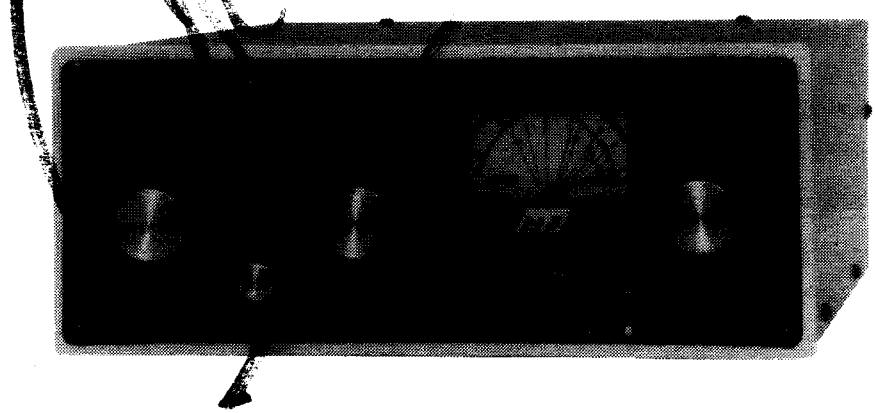
VersaTuner III

Model MFJ-962C



INSTRUCTION MANUAL

CAUTION: Read All Instructions Before Operating Equipment

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VERSION 4C

Introduction

The MFJ-962C is a "T" network tuner with built-in antenna switching, RF power and SWR metering and a 1:1 balun. The MFJ-962C is designed to match amplifiers operating at 1500 watt **PEP** or less plate ***input power***. The largest amplifiers that can safely be used include the Heathkit SB-200 and 201, Collins 30L1, and Ameritron's AL-600 and AL-811 series of amplifiers. This tuner is designed for maximum RF output power levels of 800 watts carrier or **PEP** on 80-10 meters, and 500 watts carrier or PEP on 160 meters. It is designed to match 50 ohm output amplifiers, transmitters or transceivers to virtually any antenna. Peak and average forward power, reflected power, and SWR are displayed on the wattmeter's illuminated cross-needle meter.

The MFJ-962C uses a switched inductor "T" matching network. It continuously tunes all frequencies from 1.8 through 30 MHz. It will match dipoles, inverted-vee's, verticals, mobile whips, beams, random wires, and many other antennas. The **built-in balun** will work with balanced open wire, twinlead, or twin-axial feedlines.

An internal six position antenna-selector switch selects two separate coaxial line outputs either in tuned (with tuner's matching network in line) or direct (no matching circuit) configurations, a balanced line output, and a coax bypass position for accessories such as an external dummy load. Long wire antennas can be connected to the center connector of the coax connector.

Understanding Power Ratings

There are no standardized power rating systems for tuners. The names used (i.e. 3 kW Tuner) carry over from the time when amplifiers were rated by peak power input, and not the true RF power output. For example, the one thousand watt Johnson Matchbox was rated to handle a 1000 watt plate modulated AM transmitter (four kilowatts PEP transmitter input and 3000 watts PEP RF output). The Heathkit SB-220 was called a two kilowatt amplifier, and the rated CW output was approximately 600 watts. Matching tuners were called 2 kilowatt tuners, and these tuners safely handled 600 watts of CW power and 1200 watts PEP SSB.

The FCC has changed the power rating system of amplifiers, and tuners no longer follow amplifier power ratings. Most typical 1500 watt tuners remain able to safely handle 400-600 watts CW, and 600-900 watts PEP SSB.

Load conditions and control settings also greatly affect the power handling capability of the tuner. T-networks typically handle more power on higher frequency bands into higher load impedances. The worst operating condition for T-network tuners are low impedance capacitive reactance loads. T-network tuners always handle the least power when operated on 160 meters into low impedance capacitive reactive loads.

Peak Reading SWR/Wattmeter

The cross-needle meter measures the peak or average FORWARD power, REFLECTED power, and SWR. The illuminated cross-needle meter operates with the antenna tuning circuit in or out of line. The wattmeter can be used without the tuning network by setting the **ANTENNA SELECTOR** to either of the two **COAX DIRECT** positions of the antenna selector. The wattmeter is active in all positions of the **ANTENNA SELECTOR**.

The meter's full scale forward and reflected power range is controlled by the left **POWER** switch that selects **2000W (HI)** or **200W (LO)**. If your transmitter runs more than 200 watts of output power, set this switch to the **2000W HI** (in) position. If your transmitter has less than 200 watts of output, set this switch to the **200W LO** switch position (out).

Peak envelope power (PEP) is measured when the **PEAK** or **AVG POWER** push button (right-hand side) in placed in the **PEAK** (in) position. Peak power and average power values are equal with steady unmodulated carriers, FSK, or FM. The meter reading on these modes will be the same whether the **PEAK / AVG** button is pressed or released. On SSB, the PEP meter reading should be twice the average power with two tone test modulation.

On SSB, the ratio of PEP to average power varies with different voice characteristics. With most voices, the PEP reading is three to five times higher than the average voice power reading. The most accurate peak envelope power readings are obtained only with sustained carrier, voice or two tone test modulation. During normal voice modulation, the wattmeter will typically indicates only 70% of the true peak envelope power.

Forward power is displayed on the left-hand FORWARD meter scale. This scale is calibrated from 0 to 200 watts and is read directly in the 200 watt position. Each picket (scale mark) represents 5 watts below 40 watts and 10 watts between 40 and 200 watts. In the **2000W (HI)** position the forward power scale must be multiplied by 10. Each picket represents 50 watts below 400 watts and 100 watts from 400 to 2000 watts.

The reflected power is read on the right-hand REFLECTED meter scale. This scale indicates 50 watts full scale when the **200W** power sensitivity is selected, and 500 watts full scale when the **2000W** power scale is selected. This scale has a picket every watt below 20 watts and every 5 watts above 20 watts. This scale is also multiplied by 10 when using the **2000W** power position.

The most accurate power readings occur in the upper half of the meter scales. When trying to measure power with a less than perfect match, the reflected power should be *subtracted* from the forward power readings.

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

The wattmeter has an internal lamp that backlights the meter scale. The lamp circuit requires power from an external 12 Vdc source, such as the optional MFJ-1312 power supply. The rear panel jack accepts a 2.5 mm plug with a positive tip polarity. The negative lead is grounded inside the tuner. The **METER LAMP ON / OFF** switch turns the meter lamp on and off.

Antenna Selector

The **ANTENNA SELECTOR** allows you to select 2 rear panel SO-239 coaxial connectors, either direct or through the tuner, a coax bypass output, and balanced feedline antennas.

Installation

*CAUTION: **Locate the tuner so that the rear panel is not accessible during operation.***

1. Locate the tuner in a convenient location at the operating position. If balanced line operation is used, the ceramic feed through insulators may have high RF voltages. These voltages can cause serious RF burns if the terminals are touched when transmitting. **Be sure to locate the tuner so that these terminals can not be accidentally contacted during operation.**
2. Install the tuner between the transmitter and the antenna as shown in the diagram below. Use a coaxial cable (such as RG-8/U) to connect the transmitter (or amplifier) to the connector marked **TRANSMITTER** on the rear of the tuner.
3. Connect the antenna(s) to the tuner as follows:

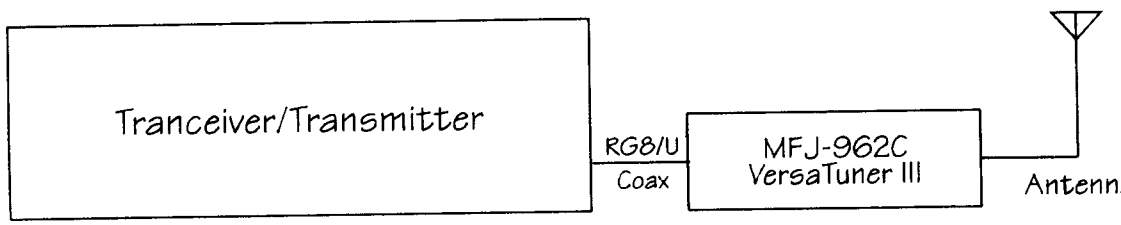
   A. Coaxial feedlines connect to the coax connectors 1 and 2 coax line (fed direct or through matching circuit as selected by the **ANTENNA SELECTOR** switch).

   B. Random wire or single wire line antennas should be connected to the center of the **COAX 1** or **COAX2 SO-239** connectors. Select the appropriate Coax position to use the antenna.

Note: Route all single and random wire antennas to prevent RF burn hazard.

   C. Any balanced feedline (open wire, twinlead, or twin-axial lines) is connected to the **BALANCED LINE** terminals.

4. A ground post is provided for an RF ground connection.



Block Diagram
Figure 1

Using The MFJ-962C

WARNING: Never change the antenna or Inductor selector switch position while transmitting!!!
Never apply more than 800 Watts to the MFJ-962C!!!

In any conventional "T" network tuner, maximum power handling and the smoothest tuning occurs when the capacitance in the network is as large as possible. In this tuner the **TRANSMITTER** and **ANTENNA MATCHING** controls have *maximum capacitance* at position **0** (fully meshed), and *minimum capacitance* at position **10** (fully open). Be sure to use the ***highest possible capacitance*** for each band. This will provide the smoothest tuning, highest efficiency, and greatest power handling capability. The chart in the tuning instructions shows typical capacitor settings that can be used for each amateur band.

The **INDUCTANCE** switch in the MFJ-962C has maximum inductance in position "**A**", and minimum inductance in position "**L**". Less inductance is needed as the frequency is increased. If too little inductance is used, the tuner may not match the load properly. If too much inductance is used, the tuner will be "touchy" and power handling will be compromised. The chart in the tuning instructions shows typical **INDUCTANCE** switch settings for each amateur band.

Note: If your transmitter uses an adjustable output circuit, it must be properly tuned into a 50 ohm load at the operating frequency. Proper tuning can be accomplished by placing the **ANTENNA SELECTOR** switch in the fully clockwise **BYPASS / DUMMY LOAD** position. Adjust the transmitter according to the manufacturer's instructions into the 50 ohm dummy load before adjusting the tuner.

Most modern solid state transceivers do not require adjustments. If the transceiver has a built in antenna tuner, be sure it is turned off or disabled.

After properly preparing the transmitter, place the MFJ-962C **ANTENNA SELECTOR** switch in the desired antenna position in the **BYPASS** area. If the SWR is low (very little or no reflected power), the tuner can be left in this position.

If the SWR is higher than desired, place the **ANTENNA SELECTOR** switch in the proper **TUNED** area that selects the desired antenna. Adjust the tuner as described below to obtain the best SWR. Do **NOT** change the transmitter's tuning (plate) or loading (antenna) controls until AFTER the tuner has been fully adjusted. The transmitter can be "touched up" (if necessary) *after* the MFJ-962C is fully tuned.

Adjustment Procedure

When using the MFJ-962C in receive only applications, adjust the MFJ-962C for the highest "**S**" meter or signal level. The Tuning Chart can be used as a starting reference. To use the MFJ-962C for transmitting, follow the steps below:

1. Select the **200W** (out) **METER** switch scale. Place the **PEAK AVG** button in the **AVG** (out) position. Turn the transmitter's power control fully down.
2. Position the **TRANSMITTER** and **ANTENNA MATCHING** controls and the **INDUCTOR SELECTOR** switch in the BOTTOM Tuning Chart position for the operating frequency.

WARNING: Full power ratings are obtained only when the bottom Tuning Chart inductor setting is used for each band. Always use the highest (highlighted) letter setting and lowest capacitor setting for each band that allows a "match".

Recommended Tuning Chart:

Freq. MHz	Transmitter	Inductor	Antenna
1.8	4	A	4-1/2
1.8	**2**	**B**	**3**
1.9	3	B	4
1.9	**2**	**C**	**2**
2.0	4	B	4
2.0	**2**	**C**	**2-1/2**
3.5	8	C	8
3.5	5	D	5
3.5	**2**	**E**	**2**
3.75	6	D	6
3.75	3	E	3
3.75	**2**	**F**	**2**
4.0	6-1/2	D	6-1/2
4.0	4	E	4
4.0	**2-1/2**	**F**	**2-1/2**
7.15	8	G	8
7.15	**6**	**H**	**6**
10.1	6	I	6
10.1	**2**	**J**	**2**
14.2	8	I	8
14.2	**7**	**J**	**7**
18.1	9	J	9
21.2	8	K	8
24.9	8-1/2	K	8-1/2
28.5	9	K	9
28.5	**7**	**L**	**7**

3. Apply just enough power on CW (or AM / FM / RTTY) to obtain noticeable deflection on the reflected power meter.

4. Carefully adjust the **TRANSMITTER** and **ANTENNA MATCHING** controls for the lowest reflected power.

Note: Since these controls interact, Adjust the **TRANSMITTER** control for minimum SWR, then adjust the **ANTENNA** control for minimum SWR. Repeat this until the lowest reflected power (best SWR) is obtained.

5. If a perfect or very low SWR can not be obtained, STOP transmitting. Try the next *lowest* alphabetic setting. Repeat from Step 3.

Note: If an SWR of 1:1 can not be obtained, move the **INDUCTOR** switch towards the end of the alphabet one position at a time. Repeat Steps 3 and 4 for each new **INDUCTOR** switch position. Always use the highest alphabetical setting possible.

WARNING: Never transmit while changing the INDUCTOR SELECTOR.

6. Increase the transmitter power until the FORWARD power level is full scale (200 watts) and observe the REFLECTED POWER or SWR. If the REFLECTED POWER and SWR are not satisfactory, adjust the MATCHING controls again.

Note: If your transmitter can not reach 200 watts, set it to the maximum power available.

7. After a low SWR is obtained, the transmitter power may be increased to any value up to 800 watts carrier or 800 watts PEP (*500 watts on 160 meters*).

Your VERSA TUNER III will reduce the SWR of most antenna systems to 1:1. In some cases, a perfect 1:1 SWR may not be obtainable. If this is the case, the length of the antenna or the feedline can be changed slightly until a low SWR can be obtained. See the antenna hints section.

In Case Of Difficulty

If this tuner fails to tune, please **double check** all connections and follow the tuning procedures again. Be sure you are using *enough inductance* (lowest letter usable for band) and have the *capacitors open far enough* (highest front panel number).

If this tuner **arcs** at the rated power levels, please **double check** all connections and follow the tuning procedures again. Be sure you are using the *least amount of inductance* and the *greatest capacitance* possible to match the load on the operating frequency.

Note: If this tuner arcs when operating on the 160 meter band, it may be necessary to reduce transmitter output power.

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

Grounding Hints

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.

For safety, please use good dc and RF grounds. 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 the single wire feedline. 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 work much 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 (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 to lightning and RF. 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.

Antenna System Hints

For operator safety, a good outside earth ground or water pipe ground should *always* be installed and connected to the case of the MFJ-962C. 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).

Location

For the best performance, an end-fed longwire wire antenna should be at least one quarter-wavelength long at the operating frequency. Horizontal antennas should be at least a half wave long and high and clear of surrounding objects. 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.

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 and heating.

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 a band 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 long wire against the station ground.

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

160 meter dipole:	35-60, 170-195 or 210-235 feet	[Avoid 130, 260 ft]
80 meter dipole:	34-40, 90-102 or 160-172 feet	[Avoid 66, 135, 190 ft]
40 meter dipole:	42-52, 73-83, 112-123 or 145-155 feet	[Avoid 32, 64, 96, 128 ft]

Some slight trimming or adding of 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 antenna fed the normal way will be extremely reactive with only a few ohms of feedpoint resistance. Trying to load an 80 meter (or shorter) 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 antenna is to load either or both feedline wires (in parallel) as a longwire. The antenna will act like a "T" antenna worked against the station ground.

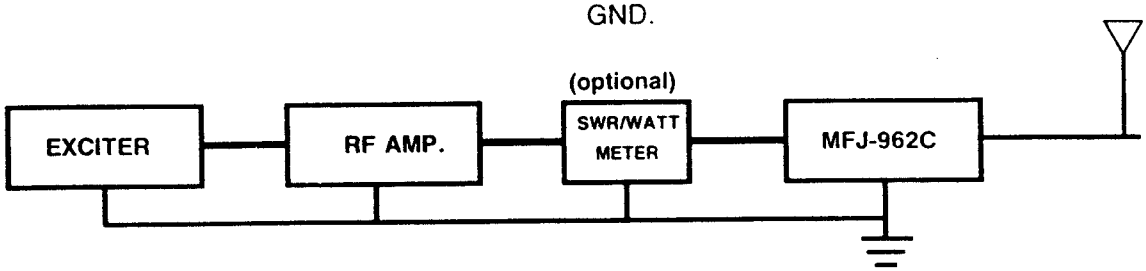
Logged Tuning Chart

Use the chart below to log values for your station. You may want to copy this chart and post it by your tuner.

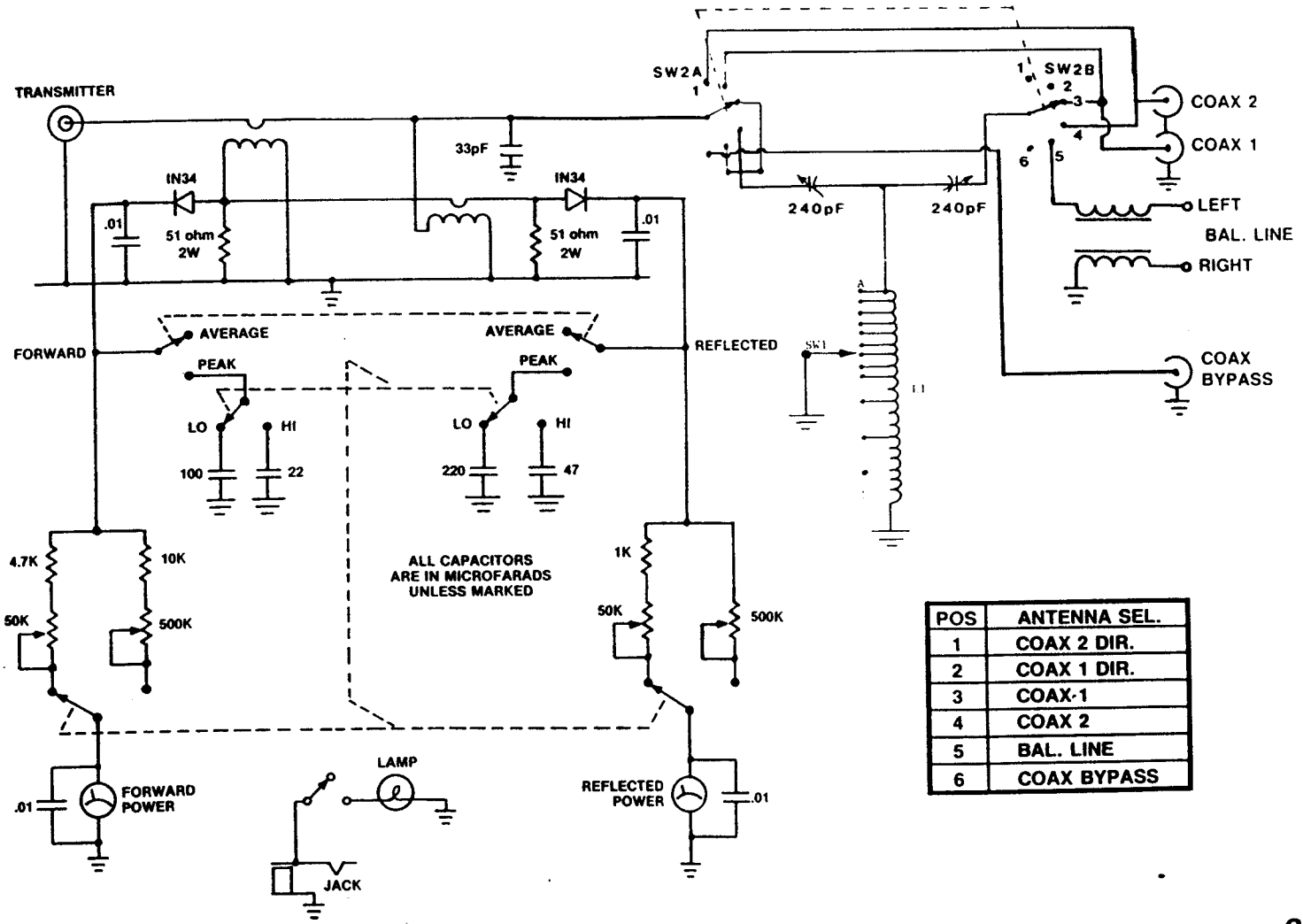
Freq. MHz	Transmitter	Inductor	Antenna
1.8			
1.8			
2.0			
2.0			
3.5			
3.5			
3.5			
3.75			
3.75			
3.75			
4.0			
4.0			
4.0			
7.15			
7.15			
10.1			
10.1			
14.2			
18.1			
18.1			
21.2			
21.2			
24.9			
28.5			

INSTALLATION

1. Locate the tuner in a convenient location at the operating station. NOTE: LOCATE THE TUNER SO THAT THE REAR OF THE TUNER IS NOT ACCESSIBLE DURING OPERATION.
2. Install the tuner between the transmitter and the antennas as shown in the diagram. Use coax cable such as RG-8/U between the transmitter output and the SO-239 connector marked TRANSMITTER on the tuner.
3. Connect the antenna(s) to the tuner as follows:
   A- Coax cable feed lines connect to the coax connectors. Two coax lines may be connected to the tuner at the same time.
   B- Balanced feed lines are connected to the terminals marked BALANCED LINE.
   C- Random wire or single wire line antennas should be connected to the center of the COAX 1 or COAX 2 SO-239 connectors. Select the appropriate Coax position to use the antenna. NOTE: ROUTE ALL SINGLE AND RANDOM WIRE ANTENNAS TO PREVENT RF BURN HAZARD.
4. Ground the tuner to the transmitter, amplifier and earth GND.



962C SCHEMATIC DIAGRAM



POS	ANTENNA SEL.
1	COAX 2 DIR.
2	COAX 1 DIR.
3	COAX-1
4	COAX 2
5	BAL. LINE
6	COAX BYPASS