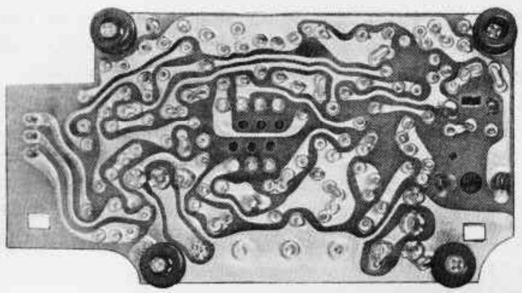
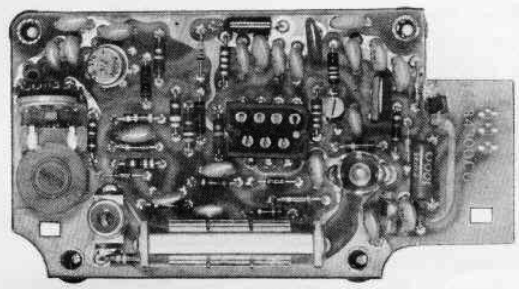
POWER CONTROL BOARD

MODEL TLD5100A



TOP VIEW



BOTTOM VIEW

AEPS-6127-A

1. DESCRIPTION

1.1 The solid-state power control board provides regulation and protection for the driver amplifier and assures a constant RF drive level to the high power P.A. The following functions are provided by the circuitry.

--Power Leveling - The board permits the adjustment of the output of the drive amplifier to the proper level and then maintains that level of output regardless of power or supply voltage fluctuations as long as the gain of the power amplifier is equal to, or above, the preset level.

--VSWR Protection - A voltage standing wave ratio (VSWR) detector operates during transmitting periods to prevent over-dissipation of the amplifier transistors should a fault occur in the high power PA input circuit. The circuitry compares power reflected from the load circuit to forward (output) power. When this ratio exceeds a predetermined amount, the output of the circuit lowers the power output of the amplifier.

--Forward and Reverse Power Metering - Metering points on the board provide a means of monitoring the amount of forward (output) and reflected (reverse) power in the load system.

1.2 The power control board is constructed on a single circuit board which is easily removed and replaced. All external connections are made by two coaxial connectors (input and output for the dual directional coupler) and three pins which plug into the control board. All metering points and the single adjustment point are accessible from the plating side of the board.

2. FUNCTIONAL OPERATION

2.1 Refer to the loop block diagram, Figure 1. The circuitry operates as a control loop which continually monitors the output from the amplifier and controls that output by regulating the gain of the first stage of the power amplifier.

2.2 Refer to the block diagram, Figure 2. The output of the integrated circuit differential amplifier, amplified by the dc amplifier is the controlling input to the amplifier board.

2.3 The output of the differential amplifier is determined by the potentials present on the non-inverting (+) and inverting (-) inputs. These potentials are developed by the power control board circuitry in the following manner.

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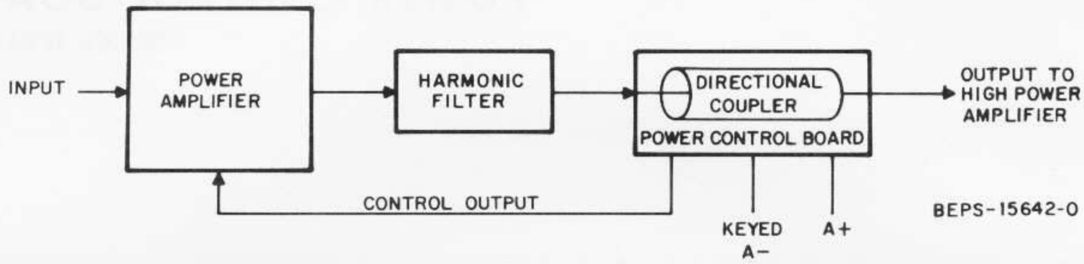


Figure 1.
Loop Block Diagram

2.4 When the impedances of the load circuitry and the power amplifier are matched (a VSWR of 1:1), a bias voltage produced by the dc reference bias circuitry is placed on the inverting input (also called the "reference input") of the differential amplifier (see Figure 5).

2.5 When the exciter/driver is keyed, the forward (output) power from the amplifier is fed through the directional coupler to the load circuit. This flow of power is sampled by the forward power sampling circuitry and places a bias, proportional to the forward power, on the non-inverting input (pin 5) of the differential amplifier. The POWER SET potentiometer is then adjusted, changing the potential on the non-inverting input. As this voltage changes, relative to the reference input voltage, the output of the differential amplifier changes, in turn changing the loop control level and therefore the output power of the amplifier.

2.6 Once the power has been set to the proper level, any change in the output power will be instantly corrected by the circuitry. If the power increases, the increase causes the differential amplifier output voltage to increase, decreasing the output from the dc amplifier which decreases the gain of the power amplifier until the output returns to the preset level. A decrease in amplifier power output causes the reverse action.

2.7 Any power reflected back from the load circuit is detected by the reverse power sampling circuit. Reverse power causes a negative current to flow, which, in turn, decreases the potential on the reference input of the differential amplifier. Therefore, increasing levels of reflected power will cause the amplifier power output to be decreased to a safe level.

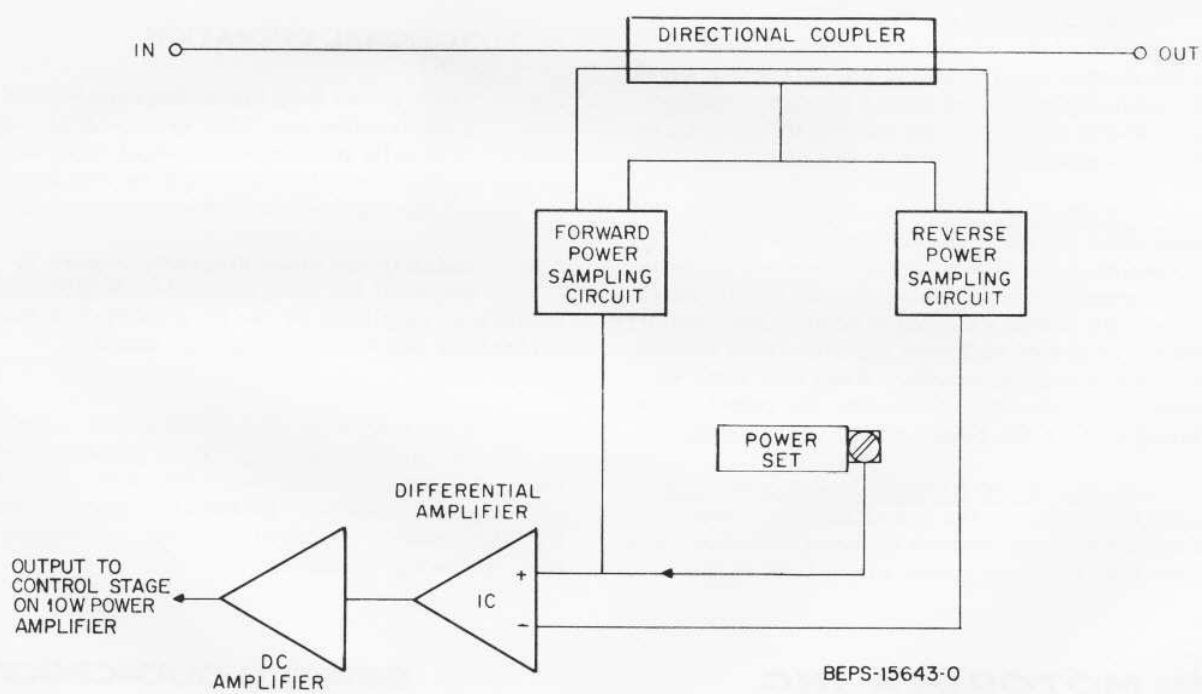


Figure 2.
Power Control Board Block Diagram

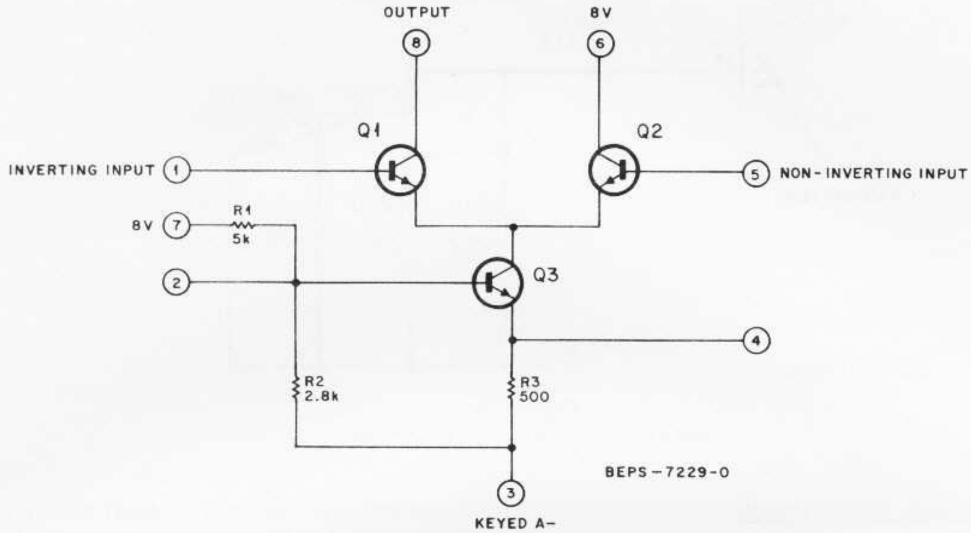


Figure 3.
IC601 Schematic Diagram

3. CIRCUIT DESCRIPTION

3.1 BIAS CIRCUITRY

Since the power control board has the capability to regulate the output of the amplifier from a completely cut-off state to above the rated output power, a definite controlled output level is necessary whenever the exciter/driver is keyed. The desired controlled output level is determined by bias voltages present on the inverting and non-inverting inputs of the differential amplifier IC601 (see Figure 3.) Under normal operating conditions (1:1 VSWR; 100% rated power out) the bias on the differential amplifier inputs are developed as described in the following paragraphs.

3.1.1 Voltage Regulator and Main Divider Line

Refer to Figure 4. The A+ supply to the board is regulated by a series regulator circuit providing a nominal voltage of 8.0 volts. The Zener diode holds the base of the series pass transistor at a fixed potential. The series pass transistor operates as a variable resistor to hold the input to the reference circuitry constant. The divider consisting of the two resistors and the diode provides the proper voltage tap points for the secondary voltage divider networks. All 220 pF capacitors in the board are used as rf bypasses.

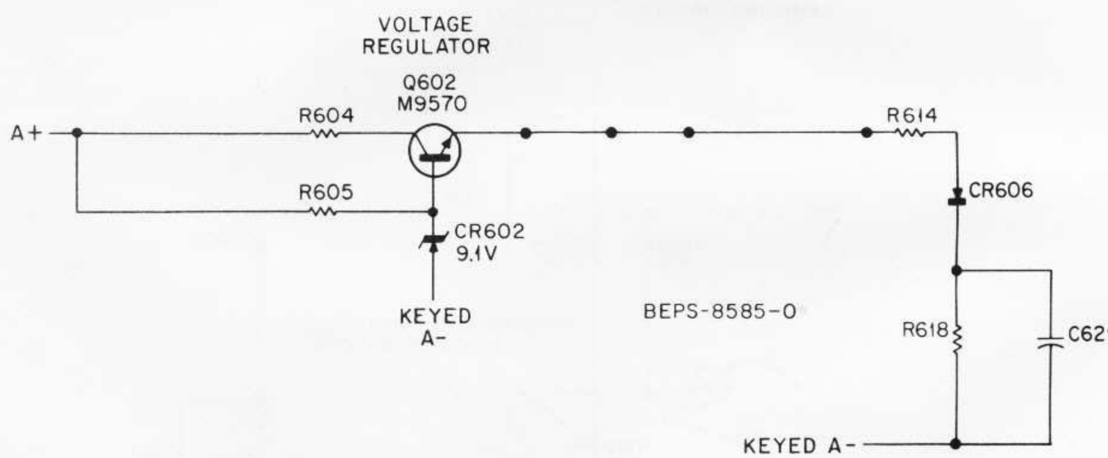


Figure 4.
Voltage Regulator and Main Divider Line

POWER CONTROL BOARD

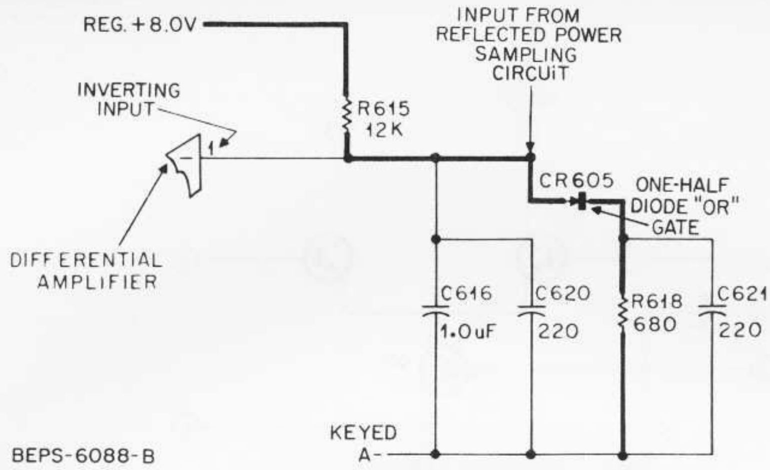


Figure 5.
Reference Power Bias Circuit

3.1.2 Reference Bias Circuit

Refer to Figure 5. The reference bias is developed (with a 1:1 VSWR) by the voltage divider made up of two resistors and a diode between the regulated supply voltage and the switched A- source. Since A+ is applied to the board continuously and A- is only applied when the exciter/driver is keyed by the push-to-talk switch, the larger capacitor connected between the inverting input and keyed A- provides a time constant which allows the inverting input bias to build up slowly when power is first applied. This prevents full power output from occurring until the leveling circuitry can react and reach a quiescent level.

3.2 DIRECTIONAL COUPLER

The directional coupler measures the voltage and the current traveling in both directions. The detection of forward (output) power causes a proportional voltage bias that is combined with the voltage-divider generated bias to set the potential on the non-inverting input of the differential amplifier. Any reverse power detected causes the VSWR circuitry to decrease the power output.

3.3 PROTECTION CIRCUITRY

3.3.1 Forward Power Bias and Detection Circuit

Refer to Figure 6. The forward power reference voltage divider comprised of two resistors and two potentiometers provides a stable potential that supplies a dc bias to the non-inverting input of the differential amplifier. With an approximately correct power output from the amplifier, a dc level proportional to that power is produced by the forward power detector circuit,

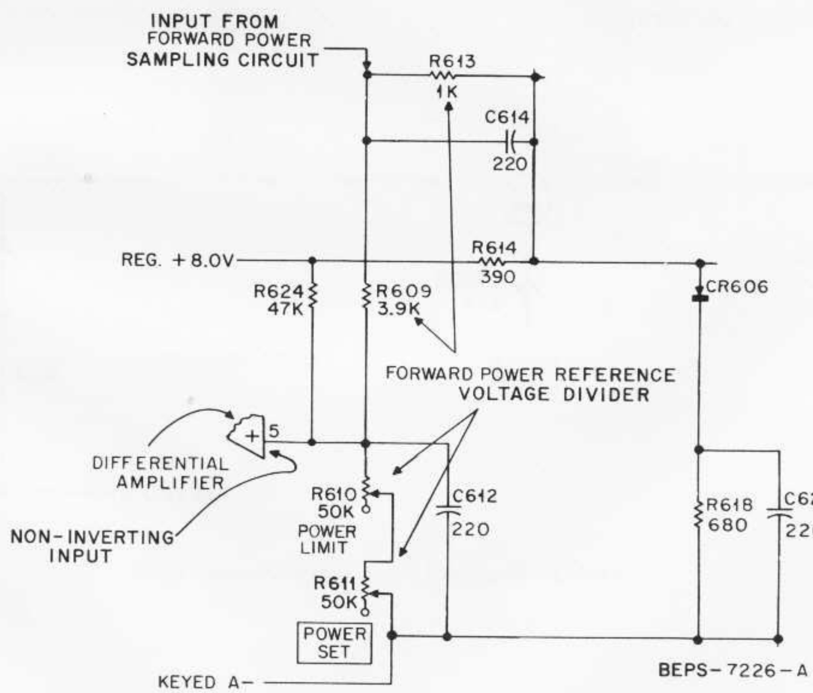


Figure 6.
Forward Power Bias Circuit

which, in combination with the voltage developed by the voltage divider, produces a bias on the non-inverting input that can be adjusted by the POWER SET potentiometer. The POWER LIMIT control is pre-set to prevent over-dissipation if the POWER SET control should be set to maximum. (Refer to the CAUTION preceding maintenance information in this section.) The dc bias value will be determined by the amplifier output and, with no reflected power (VSWR 1:1), balanced against the reference bias present on the inverting input of the differential amplifier. Once the bias has been set, any change in power output will change the bias on the non-inverting input causing the differential amplifier to compensate for the deviation. The forward power detector circuit (refer to Figure 7) detects rf power flowing through the directional coupler when the exciter/driver is keyed, and causes a small proportional current flow in the forward power sampling circuit. The diode converts the rf sample into a pulsating dc voltage and the dc filter removes the ripple. This is the dc voltage which is added to the dc bias already applied to the non-inverting input of the differential amplifier from the secondary divider circuitry.

3.3.2 VSWR - Reverse Power Detection Circuit

3.3.2.1 Since the power control board is now operating correctly with the proper amount of forward power and the correct biases, the detection of reflected power causes a decrease in the power amplifier's output in the following manner.

3.3.2.2 Refer to Figure 8. The components of the reverse power detector circuit function the same as those in the forward power detector. The voltage divider develops a bias voltage that isn't quite enough to forward bias the diode that makes up one-half of a diode "OR" gate. When reflected power is detected, the resultant negative-going dc level lowers the dc bias level and the combination of the two forward bias the diode. The negative-going dc level on the inverting input increases the output voltage of the differential amplifier, decreasing the dc control output to protect the amplifier.

3.3.3 DC Level Output Amplification

The output of the differential amplifier is applied to the base of a voltage-inverting transistor amplifier whose output supplies the output control current. As the forward power increases above the normal value, the output of the differential amplifier increases proportionally. Since the dc level is increasing the base, the PNP transistor conducts less and the potentials across the output load resistor, and on the control output line, decrease.

4. MAINTENANCE

CAUTION

The power control board is incorporated in the transmitter to provide protection for the rf power transistors under environmental conditions such as voltage, load variation, and device variations. In order for the circuitry to operate properly and provide protection it is necessary to set the power output control (POWER SET) in accordance with the station alignment procedure.

4.1 GENERAL

4.1.1 Two basic maintenance approaches may be used for localizing and replacing trouble in these radio sets.

- Replace the defective circuit board with a spare and return the defective board to a maintenance shop for repair.

- Isolate and repair the trouble on the spot. This approach must be used if spares are not available.

4.1.2 Regardless of the maintenance approach used, a few simple tests on the overall radio set will localize the trouble to the power control board if it is defective. These procedures are given elsewhere in the manual. This section of the manual provides the maintenance shop level procedures for the power control circuitry. It assumes that preliminary tests have already localized the trouble to the power control board. These bench test type procedures include measurements with a Motorola portable test set, a simple set of performance tests, and complete troubleshooting procedures including step-by-step circuit check-out.

NOTE

The power control board must be installed in the station for testing to provide the necessary power, ground, control, and signal connections. For bench testing of a board that has been removed from the station and replaced by a spare, another station is required as a test fixture for troubleshooting.

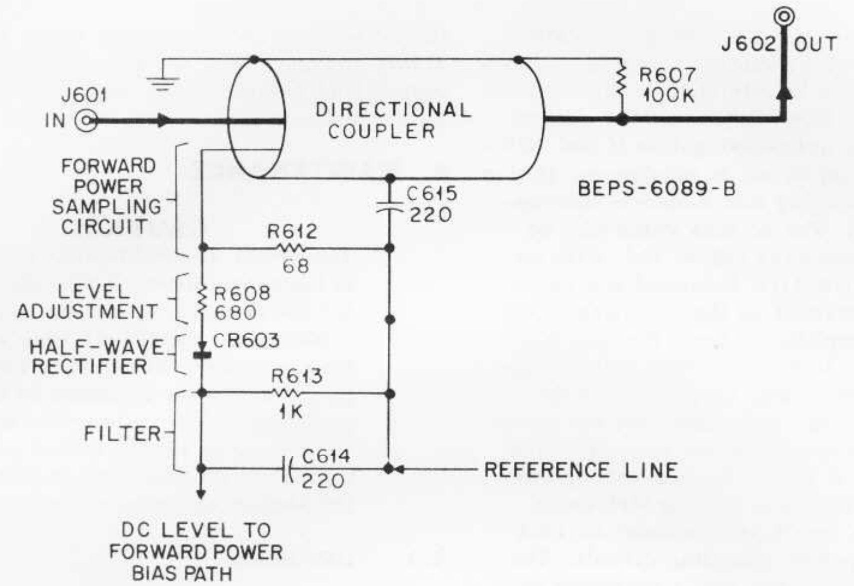


Figure 7.
Forward Power Detector Circuit

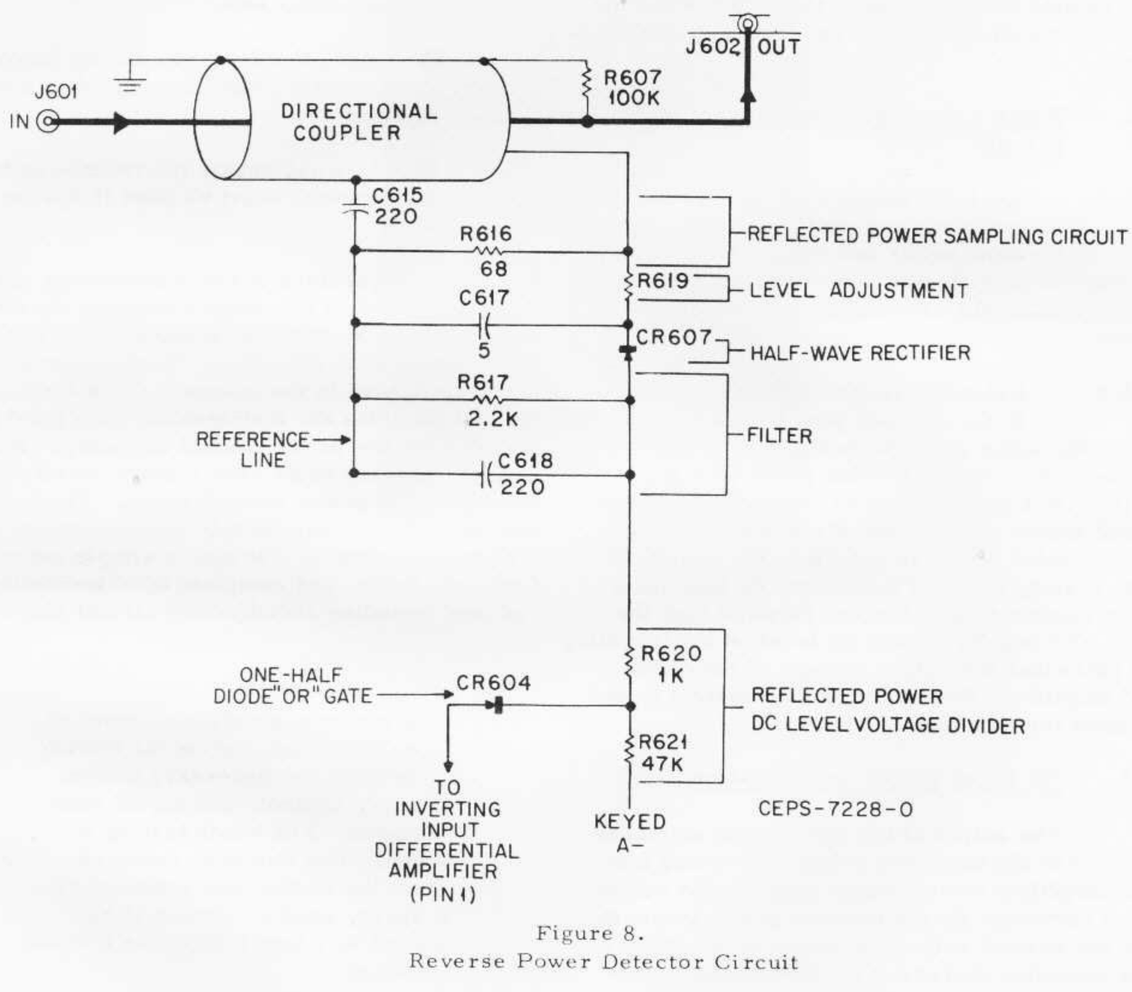


Figure 8.
Reverse Power Detector Circuit

4.2 RECOMMENDED TEST EQUIPMENT

The following test equipment is the minimum required for troubleshooting and adjusting the board. All such equipment is battery operated. When ac operated equipment is used, the ground lead must not be electrically connected to ac line ground.

4.2.1 Built-in station metering or Motorola S1056B through S1059B Portable Test Set and Model TEK-37 or TEK-37A Adapter Cable. (The meter or portable test set is necessary to monitor forward and reverse power detectors.)

4.2.2 Motorola Solid-State DC Multimeter or equivalent. A 20,000 ohm-per-volt multimeter may be used but a low impedance volt-ohm meter may not be used. This meter is used for measuring dc voltages and resistance.

4.2.3 Motorola T1013A RF Load Resistor (Dummy Load) or equivalent.

4.3 METERING

The power control board is equipped with a metering receptacle which allows three major test points (forward power, reflected power and control current) to be measured. Refer to the troubleshooting charts or the schematic diagram for the correct meter indications.

4.3.1 Using Built-In Station Metering

Step 1. The output of the power control board must be terminated into a dummy load such as Motorola's T1013A RF Load Resistor or a "Termaline" wattmeter.

Step 2. Turn the station ON.

Step 3. Set the selector switch on the metering chassis to the "XCTR" position.

Step 4. Set the selector switch on the exciter/driver chassis to "PWR CONT" position and key the transmitter. Observe the wattmeter, or the meter reading if a dummy load is used. Unkey the transmitter. Under normal conditions at rated power out, meter should read between 24 uA and 50 uA typically.

4.3.2 Using Portable Test Set

Step 1. Set the function selector switch of the portable test set to the XMTR position.

Step 2. Set the meter reversing switch of the test set to the METER REV position.

Step 3. Set the REF switch to position A or B.

Step 4. Connect the 20-pin meter cable plug to the test set. When the test set is not in use, disconnect the 20-pin plug to conserve battery life. The plug acts as an on-off switch completing the battery circuit.

Step 5. Connect the red "control" plug of the adapter cable to the control receptacle on the rear remote control chassis interconnect circuit board. Connect the white "metering" plug of the adapter cable to the receptacle on the power control board.

Step 6. The output of the power control board must be terminated into a dummy load such as Motorola's T1013A RF Load Resistor or a "Termaline" wattmeter.

Step 7. Turn the station ON.

Step 8. Set the selector switch of the test set to position 1 and key the transmitter with the XMTR ON button on the test set. Observe the wattmeter, or the meter reading if a dummy load is used. Unkey the transmitter. Under normal conditions at rated power out, meter 1 should read between 24 uA and 150 uA typically.

4.3 PERFORMANCE TEST, POWER SET CONTROL

4.3.1 This control allows the power output of the radio set to be varied from zero (0) power out with the control fully counterclockwise to greater than the rated output.

CAUTION

For proper operation of the protection circuitry, it is imperative that the POWER SET control never be left in a position that exceeds rated power output.

Refer to the driver amplifier tune-up procedure.

Step 1. Key the transmitter.

Step 2. Adjust the POWER SET control until the rated power output is reached.

Step 3. Unkey the transmitter.

4.4 TROUBLESHOOTING

4.4.1 Isolating Defective Components

If built-in station meter or test set readings are abnormal or tests indicate subnormal performance, a logical troubleshooting procedure is required to isolate the defective component efficiently. The accompanying troubleshooting charts summarize these results in a logical sequence. A few voltage and resistance checks in the suspected circuit should readily isolate the defective component. Note that all circuits powered by A+ and A- are not referenced to chassis ground, but to A-.

4.4.2 Troubleshooting Integrated Circuits

4.4.2.1 Integrated circuits (IC's) are very reliable components and should not be replaced until all checks have proven definitely that the IC is the defective component. Removal of an IC is time consuming and often ruins the part. Therefore, a few extra checks before that task is attempted are worthwhile. Before replacing a bad IC, make sure that the external components in the circuit are normal. Otherwise, the conditions which caused the IC to fail initially may still be present and destroy the new IC.

4.4.2.2 A defective IC on the power control board may be located by dc voltage measurements. Measure the dc voltages at the pins of the IC, as shown in the troubleshooting charts. Refer to the troubleshooting charts or the IC601 Schematic Diagram (Figure 3.) to locate and isolate any defective component on the board.

4.4.2.3 If the IC is to be replaced, use a "desoldering" iron with a vacuum bulb to remove solder.

4.5 TROUBLESHOOT NOTES

The schematic diagram of the power control board contains the voltages necessary for troubleshooting. These voltages are typical for normal operating conditions at rated power out for the station. Refer to the troubleshooting charts and the schematic when troubleshooting and a defect is suspected on the power control board.

NOTES

(1) Slight variations in meter readings or power out may occur during measurements. This is normal and does not necessarily indicate any problem.

(2) With 0 reflected power (1:1 VSWR), meter 2 will read between -5 uA and -20 uA. Again, this is normal and does not indicate a defect. The meter reversing switch on the portable test set must be placed in the OFF position for upscale readings of meter 2. Built-in station metering automatically reverses polarity when position 2 is selected.

4.6 COMPLETE DRIVER AMPLIFIER ALIGNMENT

A complete realignment of the driver amplifier tuning controls and power control board adjustments may be necessary under the following conditions:

--Major changes, repairs (such as transistor replacement) or complete replacement of the power amplifier board.

--Repair or replacement of the control board.

--A change in transmitter frequency greater than approximately ±1 MHz.

A complete alignment procedure is at the end of this section.

IMPORTANT

The complete alignment procedure differs from the standard tune-up procedure in that a factory set control which has been adjusted for full power amplifier protection under tune-up conditions must be readjusted. This complete alignment procedure is not required and should not be performed when an alignment check is required or if frequency has been changed less than ±1 MHz.

EXCERPTS FROM FCC REGULATIONS

FCC Regulations state that:

1. Radio transmitters may be tuned or adjusted only by persons holding a first or second class commercial radiotelephone operator's license or by personnel working directly under their immediate supervision.

2. The power input to the final radio frequency stage shall not exceed the maximum figure specified on the current station authorization. This power input shall be measured and the results recorded:

   a. When the transmitter is initially installed.
   b. When any change is made in the transmitter which may increase the power input.
   c. At intervals not to exceed one year.

3. Frequency and deviation of a transmitter must be checked:

   a. When it is initially installed.
   b. When any change is made in the transmitter which may affect the carrier frequency or modulation characteristics.
   c. At intervals not to exceed one year.

COMPLETE DRIVER AMPLIFIER ALIGNMENT PROCEDURE

NOTE

If the transmitter frequency is to be changed, first realign the exciter board per the exciter alignment procedure.

STEP	ADJUST	METERING CHASSIS SELECTOR SWITCH POSITION	EXCITER/ DRIVER METERING SELECTOR SWITCH POSITION	STAGE AND PROCEDURE
1				If the driver amplifier is to be re-aligned greater than ±1 MHz from the original frequency, proceed to Step 2. If the driver amplifier is to be re-aligned less than ±1 MHz from the original frequency, proceed to Step 7.
2	C501 R610 (POWER LIMIT)			PRE-ALIGNMENT: Set C501 fully clockwise. Use tuning tool to pre-align R610 on the component side of the power control board. Access to this control is provided by a small slot located approximately 3/4-inch from the POWER SET control access hole. Use the tuning tool to rotate the outer edge of the serrated knob. Adjust the POWER LIMIT control to the end of its travel by rotating the end of the knob toward the top of the chassis.
3				Disconnect the coaxial cable from the exciter-driver chassis output terminal. Connect a wattmeter and a 50 ohm rf load to the output terminal.
4	R611 (POWER SET)			TRANSMITTER OUTPUT: Adjust POWER SET control R611 to the maximum clockwise position.

ALIGNMENT PROCEDURE (CONT'D)

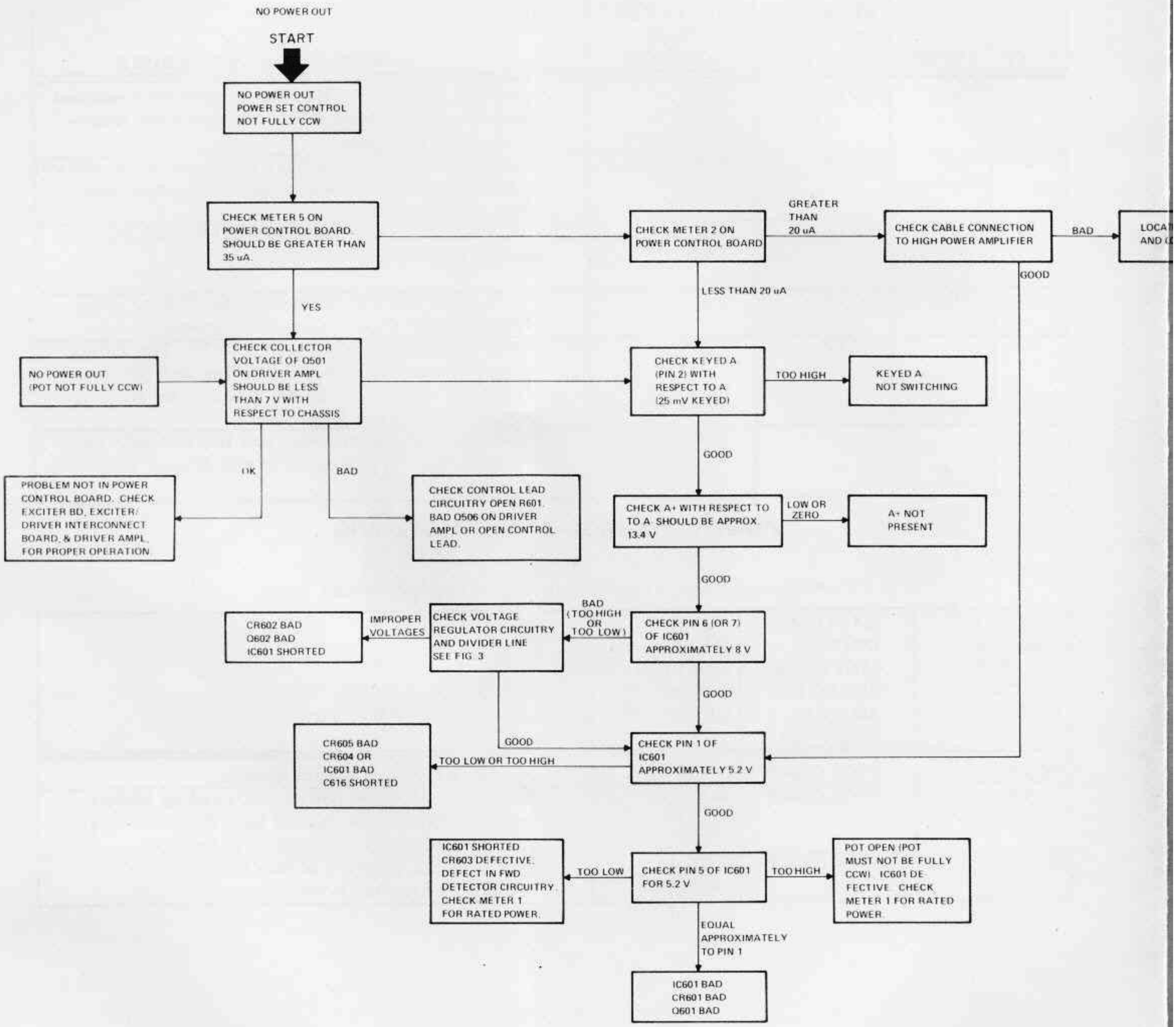
STEP	ADJUST	METERING CHASSIS SELECTOR SWITCH POSITION	EXCITER/ DRIVER METERING SELECTOR SWITCH POSITION	STAGE AND PROCEDURE
5	C501	XCTR	PWR CONT 1	DRIVER OUTPUT: Key the transmitter without modulation and tune C501 clockwise for maximum power output.
6	R610 (POWER LIMIT)	XCTR	PWR CONT 1	DRIVER OUTPUT: Adjust R610 gradually toward the bottom of the chassis until the output power just starts to drop.
7	R611 (POWER SET)	XCTR	PWR CONT 1	DRIVER OUTPUT: Adjust R611 for 10 watts output power.
8	C501	XCTR	PA 5	Tune C501 clockwise for a meter 5 dip. (The output power should remain 10 watts.)
9		XCTR	PA 5	DRIVER COLLECTOR CURRENT: The relationship between the meter 5 reading and the driver collector current is 10 uA = 1A. The reading should be between 10 to 18 uA.
10				Disconnect the wattmeter and the rf load. Reconnect the coaxial cable to the driver amplifier output.

POWER CONTROL BOARD METERING

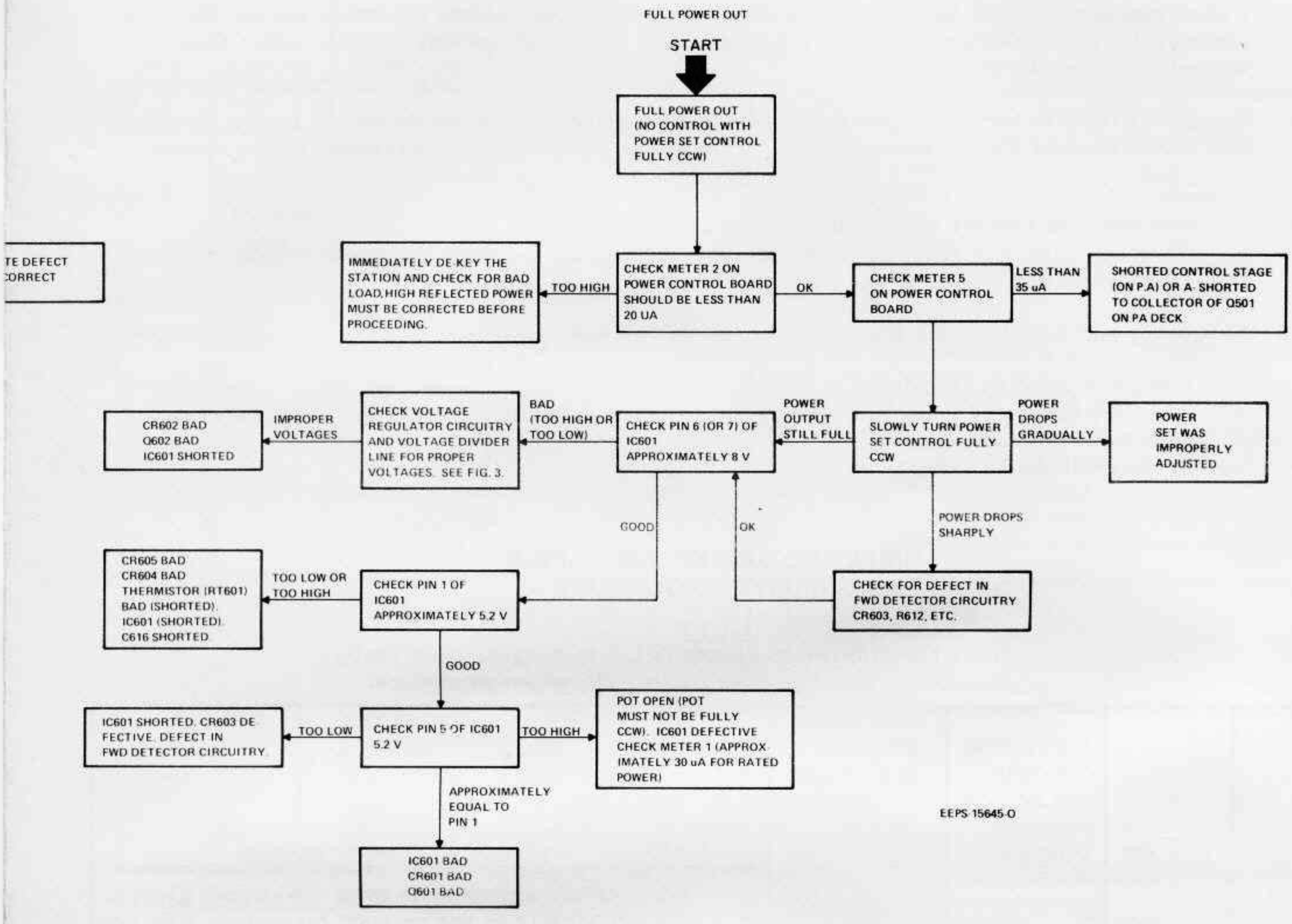
NOTE

Radio operating at rated power into proper 50 ohm load.

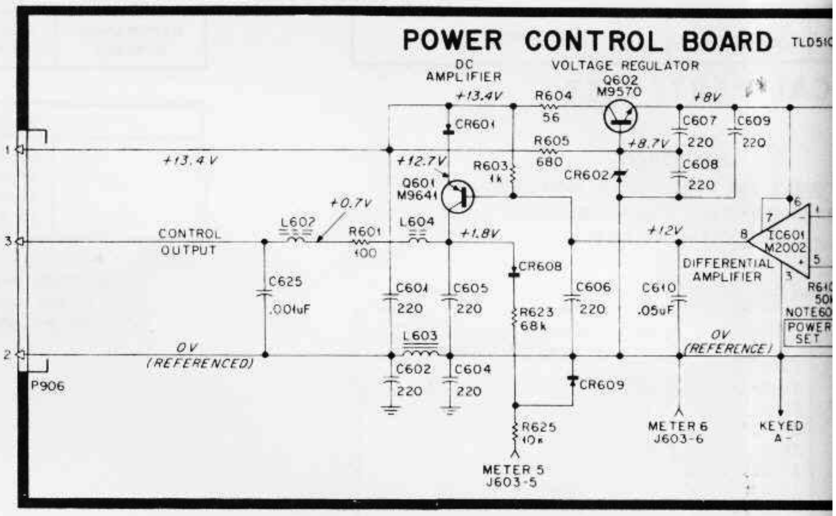
METERING CHASSIS SELECTOR SWITCH POSITION	EXCITER/ DRIVER METERING SELECTOR SWITCH POSITION	NORMAL METER READING TO BE OBSERVED	FUNCTION
XCTR	PWR CONT 1	24-50 uA	Indicates forward output power.
XCTR	PWR CONT 2	5-20 uA	Indicates reflected power. A reading higher than normal can be caused by a defective high power amplifier or defective rf cables.
XCTR	PWR CONT 5	3-25 uA	Indicates the relative level of the drive sent to the driver amplifier via the control lead.



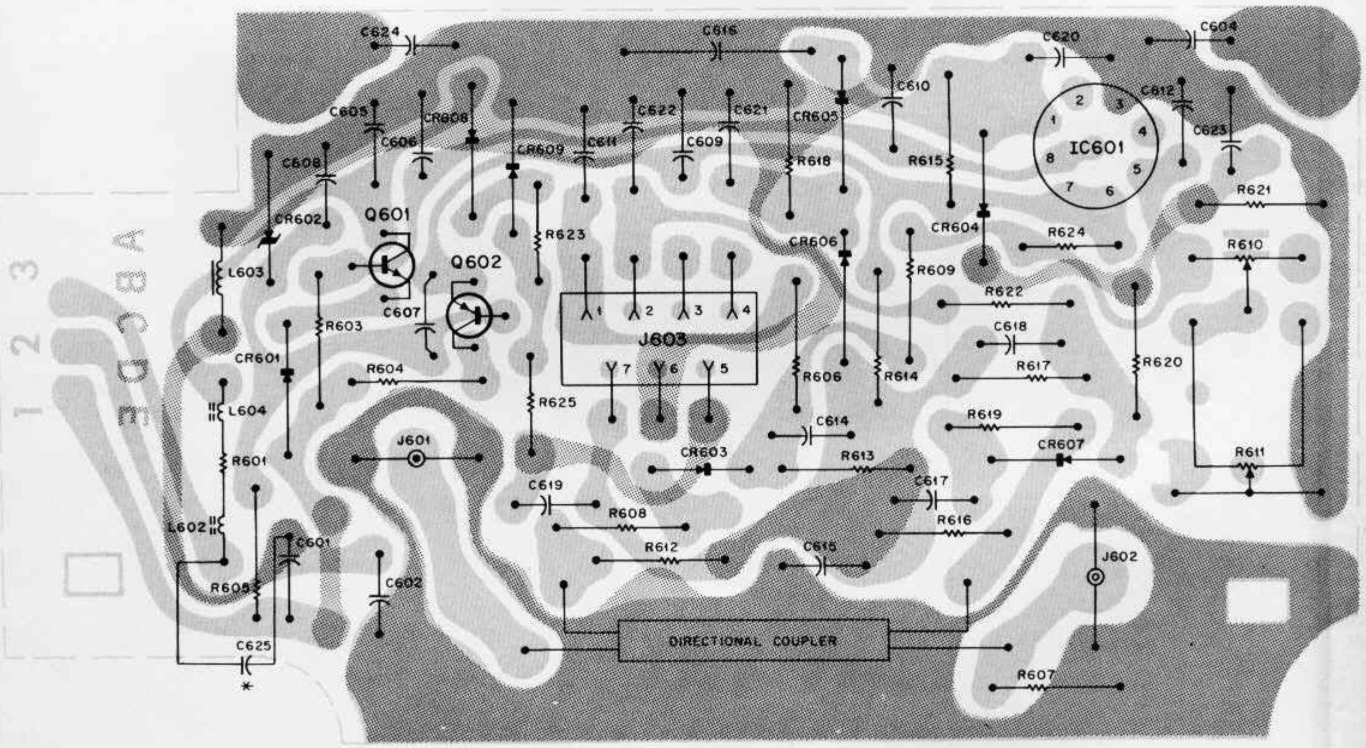
Power Control Board
Troubleshooting Chart
Motorola No. EEPS-15645-O
9/10/74-UP


FULL POWER OUT
START
FULL POWER OUT (NO CONTROL WITH POWER SET CONTROL FULLY CCW)
CHECK METER 2 ON POWER CONTROL BOARD SHOULD BE LESS THAN 20 UA
TOO HIGH
IMMEDIATELY DE-KEY THE STATION AND CHECK FOR BAD LOAD, HIGH REFLECTED POWER MUST BE CORRECTED BEFORE PROCEEDING.
TE DEFECT
CORRECT
OK
CHECK METER 5 ON POWER CONTROL BOARD
LESS THAN 35 uA
SHORTED CONTROL STAGE (ON P.A) OR A- SHORTED TO COLLECTOR OF Q501 ON PA DECK
SLOWLY TURN POWER SET CONTROL FULLY CCW
POWER DROPS GRADUALLY
POWER SET WAS IMPROPERLY ADJUSTED
POWER OUTPUT STILL FULL
CHECK PIN 6 (OR 7) OF IC601 APPROXIMATELY 8 V
BAD (TOO HIGH OR TOO LOW)
CHECK VOLTAGE REGULATOR CIRCUITRY AND VOLTAGE DIVIDER LINE FOR PROPER VOLTAGES. SEE FIG. 3.
IMPROPER VOLTAGES
CR602 BAD
Q602 BAD
IC601 SHORTED
POWER DROPS SHARPLY
CHECK FOR DEFECT IN FWD DETECTOR CIRCUITRY CR603, R612, ETC.
OK
GOOD
CHECK PIN 1 OF IC601 APPROXIMATELY 5.2 V
TOO LOW OR TOO HIGH
CR605 BAD
CR604 BAD
THERMISTOR (RT601) BAD (SHORTED).
IC601 (SHORTED).
C616 SHORTED
GOOD
CHECK PIN 5 OF IC601 5.2 V
TOO LOW
IC601 SHORTED. CR603 DEFECTIVE. DEFECT IN FWD DETECTOR CIRCUITRY.
TOO HIGH
POT OPEN (POT MUST NOT BE FULLY CCW). IC601 DEFECTIVE CHECK METER 1 (APPROXIMATELY 30 uA FOR RATED POWER)
APPROXIMATELY EQUAL TO PIN 1
IC601 BAD
CR601 BAD
Q601 BAD

EEPS-15645-O



EARLIER VERSION

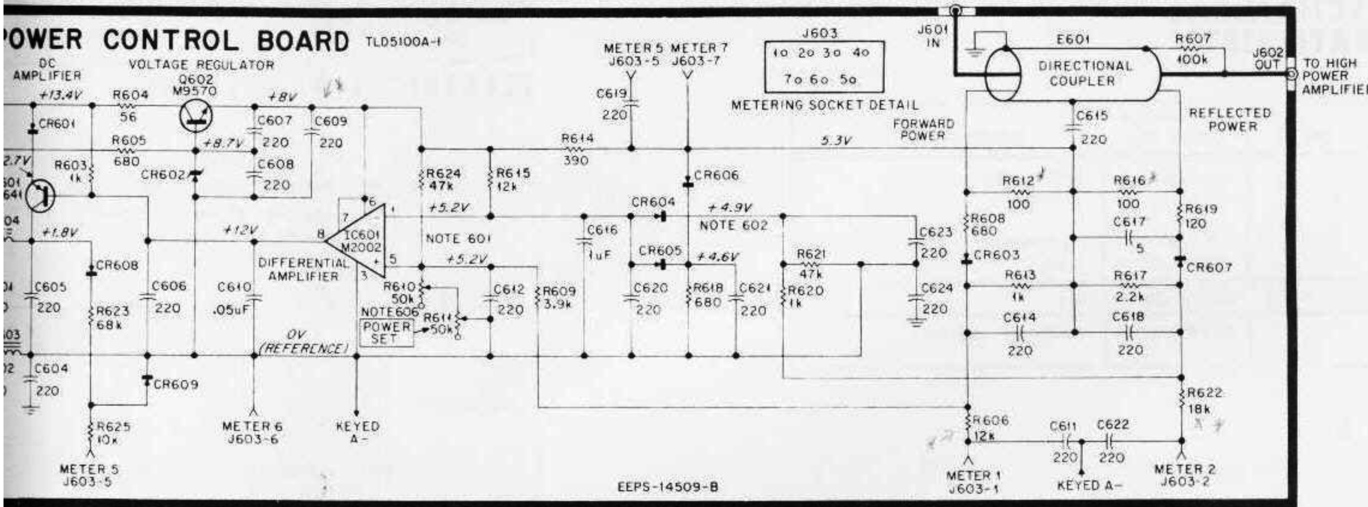


* MOUNTED ON FOIL SIDE OF BOARD

COMPONENT SIDE BD-CEPS-5328-0

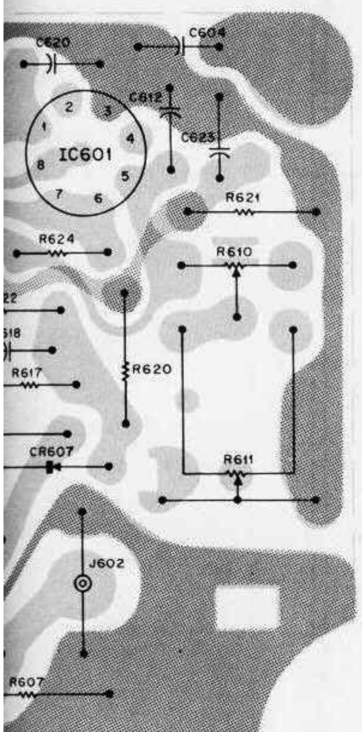
SOLDER SIDE

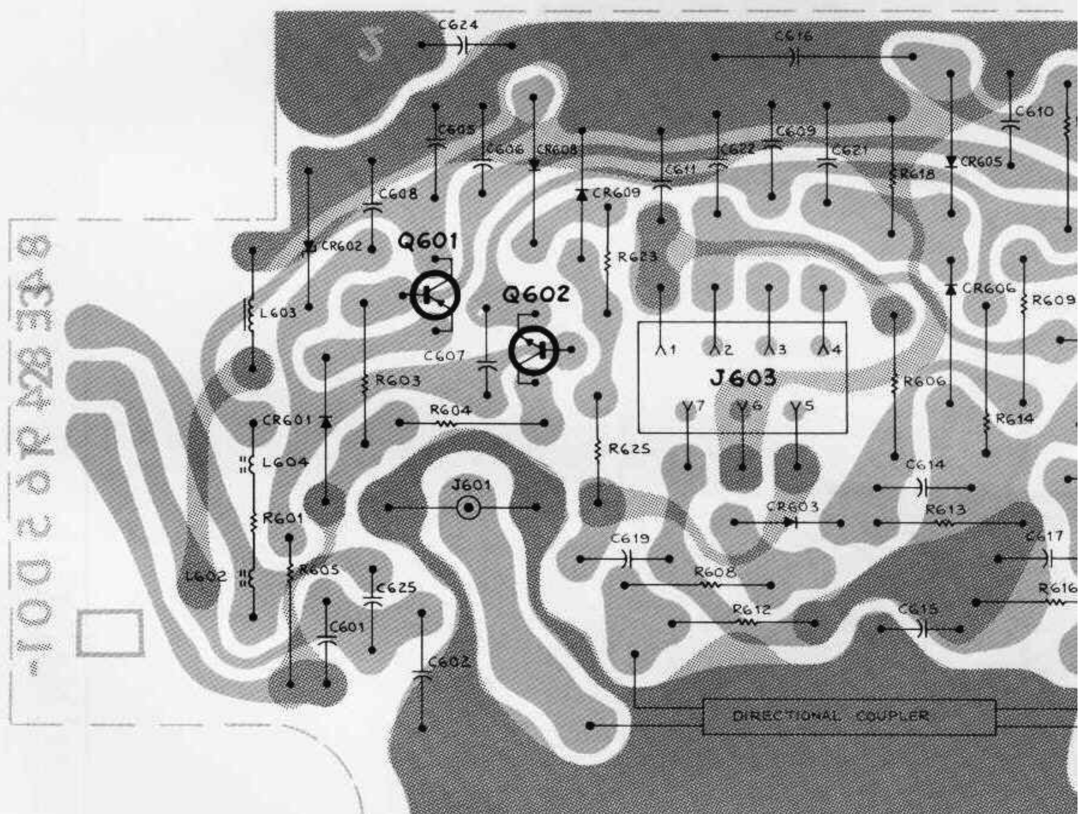
OL-CEPS-16817-0



LATER VERSION

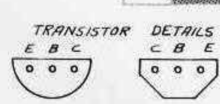
SHOWN FROM SOLDER SIDE





NT SIDE BD-CEPS-5328-0

ER SIDE OL-CEPS-16817-0



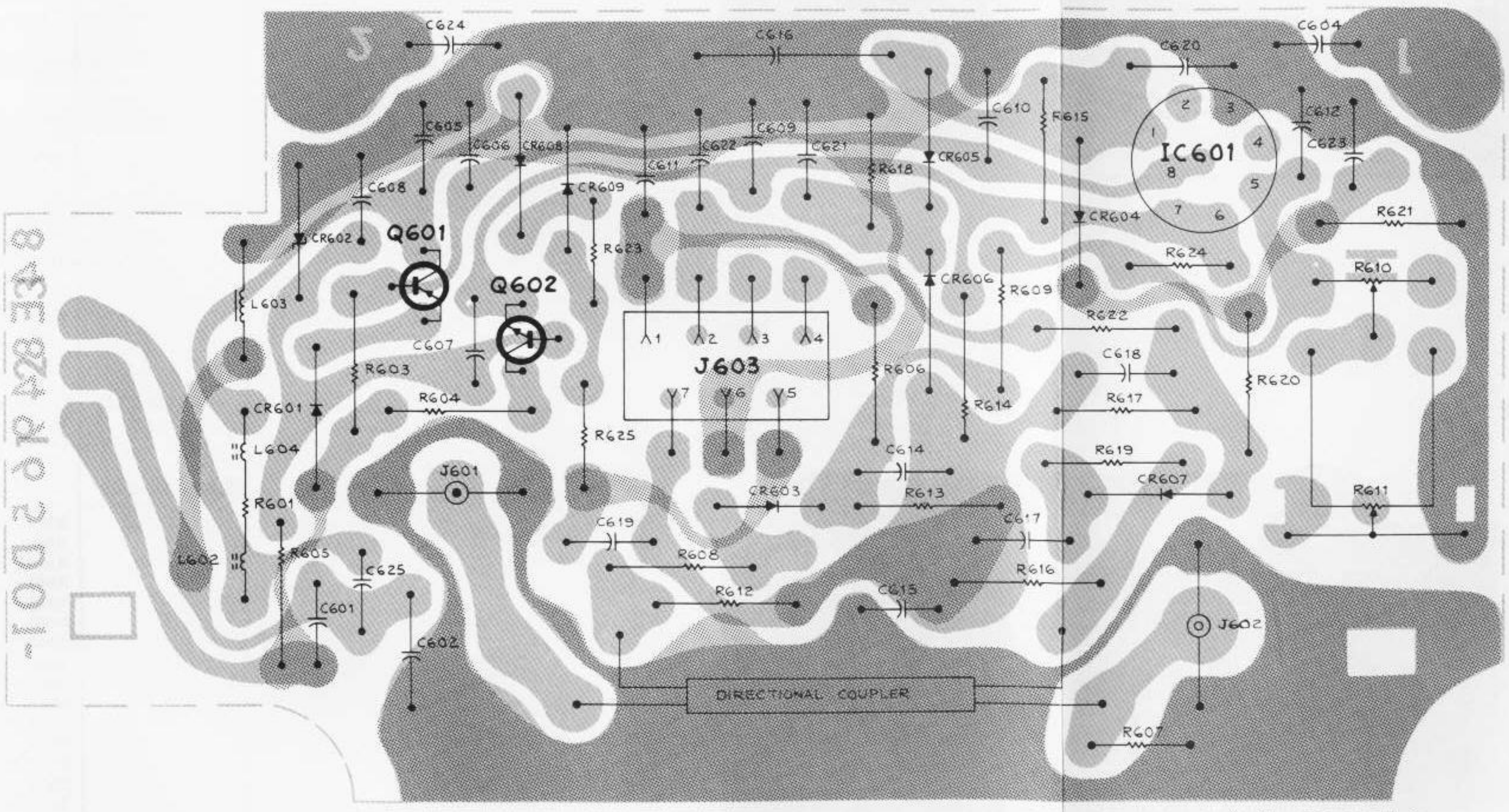
LATER VERSION

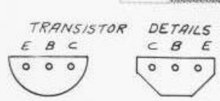
POWER CONTROL BOARD NOTES

601. VOLTAGES AT PINS 1 AND 5 SHOULD DIFFER BY LES
602. VOLTAGE MEASURED AT 25 C.
603. TYPICAL VOLTAGES UNDER NORMAL OPERATING C
604. UNLESS OTHERWISE STATED: CAPACITOR VALUES A PICOFARADS.
605. FACTORY ADJUSTMENT.

N

SHOWN FROM SOLDER SIDE





PARTS LIST SHOWN ON BACK OF THIS DIAGRAM

TLD5100A-1 Power Control Boa
Schematic Diagram and Circuit
Motorola No. PEPS-15646-C
(Sheet 1 of 2)
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