

OPERATOR'S
MANUAL

10-25-93

MODEL 253
AUTOMATIC
ANTENNA COUPLER

10A10012

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SPECIFICATIONS

CIRCUIT TYPE:	Reversible "L" network.
RF POWER RATING:	2 KW maximum.
FREQUENCY RANGE:	1.8 to 30 MHz.
INPUT IMPEDANCE:	50 Ohms, nominal.
DC POWER INPUT:	12-14 Volts, 2 Amps maximum.
TUNING ACCURACY:	1.5:1 VSWR maximum after tuning. 2.5:1 VSWR maximum during tuning.
AUTOMATIC TUNING TIME:	5 seconds typical, 30 seconds maximum (from home position).
MANUAL TUNING:	Full range manual tuning available via front panel up/down switches.
MEMORY TUNING:	Tuner automatically returns to settings last used for each antenna switch position. Separate settings are stored for each band if remote band connector is used. Retuning (auto or manual) updates memory.
TUNE POWER:	50 Watts minimum, 150 Watts maximum. Radiated power at least 6 dB below input during tuning.
ANTENNA SWITCH:	4 position. Position 4 configurable for coax, single wire, or balanced line feed. Internal balun standard.
OUTPUT MATCHING RANGE:	At least 10:1 VSWR, any phase angle, 1.8 to 30 MHz. 1300 Ohms maximum parallel equivalent resistance at 1500 Watts output (2 KV peak, >26:1 VSWR). 5000 Ohms maximum parallel equivalent resistance across balanced line at 1500 Watts output (4 KV peak).
MINIMUM FULL POWER LONGWIRE LENGTH:	Single wire feed: 180/F (MHz) feet at 1500 Watts output.
OVER VOLTAGE:	"ARCING" indicator illuminates when RF voltage exceeds 2 KV. Tuner is reset to bypass mode if ARCING or OVER indication remains on for more than 1 second. Hot switching protection provided by internal relay interlock system.
SIZE:	HWD 5.5" x 14" x 10.5", overall (138 x 356 x 267 mm).
WEIGHT:	9 lbs 9 oz., (4.34 Kg).

INTRODUCTION

The Model 253 Automatic Antenna Coupler 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 automatically perform this function over a frequency range of 1.8 to 30 MHz. Capacitor and Inductor up/down switches are also provided for manual adjustment of the

reactive elements. Provision is made for selecting one of four antennas or for bypassing the matching network. In addition, a built-in memory stores settings for each of the four antenna positions on each of seven band settings, giving a total of 28 memory combinations. A dual range power and SWR meter is also included.

UNPACKING

Carefully remove the antenna coupler from the packing carton and inspect it for signs of shipping damage. If the antenna coupler 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 form and mail to TEN-TEC immediately.

Save the packing material for re-use in the event that moving, storage, or reshipment is necessary. Shipment of your TEN-TEC

antenna coupler in other than factory packing may result in damage which is not covered under warranty. The following hardware and accessories are packed with your Model 253. Make sure you have not overlooked anything.

1—#74020	Warranty Card
1—#74203	Operator's Manual
1—#86027-26	Cable-26 253

If any of the above items are missing, contact the customer service department at Ten-Tec for replacements.

CHAPTER 1

INSTALLATION

1-1 INTRODUCTION The Model 253 Automatic Antenna Coupler may be set up in any convenient location in your shack. The following sections describe the required connections.

1-2 TRANSMITTER CONNECTIONS The Model 253 is designed for connection to transmitters having a 50 ohm nominal output impedance. To protect the relays in the Model 253 from being hot switched, you **MUST** use the EXCITER CONTROL connections on the rear panel of the Model 253, as shown in FIGURES 2-4 through 2-11. If you will be using only a low power transmitter (less than 150 watts output), you may connect the transmitter as shown in FIGURE 2-6, which does not require the use of the EXCITER CONTROL connectors.

FOR ALL OTHER TRANSMITTER/LINEAR COMBINATIONS YOU MUST USE THE EXCITER CONTROL CONNECTIONS AS SHOWN IN THE APPROPRIATE DIAGRAMS. FAILURE TO DO SO MAY CAUSE SERIOUS DAMAGE TO THE MODEL 253.

If you will be using the Model 253 with Ten-Tec transceivers having TX OUT and TX EN connections, refer to FIGURES 2-4, 2-5 and 2-10 for suggested hookups. The EXCITER CONTROL connectors are standard RCA phono type and the INPUT coax connector is an SO-239 type. You should use a good

quality coax cable (RG-58) between the transmitter and the EXCITER CONTROL connectors. You may use either RG-58 or RG-8 coax cable for the INPUT connector.

Note: To reduce the possibility of rf getting into the transmitter, position the Model 253 as far away from the transmitter as is practical, especially when using a long wire antenna.

1-3 GROUND CONNECTIONS Connect the station ground buss to the GND terminal on the rear panel of the Model 253 with heavy metallic braid or wire. This lead should go directly to the earth ground system with as short a lead length as possible.

1-4 ANTENNA CONNECTIONS Connect antenna transmission line(s) to the appropriate terminal(s) on the antenna coupler as follows:

- A. For coax-fed antennas (unbalanced transmission lines), use either ANT 1, ANT 2, ANT 3 or ANT 4.
- B. For a single wire antenna, connect to SINGLE WIRE terminal.
- C. For balanced feed line systems, follow the diagram screened on the rear panel, and add a jumper from SINGLE WIRE to one of the BALANCED LINE terminals using a short wire. Then, connect the feed line to the two BALANCED LINE terminals.

In both single wire and balanced line systems, take special care to route the transmission line as far away from 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 and a **serious shock hazard**.

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

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

1-5 DC POWER CONNECTION Connect a 12 to 14 VDC negative ground power source, capable of delivering at least 3 amperes, to the 12-14 VDC connector on the rear panel.

1-6 REMOTE CONTROL CONNECTIONS The Model 253 may be used without any connections to the REMOTE CONTROL connector. This connector is used for automatic bandswitching and/or band presets. For further information see section 2-3.5.

CHAPTER 2

OPERATING INSTRUCTIONS

2-1 INTRODUCTION The following instructions will enable the operator to quickly place the Model 253 Automatic Antenna Coupler into operation. Included are descriptions of the Front Panel controls and their functions followed by descriptions of the Rear Panel connections. Also included are instructions for antenna matching and selection, operating hints, and a discussion of antenna systems matching theory.

2-2 FRONT PANEL CONTROL FUNCTIONS The following sections describe the front panel controls and their functions. Refer to FIGURE 2-1 for control locations.

2-2.1 OPERATE / BYPASS SWITCH This rocker switch is used to apply or remove the 12-14 VDC from the Logic board. When the switch is in the BYPASS position all control circuits and relays are turned off and any rf applied to the INPUT is routed directly to the antenna connectors. The tuning network is disconnected from the system. The Power-SWR meter is still in line and may be used to monitor your forward and reflected power levels. Note however, that the meter pilot lamp and all annunciators will be turned off. Placing this switch in the OPERATE position applies the 12-14 VDC input power to the Logic board, turns on the meter pilot lamp, and enables all circuitry required for using the Model 253 in either manual or automatic tuning modes. When switching to the OPERATE position, if either the ANTENNA selector switch or the REMOTE CONTROL

band information has changed since the Model 253 was last used, then the preset memories for the new antenna and/or band settings will be recalled and the tuning network adjusted accordingly.

2-2.2 TUNE SWITCH This is a center off, spring return, momentary contact rocker switch, which is used to activate the automatic tuning procedure in the Model 253. To use this switch you must be in the OPERATE mode. Refer to section 2-4 for a complete tune up procedure and more detailed description of the TUNE switch's function.

2-2.3 MANUAL CAPACITOR/INDUCTOR SWITCHES These are spring return momentary rocker switches with a center off position. To use these switches you must be in the OPERATE mode. Pressing and holding the CAPACITOR switch in the up position will either increment or decrement the tuning capacitor one step at a time. Pressing and holding the switch in the down position will reverse the direction of the capacitor steps. The INDUCTOR switch functions in a similar manner to control a stepping motor attached to the roller inductor. When using the INDUCTOR switches you will notice a difference in motor speed depending on how long you hold the switch in. This occurs because the stepper motor speed must initially be ramped up slowly to overcome the starting torque of the motor and inductor. Also, you will notice that the motor appears to run for a short time after you have released the INDUCTOR switch.

This ramp down is required because of the inertia of the roller inductor system. *NOTE: When using either the CAPACITOR or INDUCTOR switches, the direction of change is not readily apparent and will depend on the matching circuit configuration selected by the logic circuits. This should not be a problem however, since these manual tuning switches are provided primarily for the purpose of fine tuning the match selected by the auto-tune routine. When fine tuning the match simply observe the reflected power on the built-in meter and adjust the CAPACITOR and INDUCTOR switches for the lowest reflected reading.*

2-2.4 METER SWITCH The meter functions are determined by a four position rotary switch. In the SWR position the meter displays the amount of reflected power on an SWR scale. When placed in the SET position the full scale SWR calibration point can be set using the SWR SET control (see below). The 2 KW switch position is used to measure forward power on the 2 KW full-scale range. Placing the switch in the 200 W position likewise measures forward power on the 200 W full-scale range.

2-2.5 SWR SET This potentiometer is used to adjust the sensitivity of the meter output circuit when you wish to determine the SWR. To use this control place the meter switch in the SET position. Next, key the transmitter and adjust the SWR SET control for a full scale deflection. While still transmitting, place the meter switch in the SWR position and read the SWR from the meter scale.

2-2.6 ANTENNA SWITCH This switch is used to select one of four possible antennas connected to the rear panel of the Model 253. After the Model 253 has successfully completed an auto-tune routine, the current antenna switch setting is stored in memory. If you then change antenna switch positions

while in the OPERATE mode, the tune-up settings for the new antenna selection will be recalled and the matching capacitors and roller inductor will automatically be set to these new values. **Note: At this time the READY annunciator will not be turned on, even though the capacitor and inductor values have been selected. You should always perform the tune up procedure to make sure that these values are acceptable. If the recalled settings provide a proper match, then the READY annunciator will come on immediately after you start the auto tune routine. If, however, the SWR is still too high, then the Model 253 will retune the system. If the newly selected antenna switch position has had its memory programmed for bypass operation, then the capacitor and inductor values will not be affected and the Model 253 tuning network will be removed from the line.**

2-2.7 ANNUNCIATORS The front panel of the Model 253 contains six LED annunciators used to inform the operator about current operations or possible problems.

TUNING — This annunciator is a yellow LED and is activated whenever the Model 253 is in the auto-tune routine. This routine is entered by pressing the TUNE switch when in the OPERATE mode.

UNDER — This annunciator is a yellow LED which will be turned on during the auto-tune routine if the input power level to the Model 253 drops below approximately 30 watts. If this occurs simply increase your transmitter output drive level until the "UNDER" annunciator is turned off. *NOTE: When the "UNDER" annunciator turns on, all tuning operations will be suspended and an internal timer will be activated. If the "UNDER" annunciator remains on for more than ten seconds then the Model 253 will power down, turn off all annunciators and the tuning network will be removed from the line. Also the selected memory will be programmed for bypass operation.*

OVER — This yellow LED annunciator will be turned on whenever the input power level to the Model 253 exceeds 150 watts. If the "OVER" annunciator remains on for more than one second, then the "FAULT" annunciator will also be turned on. When this occurs, the EXCITER CONTROL relay will remove transmitter input power from the Model 253. **If the "OVER" annunciator comes on, you should immediately reduce the transmitter power level or turn the transmitter off.**

READY — This green LED annunciator will be turned on after the Model 253 has successfully completed its auto-tune routine. When this annunciator is on the Model 253 is tuned-up and you can proceed to operate at a higher power level if desired. When tuned-up the SWR will typically be less than 1.3 to 1.

ARCING — This is a red LED annunciator which will be turned on whenever internal rf voltages are dangerously high (typically greater than 2 KV). When this annunciator comes on it usually means that there is something seriously wrong with your antenna or feedline (possibly open or shorted), or that you may have the ANTENNA switch set to an unused position. The "FAULT" annunciator will come on immediately after the "ARCING" and the Model 253 will be disconnected from the line to protect its circuitry. **If the "ARCING" LED comes on, shut down your transmitter and check your antenna and feedline before trying to tune up again.**

FAULT — This red LED annunciator is used to alert the operator to potentially serious problems that may damage the components in the Model 253. This annunciator will be turned on if a particular antenna/feedline combination cannot be matched by the auto-tune routine. This usually will not occur, but if it does it usually means that the SWR you are trying to match is outside the range (greater than 10 to 1) of the Model 253 matching system. You may be able to resolve this

problem by changing your feedline lengths. This annunciator will also be turned on for conditions of excessive input power while tuning up ("OVER"), and for excessive internal rf voltages possibly due to antenna problems ("ARCING"). When a "FAULT" condition occurs, the EXCITER CONTROL relay will be turned-on to remove rf from the INPUT connector of the Model 253. After a short delay (about 100 mS), the tuning network is placed in the bypass position and any power applied to the EXCITER CONTROL IN connector is fed to an internal load resistor. This protection system is required to prevent possible damage to the relay contacts caused by hot switching of the relays when going from their auto-tune position into the bypass position. **The "FAULT" annunciator can only be cleared by placing the front panel switch, S4, into the STANDBY position and then back into the OPERATE position.**

2-3 REAR PANEL CONNECTIONS The following sections describe the rear panel connectors and their function. Refer to FIGURE 2-2 for the connector locations.

2-3.1 INPUT COAX CONNECTOR This connector is an SO-239 type and is designed to mate with a PL-259 coaxial cable connector. This INPUT should be connected to your transmitter rf output connector with a short length of good quality 50 ohm coaxial cable, either RG-8 or RG-58. To reduce the possibility of rf getting back into your transmitter, the Model 253 should be placed as far away from the transmitter as is practical. This is especially important when using a long wire antenna.

2-3.2 EXCITER CONTROL CONNECTORS These connectors are RCA phono type. The IN and OUT jacks are used to provide hot switching protection for the Model 253. The IN connector is usually

connected to your exciter's rf output connector. The OUT connector is usually connected to the rf input of your linear amplifier or the INPUT of the Model 253. However, if you are using the Model 253 with Ten-Tec transceivers having TX OUT and TX EN connections, the IN connector should go to the transceiver TX OUT connector and the OUT connector should go to the transceiver TX EN connector. Refer to FIGURES 2-4 through 2-8 for more detailed information. Use a good quality coax cable such as RG-58 for these connections. **Do not use shielded audio cables.** UHF-to-phono adapters are available at most electronics supply stores to enable you to use PL-259 coaxial connectors for these cables. To reduce the possibility of rf getting back into your transmitter, the Model 253 should be placed as far away from the transmitter as is practical. This is especially important when using a long wire antenna.

2-3.3 ANT 1 — ANT 4 CONNECTORS

These are SO-239 type coaxial connectors designed to mate with PL-259 type cable connectors. Connectors ANT 1, ANT 2, and ANT 3 should be used with coax-fed antennas (unbalanced transmission lines). Connector ANT 4 can be used with coax, single wire or a balanced line (requires a jumper wire).

2-3.4 SINGLE WIRE AND BALANCED LINE For a single wire antenna, connect to the SINGLE WIRE terminal or to connector ANT 4. For balanced feed line systems, connect a short jumper wire (16 to 18 gauge) from the SINGLE WIRE terminal to one of the BALANCED LINE terminals. Then connect the feed line to the two BALANCED LINE terminals.

2-3.5 REMOTE CONTROL This is a 15 pin Molex® type connector which is used to provide remote band select information to the Model 253. This band information, along with the ANTENNA switch information, is used to

provide rapid tune up from the memorized presets. The seven band programming lines and four antenna positions yield a maximum of 28 possible preset combinations. For further information on how the memory presets work, see section 2-6. To use the Model 253 with Ten-Tec transceivers having band information output; you will need to have one Model 236 Remote Control Cable. If you intend to use the band information with a Ten-Tec Model 420 Linear Amplifier and also with the Model 253, then you must have one Model 236 Remote Control Cable and one Model 264 Remote Control Extension Cable. Refer to FIGURES 2-4 and 2-5 for the correct interconnections. If you wish to build your own cable, use a Molex® 15 pin plug (03-06-2151) and Molex® male pins (02-06-2103) to connect to the REMOTE CONTROL receptacle on the rear of the Model 253. These parts are available from the Ten-Tec Service Department under part numbers 35205 and 41023 respectively.

Note: Some transceivers may use the same band select line for operation on more than one band. If you change to a band which shares a common output line with your previous band setting, the Model 253 will not detect that a band change has occurred. In this case, you will have to tell the Model 253 to auto tune the new band by pressing the TUNE switch.

The pinout designations and functions are listed below for your reference. Typical connection diagrams are shown in FIGURE 2-4 through FIGURE 2-11. If you wish to use the band select lines with a selector switch (as shown in FIGURE 2-9) or with other transceivers (FIGURES 2-6 through 2-8, 2-11) keep in mind that only one select line at a time can be used. This line must have a positive 10-14 VDC applied when selected and no voltage when deselected. The band lines should also be capable of sourcing about 3 mA of current.

REMOTE CONTROL PINOUTS

PIN NO.	FUNCTION
1	BAND SELECT #1
2	BAND SELECT #6
3	NOT USED
4	BAND SELECT #2
5	BAND SELECT #7
6	NOT USED
7	BAND SELECT #3
8	NOT USED
9	REMOTE READY LED OUTPUT
10	BAND SELECT #4
11	GROUND
12	NOT USED
13	BAND SELECT #5
14	NOT USED
15	REMOTE TUNE SWITCH INPUT

Pin #9 is an auxiliary "READY" output line designed to connect to a remotely located LED. The anode of the LED should be connected to Pin #9 and the cathode of the LED connected to ground. The Model 253 provides for current limiting with an internal 560 ohm series dropping resistor. Any LED having a forward voltage of 1.6 to 2.4 volts and a maximum operating current of 30 mA can be used. Pin #15 is for connection to a remotely located TUNE switch. This should be a normally open, SPST, momentary rocker or push-button switch. It should be connected between Pin #15 and ground using a good quality shielded cable such as RG-174U. By using the remotely located READY annunciator and TUNE switch, minimal remote installation of the Model 253 is possible. Note however, that if a problem in tuning or a malfunction occurs you will not be able to remotely monitor the other annunciators. The remote READY indicator and TUNE switch are intended primarily to improve operating convenience rather than provide for complete remote installation and operation.

2-3.6 DC POWER INPUT This is an RCA type phono connector used to supply all dc operating power for the Model 253. It should be connected to a well regulated dc power supply capable of supplying at least 3 Amperes at 12-14 VDC. A cable (#86027-26) is provided with the Model 253. If you need a longer cable, be sure to use wire no smaller than 18 gauge and keep the length as short as possible to minimize loss. If desired, a good quality shielded cable may also be used, but this is usually not necessary.

2-3.7 FUSE To protect the internal control circuits from excessive current in the event of a major component failure, a 4 Ampere Slow Blow fuse should be used. Typical operating current required by the Model 253 is between two and three amperes. If the fuse ever fails, do not operate the Model 253 until the cause of the excessive current has been corrected.

2-4 AUTO-TUNE PROCEDURE The procedure below will enable you to quickly match almost any antenna system. Always use the minimum transmitter power necessary to operate the input detector circuits of the Model 253. To do this proceed as follows:

1. Select the desired operating antenna with the ANTENNA switch and set your transmitter to the desired transmitting frequency. **Set your transmitter drive control for minimum output. This level must be less than 150 watts for tune up purposes! The recommended value is 50 watts.**
2. Place the OPERATE/BYPASS switch in the OPERATE position. The meter pilot lamp should turn on. *The capacitors and inductor will be activated for a moment if you have changed antenna switch or band settings since the Model 253 was last placed in BYPASS mode.*

3. Place the METER switch in either the 2 KW or 200 W position.
4. Press and release the TUNE switch. You will hear the relays click and the roller inductor will be placed at its minimum value. The TUNING annunciator will light followed shortly by the UNDER annunciator.
5. Key your transmitter and increase your output drive level until the UNDER annunciator turns off.
6. The Model 253 will now begin its auto-tune routine and you will hear the rapid clicking of the capacitor select relays and the whirring of the stepper motor and roller inductor. Tuning time will vary from about 1 second up to a maximum of about 30 seconds. In general, the higher frequency bands will tune up much faster than the lower frequency bands. The 160 meter band will require the longest tune up time since it usually uses most of the roller inductor and the larger capacitor values.

Note: During the auto-tune procedure, a resistive pad is switched into the line which causes the SWR shown on the meter to be inaccurate. Once tune up has been completed, the meter will correctly read the SWR.

7. When the Model 253 has reached an optimum match with the auto-tune routine, the READY annunciator will be turned on and the TUNING annunciator will be turned off. You may now increase your transmitter power to the final desired output level (2 KW maximum). **Note:** As you increase your transmitter output power, the SWR reading on the meter will appear to

increase. To obtain an accurate SWR reading at the higher power level you must readjust the meter SET point.

8. Once the Model 253 has found an optimum match you may wish to verify that the SWR is sufficiently low by placing the METER switch in the SET position and keying your transmitter. Using the SWR SET control adjust the meter to the full scale SET mark. Place the METER switch in the SWR position and read the SWR on the lower meter scale. A reading less than 1.5 is usually acceptable.
9. If you wish to try to improve the match manually, you can use the CAPACITOR and INDUCTOR switches to adjust the matching network for a lower SWR reading. You will have to alternate between capacitor and inductor changes while monitoring the SWR reading on the meter. **DO THIS AT LOW POWER ONLY.**

WARNING!!!

Never press TUNE or use MANUAL TUNE CONTROLS at greater than 150 watts input power!!!

To measure the unmatched antenna SWR while in the OPERATE position proceed as follows:

1. Press TUNE and hold in for more than 1 second, then release.
2. Do NOT key transmitter. After 10 seconds the Model 253 will default to bypass but will not affect the memories.
3. Place the Meter switch in the SWR position.
4. Key transmitter and read the SWR on the Model 253 meter.

5. When finished, cycle the **STANDBY/OPERATE** switch to **STANDBY** and back to **OPERATE** to reset the tuning network.

2-5 ANTENNA SELECTION A maximum of four antennas may be connected to the Model 253 at one time, only one of which may be a wire fed antenna.

ANTENNA switch position 4 feeds **ANT 4, SINGLE WIRE** or with a jumper wire, **BALANCED LINE**. Only one antenna, coax, single wire or balanced line feed may be selected at one time. When using either **ANT 4** (coax) 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.

2-6 MEMORY PRESETS The Model 253 contains a non-volatile RAM for storage of memory preset information. This information is used for rapid preset tune ups when changing antenna or band switch settings. Details of memory operation are described below.

2-6.1 BAND INFORMATION There are seven band select lines available at the **REMOTE CONTROL** connector on the rear panel. These lines can be connected to a transceiver's band output connector or an external selector switch as described in section 2-3.4. Normally these lines are all pulled to ground by resistors on the Logic board. By applying a positive 10 to 14 VDC to these lines, only one at a time, seven possible band settings are available.

2-6.2 ANTENNA INFORMATION There are four possible **ANTENNA** switch positions available. Since there are seven band settings available, each with four possible antenna settings, a total of up to 28 combinations can be stored in memory.

2-6.3 MEMORY OPERATION When the **TUNE** switch is momentarily pressed and released, the Model 253 begins its auto-tune routine and tries to match the selected antenna system. If the match is successful, the **READY** annunciator comes on and the matched capacitor and inductor values are saved in a memory location determined by the current band and antenna switch settings. If for some reason the antenna can't be matched, (too high an SWR for example) a special **BYPASS** code is stored instead of the normal capacitor and inductor values. This **BYPASS** code will also be saved if the tune up procedure results in a **FAULT** indication. If you change band settings or antenna positions while the Model 253 is in the **OPERATE** mode, the new capacitor and inductor values will be recalled from the memory location determined by your new band and/or antenna selection. The capacitor and inductor will quickly be set to these new positions.

Note: There will be a delay of about one second from the time you change band or antenna settings until the Model 253 updates the capacitor and inductor settings. This delay is necessary to eliminate any possibility of false readings on the band and antenna switch lines caused by changing more than one step at a time. Also, after the completion of the capacitor and inductor update, the READY annunciator will NOT be turned on. The READY annunciator will be turned on immediately after you press the TUNE switch if the recalled settings provide an acceptable match.

If the recalled memory contains the special **BYPASS** code, then the capacitor and inductor will not be changed and the tuning network will be removed from the line for straight-through operation.

2-6.4 PROGRAMMED BYPASS

Occasionally you may wish to use a selected antenna and band combination that already has a good match and does not need to be tuned. To do this, first select the desired band and antenna settings. Then initiate the auto-tune routine by pressing and releasing the TUNE switch as usual, however, don't apply any transmitter power to the Model 253. The UNDER annunciator will turn on and after about ten seconds the Model 253 will power down and turn off all annunciators. Just before it powers down, it will store the special BYPASS code in the selected band/antenna memory location. Whenever this location is recalled in the future, the Model 253 will be placed in a straight-through bypass condition instead of going through the auto-tune routine.

2-6.5 SKIP MEMORY OPTION This is a memory option that will allow you to perform the auto-tune routine but will not cause the preset memories to be changed. Use this technique when you wish to experiment with different antenna and band combinations, but don't want to affect the memory presets you have been using. To use this option follow the auto-tune procedure as usual, except when you press the TUNE switch, **hold the TUNE switch in for more than 2 seconds before releasing it.** This will tell the program not to save the new capacitor and inductor values obtained when the auto-tune routine has finished.

2-7 POWER-SWR METER The meter circuit allows measurement of forward and reverse power in two ranges, 0 - 200 W and 0 - 2 kW. A relative SWR scale is also provided for reading voltage standing wave ratio.

2-8 INDUCTOR REALIGNMENT The stepper motor and roller inductor position

have been checked and aligned at the factory. Occasionally, however, the stepper motor position and roller inductor position may lose alignment. This is most likely to occur when dc power is suddenly removed from the Model 253 logic circuits while in the middle of the auto-tune routine. Possible symptoms for this condition include the inability to match antenna systems which previously could be matched or a longer than usual tune up time. If you suspect that the alignment is off, simply perform the following steps to properly align the stepper and roller inductor.

1. Place the OPERATE/BYPASS switch in the OPERATE position.
2. Simultaneously place the manual CAPACITOR and INDUCTOR switches in the up (top) position and keep them depressed for about 1 second.
3. Simultaneously release both switches. You will hear the stepper motor and roller inductor begin operating. Within a few seconds you should hear a clacking sound as the roller inductor hits the built-in safety stop. Once the noise stops, the stepper motor and roller inductor will again be aligned and you can proceed to use the Model 253 as usual. *Note: This procedure will not harm any of the components in the Model 253 or affect any of the memory presets.*

2-9 OPERATING HINTS If it is noticed that placing your hand on the top of the Model 253 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 5000 ohms. Changing the length of the antenna and/or feedline will usually cure this problem.

CAUTIONS

1. IN THE NORMAL OPERATION OF THE MODEL 253 AUTOMATIC ANTENNA COUPLER, VERY HIGH RF VOLTAGES AND CURRENTS CAN OCCUR AT SOME POINTS IN THE CIRCUIT. BE VERY CAREFUL IF THE MODEL 253 IS EVER USED WHILE THE COVER IS REMOVED.
2. WHILE ALL THE COMPONENTS ARE RATED TO EASILY HANDLE CONTINUOUS OPERATION AT MAXIMUM POWER, CERTAIN LOADS WILL PRODUCE CURRENTS WHICH CAN EXCEED THE "HOT SWITCHING" CAPABILITIES OF THE CERAMIC WAFER SWITCH. THEREFORE, NEVER CHANGE THE POSITION OF THE ANTENNA SWITCH WITH HIGH RF POWER APPLIED. FAILURE TO OBSERVE THIS WARNING MAY RESULT IN PERMANENT DAMAGE TO THE CONTACTS OF THE WAFER SWITCH.
3. **NEVER** USE THE MANUAL CAPACITOR OR INDUCTOR SWITCHES WHILE TRANSMITTING MORE THAN 150 WATTS.
4. ALWAYS BE SURE THAT A DUMMY LOAD OR ANTENNA IS PROPERLY CONNECTED WHEN POWER IS APPLIED. VOLTAGES IN EXCESS OF RATINGS CAN OCCUR

IF NO LOAD IS CONNECTED. IN SUCH CASES THE "ARCING" ANNUNCIATOR WILL USUALLY BE TURNED ON TO ALERT YOU TO THIS CONDITION.

2-10 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 253 provides a coupling method to convert the resistive/reactive load to a pure resistance of 50 ohms that will accept maximum power 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) and other antenna books available from the publishers of amateur radio magazines are excellent sources of information.

2-10.1 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 on 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 than instantaneous and that the conductor possesses a certain amount of self-inductance and capacitance, the current at the feed point 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 cancelling the reactance out would be 150 ohms. Connecting this load to the transmitter designed to operate with 50 ohms 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.

2-10.2 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 half the 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 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, and in parallel lines, it may be the plastic between the conductors in the case of twin-lead type line, or the air and plastic spacers in open wire types. 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.

2-10.3 TRANSMISSION LINE EFFECT 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 then 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 frequency is changed.

2-10.4 STANDING WAVE RATIO

A measure of how badly a system is mismatched is given by the standing wave ratio (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 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 to 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 to 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 noticeable in signal strength. At a 3 to 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 to 1 match, but in reality, anything below 2 to 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.

2-10.5 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 capacitive.
2. Antenna impedance is a function of frequency, configuration, selection of feed point location, height above the 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 special 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 measure of the 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 to 1 indicates two possible impedances, one greater and one less than the characteristic impedance.
12. Any SWR value less than 2 to 1 is considered an acceptable match.

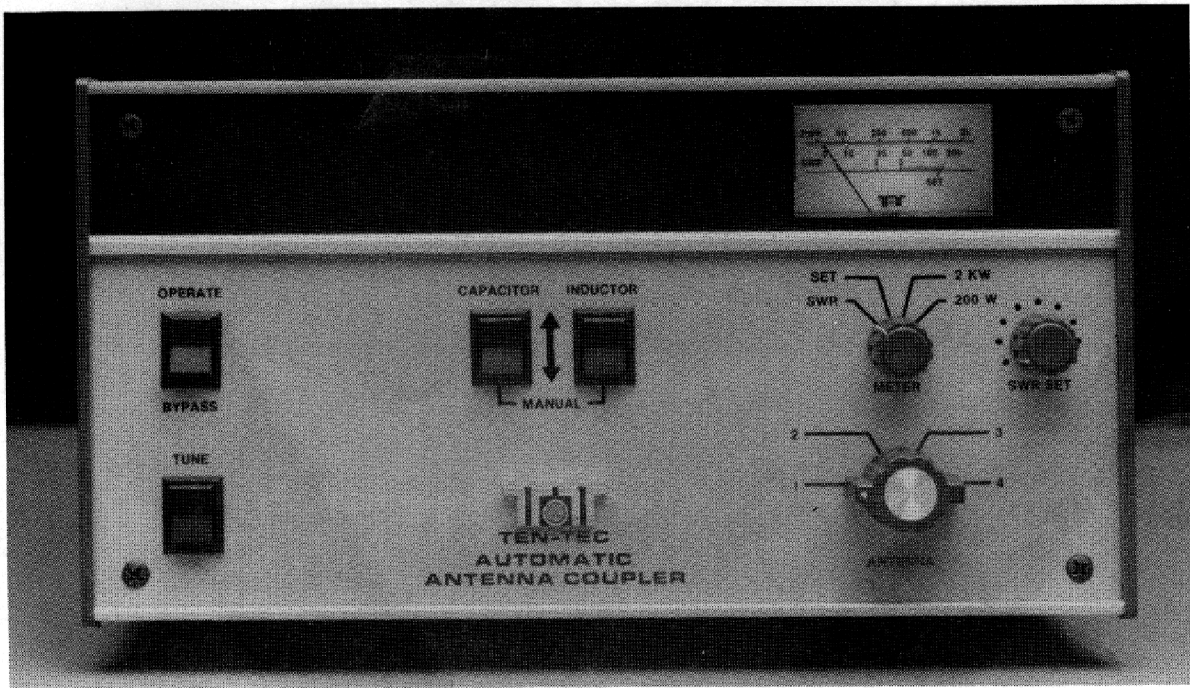


FIGURE 2-1. MODEL 253 FRONT PANEL

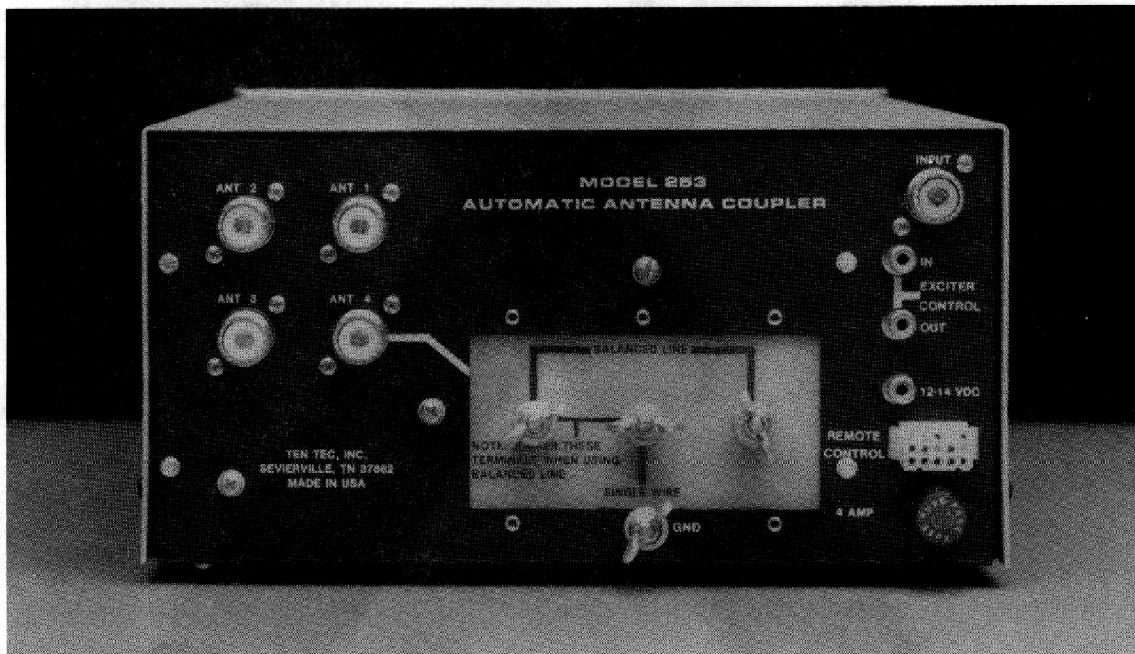


FIGURE 2-2. MODEL 253 REAR PANEL

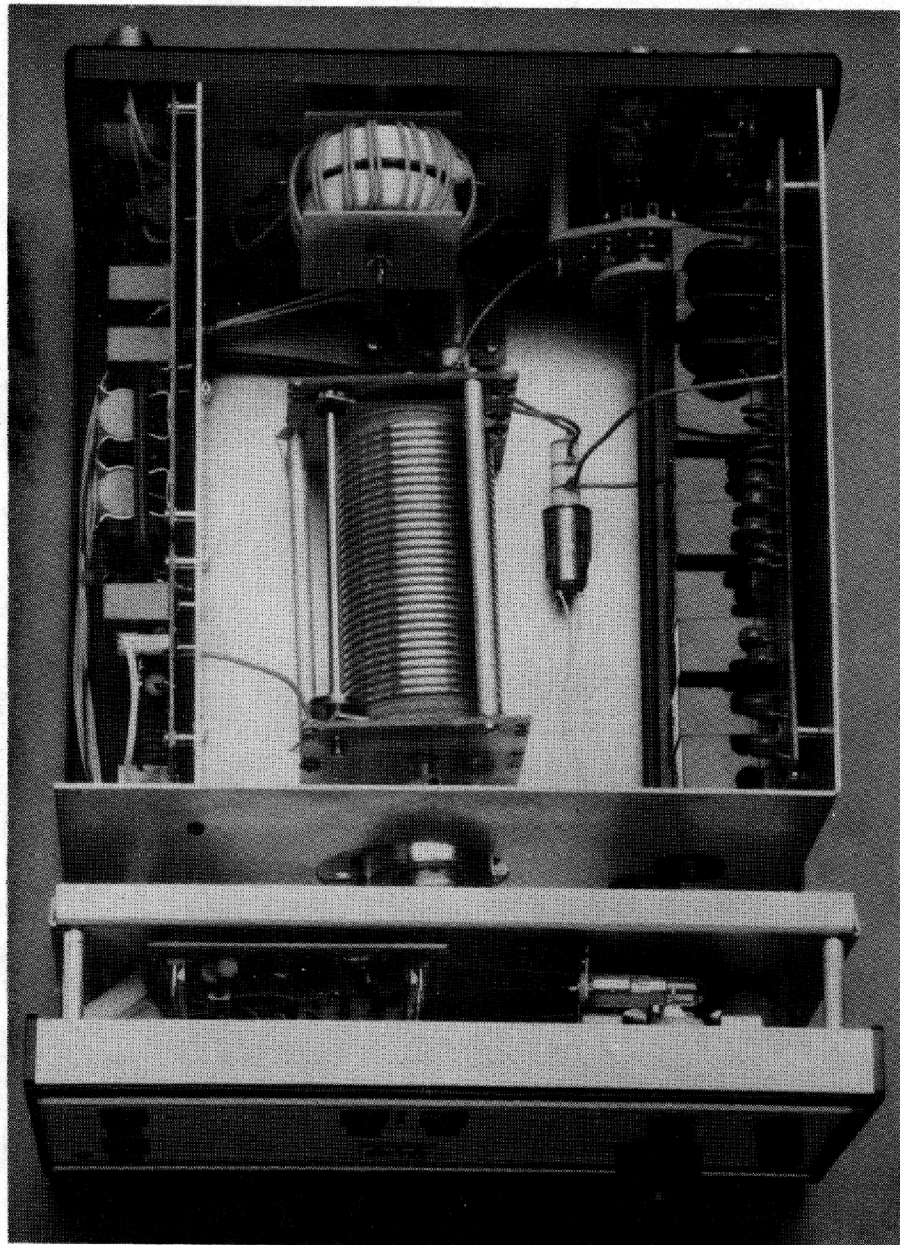


FIGURE 2-3. MODEL 253 INSIDE VIEW

SPECIAL NOTE: NEVER install station coaxial accessories, such as a Low Pass Filter, between the Model 253 and your antenna. The power ratings on the accessories will be greatly reduced. Install them between the transmitter output and the INPUT to the Model 253.

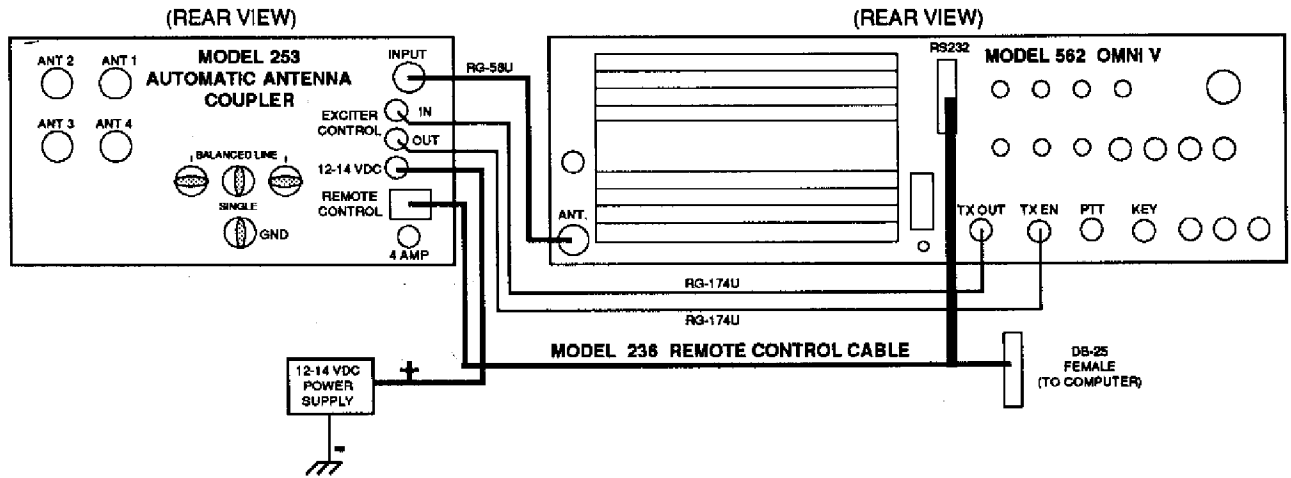


FIGURE 2-4. MODEL 253 WITH TEN-TEC TRANSCEIVER

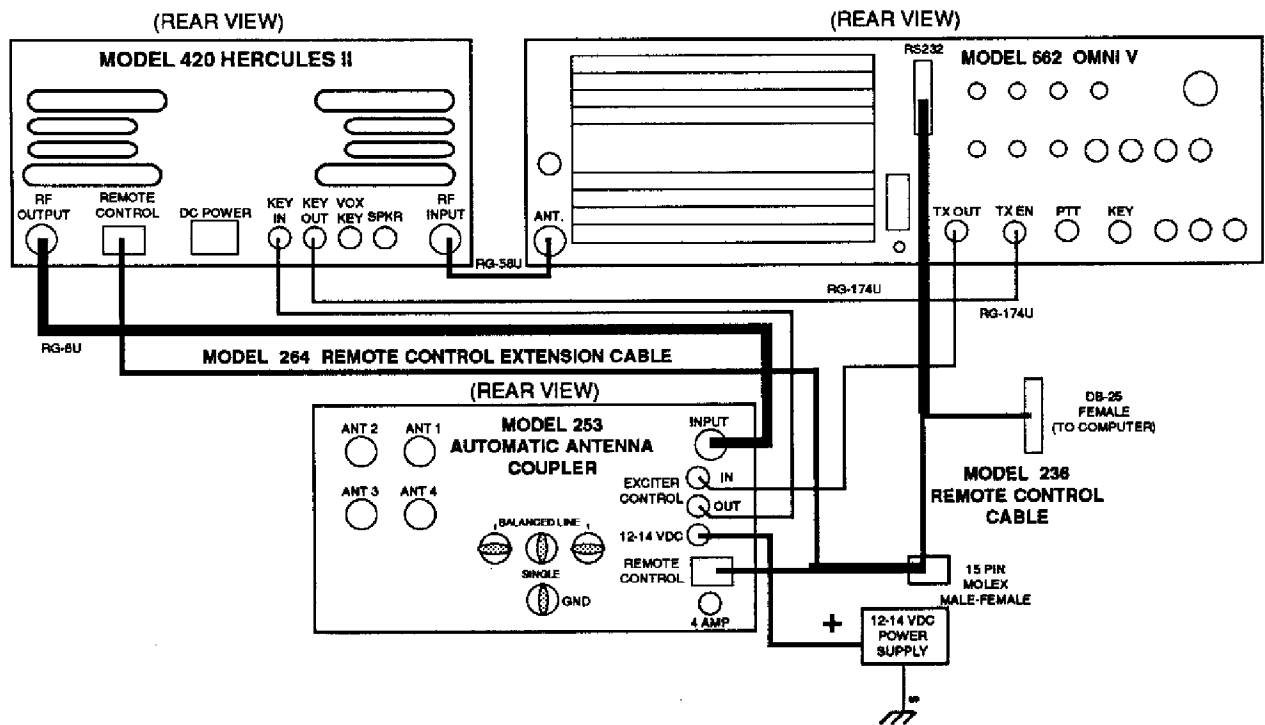
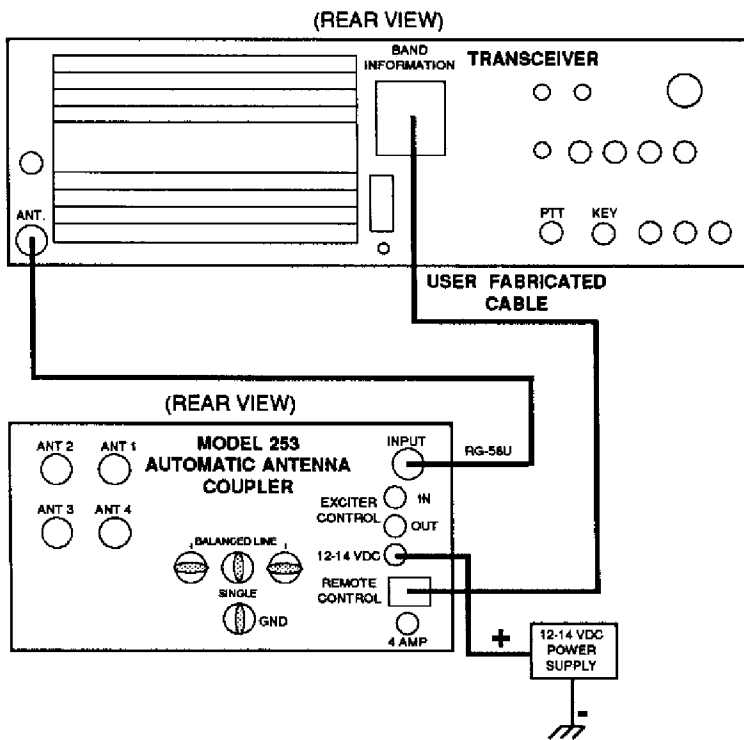


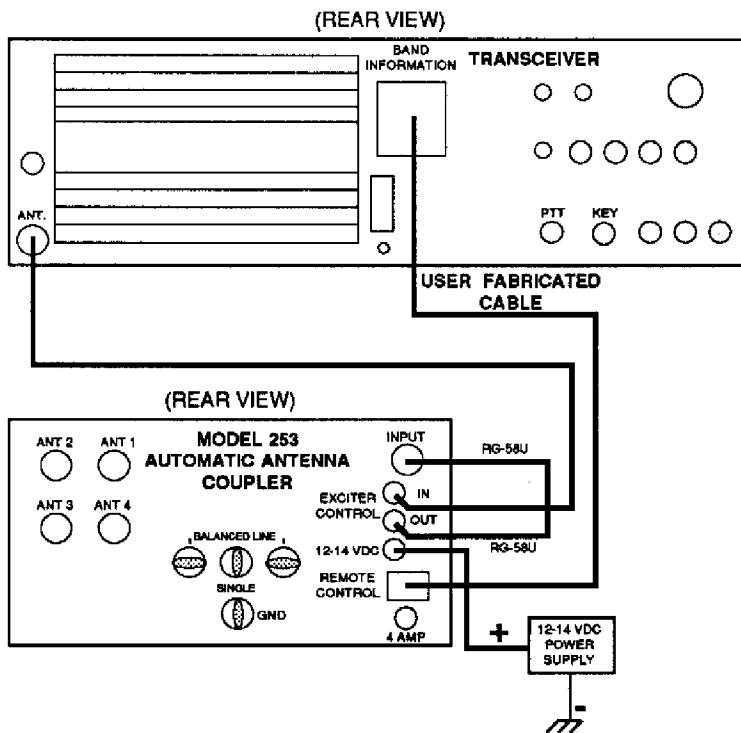
FIGURE 2-5. MODEL 253 WITH TEN-TEC TRANSCEIVER AND MODEL 420 AMPLIFIER



REMOTE CONTROL PINOUTS

PIN NO.	FUNCTION
1	BAND SELECT #1
2	BAND SELECT #6
3	NOT USED
4	BAND SELECT #2
5	BAND SELECT #7
6	NOT USED
7	BAND SELECT #3
8	NOT USED
9	REMOTE READY LED OUTPUT
10	BAND SELECT #4
11	GROUND
12	NOT USED
13	BAND SELECT #5
14	NOT USED
15	REMOTE TUNE SWITCH INPUT

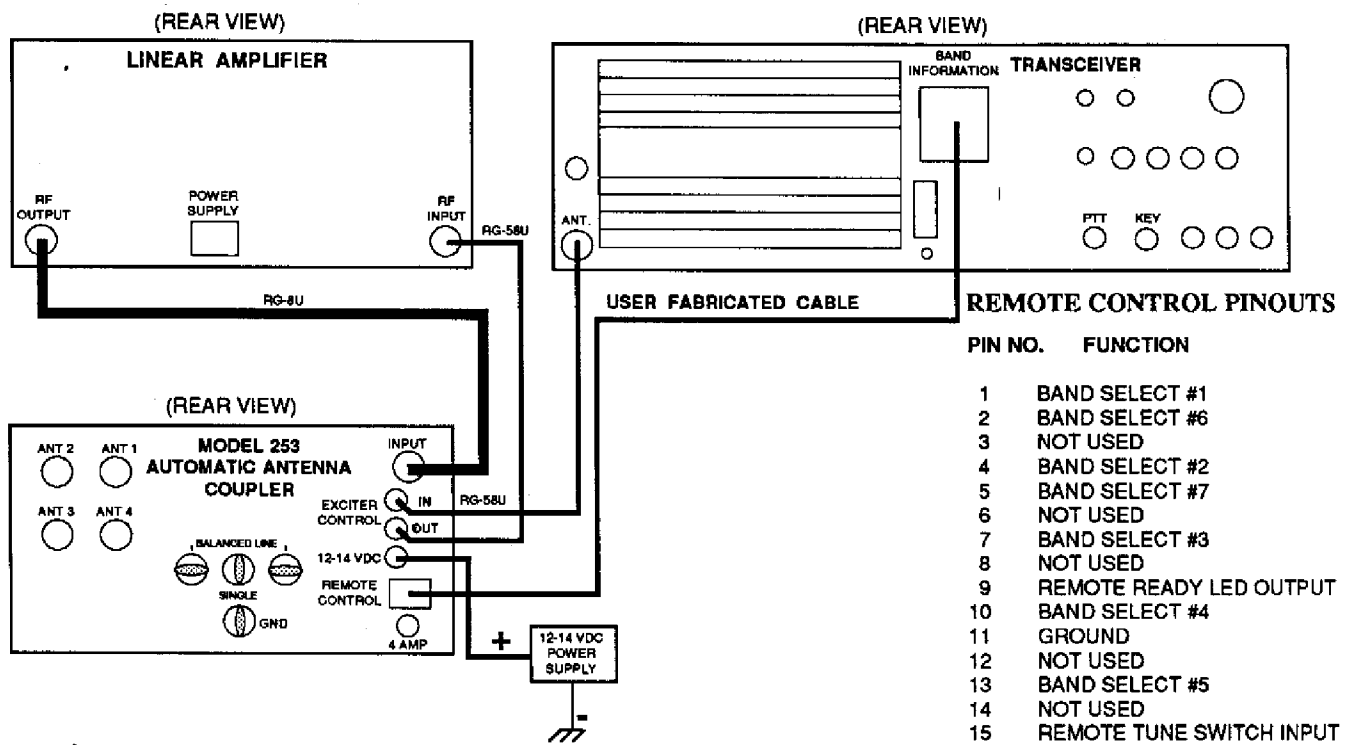
**FIGURE 2-6. MODEL 253 WITH OTHER TRANSCEIVER
(Less Than 150 Watts Output Power)**



REMOTE CONTROL PINOUTS

PIN NO.	FUNCTION
1	BAND SELECT #1
2	BAND SELECT #6
3	NOT USED
4	BAND SELECT #2
5	BAND SELECT #7
6	NOT USED
7	BAND SELECT #3
8	NOT USED
9	REMOTE READY LED OUTPUT
10	BAND SELECT #4
11	GROUND
12	NOT USED
13	BAND SELECT #5
14	NOT USED
15	REMOTE TUNE SWITCH INPUT

**FIGURE 2-7. MODEL 253 WITH OTHER TRANSCEIVER
(More Than 150 Watts Output Power)**



➤ FIGURE 2-8. MODEL 253 WITH OTHER TRANSCEIVER AND AMPLIFIER

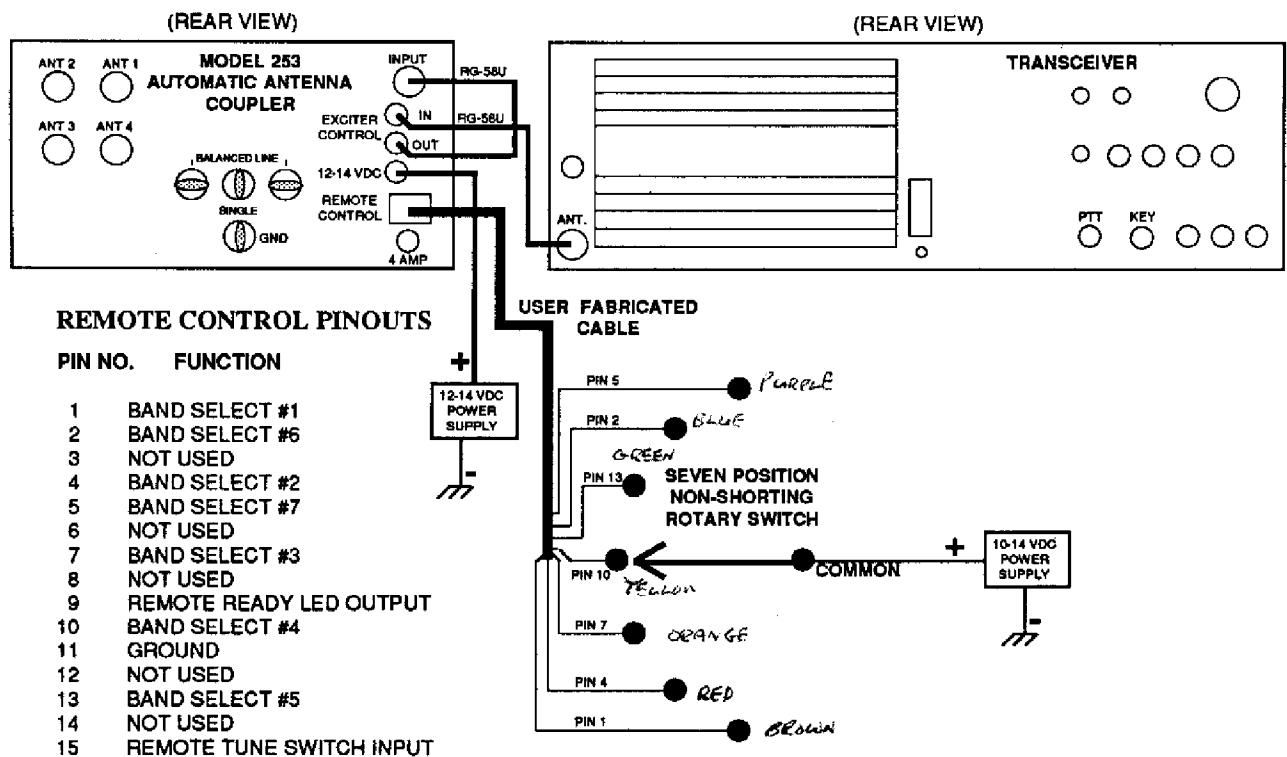


FIGURE 2-9. MODEL 253 WITH REMOTE SELECTOR SWITCH

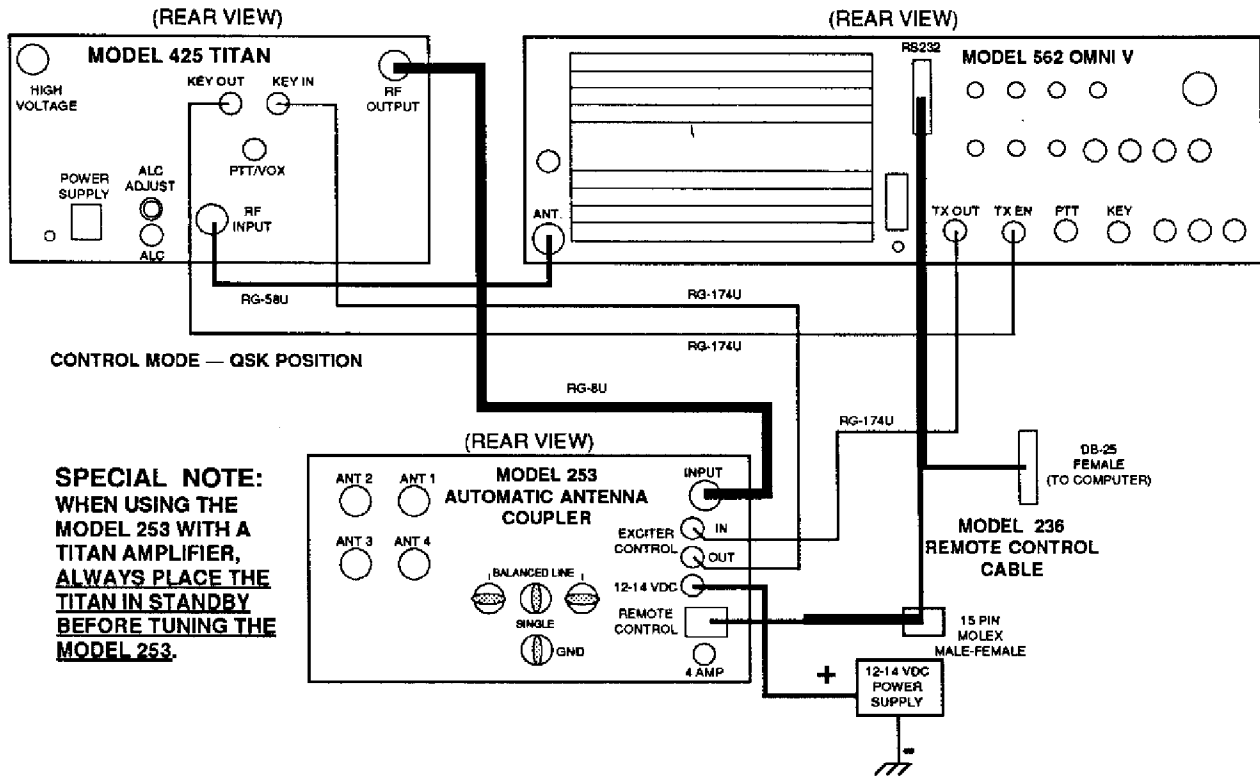


FIGURE 2-10. MODEL 253 WITH TEN-TEC TRANSCEIVER AND MODEL 425 TITAN AMPLIFIER

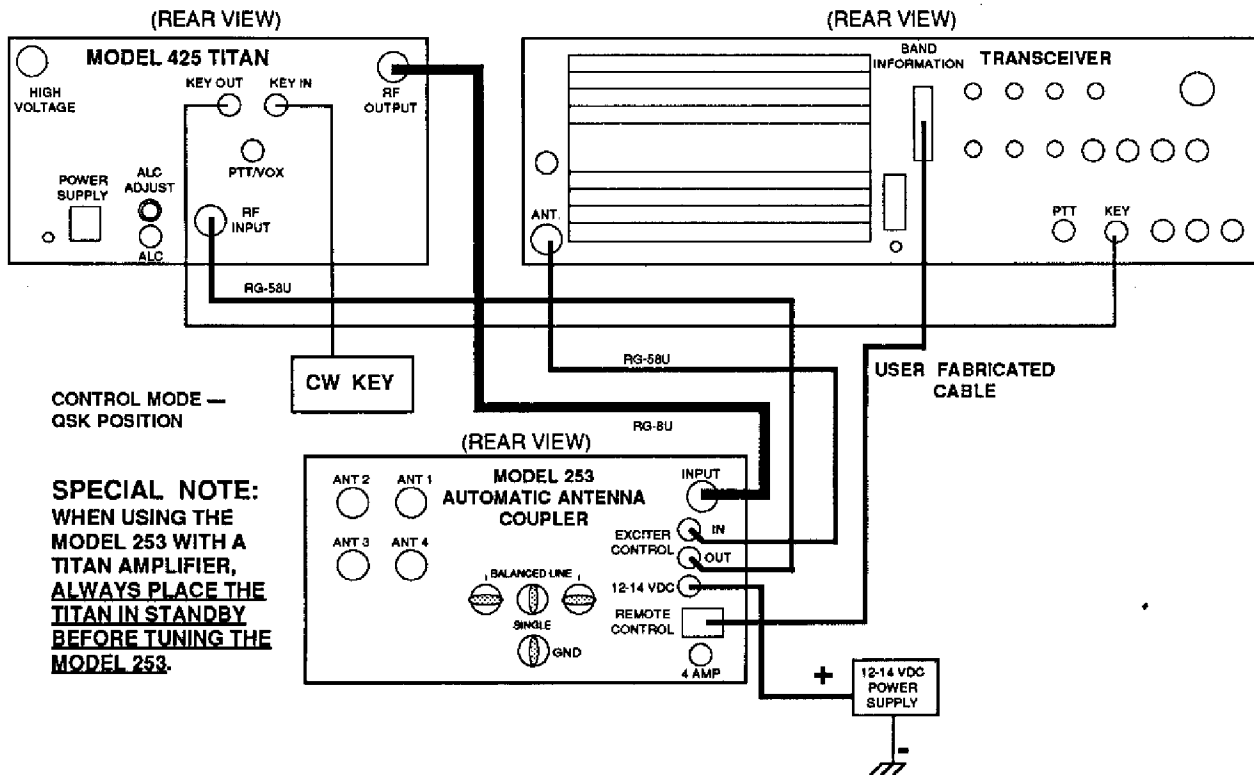


FIGURE 2-11. MODEL 253 WITH OTHER TRANSCEIVER AND MODEL 425 TITAN AMPLIFIER

CHAPTER 3

CALIBRATION AND SERVICE

3-1 INTRODUCTION The following sections contain calibration and service procedures for the Model 253. These are followed by a trouble shooting chart. There are very few adjustments required and usually if a component fails or is damaged you should return the Model 253 to the factory for service. We suggest that you contact our customer service department prior to returning the unit. Also, be sure to include a note listing all problems encountered and any information that might prove helpful in servicing the unit.

3-1.1 SWR BRIDGE The SWR bridge is permanently calibrated at the factory and should not be modified.

3-1.2 WATTMETER CALIBRATION
To calibrate the built-in wattmeter proceed as follows:

1. Remove top cover from Model 253.
2. Connect a 50 ohm dummy load to any coaxial antenna jack.
3. Turn the ANTENNA switch to the same antenna position and place the OPERATE/BYPASS switch in the BYPASS position.
4. Connect the transmitter through a calibrated wattmeter to the INPUT.

5. Set the METER switch to the 200 W position.
6. Apply 50 to 100 watts from the transmitter and adjust R2 (on the 81487 METER SWITCH board) to agree with an external wattmeter of known accuracy.
7. Set the METER switch to the 2 kW range.
8. Apply 500 to 1000 watts from the transmitter and adjust R1 (on the 81487 METER SWITCH board) to agree with the external wattmeter.
9. Turn off transmitter and install top cover.

3-1.3 PILOT LAMP REPLACEMENT
The meter lamp is a 6.3 volt, bayonet type, No. 47. Access to this bulb is obtained by removing the top cover of the unit.

3-1.4 TROUBLE SHOOTING If you find that the Model 253 is not performing as expected, refer to the symptoms in TABLE 3-1 to help isolate the possible problem. Since the Model 253 contains **dangerously high rf voltages** when in operation, all but the simplest of problems should be referred to the factory for resolution.

SYMPTOM	POSSIBLE CAUSE
Model 253 dead, no meter illumination, no annunciators, manual switches don't work.	Check Operate/Bypass switch, should be in Operate position. Check Fuse on rear panel of Model 253. Check power switch on power supply. Check power cable. Check power supply for correct voltage.
FAULT comes on during auto-tune.	Check ANTENNA switch for correct position. Make sure it is not set to an open position. Check SWR with switch S4 in BYPASS position. It should not be greater than 10 to 1. Check antenna and coax for shorted or open connections. If FAULT occurs only at higher frequencies, try changing antenna feedline length.
FAULT and ARCING come on in transmit.	Check ANTENNA switch for correct position. Make sure it is not set to an open position. Check antenna and coax for shorted or open connections. If operation is normal on this antenna on other frequencies, try changing feedline length.
OVER comes on during auto-tune.	Reduce transmitter drive level. Check transmitter output power level. It must be less than 150 watts during tune up.
OVER and FAULT come on during auto-tune.	Reduce transmitter drive level. Check transmitter output power level. It must be less than 150 watts during tune up. Check for possible parasitic oscillation in transmitter.
UNDER comes on during auto-tune.	Increase transmitter drive level. Transmitter output must be at least 30 watts during tune up. Check coax cable between transmitter and INPUT on Model 253 for opens or shorts.
FAULT annunciator on. High SWR indicated on transceiver's meter. Low receive sensitivity.	Clear FAULT annunciator by placing front panel switch in STANDBY position.

TABLE 3-1. TROUBLE SHOOTING CHART

CHAPTER 4

CIRCUIT DESCRIPTIONS AND ILLUSTRATIONS

4-1 INTRODUCTION The following sections contain detailed circuit descriptions for all of the printed circuit board subassemblies used in the Model 253 Automatic Antenna Coupler. Also included are circuit trace drawings and detailed component layout diagrams. These drawings are followed by schematic diagrams for each circuit board subassembly.

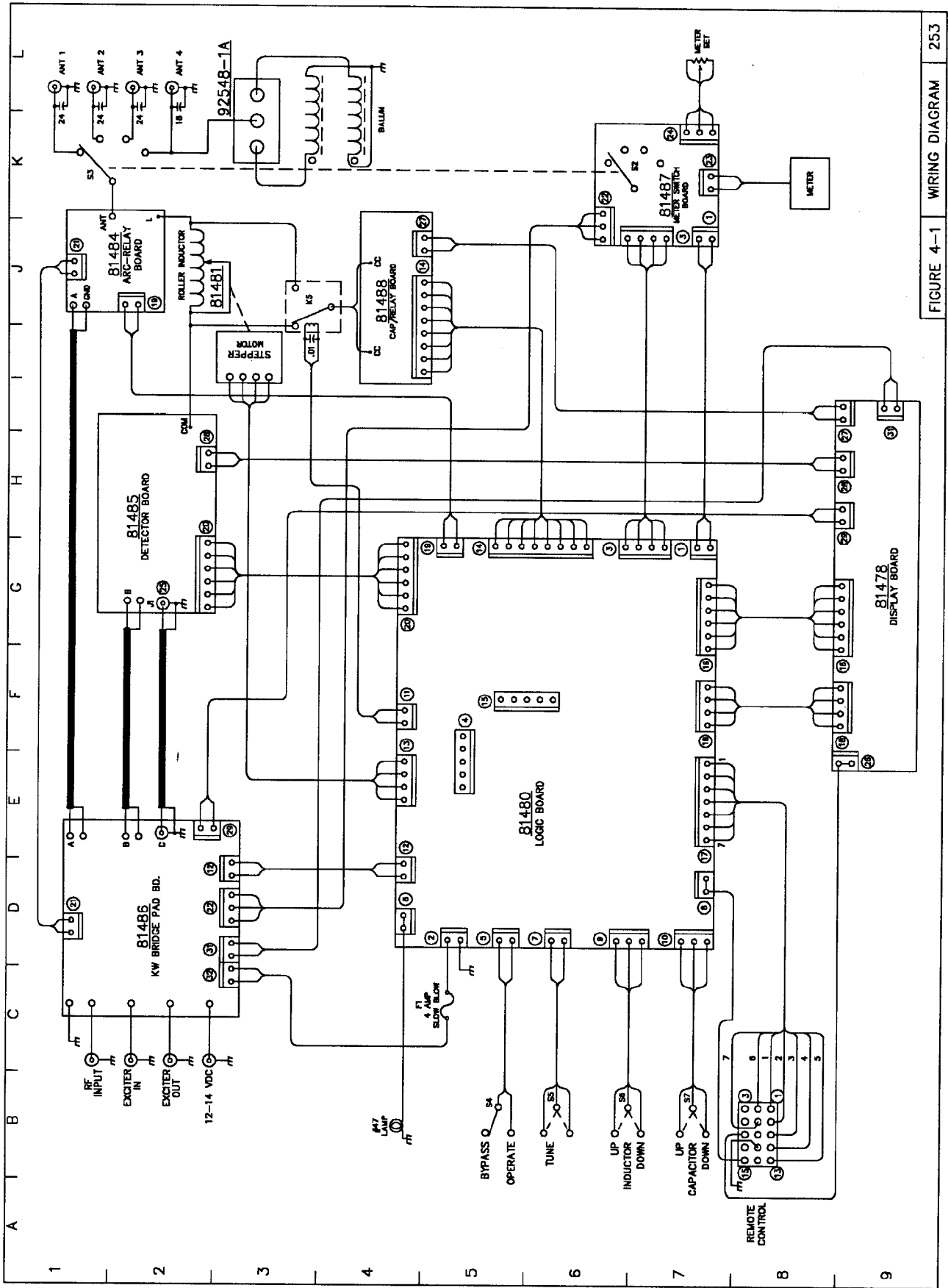


FIGURE 4-1 WIRING DIAGRAM 253

4-2 THEORY OF OPERATION The problem of matching a 50 Ω transmitter to an unknown antenna impedance can be solved by several different circuit configurations. For the Model 253 Automatic Antenna Coupler, a reversible low pass L-network was chosen over a PI or TEE configuration for the following reasons:

1. After tuning, the bandwidth of the match is wider than can be obtained with a single section PI or TEE network and, for a given inductor Q, the loss is lower. This means that after tuning on a given frequency, larger excursions from that frequency can be tolerated without having to retune. Also, lower inductor loss translates to higher coupler efficiency.

2. The L-network offers the lowest component count possible for a general impedance matching network. This is especially important in an automatic coupler since the component values must be variable. Each additional network component requires another motor or relay bank to adjust its value.

3. There are no "internal" nodes or loops in an L-network. This means that the voltages and currents inside the coupler are never higher than the input and output voltages and

currents. Any network with internal nodes or loops can develop voltage or current stresses on internal components that are several orders of magnitude higher than would be expected based on external conditions.

4. For an L-network, there is only one set of component values that provides an impedance match to any given load. Therefore, when a match is found, it is automatically the "best match" (lowest loss and widest bandwidth). PI and TEE networks can produce a match at several different settings, each with a different circuit Q.

5. The lowpass configuration of the L-network provides 2 additional poles of harmonic filtering at the transmitter output. This can help reduce TVI caused by harmonic and high frequency spurious outputs of the transmitter. Many antenna tuners use a highpass circuit configuration. Although a properly operating highpass tuner will not cause TVI, it will not help it either!

6. With only two variable circuit elements (and a reversing switch) the automatic tuning procedure or "algorithm" is much simplified.

To get an idea of how the tuning algorithm in the Model 253 works, refer to FIGURE 4-2.

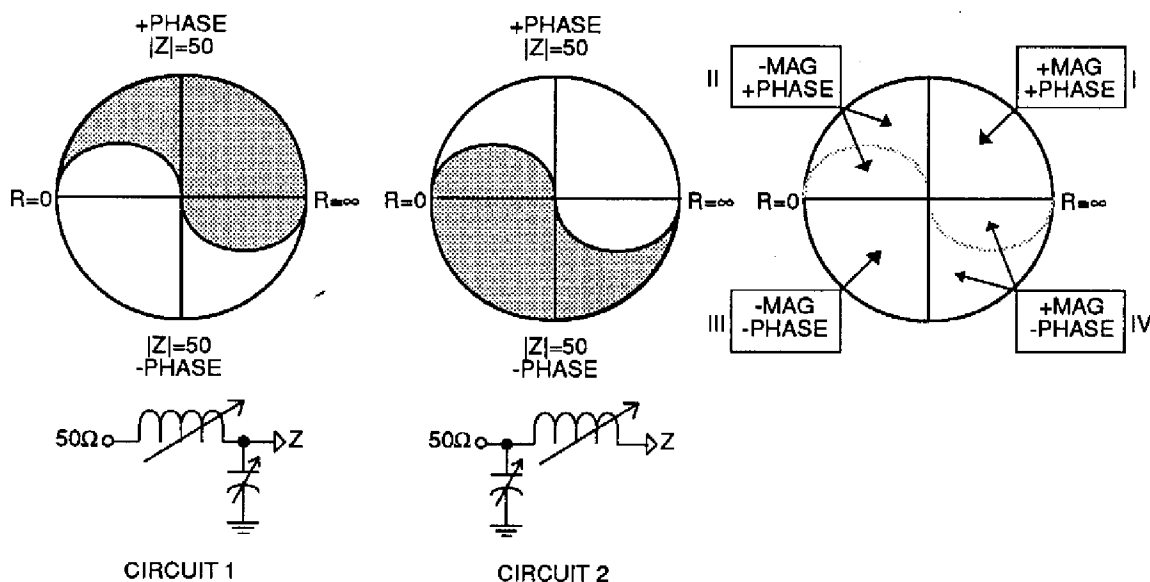


FIGURE 4-2. TUNING ALGORITHM SMITH CHARTS

The diagrams in FIGURE 4-2 represent "smith" charts in which all possible load impedances Z are mapped inside the circle bounded on the horizontal axis by $R=0$ and $R=\infty$. All points above the horizontal axis represent impedances with positive phase angles and all points below the horizontal axis represent impedances with negative phase angles. Points on the horizontal axis have a phase angle of zero and are therefore purely resistive. The vertical axis represents all impedances with magnitudes of 50 ohms. Impedances to the left of the vertical axis have magnitudes less than 50 ohms while those to the right have magnitudes greater than 50 ohms.

The purpose of a matching network is to "transform" a load impedance located anywhere inside the smith circle to the point in the exact center where the axes cross, that is to say, to 50 ohms magnitude and zero phase angle. The L-network can accomplish this transformation for exactly half of the area inside the smith circle — and the "reverse L-network" can transform the other half of the area. The schematic diagrams of FIGURE 4-2 illustrate the lowpass L-network that transforms the shaded area of the smith chart directly above it.

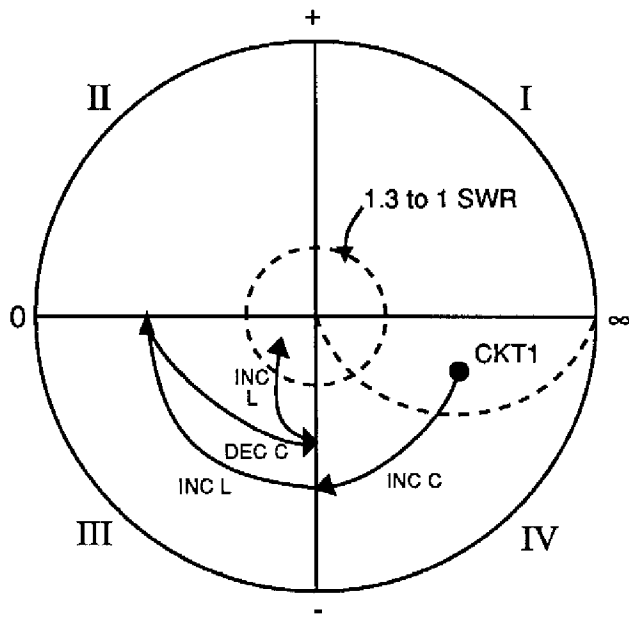
The smith chart on the right in FIGURE 4-2 illustrates the action of the phase and magnitude detectors in the Model 253. The detector outputs are "binary", that is, magnitude is detected as either greater than 50 ohms (+) or less than 50 ohms (-) indicated by the output of a comparator circuit. Likewise, phase is detected with one bit of resolution — it is either positive or negative. Therefore, the phase and magnitude detectors keep track of what quadrant the transformed impedance is in as the network component values are varied.

The problem for the tuning algorithm, then, is: "based on the present quadrant location of the transformed load impedance, adjust the values of the L-network components to move the transformed load impedance closer

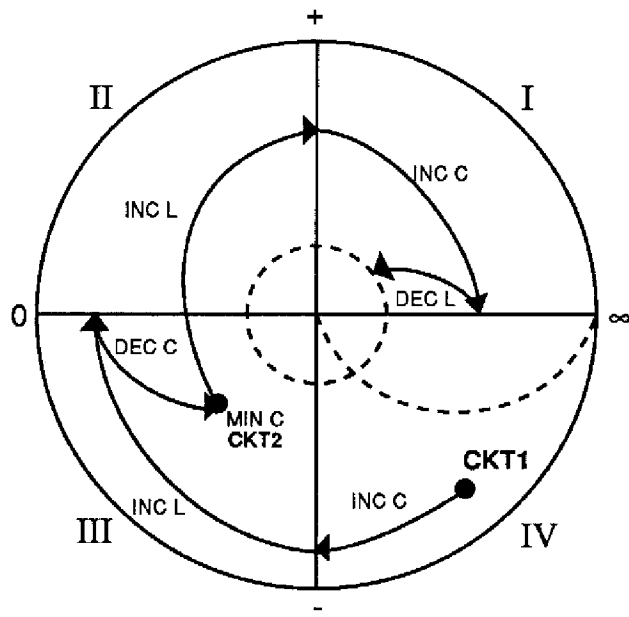
to the center of the smith circle." Also, since the proper configuration is not entirely determined by quadrant boundaries (notice the dashed line in the right hand smith chart dividing quadrants II and IV into circuit 1 and circuit 2 areas), the algorithm must determine somewhere along the way "which network configuration to use."

The entire tuning algorithm of the Model 253 is too complicated to discuss here, but a simplified version which neglects stray reactances and various timing and control functions is flow charted in FIGURE 4-4. This is the basic routine that the microprocessor in the Model 253 follows until the SWR at the L-network input is reduced below 1.3 to 1.

FIGURE 4-3 shows two examples of the kind of "path" that the input impedance takes on its way to a match. Notice that the decisions made at the quadrant boundaries are controlled by the algorithm of FIGURE 4-4. The decision to change from an initial Circuit 1 configuration to Circuit 2 is made upon reaching a minimum C condition in the lower diagram. With each loop through the algorithm, the input impedance gets closer to the center (50 ohm zero phase) point. The tuning is completed when the transformed impedance falls inside the SWR=1.3 circle.



Tuning an impedance
from the CIRCUIT 1
area of Quadrant IV



Tuning an impedance
from the CIRCUIT 2
area of Quadrant IV

FIGURE 4-3. TYPICAL TUNING PATHS

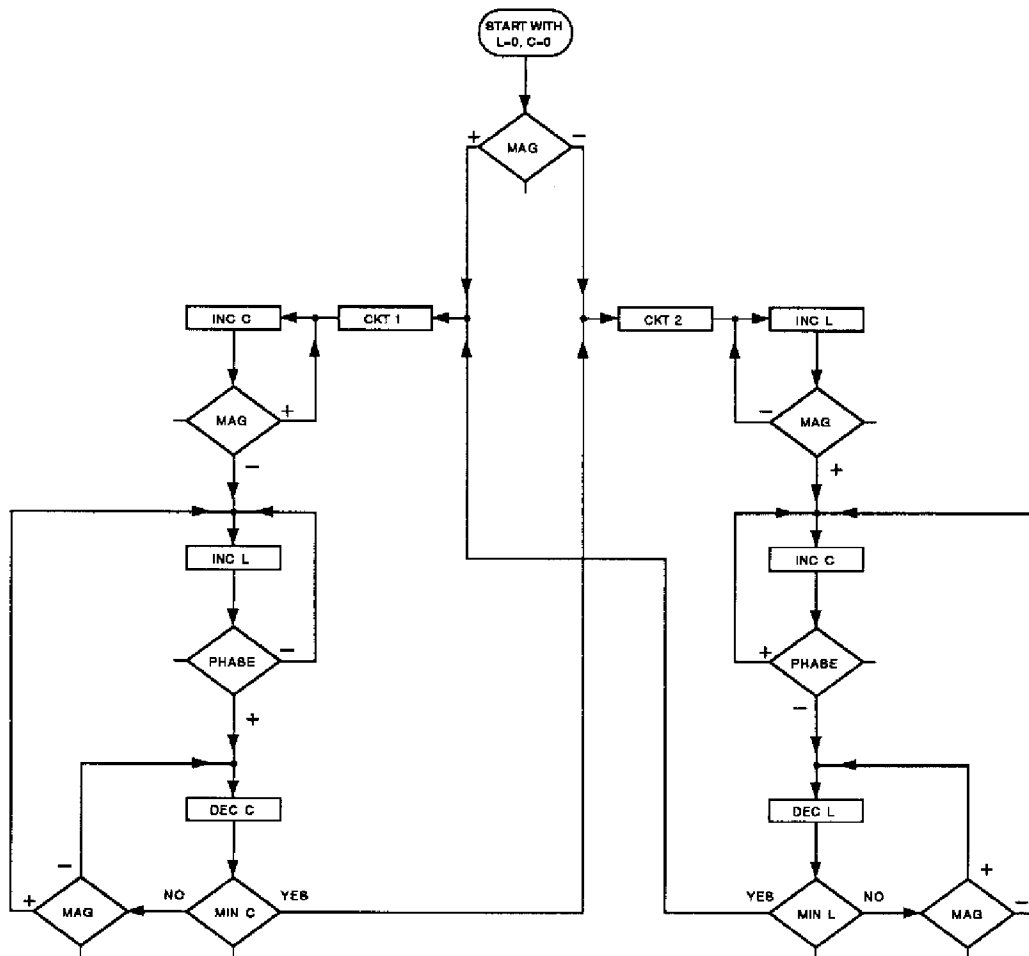


FIGURE 4-4. TUNING ALGORITHM FLOW CHART

4-3 KW BRIDGE PAD BOARD (81486)

The KW Bridge Pad board is located between the RF Input connector and the Detector board. It contains the high power SWR bridge, input and detector bypass relays, and tuning attenuator pad.

The SWR bridge is a standard reflectometer circuit with the addition of two low-Q tuned circuits to flatten the frequency response. This bridge is in the circuit at all times. It indicates the SWR reflected to the transmitter during all modes of operation.

During tuning, detector bypass relay K3 connects resistive pad R5-R6 in front of the detector board at connector C to reduce the SWR presented to the transmitter. After tuning is completed, K3 connects the input power directly to the tuning network through connection B and the N.C. contact of relay K4 on the 81485 Detector board.

In Bypass (or power off) mode, input bypass relay K1 connects the input power directly to the antenna switch through connector A and the vacuum relay, K2, located on the 81484 Arc-Relay board.

This board also contains the EXCITER CONTROL relay K6. Exciter rf (or the exciter's TX OUT signal) is connected to the EXCITER IN connector and is routed via the normally closed contacts of K6 to the EXCITER OUT connector, and then on to the input of an external linear amplifier (or to the exciter's TX EN connector). Whenever the FAULT annunciator is turned on, a signal supplied via connector 31 energizes K6, breaking this control loop. After a short delay of about 100 mS, relays K1, K2, K3, and K4 are all placed in their bypass positions. The activation of K6 thus prevents hot switching of the other relay contacts in the event of a FAULT condition.

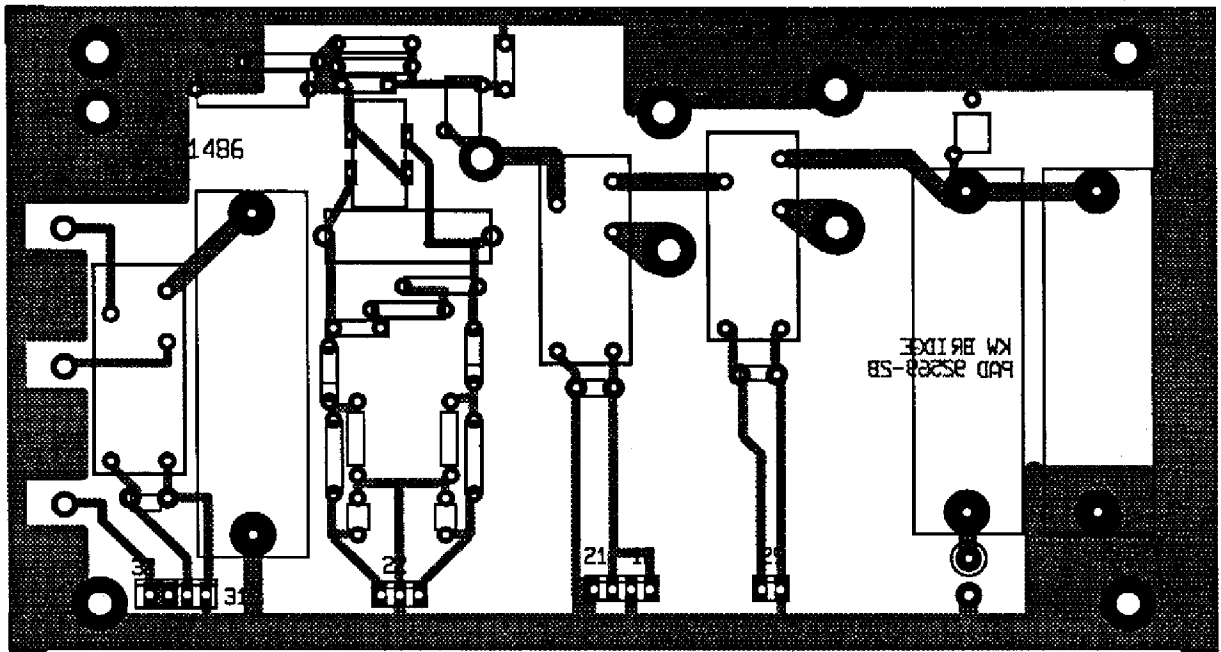


FIGURE 4-5. 81486 KW BRIDGE PAD BOARD CIRCUIT TRACE

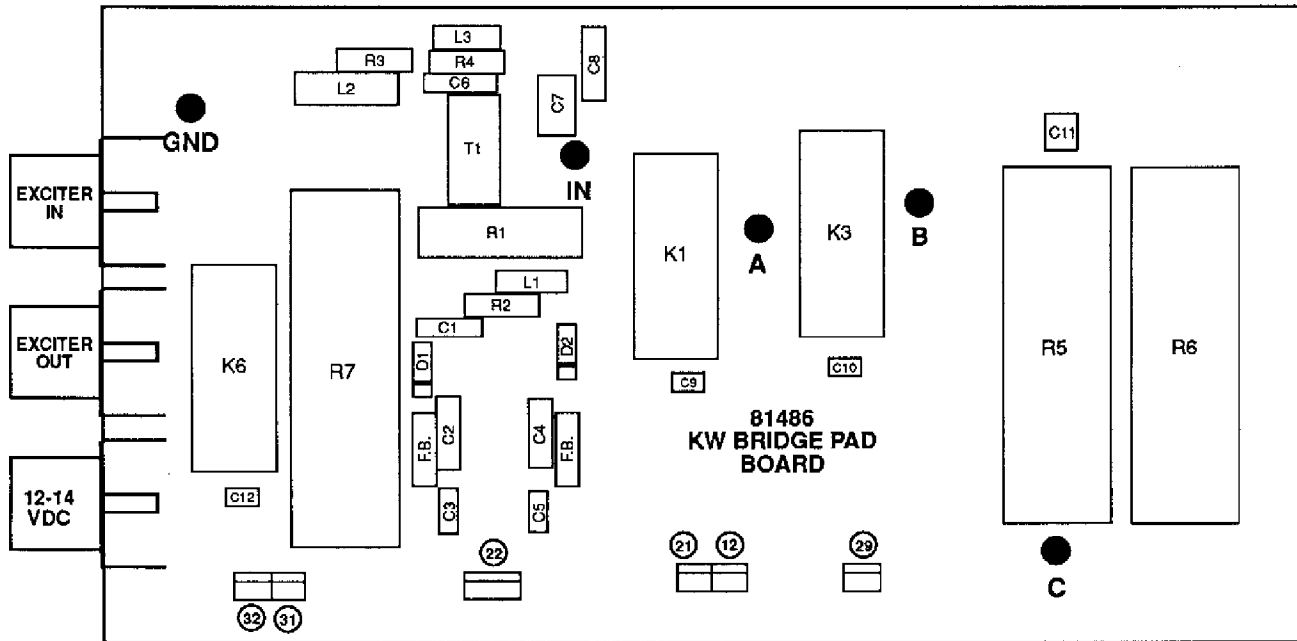


FIGURE 4-6. 81486 KW BRIDGE PAD BOARD COMPONENT LAYOUT

4-4 DETECTOR BOARD (81485) The Detector board, located at the input side of the matching network, provides magnitude, phase and SWR information to the Logic board at connector 20. Three detector circuits on this board resolve the tuning network input impedance into four components: magnitude, phase, forward power and reflected power.

Magnitude is detected by comparing the input voltage at connector J1 and the load current flowing to the matching network through T2 and K4. A sample of the input voltage from capacitive divider C1-C3 is rectified by D1 and applied to the inverting terminal of a comparator on the Logic board. A sample of the load current, developed by T2-R3, is rectified by D4 and applied to the non-inverting terminal of the same comparator. Trimmer C2 is adjusted for equal d.c. voltages at the comparator inputs when the voltage to current ratio at J1 is 50. The resulting output of the magnitude comparator is low when the impedance magnitude is greater than 50 ohms

and high when the magnitude is less than 50 ohms.

Phase is detected by comparing the magnitudes of the sum and the difference of a quadrature voltage sample (Q) and an in phase current sample (I) [see Vector Diagram below]. When the impedance phase angle is zero, the magnitude of the sum $|Q + I|$ is equal to the magnitude of the difference $|Q - I|$. The quadrature voltage sample is developed by phase shift network C4-R1 and applied to the center tap of current sample transformer T1. The sum voltage is rectified by D3 and applied to the inverting terminal of a comparator on the Logic board. The difference voltage is rectified by D2 and applied to the non-inverting terminal of the same comparator. The d.c. voltages on the comparator inputs will be equal when the impedance phase angle is zero. The comparator output is high for negative phase angles and low for positive phase angles.

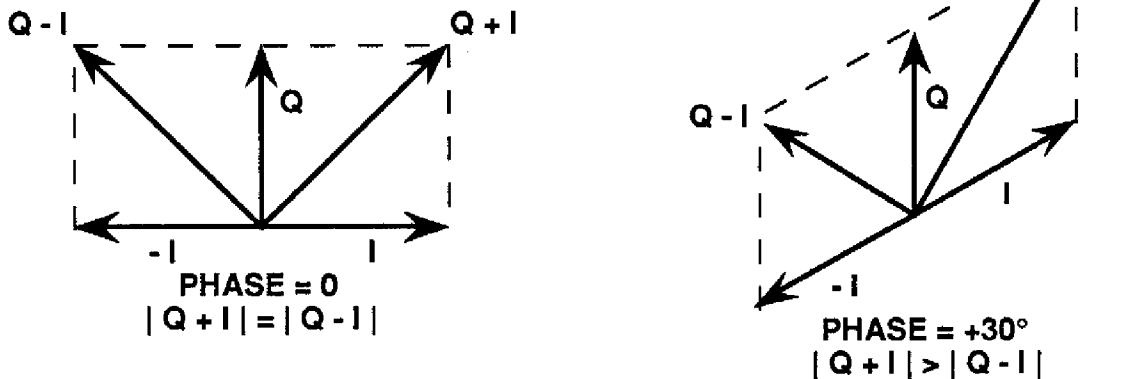


FIGURE 4-8. PHASE DETECTOR VECTOR DIAGRAMS

Forward and reflected power are detected by a directional coupler composed of T3, T4, R4 and R5. The forward power sample from D6 is applied to the inverting terminal of a comparator through a voltage divider on the Logic board. The reverse power sample from D5 is applied directly to the non-inverting terminal of the same comparator. The voltage divider ratio is chosen so that at an SWR of 1.3

to 1 the d.c. voltages on the comparator inputs are equal. The comparator output is then high when the SWR is greater than 1.3 to 1 and low when the SWR is less than 1.3 to 1.

After tuning is completed, relay K4 bypasses the rf input power around the detectors via the N.C. relay contacts to connection B on the KW Bridge Pad board.

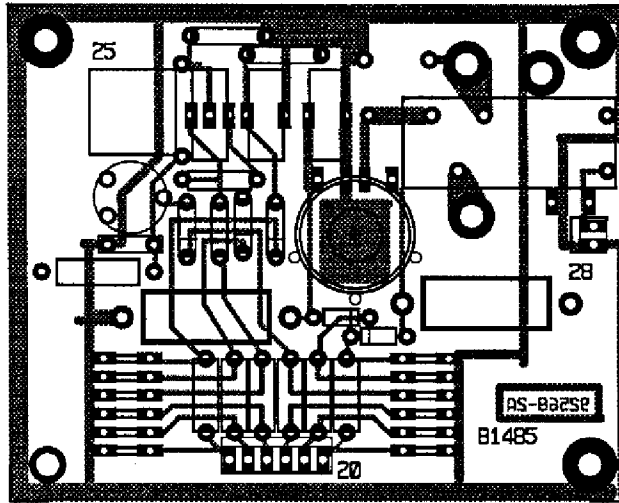


FIGURE 4-9. 81485 DETECTOR BOARD CIRCUIT TRACE

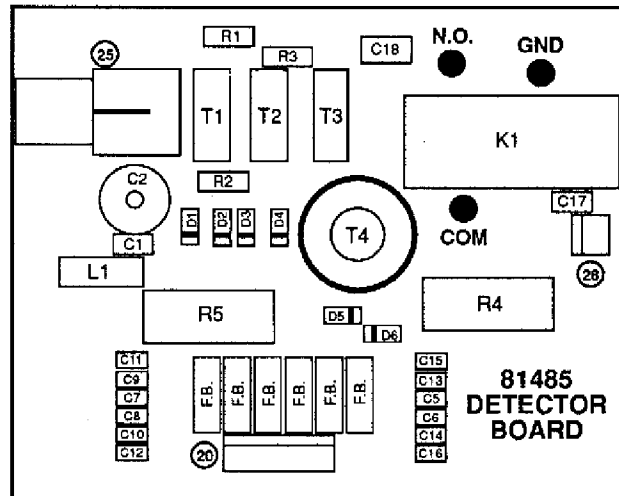


FIGURE 4-10. 81485 DETECTOR BOARD COMPONENT LAYOUT

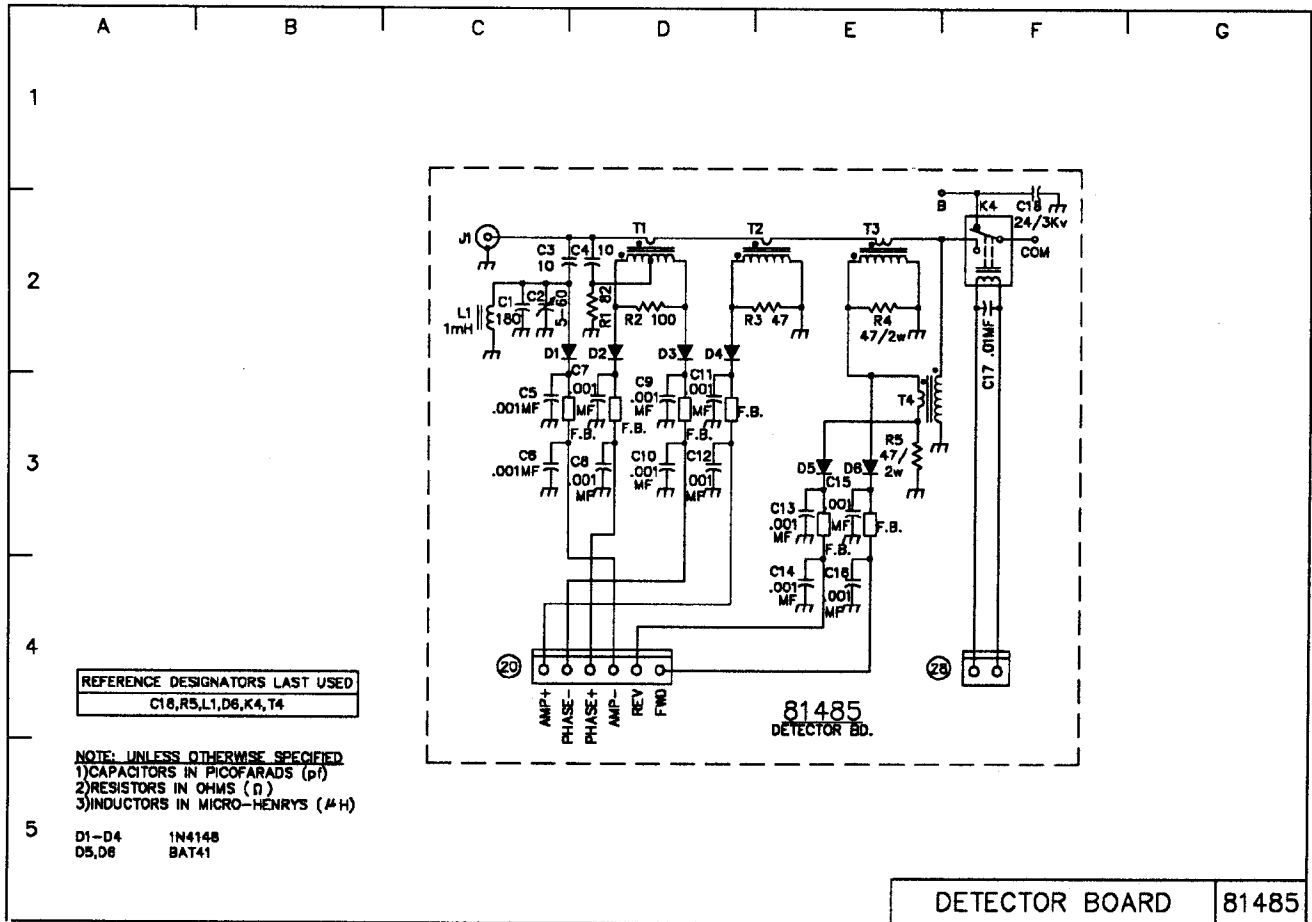


FIGURE 4-11. 81485 DETECTOR BOARD SCHEMATIC

4-5 CAPACITOR-RELAY BOARD

(81488) This board provides for the selection of the appropriate capacitors to be used in tuning the L-network. Relays K1-K10 each select a value of capacitance to be used with the roller inductor to match the antenna system. Selection of the relays is provided via connectors 27 and 14 and determined by the microprocessor on the Logic board. The capacitors are arranged in a binary sequence beginning with C11,C12 [5 pf] and progressing upwards through C43-C50 [2560 pf]. This enables a wide range of values to be generated with the minimum number of components. Connection point CC is routed to the common terminal of external relay K5, which is used to select the configuration of the L-network. Capacitors C1-C10 provide rf bypassing for relays K1-K10.

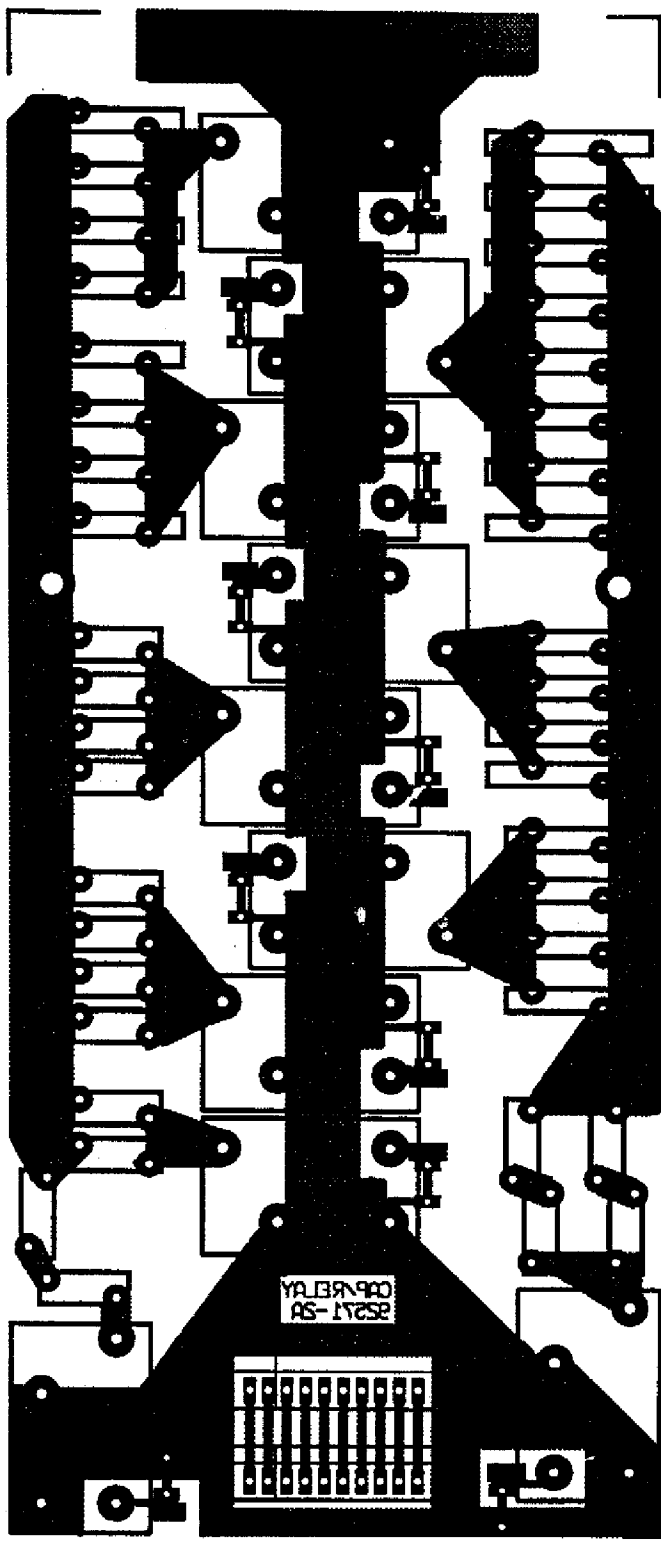


FIGURE 4-12. 81488 CAPACITOR-RELAY BOARD CIRCUIT TRACE

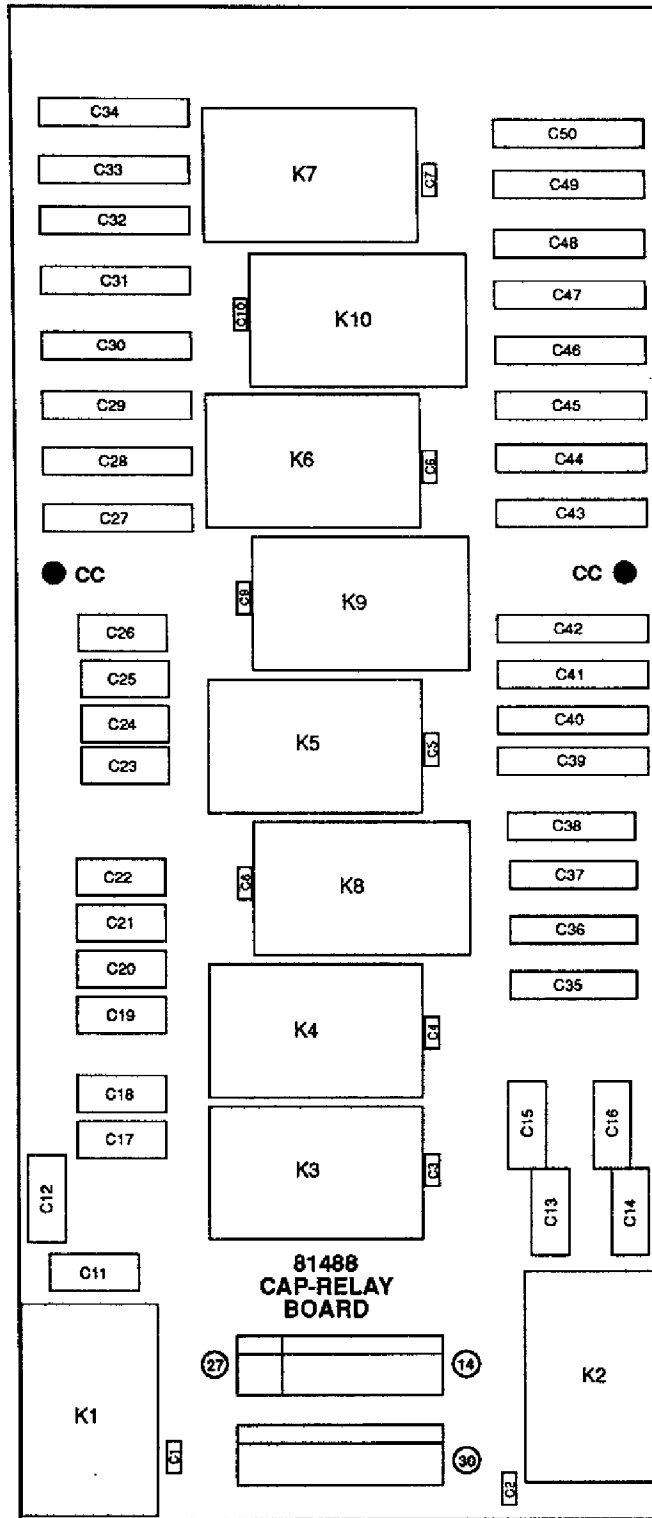


FIGURE 4-13. 81488 CAPACITOR-RELAY BOARD COMPONENT LAYOUT

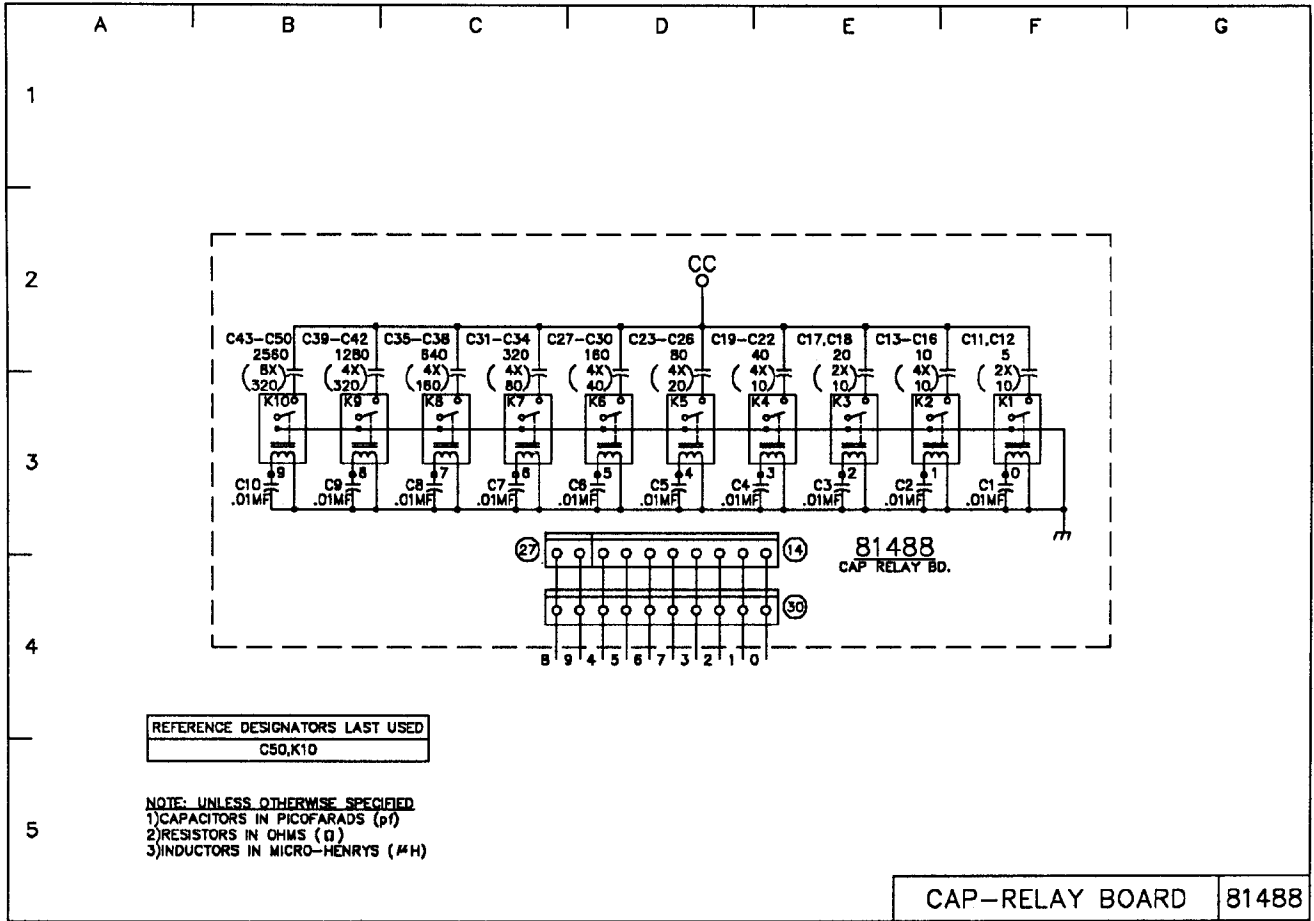


FIGURE 4-14. 81488 CAPACITOR-RELAY BOARD SCHEMATIC

4-6 METER SWITCH BOARD (81487)

The Meter Switch board provides two switches used to select the Meter functions and provide Antenna select information to the Logic board. Switch S1 is a 3-pole 4-position rotary switch. The wiper of S1A is connected to the Meter via connector 23. This switch determines which voltage the Meter is displaying. In the SWR and SET positions, the Meter is connected to the wiper of the METER SET potentiometer. In the SET position, KW FWD from the bridge circuit on the 81486 KW Bridge Pad board is routed via connector 22 and switch S1B to the METER SET potentiometer. When placed in the SWR position, switch S1C routes the KW REV signal from connector 22 to the METER SET potentiometer. In the 2KW position, KW FWD is applied via S1B to the 2KW calibration potentiometer R1, and then via S1A to the Meter. Likewise, in the 200W position KW FWD is applied via S1B to the 200W calibration potentiometer R2 and then on to the Meter via S1A.

Switch S2 is a 11 position rotary switch. The switch positions are set up on 30° indexing but the switch index is modified for 60° selections. Thus, the switch stops only in the 60° detented positions but passes through each 30° position in sequence. The purpose of this is to generate a negative going pulse each time the Antenna switch is rotated to a new position. This occurs as the wiper of S2 momentarily connects to the intermediate non-detented switch positions. This negative pulse is applied via connector 3 to the INT pin of the microprocessor on the Logic board, and is used to tell the microprocessor that a new antenna selection has been made. The antenna selection is decoded by D1 and D2 and routed via connector 3 to the Logic board.

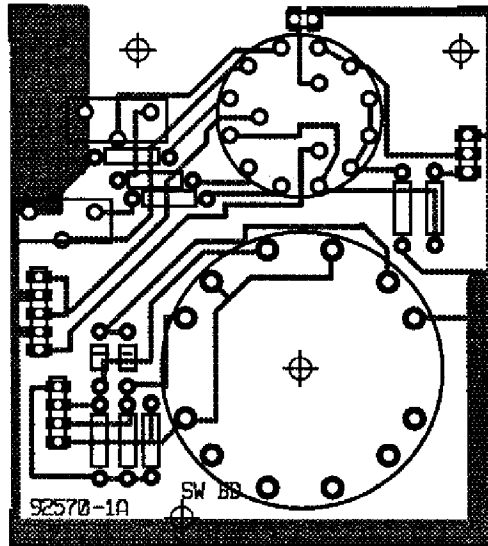


FIGURE 4-15. 81487 METER SWITCH BOARD CIRCUIT TRACE

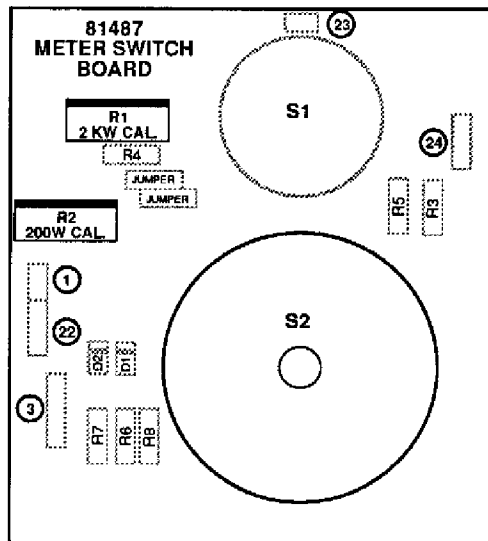


FIGURE 4-16. 81487 METER SWITCH BOARD COMPONENT LAYOUT

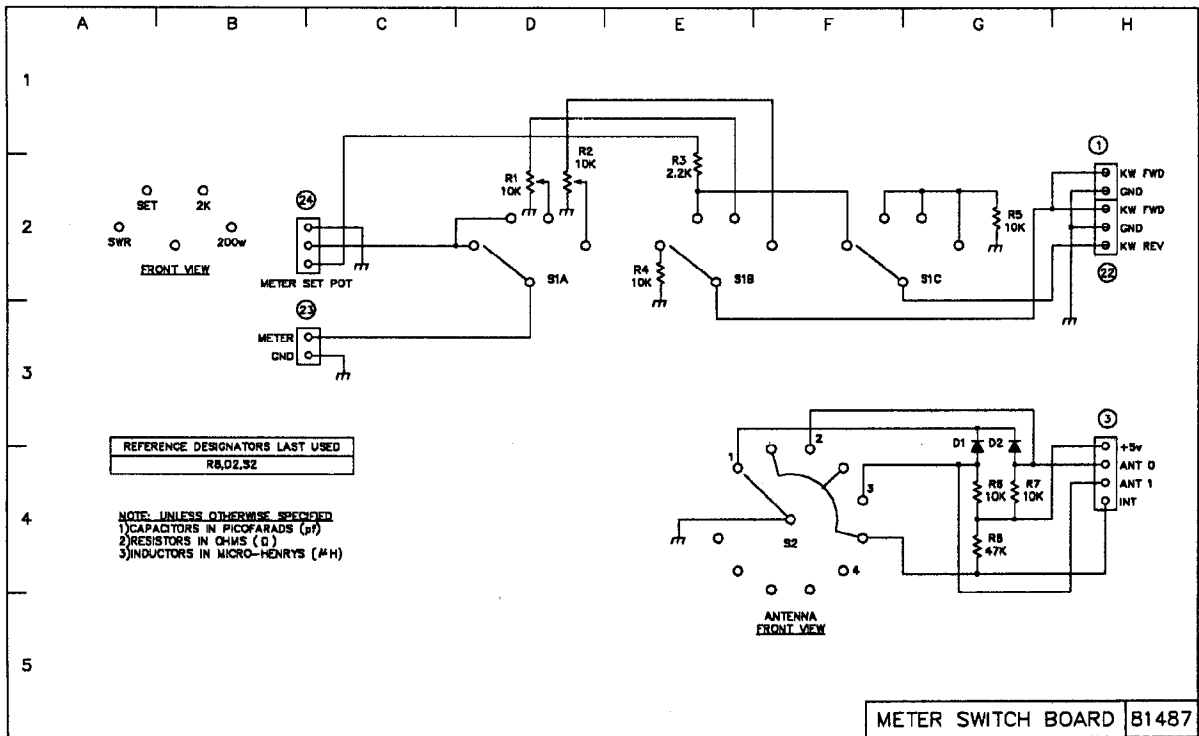


FIGURE 4-17. 81487 METER SWITCH BOARD SCHEMATIC

4-7 LOGIC BOARD (81480) The Logic board controls all functions of the Model 253. The heart of the system is U9, an eight bit CMOS microprocessor. System timing for U9 is provided by crystal X1. On initial power up U9 scans the front panel switches for activity. If there is no activity, it then goes into a power down stop mode. This is done to eliminate the possibility of U9 generating any RFI when it is not needed, such as during receive operations. During the stop mode, if any switch closure occurs a negative pulse will be generated and coupled to the INT pin via C41. This interrupt pulse will wake the microprocessor up and direct it to decode which switch has been pressed. U9 may also be awakened by an interrupt pulse coming from the Antenna switch via connector 3 or from the band line decoding circuit via Q4. The front panel switch signals are applied to PD1-PD5 and internally decoded. PA6 and PA7 receive the coded antenna select information. The band information from the rear panel REMOTE CONTROL connector is routed via connector 17 to PB0 through PB7.

Phase and magnitude information from the 81485 Detector board is routed via connector 20 to comparators U3 and U4. One section of U3 is used to monitor the REV signal from the Detector board and determines when the SWR is below 1.3 to 1. The other section of U3 is used to determine the value of the amplitude signal coming from the Detector board. One section of U4 is used to determine the value of the phase signal coming from the Detector board and the remaining section monitors the arc detector output from the 81484 Arc-Relay board via connector 19. All of the comparator outputs are read by microprocessor U9. Comparator U2 is used to evaluate the forward power signal from the 81486 KW Bridge Pad board. One section of U2 is set to provide an output to U9 when the forward power exceeds 150 watts. The other section tells the microprocessor when the input power level is below 30 watts.

Additionally, there is a stepper motor control circuit consisting of U7 and associated components. The motor control signals are routed via connector 13 to an externally mounted stepper motor. This motor is connected to the shaft of a roller inductor which is one part of the tunable L-network. Control information for U7 is provided by U9.

Also on the Logic board is an 8 bit shift register, U5 and a high current driver, U6. These circuits provide the capacitor select signals which drive the relays located on the 81488 Capacitor-Relay board. Information for U5 is provided serially by U9. Control signals for relays K1, K2, and K5 are generated by U9 and buffered by Q1 and Q2 before being sent out connectors 12 and 11.

U8 is a non-volatile RAM that is used to store the antenna and band preset information. The last settings of the inductor and capacitors used in the matching network are also saved here. This enables the Model 253 to retain all operating information and parameters even with all power removed. Since the memory is non-volatile, no backup battery is required.

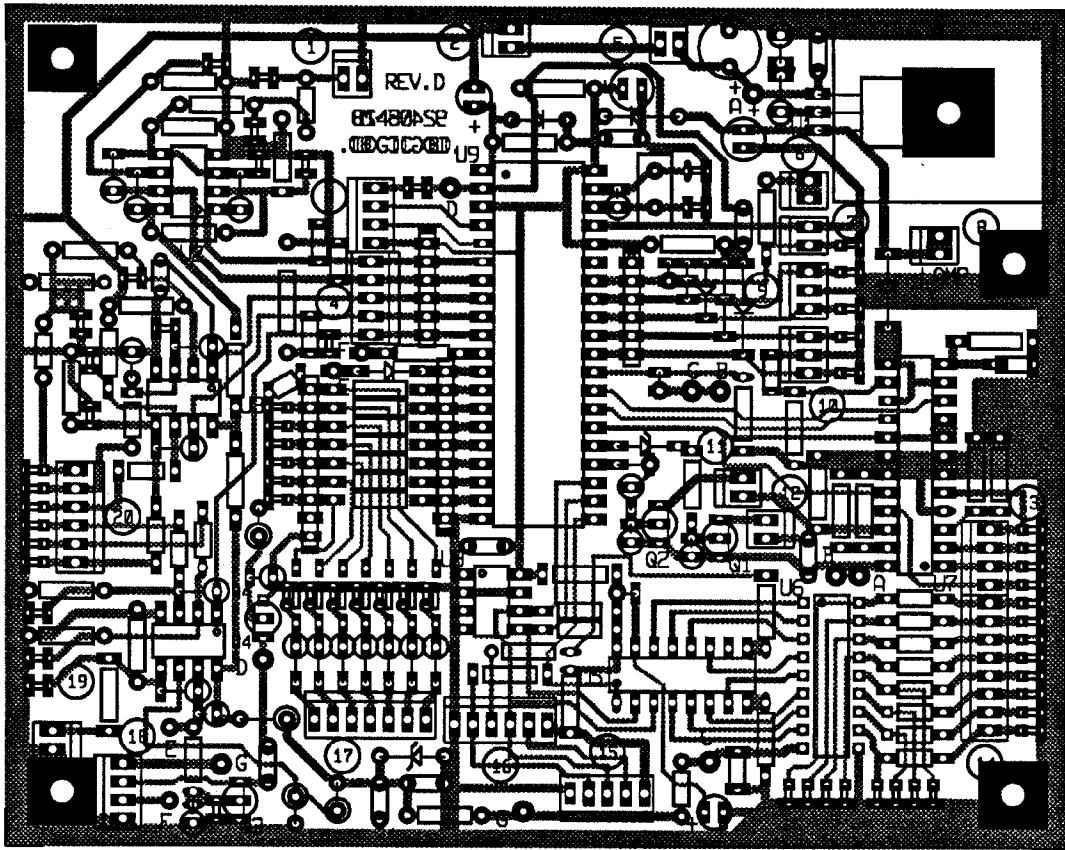


FIGURE 4-18. 81480 LOGIC BOARD CIRCUIT TRACE

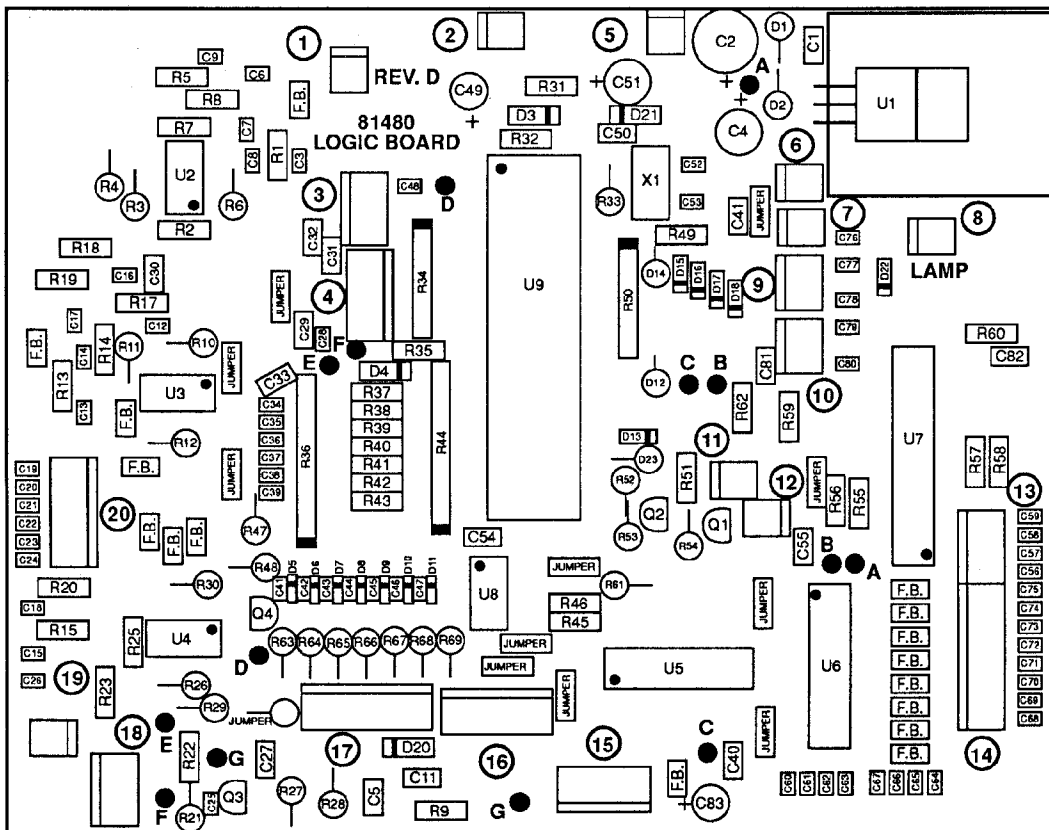


FIGURE 4-19. 81480 LOGIC BOARD COMPONENT LAYOUT

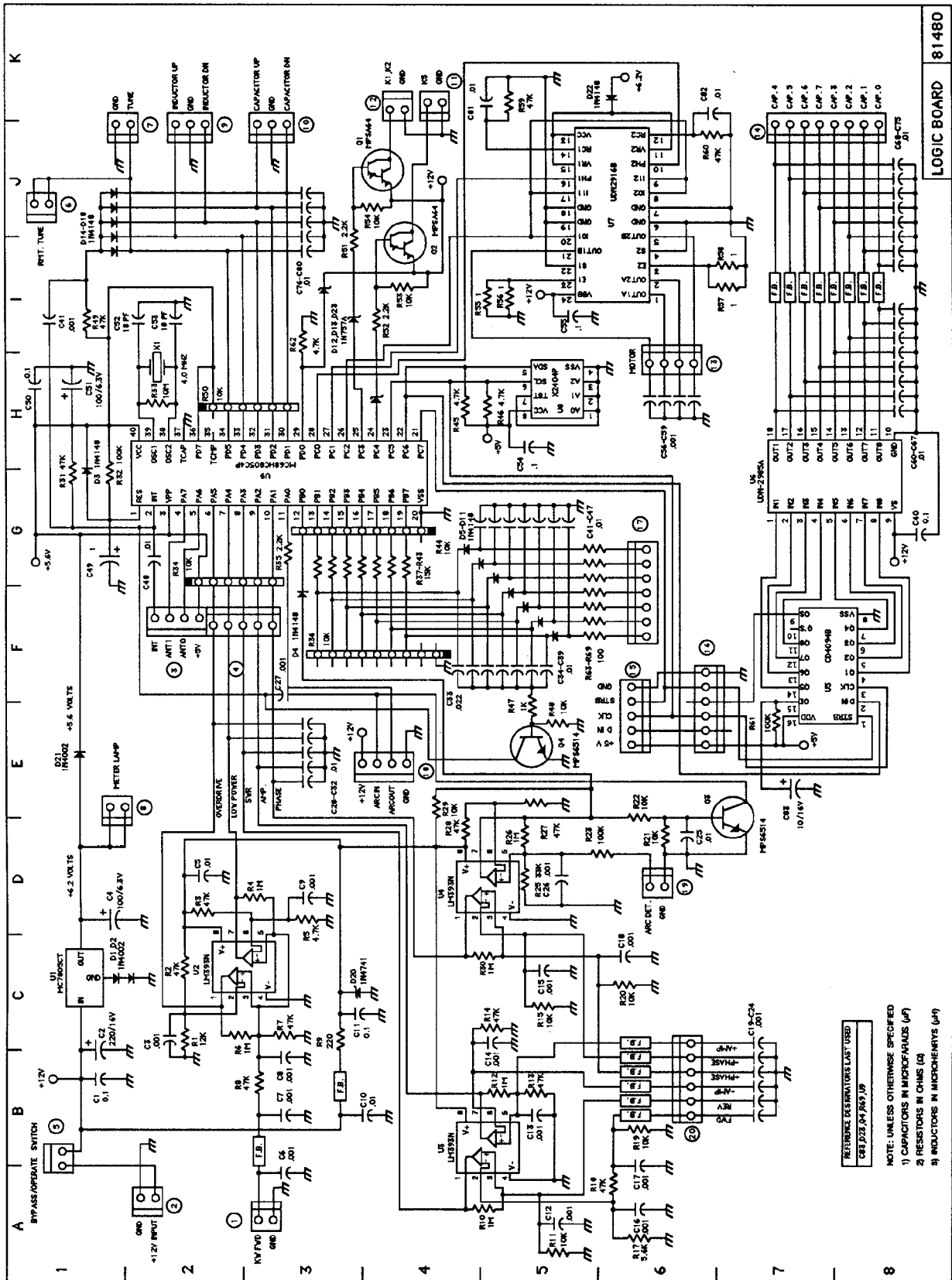


FIGURE 4-20. 81480 LOGIC BOARD SCHEMATIC

4-8 LED DISPLAY BOARD (81478) The Display board contains six LED annunciators, LED1-LED6, used to monitor the Model 253's operation. LED1 (UNDER) provides an indication that the input rf level is below 30 watts. LED4 (OVER) is turned on whenever the input to the Model 253 exceeds 150 watts during tune up or manual tuning operations. LED3 (TUNING) is turned on during the auto-tune routine. At the end of a successful tune up LED2 (READY) will be turned on. LED5 (FAULT) and LED6 (ARCING) alert the operator to possible problems encountered during tune up. Connector 31 routes the FAULT signal to relay K6 located on the 81486 KW Bridge Pad board.

Also located on this board is an 8-bit serial shift register, U1, and an 8 line high current driver, U2. Data for U1 is shifted in serially from the Logic board via connector 16. This information includes the annunciator selection, relay control signals for K3 and K4, and also capacitor select lines #8 and #9 for use on the 81488 Capacitor-Relay board. The eight parallel output lines from U1 are connected to the inputs of U2, which provides increased current drive capability. Transistor Q1 is used in the arc detect output circuit to turn on LED6. Resistor R8 and capacitor C9, connected to U1, keep the output lines of U1 from all going high during initial power up.

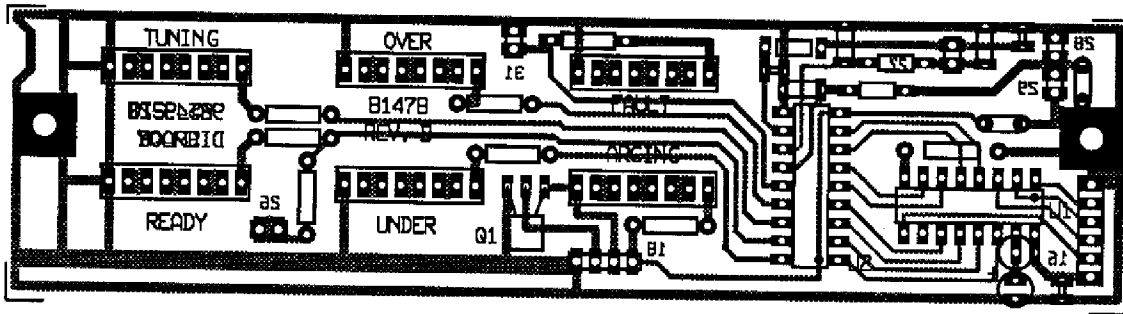


FIGURE 4-21. 81478 LED DISPLAY BOARD CIRCUIT TRACE

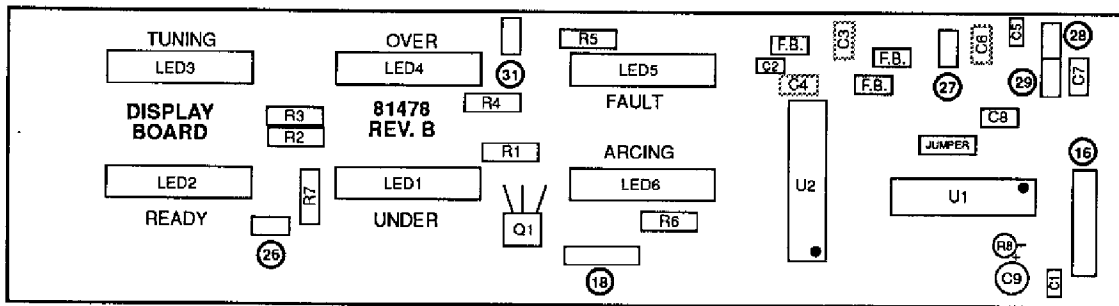


FIGURE 4-22. 81478 LED DISPLAY BOARD COMPONENT LAYOUT

4-9 ARC-RELAY BOARD (81484) This board contains a vacuum relay, K2, which is used to switch the antenna output line. When in the BYPASS mode, rf power applied to the RF INPUT connector on the rear panel will be routed through K1 on the 81486 KW Bridge Pad board and K2 on the Arc-Relay board to the wiper of ANTENNA switch S3, and then on to the selected antenna connector, bypassing the matching network and detector circuits. During tune up, and when used in the OPERATE mode, relay K2 connects the antenna circuit to the output of the matching network. Also on this board is an rf detector consisting of D1, R1, C2, C3, and C4. This circuit monitors the rf voltage present at the antenna output connectors. The dc voltage from the detector is routed to the Logic board via connector 19.

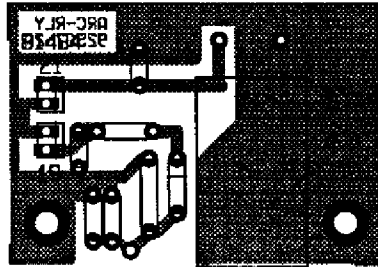


FIGURE 4-24. 81484 ARC-RELAY BOARD CIRCUIT TRACE

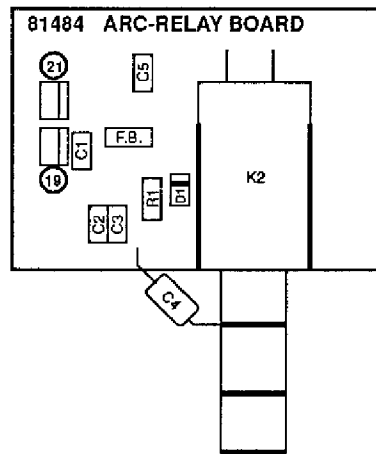


FIGURE 4-25. 81484 ARC-RELAY BOARD COMPONENT LAYOUT

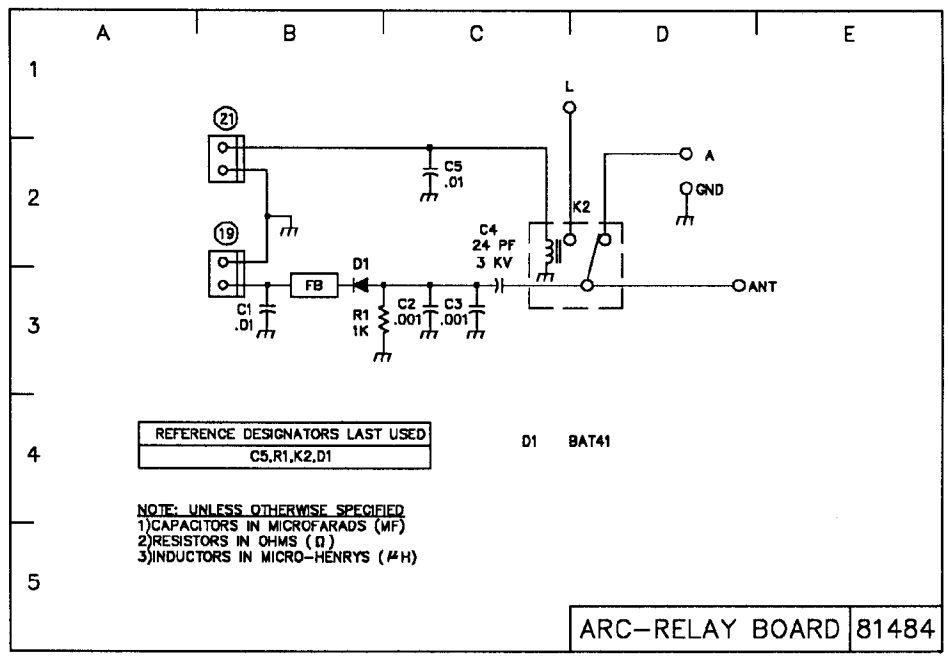


FIGURE 4-26. 81484 ARC-RELAY BOARD SCHEMATIC

TEN-TEC, Inc.
Highway 411 East
Sevierville, TN 37862

CUSTOMER SERVICE TELEPHONE
615-428-0364

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

TEN-TEC, Inc. warrants this product to be free from defects in material and workmanship for a period of one 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 to establish you as the owner of record. This will also insure that any bulletins pertaining to this equipment will be sent to you.
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 that you contact our customer service group direct. The selling dealer is not obligated by us to perform service in or out of warranty. It has been our experience that factory direct service is expeditious and usually results in less down-time on the equipment. Some dealers do offer warranty service and of course, have our complete support.
4. WE ENCOURAGE SELF HELP. Taking the covers off does not void the warranty. In many cases our customer service technicians, with your help, can identify a faulty circuit board. In these cases we will send you a replacement board which you can change out. This will be shipped on a 30 day memo billing and when the defective board is returned, we will issue credit.
5. EQUIPMENT RETURNED TO THE FACTORY must be properly packaged, preferably in the original shipping carton. You pay the freight to us and we prepay surface freight back to you.
6. 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.
7. TEN-TEC RESERVES the right to make design changes without any obligation to modify equipment previously manufactured.
8. THIS WARRANTY is given in lieu of any other warranty, expressed or implied.

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Many of our 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 all freight expense, customs and broker fees will be paid by you.