MPAC
UHF
Base Station Transmitter

Instruction Manual

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4201-0810-001

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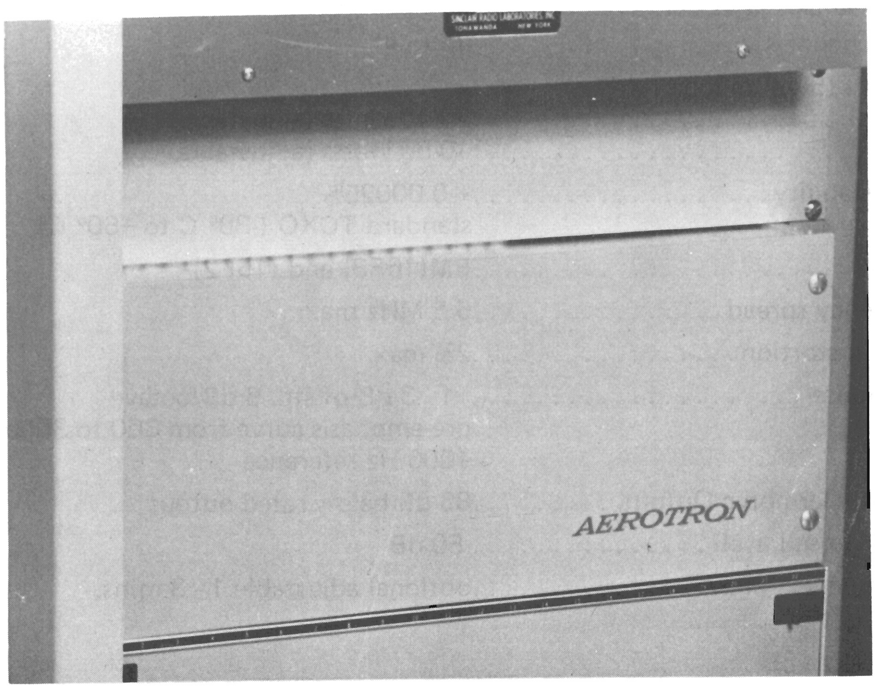
INSTRUCTION MANUAL

Section 1
GENERAL DESCRIPTION

The 80BT40/90 base station transmitter is a high-performance, fully modular transmitter capable of operating in the most demanding environments in FM simplex and duplex base stations and repeaters.

Plug-in circuit boards minimize the use of interconnecting wire. Modern solid-state devices, FET's integrated circuits, TCXO's and completely electronic function switching results in high quality and reliability at a reasonable price.



Changed information, if any, affecting this section is found at the rear of the manual.

GUARANTEED MINIMUM PERFORMANCE

General Specifications

Size	7"H x 19"W x 7"D (18cmH x 48cmW x 18cmD)
Weight	16 pounds
Input Voltages:	
80BT40	+12.5 VDC, 12 Amps. +12.5 VDC, 0.5 Amps. + 9.5 VDC, 0.1 Amps.
80BT90	+12.5 VDC, 28 Amps. +12.5 VDC, 0.5 Amps. + 9.5 VDC, 0.1 Amps.
FCC Data	
80BT40	40 Watts
80BT90	90 Watts
Frequency Range	450 - 512 MHz
Number of channels	up to 4
Power output (50 ohm load)	
80BT40	20-40 Watts (adjustable)
80BT90	40-90 Watts (adjustable)
Frequency stability	+ 0.00025% standard TCXO (-30° C to +60° C)
Modulation	FM(16F3) and (15F2)
Multi-frequency spread	5.5 MHz max.
Modulation distortion	2% max.
Audio Response	+1, -3 dB of std. 6 dB/octave pre-emphasis curve from 300 to 3000 Hz, 1000 Hz reference
Spurious and Harmonic Output	85 dB below rated output
FM Hum & Noise Level	-50 dB
Time-out Timer	optional adjustable 1 - 3 mins.

All Measurements per EIA RS-152B

Section 2
OPERATING INSTRUCTIONS

All controls for the transmitter are external to the unit. All control functions are available at the terminal strips on the rear.

Section 3
CIRCUIT DESCRIPTIONS

The channel oscillators are Colpitts type with output derived from a voltage divider in the emitter. When more than one oscillator is used, the emitter resistor of each oscillator is tied to a common bus which is connected to ground through a 47 OHM resistor and a transistor switch. The oscillator voltage which appears on the bus is low. This division reduces loading of the oscillator itself and prevents "pulling" of the transmitter frequency by the following circuitry. Additional isolation is obtained by untuned buffers which drive the phase modulator. The output of the buffer is then coupled to a sawtooth generator consisting of Q1308, a Schottky diode (CR1303), and an emitter follower (Q1309). The output of the sawtooth generator is a positive going ramp at the oscillator frequency and is capacitively coupled to one input of a comparator (IC 1301).

The transmitter audio, also located on the modulator board, contains a pre-emphasis network and a mike amplifier (Q1301, Q1302, Q1303) ahead of the double diode limiter (CR1301, 1302). Following the limiter, a de-emphasis network, and an active low pass filter (Q1304, Q1305) connect to the other comparator input. The output of the comparator consists of a square wave whose rise is controlled by the audio signal and whose fall is coincident with the ramp fall. This square wave is fed into the third buffer (Q1310) which drives a leading edge pulse amplifier (Q1311). The tuning and amplification provided by Q1311 result in a phase modulated sinusoidal output at the crystal frequency.

Q201 is a buffer which amplifies the fundamental frequency. The buffer in turn drives the first tripler, which operates Class B. A triple-tuned circuit follows the first tripler to reject other harmonic products generated by the multiplier.

The 37 MHz signal is next applied to a Class C tripler, which is followed by a double-tuned circuit to reduce undesired output signals. The 112 MHz output from the second tripler is doubled by the first doubler. This 225 MHz signal is then doubled to the output frequency by the second doubler. The output circuit of the exciter final is a low Q tuned circuit providing a match to 50 ohms. An output jack permits coupling exciter output to a highly selective three section tuned bandpass filter. The filter output is coupled to the final amplifier assembly.

The 80BT40 final amplifier consists of three power transistors which amplify the output of the exciter (.2W nominal) to the 40 Watt level. Q301 amplifies the exciter output to the four Watt level; Q302 increases this level to approximately 20 Watts, and Q303 produces the nominal 45 Watts required for 40 Watts at the antenna connector.

The 80BT40 final amplifier serves as a driver for the 90 Watt final amplifier consisting of Q3104 and Q3105 in the 80BT90.

Transmit/receive switching and power control sensing is provided by the T/R switch in both the 80BT40 and 80BT90. In this T/R switch three diodes are also used – one in the series path between transmitter and antenna port – and two in shunt with two quarter wave sections of 50 ohm line between antenna port and the receiver input port (see schematic). The two series quarter wave lines are required to reduce RF levels at the receiver port during transmit mode. The power control sensing circuit rectifies a small amount of RF energy and creates a bias which is fed to the power control board.

The power control board performs two functions:

1. It responds to the level of bias fed back from the T/R switch so that power can be adjusted to rated output and protect against VSWR conditions in the antenna system.

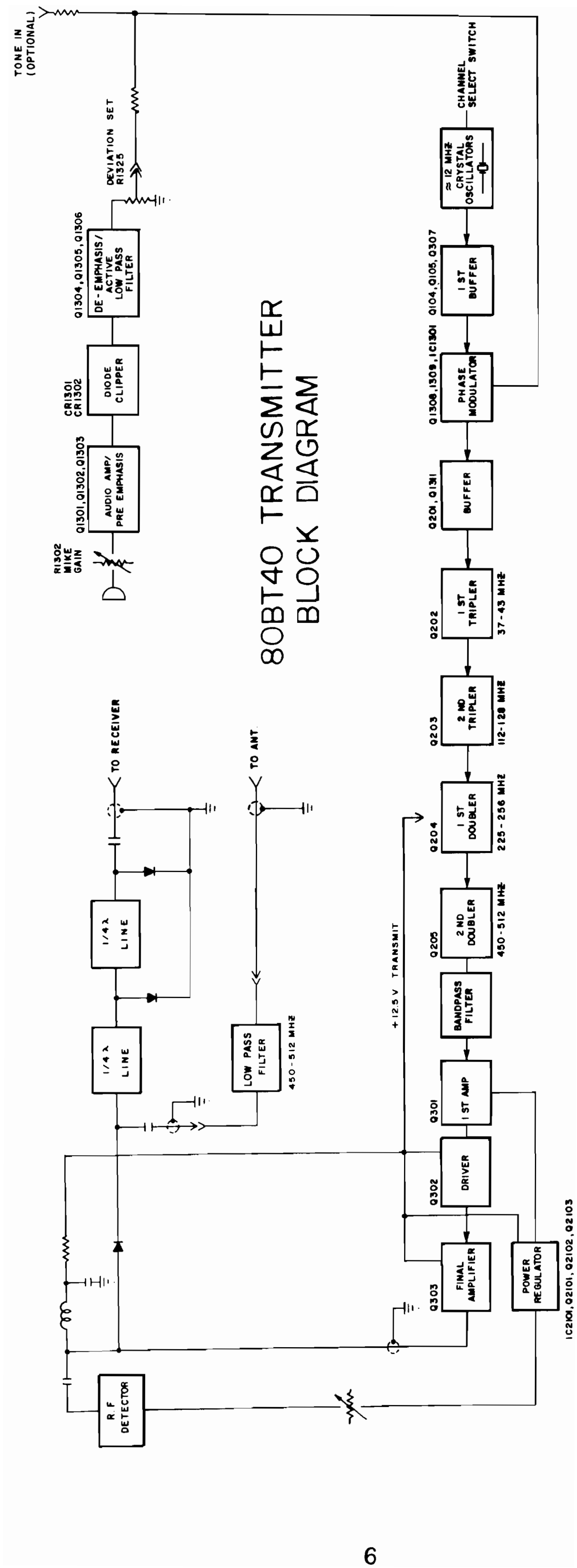
2. It responds to excessive heat on the final amplifier heat sink.

In each of the above cases, voltage is reduced to Q301 to bring power down (by adjustment of R503) to rated levels or to safe levels after extended use or under conditions of extreme VSWR.

Frequency Control:
Frequency control of the carrier is obtained by using high stability crystals which maintain $\pm$.00025% stability from 0 to +60^{o} C. A negative temperature co-efficient thermistor located adjacent to the channel crystal senses the crystal ambient temperature. At nominal ambient temperature, (0 to 60^{o} C) the resistance of this thermistor is very low, placing a selected fixed NPO capacitor essentially across the crystal to produce a nominally 32 pf load capacitance. At low ambient temperatures (below 0^{o} C) at which high stability AT cut crystals drop in resonant frequency, the resistance of this thermistor increases exponentially. This causes a net reduction in the load capacitance across the crystal, so that the oscillator frequency is held constant within $\pm$.00025%. A high-stablilty air dielectric capacitor is used for frequency adjustment, and the oscillator is powered from a regulated 9.5B supply. Resistive isolation of the oscillator output as well as an untuned buffer amplifier assure that load variations do not affect the transmitter frequency. The oscillators are housed in a metal compartment to minimize radiation of unwanted spurious signals as well as to provide an isothermal surface surrounding both the crystal and thermistor.

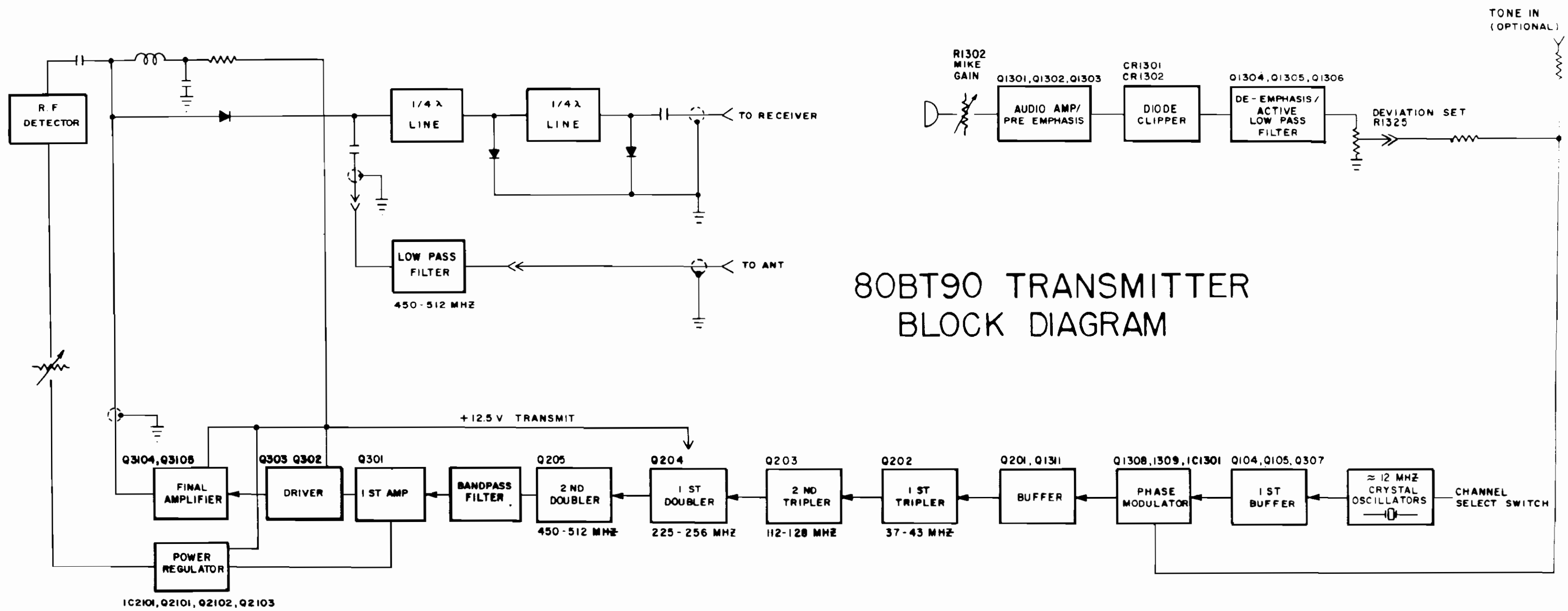
Channel Selection:
The basic 80BT40/90 is supplied with four channel capability. Channel selection is made by selecting the appropriate transmit channel and applying +9.5 VDC to the oscillators.

Transmitter Automatic Gain Control 80BT40/90:
Automatic gain control is provided in the transmitter power amplifier to maintain constant output power as well as to permit operation at reduced power. The RF power level at the T/R switch is detected and, through a potentiometer, applied to one side of a differential amplifier. A fixed voltage is applied to the other side of the differential amplifier. The resulting difference voltage is amplified in Q2102 and Q2103, which regulates the DC voltage applied to the pre-driver stage of the power amplifier. Any increase in power output across the 50 ohm transmitter load or higher RF voltage due to antenna VSWR will therefore result in an increase in detector output at the differential amplifier, and consequently a decrease in DC voltage at the collector of Q301, the RF pre-driver. This in turn will reduce the RF power output of the pre-driver, through the driver and final stages, the output power of the transmitter, and thus stabilizing the output power of the transmitter. At any set power level, the final stage matching network, C322 in 80BT40, C3116 in 80BT90 must be adjusted for minimum DC input current. Additional circuitry is provided on the transmitter power control board to protect the transmitter. against damage due to excessive transistor temperature. A thermistor coupled to the final heat-sink controls a second differential amplifier which reduces the DC reference voltage of the power control differential amplifier (IC2101) when the heatsink temperature exceeds 100° C. RF power is reduced approximately 50% from the pre-set level to reduce dissipation and hold down heat sink temperature.

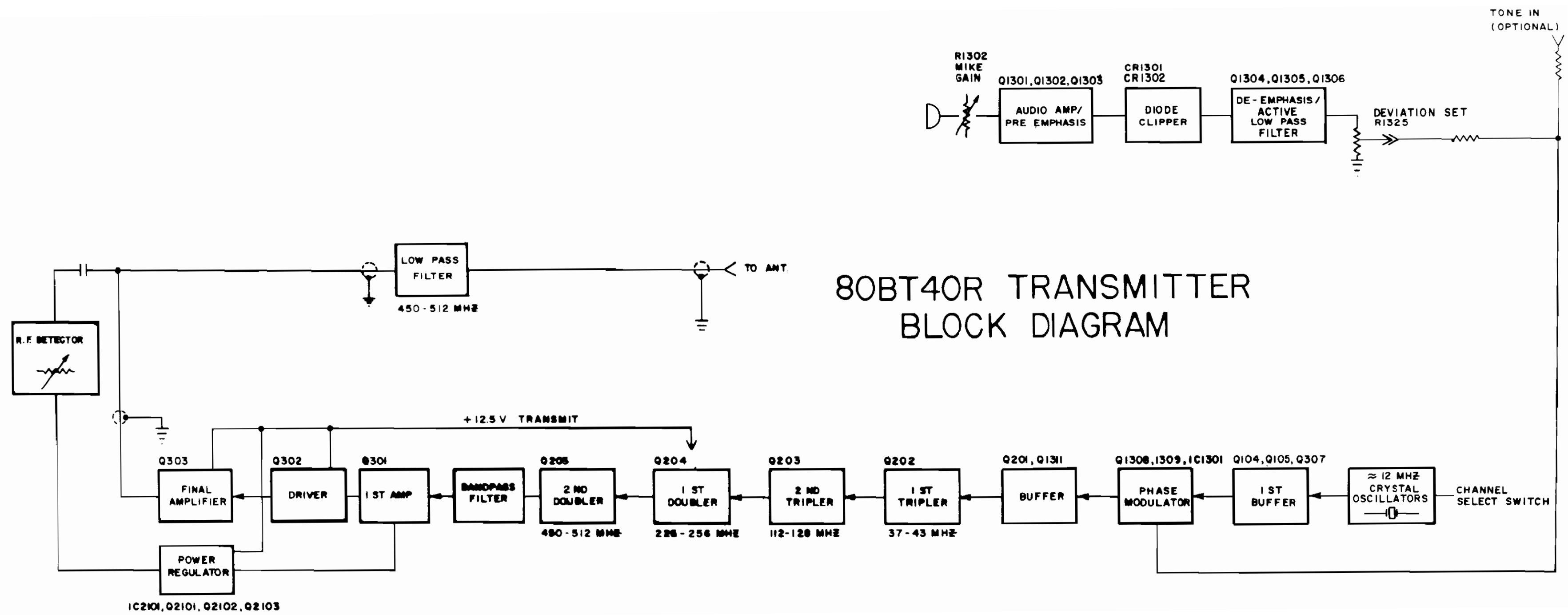


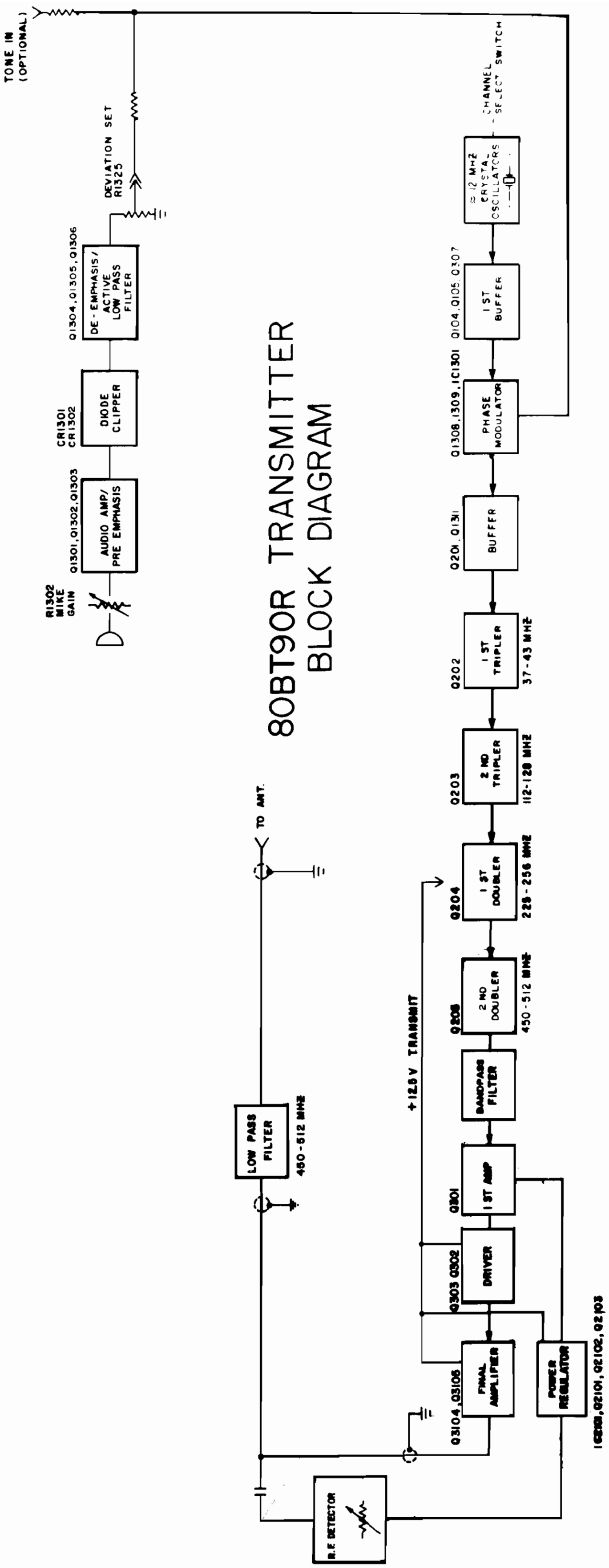
80BT40 TRANSMITTER
BLOCK DIAGRAM
TONE IN (OPTIONAL)
DEVIATION SET R1325
R1302 MIKE GAIN
Q1301, Q1302, Q1303
AUDIO AMP/ PRE EMPHASIS
CR1301 CR1302
DIODE CLIPPER
Q1304, Q1305, Q1306
DE-EMPHASIS/ ACTIVE LOW PASS FILTER
CHANNEL SELECT SWITCH
≈ 12 MHZ CRYSTAL OSCILLATORS
Q104, Q105, Q307
1 ST BUFFER
Q1308, 1309, IC1301
PHASE MODULATOR
Q201, Q1311
BUFFER
Q202
1 ST TRIPLER
37-43 MHZ
Q203
2 ND TRIPLER
112-128 MHZ
Q204
1 ST DOUBLER
225-256 MHZ
Q205
2 ND DOUBLER
450-512 MHZ
BANDPASS FILTER
Q301
1 ST AMP
Q302
DRIVER
Q303
FINAL AMPLIFIER
POWER REGULATOR
IC2101, Q2101, Q2102, Q2103
+12.5 V TRANSMIT
RF DETECTOR
1/4 λ LINE
1/4 λ LINE
LOW PASS FILTER
450-512 MHZ
TO RECEIVER
TO ANT.

80BT90 TRANSMITTER BLOCK DIAGRAM



80BT40R TRANSMITTER BLOCK DIAGRAM




80BT90R TRANSMITTER
BLOCK DIAGRAM
TONE IN (OPTIONAL)
DEVIATION SET R1325
R1302 MIKE GAIN
Q1301,Q1302,Q1303
AUDIO AMP/ PRE EMPHASIS
CR1301 CR1302
DIODE CLIPPER
Q1304,Q1305,Q1306
DE-EMPHASIS/ ACTIVE LOW PASS FILTER
≈12 MHZ CRYSTAL OSCILLATORS
CHANNEL SELECT SWITCH
Q104,Q105,Q307
1 ST BUFFER
Q1308,1309,IC1301
PHASE MODULATOR
Q201,Q1311
BUFFER
Q202
1 ST TRIPLER
37-43 MHZ
Q203
2 ND TRIPLER
112-128 MHZ
Q204
1 ST DOUBLER
225-256 MHZ
Q205
2 ND DOUBLER
450-512 MHZ
BANDPASS FILTER
+12.5V TRANSMIT
Q301
1 ST AMP
Q303 Q302
DRIVER
Q3104,Q3105
FINAL AMPLIFIER
POWER REGULATOR
IC2101,Q2101,Q2102,Q2103
LOW PASS FILTER
450-512 MHZ
TO ANT.
R.F DETECTOR

Section 4
TRANSMITTER ALIGNMENT PROCEDURE

1. Connect the exciter cleanup cavity output directly to a wattmeter and dummy load through a suitable coaxial cable. Monitor J4-7 with a VOM or VTVM on the +1.5 volt scale and key the transmitter. Adjust the slug in L201 for maximum positive meter reading.

2. With VOM connected to J4-7, key transmitter and adjust L202 for a dip-then L203 for a slight peak. Connect VOM to J4-8 and adjust L204 for a peak. Readjust L202 and L203 for maximum at J4-8.

3. With VOM still connected to J4-8, key transmitter and adjust L205 for a dip. Connect VOM to J4-9 and adjust L206 for a peak. Repeak L205, (1.5V).

4. With VOM connected to J4-9, key transmitter and adjust L207 for a dip. Connect VOM to J4-10 and adjust L208 for a peak. Repeak L207, (1.3V).

5. With VOM connected to J4-10 key transmitter, adjust C238 for a minimum reading. Use 1 watt full scale R.F. power meter for output indicator. Connect VOM to J4-11. Adjust C2201, C2202, C2203 in exciter cleanup cavity for a maximum reading on wattmeter. Readjust each capacitor until no further increase is measured on wattmeter. A voltage reading of approximately 3 volts should be obtained at TP11 with the transmitter keyed.

6. While monitoring J4-11 with VTVM, readjust each coil L201 through L208 and each capacitor C238, C2201, C2202, C2203 for maximum indication. Unkey transmitter.

7a. (80BT40)
Disconnect wattmeter and reconnect the amplifier input cable to the exciter cleanup cavity output jack. Connect a wattmeter with 50 watt element and a 50 ohm load for the antenna connector. Adjust R503 to full clockwise (onT/R). Key transmitter and observe power output. While transmitter is keyed, adjust C302 and C322 for maximum indication on wattmeter. Adjust R503 counterclockwise until 40 watt indication on wattmeter is obtained.

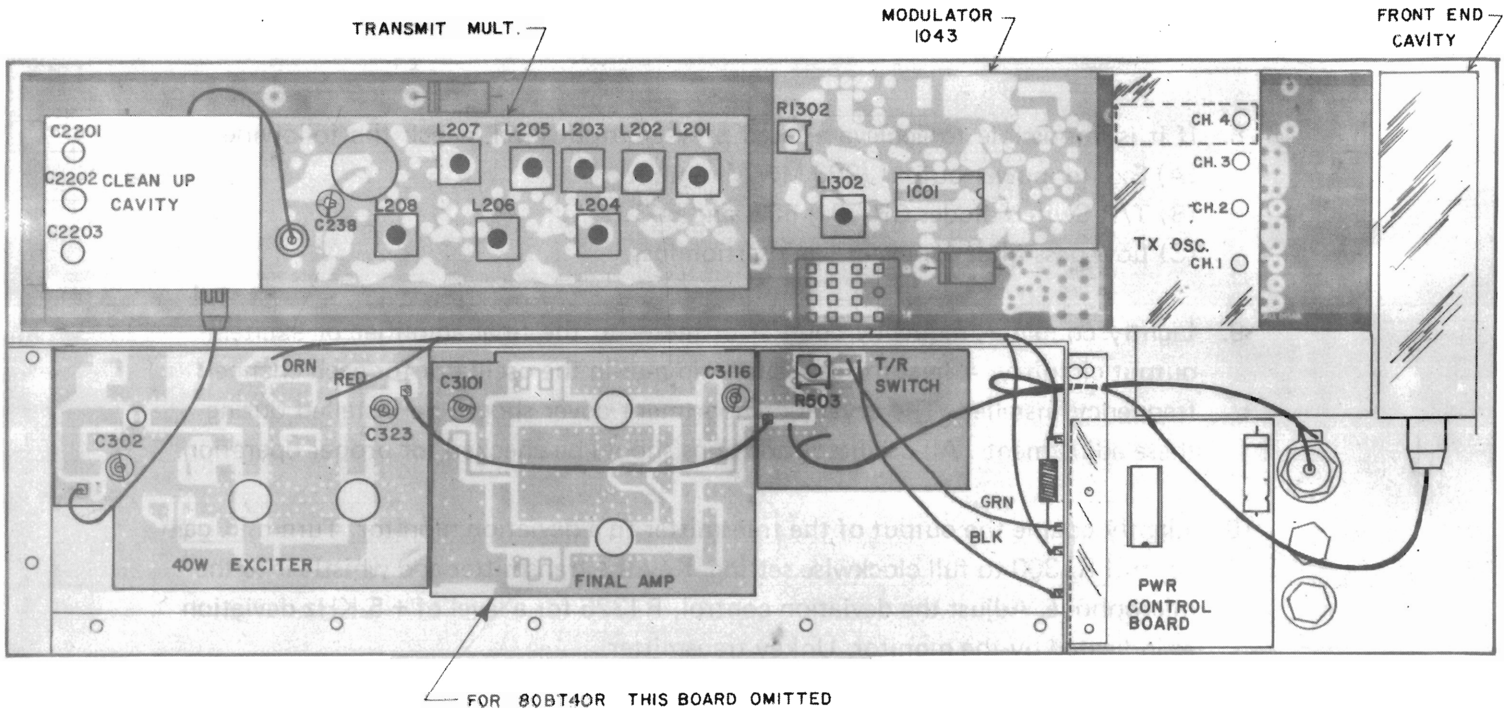
7b. (80BT90)
Disconnect wattmeter and reconnect the amplifier input cable to the exciter cleanup cavity output jack. Connect a wattmeter with100 watt element and a 50 ohm load to the antenna connector. Adjust R503 (onT/R) to full clockwise. Key transmitter and observe power output. While transmitter is keyed, adjust C302 and C322 on driver board and C3101 and C3116 on final amplifier board for maximum output. Adjust R503 counterclockwise for 90 watt indication on wattmeter.

8. If it is impossible to achieve a rated power output level, check the following:
   (A) Exciter power output (200 MW Minimum)
   (B) T/R Switch diodes CR-501, 502, and 503
   (C) Low pass filter for excessive insertion loss.

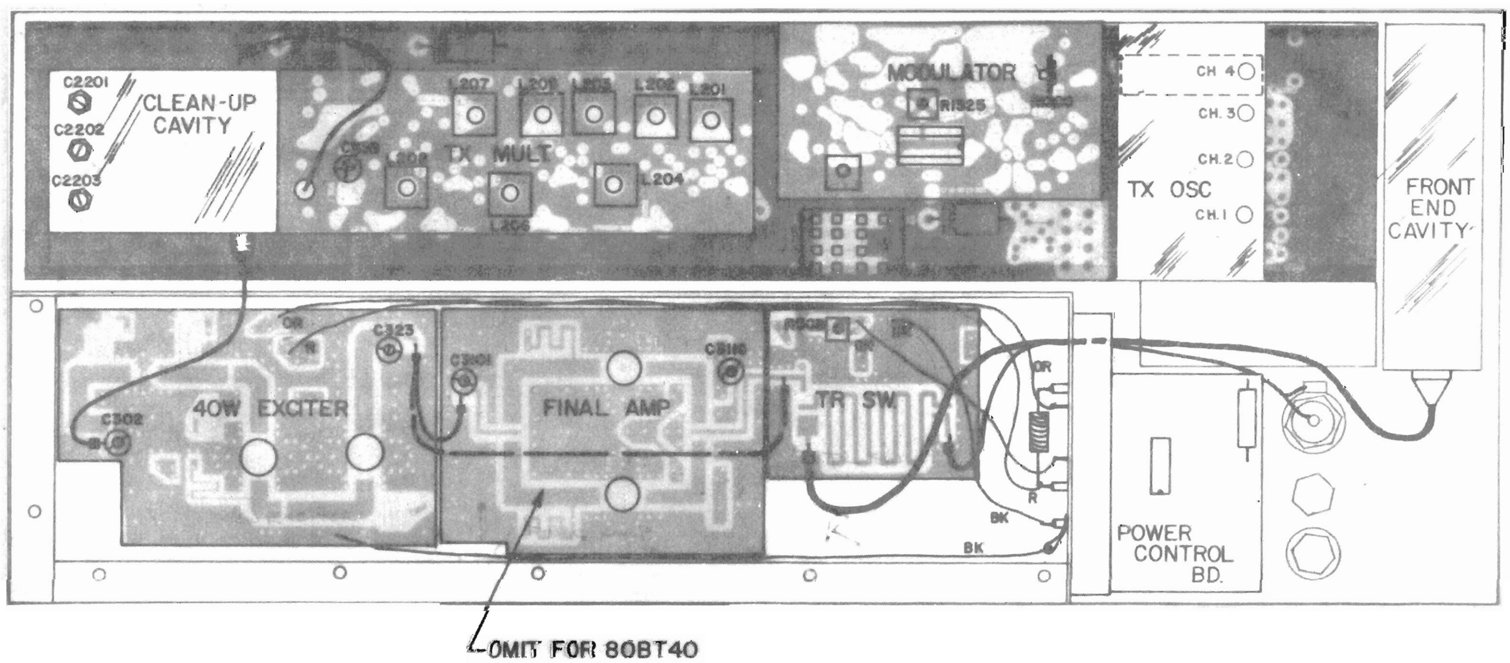
9. Lightly couple a frequency counter or meter to the final amplifier or exciter output circuitry. Adjust the capacitor trimmer in the oscillator for each channel frequency installed. The crystal compartment cover should be installed during these adjustments. All oscillator positions should be checked for proper operation.

10. Lightly couple the output of the transmitter to a deviation monitor. Turn mic. gain control R1300 to full clockwise setting. Key the transmitter and whistle into the microphone. Adjust the deviation control, R1325 for a level of + 5 KHz deviation as indicated by the monitor. Unkey transmitter.

11. Key transmitter and speak in a normal voice into the microphone. Adjust R1300 (mic. gain control) downward until voice peaks no longer reach + 5KHz. Note this pot setting and its relation to full counterclockwise. Now advance the mike gain (clockwise rotation) to a point approximately two times as far from full counterclockwise.



80BT40R/90R ADJUSTMENT LOCATION



80BT40/90 ADJUSTMENT LOCATION

Section 5
TROUBLESHOOTING

(Refer to schematics and parts list in the manual when performing maintenance on the unit. Also, refer to circuit descriptions in Section 3. Transistor and integrated circuit pin layouts as well as color code information is given below.)

The radio is constructed with individual circuit "Blocks" contained on separate modules or plug-in printed circuit boards. The major assemblies are shown to aid in fault isolation as well as normal preventive maintenance and alignment.

Most of the subassemblies simply plug in, and fault isolation can often be simplified by substituting a known good module for the suspect assembly.

Because individual boards plug in, emergency repairs can usually be made by simply replacing the defective board. The defective board can then be repaired at the serviceman's convenience.

BE SURE NOT TO TRANSPOSE WIRES WHEN SERVICING THE UNIT, SINCE SEVERE DAMAGE TO CIRCUIT BOARD AND COMPONENTS MAY RESULT.

Troubleshooting Equipment:
The following equipment is helpful for troubleshooting the radio.

1. Aerotron Model 1037 Test Set. (contains voltmeter and 10.7 MHz signal source)

2. Oscilloscope, to observe RX and TX audio and for sweep alignment.

3. Wattmeter and dummy load, 50 ohm nominal impedance, 100 or 250 watts and 1 watt full scale sensitivity. (Bird Model 43 or equivalent)

4. Power supply adjustable from 11.5 to 14.0 VDC at 25 amp load.

5. Deviation monitor (Radio Specialty Model 1163)

6. Frequency Counter with time base stability of .0001% or better.

7. VOM or VTVM with low DC voltage range and 20K ohm/V or higher input impedance. (SIMPSON 260 or equivalent)

A number of companies manufacture combined test equipment that may be used for most adjustments and troubleshooting.

When circuit malfunctions exist, a visual check of the unit may reveal the portion of the unit in which the trouble is located. Check for broken or disconnected wires, damaged circuit boards, damaged components, etc.

In any signal tracing analysis, a good oscilloscope is indispensable. Care should be exercised, of course, to avoid misinterpretation of readings which appear to indicate malfunctions in tuned circuits. A scope can severely detune a critical circuit so that any readings taken are rendered meaningless. This is minimized with a compensated 10X probe, but not entirely eliminated.

TROUBLESHOOTING CHART

The following chart may be helpful, in conjunction with schematic, voltage charts, and circuit description, for all troubleshooting work.

PROBLEM	CHECK CIRCUIT BLOCK
1. Transmitter Deviation fails	Modulator Board
2. Transmitted signal distorted	Oscillator or phase modulator on modulator, microphone
3. Transmitter won't key	Power Supply, mike
4. Transmitter keyed continously	Power Supply, mike push-to-talk circuit
5. Transmitter power coupled to reciever, resultant damage to receiver front end	Final Board, T/R switch, mixer board

TRANSMITTER VOLTAGE CHART

Transistors			
Q	E	B	C
1	.8Tx	1.4Tx	7.1Tx
2	6.4Tx	7.1Tx	9.0Tx
4	0.0Tx	.6Tx	.1Tx
201	3.1	3.3	11.7
202	.9	.15	12.2
203	1.8	.13	12.5
204	2.3	.05	12.2
205	1.0		12.5
1301	2.7Tx	3.3Tx	9.2Tx
1302	2.7Tx	3.3Tx	6.2Tx
1303	5.7Tx	6.2Tx	9.2Tx
1304	1.4Tx	2.0Tx	9.2Tx
1305	.83Tx	1.4Tx	8.5Tx
1306	9.2Tx	8.5Tx	3.9Tx
1307	0.0Tx	.1Tx	2.4Tx
1308	1.2Tx	1.5Tx	2.3Tx
1309	1.3Tx	2.3Tx	7.6Tx
1310	6.2Tx	7.4Tx	8.6Tx
1311	.32Tx	1.0Tx	1.75Tx

14 & 16 PIN

I.C. Number	1301 Tx
(1)	4.3
(2)	
(3)	3.7
(4)	3.7
(5)	0.0
(6)	
(7)	7.4
(8)	7.4
(9)	
(10)	9.2
(11)	3.8
(12)	3.7
(13)	
(14)	4.5
(15)	
(16)	

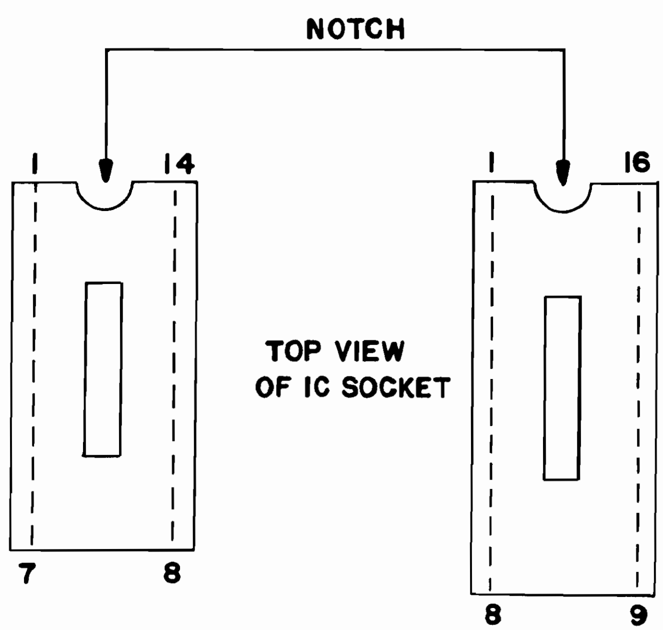
Warning:

It is advisable to disconnect the unit from the power source before replacing modules or components, but the unit should, in any case, be turned off. USE ONLY ROSIN CORE SOLDER AND LOW HEAT IRONS, preferably not exceeding 30 Watts.

When components must be replaced, check the parts list and schematic to determine whether exact replacement parts must be used. In certain cases, component type, as well as value is highly critical. ALL subminiature capacitors MUST BE REPLACED WITH EXACT REPLACEMENT. Also, substitution of values in certain circuits may result in improper performance, INCLUDING VIOLATION OF FCC RULES AND REGULATIONS.

Removing components from plated-through-hole printed boards may be more difficult than from standard boards, because a pronounced solder "wicking" effect is obtained with plated through boards. However, use only sufficient heat and tension to remove any components. It may be easier to remove some by simply cutting the component off the top side of the board (if the part is known to be defective); the leads will then come out easily by heating the pad.

Care should be exercised in replacing dual in-line integrated circuits, as the pins are quite delicate. The easiest way to insert an in-line pin IC is to place one row of pins lightly in the socket, use a straight edge to push the other row of pins into alignment, and press firmly in the IC to seat it. Do NOT attempt to remove an IC with fingers - use an IC puller or a soldering aid to lightly pry the IC from the socket. All IC's mounted in sockets should be oriented so the notch on one end of the IC is aligned with the notch in the socket. See the figure below.

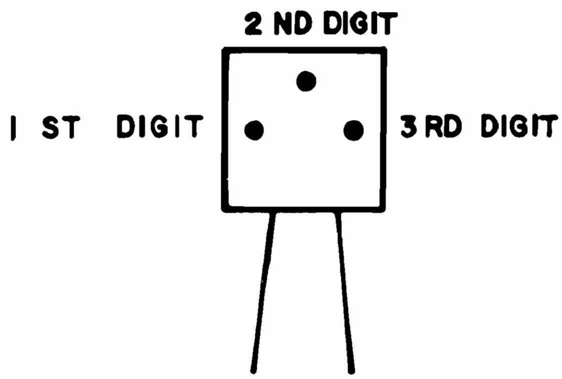


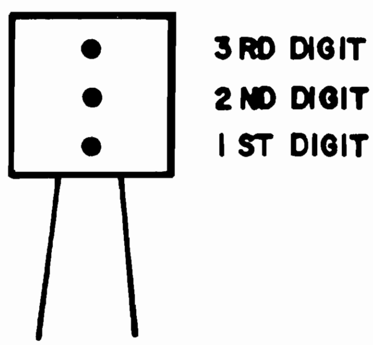
Component color codes:

All resistor color codes are standard. However, some resistors have an additional band which should not be confused with the value color code.

Most capacitors actually have values stamped on the capacitor body. In some cases, however, stamped values are coded as a combination number and letter. Unfortunately, all manufacturers are not entirely consistent in coding capacitors with a single numbering system, so some judgement must be used. In general, the capacitor will be marked, for example, 271J, which signifies 270 pf, ±5%, so that at least two significant figures are known, and a final value determination can be made by reference to the schematic.

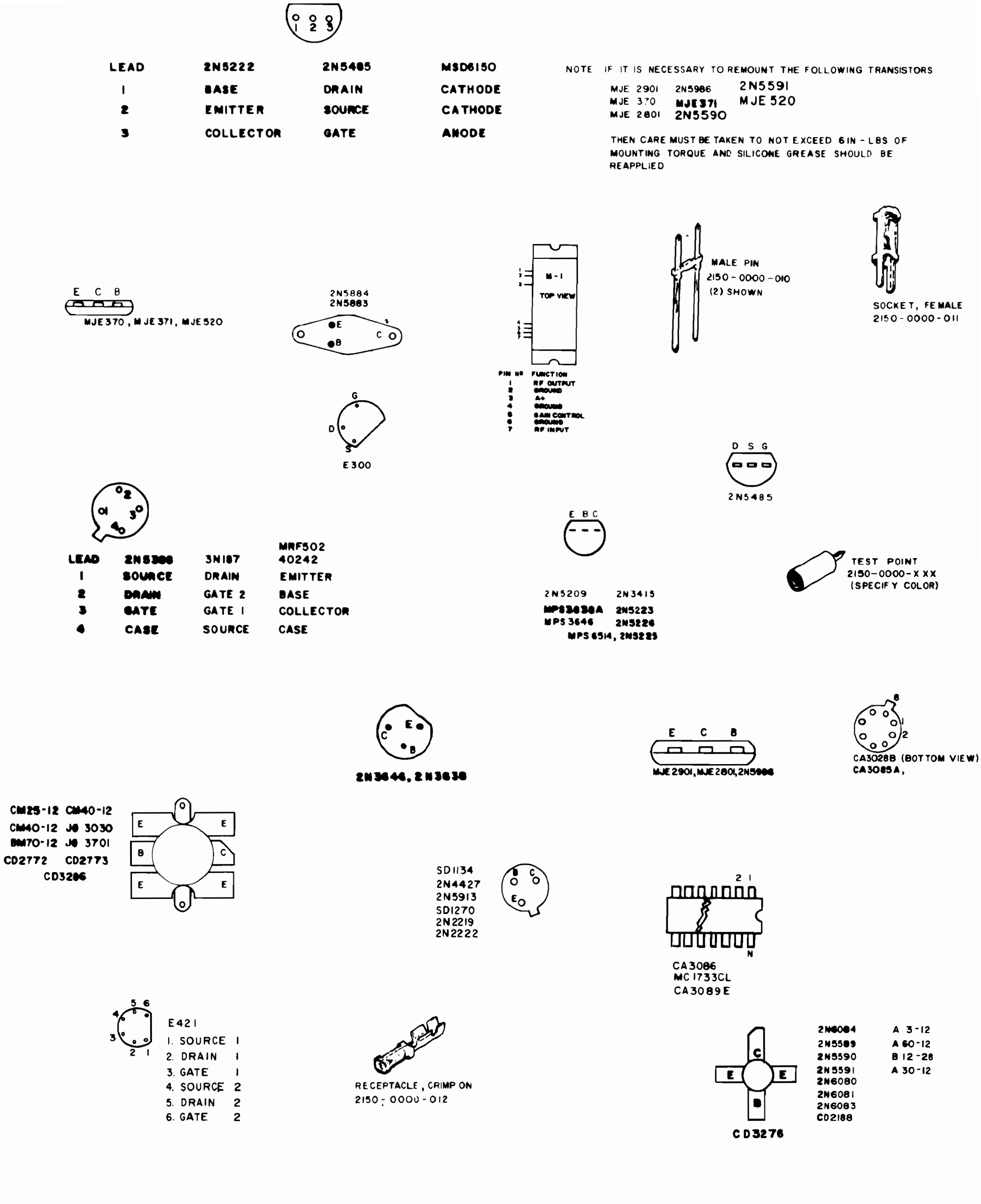
A few capacitors will be color-coded, and a three dot system is used. The value is read as follows:



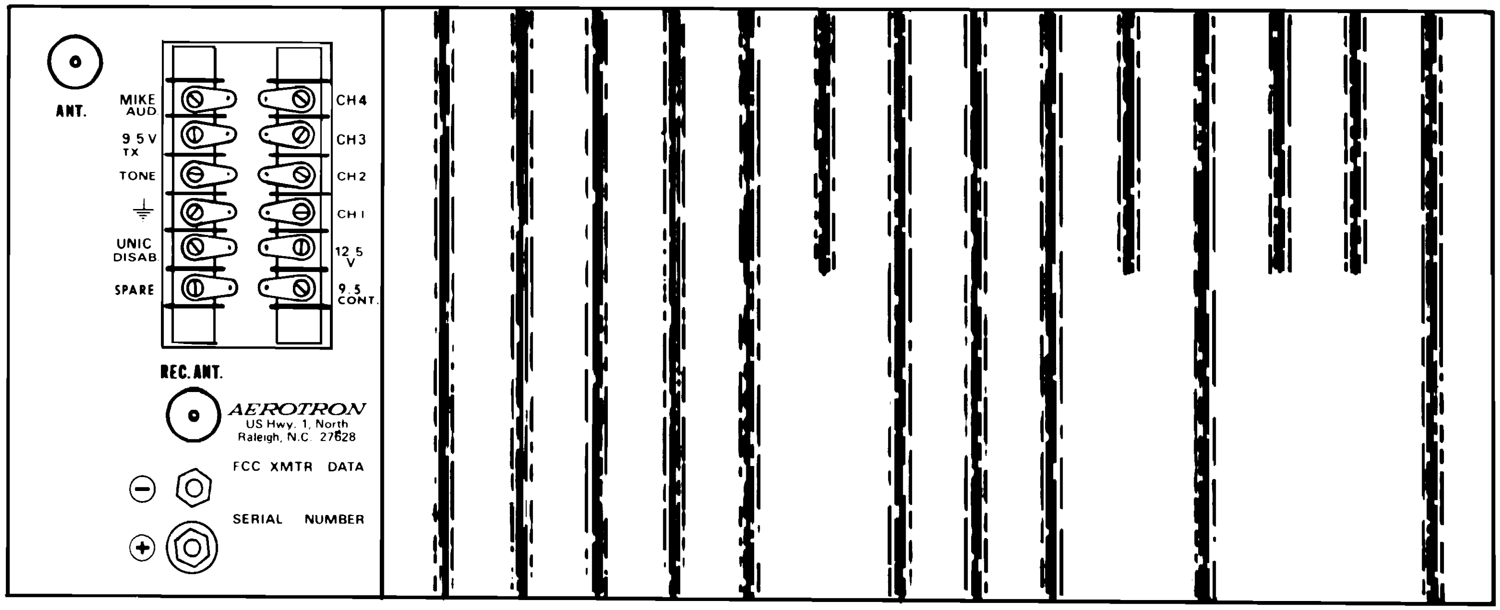


* Exception: For 1-10pf, the least digit will be white.

EXAMPLES:
1pf = Brown/Black/White (109)
10 pf = Brown/Black/Black (100)
100pf = Brown/Black/Brown (101) 1000 pf = Brown/Black
1000 pf = Brown/Black/Red (102)
10 uf = Brown/Black/Blue (106)



SEMICONDUCTOR PIN IDENTIFICATION



REAR PANEL LAYOUT