TEN - TEC

OPERATOR'S MANUAL

MODEL 238B
Antenna Tuner

1

Front View

Rear View

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Part No. 74271
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LIST OF ILLUSTRATIONS

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SPECIFICATIONS

CIRCUIT TYPE:	Modified "L" network.
RF POWER RATING:	2 kW maximum.
FREQUENCY RANGE:	1.8 TO 30 MHz.
OUTPUT MATCHING RANGE:	At least 10:1 SWR, any phase angle, 1.8 to 30 MHz. 3000 ohms maximum at full power.
INPUT IMPEDANCE:	50 ohms, nominal.
CAPACITOR VOLTAGE RATING:	3.5 kV.
INDUCTOR:	18 microhenry silver plated roller inductor.
SIZE:	HWD 5" x 12.125" x 12.25" (12.7 x 30.8 x 31 cm). Depth measurement includes rear panel connectors.
WEIGHT:	10 lbs. (4.53 kg.)

CHAPTER 1

INSTALLATION

1-1 INTRODUCTION The model 238A High Power Antenna Tuner is an adjustable reactive network used for matching the unbalanced 50 ohm output impedance of transmitters and transceivers to a variety of balanced and unbalanced loads. It will perform this function over a frequency range of 1.8 to 30 MHz. Provision is made for selecting one of four antennas or for by-passing the matching network. A dual range power and SWR meter is included.

1-2 UNPACKING Carefully remove the 238A antenna tuner from the packing carton and inspect it for signs of damage. If the antenna tuner has been damaged, notify the delivering carrier immediately stating the full extent of the damage. Save all damaged cartons and packing material. Liability for any shipping damage rests with the carrier. Complete the warranty registration card and mail to TEN-TEC. Save the packing material for re-use in the event that moving, storage, or reshipment is necessary. Shipment of your TEN-TEC tuner in other than factory packing may result in damage not covered under warranty. The following hardware and accessories are packed with your model 238A. Make sure you have not overlooked anything.

(1) #23160 Capacitor, 1000 pF, 500V
(1) #38040 .050" hex Allen wrench
(1) #38088 .062" hex Allen wrench
(1) #74020 Warranty card
(1) #74271 Operator's Manual

If any of the above items are missing, contact customer service at (865) 428-0364 for replacements.

1-3 TRANSMITTER CONNECTION The model 238A is designed for connection to transmitters having a 50 ohm nominal output impedance. Connect the coaxial output of your transmitter to the INPUT connector (SO-239 type) on the rear panel of the tuner with a short length of RG-8 or RG-58 cable. To reduce the possibility of RF getting into the transmitter, position the tuner as far away from the transmitter as is practical, especially if using a long wire antenna.

1-4 GROUND CONNECTION Connect your station ground system to the GND wing nut terminal on the rear panel of the tuner with heavy metallic braid or wire. The lead should go directly to the earth ground system using as short a lead as possible.

1-5 ANTENNA CONNECTIONS Connect antenna transmissions line(s) to the appropriate terminal(s) on the tuner as follows:

A. For coax-fed antennas (unbalanced transmission lines) use ANT 1, ANT 2, ANT 3, or ANT 4.

B. For a single wire antenna, connect to SINGLE WIRE terminal.

C. For balanced feedline systems, add a jumper from SINGLE WIRE to one of the BALANCED LINE terminals as shown on the rear panel, using a short wire. Then, connect the feedline to the two BALANCED LINE terminals.

D. ANT 4 position can be coax, single wire, or balanced line. ANT 1, ANT 2, ANT 3 must be coax only.

In both single wire and balanced line systems, take special care to route the transmission line as far away from the station equipment as possible. Never drape lines over the transmitter. These lines may have high voltage points inside the shack which can produce strong RF fields.

NOTE: The SWR bridge/power meter is in the circuit at all times, even in the BYPASS position.

1-6 METER LIGHTING The SWR bridge/power meter is lit by a 13.8 VDC light bulb. There is an RCA-style phono connector on the rear panel where 13.8 VDC can be applied to light the meter lamp. Positive voltage to center conductor, negative to ground.

CHAPTER 2

OPERATING INSTRUCTIONS

2-1 INTRODUCTION The following instructions will enable the operator to quickly place the model 238A into operation. Included are descriptions of the front panel controls and their functions. This is followed by instructions for antenna matching and selection, operating hints, and a discussion on antenna systems matching theory.

2-2 FRONT PANEL CONTROL FUNCTIONS The following sections describe the front panel controls and their functions.

2-2.1 CAPACITOR This control connects to the variable tuning capacitor, C2, which is used as one of the elements in the "L" type matching network. This capacitor has a tuning range of 40-500 pF and is continuous tuning with no stops.

2-2.2 INDUCTOR This control is connected to roller inductor, L2, another element in the "L" type matching network. This inductor has a tuning range of approximately .2-18 uH which is covered in approximately 27 revolutions of the control knob. There is a mechanical limit stop at each end of its' travel.

2-2.3 IMPEDANCE SWITCH This 11 position rotary switch is used to change the configuration of tuning network for matching either low or high impedance antenna systems. This switch also selects additional capacitors as needed for matching at lower frequencies. When placed in the 12 o'clock position, the tuner is connected in the BYPASS configuration and the network has no effect on the transmission line system.

2-2.4 METER SELECT KNOB The meter functions are determined by a four position switch selector directly below the SWR bridge/power meter. The left most position, SWR, sets the meter to read standing wave ratio. The SET position is to adjust the sensitivity of the meter output circuit (see section 2-2.5). The third position, 200W, is for a forward power scale reading of 0 to 200 watts on the meter. The right-most setting, 2000W, is for a forward power scale reading of 0 to 2000 watts.

2-2.5 SWR SET This potentiometer is used to adjust the sensitivity of the meter output circuit when you wish to determine SWR. To use this control, place the meter select knob in the SET position. Next key the transmitter and adjust the SWR SET control for a full scale deflection. While still transmitting, turn the meter select knob to SWR and read the SWR from the meter scale. Note that changing power output from your transmitter through the tuner will usually require resetting of the SWR SET control for accurate SWR reading.

2-3 ANTENNA MATCHING The procedure shown below will enable you to quickly match almost any antenna system. Always use the minimum transmitter power necessary to operate the SWR bridge/power meter. To do this, proceed as follows:

A. Set the meter select knob to SET and turn the SWR SET knob fully counterclockwise.
B. Set CAPACITOR to 2, the INDUCTOR to fully counterclockwise ("0") and S1 to BYPASS.
C. Apply 20 to 30 watts of transmitter drive to the antenna tuner from your transceiver.
D. Adjust SWR SET knob until meter pointer moves to the right and points to 'SET' on the right side of the meter.
E. Unkey transmitter.
F. Move meter select knob to SWR.
G. Apply 20 to 30 watts of transmitter drive to the antenna tuner from your transceiver.
H. Switch S1 to both sides of the BYPASS position to determine which results in a lower meter reading. Leave S1

whatever position produces the lowest SWR value.

I. Alternately adjust the CAPACITOR and INDUCTOR for lowest meter reading.

J. If CAPACITOR shows best meter null at a setting of '0', turn S1 to the other side of BYPASS.

K. If the best meter null is with the CAPACITOR at 10, turn S1 to the next higher position.

L. Once a null is reached, to determine if the SWR is sufficiently low, set the meter select knob to FWD and adjust the SWR SET control to the full scale SET mark. Switch meter select knob back to SWR and read SWR on the lower meter scale.

Note that as you change output power from the transmitter that the SWR SET knob will need to be readjusted as described in section 'L' above.

2-4 ANTENNA SELECTION A maximum of four antennas may be connected to the model 238A at one time, only one of which may be a wire fed antenna. Whether the antenna selected is matched or fed directly is determined by the setting of S1. The 50 ohm BYPASS position bypasses only the matching network, leaving the SWR/power meter in line.

Antenna position 4 feeds ANT 4, SINGLE WIRE, or with a jumper installed BALANCED LINE. Only one antenna, coax, single wire or balanced line feed may be attached at one time to these outputs; otherwise, the antennas will be fed in parallel and the lowest impedance antenna will receive the most power. When using either ANT 4 (coax connected) or the SINGLE WIRE terminal, **DO NOT** connect the jumper between SINGLE WIRE and one BALANCED LINE terminal as damage to the balun may result.

2-5 POWER-SWR METER The meter circuit allows measurement of forward power in two ranges, 0-200 and 0-2000 watts. SWR is measured by the meter after SWR SET knob has been adjusted as in section 'L' above.

CAUTIONS

1. IN THE NORMAL OPERATION OF THE MODEL 238A MATCHING UNIT, VERY HIGH RF VOLTAGES AND CURRENTS CAN OCCUR AT SOME POINTS IN THE CIRCUIT. WE DO NOT RECOMMEND OPERATION OF THIS TUNER WITHOUT THE TOP COVER SECURELY INSTALLED DUE TO DANGER OF CONTACT WITH HIGH VOLTAGE.
2. WHILE ALL OF THE COMPONENTS IN THE MODEL 238A ARE RATED TO EASILY HANDLE CONTINUOUS OPERATION AT MAXIMUM POWER, CERTAIN LOADS WILL PRODUCE CURRENTS WHICH EXCEED THE "HOT SWITCHING" CAPABILITIES OF THE CERAMIC WAFER SWITCHES. THEREFORE, NEVER CHANGE THE POSITION OF EITHER THE S1 OR ANTENNA SWITCHES WITH HIGH RF POWER APPLIED. UP TO 100 WATTS OF RF MAY BE HOT SWITCHED ON S1 DURING THE INITIAL TUNE UP PROCEDURE. **FAILURE TO OBSERVE THESE WARNINGS MAY RESULT IN PERMANENT DAMAGE TO THE CONTACTS OF THE WAFER SWITCHES.**
3. ALWAYS BE SURE THAT A SUMMY LOAD OR ANTENNA IS PROPERLY CONNECTED WHEN POWER IS APPLIED. VOLTAGES IN EXCESS OF RATINGS CAN OCCUR IF NO LOAD IS CONNECTED.

2-6 OPERATING HINTS If it is noticed that placing your hand on top of the tuner causes a shift in SWR, it is an indication of excessive "RF in the shack". Improve the ground system or change the length of the feedline slightly. This is especially noticeable when using wire-fed antennas.

When using BALANCED LINE, if the SWR rises during a long transmission, it is an indication that a significant portion of the transmitter power is being lost in the balun. This will be the case when the antenna impedance is greater than 500 ohms. Changing the length of the antenna and/or feedline will usually cure this problem.

160 METER NOTE: Some low impedances on 160 meters may require more capacitance than the 2400 pF available with the variable tuning capacitor at full mesh and S1 at position 5 on the LOW Z side. Under such a condition, adding an additional 1000 pF (.001 uF) 1 kV capacitor across the variable capacitor will usually produce a perfect match. A low loss ceramic or mica transmitting capacitor should be used. A ceramic capacitor is included in the model 238A packing kit for your use. If needed, install the capacitor by connecting one lead to the EXTERNAL CAPACITOR terminal (on the rear panel) and the remaining lead to a ground lug located below the capacitor terminal.

2-7 ANTENNA SYSTEMS MATCHING THEORY Most transmitters are designed to work into a 50 ohm resistive load, and they are not able to effectively supply RF power to loads that depart far from this value. However, many antenna systems, which include the antenna and the transmission line, have complex impedances that make it difficult, if not impossible, to load the transmitter properly. These impedances are a function of the operating frequency, type of antenna, type and length of transmission line, height of antenna and its' proximity to other objects.

The model 238A provides a coupling method to convert the resistive/reactive load to a pure resistance of 50 ohms that will accept maximum from the transmitter. This is not to say that any and all antennas, when converted to a 50 ohm resistive impedance by means of a tuner will give identical performance. To best understand the tuner adjustments required, it is necessary to have a fundamental knowledge of how antenna systems function. To this end, a short technical discussion follows. It is recommended that additional reading on the subject be done by those interested in obtaining maximum performance from their antenna systems. The ARRL Antenna Handbook, ARRL Radio Amateur's Handbook (antenna and transmission line sections), Low Band DXing by John Delvedore ON4UN, and other antenna books published by the publishers of amateur radio magazines are excellent sources for information.

2.7-1 THE ANTENNA Any conductor that has RF currents flowing in it can be looked on as an antenna or radiator. The extent to which power leaves the conductor and radiates into the surrounding medium depends upon many factors – length, frequency, amount of current, configuration, etc. Since the antenna absorbs power from the device feeding it, it can be replaced with a resistance whose value is such that the power delivered to this resistance is the same as that delivered to the antenna. The value of this resistance is now a measure of the radiating effectiveness of the antenna and is termed "radiation resistance". For a given value of antenna current, the higher this resistance, the more power that is radiated. ($P=I^2R$).

Due to the facts that an antenna has physical length, that currents travel at a velocity less then instantaneous and that the conductor possesses a certain amount of self-inductance and capacitance, the current at the feed point may or may not be in phase with the voltage at this point. As a result, the impedance at this point may not look like the pure resistance first suspected, but as an impedance consisting of resistance and either inductive or capacitive reactance. This added reactance will limit the amount of current supplied to the antenna for a given voltage, and therefore reduce the amount of radiated power. The reactance does not absorb power in itself – only a resistance can do that – but its' presence reduces the overall radiated power and antenna current.

There are two ways to restore the power to its' non-reactive value. The first, which is not the preferred way because it does not maximize power transfer, is to raise the feed point voltage enough so that the current returns to its' original value. The second, and preferred method, is to add a reactance in series, equal in value but opposite in type (sign) to the reactance value of the antenna. For example, if the antenna at the operating frequency presents an inductive reactance of 100 ohms (+j100) along with a resistance of 50 ohms, inserting a capacitor whose reactance is also 100 ohms (-j100) in series has the effect of cancelling out the reactance of the antenna, leaving only the 50 ohms resistive. This can be looked on as a series R,L,C circuit that is in resonance, whose total impedance is only that of the resistance. Another term for this approach to maximize power transfer is "conjugate impedance matching".

In the above example, we used a value of 50 ohms for the radiation resistance. If this value were not 50 but 150 ohms, the impedance after canceling the reactance out would be 150 ohms. Connecting this load to the transmitter designed to operate with a 50 ohm load would not result in optimum power transfer. It would, however, be better than leaving the inductive reactance in, since the antenna current is maximized for the conditions that do exist. To obtain design performance, it is necessary to transform the 150 ohms to 50 ohms. This can be done with a transformer with a turns ratio of 1.73 to 1. (Impedance transformation is equal to the square of the turns ratio). It is also possible to accomplish this transformation with a parallel tuned circuit with primary and secondary taps properly located on the inductor, or using two or more capacitors in series with taps taken from the series string. Under these conditions, the transceiver will deliver rated power to the antenna.

One last observation before we go on. The antenna impedance in the above example was stated as that at the feed point. If we now feed the antenna at a different location along the conductor, the impedance will be different, both resistive and reactive components. There are an infinite number of impedance choices available, depending on where the tap is made. This factor is helpful in designing and matching antennas. The factors that determine this impedance are the current and voltage values at this point, and the phase between them.

2-7.2 THE TRANSMISSION LINE In the above example, we assumed that the transmitter output was connected directly to the feed point. This is hardly practical. So that the transmitter can be located at a distance from the antenna, we use a transmission line to deliver the power. Unless we have a perfectly matched system, i.e. antenna, line and transmitter output impedances all the same value without reactive components, the addition of the transmission line completely changes the picture. The transmitter will not see the antenna impedance of 50 ohms resistive and 100 ohms inductive reactance, but some other combination. It will depend on the electrical length of the line, its' characteristic impedance and frequency. The impedance at the transmitter end is what we are interested in, and the inductive component may even be changed to capacitance. (Only when the electrical length of the line is an exact multiple of the half wavelength will the impedance at the transmitter be the same as the antenna impedance).

Briefly, the line characteristic impedance is determined by the physical dimensions of the line – wire diameter and spacing – and the dielectric of the material in between. The wire also possesses a resistive component which will dissipate power when current flows through it to the antenna. This shows up as heat loss and dictates the use of low loss cable. Formulas for coax and open wire line impedances are given in the handbooks.

Since RF currents flow in the transmission line, one may ask if it then becomes an antenna. In the case of coax type lines, the current should flow on the inside surface of the outer conductor and outer surface of the inner conductor. The electric and magnetic fields caused by the current flow are confined between the two, so none can escape and be radiated. If a system configuration results in some RF current flowing on the outer surface of the outer conductor, such as when a dipole is fed with coax without a balun or other means of changing the feed line from an unbalanced to balanced configuration, it will radiate power. In the case of parallel lines, the current in one conductor at a given location should be flowing in the opposite direction to the current in the adjacent conductor, and if the system is well balanced the amplitudes of the two will be equal. Under these conditions, the two sets of fields exactly cancel each other and very little radiation will result. If the two currents are not equal or not in exact opposite phase, there will be radiation. Also, if the spacing between lines is a considerable portion of the wavelength, radiation will occur. This is not a factor below VHF frequencies.

One final characteristic of transmission lines should be mentioned. The RF current flowing in the line travels at a speed less than that of radiated power in a vacuum, or the speed of light, both 186,000 miles per second. This slowing is caused by the dielectric property of the medium through which the field traverses. In coax cables it is polyethylene between inner and outer conductors. In parallel lines, (like twin-lead) it may be the plastic between the conductors. Air and plastic spacers in open wire lines. The ratio of the speed in the line to the speed in a vacuum (air is almost the same) is called the velocity factor of the cable. It is always less than unity. Because of this slowing, the physical length of a transmission line is not the same as the electrical length. For example, the wavelength in free space of a 30 MHz signal is exactly 10 meters. A transmission line 10 meters long will be one full wavelength only if the dielectric between the conductors is air. In the case of coax cable with polyethylene dielectric, the velocity factor runs about 0.67. The same 10 meter length of cable will now appear electrically as an open wire or air dielectric cable 15 meters long (10 divided by 0.67). This is equivalent to one and one half wavelengths. A polyethylene type cable would only have to be 6.7 meters long to be one wavelength.

2-7.3 EFFECT OF THE TRANSMISSION LINE ON ANTENNA IMPEDANCE As a result of all of the above, in situations where we do not have a matched system throughout – and this is most of the time – the impedance presented to the transmission line by the antenna sets up standing waves on the line. These standing waves will alter the antenna impedance all along the line towards the transmitter. What we really want to accomplish with the antenna tuner is to take whatever impedance that is established at the transmitter end of the line and alter it to a 50 ohm resistance. Then the transmitter will be happy, at least. The tuner will not affect the mismatch of antenna to line – only constructing the antenna differently will do that – nor eliminate a standing wave on the transmission line. It will eliminate a standing wave on the line between transmitter and tuner input, but not on the output side of the tuner. A good antenna is still needed to 'get out'. If the antenna has a low resistance, the tuner will transform it, along with the cable loss resistance, to 50 ohms. The full power will enter the system, but it will be divided between radiation and cable heat loss. It is not uncommon that more than half of the available power is wasted in cable losses, even with low loss cable. It just gets a bit hotter. The split depends entirely on the ratio of radiation resistance to loss resistance.

What is the impedance established at the transmitter end of the line? It depends first on the antenna impedance, which is them transformed by the line. This transformation is dependent on frequency, electrical length of the line and the loss in the line. In an amateur setup where many different frequencies are used with the same antenna, there will be a multitude of impedances presented to the tuner, so adjustment of the matching network will be required as the frequency is changed.

2-7.4 STANDING WAVE RATIO A measure of how badly a system is mismatched is given by the standing wave radio (SWR) on the line. SWR is the ratio of the maximum voltage encountered along a transmission line, greater than one half wavelength long, to the minimum voltage. It is also the ratio of maximum to minimum current. The more nearly uniform the voltage distribution along the line, the more closely matched it is, and the ultimate is when the voltage is constant down the length of a lossless line, or drops slowly and uniformly along a line with losses. This is the matched condition, represented by a 1 to 1 SWR. The impedance at the load end of such a line is the same as that at the generator end and maximum power is delivered to the load. When adjusting a matching network properly, the way to do it is to observe the SWR and tune for as low a ratio as possible.

The SWR is also an indication of the value of the resistance at the load end. The ratio is the same as the ratio of load resistance to line characteristic impedance. This ratio can mean that the load is either greater than or less than the line's impedance. For example, if the SWR on a length of 50 ohm line is 3:1, the load resistance is either 150 ohms or 16.7 ohms (3 times 50 or one-third of 50). This is only accurate with pure resistive loads.

It can be shown mathematically that a 2:1 SWR in a system which has the transmitter output impedance equal to the line impedance delivers 89% of the measured forward power to the load. This relates to a power loss of half a decibel – hardly noticable in signal strength. At a 3:1 ratio, the loss becomes appreciable with 75% of the measured forward power delivered. When adjusting antenna tuners, it is a nice feeling if you achieve a 1:1 match, but in reality, anything below 2:1 is satisfactory. Line losses do increase a bit also with increasing SWR, but it is still a small fraction of a dB at 2:1.

2-7.5 OVERALL SUMMARY

1) Any antenna can be represented as an equivalent resistive/reactive impedance whose resistive component, termed radiation resistance, is a measure of the power radiated. Reactance can be either inductive or capactive.
2) Antenna impedance is a function of frequency, configuration, selection of feed point location, height above ground and nearness to surrounding objects.
3) The reactive portion of the impedance does not absorb power but limits the amount of power radiated by the resistive component. It is best to eliminate the reactive component, by inserting an equal value reactance in series, but of the opposite type.
4) Best system performance is attained when antenna impedance is purely resistive with a value equal to the transmission line impedance, which in turn equals the transmitter output impedance.
5) Since antennas seldom present matched impedances to a line over a band of frequencies and from band to band, a partial solution to using these mismatched systems is to convert the impedances at the transmitter end of the line to what the transmitter is designed for, with an antenna tuner.
6) The transmission line will change the antenna impedance in both resistive and reactive values at the transmitter end, depending on the line's electrical length, frequency and characteristic impedance.
7) Due to slowing down of the current flow in the transmission line from that in free space, the electrical length of a line will be longer than the physical length.
8) One situation where the line does not alter the impedance is when its' length is an exact multiple of the electrical half wavelength.
9) An antenna tuner will not affect the antenna impedance nor the standing wave condition on the transmission line. It will correct the SWR on that portion of the line between transmitter output

and tuner input, so that the transmitter will supply rated power to the system.

10) Standing wave ratio, SWR, is a mesaure of mis-match of the system and is used as the indicator when making tuner adjustments. SWR is the direct ratio of load resistance to a line's characteristic impedance.
11) SWR other than 1:1 indicates two possible impedances, one greater and one less than the characteristic impedance.
12) Any SWR value less than 2:1 is considered a good match

2-8 ALIGNMENT AND CALIBRATION
The following sections describe the proceedures for aligning and calibrating the SWR bridge and RF wattmeter.

2-8.1 SWR BRIDGE In the unlikely event that SWR bridge adjustment becomes necessary, proceed as follows:

1) Connect a 50 ohm dummy load to any antenna jack
2) Turn the ANTENNA switch to the same antenna position and S1 to BYPASS.
3) Set the meter switch knob to SWR.
4) Turn the SWR SET knob fully clockwise.
5) Apply power from the transmitter on 14 MHz and adjust the trimmer, C16, on the 81898-2 SWR board for a null.

2-8.2 WATTMETER CALIBRATION
To calibrate the built-in wattmeter proceed as follows:

1) Place S1 in the BYPASS position
2) Connect a 50 ohm dummy load to any antenna jack
3) Turn the ANTENNA switch to the same antenna position.
4) Connect the transmitter through a calibrated wattmeter to the input of the tuner.
5) Set the meter select knob to 200W.
6) Apply 50 to 100 watts from the transmitter on 14 MHz and adjust R30 (on the 81898-1 MAIN board) to agree with the external calibrated wattmeter.

CHAPTER 3

ILLUSTRATIONS AND CIRCUIT SCHEMATICS

3-1 INTRODUCTION The following sections contain circuit trace drawings and detailed component layout diagrams for all of the printed circuit board assemblies used in the model 238A antenna tuner. Also included is a detailed circuit description and a schematic diagram of the tuner.

3-2 CIRCUIT DESCRIPTION The matching circuit used in the model 238A is basically an "L" network. The "L" network has several advantages over other circuit configurations. It has only two adjustable parts, one inductor, L4, and one capacitor C12; most other networks use three. Because there are no internal nodes in the network, the maximum circuit voltages and currents which occur are never more than those present at the input or output terminals. Because there are only two variable components, there is only one setting of each which will provide a perfect match to a given load impedance, and this unique setting automatically provides the lowest network Q possible. Low Q means low circulating currents, hence low loss, and it also provides the widest frequency bandwidth of operation before retuning is necessary. Finally, since the inductor is always series, the network always provides a two-pole lowpass response to provide harmonic rejection.

There are, however, some disadvantages which have prevented wider use of the "L" network in the past. First, to match all possible antenna loads, two configurations are required. One, for impedances greater than 50 ohms, requires the capacitor to be across the antenna. The other requires the capacitor to be placed across the transmitter when the antenna impedance is less than 50 ohms. This function is performed by switch S1. At high frequencies, as the load impedance approaches 50 ohms, i.e. the antenna has a fairly low SWR already, the values of L and C in the network required for a perfect match become very small – smaller than the stray or minimum values of the components used. To circumvent this problem, a small fixed compensating capacitor or inductor is placed into the circuit depending upon whether the network is configured for high or low impedance respectively (HI or LO on switch S1). At low frequencies, the value of network capacity needed to match some loads is quite large, requiring a large and expensive capacitor. To provide for this, fixed capacitors are placed in parallel with the variable capacitor to obtain the value needed. This function is also performed by switch S1; further rotation from the center position increases the value of capacitance in the circuit.

The 81898-2 SWR board contains the SWR bridge circuit. Transformer T1 samples the incoming RF and feeds the balanced signals to detector diodes D1 and D2. The balance of the transformer bridge circuit is adjusted by trimmer C16 for a null. The DC voltages, filtered by C14, C15, C19, and C20 are fed to the meter circuits via a three pin connector. 81898-2 SWR board also contains a four position selector switch, S4, used to select the metering functions.

On the 81898-2 MAIN board, R4 is used to calibrate the 200 watt meter position. R10 is used to calibrate the 2000 watt meter position. When S4 is placed in the SWR position, the SWR SET control (R9), determines the signal level sent from the bridge diodes to the meter.

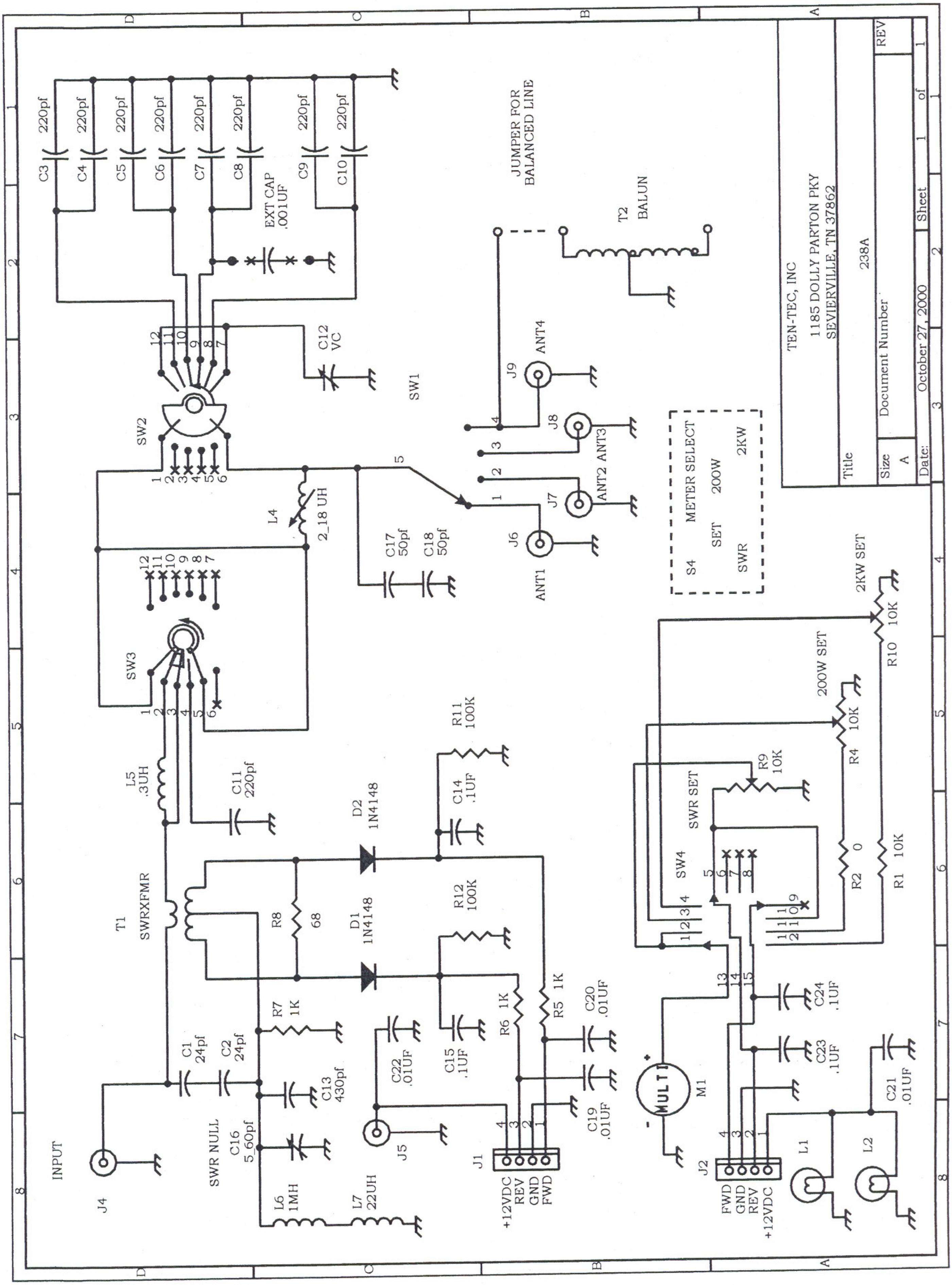

FIGURE 3-1. MODEL 238A SCHEMATIC DIAGRAM

3-3 TUNER CONFIGURATIONS
The following diagrams show the possible configurations of L and C used in the model 238A antenna tuner. These combinations are selected by S1. (Refer also to Figure 3-1).

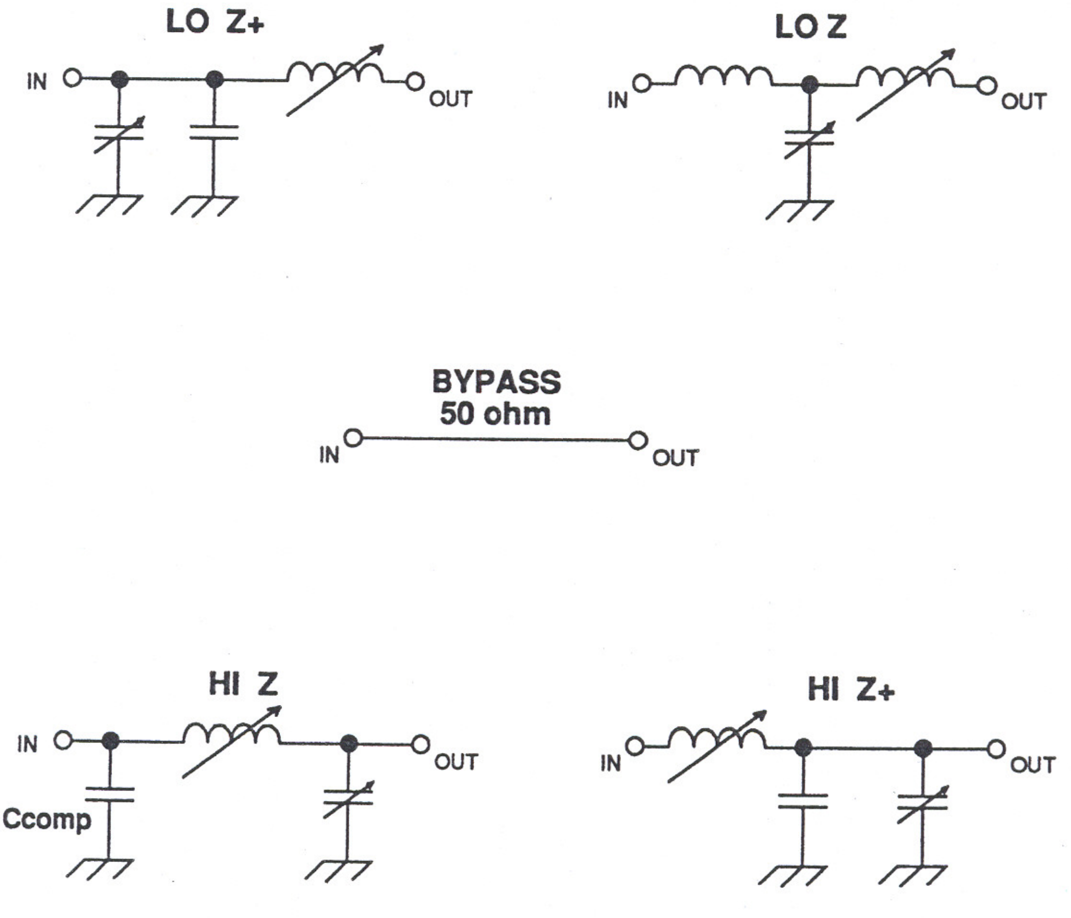

FIGURE 3-2. MODEL 238A TUNER CONFIGURATION DIAGRAMS

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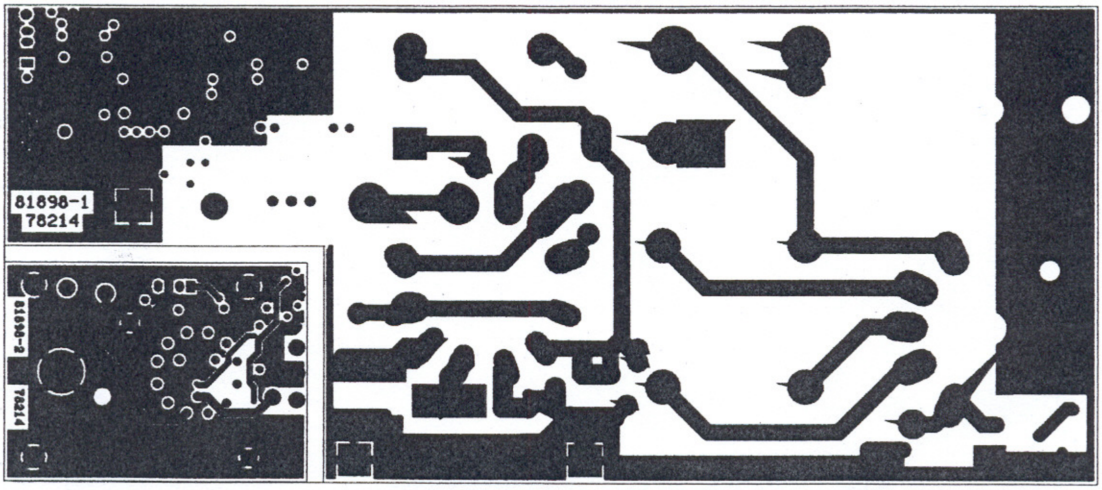
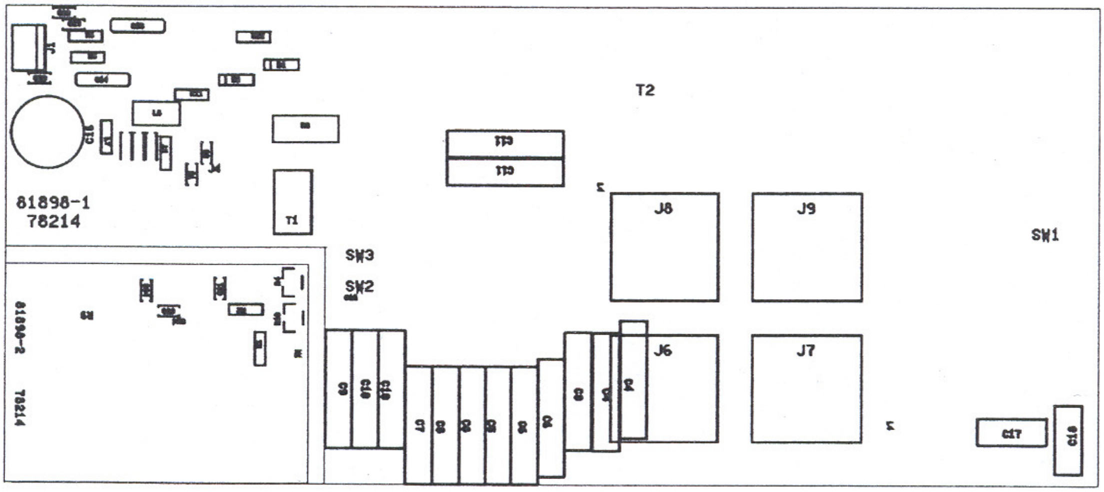


TOP SILK SCREEN



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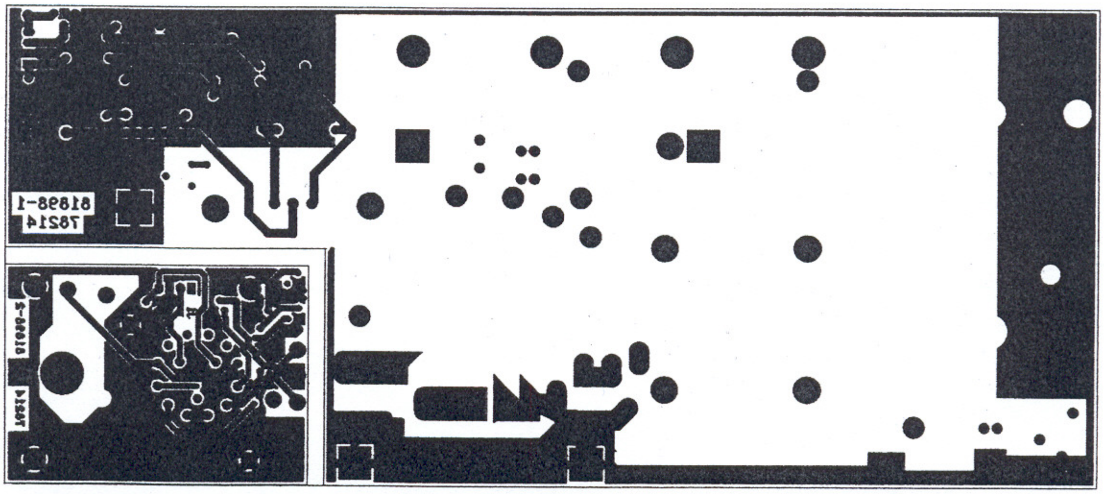

FIGURE 3-3. CIRCUIT BOARD TRACE LAYOUTS FOR 81898-1 MAIN BOARD AND 81898-2 SWR BOARD

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3-4 MASTER PARTS LISTS Below are parts lists for PC mounted components and chassis parts for model 238A.

238A FINAL ASSEMBLY PARTS LIST

1	1	C12	CAP 40-500PF	80858	
2	4	R9	10K VAR	98272	FROM 30095
3	4	J6,J7,J8,J9	SO239	35007	
4	2	L2,L1	LIGHT	34060	
5	1	L4	2_18 UH	81040	
6	1	CAPACITOR DIAL SKIRT		93563-FG1A	
7	1	1NDUCTOR DIAL SKIRT		93564-FG1A	
8	1	CAPACITOR KNOB		92287-1	
9	1	INDUCTOR KNOB		92468-1	
10	1	INDUCTOR KNOB		92468-1	
11	1	KNOB S/A BAR		80760	
12	1	KNOB S/A SMALL		81724	
13	1	TOP COVER		93552-FG	
14	1	BOTTOM CHASSIS		93553-FG	
15	1	BAIL		92487	
16	1	FOOT BAIL LEFT		90925	
17	1	FOOT BAIL RIGHT		90926	
18	1	SHAFT COUPLER FLEXIBLE		91963	

238A PC BOARD PARTS LIST

1	2	C1,C2	22pf	23374
2	9	C3,C4,C5,C6,C7,C8,C9,C10, C11	180pf	23367
3	1	C13	330pf	23165
4	2	C15,C14	.1UF	23006
5	1	C16	5_60pf	23061
6	2	C17,C18	50pf	23364
7	4	C19,C20,C21,C22	.01UF	23260
8	2	C24,C23	.1UF_50V	23261
9	1	C25	100pf	23125
10	2	D1,D2	1N4148	28001
11	1	L5	.3UH	85119
12	1	L6	1MH	21007
13	1	L7	22UH	21104
14	1	M1	METER	34046
15	4	R1,	10K	30150
16	4	R4, R10,	10K VAR PC	30724
17	1	R2	0	30353
18	3	R5,R6,R7	1K	30138
19	1	R8	68	30082
20	2	R11,R12	100K	30161
21	1	SW1	4POS_SW_C	32037
22	1	SW2 AND SW3	6POS_SW_M	32046
23	1	SW4	3POLESW	32069
24	1	T1	SWRXFMR	85168
25	1	T2	BALUN	85200

Ten-Tec, Inc.
1185 Dolly Parton Parkway
Sevierville, TN 37862
Repair Service: (865) 428-0364

LIMITED WARRANTY AND SERVICE POLICY, U.S.A. AND CANADA

Ten-Tec, Inc., warrants this product to be free from defects in material and workmanship for a period of one (1) year from the date of purchase, under these conditions:

1. THIS WARRANTY APPLIES ONLY TO THE ORIGINAL OWNER. It is important that the warranty registration card be sent to us promptly.

2. READ THE MANUAL THOROUGHLY. This warranty does not cover damage resulting from improper operation. Developing a thorough understanding of this equipment is your responsibility.

3. IF TROUBLE DEVELOPS we recommend you contact our customer service group direct at the address or phone number shown above. It has been our experience that factory direct service is expeditious and usually results in less down-time on the equipment. Some overseas dealers do offer warranty service and, of course, have our complete support.

4. EQUIPMENT RETURNED TO THE FACTORY must be properly packaged, preferably in the original shipping carton(s). You pay the freight to us and we prepay surface freight back to you. Canadian customers must have proper customs documentation sent with incoming repair equipment. Duties or fees charged due to improper documenting are the responsibility of the owner of the equipment.

5. EXCLUSIONS. This warranty does not cover damage resulting from misuse, lightning, excess voltages, polarity errors or damage resulting from modifications not recommended or approved by Ten-Tec. In the event of transportation damage, a claim must be filed with the carrier. Under no circumstances is Ten-Tec liable for consequential damages to persons or property caused by the use of this equipment.

6. TEN-TEC RESERVES the right to make design changes without any obligation to modify equipment previously manufactured, or to notify owners of changes to existing equipment.

7. THIS WARRANTY is given in lieu of any other warranty, expressed or implied.

SERVICE OUTSIDE OF THE U.S.A. OR CANADA

Many of our international dealers provide warranty service on the equipment they sell. Many of them also provide out of warranty service on all equipment whether they sold it or not. If your dealer does not provide service or is not conveniently located, follow the procedure outlined above. Equipment returned to us will be given the same attention as domestic customers but roundtrip freight expense, customs and broker fees will be paid by you.

Part no. 74244