Menu**), so that the operator can fit the width of the segments to the specifics of each antenna used:

- **SHARP** (narrow)
- **REGULAR** (regular, normal) - default setting
- **WIDE** (broad-band)
- **FIXED** (for fixed frequencies).

The selectivity degrees (tuning rates, antenna types) are not related to the output number, i.e., each output can be declared for each type, regardless of the other ones.

Unless the operator changes it, **REGULAR** (normal) type is set by default for all four antenna outputs.

#### **4.1.1. SHARP**

For moderately reduced dimensions, such as 20-25 m vertical for operation at 160 m, you may select **SHARP** (narrow or small-band, with sharp tuning). The width of the frequency segments will be approximately 0.25% of the operating frequency (e.g., 5 kHz at 160 m).

This option is convenient for small-size and low-band antennas that are artificially lengthened (moderately) with load coils, or "hats / caps", or antennas with preliminary matching, with dipoles, verticals or loops that are not too short, with selective circuits (traps or stubs) included in the design, etc.

#### **4.1.2. REGULAR**

Full-size dipoles, inverted V, loops, 2-3 element square or delta loops, Yagi, etc. common antennas, should be declared as type **REGULAR** (normal) - the option is provided as basic by default. The width of the frequency segments is approximately 1% of the operating frequency.

#### **4.1.3. WIDE**

Naturally broad-band antennas could be declared as **WIDE** (broad-band). The width of the frequency segments is approximately 4% of the operating frequency. This option is convenient for special broad-band radiators, e.g., exponential, log-periodic, "thick" or aperiodic (with absorbing loads) - rhombic etc. similar antennas.

#### **4.1.4. FIXED**

An extreme reduction of the physical dimensions of antennas, such as for a loop of 2-3 m diameter for 80 m band, would probably limit the capability to operate on a single fixed frequency only. If this is the case, select **FIXED** (for fixed frequencies) type. Naturally, you can also make the same choice with more broad-band antennas, if this is convenient for any other reason. This option is also convenient for reducing the probability of operating with random settings at specifically set frequencies.

## 4.2. Tuner Assignment and Unassignment

Tuner assignment and unassignment is done in the USER PREFERENCES menu of the amplifier.

If the top row of the "Antenna tuner/switch installed NO - YES" menu is not selected (if it is shaded), first select it with the ▾ **ITEM** or **ITEM** △ buttons.

To assign the tuner, use the **SELECT** ▷ button and select YES. To unassign the tuner, use the ◀ **SELECT** button and select NO. Leave the menu with the **EXIT** button.

## 4.3. Tuning Modes: FULL, QUICK and BYPASS

The tuner can operate in two main modes of tuning: full and quick. In addition, the tuner can be switched to BYPASS mode, without tuning. This is a non-basic mode, but it can be useful.

- "Full tuning" is the basic cycle for active searching the relays setup for a new frequency and antenna, see details in Section [5 BASIC FULL TUNING CYCLE](#).

- "Quick tuning" passively retrieves information stored in the tuner non-volatile memory of full tuning settings prepared earlier - see Section [4.4 Quick Tuning and Non-Volatile Memory](#).

- "BYPASS" mode eliminates the action of the coils and capacitors in the matching network of the tuner in order to be able to change frequency segments or bands without retuning, e.g. at broad-band or preset antenna - see Section [4.5 Operation in BYPASS Mode](#). In addition to operation, the BYPASS mode can be used for diagnostics and maintenance of the antenna-feeder path (see Section [7.4 Troubleshooting - Monitoring the Antenna-feeder Path Status](#)).

## 4.4. Quick Tuning and Non-Volatile Memory

Quick tuning is performed automatically at each change of frequency segment, band and/or antenna. The tuner checks if there is a stored tuning setting for the desired frequency and antenna in the non-volatile memory. If there is none, the tuner automatically stays in BYPASS mode and the amplifier displays the warning message:

**ATU FULL TUNING REQUIRED.**

If there is a stored setting, the tuner reads the relay combination settings from its nonvolatile memory and immediately performs it by switching all relays in one step (and if necessary, switches the antenna as well) without any emission. The amplifier refreshes its indication - the new frequency segment is enclosed in a thin orange frame on the frequency range, "Memory settings" is displayed in front of the numerical segment boundaries and the number, type, and name of the antenna in use are updated. At this moment the amplifier is ready for transmission.

If the tuning found in memory is too old, the alarm message **TUNING OUTDATED** is displayed (see Section [6.2.8 Aging and Refreshing of Settings](#)), but the outdated tuning setting can still be used. If the operator wants to refresh it, he can immediately start a new full tuning cycle and the data in the non-volatile memory will be refreshed and the message will disappear.

If there is no tuning setting stored in the memory, the tuner automatically stays in **BYPASS** mode and the operator can proceed in either of the following ways:

- Start a full tuning cycle by briefly pressing the **TUNE** button (see Section **5 BASIC FULL TUNING CYCLE**);
- Change the frequency and/or antenna to find a stored tuning setting from the tuner nonvolatile memory.

## Organization and use of the tuning settings memory

We recommend preparing custom tuning settings for the frequencies and antennas that will be used most frequently. They will be automatically stored in the tuner memory, and automatically retrieved when a frequency and/or antenna is changed.

The tuner memory is divided into four large groups - one per each antenna number. Each group is additionally divided into 4 subgroups for the four degrees of selectivity (**Sharp, Regular, Wide** and **Fixed**). The number of segments in each band increases with selectivity (sharpness degree - **S, R, W, F**, see Section **4.1 What is tuning type / Rate (Selectivity Degree, Sharpness)**). For each of the four degrees the segments width increases with frequency, aiming same relative coverage on all bands (narrower at the LF end and wider at the HF bands).

Retrieving tuning settings from the memory is much faster than the main cycle of full tuning, with no emissions of RF power. However, in the meantime the antenna may have changed its parameters to a smaller or larger degree, so an old tuning may be ineffective and may need to be refreshed through a new cycle of full tuning.

### NOTICE

If the conditions at the antenna have changed since the time the tuning was memorized, using outdated tuning settings may lead to a high SWR at the amplifier end. We recommend updating the tuning settings with the **TUNE** button in this case.

For the purpose of **quick tuning without CAT**, the operator should adhere to the following rules of operation for frequency and/or antenna change:

- Frequency segments can only be changed during reception using the  $\nabla$  **SEGMENT** or **SEGMENT**  $\triangle$  buttons or by sending a short preliminary transmission. Start the main transmission after a pause of at least 0.5 seconds.
- The pause between the short and the main transmission is needed so that the amplifier can first check the new operating frequency and switch its harmonic filters, if necessary, to send a "quick tuning" command to the tuner (possibly with a new antenna), to evaluate the response from the tuner and to refresh the onscreen indication.

#### 4.5. Operation in BYPASS Mode

If the operator has chosen BYPASS mode, he takes full responsibility for matching the antennas to the feedline and amplifier - same as without a tuner in place.

In order to place the tuner in BYPASS mode, the operator should press and hold the **TUNE** button for at least 1 second. The tuner bypasses the matching network in order to eliminate its action. BYPASS is displayed onscreen (in front of the frequency).

In BYPASS state, the **ANT** button is still enabled. The antennas can be switched according to their assignments in the ANTENNA ASSIGNMENTS menu (see Section **6.1 ANTENNA ASSIGNMENT Menu**). In this mode, the tuner can be used as an automatic antenna switch to select antennas using the antenna assignments by bands or as a manual switch, if more than one antenna is assigned per band.

The tuner stays in BYPASS state until reactivated by pressing and holding the **TUNE** button again (**1s - Use ATU**). Regardless of whether or not a frequency and/or antenna were changed in the meantime, a new quick tuning is completed from the tuner memory for the current antenna and frequency in use. If there is no stored tuning in the tuner memory, the tuner will stay in BYPASS mode until it is tuned.

#### 4.6. Changing Frequencies and Antennas

Changing a frequency segment or band with a respective quick tuning can be performed in three ways:

- Automatically - utilizing transceiver CAT;
- Semi automatically (when no CAT is active) - by a short transmission at the new frequency, followed by a short pause, during which "quick tuning" will be completed (see Section **4.4 Quick Tuning and Non-Volatile Memory**).
- Manually - by pressing the  $\nabla$  **SEGMENT** or **SEGMENT**  $\triangle$  button (unless there is an active CAT) or by changing the antenna with the **ANT** button (only if more than one antenna was declared for the operating frequency (see section **6.1 ANTENNA ASSIGNMENT Menu**). The last used antenna is memorized.

The frequency segment (boundaries of validity of the current tuning) is numerically indicated on the basic screen of the amplifier, above the tuner setting area. If the new frequency is outside the current frequency segment, a quick tuning will be performed.

If the tuning found in memory is too old, the operator will see the message

**WARNING: TUNING OUTDATED.**

Please, see Sections **4.4 Quick Tuning and Non-Volatile Memory** and **6.2.8 Aging and Refreshing of Settings**.

#### 4.7. Specific of Operation in TRANSMISSION Mode

##### **NOTICE**

Under no circumstances should operation with antenna output SWR above 10:1 be allowed!

In many cases, the tuner may be able to handle SWR even higher than 3:1 at the antenna output, but if the protection for antenna overcurrent, overvoltage, forward or reflected power is activated, the operator should reduce power input to the tuner (e.g., transceiver excitation).

#### 4.8. Power Reduction at Overload

When matching of loads with SWR above 3:1 (up to 10:1) is possible, the maximum allowed tuner power must be reduced gradually as per **Table 8-1 Maximum input power of the tuner as function of the antenna SWR**.



## 5. BASIC FULL TUNING CYCLE

### 5.1. What a Full Tuning Cycle Does

The impedance matching is a transformation to resistive 50 Ohm of the complex RF impedance, presented to the selected antenna output. This is typically done with a residual SWR allowance under 1.3:1 in the ACOM 04AT. A full tuning cycle is the "seek and find" process for a combination of tuner relays that leads to this impedance matching condition.

The necessary relay combination depends on the frequency and the complex impedance, presented to the selected antenna output. Searching for the suitable combination is performed following a specific algorithm. A series of impedance measurements is performed during the cycle and the results are used to determine both the necessary configuration of the matching circuit (L or reversed L-shape matching network), and the necessary values of the coils and capacitors in it.

A full tuning cycle is started by briefly pressing the **TUNE** button. Next, an RF signal has to be applied from the transceiver - 25 W continuous carrier at the operating frequency (when using transceivers with CAT this is automatically done). The RF signal is used to activate the impedance sensors of the tuner.

The automatic tuning process consists of a series of steps, in each one performing measurement and evaluation of the RF impedance transformed by the matching circuit (L-network). With more than 20 RF relays, coils and capacitors of various values are added to the circuit or excluded from it. Each switching is completed with no RF power, to prevent relay contacts from burning. For this purpose, the tuner has a built-in electronic switch for local enabling and blocking of the RF power at the required moment (synchronously with the algorithm steps), while the transceiver power is maintained continuous during the entire tuning cycle.

In each algorithm step, a short pulse of RF power (a few milliseconds) is emitted to activate the tuner impedance sensor and evaluate the current state of the antenna impedance transformed by the matching circuit. At the end of the pulse, data from the sensor is read and RF power is blocked. The result of the step is evaluated by analyzing the measured data - R, G, PH, the forward and reflected power at the matching circuit input. Upon evaluation, the tuner controller makes a decision what switching combination to be applied at the next step, following the tuning algorithm stored in its program memory. The algorithm is designed in such a way, that the time needed for seeking is substantially reduced - the combinations checked are tens of thousands of times fewer than all 2 million possible relay combinations.

The "measurement - evaluation - switching" cycles continue, each subsequent switching decision being made according to the algorithm logic and accumulated changes of the impedance transformation by the matching circuit.

Further, the algorithm is designed in such a way that it unambiguously leads the impedance, transformed by the matching circuit (L-network), to the goal (50 Ohm). This process is complete when the impedance is close to 50 Ohm with a tolerance less than SWR of 1.3:1, or if the possible steps of the algorithm are exhausted.

This way, at the end of the matching cycle, the necessary combination of relays to achieve the matching of the connected antenna impedance to 50 Ohm is found. At the end of the cycle, this relay combination is stored in the tuner nonvolatile memory. The stored values are organized in memory by the boundaries of the frequency segments, in separate tables, by antenna number and type of selectivity. The stored data is used later for quick tuning (see Section [4.4 Quick Tuning and Non-Volatile Memory](#)), when it is required to operate with the same antenna and in the same frequency segment.

The basic cycle of a full (user) tuning may have different duration, depending on the value of the particular antenna impedance, but the tuning time will never exceed 5 seconds.

## 5.2. Operator Actions for a Full Tuning Cycle



If you use more than one antenna for a specific band, you should select the desired antenna for the operating frequency before starting the tuning cycle.

### 5.2.1. Full Tuning for Transceivers with CAT

When the capabilities of modern transceivers with CAT control are used, no manual operations for transceiver control when performing full tuning cycle are required; the transceiver even restores the previous operating mode afterwards. The operator should only do the following:

- Select the new frequency in receive mode;
- Change the antenna immediately, if another antenna is required (if there is more than one antenna assigned for the selected band);
- Briefly press the **TUNE** button at the specified frequency and antenna.

The transceiver, amplifier, and tuner then perform in sync all necessary operations which would be performed for a manually controlled transceiver, but with CAT this is done automatically, quickly, and transparently. The amplifier remains in STBY mode throughout the tuning. At the end of the cycle, the state of the transceiver and amplifier before the tuning cycle initialization is restored (modulation mode, power, OPER/STBY, etc.).

### 5.2.2. Full Tuning for Transceivers without CAT Capability

To complete the same cycle of full tuning of the tuner with a transceiver without CAT connected, the operator should proceed as follows:

- Select the new frequency of the transceiver in receive mode;
- Select a constant carrier mode for the transceiver (e.g., CW or FSK);
- Adjust the RF power of the transceiver to approximately 25 W (unless previously adjusted). You may apply more power to compensate RF losses if the coaxial cable to the tuner is too long.

**NOTICE**

Never exceed 50 W during tuning as described above!

- Transmit a short pulse so that the amplifier can measure the new frequency, automatically select its new frequency band and, possibly, a new antenna as per the assignment in the ANTENNA ASSIGNMENTS menu (see Section **6.1 ANTENNA ASSIGNMENT Menu**);
- Change immediately the antenna, if another antenna is required (if there is more than one antenna assigned for the selected band in the ANTENNA ASSIGNMENTS menu), see Section **6.1 ANTENNA ASSIGNMENT Menu**;
- When the operating frequency and antenna settings are complete, the operator should briefly press the TUNE button of the amplifier to start a full tuning cycle. The amplifier will prompt him to apply RF power for tuning:

**APPLY 20-30 W RF;**

- In this state, the tuner will wait for up to 30 s for the operator to transmit a non-modulated signal (carrier frequency only) of power between 20 W and 30 W with the required frequency for tuning;
- Unless power is applied within 30 s, a message will be received that the waiting period has expired and the procedure will be automatically terminated:

**TIMEOUT EXPIRED - INCOMPLETE PROCESS;**

- For normal tuner operation, the operator will transmit and adjust power with the current level of the transmitted power being indicated with a green mark on a smaller scale under the frequency range of the segments. The aim is to get the pointer to the center of the scale;
- The proper tuning process starts automatically after the power stabilizes and remains at approximately 25 W. "Matching cycle..." is then displayed in front of the numerical boundaries of the indicated segment;
- The tuning process is completely automated and may continue up to 5 s (depending on the frequency and impedance connected to the antenna output);
- When tuning is complete, the amplifier prompts the operator to stop transmitting:

**TUNING COMPLETED: STOP DRIVE POWER.**

After the drive power is removed, the frequency range with the tuner segments is refreshed on the amplifier screen, and **ATU MATCHED** is displayed in front of the numerical boundaries of the current segment. If for any reason a good tune is not achieved, **NO MATCH FOUND** is displayed instead.

## 6. ADVANCED FUNCTIONS AND OPTIONS

### 6.1. ANTENNA ASSIGNMENT Menu

In this menu, the operator can specify the name, type (degree / rate of selectivity) for each antenna and frequency bands to be used with it.

On the screen, the antenna attributes row selected for editing is enclosed in a color frame. The next antenna (row) is selected by pressing the two  $\nabla$  **EDIT**  $\triangle$  buttons simultaneously.

By pressing the **ESC** button, you will leave the ANTENNA ASSIGNMENTS menu and the current state of the table will be accepted.

#### 6.1.1. Antenna Assignments by Bands

Using the  $\triangleleft$  **ITEM** and **ITEM**  $\triangleright$  buttons, the cursor is moved within the band columns from 160 m to 6 m. When an antenna will be used in a particular range, the cursor should be positioned in the respective column.

Then, after pressing the **EDIT**  $\triangle$  button, a tick mark will appear in the respective cell, indicating that the antenna is assigned to this range. The same antenna may be assigned to operate in multiple ranges, not necessarily adjacent. The left  $\nabla$  **EDIT** button cancels the selection.

During amplifier operation, at a manual antenna change, the **ANT** button selects only the antennas assigned in the table for the current band and the unassigned antennas are skipped. For example, if only one antenna is assigned for a band, it is selected with the band, but the **ANT** button does not change anything. If antennas 1, 3 and 4 are assigned for a band in the table, but A2 is not assigned, the **ANT** button will change in order: A1-A3-A4 – A1-A3-A4 – A1-A3... in a loop.

If no antenna is assigned for a certain frequency band, when a frequency is selected in this band (by CAT, by delivering power, or by **BAND** buttons), A1 will be selected by default, and this will be explicitly communicated to the operator:

#### A1 SELECTED BY DEFAULT – USE ANTENNA ASSIGNMENTS MENU TO CHANGE

When the table is empty, this message will appear at each new band.

#### 6.1.2. Setting the Tuning type / Rate (Sharpness, Selectivity), (S, R, W, F)

The four degrees of selectivity (tuning sharpness) - **Sharp**, **Regular**, **Wide** or **Fixed**, set the width of the segments, in which the user tuning settings will be considered valid (see Section [4.1 What is tuning type / Rate \(Selectivity Degree, Sharpness\)](#)).

By moving the cursor more to the left of the 160m band column, you will reach the TYPE column. There, by briefly pressing of  $\nabla$  **EDIT** or **EDIT**  $\triangle$  button, you can set the antenna type (tuning sharpness) - the first letter of the type is displayed: **Sharp**, **Regular**, **Wide** or **Fixed**. For details about the application of the four types of tuning settings see Section [4.1 What is tuning type / Rate \(Selectivity Degree, Sharpness\)](#).

### 6.1.3. Editing Antenna Names

At the leftmost part of the table row, below the number of each antenna, there is a text field for its associated name (set to **\*\*No name\*\*** by default). You can enter any text, in free format, up to 12 characters. The name of the currently connected antenna will appear on the main screen, to the right of the numerical boundaries of the frequency segment.

The selected position of the name character to be edited is highlighted by a small square frame, which can be moved within the name area using the buttons ◀ **ITEM** or **ITEM** ▶ Replacing the character is done with the ▾ **EDIT** or **EDIT** ▲ buttons, causing all printable characters of the basic ASCII table to appear (there is a REPEAT function - just hold the button). The antenna name content or meaning does not affect the operation of the tuner or amplifier.

## 6.2. Maintenance Functions - ATU SERVICE Menu

In the MAIN menu you can select the row ATU SERVICE using the ▾ **ITEM** or **ITEM** ▲ buttons, and activate selected function with the **SELECT** ▶ button. You can leave the function by pressing the ◀ **SELECT** button.

To avoid accidental activation, if you want to intentionally erase the memory, you should press the two ◀ **SELECT** ▶ buttons simultaneously, and hold them for 2 seconds. Deletion can still be cancelled by pressing the right arrow key.

### 6.2.1. ATU Individual Data

The screen displays information about: model (04AT), hardware version (HW Ver: ...) and firmware version (FW Ver: ...) of the Control board of the tuner and the number of working hours - the hours, during which the tuner was powered up (Working hours: nnn h).

### 6.2.2. ATU Status

When you select the ATU STATUS function, the tuner returns the tuning mode information (ATU matched, Memory settings, ATU in bypass), the currently connected antenna number, and the boundaries of the current frequency segment.

### 6.2.3. Deletion of Individual or Group of Stored Tuning settings

- ERASE CURRENT TUNING - erases the tune settings of the current frequency segment from the tuner memory;
- ERASE TUNING SETTINGS FOR: [ANTn] - erases the tune settings for all frequency segments of antenna "n" from the tuner memory;
- ERASE ALL TUNING SETTINGS w/o names neither assignments - erases all tune settings from the tuner memory, and also resets the working hour count, but leaves the antenna names and assignments unchanged in the amplifier memory.

**6.2.4. Erasing the Whole NON-Volatile Memory**

ERASE WHOLE N.V. MEMORY - erases the whole tuner memory, resets the working hour count, and also erases the antenna names and assignments from the amplifier memory.

**6.2.5. Checking the Resource Used for the Current Tuning**

L-C RESOURCE USED (current tuning) - the percentage of coils and capacitors used for the current tuning (see Section **6.3 Overview of TUNING SETTINGS and Resources Used**).

**6.2.6. Dumping the NON-Volatile Memory in a File on a PC**

This function allows backup of antenna assignments by band and antenna names, as well as all user tune-ups from the non-volatile memories of the tuner and amplifier in a computer file. The tuner data will pass through the amplifier and be available at its serial (RS-232) port to a computer. Please, use the "ACOM Terminal S" software, distributed by ACOM free of charge, for the dump. Downloaded backup files can be stored and used later to restore tuning settings and antenna assignments / names you made for various antenna configurations (see Section **6.2.7 Restoring (Loading) the NON-Volatile Memory from a File - Memory Load from File**).

**NOTICE**

The ACOM 04AT tuning-memory DUMP/LOAD procedures are initiated ONLY from the amplifier "ATU Service" menu and NOT from the "ACOM Terminal S" program (see **Figure 6-1 ACOM Terminal S screenshot**).

Do not use the **Firmware Update** button for tuning memory DUMP as the AMPLIFIER Firmware Update procedure will be initiated instead (see the amplifier manual).

Do NOT change the order of the steps in the following procedures.

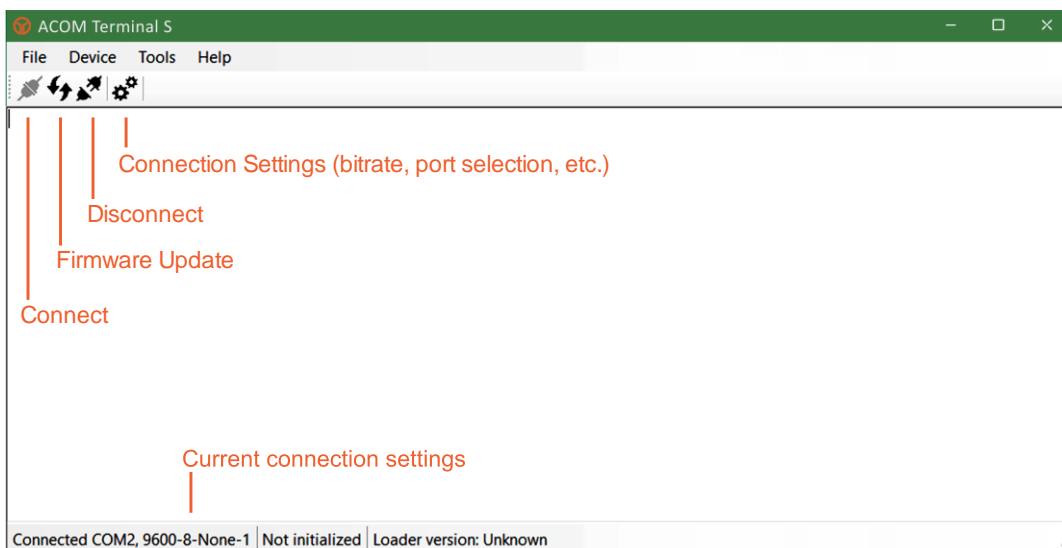


Figure 6-1 ACOM Terminal S screenshot

The ACOM 04AT tuning memory dump file generation and download procedure is performed as follows:

- a) Turn OFF the amplifier. Connect a serial interface cable between the amplifier rear-panel RS-232 connector and the PC. See the amplifier manual for details on serial cable connection;
- b) With the amplifier powered OFF, launch the **ACOM Terminal S** program from the PC and:
  - Press the **CONNECTING SETTINGS** button and select a COM port available on your PC. Configure the connection settings at 9600 bps / 8 bit / No parity / 1 stop bit. Double check the connection settings before the next step!;
  - Press the **CONNECT** button to open the serial port;
  - **Do NOT** press the **FIRMWARE UPDATE** button during this procedure!;
- c) Turn on the amplifier to STBY mode and assign the tuner (if not assigned already - see Section **4.2 Tuner Assignment and Unassignment**). The CAT interface connection is not necessary;
- d) Call up the "ATU Service" menu on the amplifier's display (see Section **6.2 Maintenance Functions - ATU SERVICE** Menu);
- e) Go to the "MEMORY DUMP IN A FILE (wait 5-10 min)" on the amplifier screen and press the **SELECT** > button to confirm the selection;
- f) A new DOWNLOAD window will open in **ACOM Terminal S**. In it click on the **BROWSE** button and select location and name for saving the newly generated dump file on your computer;
- g) Click the **SAVE** button. The terminal program will then return to the previous window, in which the **DOWNLOAD** button should be clicked to start the download of the dump file;
- h) A progress bar will appear, showing the state of the download. It can take 5-10 minutes before the progress bar is full and the following message is displayed:
 

**Operation completed successfully;**
- i) After the download is complete a short beep sound is generated, signaling that the Download window can be closed. Press the **DISCONNECT** button and close the **ACOM TERMINAL S** program after that;
- j) At the selected location on the hard drive a backup file with a ".bkp" as named above can be found, containing the dump;
- k) Turn OFF the amplifier and disconnect the serial cable between amplifier and PC.



In the rare case something goes wrong and the procedure fails, close the DOWNLOAD window with the **CLOSE** button. In the ATU SERVICE menu select a different line on the amplifier screen and then go back to the DUMP position. Repeat the procedure as described above.

### 6.2.7. Restoring (Loading) the NON-Volatile Memory from a File - Memory Load from File

This function is the reverse of the memory dump (see Section [6.2.6 Dumping the NON-Volatile Memory in a File on a PC](#)). It is used to load (restore) from a computer file, backed up earlier, the tuner settings memory and the assignments / names for a particular antenna farm.

All user tunings are restored and the table ANTENNA ASSIGNMENTS is filled-in with antenna assignments and names by band automatically.

The data is input through the serial (RS-232) channel of the amplifier, and transferred by amplifier control to the tuner, which in turn writes it in its own memory. Please use the **ACOM TERMINAL S** software, distributed by ACOM free of charge.

#### NOTICE

The ACOM04AT tuning memory DUMP/LOAD procedures are initiated ONLY from the amplifier ATU SERVICE menu and NOT from the **ACOM Terminal S** program (see [Figure 6-1 ACOM Terminal S screenshot](#)). Do not use the **FIRMWARE UPDATE** button for tuning memory LOAD as the AMPLIFIER Firmware Update procedure will be initiated instead - see the amplifier manual. Do NOT change the order of the steps in the following procedures.

The ACOM 04AT tuning memory LOAD FROM FILE procedure is performed as follows:

- a) Turn OFF the amplifier. Connect a serial interface cable between the amplifier rear-panel RS-232 connector and the PC. See the amplifier manual for details on serial cable connection;
- b) With the amplifier powered OFF, launch the **ACOM Terminal S** program from the PC and:
  - Press the **CONNECTION SETTINGS** button and select a COM port available on your PC. Configure the connection settings at 9600 bps / 8 bit / No parity / 1 stop bit. Double check the connection settings before the next step!;
  - Press the **CONNECT** button to open the serial port;
  - **Do NOT** press the **FIRMWARE UPDATE** button during this procedure!;
- c) Turn on the amplifier to STBY mode and assign the tuner (if not assigned already - see Section [4.2 Tuner Assignment and Unassignment](#)). The CAT interface connection is not necessary;
- d) Call up the ATU SERVICE menu on the amplifier's display (see Section [6.2 Maintenance Functions - ATU SERVICE](#) Menu);
- e) Go to the "MEMORY LOAD FROM FILE (wait 5-10 min)" on the amplifier screen and press the **SELECT** > button to confirm the selection;
- f) A new UPLOAD window will open in **ACOM Terminal S**. In it, click on the **BROWSE** button and from the drop-down menu in the bottom right corner select location and name of an existing backup file ".bcp" on your computer. After locating the required file, the **OPEN** button is pressed;



- g) From the **UPLOAD** menu in the terminal program locate and click on the **UPLOAD** button, starting the procedure;
- h) A progress bar will appear, showing the state of the upload. It can take 5-10 minutes before the progress bar is full and the following message is displayed:

**Operation completed successfully;**

- i) After the upload is complete a short beep sound is generated, signaling that the **UPLOAD** window can be closed. Press the **DISCONNECT** button and close the **ACOM TERMINAL S** program;
- j) The tuner non-volatile memory and the table **ANTENNA ASSIGNMENTS** are automatically restored with tuning settings, antenna types, names, and band coverage from the uploaded backup file ".bkp" after a successful procedure;
- k) Turn **OFF** the amplifier and disconnect the serial cable between amplifier and PC.



In the rare case something goes wrong and the procedure fails, close the **UPLOAD** window with the **CLOSE** button. In the **ATU SERVICE** menu select a different line on the amplifier screen and then go back to the **UPLOAD** position. Repeat the procedure as described above.

### 6.2.8. Aging and Refreshing of Settings

The **TUNING SETTINGS OUTDATED** function allows the operator to specify a "period of validity" or "time period allowed" of the settings retrieved by the "quick tuning" commands from the tuner memory. The hours are presented as a "total time the tuner was powered".

The limits of the aging alarm can be specified by the operator in four stages: [100 - 300 - 1000 - 3000] hours.

Each setting retrieved from tuner memory comes with the number of hours that the tuner has been in operation since the time the setting was stored, up to the time it was retrieved. If the time period of the retrieved setting is older than the limit specified by the operator, the alert text **TUNING OUTDATED** is displayed on the amplifier screen, but the outdated tuning settings can still be used.

### 6.3. Overview of TUNING SETTINGS and Resources Used

When the menu ATU TUNING SETTINGS LOOK UP/ERASE is accessed, data lines start scrolling the screen (for approximately 5 seconds) - a line per frequency segment with the current operating band, and the current operating antenna. If up/down arrows appear on the right of the screen, this means there are more frequency segments to be viewed by scrolling up/down.

The following data is displayed on each line:

- Antenna number, selectivity and name;
- Frequency boundaries of tuning validity (frequency segment);
- Resource used (in percentage of maximum inductors and capacitors usable for the respective frequency);
- Tuning age in hours ("----" means "no tuning").

ACOM 04AT uses an L-shape matching network configuration. The abbreviations used below mean:

- CT is the capacitor connected in parallel to the transmitter (tuner input);
- L is the inductance connected between transmitter and antenna;
- CA is the capacitor connected in parallel to the antenna (tuner output).

The percentages for CT, L and CA show what part of the coil and capacitor resource was used for this frequency to achieve the tune. The resource is the maximum useful inductance L and capacitance C depending on the frequency.

If CT is not zero, then CA is zero and the configuration of the matching network is "L" (typical for low impedances at the antenna output).

If CA is not zero, then CT is zero and the configuration of the matching network is "reverse L" (typical for high impedances at the antenna output).

In some cases, it may be that both CT and CA are zero (or a very low percentage on one side). If the inductance is also a low percentage, then the load is with impedance close to 50 Ohm.

This data may lead you to conclude:

- What reserves you have left for compensating possible fluctuations in antenna impedance as a result of external effects in the future, such as a change in weather conditions, change in antenna environment, e.g., newly installed or removed antennas, bulky conducting objects in antenna vicinity, etc.;
- If you record the data of the tuner resource used in the frequency bands for your antennas, you can use their changes in the future to determine the stability of the antenna impedance in time, thus you can prevent possible failures in an antenna or feeder, and you can promptly take precautions to improve the reserve resource before it is too late.

The ◀ **ANTENNA** or **ANTENNA** ▶ buttons can be used to review the resource table for another antenna in the same band.

The ▼ **SEGMENT** or **SEGMENT** ▲ buttons are used to select (highlight) a different frequency segment in the table. Simultaneously pressing the two ▼ **SEGMENT** ▲ buttons for more than 1 second selects the next **BAND** for review (the preceding band cannot be selected).

Simultaneously pressing and holding for more than 2 seconds the two ◀ **ANTENNA** ▶ buttons delete the shaded segment tuning, and "- - -" is displayed in place of the hours.

#### 6.4. Measurements in the Tuner - ATU MEASURE Menu

This menu allows remote measurements of some RF values directly at the antenna outputs of the tuner (without the transformation action of the matching circuit). This data can be used to troubleshoot and diagnose the status of the antennas and feeders (see Section [7.4 Troubleshooting - Monitoring the Antenna-feeder Path Status](#)).

Five values are measured for the current operating frequency segment and current antenna output, as well as three general tuner values:

ANTENNA VOLTAGE: ... V (rms)  
 ANTENNA CURRENT: ... A (rms)  
 ANTENNA FORWARD POWER: ... W  
 ANTENNA REFLECTED POWER: ... W  
 ANTENNA SWR: ...  
 ATU PS VOLTAGE: ... VDC  
 ATU TEMPERATURE: ... °C  
 ATU WORKING HOURS: ...

The measurements can be performed in STBY mode or OPER mode. The operator should manually start and stop RF power to the tuner when performing these measurements.

#### NOTICE

In ATU MEASURE menu the tuner protection systems are temporarily blocked, so the RF power limits (see [Table 8-1 Maximum input power of the tuner as function of the antenna SWR](#)) should be monitored by the operator (see Sections [6.4.1 Voltage and Current at the Antenna Output](#), [6.4.2 Reflected Power, Forward Power and SWR at Antenna Output](#) and [6.4.3 Power Supply Voltage and Temperature in the Tuner Unit](#)).

#### 6.4.1. Voltage and Current at the Antenna Output

The antenna voltage and current are indicated in root-mean-square (rms) values. They should not exceed:

ANTENNA VOLTAGE < 500 V (rms);

ANTENNA CURRENT < 10 A (rms).

#### 6.4.2. Reflected Power, Forward Power and SWR at Antenna Output

The reflected power, forward power and SWR should not exceed:

ANTENNA REFLECTED POWER < 400 W;

ANTENNA FORWARD POWER < 1600 W;

ANTENNA SWR < 10:1.

Note that at  $SWR > 1:1$  at the tuner output, the forward power will exceed the tuner input power by the value of the reflected from the output power. Therefore, it would be normal, e.g., at ANTENNA  $SWR = 3:1$ , and input power from the amplifier 1000 W, to measure:

ANTENNA FORWARD POWER = 1250 W and

ANTENNA REFLECTED POWER = 250 W

at the antenna output.

#### 6.4.3. Power Supply Voltage and Temperature in the Tuner Unit

These two values should be within the following ranges:

ATU PS VOLTAGE = 22 ... 30 VDC;

ATU TEMPERATURE = -40...+65 °C (-40...+150 °F).

#### 6.4.4. Tuner Working Hours

This is the number of hours during which the tuner has been powered.

## 7. MAINTENANCE

The user **IS NOT** expected to perform any repairs, except replacing fuses (see Section **7.2 Fuse Replacement**) and repairing antennas or coaxial cables on the feeders.

If needed, call your dealer's service provider or the manufacturer directly (see Section **1.2 Owner Assistance**).

### 7.1. Cleaning

#### ⚠ CAUTION

Do not use any solvents for cleaning. They may be dangerous to you and damage tuner surfaces.

Do not disassemble the tuner. Cleaning of the tuner outer surface can be done with a piece of soft cotton cloth lightly moistened with clean water.

### 7.2. Fuse Replacement

#### NOTICE

For replacement, only use standard fuses from the types recommended below.

There are two fuses in the tuner. They are located under a small cover on the front panel (see **Figure 2-1 ACOM 04AT tuner**, Pos. 6). The fuses are European size 5x20 mm, ceramic (or glass) body cartridge.

**Fuse F1** specification:

- "F" type (fast-acting / quick-acting / fast blow / quick blow);
- Rated for 2 A and 250 V.

Suitable fuses are:

- EATON Bussmann, PN: GMA-2-R (glass body cartridge);  
This fuse can be ordered from:
  - Farnell ([www.farnell.com](http://www.farnell.com)), PN: 1150627;
  - Mouser ([www.mouser.com](http://www.mouser.com)), PN: 504-GMA-2-R.
- Littelfuse, PN: 0235002 (glass body cartridge);  
This fuse can be ordered from:
  - DigiKey ([www.digikey.com](http://www.digikey.com)), PN: F4724-ND or F2680-ND;
  - Farnell ([www.farnell.com](http://www.farnell.com)), PN: 1608243;
  - Mouser ([www.mouser.com](http://www.mouser.com)), PN: 576-0235002.

**Fuse F2 specification:**

- "T" or "L" type (time-lag / slow blow / träge);
- Rated for 0.8 A and 250 V.

## Suitable fuses are:

- EATON Bussmann, PN: S506-800-R (glass body cartridge);  
This fuse can be ordered from:
  - DigiKey ([www.digikey.com](http://www.digikey.com)), PN: 283-2708-ND;
  - Farnell ([www.farnell.com](http://www.farnell.com)), PN: 1241969;
  - Mouser ([www.mouser.com](http://www.mouser.com)), PN: 504-BK/S506-800-R.
- Littelfuse, PN: 0218.800 (glass body cartridge);  
This fuse can be ordered from:
  - DigiKey ([www.digikey.com](http://www.digikey.com)), PN: F1744-ND;
  - Farnell ([www.farnell.com](http://www.farnell.com)), PN: 1271631;
  - Mouser ([www.mouser.com](http://www.mouser.com)), PN: 576-0218.800.

**NOTICE**

If any of the two fuses blows, it is most probably the result of too much power applied (over 60 W) during tuning (e.g., due to operator error).



If, after fuse replacement, the device does not operate normally, we recommend repair, performed only by a trained service technician.

Contact your ACOM dealer for assistance (see Section [1.2 Owner Assistance](#)).



Besides specific national standards, the principal fuses standard applied worldwide is IEC 60127.

### 7.3. Block Diagram and Principle of Operation

Please, see **Figure 7-1 Tuner Block Diagram**.

The ACOM 04AT tuner consists of the following main assemblies:

- Input switch board;
- Input sensor board (located on the Capacitors board);
- Inductors board;
- Capacitors board;
- Output sensor and antenna switch board;
- Control board (includes modem, four service LEDs and two buttons).

The matching RF circuit is an L-shape matching network configuration and is comprised of the Capacitors board and Inductors board.

The Inductors board contains 9 discrete coils that can be bypassed or added in series by relays KL1 to KL9. Together, they form an inductor with a maximum value of over 6.25 mH, variable in 0.015 mH increments. The discretely controlled inductor is connected in series between the tuner input (to the transmitter) and output (to the antenna).

The Capacitor board contains 10 discrete capacitors that can be switched off or connected in parallel by relays KC1 to KC10. Together, they form a capacitor with a maximum value of over 2800 pF, variable in 3 pF increments.

The discretely controlled capacitor can be connected in parallel to the tuner input (from the transmitter) or to the output (to the antenna) using two relays: KCT and KCA, respectively, forming the two basic configurations of an L or reverse L matching network, required for the different antenna impedances:

- L-network (KCT on, KCA off) - for matching of mainly low impedances;
- Reverse L-network (KCT off, KCA on) - for matching mainly high impedances.

After the matching circuit, the RF power passes through the output sensor and the antenna switch, reaching the selected antenna output (1 of 4). The output sensor produces four analog signals for the output forward and reflected power, antenna current and antenna voltage: fwda, rfla, ia, and ua. The antenna switch is controlled by four relays, KA1 to KA4. There is a lightning surge arrestor (not shown in the block diagram) at the output sensor to protect the tuner and the devices connected to it from atmospheric discharges.

The input RF power from the amplifier, along with the +26 VDC power supply and the modem 60 kHz control signal is fed to the input switch board, at the RF Input connector.

Here, by using suitable filters, the 60 kHz modem signal is separated and fed to and from the Control board. The power supply +26 VDC is separated and used to derive a +5 V power supply and three auxiliary DC voltages: +180 V, +12 V, and -12 V for the MOSFET INPUT SWITCH. The CROWBAR relay has a protection function and is normally open. The +180 V auxiliary voltage is enabled and disabled by the HVON signal from the Control board.

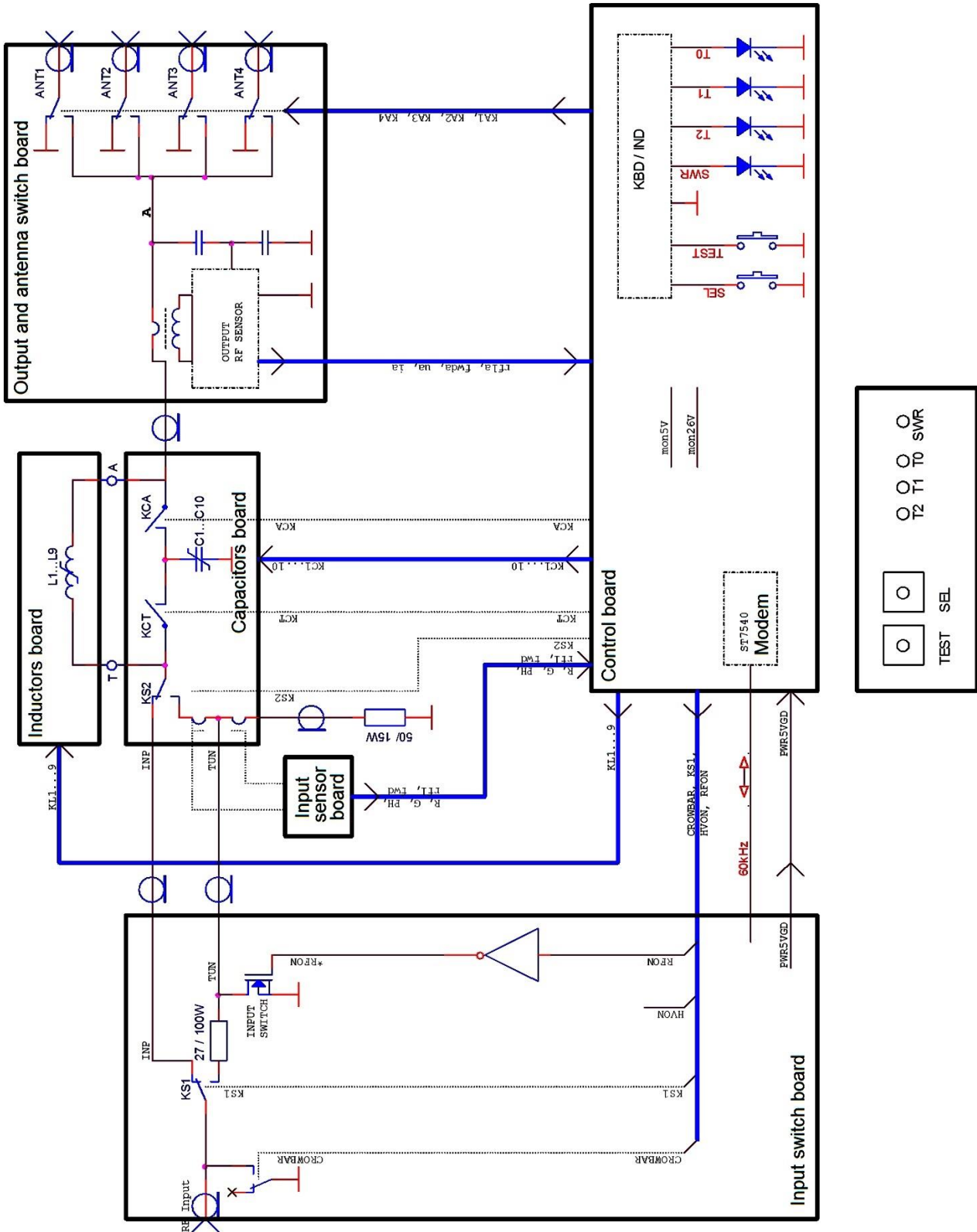


Figure 7-1 Tuner Block Diagram



During tuner operation (after tuning), in normal state of the relays KS1 and KS2, the input RF power is directly fed from the RF Input to the input of the L matching network.

During the basic cycle of tuning, by switching the KS1 relay over to the Input switch MOSFET, the input RF power is directed through a 27 Ohm / 100 W resistor to the transistor MOSFET INPUT SWITCH and to the TUN input of the Sensor board. In this case, the KS2 relay on the Capacitors board is used to connect the input sensor output to the input of the matching circuit (L-network), so that the sensor measures the antenna impedance, transformed by the matching circuit.

In tuning mode, the input RF power is fed through the 27 Ohm / 100 W resistor and primary windings of two current transformers, TA1 and TA2, to two branches - one to the input of the matching circuit and another to a reference resistor 50 Ohm / 15 W, which is compared to the input impedance of the L-network, thus forming a RF impedance bridge.



The transformers TA1 and TA2 are located on the Capacitors board, while the block diagram shows them with their primary windings only.

The secondary windings of TA1 and TA2 feed to the input sensor RF voltages, proportional to the RF currents in the two branches - the reference 50 Ohm / 15 W resistor and the antenna impedance transformed by the matching circuit. The relation of amplitudes and phases of these two signals represents unambiguously the complex value of the antenna impedance transformed by the matching circuit.

By comparing properly selected parts of these two signals and their combinations by module and by phase, the sensor produces the following three logic output signals, characterizing the position of the antenna impedance transformed by the matching circuit, towards the target of the tuning, i.e. towards the point (50+j0) Ohm, on the complex impedance plane:

- "R": logic output - shows whether the real part of the transformed impedance is above or below 50 Ohm;
- "G" logic output - shows whether the real part of the transformed admittance is above or below 1/50 S (20 mS);
- "PH" logic output - shows whether the phase sign of the transformed impedance is inductive or capacitive.

The three logic signals in question, "R", "G", "PH", and the detected forward and reflected power "fwd" and "rfl" (from the input of the matching circuit) are the main sources of information, which are fed by the input sensor to the Control board during the full-tuning process. They are processed by the Control board, which provides the tuner operation algorithm (including the tuning algorithm).

As mentioned above, in tuning mode, the input RF power is mainly fed to the 27 Ohm / 100 W resistor. The INPUT SWITCH MOSFET is normally saturated (high level on gate from \*RFON signal), so the RF current is diverted to the ground through its drain-source channel. In this state, almost all input RF power is dissipated by the 27 Ohm / 100 W resistor and nothing is fed to the matching network. When the MOSFET is saturated, the control system can switch over the tuner relays without a risk of relay contact arcing and deterioration, while the tuner input impedance is kept below SWR of 2:1.

The process of full tuning runs in a number of steps (see Section [5.1 What a Full Tuning Cycle Does](#)) and at each step the Control board enables and blocks the RF power through the MOSFET INPUT SWITCH mentioned above. During that time, the transceiver feeds continuous RF power. At each step the controller first activates the sensors with a short pulse of RF power by blocking the MOSFET for a short time, and in a few milliseconds reads out the status of the sensors, then it blocks the power to the relays by saturating MOSFET again, and in this manner switches the relays synchronously with the power and keeps the contacts safely clean (see Section [5.1 What a Full Tuning Cycle Does](#)).

After each relay switchover cycle, the control board applies RF power to update sensor measurements and read their new state. This is done by the \*RFON signal and only lasts a few milliseconds (until the sensor readings are stabilized); then the control analyzes again the information read by the input sensor - "R", "G", "PH", "fwd" and "rfl", in order to evaluate the current position of the transformed impedance against the goal (50+j0) Ohm. While the RF power is enabled the relays won't switch.

After analyzing and evaluating the result of the subsequent relay switching, the Controller board makes a decision which capacitors and inductors to be included and which ones to be excluded from matching circuit at the next step. The decision is made following a specific tuning algorithm in the program memory of the Controller board.

The algorithm is built in such a way that the process is always convergent, i.e., the transformed impedance converges to the circle with SWR < 1.3:1 toward 50 Ohm, regardless of the wide variety of expected antenna impedances in the frequency range, using the available resource of coils and capacitors to the maximum possible extent, according to the operating frequency.

At each subsequent step, the Controller board enables RF power briefly, analyzes again the result from the data of the input sensor, makes a decision for the subsequent commutation, etc.

The tuning proceeds with multiple successive attempts, following the controller algorithm. Before switching each relay, the power is stopped and the new relay state is set.

After waiting a certain amount of time for the relay contacts to settle, a new RF pulse follows, with sensor reading power included, etc., until the impedance transformed by the L-network enters the range of impedances with SWR < 1.3:1, or until the coil and capacitor resource is depleted (e.g., if the SWR of the antenna is too high, so no tuning can be found).

At the end of the tuning process, the tuner Controller board reports the result of the tuning to the amplifier, and waits until the operator stops transmitting. Then the tuner Controller board disables the relays KS1 and KS2 (RF power delivery to the tuner is stopped). This switches the RF output of the amplifier directly to the input of the already tuned antenna circuit, and the tuner is ready for operation. The combination of relays found to achieve good tuning is stored in the tuner nonvolatile memory automatically.

## 7.4. Troubleshooting - Monitoring the Antenna-feeder Path Status

Using the ATU MEASURE function, you can evaluate the status of the antenna-feeder path and the coaxial cable from the amplifier to the tuner.

- a) We recommend that you access the ATU MEASURE menu, and check the SWR of the antenna output there, while you are sure of the good working condition of the antennas and feeders. Run this measurement for both the operating frequencies and at least one non-operating frequency, where SWR should be poor (if the tuner cannot be tuned to this frequency, use BYPASS mode during measurements). Copy and store the data for your antennas and then use it as a reference in diagnostics;

- b) When running diagnostics, use the ATU MEASURE menu to check SWR at the antenna output at a frequency for which you know that the antenna SWR should be poor (if the tuner cannot be tuned to this frequency, use BYPASS mode). If you measure a good instead of poor SWR at the antenna output, this indicates high losses in the feeder from the antenna output to the antenna or in the antenna itself. If SWR in the ATU MEASURE menu is really poor (as it was earlier), go to the tuner's BYPASS mode and measure the SWR at the input of the coaxial cable in the radio station: if it is also poor and if the SWR to the amplifier becomes good after a tuning, then the cable to the radio station is with low losses;

If SWR at the antenna output (in the ATU MEASURE menu) is poor, but bypassing the tuner it becomes better at the input to the radio station, then probably the losses at the cable from the radio station to the tuner are high. E.g., there may be moisture in the braid, the dielectric may be soaked with water (if it isn't solid), or the braid may be corroded. Such coaxial cable should be replaced with a new one, because it will introduce high losses and impedance instability in both transmission and reception, and could also induce interference at reception;

- c) If after tuning the tuner shows that it has achieved a good SWR, but you find poor SWR at the amplifier end (e.g., by the SWR indicator of the transceiver or amplifier), this shows that the feeder from the radio station to the tuner may be unsuitable or faulty (the cable impedance may differ from 50 Ohm, or there is a poor contact or leakage at some connector);
- d) If you receive a **TIMEOUT EXPIRED** message while trying to tune the unit (even when the tuning power is increased to 50 W) and, at the same time, SWR at the bottom end of the feeder (in the radio station) is good during tuning, this means that:

- The losses at the feeder may be so high that out of the 50 W fed, under 12 W reach the remote unit, which is not enough to tune the tuner;
- There may be a blown fuse F2 at the tuner (see Section [7.2 Fuse Replacement](#));

- e) If you receive a **TIMEOUT EXPIRED** or **UNSTABLE RF POWER** message while trying to tune the unit (even when the tuning power is increased to 50 W) and, at the same time, SWR at the bottom end of the feeder (in the radio station) is much higher than 2:1 during tuning, this means that:

- The cable impedance from the radio station to the remote unit may be other than 50 Ohm or may be faulty or disconnected;
- The transceiver power may be modulated or unstable (it should be unmodulated carrier); check for loose or contaminated connectors;
- There may be a blown fuse F1 at the tuner (see Section [7.2 Fuse Replacement](#));

- f) If you get a **COMMUNICATION TO ATU/ASEL FAILING** message, then most probably the cable connection from the amplifier to the tuner is unstable. Check the cable DC resistance (see Section **8.1.10 Maximum Length of the Input Coaxial Cable**). Check if the panel socket holds the cable pin tightly and there is no solder buildup on the pin tip. Clean and fasten the male and female connector parts carefully. Check the same at both the amplifier and the tuner sides;
- g) If the associated tuner menus are unavailable on the amplifier, check whether the tuner is assigned (see Section **4.2 Tuner Assignment and Unassignment**) and also check the cable as described in Point **f**) above.

## 8. SPECIFICATIONS

### 8.1. Parameters

#### 8.1.1. Operating Frequency Range

Continuous from 1.8 to 30 and from 50 to 54 MHz, extensions and changes on request.

#### 8.1.2. Minimum Range of the Matched Impedances (at Each of the Four Antenna Outputs)

All impedances with SWR from 1:1 to 3:1 towards 50 Ohm, any phase angle, unbalanced input and output.

#### **NOTICE**

For some frequencies and impedances, matching is possible at SWR above 3:1 at the antenna output (up to 10:1), but the maximum allowed power is reduced (see Section **8.1.3 Maximum Allowed Input Power**).

#### 8.1.3. Maximum Allowed Input Power

(PEP, Mean or Continuous Carrier, Without Mode Limitation)

When tuning is possible for antenna SWR above 3:1, the maximum permissible input power is reduced gradually as per **Table 8-1 Maximum input power of the tuner as function of the antenna SWR**.

SWR	1-3:1	3.5:1*	4:1*	5:1*	7:1*	10:1*
Pin, W	1200	900	700	500	300	200

Table 8-1 Maximum input power of the tuner as function of the antenna SWR

#### **NOTICE**

Operation with antenna output SWR above 10:1 is not allowed.

#### 8.1.4. RF Input Characteristics

- Rated impedance: 50 Ohm unbalanced;
- Input connector type: UHF/PTFE (SO-239A) - 1 pc.;
- SWR during full tuning (basic cycle): no higher than 2:1;
- SWR immediately after full tuning: no higher than 1.5:1 (1.3:1 typically).

\* When tuning is possible for SWR above 3:1

#### 8.1.5. Antenna Outputs Characteristics, Antenna 1 to Antenna 4

- Rated impedance: 50 Ohm unbalanced;
- Maximum antenna output SWR: 3:1 (up to 10:1 with RF power limitations (see Section **8.1.3 Maximum Allowed Input Power**));
- Output connectors type: UHF/PTFE (SO-239A) - 4 pcs.

#### 8.1.6. Full Tuning Duration (Basic Cycle)

Basic cycle for preparation of user full tuning settings, with automatic storage in the non-volatile memory:

- In the range of 1.8 to 10 MHz: no more than 5 seconds (2-3 seconds typically);
- In the range of 10 to 54 MHz: no more than 3 seconds (1-2 seconds typically).

#### 8.1.7. Input Signal Needed to Prepare User Tuning Settings

Non-modulated carrier power 25 W +3/-3 dB (12.5 to 50 W).

#### 8.1.8. Power Supply

- +26 VDC +10/-15%, consumption of 25 W at most;
- Supplied by an amplifier of the ACOM transistor series over the input RF coaxial cable.

#### 8.1.9. Remote Control

The remote control and indication from an amplifier of the ACOM transistor series is provided over the input RF coaxial cable of the tuner using a 60 kHz / 4800 bps bidirectional FSK modem.

#### 8.1.10. Maximum Length of the Input Coaxial Cable

The maximum length of the RF coaxial cable between the amplifier output and the tuner input (see Sections **8.1.4 RF Input Characteristics**, **8.1.8 Power Supply**, **8.1.9 Remote Control** and **8.2.9 Cable Required from the Radio Station**) is 100 m (330 ft) for a cable of RG213 type or similar. The cable characteristic impedance should be 50 Ohm and the DC resistance should be below 1 Ohm for inner and outer conductors altogether.

### NOTICE

To achieve maximum distance the coaxial cable must be of copper, not steel conductors (even though silver plated).

#### 8.1.11. Size & Weight (operating, excluding fastening elements and connected cables)

- WxDxH: 345x250x190 mm, 4.2 kg (13.6x9.9x7.5 inches, 9.3 lbs.).

### 8.1.12. Operating Environment

- Protection class: IP 53 (NEMA Type 3);
- Temperature range: -40 to +65 degrees Celsius (-40 °F to 150 °F);
- Relative air humidity: Up to 98% @ +40 degrees Celsius (104 °F);
- Height: up to 3050 m (10000 ft) above sea level without output deterioration.

## 8.2. Functions

### 8.2.1. Process of Matching of Antenna Impedance

- Fully automated.

### 8.2.2. Modes of Tuning

Two modes: Full (basic cycle of user tuning) and Quick (restoring preset full tune settings from the non-volatile memory).

### 8.2.3. Memory for the User Tune Settings

Integrated non-volatile memory, separate for all four antenna-selectivity types and outputs.

### 8.2.4. Types of Antenna Selectivity / Bandwidth

For fitting the width of frequency segments to the natural bandwidth of antennas, four antenna selectivity types can be declared:

- **Sharp** (narrow bandwidth): the width of frequency segments is approximately 0.25% of the central frequency of the band;
- **Regular** - used by default. The width of frequency segments is approximately 1% of the central frequency of the band;
- **Wide** (wide/broad-band). The width of frequency segments is approximately 4% of the central frequency of the band;
- **Fixed** - for the tuning to be valid, it requires coincidence of the operating frequency with tolerance +/-4 kHz to the stored value.

### 8.2.5. Bypass and Use ATU Modes

In BYPASS mode all components of the matching network are excluded, allowing direct operation of broadband antennas. The normal mode is USE ATU.

### 8.2.6. Overview of Tuning Settings

Method for overview of all tuning settings is provided. Also, provided is method for deletion of individual or all tuning settings.

### 8.2.7. Evaluation of the Resource Used

Provided is a method for evaluation of resource of inductors and capacitors used for each stored user tuning.

### 8.2.8. Backing Up the NON-Volatile Memory

Method for backing up to a file, and restoring from a file the contents of the non-volatile memory of the tuner using a computer connected through the amplifier RS-232 port (using the **ACOM TERMINAL S** program, freely distributed).

### 8.2.9. Cable Required from the Radio Station

A single cable is required from the radio station to the tuner. Along with the RF power, the coaxial cable from the ACOM amplifier to the tuner combines also the DC power supply of +26 VDC and the 60 kHz FSK data for bidirectional control. Note the type and maximum cable length (see Section **8.1.10 Maximum Length of the Input Coaxial Cable**).

### 8.2.10. Protection Mechanisms

- From too high or too low power supply voltage (22 to 30 VDC);
- From power supply voltage with reverse polarity;
- From excessive RF voltage at the antenna output (above 500 Vrms);
- From excessive RF current at the antenna output (above 10 Arms);
- From excessive reflected power at the antenna output (above 400 W);
- From excessive forward power at the antenna output (above 1600 W);
- From excessive input power during tuning (above 60 W);
- From relay switching under RF power (hot switching);
- From extreme air temperatures within the internal volume of the tuner (-40...+65 °C / -40...+150 °F);
- From accumulation of atmospheric electricity and lightning strike close to the antenna - by a leakage resistor and lightning arrestor in the circuit of the operating antenna and direct grounding of the unused antennas;
- When the power supply is turned off, all antennas are automatically grounded.



## 8.3. Storage and Shipment

### 8.3.1. Storage Environment

The antenna tuner may be kept packed in a dry, ventilated and unheated location (with no chemically active substances such as acids or alkalis) within the following environment ranges:

- Temperature range: -40 to +70 degrees Celsius (-40 °F to 158 °F);
- Humidity: up to 75% @ +35 degrees Celsius (95 °F).

### 8.3.2. Shipping Size and Weight

- WxDxH: Approx. 520x400x300 mm, 7.0 kg (20.5x15.8x11.9 inches, 15.5 lbs.);

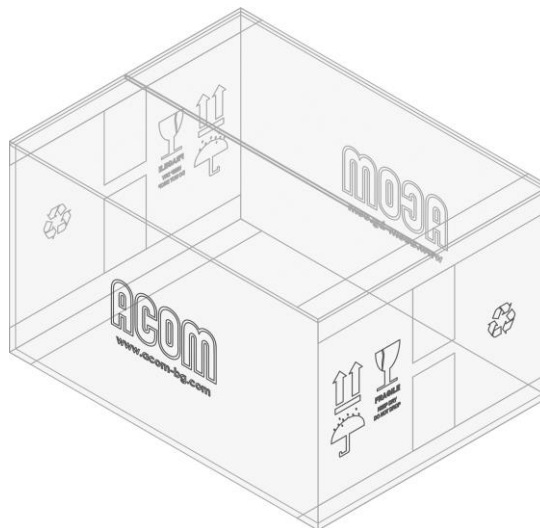


Figure 8-1 Packaging cardboard box

### 8.3.3. Transportation

All types of transportation may be used, including storage in an aircraft baggage compartment at up to 12000 meters (40000 ft) above sea level.

### 8.3.4. Returning to the Service Provider

#### **NOTICE**

Should it be necessary to ship the amplifier, use the original packing as described below.

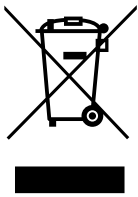
At first, disconnect all cables from the tuner (disconnect grounding last). Then, uninstall the assembly by following the requirements of Sections [2.3 Installation and Connection for Indoor Operation](#) and [2.4 Installation and Connection for Outdoor Operation](#), but perform the actions in reverse order. Finally, pack the assembly, and if necessary, the installation accessories in the original boxes.

### 8.4. Information on Disposing and Recycling of Old Electrical and Electronic Equipment



The information in this section is applicable for countries that have adopted separate waste collection systems.

ACOM products cannot be disposed as household waste.



Waste electricals

This symbol (crossed-out wheeled bin) explains that you should not place the electrical item in the general waste.



Waste electricals

This symbol (three green arrows going in a triangle with electrical plug in the center) means that according to local laws and regulations this product should be sent for recycling.

Old electrical and electronic equipment and batteries should be recycled at a facility capable of handling these items and their waste byproducts.

Contact your local authority for details in locating a recycle facility nearest to you.

Proper recycling and waste disposal will help conserve resources whilst preventing detrimental effects on our health and the environment.

## APPENDIX 1 | Lightning Protection

Never underestimate the danger of lightning! Lightning may create dangerous current and voltage surges in antennas, antenna feeders, and the equipment connected to them, measured in tens and hundreds of thousands of Amperes and Volts, with steep (fast) rises (a few milliseconds) and a huge quantity of energy dispersed momentarily, comparable to, e.g., an explosion of hundreds of tons of dynamite, yet released in less than a thousandth part of a second.

The measures for safety and reduction of damage to people, animals, buildings, equipment, etc. that may be caused by such a terrifying natural phenomenon, with parameters far beyond the range of human activity, require a clear understanding and strict compliance with clearly defined principles and rules, the most important or which are stated below:

- 1) A short and low-impedance path for discharging the lightning charges into the ground is the key to safeguarding from lightning.

### DANGER

Lightning always seeks the shortest path to ground. Regardless of what obstacles it may meet in its way to it, and regardless of whether such obstacles are good or bad electrical conductors or excellent electrical insulators, lightning ALWAYS overcomes the obstacles - it can burn, destroy or blow-up obstacles, but lightning charges always reach the ground!

Lightning strikes cannot be stopped and it is not possible for protected objects to be "insulated" from them by any means, because lightning strikes act as "current generators" with an electromotive force (EMF) exceeding one billion Volts.

The only possibility is to "capture" lightning and "discharge" it along safe paths to the ground. If such paths are well designed and built, damage will be prevented or minimized.

- 2) Due to the exceptional speed of rising of the lightning pulses (thousands and tens of thousands of Amperes per microsecond), the lower HF impedance we provide for the lightning currents, the lower and less dangerous potential will be generated by such currents in the protected object and, consequently, the danger of secondary discharges to adjacent objects in the protected area will be much lower.
- 3) Due of the exceptional magnitude of lightning currents (tens and hundreds of thousands of Amperes), they instantly create a huge amount of heat in objects they pass through, so the objects can ignite, melt down, rupture or explode.

Consequently, the lower active resistance we provide for such currents on their path to the ground, the less heat will be released in these objects. The main part of the energy will dissipate in the soil, which is considered a favorable outcome.

E.g., a tree with a diameter of 30 cm or more can be split, exploded, broken or set on fire by a branch of the main channel of the lightning, while a standard metal lightning rod, taking the main strike of the lightning, survives, although it is much thinner than the tree.

- 4) The enormous electrical pulses induce high currents and create high mechanical forces in both the stricken and nearby objects. To prevent mechanical damage, the masts, antennas, antenna feeders and the entire equipment of the respective grounding system should be mechanically strong, reinforced and corrosion-proof, in accordance with the expected local effects on the surface and underground.
- 5) The grounding system should be built in such a way that the lightning current does not flow through the protected object, or if it does, it should at least be considerably reduced by redirecting its main part along the paths provided in the design. For that purpose, the grounding system should be carefully planned and designed by thoroughly evaluating the possible paths the lightning currents could go along. Some essential paths for such currents are antennas, antenna feeders and the mains, because they are widely spread and have low impedance to the ground.
- 6) Currents passing through the protected object can be additionally reduced by creating obstacles along the paths through the object, and redirecting the currents along the planned protection paths. This can be done by threading ferrite tubes (toroids) along "unfavorable" paths (i.e. the cables going to and from the protected object). This way, the predominant part of the currents will be tapped to the planned protection path, i.e., through the main grounding plate and all wires and cables connected to it and external to the building. The latter are intentionally left without ferrite tubes - e.g., the system of grounding electrodes, the securing ring of the building, the connections and the cables of the mains coming from outside.

Apart from lightning protection improvement, threading of ferrite tubes (toroids) on the power and signal cables of the equipment in the radio station improves the electromagnetic compatibility (EMC) both between the devices inside the radio station and between them and the outside devices.

- 7) All objects in the area of antennas and nearby devices (within 6 m radius) – tuners, rotators and alike - should be connected by low-impedance connections to a common point called main grounding plate for the antennas and antenna devices, which in turn should be grounded using low-impedance connection to the closest main grounding conductor of an existing or purpose-built (individual) low-impedance grounding system for lightning protection in accordance with all requirements of the local standards and regulations for electric safety, fire safety and lightning protection.

Where antenna counterpoises exist, their connections to the main grounding plate and the connections of the antenna devices should be positioned under the level of the counterpoises or buried underground, if the antennas are designed this way.

To avoid damage or destruction by lightning, the antenna isolators, and the isolators sectioning the antenna and mast bracings into smaller lengths, should be bypassed by pulse overvoltage limiters (lightning surge arrestors). The limiter closest to the ground should be grounded to the main grounding plate, and if the distance is too great, to an individual low-impedance grounding system for lightning protection.

- 8) All cables entering the building should only be laid out in one zone, low in building foundation, and the cable braids and grounding terminals of their pulse overvoltage limiters (surge arrestors) should be grounded immediately after coming out from underground, in a common point called the main grounding plate of the building, to which are connected the mains neutral, (this would not be permitted in the UK) and the structural metal elements of the building – concrete reinforcement, metal pipe installations, metal frames, electrical panels, and other electrically conductive elements of the building (dangers with much plastic tubing in use in domestic water and central heating pipe systems).

The main grounding plate of the building should in turn be equipped with a special individual low-impedance grounding system, driven or buried directly in the ground, deep enough under the expected frost level of soil in your area, and in compliance with all requirements of the local standards and regulations for electric safety, fire safety and lightning protection.

The expected frost level of soil in your area can be obtained from the local electricity company or weather service. This is very important, since when soil freezes, its resistance dramatically increases. While the frost level of soil is not normally critical in the case of buried counterpoises of RF antennas, an insufficient depth of driving or burying in the ground could increase the resistance of the protective grounding system to exceed the standard requirements several times, i.e., you may be often left without electrical and lightning protection in the winter.

- 9) All objects located in the room of the radio station should be grounded to a common point called the main grounding plate of the radio station, which in turn should be connected through a low-impedance connection to the main grounding plate of the building (see Point **8** above).
- 10) The grounding terminals of all equipment in the room, the shields of all cables coming in and going out of the room (including telephone, telegraph, network, video, Internet, TV, etc.), as well as the grounding terminals of all pulse overvoltage limiters (surge arrestors), that normally supply any of the wires of these cables, should be connected to the main grounding plate of the radio station.



## NOTES

A series of 22 horizontal dotted lines for taking notes.

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