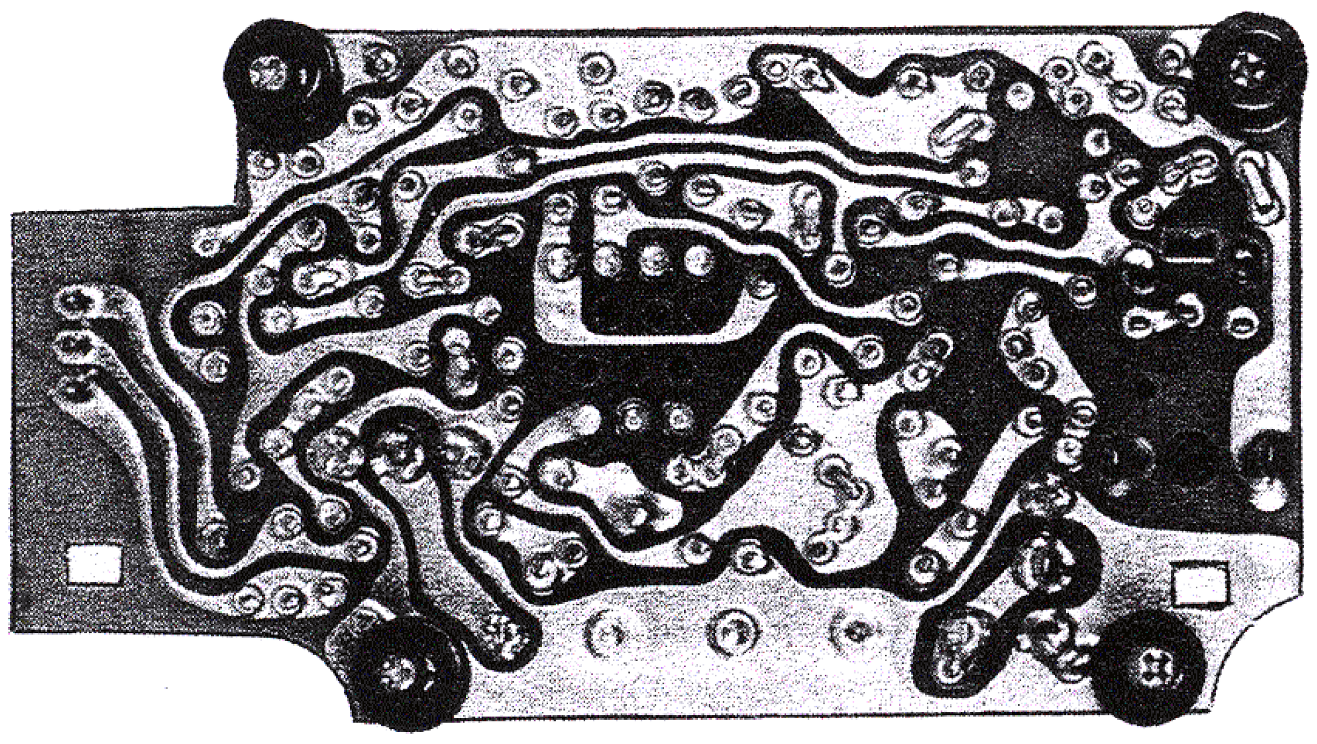
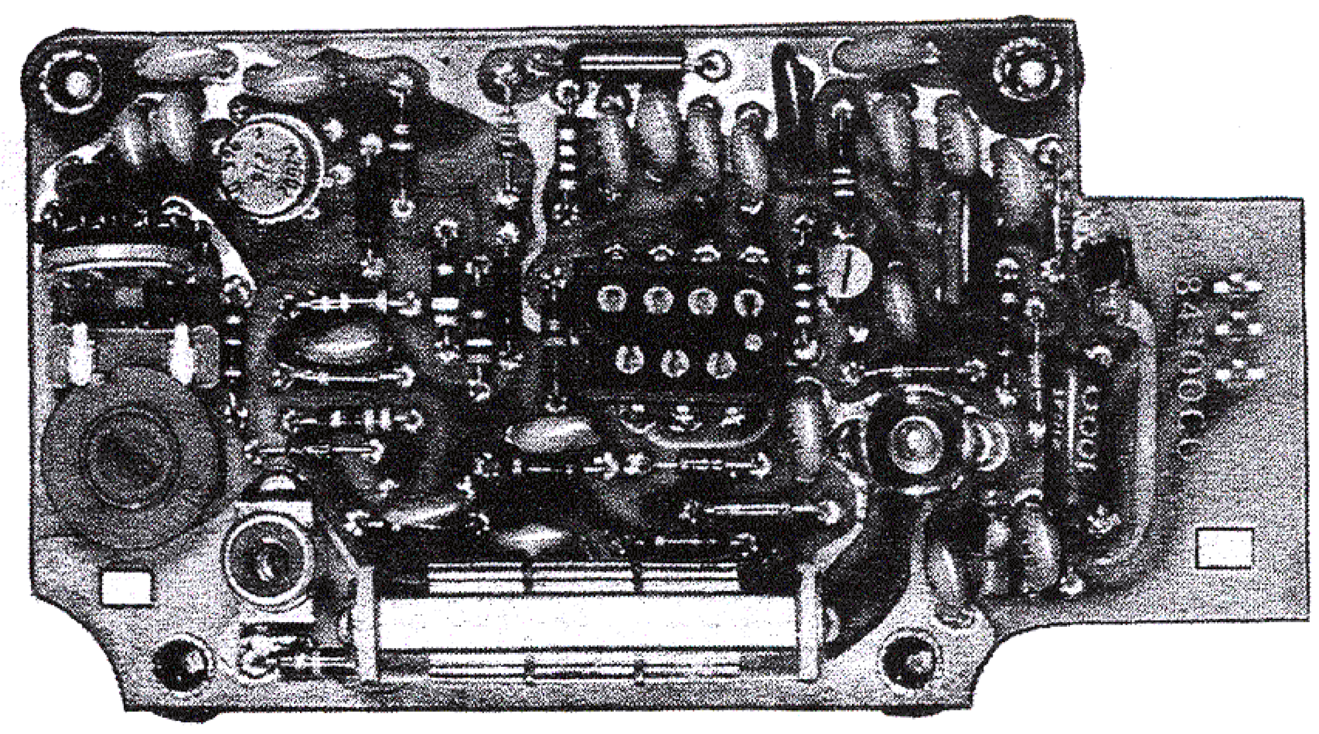
POWER CONTROL BOARD

MODEL TLB6940A

AND TLB6940AV



TOP VIEW



BOTTOM VIEW

AEPS-6127-A

1. DESCRIPTION

The solid-state power control board provides regulation and protection for the rf transistors. The following four functions are provided by the circuitry.

--Power Leveling - The board permits the adjustment of the output of the power 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 final amplifier transistors should a fault occur in the antenna circuit. The circuitry compares power reflected from the antenna circuit to forward (output) power. When this ratio exceeds a predetermined amount, the output of the circuit lowers the power output of the power amplifier.

--Temperature Protection (Intermittent Only) -- A portion of the circuitry continually monitors heat sink temperature. When a temperature of approximately 80°C is reached, the power control board begins to reduce the power amplifier output to prevent damage to the final stage

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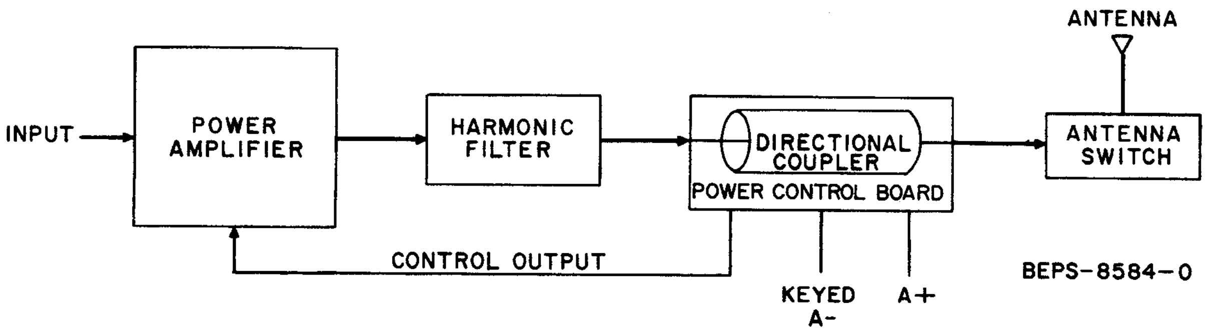


Figure 1.
Loop Block Diagram

power transistors. Any further increase in heat sink temperature will cause a correspondingly greater decrease in power output. A reduced power output level will be maintained until the heat sink temperature drops below 80°C. Thermal protection is not needed on the continuous duty version due to the large heat exchanger used.

--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.

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

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

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 power amplifier board.

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.

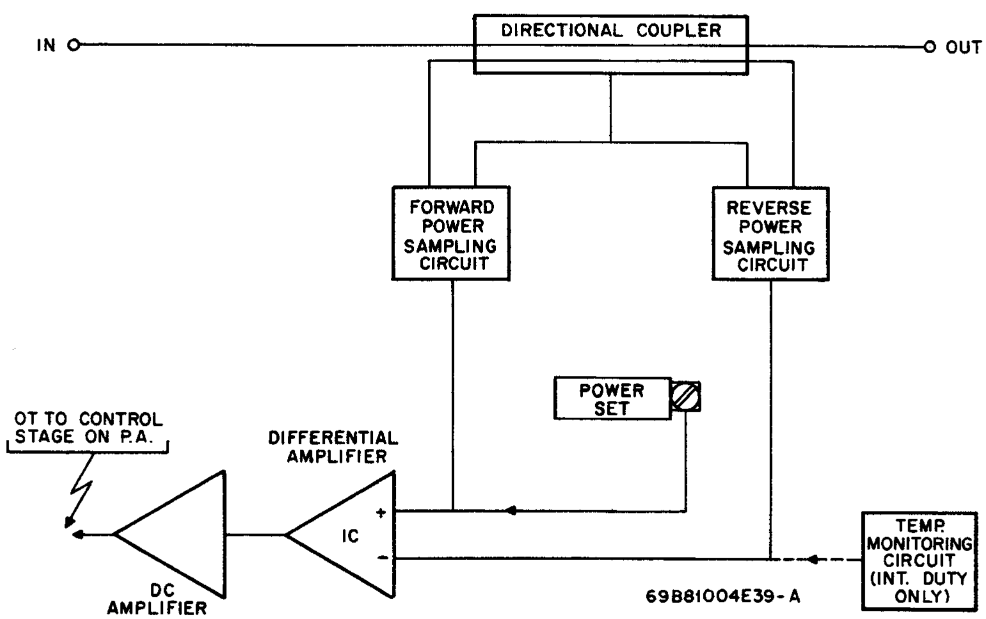


Figure 2.
Power Control Board Block Diagram

When the impedances of the antenna circuitry (load) and the power amplifier are matched (a VSWR of 1:1), and the heat sink temperature is below 80°C (for intermittent duty stations), 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).

When the transmitter is keyed, the forward (output) power from the final stages of the power amplifier is fed through the directional coupler to the antenna 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 of the power amplifier.

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 transmitter power amplifier output causes the reverse action.

Any power reflected back from the antenna 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 transmitter power output to be decreased to a safe level.

On intermittent duty stations, temperature increases detected by the temperature monitoring circuit will also decrease the reference level at the inverting input of the differential amplifier, reducing the output power as the heat sink temperature increases above a safe operating point for the power transistors. The higher the temperature, the more the decrease in power out. If the output has been reduced due to temperature, the VSWR circuit becomes more sensitive to reverse power, thus providing further protection for the rf power amplifier transistors.

3. CIRCUIT DESCRIPTION

a. Bias Circuitry

Since the power control board has the capability to regulate the output of the transmitter power amplifier from a completely cut-off state to above the rated output power, a definite controlled output level is necessary whenever the transmitter 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

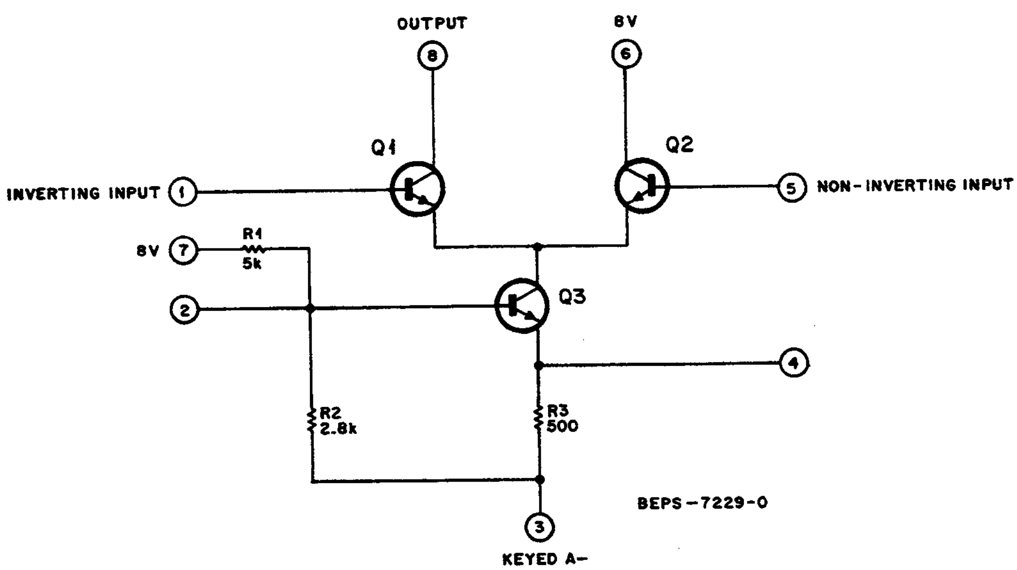


Figure 3.
IC601 Schematic Diagram

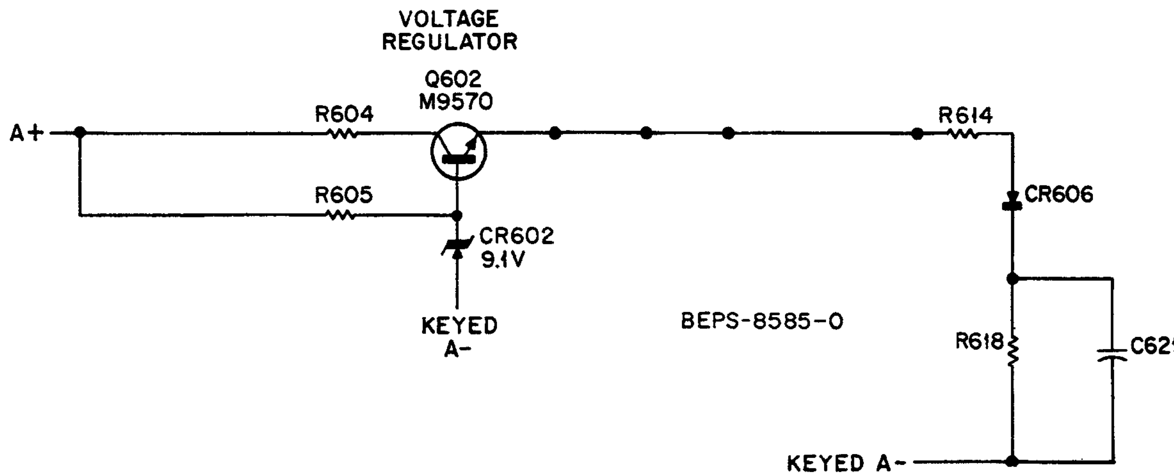


Figure 4.
Voltage Regulator and Main Divider Line

normal operating conditions (1:1 VSWR; 100% rated power out and normal heat sink temperature on intermittent duty stations) the bias on the differential amplifier inputs are developed as described in the following paragraphs.

(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 1000 pF capacitors in the board are used as rf bypasses.

(2) Reference Bias Circuit

Refer to Figure 5. The reference bias is developed (with a 1:1 VSWR and normal heat sink temperature on intermittent duty stations) by the voltage divider made up of two resistors and a diode between the regulated supply voltage and the keyed A- source. Since A+ is applied to the board continuously and A- is only applied when the transmitter is keyed by the push-to-talk

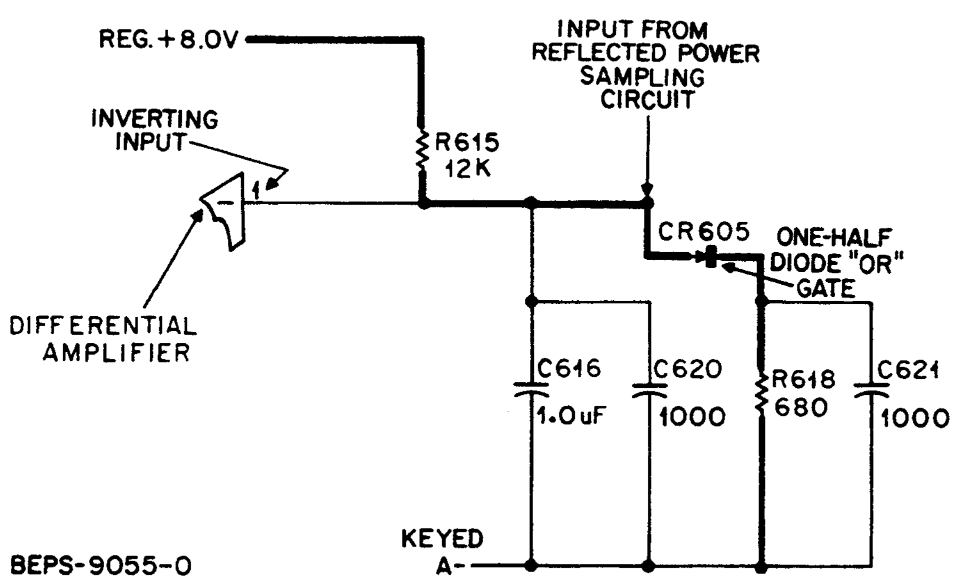


Figure 5.
Reference Power Bias Circuit

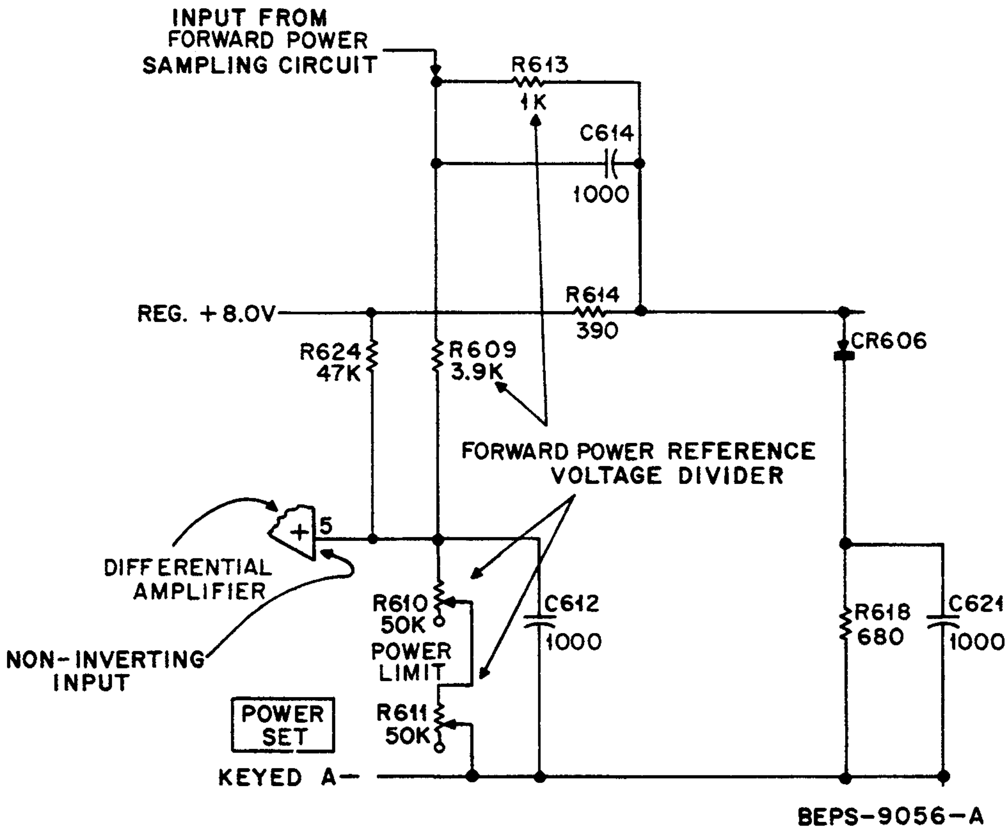


Figure 6.
Forward Power Bias Circuit

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.

b. 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.

c. Protection Circuitry

(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 final stages of the power amplifier, a dc level proportional to that power is produced by the forward power detector 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 power 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, and 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 transmitter 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

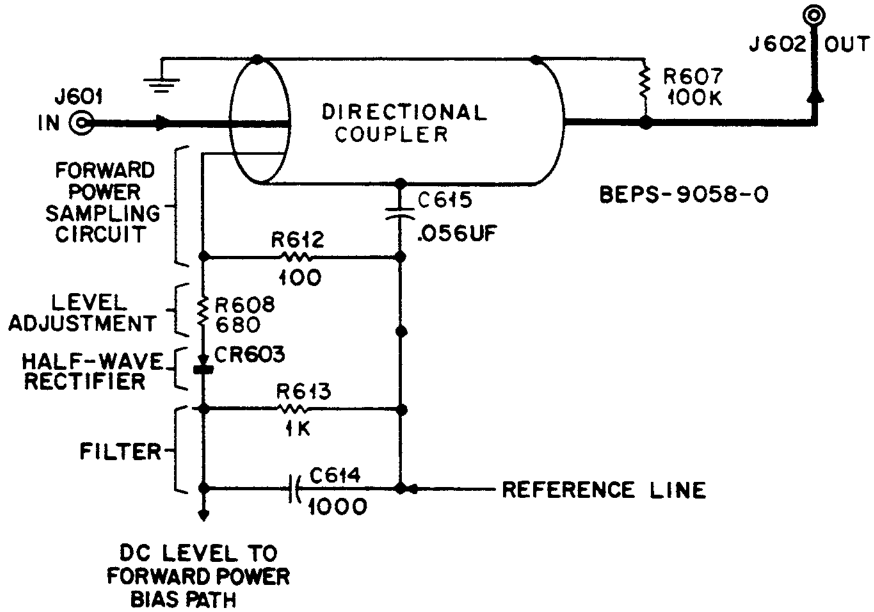


Figure 7.
Forward Power Detector Circuit

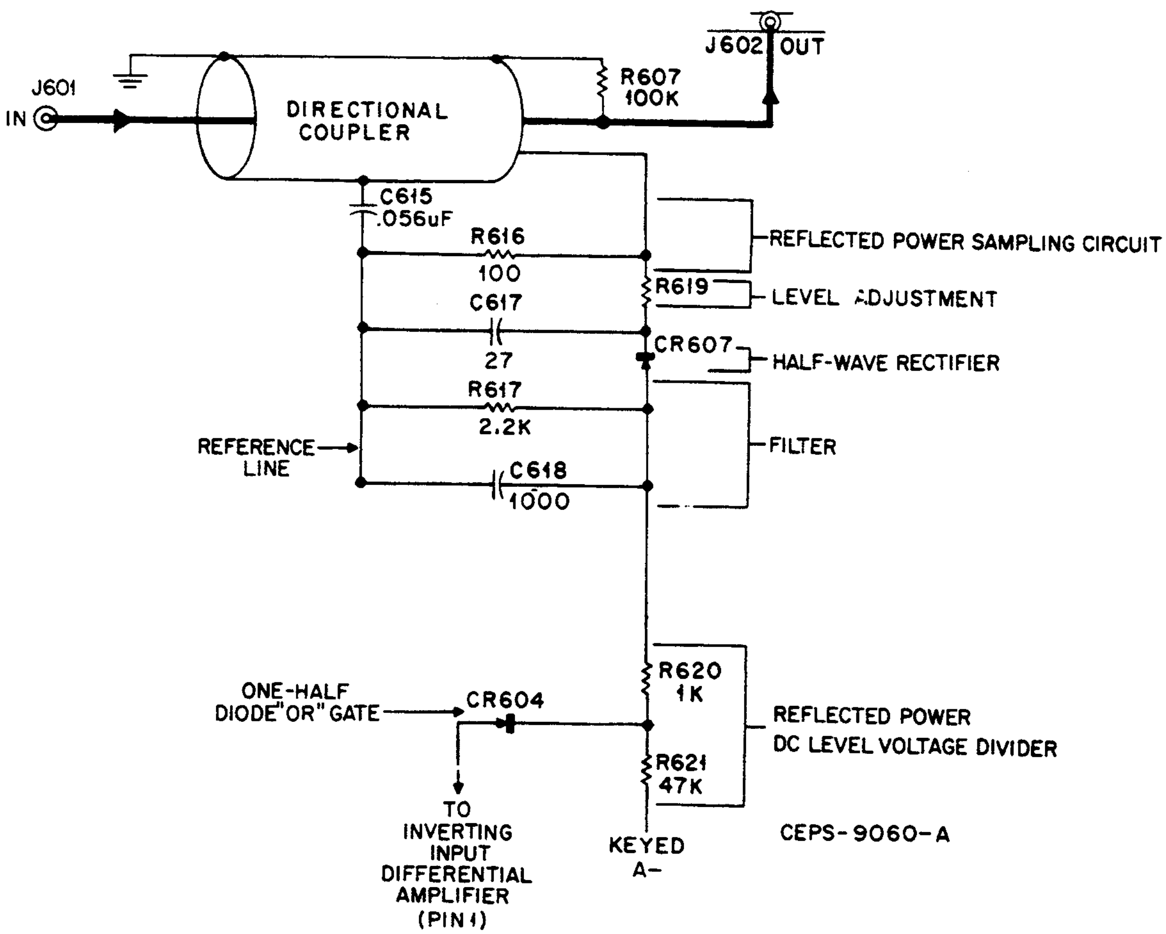


Figure 8.
Reverse Power Detector Circuit

input of the differential amplifier from the secondary divider circuitry.

(2) VSWR - Reverse Power Detection Circuit

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.

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 final stages of the power amplifier.

(3) Temperature Protection Circuit

Refer to Figure 9. When the heat sink temperature rises above approximately 80°C, the thermistor in parallel with the lower half of the VSWR voltage divider reaches a value of resistance which allows a more negative potential to be applied through the diode "OR" gate to the inverting input of the differential amplifier. The temperature protection decreases the level of the reference and therefore the power output of the power amplifier board.

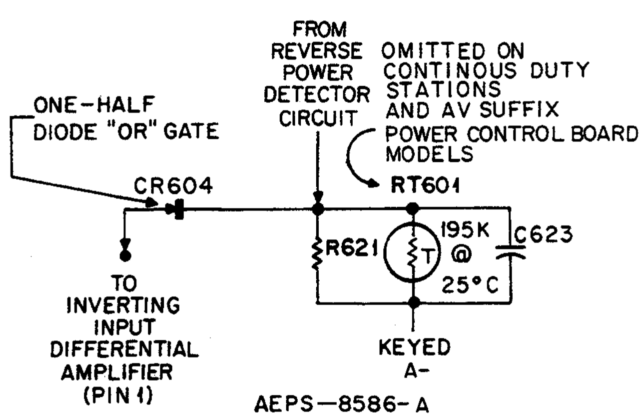


Figure 9.
Temperature Protection Circuit

Thermistor RT601 is omitted on continuous duty stations. Temperature protection is not needed due to the large exchanger used.

(4) 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 P-N-P 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, temperature, 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.

a. General

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.

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.

b. 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.

(1) Optional 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.)

(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.

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

c. 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.

(1) Using Built-In Station Metering

(a) The output of the power control board must be terminated in one of three types of loads.

--The antenna load

--A dummy load such as Motorola's T1013A RF Load Resistor.

--An RF wattmeter.

NOTE

A dummy load is preferred to the antenna to eliminate the possibility of shutback due to a defective antenna.

(b) Turn the station ON.

(c) Set the selector switch of the built-in station meter to position PWR CONT 1 and key the transmitter. Observe the wattmeter, or the meter reading if a dummy load is used or if the antenna is used. Unkey the transmitter. Under normal conditions at rated power out, meter 1 should read between 22 uA and 40 uA typically.

(2) Using Portable Test Set

(a) Set the function selector switch of the portable test set to the XMTR position.

(b) Set the meter reversing switch of the test set to the METER REV position.

(c) Set the REF switch to position A or B.

(d) 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.

(e) Connect the red "control" plug of the adapter cable to the control receptacle on the local or remote control circuit board. Connect the white "metering" plug of the adapter cable to the receptacle on the power control board.

(f) The output of the power control board must be terminated in one of three types of loads.

--The antenna load.

--A dummy load such as Motorola's T1013A RF Load Resistor.

--An RF wattmeter.

NOTE

A dummy load is preferred to the antenna to eliminate the possibility of shutback due to a defective antenna.

(g) Turn the station ON.

(h) 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 or if the antenna is used. Unkey the transmitter. Under normal conditions at rated power out, meter 1 should read between 22 uA and 40 uA typically.

d. Performance Test, Power Set Control

This control allows the power output of the station 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 power amplifier tune-up procedure.

(a) Key the transmitter.

(b) Adjust the POWER SET control until the rated power output is reached.

(c) Unkey the transmitter.

e. Troubleshooting

(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-. This feature allows operation from positive or negative ground power sources.

(2) Troubleshooting Integrated Circuits

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.

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.

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

f. Troubleshooting 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 -3 uA and -8 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 polarity switch must be set to FWD when metering the power control board.

g. Complete Power Amplifier Alignment

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

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

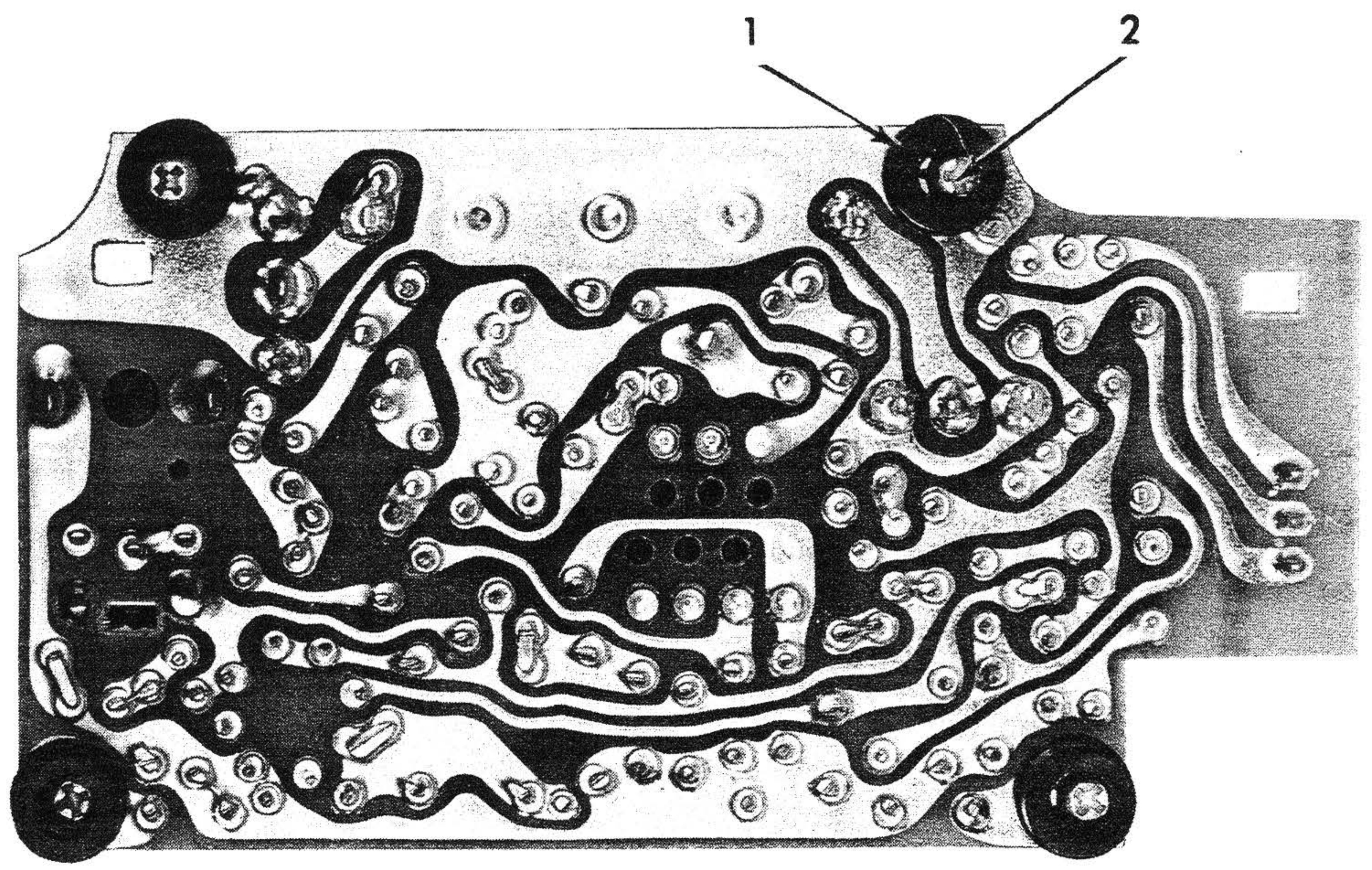
(2) Repair or replacement of the power control board.

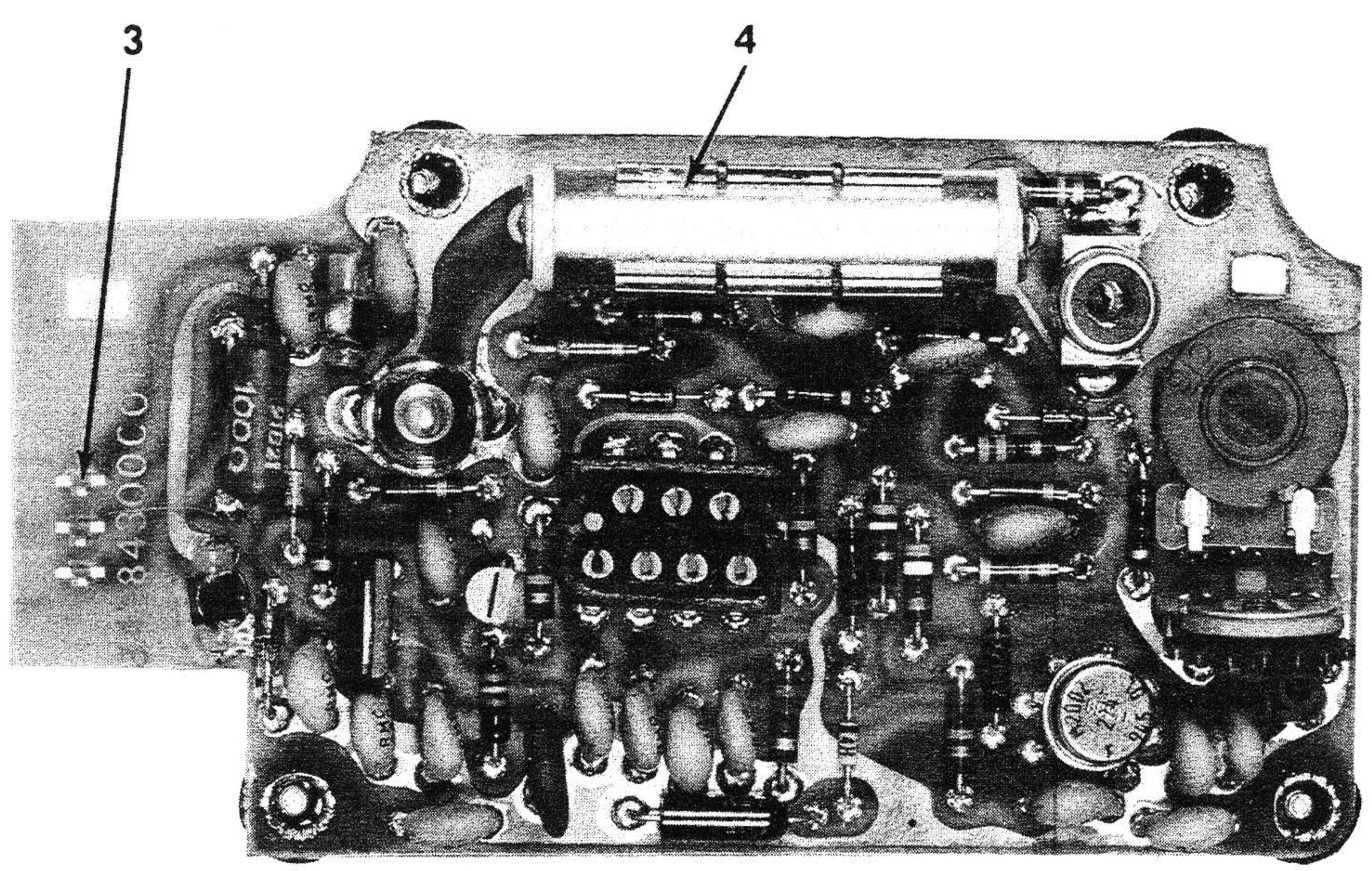
(3) A change in transmitter frequency greater than approximately ±1 MHz.

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.





BEPS-6542-O

MECHANICAL PARTS LIST

PL-1801-A

CODE	MOTOROLA PART NO.	DESCRIPTION
1	42-84284B01	RETAINER
2	3-139506	SCREW, tapping: 4-40 x 3/8"
3	29-84028H01	TERMINAL
4	42-84678B01	CLIP
NON-CODED ITEM		
	55-84300B04	HANDLE, plastic
	1-80797B34	CABLE ASSEMBLY (TLB6940AV) includes:
	42-10217A02	STRAP, tie
		CONNECTOR P1000

REVISIONS

63P81016E59-E

CHASSIS AND SUFFIX NO.	REF. SYMBOL	CHANGE	LOCATION
TLB6940A-1	C626	ADDED 1000 pF; MOTOROLA PART	DC AMPLIFIER
TLN4780A-1	C780	ADDED 23-83214C20, 10 uF	P.A. INPUT (A+, A-)
	L780	ADDED 24-80900A61, 0.62 MH	
	R780	ADDED 6-124B67, 8.2 OHMS	
TLN6940AV		NEW MODEL ADDED	

ELECTRICAL PARTS LIST

NOTE

This parts list covers more than one model. Where differences exist the model number of the applicable unit is given in the Description column.

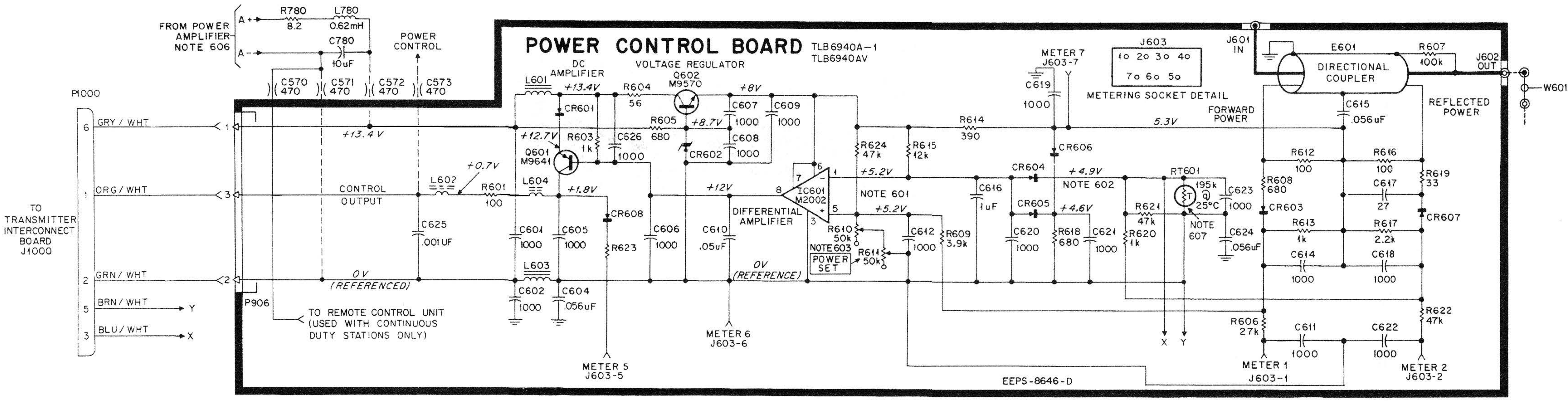
TLB6940A/AV Power Control Board PL-1764-D

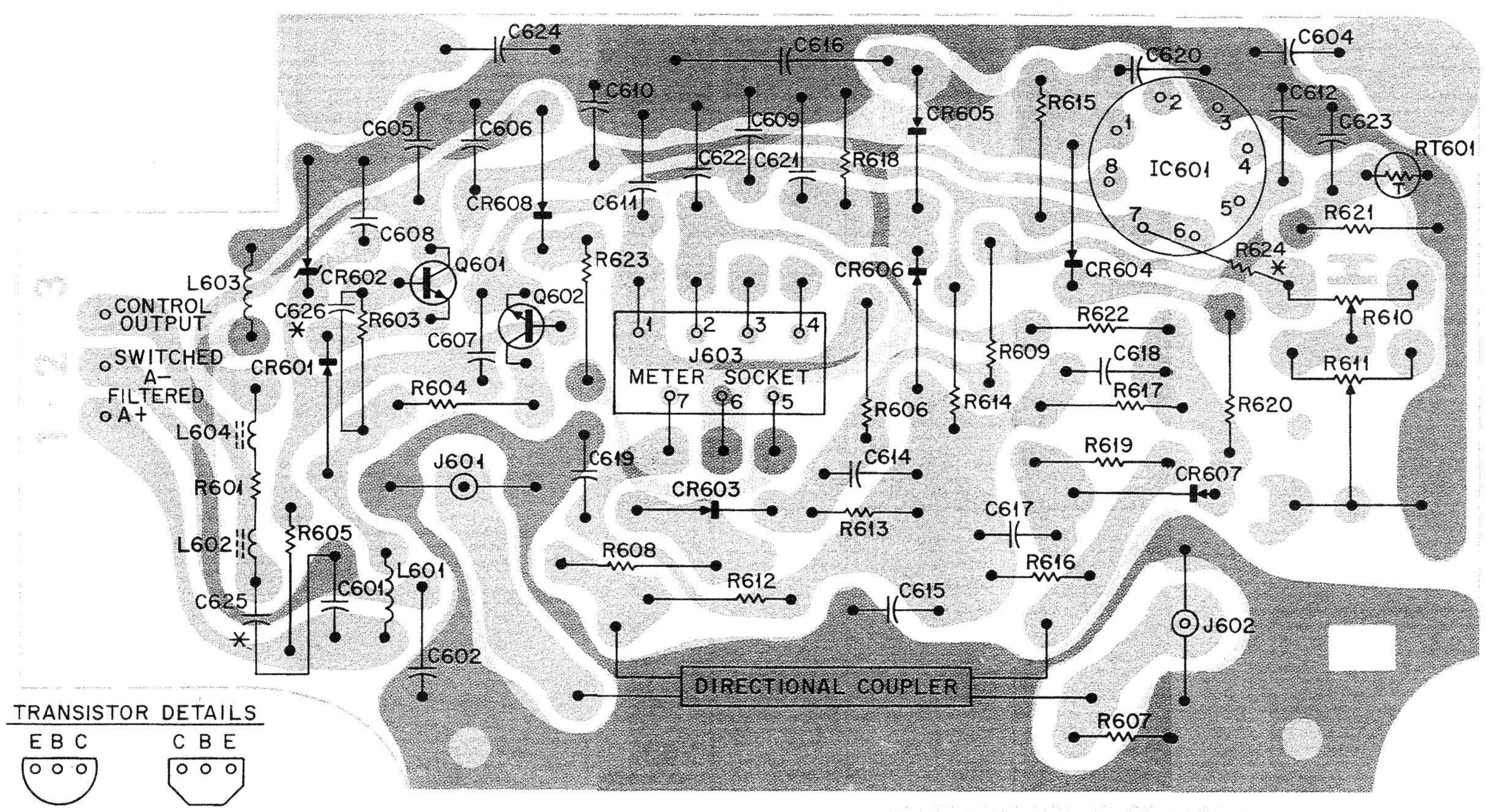
REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
		CAPACITOR, Fixed: pf; ±10%; 200V; unless otherwise stated
C601	21D83596E22	1000
C602	21D83596E22	1000
C603		NOT USED
C604	21D84008H07	.056 uF ±10%; 100V
C605	21D83596E22	1000
C606	21D83596E22	1000
C607	21D83596E22	1000
C608	21D83596E22	1000
C609	21D83596E22	1000
C610	21C82372C04	.05 uF +80 -20%; 25V
C611	21D83596E22	1000
C612	21D83596E22	1000
C613		NOT USED
C614	21D83596E22	1000
C615	21D84008H07	.056 uF ±10%; 100V
C616	23D83214C04	1 uF ±20%; 15V
C617	21D83406D68	27 ±5%; 500V; NPO
C618	21D83596E22	1000
C619	21D83596E22	1000
C620	21D83596E22	1000
C621	21D83596E22	1000
C622	21D83596E22	1000
C623	21D83596E22	1000
C624	21D84008H07	.056 uF ±10%; 100V
C625	21D83596E22	1000
C626	21D83596E22	1000
		SEMICONDUCTOR DEVICE, diode: (SEE NOTE)
CR601	48C83654H01	silicon
CR602	48C83696E04	silicon; Zener type; 9.1V
CR603	48C84616A01	silicon
CR604	48C82392B18	silicon
CR605	48C82392B18	silicon
CR606	48C82392B18	silicon
CR607	48C84616A01	silicon
CR608	48C82392B03	silicon
		COUPLING DEVICE, RF transmission line:
E601	58-84497B01	("directional coupler")
		INTEGRATED CIRCUIT:
IC601	51R84320A02	type M2002
		CONNECTOR, receptacle:
J601	28C84227B02	male; coaxial; miniature type
J602	9C84231B02	female; coaxial; miniature type
J603	9C84207B01	female; 7-contact
		COIL, RF:
L601	76B83960B01	ferrite bead
L602	24C83961B01	choke; 3 turns; coded BRN
L603	76B83960B01	ferrite bead
L604	24-83961B01	choke; 3 turns; coded BRN
		CONNECTOR, plug:
P1000	--	consists of: (TLB6940AV)
	15-83498F06	HOUSING, connector
	29-83499F01	CONTACT, terminal: 5 used
	46-84549F01	PLUG, polarizing
		TRANSISTOR: (SEE NOTE)
Q601	48R869641	P-N-P; type M9641
Q602	48R869570	N-P-N; type M9570
		RESISTOR, fixed: ±5%, 1/4W; unless otherwise stated
R601	17C82291B21	100 ±5%; 3W
R602		NOT USED
R603	6S127802	1k
R604	6-124A19	56
R605	6-124A45	680
R606	6S129886	27k
R607	6-124A97	100k
R608	6S129984	680
R609	6-124A63	3.9k
R610	18C83083G26	variable: 50k ±30%
R611	18C83083G20	variable: 50k ±30%; (opens at fully clockwise position)
R612	6S131524	100
R613	6-124A99	1k
R614	6S124A39	390
R615	6-124A75	12k
R616	6S131524	100
R617	6-124A57	2.2k
R618	6S129984	680
R619	6S124A13	33
R620	6-124A49	1k
R621	6-124A89	47k
R622	6-124A89	47k
R623	6-124B06	220k
R624	6-124A89	47k
		THERMISTOR:
RT601	6K867628	194k ±10% @25°C; 3/4 watt max. (TLB6940A)

NOTE:
Replacement diodes and transistors must be ordered by Motorola part number only for optimum performance.

Power Amplifier Heatsink Kit (P/O TLN4780A) PL-2657-A

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
		CAPACITOR, fixed:
C780	23-83214C20	10 uF ±20%; 20 V
		COIL, RF: choke;
L780	24-80900A61	0.62 mH; coded BRN-ORG
		RESISTOR, fixed:
R780	6-124B67	8.2 ±5%; 1/4 W





* CONNECTED ON FOIL SIDE OF BOARD.

SHOWN FROM SOLDER SIDE

OL-CEPS-6536-E

POWER CONTROL BOARD

601. VOLTAGES AT PINS 1 AND 5 SHOULD DIFFER BY LESS THAN 50 mV.
602. VOLTAGE MEASURED AT 25°C.
603. FACTORY ADJUSTMENT.
604. TYPICAL VOLTAGES UNDER NORMAL OPERATING CONDITIONS.
605. UNLESS OTHERWISE STATED: CAPACITOR VALUES ARE IN PICOFARADS; RESISTOR VALUES ARE IN OHMS.
606. CAPACITORS C570, C571, C572, AND C573 ARE USED WITH ALL CONTINUOUS DUTY STATIONS EXCEPT 72-76 MHz STATIONS.
607. RT601 OMITTED IN CONTINUOUS DUTY STATIONS AND FOR MODEL TLB6940AV.

EPS-8647-B

PREVIOUS REVISIONS AND PARTS LIST SHOWN ON BACK OF THIS DIAGRAM

Power Control Board Model TLB6940A/TLB6940AV
Schematic Diagram and Circuit Board Detail
Motorola No. 63P81016E59-F
7/18/77-PHI