

## **1.0 INTRODUCTION**

The ATR-20 is a high power antenna tuner. The ATR-20's roller inductor "T" matching network continuously tunes all frequencies from 1.8 through 30 MHz. It also features a built-in 3 kilowatt peak or average detecting directional power meter. The ATR-20 has rear panel connectors for coaxial and wire feedlines. A heavy duty, high voltage insulated, current-type balun allows use with balanced feedlines.

Properly tuned, the ATR-20 safely operates on all bands with RF power levels of 1.2 kilowatts SSB and 600 watts CW with load impedances from 25-800 ohms. Matching range also extends from one ohm to 2500 ohms (5 ohms to 500 ohms on 160 meters) at slightly reduced power ratings. Peak and average forward power, reflected power, and SWR are displayed on an illuminated cross-needle meter.

An internal six position antenna-selector switch selects three coaxial line outputs, or a single wire line-balanced line output. Two coaxial line outputs, ANTENNA 1 and 2, are available in either "tuned" (with tuner's matching network in line) or "direct" (no matching circuit) configurations.

Coaxial output port ANTENNA 3 is available only as a direct (no matching system) configuration. WIRE / BALANCED LINE positions are available only as "tuned" configurations.

### **1.1 Understanding Power Ratings**

Unlike amateur radio service amplifiers (commonly rated in RF power output delivered to 50 ohm resistive loads), tuners have no standard power rating method. Power level descriptions (i.e. "3 kW Tuner") used for tuners often carry over from the time when amplifiers were rated by peak power input.

For example, the Kilowatt Johnson Matchbox was designed to handle a typical 1000 watt dc input plate modulated AM transmitter. Such transmitters developed 3000 watts PEP RF output on AM. Matching tuners were called one kilowatt tuners.

Years later SSB became popular. The Heathkit SB-220 was called a two kilowatt amplifier, even though rated CW output was approximately 600 watts. Tuners from the same era were called 2 kilowatt tuners, because they safely handled the 2 kilowatt PEP input SB-220. The 2 kW tuner only had to handle 600 watts of CW and 1200 watts PEP SSB to be compatible with a 2 kW amplifier of the same era.

Around 1980, the FCC changed the amateur radio power rating system from dc power amplifier input power to RF envelope (output) power. Most tuners stayed with the old system, and no longer follow amplifier power ratings. Typical "1500 watt tuners" safely handle only 400-600 watts CW, and 600-900 watts PEP SSB.

**Note:** This tuner is rated by true RF *output* power, not by the old method of using amplifier *peak input* power.

Load conditions and control settings greatly affect tuner power ratings. T-networks typically handle more power on higher frequency bands into higher load impedances. The worst operating condition (for T network tuners) is a low-impedance capacitive-reactance load. T-network tuners handle the least power on 160 meters with low-impedance capacitive-reactive loads.

Follow the guidelines in this manual to avoid exceeding the ratings of this tuner!

## **1.2 Peak Reading SWR/Wattmeter**

The ATR-20's cross-needle meter displays peak or average FORWARD power, peak or average REFLECTED power, and SWR.

The wattmeter can be used without the tuning network by setting the ANTENNA SELECTOR to any of three **COAX DIRECT** positions of the antenna selector. The wattmeter is active in all six positions of the ANTENNA SELECTOR switch.

The ATR-20 must have a power source, or the meter won't function. Power can be provided by an external 12 Vdc supply (negative ground only) or an internal 9 Volt "transistor radio" battery. The meter lamp will not illuminate unless an external supply is used.

Battery life is greatly increased through use of an RF controlled solid state battery switch. After a short period of inactivity, the battery is electronically disconnected.

Full scale forward and reflected power range is controlled by the left **METER** switch, selecting 3000 watt (**HI**) or 300 watt (**LO**). If your transmitter runs more than 300 watts of peak output power, set this switch to the 3000 watt **HI** (in) position. If your transmitter has less than 300 watts of peak output, set this switch to the 300 watt **LO** switch position (out). Peak envelope power (PEP) is measured by placing the **PEAK** or **AVG** push button (middle **METER** button) in the **PEAK** (in) position.

Peak and average power values are equal with steady unmodulated carriers such as closed-key CW, RTTY, FSK, or FM. The meter reading on these modes will be the same in either peak or average modes. On SSB, the ratio of PEP to average power varies with different voice and modulation characteristics. With most voices, the PEP reading is three to five times higher than the average voice power reading.

Forward power is displayed on the left-hand **FORWARD** meter scale. This scale is calibrated from 0 to 300 watts and is read directly in the 300 watt **LO** METER position. Each picket (scale mark) represents 5 watts below 10 watts, 10 watts between 10 and 100 watts, and 25 watts between 100 and 300 watts. In the 3000 watt (**HI**) position, multiply the forward power scale 10 times (EXAMPLE: 50 = 500 and 150 =1500 watts).

Reflected power is read on the right-hand REFLECTED meter scale. Full scale reflected power is 60 watts when the meter switch is in the **LO** position, and 600 watts in the **HI** position. This scale is marked with a picket every one watt below 10 watts and every 5 watts above 10 watts. This scale is also multiplied by 10 when using the **HI** meter power position.

Power readings are most accurate over the upper half of the meter scales. When measuring power with a less than perfect match, subtract reflected power from forward power. The result will be the true power.

SWR is read directly from eleven red SWR curves that range from 1:1 to infinity. SWR is measured by observing the point where forward and reflected meter pointers cross. The SWR is indicated by the red curve closest to the pointer crossing point. No cumbersome or time consuming SWR sensitivity adjustments are required with this method.

The power meter and turns counter are backlit with internal lamps. The meter and counter lamps require power from an external 12 Vdc source. A rear panel jack accepts a 2.1 mm coaxial plug with the center conductor positive (+) and the outer sleeve negative (-) for powering lamps and metering circuitry. The negative lead (outer sleeve) is grounded inside the tuner. A meter **ON / OFF** switch turns the meter and turns counter lamps off and on, and also turns the meter circuitry off when using battery power.

## **1.3 Antenna Selector**

The **ANTENNA SELECTOR** selects one of 3 rear panel SO-239 coaxial connectors or the wire-type wing-nut connections. Of the three rear panel coaxial connectors, only **COAX 1** and **COAX 2** connectors are available using the matching network in the tuner. **COAX 3** is bypass only, with no tuning functions available. Single wire or balanced wire outputs are available only as tuned antennas.

## **2.0 INSTALLATION**

**CAUTION:** To prevent RF burns from high voltages when using open wire or single wire feeds, locate the tuner to prevent rear panel connections from being accessible during operation. Be sure the tuner is properly grounded.

1. A power source must be connected for the power meter to operate. There are two choices:
  - a. Connect a 12 Vdc power source to the back of the tuner marked 12 VDC. This method will also supply power to the meter and turns-counter lamps.
  - b. Remove the small bottom cover from the tuner and connect a standard 9 volt battery to the battery clip. Snap the battery into the metal holder, and replace the battery cover. When a 9 volt battery is used as the only power source, meter and turns-counter lamps will not function.
2. Locate the tuner in a convenient location at the operating position. If random wire or balanced lines are used, the rear panel ceramic feed-throughs may operate with high RF voltages. These voltages can cause serious RF burns if contact is made with ceramic standoff terminals while transmitting. **Locate the tuner where the wire feedline terminals can not be contacted during operation.**
3. Install the tuner between the transmitter and the desired antennas. Use good quality coaxial cable (such as RG-8/U) to connect the transmitter (or amplifier) to the rear panel connector marked **“TRANSMITTER”**.
4. Connect the antenna(s) to the tuner as follows:
  - a. Coaxial feedlines that might require use of the tuner connect to coax connectors 1 and 2. Coaxial cables not requiring a tuner connect to coax connector 3.
  - b. Single wire feedline antennas should be connected to the **WIRE** connector on the back of the unit.
  - c. Balanced feedlines (open wire, twinlead, or twin-axial lines) are connected to the **BAL. LINE** terminals and a short jumper is installed between the WIRE post and the unmarked post below it.

**WARNING** High RF Voltages! Route all single and open wire feedlines to prevent RF burn and arcing hazards.

5. A ground post is provided for an RF ground connection. This tuner must always be connected to the station ground buss.

## **3.0 OPERATION**

The roller inductor has *maximum inductance* when fully counter-clockwise (turns counter 000) and *minimum inductance* when fully clockwise (turns counter approximately 124) on the reference counter. The capacitors have *maximum capacitance* at 0 and *minimum capacitance* at 10. In simple language, as frequency is increased normal control operating positions rotate clockwise.

**Note:** Always use the most capacitance (capacitor settings closest to 0) allowing a “match”. This insures the tuner is being operated with the highest power handling capacity and least loss possible. Use the lowest possible inductance (the highest number possible) on the turns counter.

Increasing the capacitor setting numbers and decreasing the INDUCTANCE number (on a given frequency) INCREASES matching range. This also REDUCES efficiency and power handling capability of the tuner!

### 3.1 Initial Antenna Tuning

1. Tune the exciter into a dummy load (most solid state transmitters are "pre-tuned" to 50 ohms and do not require adjusting with the dummy load).
2. Select the desired antenna with the **ANTENNA SELECTOR**.
3. Position the **ANTENNA, TRANSMITTER, and INDUCTANCE** controls at the following settings:

Band	ANT/TRANS	IND	Band	ANT/TRANS	IND
160 M:	1	45	20 M:	3	118
80 M:	1	93	17 M:	3.5	119
75 M:	1.5	98	15 M:	4.5	120
40 M:	2	111	12 M:	5	121
30 M:	2.5	116	10 M:	6	121

4. Place the **POWER** switch in the LO and AVG meter positions, apply a slight amount of power (25 to 50 watts).
5. Starting from the recommended **INDUCTANCE** position for the band used, turn the **INDUCTANCE** control counter-clockwise (adding more inductance). Tune for lowest reflected power and maximum forward power (best SWR).
6. In order, adjust the **ANTENNA** and **TRANSMITTER** controls for lowest reflected power (best SWR). Repeat this step a few times until the reflected power is zero or as close to zero as possible.
7. If SWR did not reach 1:1 in step 5, turn the **INDUCTOR** control counter counter-clockwise (to a lower number) and repeat Step 5. For maximum power handling and efficiency, always adjust the capacitors to the lowest front panel number (highest capacitance) that allows proper antenna matching. This insures maximum power handling and lowest power loss in the tuner.
8. Fully advance the power and, if necessary, touch up the **ANTENNA** and **TRANSMITTER** controls for minimum reflected power and maximum forward power (lowest SWR). Remove the power.

9. After adjusting the tuner for minimum SWR, the amplifier may be turned on. The **METER** switch should be placed in the HI position, and the amplifier tuned according to the manufacturer's instructions.
10. For quick retuning of the tuner, record the control settings for each band and use them as starting points.

**Note:** Maximum power handling occurs when both the **TRANSMITTER** and **ANTENNA** capacitors are set at the lowest front panel numbers that permit matching the antenna. Following this guideline will insure maximum power handling capability and efficiency, and the least critical tuning adjustments.

## **4.0 OPERATING HINTS**

1. While this tuner is designed to have the largest tuning range possible, there are limits to the range of individual components. Some antennas may require either more or less capacitance, or more or less inductance than practical components provide. In these special cases, SWR may not reduce to 1:1. If the SWR is higher than acceptable, changing antenna or feedline length will probably bring the antenna impedance within the useful tuning range.
2. When adjusting the tuner, use the lowest number on the **TRANSMITTER and ANTENNA**, and the highest **INDUCTOR** number, that produces a good SWR. This reduces tuner losses and increases tuner power rating.

### **WARNING :**

1. *Never* operate the tuner with the top removed. Voltages inside the tuner can cause painful RF burns.
2. *Never* rotate the **ANTENNA SELECTOR** switch while transmitting. Doing so may permanently damage the switch.
3. If you use balanced or single wire feedlines, locate the tuner where the rear terminals can *NOT* be contacted by people, wiring, or metallic objects. The single wire and balanced line connections will generally have high voltages when used. Be sure the tuner case is properly grounded.
4. Disconnect *all* antennas from the tuner during lightning storms. Do not depend on lightning "protectors".
5. Tune with low power (i.e. less than 100 watts). Apply high power only after tuning up.

### **4.1 In Case Of Difficulty**

If the tuner fails to tune, **double check** all connections and follow the tuning procedures again. Be sure to use *enough inductance* (lower number) and have the *capacitors open far enough* (higher front panel numbers).

If the tuner **arcs** at the rated power levels, **double check** all connections and follow the tuning procedures again. The typical RF power rating of this tuner is 1200 watts PEP into load impedances between 25 and 800 ohms, and less into higher or lower impedance loads. Always use the *least amount of inductance* (highest number) and the *greatest capacitance* (lowest number) possible that still allows matching the load on the operating frequency.

**Note:** If internal arcing occurs it may be necessary to reduce transmitter output power or modify antenna or feedline length.

If unsuccessful, but the tuner does adjust and operate when switched to a dummy load or a different antenna, read the **Antenna System Hints** section.

## **5.0 GROUNDING**

To minimize RFI, single wire feedlines (such as used with Windom or longwire antennas) should be kept away from other wiring. Radiation will be minimized if the single wire feeder runs parallel and reasonably close to the wire that connects the tuner to the outdoor ground. The antenna feed wire should be adequately insulated to prevent arcing or accidental contact.

Safety requires good dc and RF tuner grounding. It is particularly important to have a good RF ground while using a single wire feeder. When using a single wire feeder, the tuner needs something to "push" against in order to force current into single wire feedlines. If a good RF ground is not available, RF will usually find it's way back into the power line (RFI), transmitter audio circuits (RF feedback), or the operator (RF burns).

Water pipes and ground rods provide good dc and ac safety grounds, but they are often inadequate for RF grounding because they are single conductors. Ground rods by themselves are almost useless for dependable RF grounding.

RF grounds perform better when "spread out" over a large area, especially when they employ multiple connections directly to the equipment ground point. Water pipes, heating ducts, and fences may work well enough in many cases (especially if they are connected together with multiple wires), but the best RF grounds are radial systems or multi-wire counterpoises. Radials and counterpoises provide large, low resistance surfaces for RF energy.

RF and lightning travels on the surface of conductors. Braided or woven conductors have high surface resistance for lightning and RF currents. Ground leads for RF and lightning should have wide smooth surfaces. Avoid the use of woven or braided conductors in RF and lightning grounds unless the lead needs to be flexible.

**CAUTION:** For operator safety, a good outside earth ground or water pipe ground should always be installed and connected to the case of the ATR-20. Make certain the safety ground also connects to the transmitter and other station accessories. A wing nut post marked GROUND is provided for ground connection(s).

## **6.0 ANTENNA SYSTEM HINTS**

1. Many people believe a ladder line fed antenna requires a 4:1 balun. The input impedance of a ladder line feedline can actually range from a few ohms to many thousands of ohms, depending on feedline and antenna length. The best balun for such systems is always a 1:1 current type balun. A current or choke-type balun guarantees minimum feedline radiation and maximum balun efficiency and power handling.
2. As a general rule, all balanced antennas should employ a choke-type balun at the feedpoint when fed with unbalanced (coaxial) feedlines. It is often a good idea to use a choke balun near any coax fed antenna regardless of antenna type. Considerable common mode currents can flow on the outside of

coaxial cables, even when feeding groundplane or gamma matched antennas, since systems are seldom perfectly designed or constructed.

3. Avoid feeding unbalanced antennas (like verticals) with balanced feedlines. Even if a good balun is used at the tuner, the line will still radiate.
4. Good antenna and feedline balance will often reduce RFI to your neighbors, as well as reduce noise coupled into your receiver from the feedline.

## **6.1 Location**

For the best performance, an end-fed longwire wire antenna should be at least one quarter-wavelength long at the operating frequency. Horizontal dipole antennas should be at least a half-wavelength long and located as high and clear as possible. While good RF grounds help the signal in almost any transmitting installation, it is extremely important to have good RF grounds with long wire or other Marconi style antennas.

## **6.2 Matching Problems**

Most matching problems occur when the antenna system presents an extremely high impedance to the tuner. When the antenna impedance is much lower than the feedline impedance, an *odd quarter-wavelength* feedline converts the low antenna impedance to a very high impedance at the tuner. A similar problem occurs if the antenna has an extremely high impedance and the transmission line is a multiple of a half-wavelength. The half-wavelength line *repeats* the very high antenna impedance at the tuner. Incorrect feedline and antenna lengths can make an otherwise perfect antenna system very difficult or impossible to tune.

One example where this problem occurs is on 80 meters when an odd quarter-wave (60 to 70 foot) open wire line is used to feed a half-wave (100 to 140 foot) dipole. The odd quarter-wave line transforms the dipole's low impedance to over three thousand ohms at the tuner. This is because the mismatched feedline is an *odd multiple* of 1/4 wavelength long. The line *inverts* (or teeter-totters) the antenna impedance.

A problem also occurs on 40 meters with this same antenna example. The feedline is now a multiple of a half-wave (60 to 70 foot) and connects to a full-wave high impedance antenna (100 to 140 foot). The half-wave line repeats the high antenna impedance at the tuner. The antenna system looks like several thousand ohms at the tuner on 40 meters.

This places enormous strain on the balun and the insulation in the tuner, since voltages can reach several thousand volts. This can cause component arcing, heating, and failure.

The following suggestions will reduce the difficulty in matching an antenna with a tuner:

1. Never center feed a half-wave multi-band antenna with a high impedance feedline that is close to an odd multiple of a quarter-wave long.
2. Never center feed a full-wave antenna with any feedline close to a multiple of a half-wave long.
3. If this tuner will not "tune" a multi-band antenna, add or subtract 1/8 wave of feedline (for the band that won't tune) and try again.
4. Never try to load a G5RV or center fed dipole on bands far below the half-wave design frequency. If you want to operate an 80 meter antenna on 160 meters, feed either or both conductors as a longwire against the station ground.

To avoid problems matching or feeding any dipole antenna with high impedance open wire lines, keep the lines around the length below. The *worst possible* line lengths are shown in brackets:

160 meter dipole	40-70 or 150- 190 feet suggested	[Avoid lines around 120 or 240 ft]
80 meter dipole	25-40, 80-100 or 140-160 feet	[Avoid lines around 60, 120, or 180 ft]
40 meter dipole	40-50, 70-80, 100-110 or 130-140 feet	[Avoid 30, 60, 90, 120 ft]

Some slight trimming or additional feedline may be necessary to accommodate the higher bands.

**WARNING:** To avoid problems, a dipole antenna should be a full half-wave on the lowest band. On 160 meters, an 80 or 40 meter dipole antenna fed like a normal dipole will be extremely reactive with only a few ohms of feedpoint resistance. Trying to load an 80 meter half-wave (or shorter) dipole antenna on 160 meters can be a disaster for both your signal and the tuner. The best way to operate 160 meters with an 80 or 40 meter dipole antenna is to load either or both (in parallel) feedline wires as a longwire or ``T'' antenna. An antenna connected like this and worked against a very good RF ground will produce a very good 160 meter signal.

## **7.0 TECHNICAL ASSISTANCE**

If you have any problem with this unit first check the appropriate section of this manual. If the manual does not reference your problem or your problem is not solved by reading the manual, you may call *Ameritron* at **662-323-8211**. You will be best helped if you have your unit, manual and all information on your station handy so you can answer any questions the technicians may ask.

You can also send questions by mail to Ameritron, 116 Willow Road, Starkville, MS 39759; by Facsimile (FAX) to 662-323-6551. Send a complete description of your problem, an explanation of exactly how you are using your unit, and a complete description of your station.



# SCHEMATIC



