ICOM

SERVICE MANUAL

144 MHz FM TRANSCEIVER

IC-228A
IC-228E
IC-228H

Icom Inc.

SCOPE OF THE SERVICE MANUAL

This service manual covers all service information related to the theoretical, physical, mechanical and electrical characteristics of the **IC-228A/E/H 144MHz FM TRANSCEIVER**.

This picture shows the IC-228H version.

ASSISTANCE

If you require assistance or further information regarding the operation, capability and servicing of the **IC-228A/E/H**, contact your nearest authorized Icom Dealer or Icom Service Center. Addresses are provided on the inside back cover for your convenience.

ORDERING PARTS

Be sure to include the following five points when ordering replacement parts or requesting equipment information from your dealer or Icom Service Center. This will ensure faster, more efficient service.

1. Equipment model and serial number
2. Schematic part identifier or service manual page number
3. Unit name and printed circuit board number (e.g., MAIN UNIT/B-1680B)
4. Component part number and name (e.g., SC-1019 IC)
5. Quantity required (e.g., 5pcs.)

REPAIR NOTE

1. **DO NOT** open transceiver covers until the transceiver is disconnected from a power source.
2. **DO NOT** connect the transceiver to an external power source of more than 15V.
3. **DO NOT** force any of the variable components. Turn them slowly and smoothly.
4. **DO NOT** short any circuits or electronic parts.
5. An insulated tuning tool **MUST BE** used for all adjustments.
6. **DO NOT** keep power ON for a long time when the transceiver is defective.
7. **DO NOT** transmit power into a signal generator or sweep generator.
8. **Always** connect a 20dB or 30dB attenuator between the transceiver and a deviation meter or spectrum analyzer when using such test equipment.
9. Read the instructions of test equipment thoroughly before connecting equipment to the transceiver.

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SECTION 1 SPECIFICATIONS

■ GENERAL

- Frequency coverage :

MODEL	VERSION	RECEIVER	TRANSMITTER
IC-228A/H	U.S.A.	138.00～174.00MHz*	140.00～150.00MHz*
IC-228A/H	Australia	144.00～148.00MHz	144.00～148.00MHz
IC-228A/H	Asia	138.00～174.00MHz*	140.00～150.00MHz*
IC-228E/H	Europe	144.00～146.00MHz	144.00～146.00MHz
IC-228E/H	Italy	140.00～150.00MHz*	140.00～150.00MHz*

*Specifications apply to 144.00～148.00MHz only.

- Mode : F3 (FM)
- Selectable tuning step (Initial) : 5, 10, 15, 20 and 25kHz (U.S.A., Australia, Asia versions)
  12.5 and 25kHz (Europe, Italy versions)
- Memory channels : 20 plus a call channel
- Antenna impedance : 50Ω
- Power supply requirement : 13.8V DC±15% (negative ground)
- Current drain (IC-228H) : Receive 450mA (standby)
  800mA (max. audio output)
  Transmit 3.5A (LOW)
  9.5A (HIGH)
- Current drain (IC-228A/E) : Receive 450mA (standby)
  800mA (max. audio output)
  Transmit 3.0A (LOW)
  6.0A (HIGH)
- Usable temperature range : −10°C～+60°C (+14°F～+140°F)
- Frequency stability : ±10ppm (−10°C～+60°C) (+14°F～+140°F)
- Dimensions : IC-228H 140(W)×50(H)×159(D) mm, 5.5(W)×2.0(H)×6.3(D) in.
  IC-228A/E 140(W)×50(H)×137(D) mm, 5.5(W)×2.0(H)×5.4(D) in.
  (Projections not included)
- Weight : IC-228H 1.1kg (2.4 lb)
  IC-228A/E 0.85kg (1.9 lb)

■ TRANSMITTER

- Output power : IC-228H 45W (HIGH), 5W (LOW)
  IC-228A/E 25W (HIGH), 5W (LOW)
- Modulation system : Variable reactance frequency modulation
- Max. frequency deviation : ±5kHz
- Spurious emissions : Less than −60dB
- Microphone impedance : 600Ω

■ RECEIVER

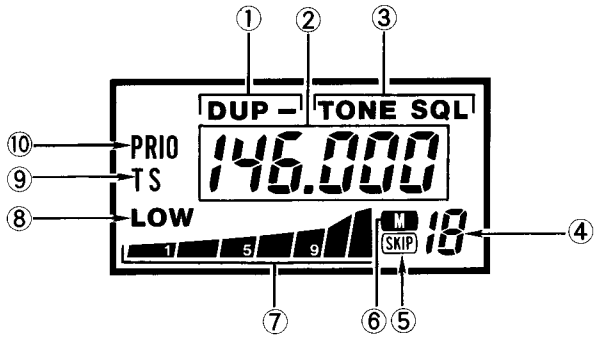
- Receiver system : Double-conversion superheterodyne
- Intermediate frequencies : 1st 17.2MHz
  2nd 455kHz
- Sensitivity : 0.18μV for 12dB SINAD
- Selectivity : More than 15kHz/−6dB
  Less than 30kHz/−60dB
- Audio output power : More than 2.4W at 10% distortion with an 8Ω load
- Audio output impedance : 8Ω

All stated specifications are subject to change without notice or obligation.

SECTION 2 OUTSIDE AND INSIDE VIEWS

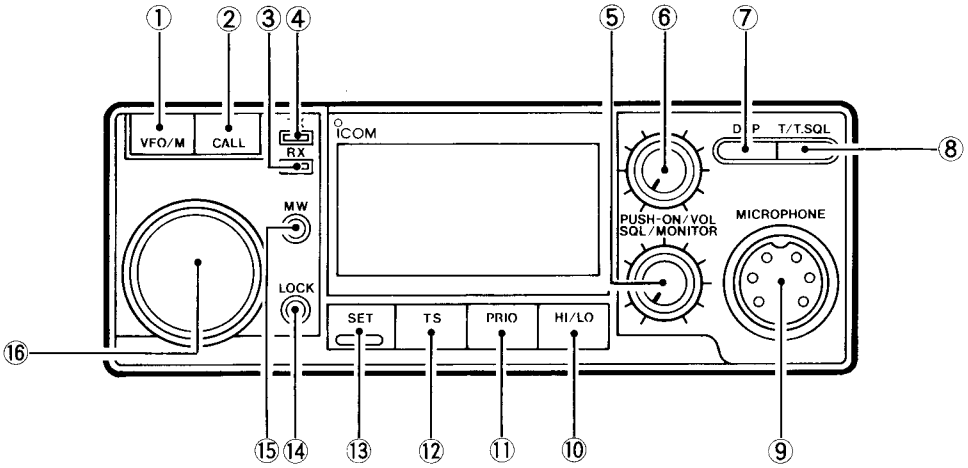
2-1 FREQUENCY DISPLAY

① DUPLEX INDICATOR
② FREQUENCY READOUT
③ TONE INDICATOR
④ MEMORY CHANNEL READOUT
⑤ SKIP CHANNEL INDICATOR
⑥ MEMORY INDICATOR
⑦ S/RF INDICATOR
⑧ LOW POWER INDICATOR
⑨ TUNING STEP INDICATOR
⑩ PRIORITY INDICATOR



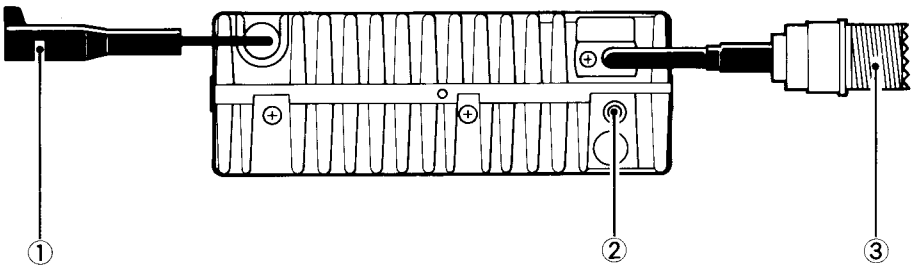
2-2 FRONT PANEL

① VFO/MEMORY SWITCH [VFO/M]
② CALL CHANNEL SWITCH [CALL]
③ RECEIVE INDICATOR [RX]
④ TRANSMIT INDICATOR [TX]
⑤ SQUELCH CONTROL/MONITOR SWITCH [SQL/MONITOR]
⑥ POWER SWITCH/VOLUME CONTROL [ON/VOL]
⑦ DUPLEX SWITCH [DUP]
⑧ TONE SWITCH [T/T. SQL]
⑨ MICROPHONE CONNECTOR
⑩ TRANSMIT POWER SWITCH [HI/LO]
⑪ PRIORITY SWITCH [PRIO]
⑫ TUNING STEP SWITCH [TS]
⑬ SET MODE SWITCH [SET]
⑭ LOCK SWITCH [LOCK]
⑮ MEMORY WRITE SWITCH [MW]
⑯ MAIN TUNING DIAL

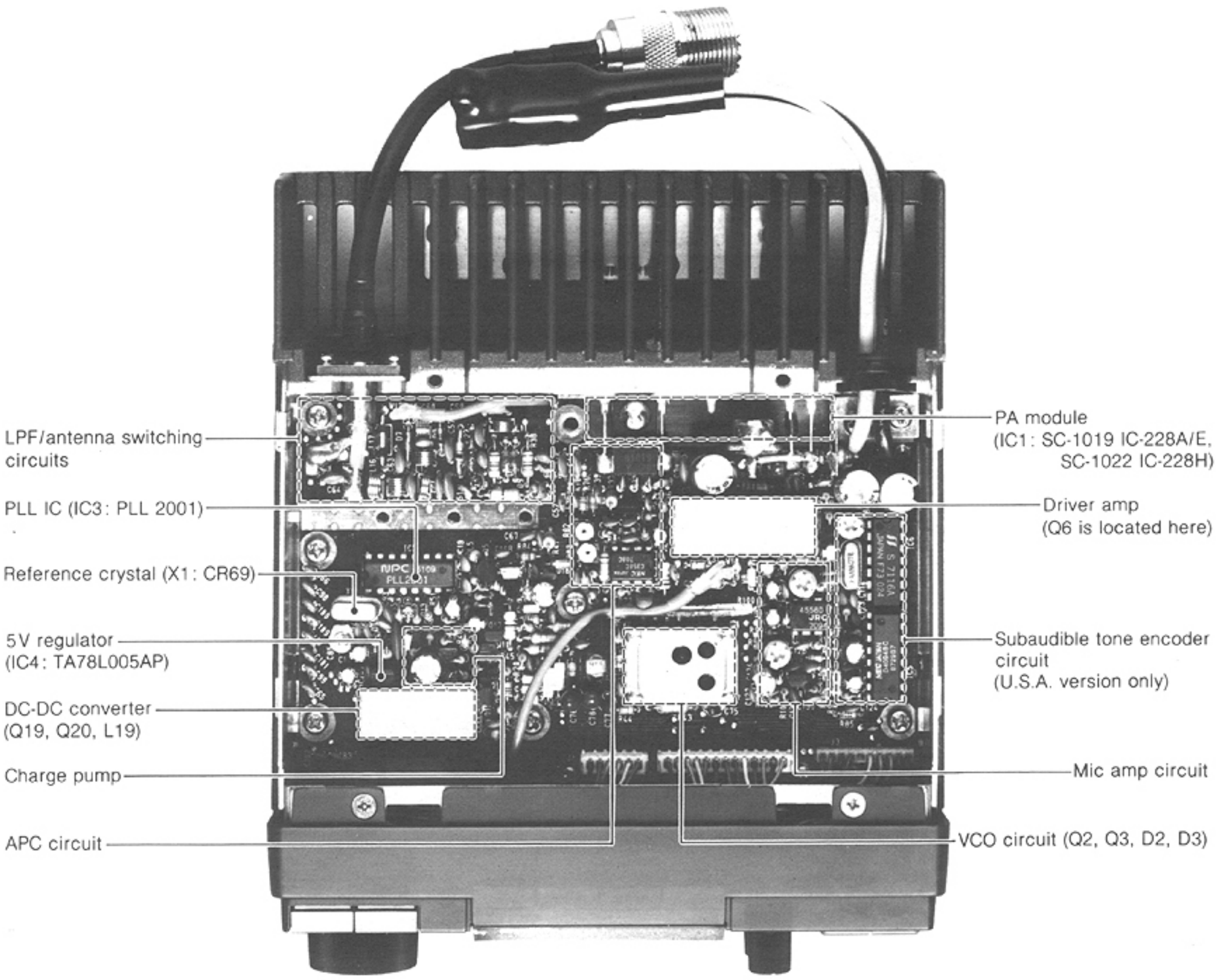


2-3 REAR PANEL

① POWER CONNECTOR
② EXTERNAL SPEAKER JACK
③ ANTENNA CONNECTOR



2-4 MAIN UNIT


LPF/antenna switching circuits
PLL IC (IC3 : PLL 2001)
Reference crystal (X1 : CR69)
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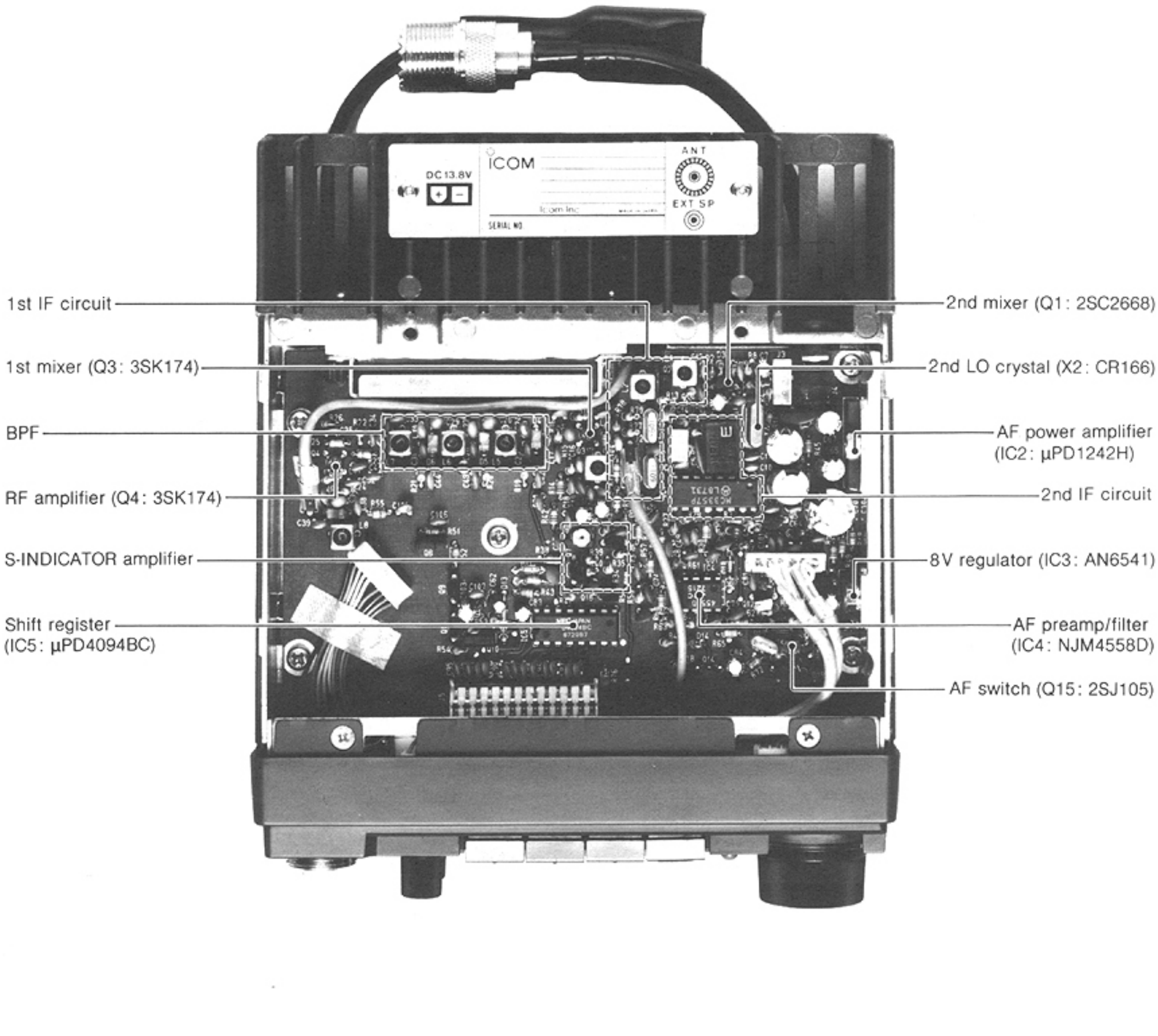
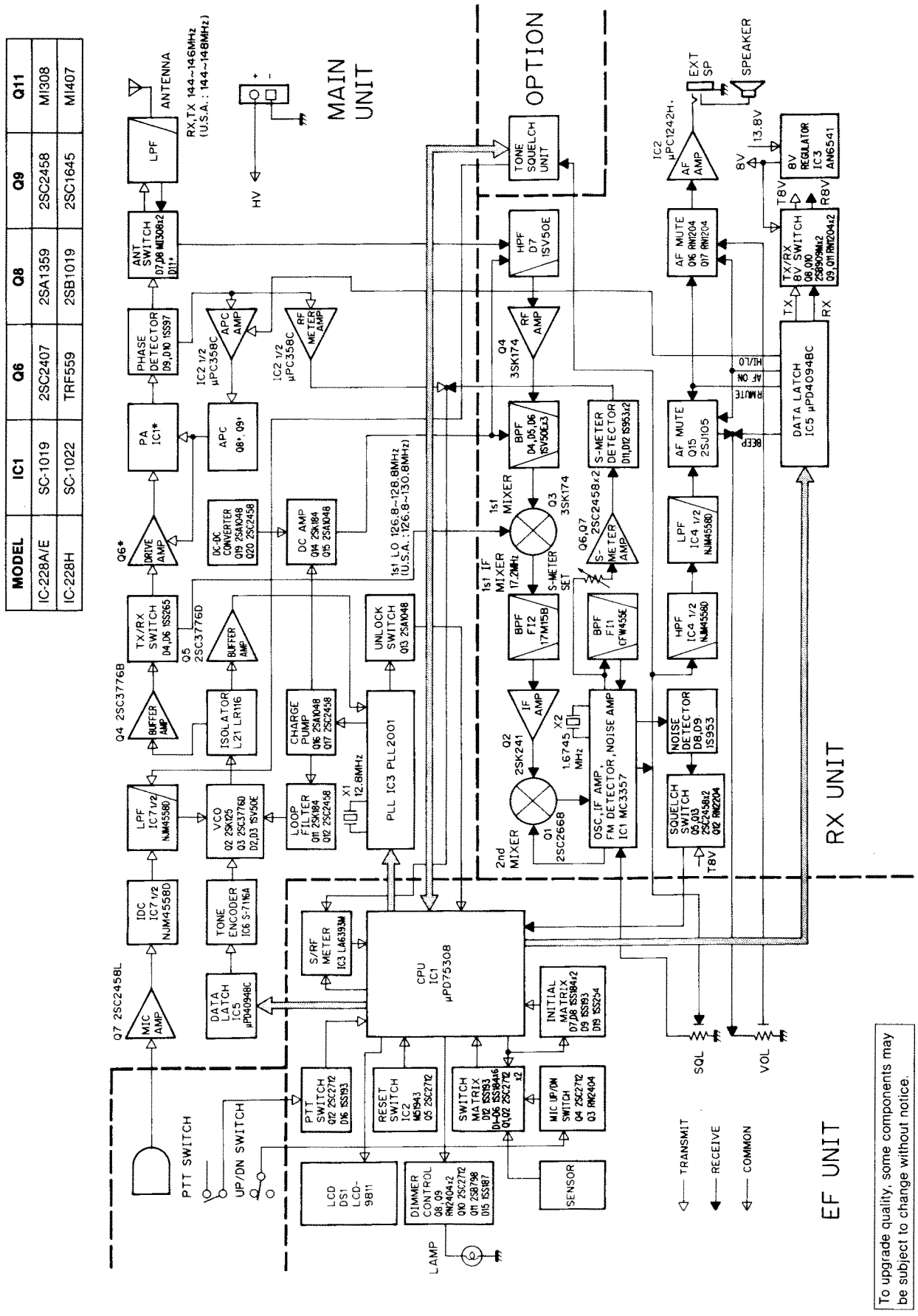
Subaudible tone encoder circuit (U.S.A. version only)
Mic amp circuit
VCO circuit (Q2, Q3, D2, D3)

2-5 RX UNIT


1st IF circuit
1st mixer (Q3: 3SK174)
BPF
RF amplifier (Q4: 3SK174)
S-INDICATOR amplifier
Shift register
(IC5: µPD4094BC)
2nd mixer (Q1: 2SC2668)
2nd LO crystal (X2: CR166)
AF power amplifier
(IC2: µPD1242H)
2nd IF circuit
8V regulator (IC3: AN6541)
AF preamp/filter
(IC4: NJM4558D)
AF switch (Q15: 2SJ105)
DC 13.8V
ICOM
ANT
EXT SP

SECTION 3 BLOCK DIAGRAM

MODEL	IC1	Q6	Q8	Q9	Q11
IC-228A/E	SC-1019	2SC2407	2SA1359	2SC2458	MI308
IC-228H	SC-1022	TRF559	2SB1019	2SC1645	MI407



To upgrade quality, some components may be subject to change without notice.

SECTION 4 CIRCUIT DESCRIPTION

4-1 RECEIVER CIRCUITS

4-1-1 ANTENNA SWITCHING CIRCUIT (MAIN UNIT)

Received signals enter the antenna connector and pass through a low-pass filter (L14~L17, C61~C64), antenna switching circuit (D7, D8, D11) and the other low-pass filter (L12, L13, C57~C59). The signals are applied to the antenna switching circuit (D7, D8, D11) and then to the RX UNIT via coaxial cable P1.

4-1-2 RF CIRCUIT (RX UNIT)

The applied RF signals from the MAIN UNIT are applied to the one-stage bandpass filter (D7, L8, C37), amplified at RF amplifier (Q4), and reapplied to the other band-pass filter (D4~D6, L5~L7, C24, C27, C30) to suppress out-of-band signals.

4-1-3 1ST MIXER CIRCUIT (RX UNIT)

1st mixer circuit Q3 converts the RF signal to the 17.2MHz 1st IF signal. RF signals from the bandpass filter are applied to gate 1 of Q3 and the 1st LO signal (PLL output) is applied to gate 2 of Q3. Q3 mixes this RF signal and a 1st LO signal and outputs 17.2MHz.

4-1-4 1ST IF CIRCUIT (RX UNIT)

The 1st IF signal is applied to a pair of mechanical crystal filters (FI2) to suppress out-of-band signals through the matching filter L3 and C16. The signal is then applied to the 2nd IF circuit through amplifier Q2.

D2 and D3 function as the limiter circuit when a strong signal is received.

IF CIRCUIT

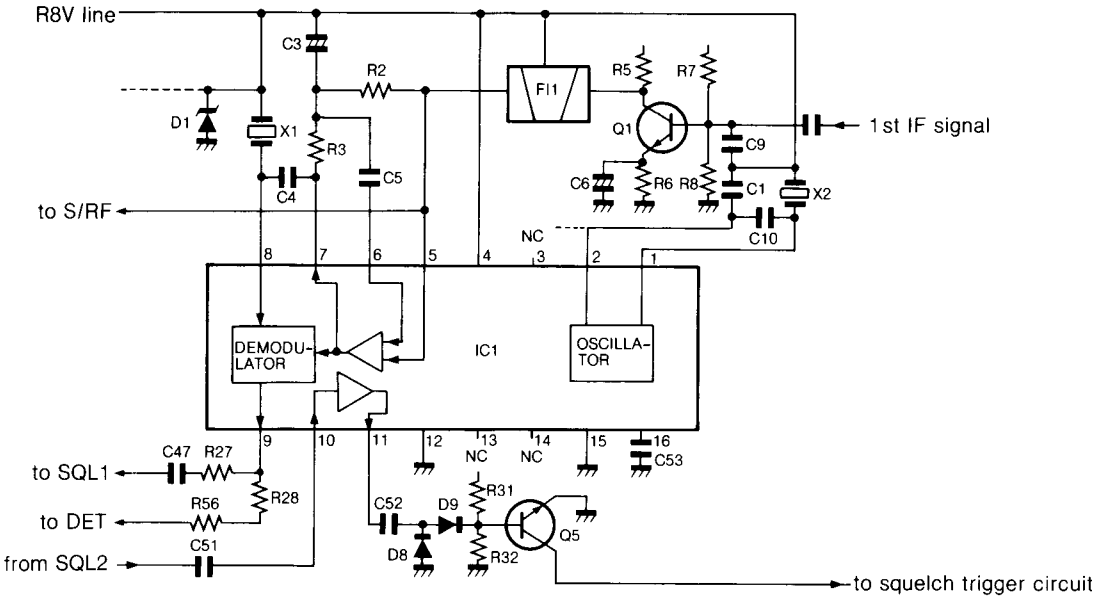


Fig. 1

4-1-5 2ND IF CIRCUITS (RX UNIT)

The 1st IF signal amplified at Q2 is applied to mixer circuit Q1. Q1 mixes the signal with a 16.745MHz 2nd LO signal to convert the 1st IF signal to a 455kHz 2nd IF signal. The converted signal is applied to pin 5 of IC1 through ceramic filter FI1.

IC1 contains the 2nd mixer circuit, the 2nd LO circuit and the quadrature detector circuit. X2 generates 16.745MHz for the 2nd LO signal.

Some of the noise components in the detected signal are applied to pin 10 of IC1 through the R2 SQUELCH CONTROL on the front panel. The SQUELCH CONTROL adjusts the noise level.

4-1-6 SQUELCH CIRCUIT (RX UNIT)

Pin 11 of IC1 outputs amplified noise components of frequencies at 20kHz and above. Output signals are rectified by D8 and D9. The rectified voltage triggers the squelch circuit consisting of Q5, Q12 and Q13.

The collector of Q13 outputs the squelch signal and is applied to CPU IC1 in the EF UNIT through the SQL.S line. An output signal of Q12 is applied to analog switch Q15 to control the AF mute circuit.

4-1-7 AF CIRCUIT (MAIN UNIT)

The detected AF signal at pin 9 of IC1 is applied to a two-stage active filter consisting of IC4a and IC4b. The filter functions as a de-emphasis circuit of +6dB/octave as well as a high-pass filter for filtering tone signals for the tone squelch.

A filtered signal is applied to AF amplifier IC2 through analog switch Q15, preamplifier Q16 and Q17 and the VOLUME CONTROL on the front panel.

AF amplifier IC2 amplifies the signal to a sufficient level to drive the speaker.

4-2 TRANSMITTER CIRCUITS

4-2-1 MICROPHONE AMPLIFIER (MAIN UNIT)

An AF signal from the microphone is applied to microphone preamplifier Q7 through the MIC line. IC7b functions as an amplifier as well as a limiter for frequency deviation. IC7b also functions as a pre-emphasis circuit with −6dB/octave characteristics.

4-2-2 MODULATION CIRCUIT (MAIN UNIT)

The signal is filtered by a low-pass filter consisting of IC7a. IC7b has a feedback circuit which functions as a pre-emphasis circuit with +6db/octave characteristics. The filtered signal is applied to the VCO circuit for FM modulation.

4-2-3 DRIVE AMPLIFIER (MAIN UNIT)

The VCO output signal is buffer-amplified at Q4, and applied to a switching circuit consisting of D4 and D6.

When transmitting, D4 is turned ON and the amplified signal is applied to pre-driver Q6. Q6 amplifies the signal to 200mW and 400mW for IC-228A/E and IC-228H respectively.

4-2-4 POWER AMPLIFIER (MAIN UNIT)

IC1 is a power amplifier and amplifies the signal to approximately 30W and 50W for IC-228A/E and IC228H respectively. The amplified signal at pin 4 of IC1 is applied to a low-pass filter consisting of L14~L16 and C61~C64 to filter out unwanted out-of-band signals.

4-2-5 ANTENNA SWITCHING CIRCUIT (MAIN UNIT)

When transmitting, a diode switching circuit consisting of D7, D8 and D11 is turned ON by a signal of T9V. Transmit signals are applied to the antenna connector through the low-pass filter.

When receiving, the diode switching circuit is turned OFF and received signals are applied to P1 through a π-type filter consisting of L12, L13 and C57~C59. The filter attenuates unwanted harmonic signals.

4-2-6 APC CIRCUIT (MAIN UNIT)

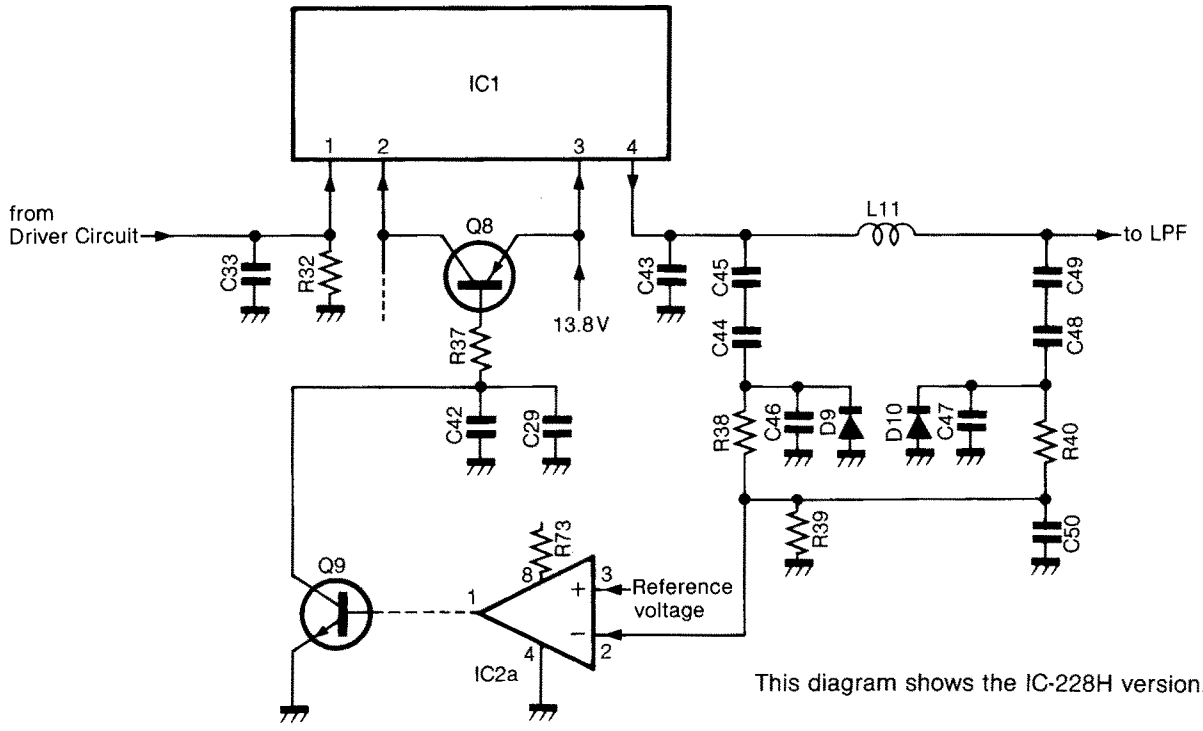
L11, C44~C49, D9 and D10 forms a mismatching detector circuit.

When the impedance of the connected antenna is matched with 50Ω, detected voltage at D9 and D10 is at a minimum. However the voltage increases when the antenna impedance is not matched with 50Ω.

The detected voltage is applied to pin 2 of IC2a and a reference voltage is applied to pin 3 of IC2a. Pins 2 and 3 form differential inputs and IC3 functions as a differential amplifier. The relation between the detected voltage level and output voltage level at pin 1 of IC3 is an inverse proportion.

If output power from pin 4 of IC1 is increased, detected voltage by D9 and D10 increases. The voltage is applied to pin 2 of IC2a. Pin 1 of the IC2a output level becomes lower than when the output power is normal. The base voltage of Q9 becomes lower and the collector of Q8 also becomes lower. Therefore, applied voltages to the collector of Q6 and pin 2 of IC1 decrease and the output power is controlled at a constant level.

APC CIRCUIT



This diagram shows the IC-228H version.

Fig. 2

4-3 PLL CIRCUITS (MAIN UNIT)

4-3-1 GENERAL

IC3 is one package of the PLL IC chip. The IC functions as a phase detector, reference oscillator, fixed divider and programmable divider.

IC3 accepts 200MHz signals directly and divides them without a mixer or prescaler. Therefore an important feature in IC3 is that it generates few spurious components.

The VCO output frequency is set by data signals from IC1 on the EF UNIT.

PLL circuit block diagram

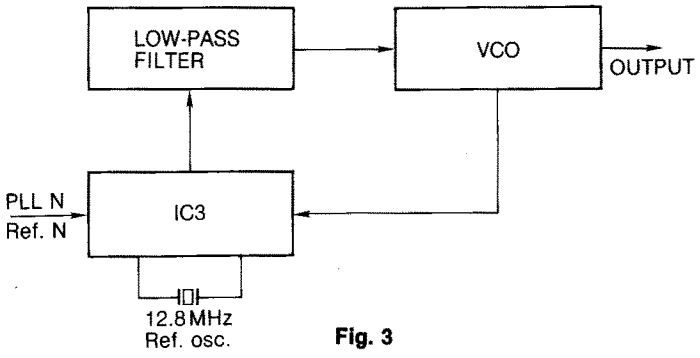


Fig. 3

4-3-2 VCO CIRCUIT

The VCO circuit forms a Hartley oscillator circuit. Q2 oscillates the desired signal and Q3 functions as a buffer amplifier.

The collector of Q3 outputs signals and the signals are applied to an isolator circuit consisting of L21 and R17 for distributing the signals to both the PLL circuit and driver circuit.

R18, R19 and R20 form a 50Ω attenuator. An attenuator is installed between VCO output and the PLL IC chip to reduce reflected waves due to mismatching.

4-3-3 REFERENCE OSCILLATOR

IC3 has an oscillator circuit for the PLL reference frequency signal in the chip. X1 is a crystal unit for oscillating a signal of 12.8MHz. The frequency is divided to either 5kHz or 12.5kHz by data signals from CPU IC1 in the EF UNIT.

4-3-4 CHARGE PUMP AND LOOP FILTER CIRCUITS

Phase-detected signals from pins 5 and 12 are converted to DC voltage by a charge pump circuit consisting of Q16~Q18. The signal is then applied to a low-pass filter circuit consisting of R43~R46 and C75~C78.

Filtered DC voltage is applied to D2 and D3 in the VCO circuit for controlling the VCO output frequency and the gate of Q14 for making voltages for receiver tuning.

4-4 OTHER CIRCUITS

4-4-1 REGULATOR CIRCUITS

IC3 on the RX UNIT is a 3-terminal voltage regulator IC chip. +13.8V is applied to pin 1 and pin 3 outputs +9V. The regulated voltage is applied to each unit.

IC4 on the MAIN UNIT is a 3-terminal voltage regulator IC chip. +13.8V is applied to an input terminal and the output terminal outputs +5V.

Q19 and Q20 form a DC-DC voltage converter for applying approximately 30V DC to the receiver RF circuit.

4-4-2 SUBAUDIBLE TONE ENCODER CIRCUIT (IC-228A: U.S.A. AND ASIA VERSIONS)

IC5 is an IC chip for converting input data from serial to parallel form. The data is sent from IC1 on the EF UNIT. IC6 is an IC chip for generating subaudible tone frequency signals from 67Hz~250.3Hz. The following table shows the relation between input data and the output frequency of IC6.

SUBAUDIBLE TONE ENCODER FREQUENCY TABLE (IC-228A: U.S.A., ASIA VERSIONS)

OUTPUT FREQUENCY [Hz]	IC6 INPUT PIN NUMBER						OUTPUT FREQUENCY [Hz]	IC6 INPUT PIN NUMBER						OUTPUT FREQUENCY [Hz]	IC6 INPUT PIN NUMBER					
	8	9	10	11	12	13		8	9	10	11	12	13		8	9	10	11	12	13
67.0	H	L	L	L	L	L	107.2	L	H	H	H	L	L	167.9	H	H	L	H	H	L
71.9	L	H	L	L	L	L	110.9	H	H	H	H	L	L	173.8	L	L	H	H	H	L
74.4	H	H	L	L	L	L	114.8	L	L	L	L	H	L	179.9	H	L	H	H	H	L
77.0	L	L	H	L	L	L	118.8	H	L	L	L	H	L	186.2	L	H	H	H	H	L
79.7	H	L	H	L	L	L	123.0	L	H	L	L	H	L	192.8	H	H	H	H	H	L
82.5	L	H	H	L	L	L	127.3	H	H	L	L	H	L	203.5	L	L	L	L	L	H
85.4	H	H	H	L	L	L	131.8	L	L	H	L	H	L	210.7	H	L	L	L	L	H
88.5	L	L	L	H	L	L	136.5	H	L	H	L	H	L	218.1	L	H	L	L	L	H
91.5	H	L	L	H	L	L	141.3	L	H	H	L	H	L	225.7	H	H	L	L	L	H
94.8	L	H	L	H	L	L	146.2	H	H	H	L	H	L	233.6	L	L	H	L	L	H
97.4	H	H	L	H	L	L	151.4	L	L	L	H	H	L	241.8	H	L	H	L	L	H
100.0	L	L	H	H	L	L	156.7	H	L	L	H	H	L	250.3	L	H	H	L	L	H
103.5	H	L	H	H	L	L	162.2	L	H	L	H	H	L							

H: HIGH L: LOW

Table 1

4-5 LOGIC CIRCUITS (EF UNIT)

4-5-1 CPU PORT ALLOCATIONS

PORT NUMBER	PIN NUMBER	DESCRIPTION
RESET	68	When a "HIGH" signal is applied here the CPU is initialized or changes to standby mode.
P00 [INT4]	38	Detects a signal for the standby mode of the CPU. The CPU enters the standby mode when the port reads a trailing edge of the signal.
P01 [SCK]	39	Outputs data signals.
P02 [DATA]	40	Outputs serial data synchronized with the SCK signal.
P03 [SQLS]	41	Detects a squelch signal. When the signal is "HIGH," the squelch opens.
P10~P13 [KIR0~KIR3]	42~45	Input ports for the initial matrix.
P20	46	Not used.
P21 [STBRX]	47	Outputs a strobe signal for serial data to the output expander.
P22 [STBPLV]	48	Outputs a strobe signal for serial data to the PLL IC.
P23	49	Not used.
P30 [UNLKV]	50	Detects a PLL unlock signal. When the signal is "HIGH," the PLL is unlocked. Normally the port is "LOW."
P31	51	Not used.
P32 [TXLED]	52	Outputs a signal for turning the TRANSMIT indicator ON and OFF. The port becomes "LOW" and "HIGH" when transmitting and receiving (squelch opens) respectively.
P33 [SRFO]	53	Outputs a reference voltage for the S/RF indicator.
P40~P43 [KR0~KR3]	29~32	These are input ports for the key matrix.
P50~P53 [KS0~KS3]	34~37	These are output ports for strobe signals for the initial and key matrix.
P60 [SRFI]	60	Inputs a reference voltage for the S/RF indicator.
P61 [PTT]	61	Inputs a signal on the PTT line. The port should be "HIGH" when the PTT switch is pushed.
P62 [TSQL]	62	Input port for an acknowledge signal in the tone squelch unit. The port is "HIGH" when the tone squelch opens.
P63 [OPT]	63	Input port whether the tone squelch is installed or not. The port is "LOW" when the tone squelch is installed.
P70 [STBOP]	64	Outputs a strobe signal for serial data to the tone squelch unit (MN6520).
P71 [STBCT]	65	Outputs a strobe signal for serial data to the subaudible tone IC (S7116).
P72, P73 [DIM01, DIM02]	66, 67	Outputs a signal for controlling intensity of the FUNCTION DISPLAY. Refer to Table 2.

Table 2

4-5-2 KEY MATRIX

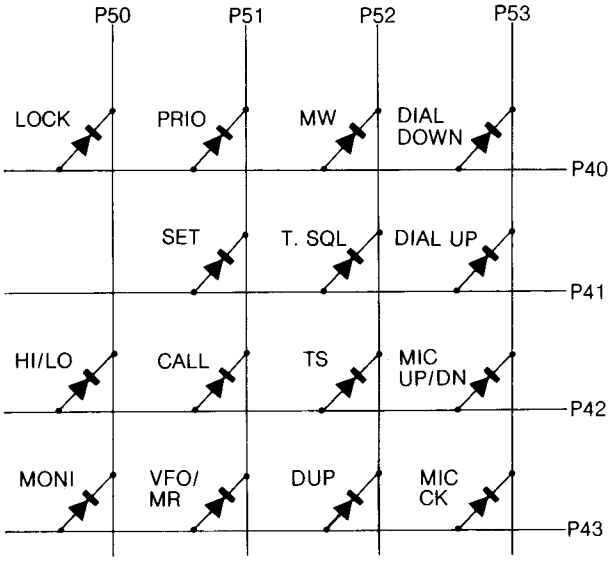


Fig. 4

4-5-3 RESET CIRCUIT

The CPU is reset when the RESET port changes from "HIGH" to "LOW" and then becomes "LOW" again. The

RESET CIRCUIT

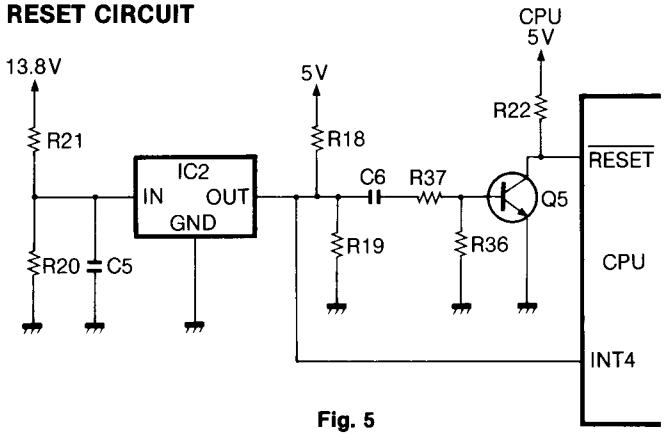


Fig. 5

RESET port remains "HIGH" except when the CPU is reset. The following is a diagram for the reset circuit and timing chart.

RESET TIMING CHART

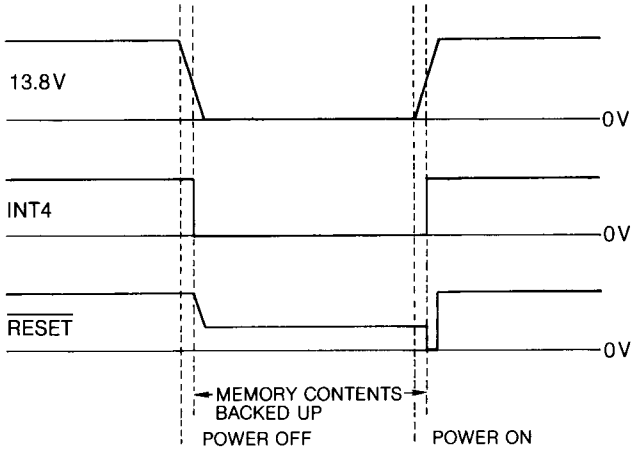


Fig. 6

4-5-4 S/RF INDICATOR CIRCUIT

IC3 functions as a comparator. Pin 53 of IC1 outputs "HIGH" as a reference voltage to a detected S/RF signal level.

• Relative signal strength indicator

When receiving, Q6 and Q7 on the RX UNIT amplifies a 455kHz 2nd IF signal. D11 and D12 on the RX UNIT rectify the signal to be converted to DC voltage as the S/RF signal. The signal is applied to pin 2 of IC3 on the EF UNIT. Pin 1 of IC3 on the EF UNIT outputs "HIGH" when the voltage at pin 3 becomes the same as or higher than the SRF voltage at pin 2. It takes time to output "HIGH" from pin 1 of IC3 after pin 53 of IC1 on the EF UNIT outputs "HIGH". The time depends on the level of the SRF voltage. The higher the level of SRF voltage the longer time it takes. IC1 measures the time and the FUNCTION DISPLAY indicates the relative signal strength.

S/RF INDICATOR CIRCUIT

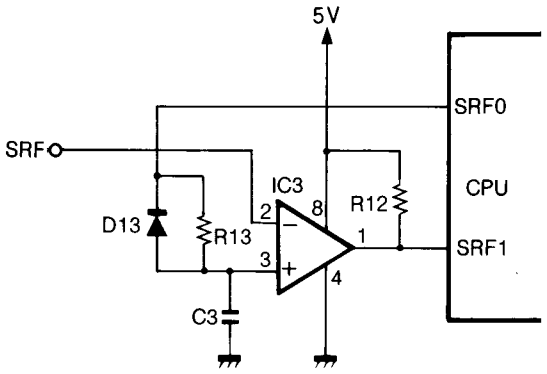


Fig. 7

• RF output power selection indicator

IC2b on the MAIN UNIT amplifies RF output power. The gain of IC2b is set very high, so the output voltage at pin 7 of IC2b is saturated even if the input RF level is small. Then the "HIGH" is applied to pin 2 of IC3 on the EF UNIT. Pin 1 of IC3 is "HIGH" when the power module of IC1 on the MAIN UNIT outputs power. IC1 on the EF UNIT detects either HIGH or LOW output power with the key matrix of P42 and P50.

4-5-5 DIMMER CIRCUIT

The FUNCTION DISPLAY changes its brightness at 4 levels using combinations of output level at P72 and P73. By changing levels at P72 and P73, the base voltage and collector current changes. Therefore, the collector voltage is changed and brightness of lamps DS2~DS4 changes.

DIMMER CIRCUIT

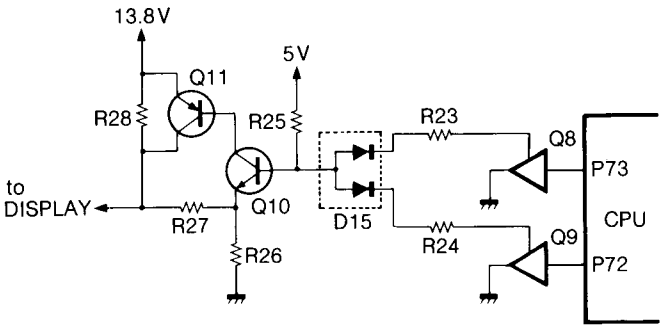


Fig. 8

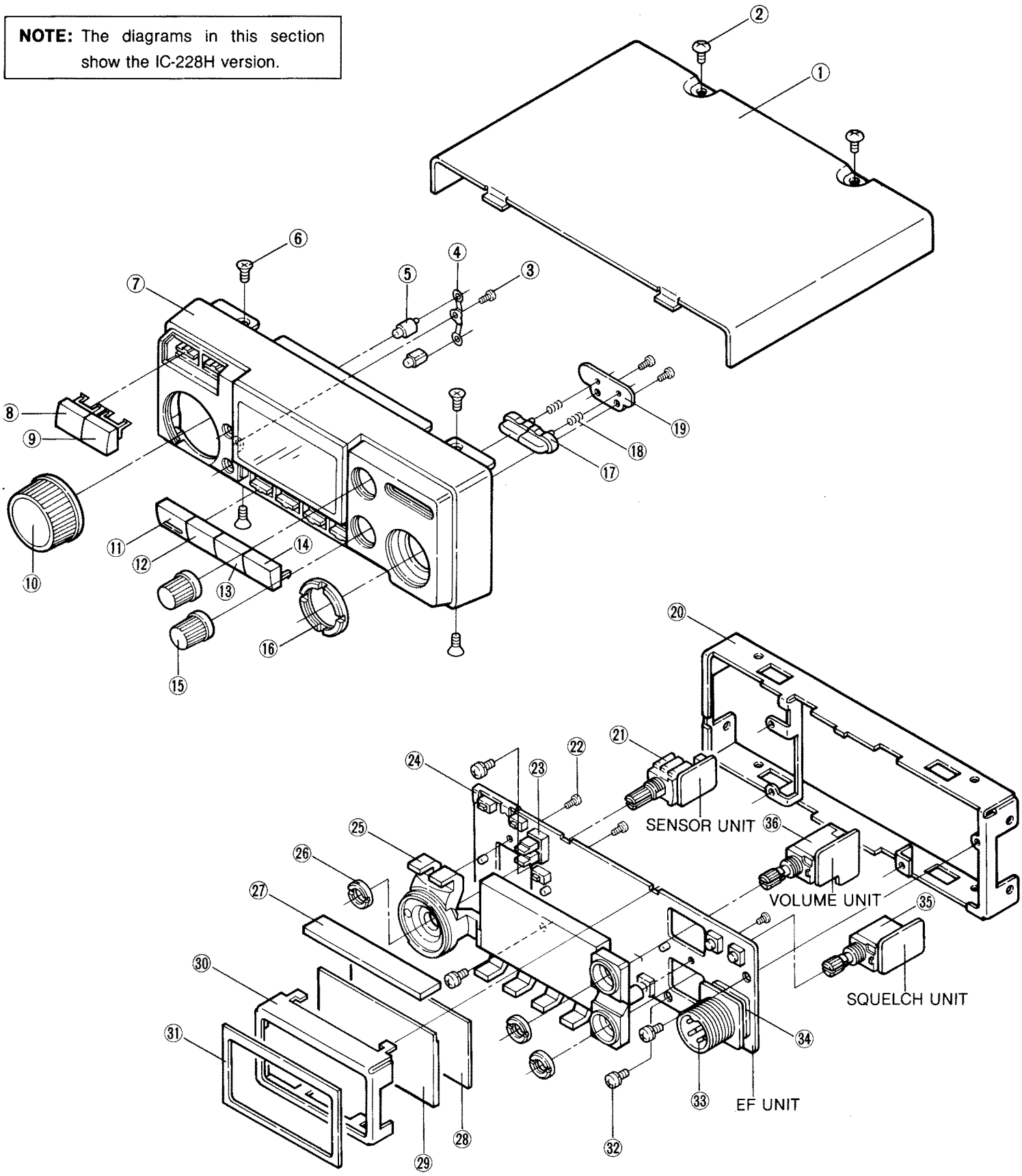
BRIGHTNESS	P72	P73	INDICATION
↑ Brightness	H	H	d-4
	L	H	d-3
Dark ↓	H	L	d-2
	L	L	d-1

H: HIGH L: LOW

SECTION 5 DISASSEMBLY AND ASSEMBLY DIAGRAMS

5-1 FRONT PANEL DISASSEMBLY

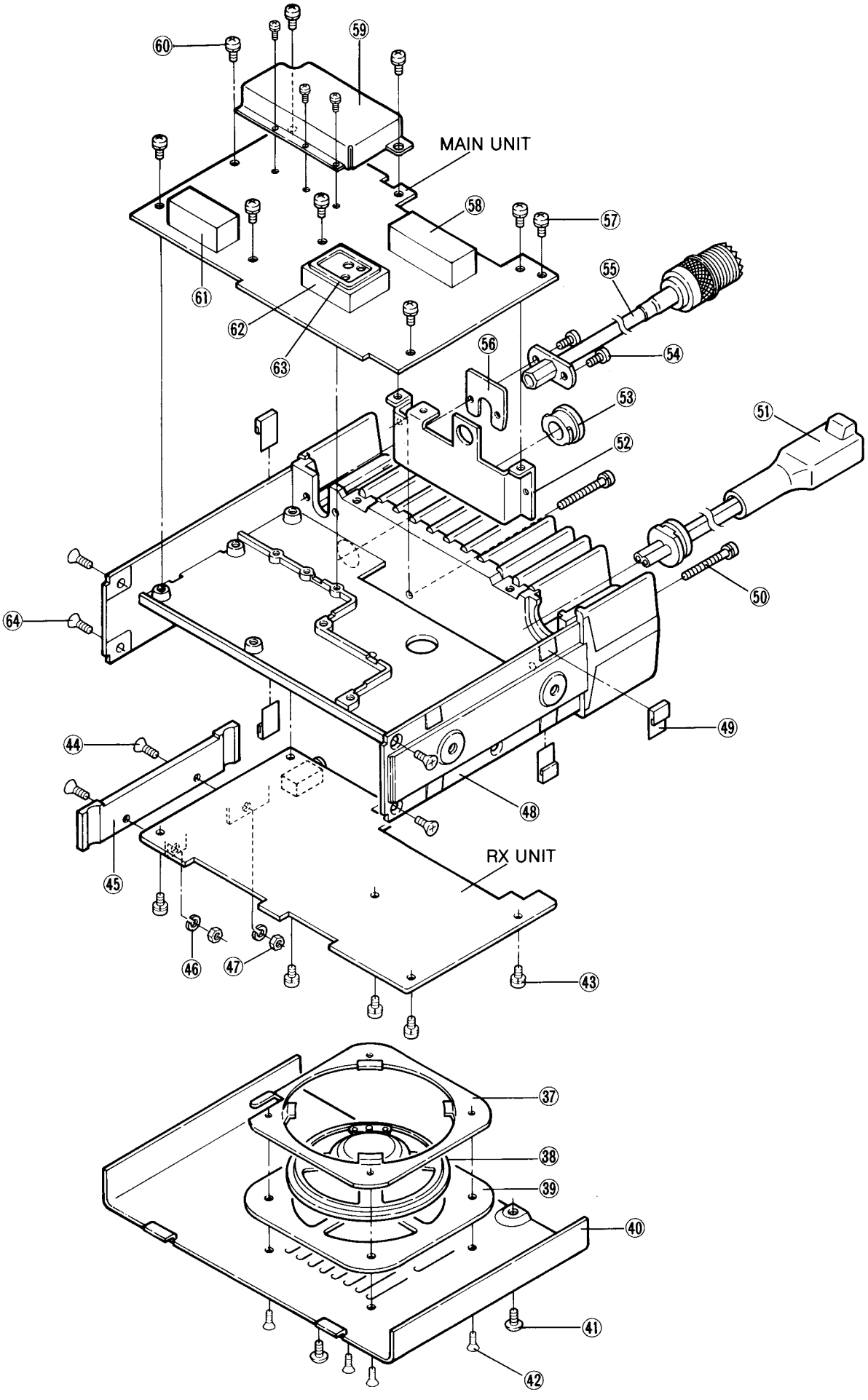
NOTE: The diagrams in this section show the IC-228H version.



LABELLED NUMBER	DESCRIPTION	ORDER NUMBER	QTY.
①	495 Top Cover (A)-1 (IC-228A/E)	8110002130	1
	301 Top Cover (A)-1 (IC-228H)	8110002070	1
②	ICOM Screw (B) 4	8810003700	2
③	PH B0 2×5	8810000990	1
④	671 Switch Spring	8930013020	1
⑤	K-113 Button	8610004330	2
⑥	FH M2.6×4	8810002100	4
⑦	671 Front Panel (A) (IC-228A)	8210003510	1
	671 Front Panel (A) (IC-228E)	8210003520	1
	671 Front Panel (A) (IC-228H)	8210003360	1
⑧	K-114 Button (E) (VFO/M)	8610004500	1
⑨	K-114 Button (F) (CALL)	8610004510	1
⑩	N-130 Tuning Control Knob	8610004400	1
⑪	K-115 Button (A) (SET)	8610004520	1
⑫	K-114 Button (B) (TS)	8610004360	1
⑬	K-114 Button (D) (PRIO)	8610004380	1
⑭	K-114 Button (C) (HI/LO)	8610004370	1
⑮	N-131 Control Knob	8610004410	2
⑯	Included with ㉝ below	——	—
⑰	K-112 Button	8610004320	2
⑱	Push Spring (H)	8930006450	2
⑲	671 Switch Plate	8930013030	1
⑳	Sub-Chassis	8010007280	1
㉑	Tuning Control SRBM1L038A	2260000880	1
㉒	PH B0 2×5	8810000990	3
㉓	LED Spacer	8930012790	1
㉔	671 Grounding Plate	8930013330	1
㉕	671 LCD Reflector	8010007520	1
㉖	VR Nut (E)	8830000550	3
㉗	LCD Contact Strip SRCN543	8930012660	1
㉘	543 LCD Filter	8930012670	1
㉙	LCD 9811J	5030000330	1
㉚	543 LCD Holder-1	8930012681	1
㉛	671 LCD Rubber	8930013420	1
㉜	Set Screw (A) 2.6×5	8810003960	4
㉝	Mic Connector Assembly 8S-S-E	6510000290	1
㉞	543 Mic Spacer	8930012430	1
㉟	SQUELCH CONTROL RK0971114005A	7210001490	1
㊱	VOLUME CONTROL RK097111200BA	7210001480	1

Screw type Screw: M2.6×4, etc. Self-tapping screw: B0 2×4, etc.
Screw's head style PH: Pan head FH: Flat head

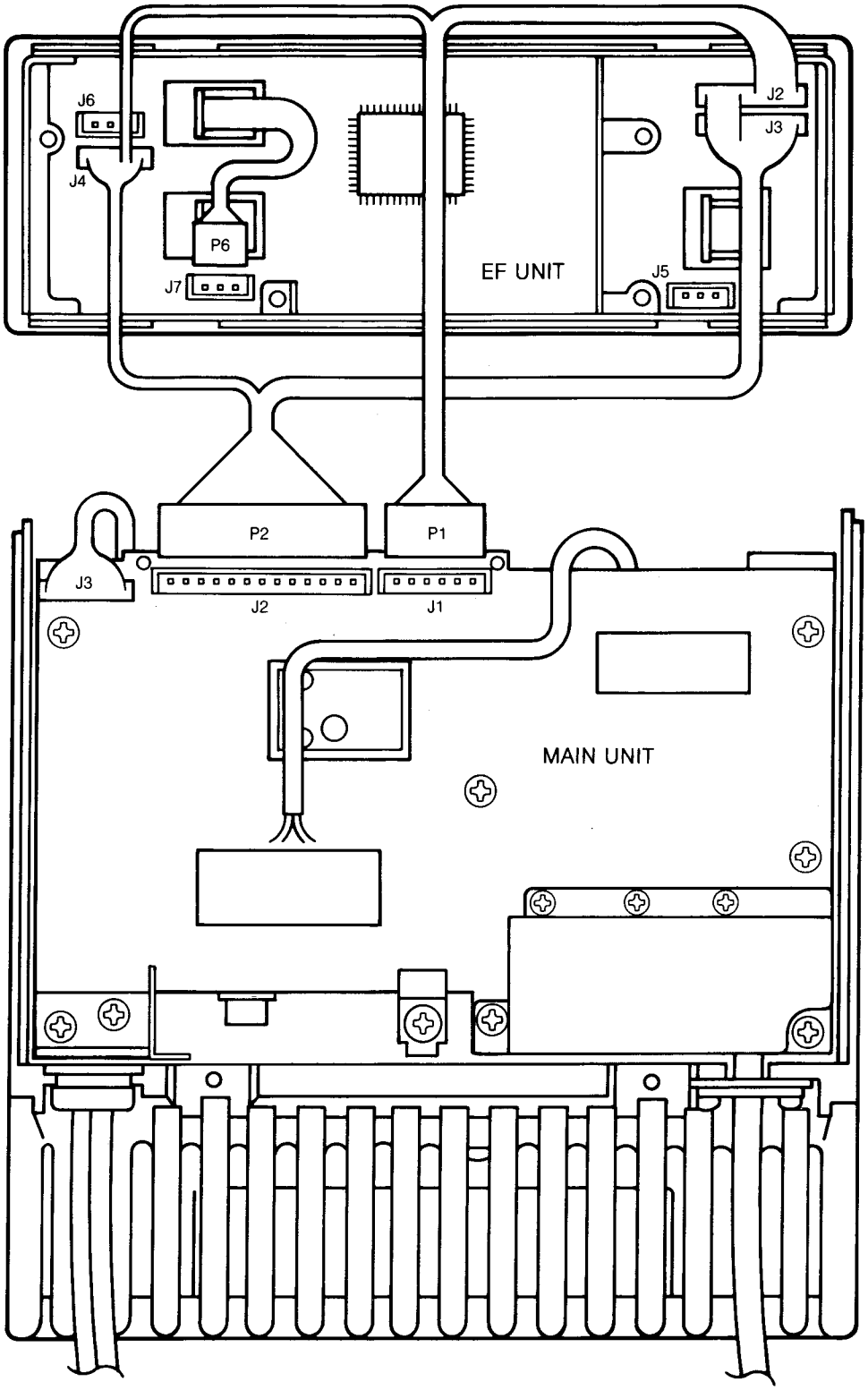
5-2 FRAME DISASSEMBLY



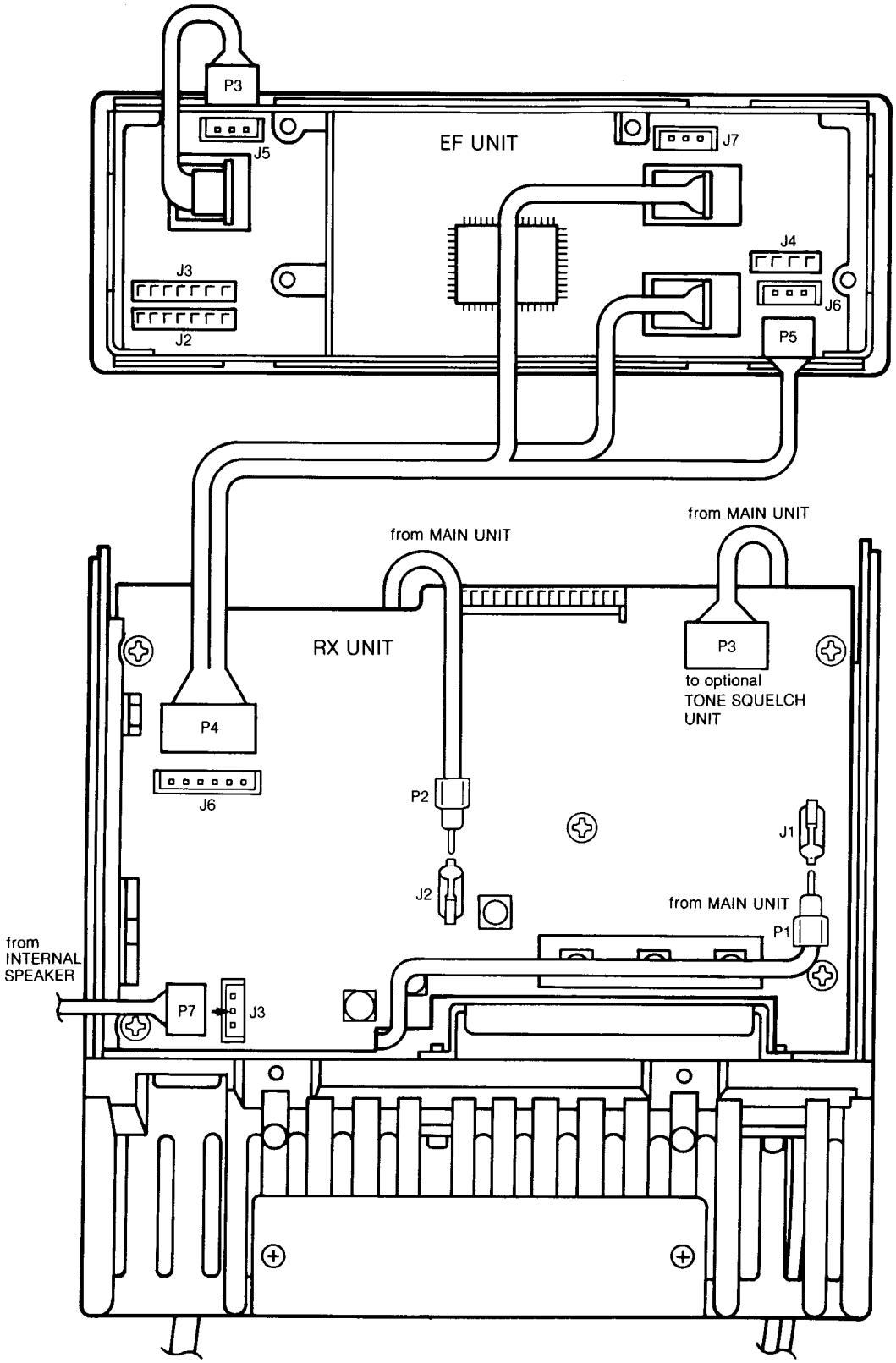
LABELLED NUMBER	DESCRIPTION	ORDER NUMBER	QTY.
㊲	57 Speaker Holder	8930002650	1
㊳	Speaker 57S38-1	2510000280	1
㊴	57 Speaker Spacer	8930004950	1
㊵	495 Bottom Cover (B)-1 (IC-228A/E)	8110002140	1
	301 Bottom Cover (B)-1 (IC-228H)	8110002080	1
㊶	ICOM Screw (B) 4	8810003700	2
㊷	FH M2.6×5 ZK	8810002450	4
㊸	Set Screw (A) 3×5	8810003150	5
㊹	FH M3×8	8810002180	2
㊺	AF Heatsink (A)	8410000980	1
㊻	Spring Washer M3 Ni	8850000420	2
㊼	Nut M3	8830000100	2
㊽	470 Chassis (A)-3 (IC-228A/E)	8110007511	1
	301 Chassis (A)-4 (IC-228H)	8010007431	1
㊾	Cover Slider	8930000820	4
㊿	ICOM Screw (A) 12 (IC-228A/E)	8810004030	2
	Set Screw (A) 3×18 (IC-228H)	8810003230	2
(51)	Power Supply Cable OPC-143 (Connector included)	8900001520	1
(52)	Module Shield Plate	8510003450	1
(53)	Rubber Bushing	8930007860	1
(54)	PH M3×6 BSBM Ni	8810001910	2
(55)	Antenna Cable OPC-186 (Connector included)	8900001890	1
(56)	Antenna Plate	8930009080	1
(57)	Set Screw (A) 3×5	8810003150	9
(58)	Mixer Shield Case	8510000470	1
(59)	Filter Shield Case	8510003070	1
(60)	Set Screw (A) 2.6×5	8810003960	3
(61)	Mixer Shield Case	8510002020	1
(62)	VCO Case (A)	8510002210	1
(63)	VCO Top Cover (A)	8510002250	1
(64)	FH M3×5	8810002160	4

Screw type Screw: M2.6×4, etc. Self-tapping screw: B0 2×4, etc.
Screw's head style PH: Pan head FH: Flat head

5-3 MAIN UNIT CONNECTOR ASSEMBLY



5-4 RX UNIT CONNECTOR ASSEMBLY



SECTION 6 MAINTENANCE AND ADJUSTMENT

6-1 PREPARATION BEFORE SERVICING

1. Detach the power cord and turn OFF the POWER SWITCH before performing any work on the transceiver.
2. DO NOT force any of the variable components. Turn them slowly and smoothly.
3. Follow the instructions exactly. If an indicated result is not obtained, repeat the instruction until the correct result is obtained.
4. Confirm defective operation of the transceiver first when checking an out-of-service unit. Verify that external sources DO NOT cause the problem.
5. Remove the transceiver case as shown in SECTION 5-1.
6. For transmission problems, attach a dummy load to the ANTENNA CONNECTOR. For reception problems, attach an antenna or signal generator to the ANTENNA CONNECTOR. DO NOT transmit into the signal generator.
7. Re-check for the suspected malfunction with the POWER SWITCH ON.
8. There are different versions of this transceiver. Adjustment procedures and results may differ for each version. Be sure to follow the correct procedure for the transceiver you adjust.

6-2 PLL ADJUSTMENT

TEST INSTRUMENTS REQUIRED

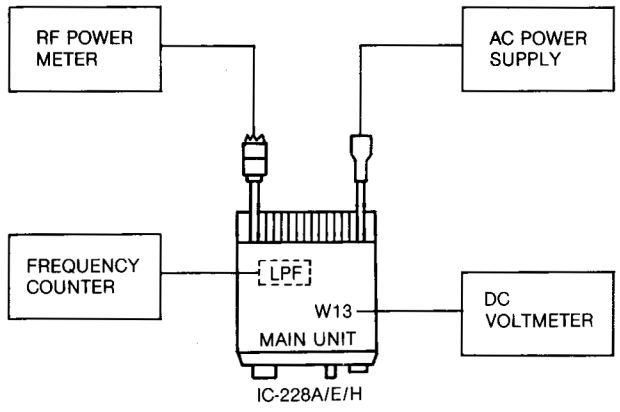
(1) AC POWER SUPPLY
- Output voltage : 13.8V DC±15%
- Current capacity : 10A or more

(2) DC VOLTMETER
- Input impedance : 50kΩ/V DC or better

(3) FREQUENCY COUNTER
- Frequency minimum : 150MHz
- Frequency accuracy : 1ppm or better
- Sensitivity : 100mV or better

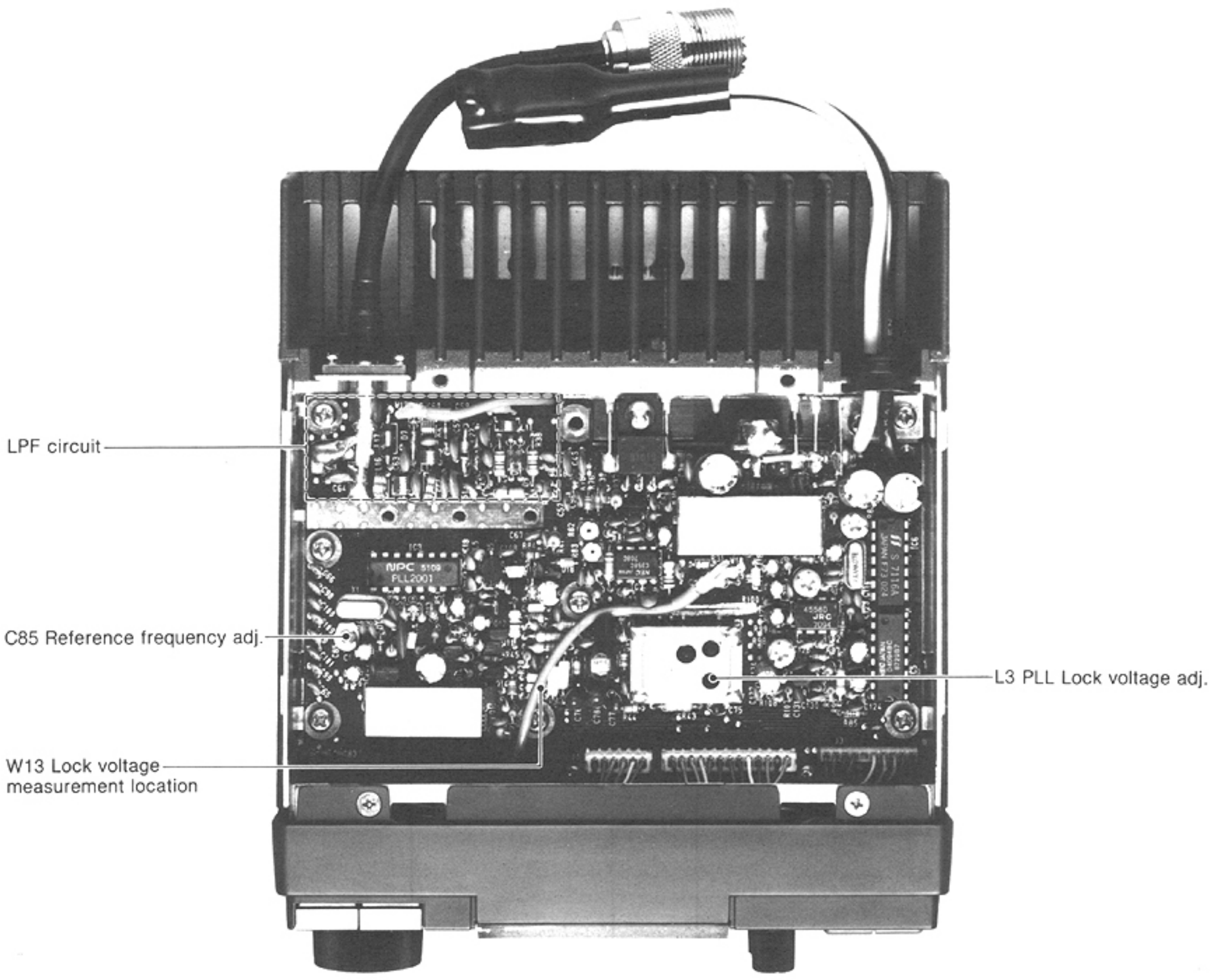
(4) RF POWER METER (or 50Ω dummy load)
- Minimum power rating: 100W
- Frequency minimum : 150MHz
- Input impedance : 50Ω
- SWR : 1.2:1 or better

MEASUREMENT CONNECTION LOCATION

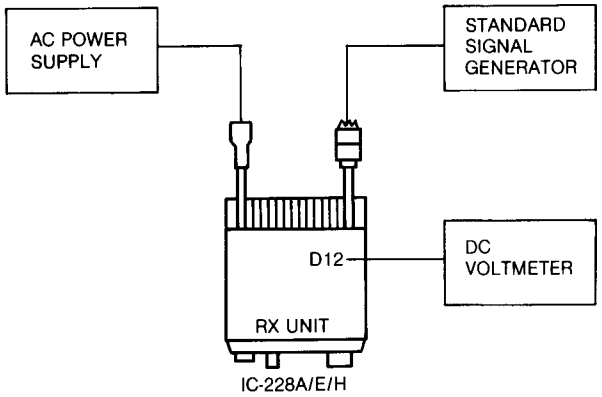


ADJUSTMENT		ADJUSTMENT CONDITIONS	MEASUREMENT		VALUE	ADJUSTMENT POINT	
			UNIT	LOCATION		UNIT	ADJUST
LOCK VOLTAGE	1	• Frequency display: 145.000MHz	MAIN	Connect the DC voltmeter to W13.	8V	MAIN (VCO)	L3
REFERENCE FREQUENCY	1	• Frequency display: 145.000MHz • Transmitting	MAIN	Loose couple the frequency counter to the LPF circuit.	145.000MHz	MAIN	C85

MAIN UNIT

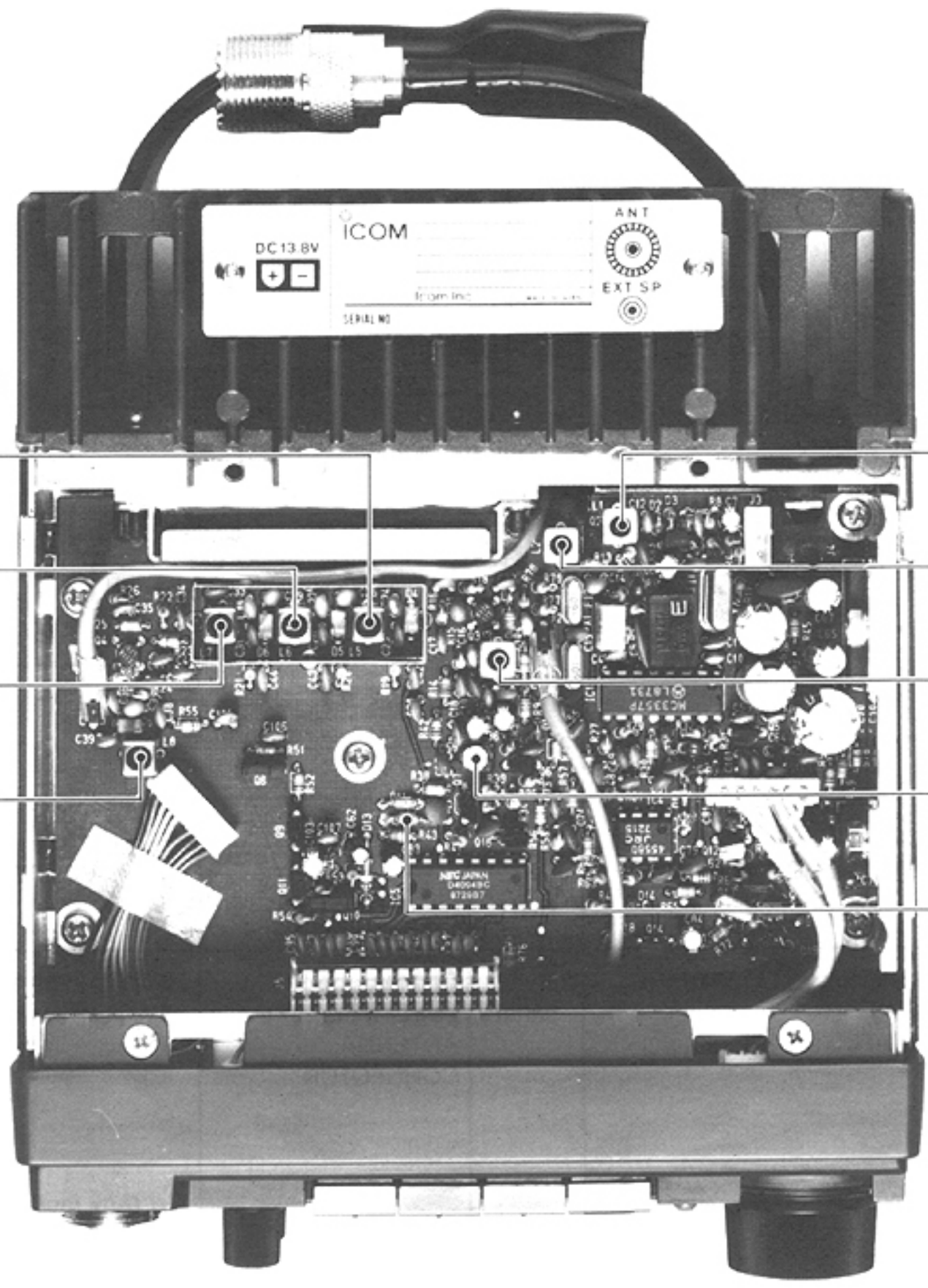

LPF circuit
C85 Reference frequency adj.
W13 Lock voltage measurement location
L3 PLL Lock voltage adj.

6-3 RECEIVER ADJUSTMENT

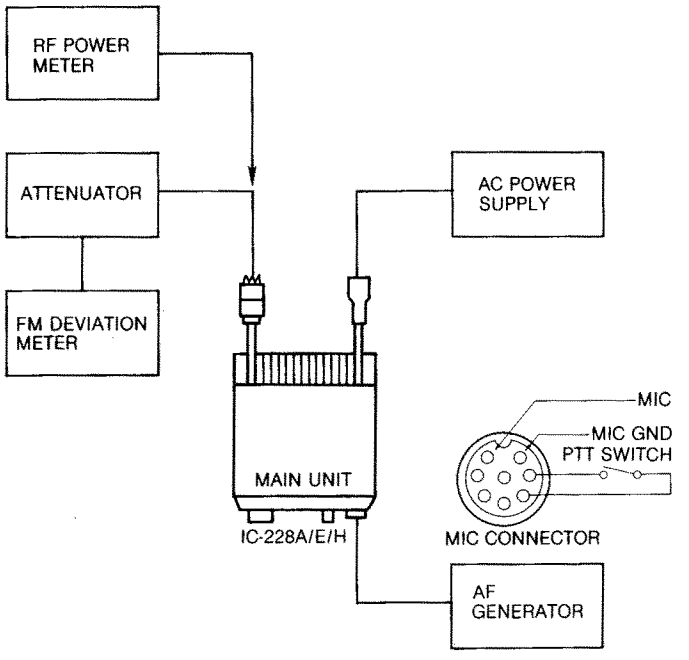
TEST INSTRUMENTS REQUIRED	MEASUREMENT CONNECTION LOCATION
(1) AC POWER SUPPLY • Output voltage : 13.8V DC±15% • Current capacity : 10A or more (2) STANDARD SIGNAL GENERATOR • Frequency range : 0.1~180MHz • Output level : −127~−17dBm (0.1μV~32mV) (3) DC VOLTMETER • Input impedance : 50kΩ/V DC or better	

ADJUSTMENT		ADJUSTMENT CONDITIONS	MEASUREMENT UNIT	MEASUREMENT LOCATION	VALUE	ADJUSTMENT POINT UNIT	ADJUSTMENT POINT ADJUST
SENSITIVITY	1	• Frequency display: 145.000MHz • Receiving • Apply an RF signal to the ANTENNA CONNECTOR. Level: −97dBm (3.16μV) Dev. : ±3.5kHz Mod. : 1kHz • R36: Max. counterclockwise	RX	Connect the DC voltmeter to the cathode of D12.	Maximum	RX	Adjust in sequence L8 L7 L6 L5 Repeat above adjust-ments 2 or 3 times.
	2	• Apply an RF signal to the ANTENNA CONNECTOR. Level: −97dBm (3.16μV) Dev. : ±7kHz					L3 L2 L1
		NOTE: Adjust the signal generator output each time until the DC voltmeter is at 30% on the full scale reading of the lowest range.					
S-METER	1	• Frequency display: 145.000MHz • Receiving • Apply an RF signal to the ANTENNA CONNECTOR. Level: −107dBm (1μV) Dev. : ±3.5kHz Mod. : 1kHz	FUNCTION DISPLAY	S/RF INDICATOR	S3 (2 dots)	RX	R36

RX UNIT


Sensitivity adjustment points:
L5
L6
L7
L8
Sensitivity adjustment points:
L1
L2
L3
R36 S-METER adj.
D12 Sensitivity measurement location

6-4 TRANSMITTER ADJUSTMENT

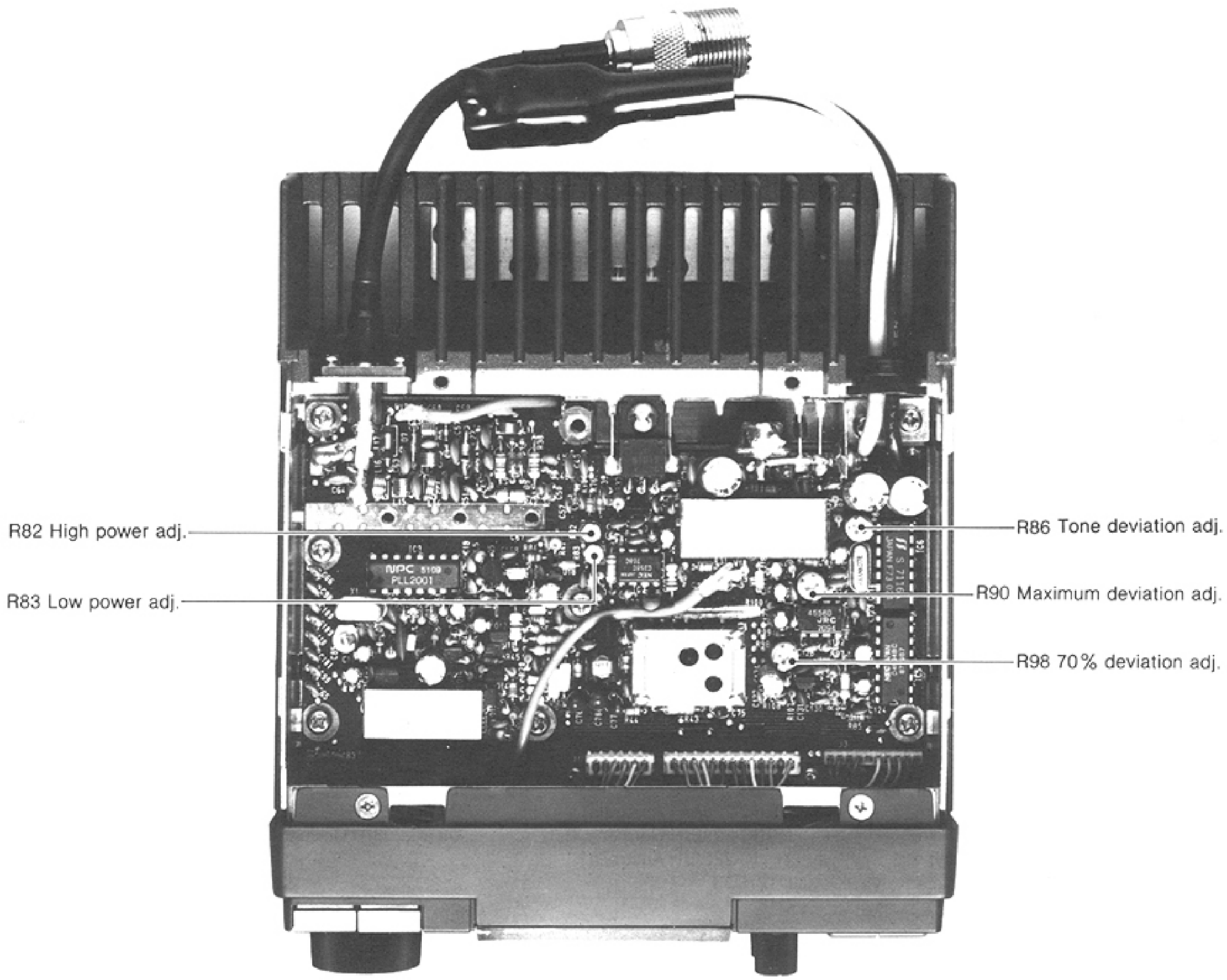
TEST INSTRUMENTS REQUIRED	MEASUREMENT CONNECTION LOCATION
(1) AC POWER SUPPLY • Output voltage : 13.8V DC±15% • Current capacity : 10A or more (2) RF POWER METER • Terminated type • Minimum power rating: 50W • Frequency minimum : 150MHz • Input impedance : 50Ω • SWR : 1.2 : 1 or better (3) FM DEVIATION METER • Frequency minimum : 150MHz • Measuring range : 0~±10kHz (4) AF GENERATOR • Frequency range : 200~2000Hz • Output range : 2~200mV (5) ATTENUATOR • Attenuation : 40dB or 50dB • Input power rating : At least 50W	

ADJUSTMENT		ADJUSTMENT CONDITIONS	MEASUREMENT		VALUE	ADJUSTMENT POINT	
			UNIT	LOCATION		UNIT	ADJUST
OUTPUT POWER	1	• Frequency display: 145.000MHz • Transmitting • [HI/LO] SWITCH: HIGH	Rear panel	Connect the RF power meter to the ANTENNA CONNECTOR.	25W (IC-228A/E) 45W (IC-228H)	MAIN	R82
	2	• [HI/LO] SWITCH: LOW			5W (Any model)		R83
DEVIATION	1	• Frequency display: 146.000MHz (IC-228E/H Europe: 145.000MHz) • Transmitting • Apply an AF signal to the MIC CONNECTOR Level: 20mV/1kHz (IC-228A/H U.S.A. 65mV/1kHz) • Set the FM deviation meter. HPF: 50Hz LPF: 20kHz • [T/T. SQL] SWITCH: OFF	Rear panel	Connect the FM deviation meter to the ANTENNA CONNECTOR via the attenuator.	±4.8kHz	MAIN	R90
	2	• Apply an AF signal to the MIC CONNECTOR Level: 2mV/1kHz (IC-228A/H U.S.A. 6.5mV/1kHz)			±3.5kHz	MAIN	R98

TRANSMITTER ADJUSTMENT (CONTINUED)

ADJUSTMENT		ADJUSTMENT CONDITIONS	MEASUREMENT		VALUE	ADJUSTMENT POINT	
			UNIT	LOCATION		UNIT	ADJUST
TONE DEVIATION (IC-228A/H U.S.A., Asia only)	1	• Frequency display: 146.000MHz • Apply no signal to the MIC CONNECTOR. • [T/T. SQL] SWITCH: ON • Tone frequency: 88.5kHz • Set the FM deviation meter. HPF: OFF LPF : 20kHz	Rear panel	Connect the FM deviation meter to the ANTENNA CONNECTOR via the attenuator.	±0.85kHz	MAIN	R86
POWER MODULE INPUT (For repair reference)	1	• Frequency display: 145.000MHz • Remove solder and disconnect IC1 pin 1 from MAIN UNIT. • Transmitting	MAIN	Connect the RF power meter (1W type) to the point where solder is removed.	More than +26dBm (400mW) (IC-228H) More than +23dBm (200mW) (IC-228A/E)		Verify

MAIN UNIT

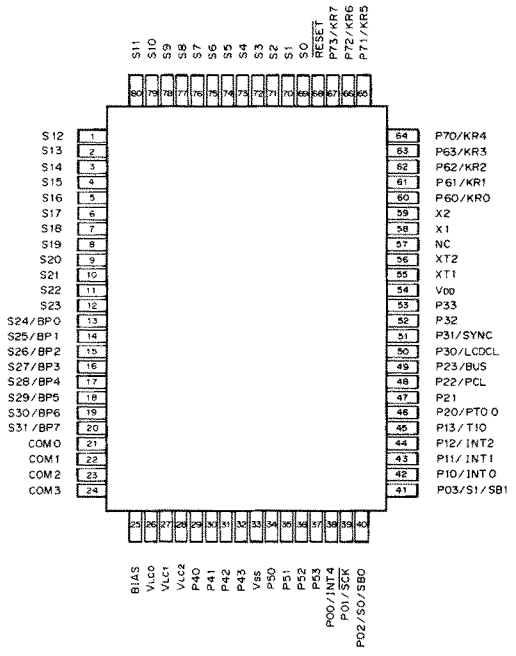


SECTION 7 BOARD LAYOUTS

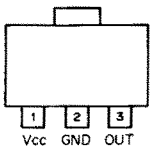
7-1 EF UNIT

• EF UNIT

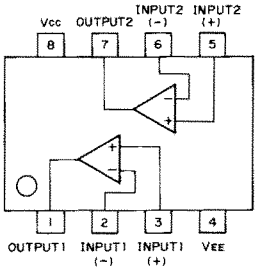
μPD75308GF-101-3B9 IC1
(CPU)



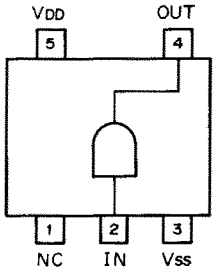
M51943BML IC2
(VOLTAGE DETECTOR)



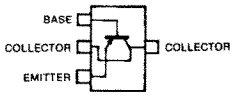
LA6393M IC3
(DUAL COMPARATOR)



TC4S81F IC4
(AND GATE)

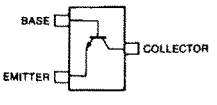


2SB798 DK
Q11



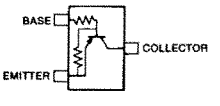
Symbol: DK

2SC2712 Y
Q1, Q2, Q4
Q5, Q10, Q12
Q14, Q15



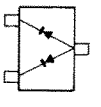
Symbol: LY

RN2404
Q3, Q8
Q9, Q13



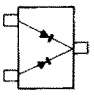
Symbol: YD

1SS181
D15, D17



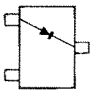
Symbol: A3

1SS184
D1, D2, D3
D4, D5, D6
D8 (IC-228E/H Italy)
D11, D14



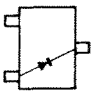
Symbol: B3

1SS193
D8 (IC-228A/H Australia)
D9 (IC-228E/H Germany, Italy
IC-228A/H Australia)
D12, D13
D16



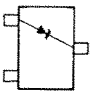
Symbol: F3

1SS196
D7 (IC-228A/H U.S.A., Australia)
D8 (IC-228/H Germany)



Symbol: G3

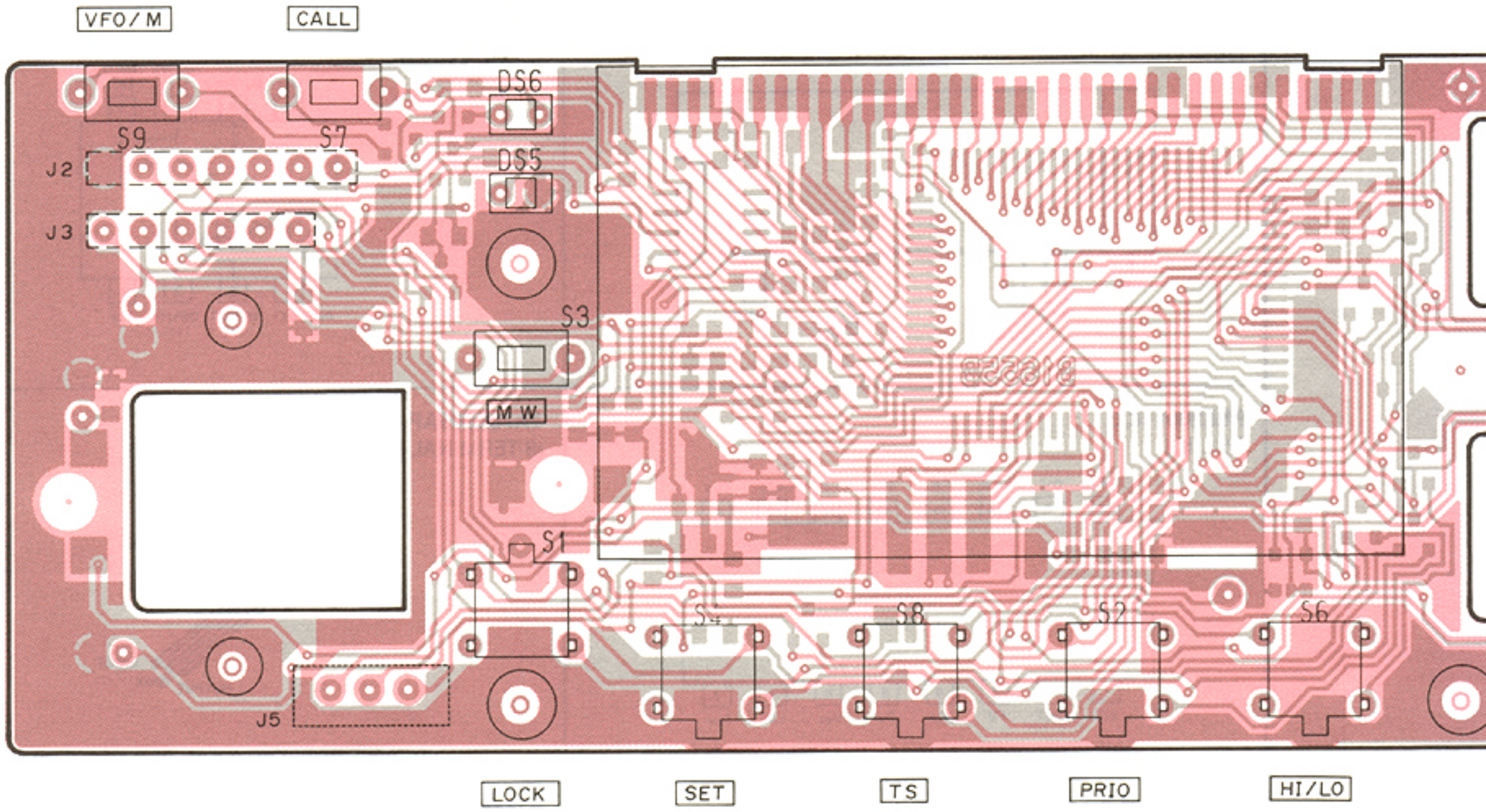
RD9.1M B2
D18



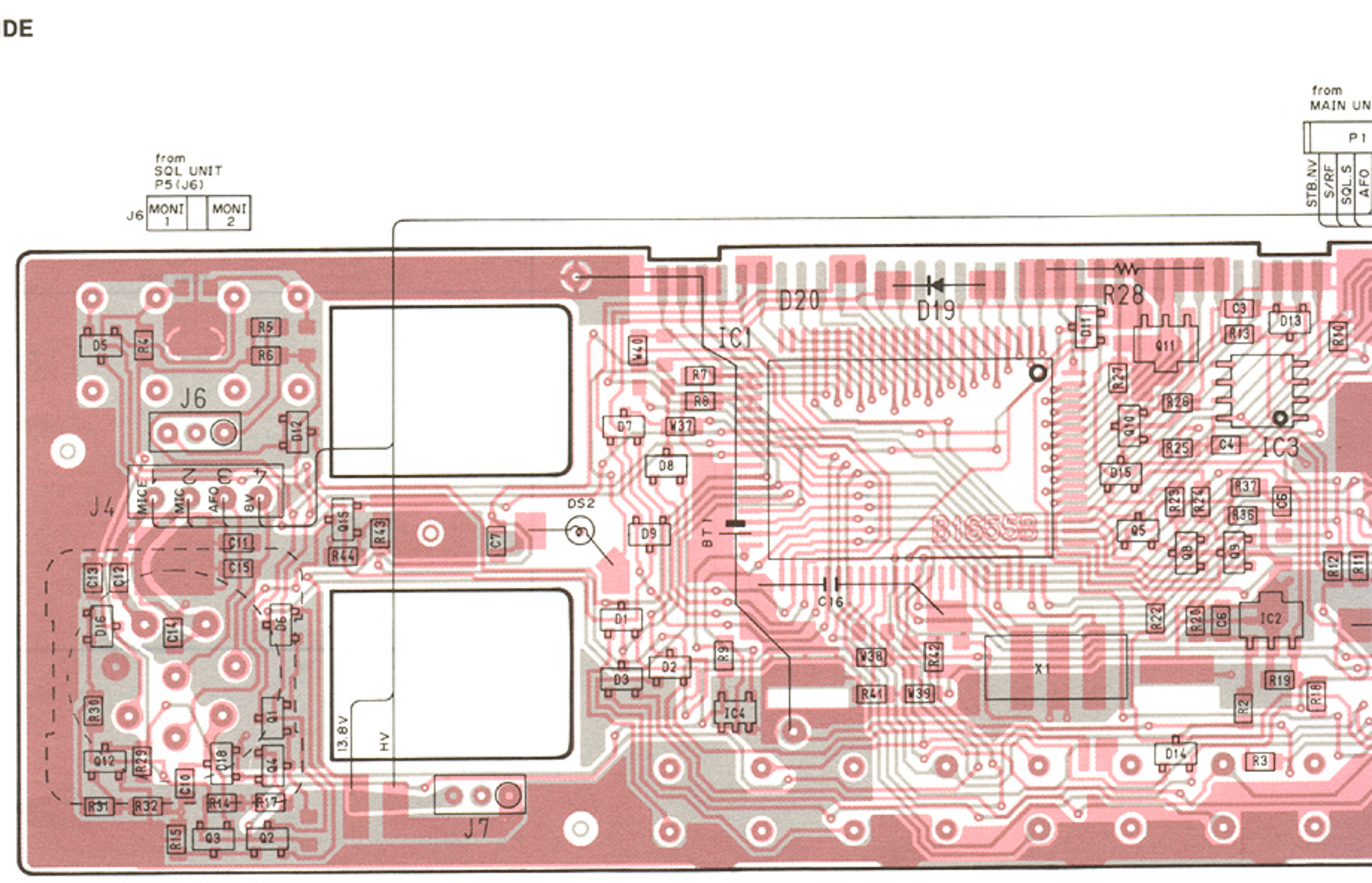
Symbol: 912

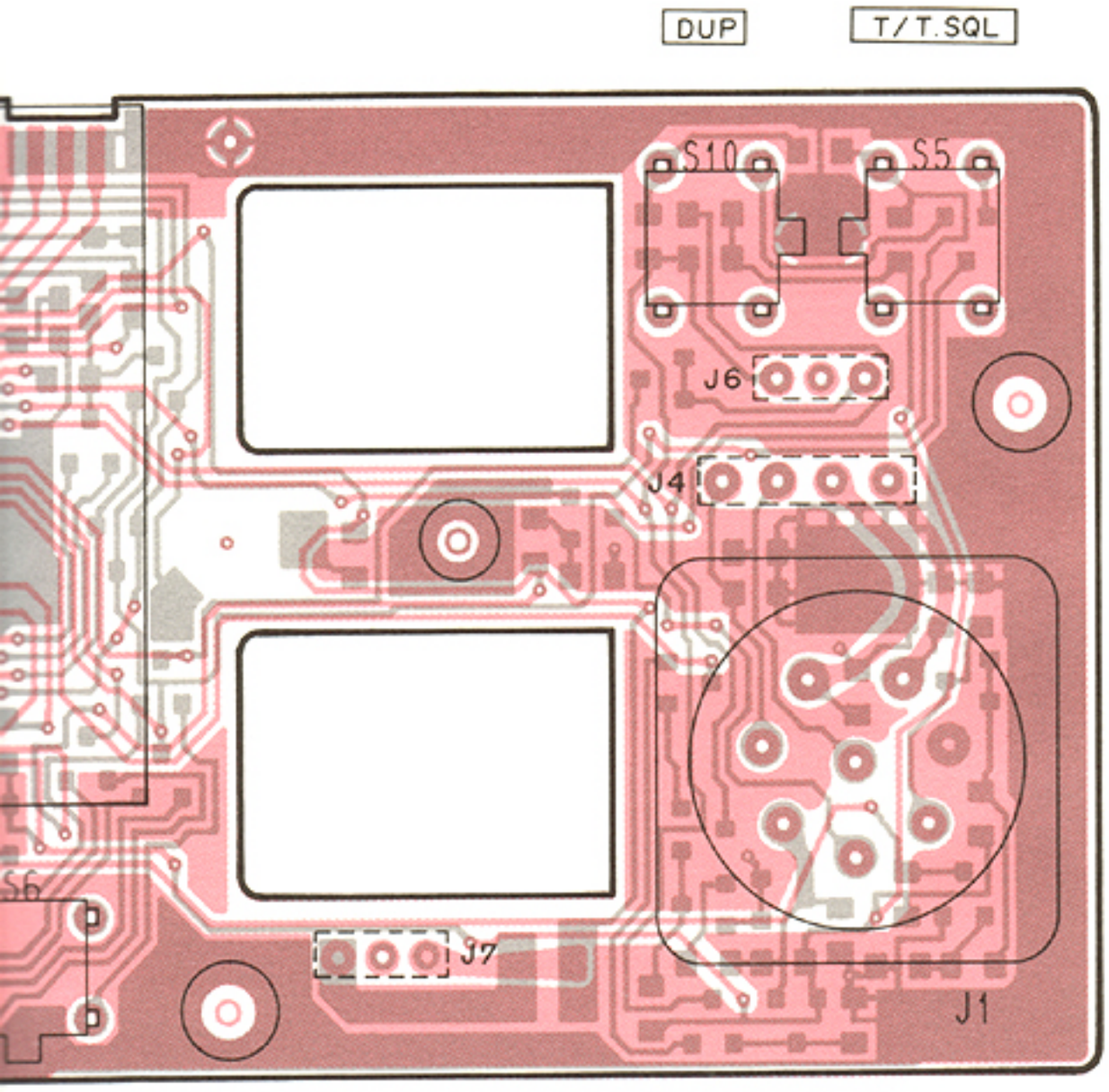
• EF UNIT

COMPONENT SIDE



FOIL SIDE

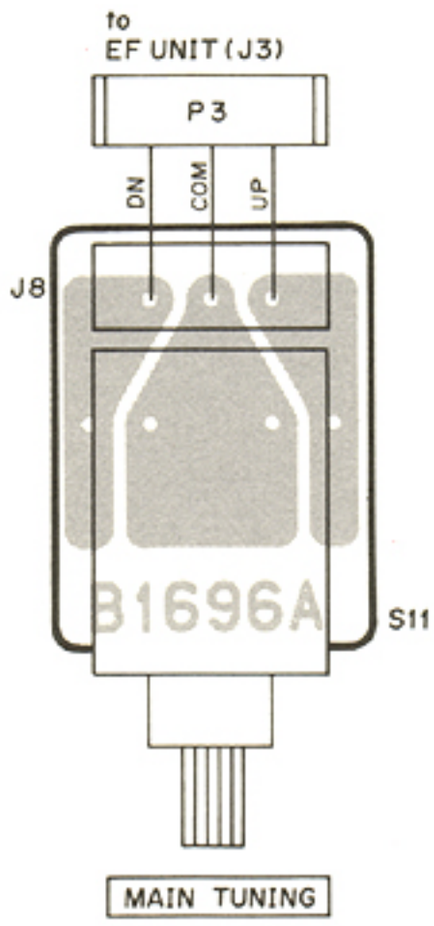




MICROPHONE CONNECTOR

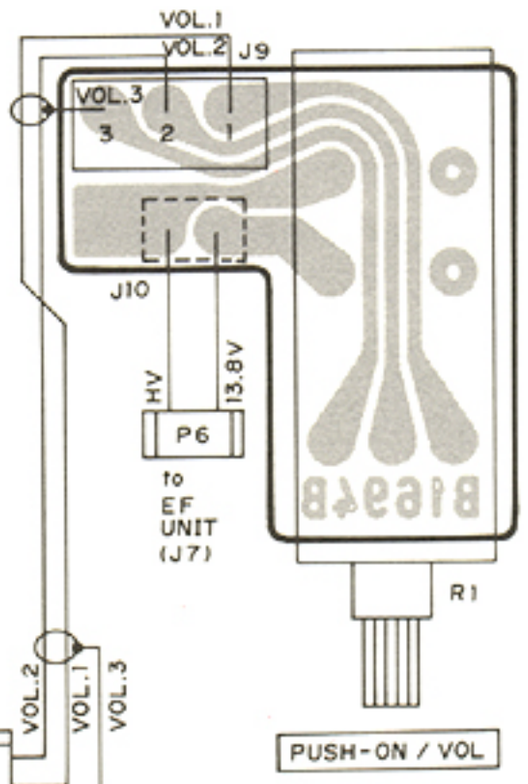
I/LO

• SENSOR UNIT



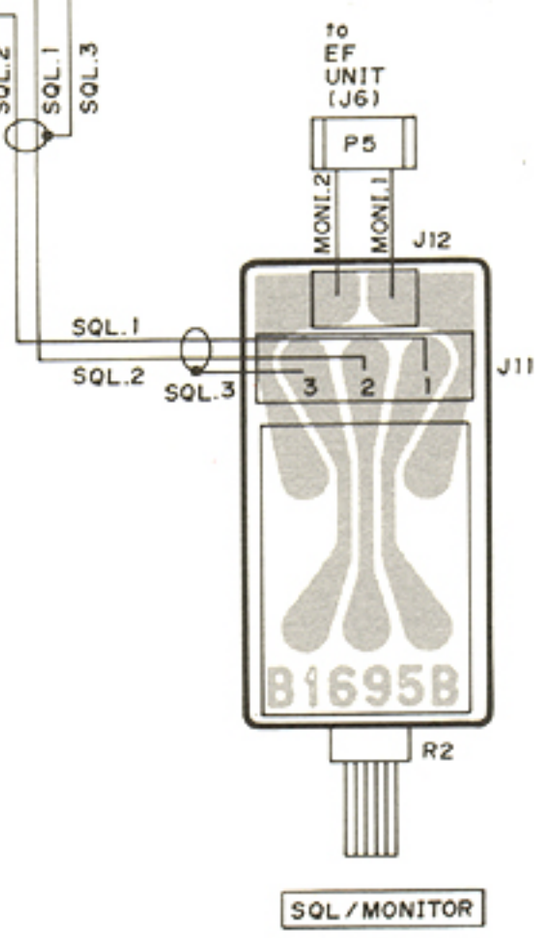
MAIN TUNING

• VOLUME UNIT



PUSH-ON / VOL

• SQUELCH UNIT



SQL / MONITOR

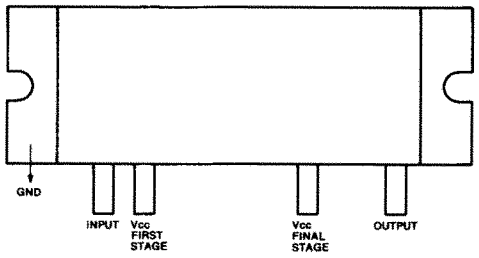
J5 | UP | COM | DN

from
VOL UNIT
P3 (J8)

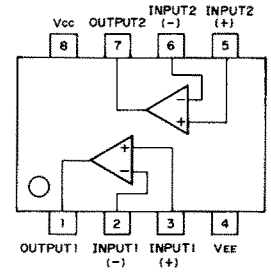
7-2 MAIN UNIT

• IC-228A/E

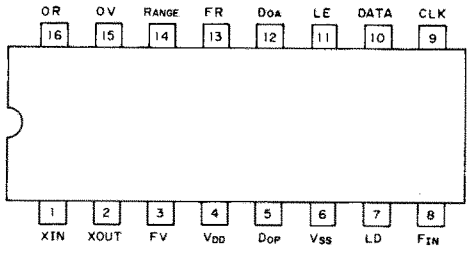
SC-1019 IC1
(25W VHF RF POWER AMP)



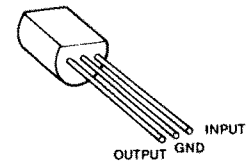
µPC358C IC2
(DUAL DRIVER)



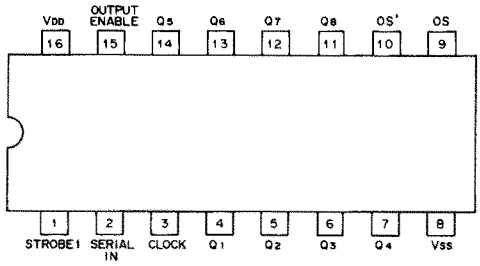
PLL2001 IC3
(PLL IC)



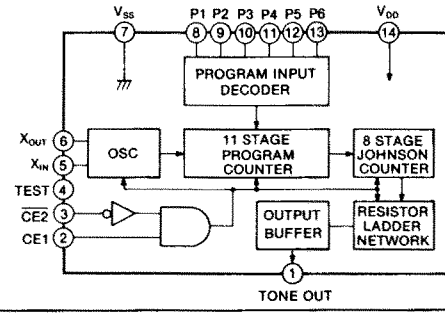
TA78L005AP IC4
(3-TERMINAL 5V REGULATOR)



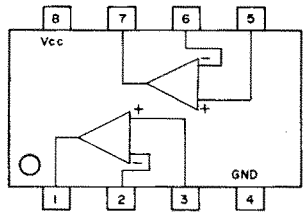
µPD4094BC (IC-228A: U.S.A., Asia) IC5
(8-STAGE SHIFT REGISTER)



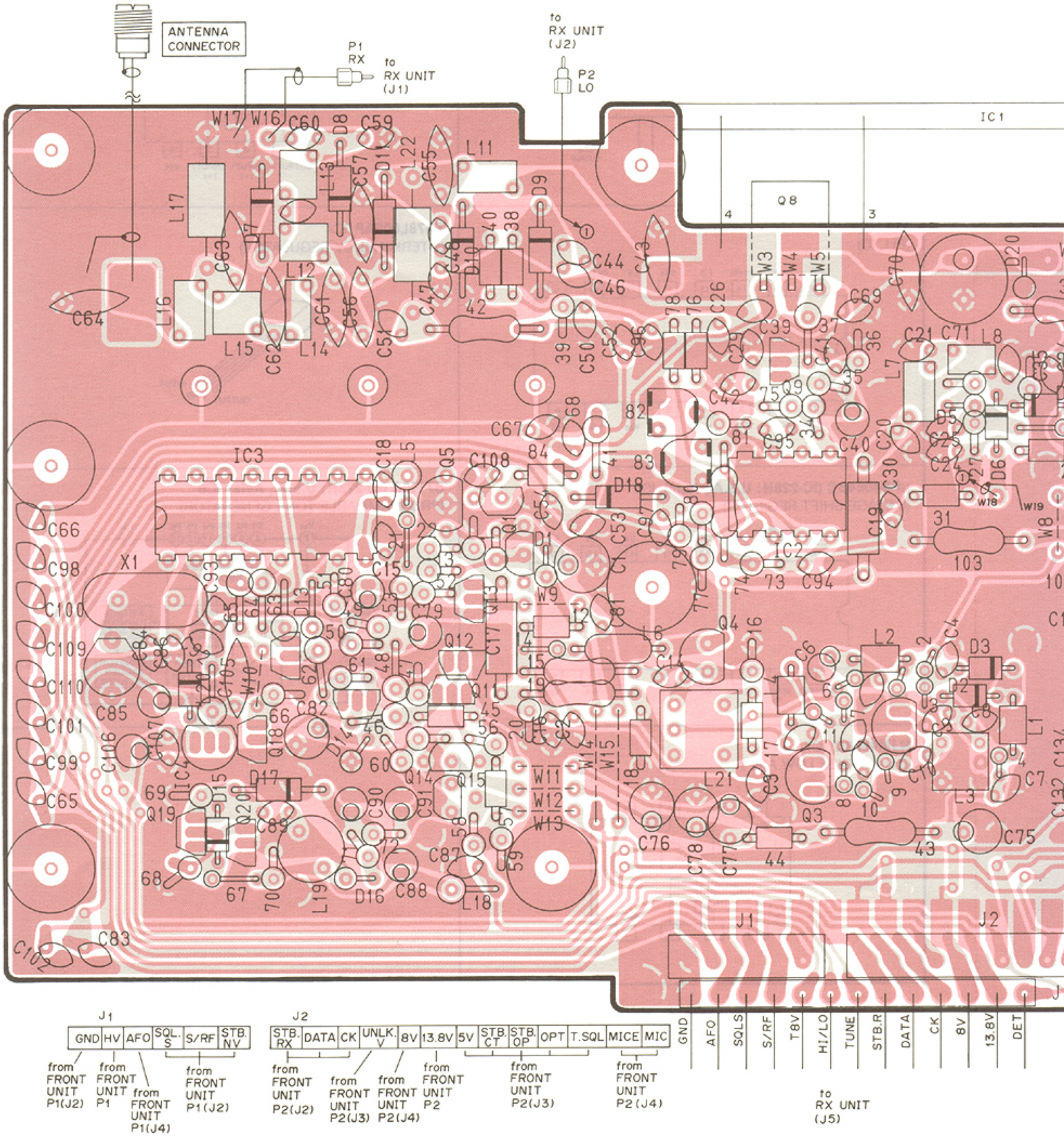
S7116A (IC-228A: U.S.A., Asia) IC6
(PROGRAMMABLE TONE GENERATOR)

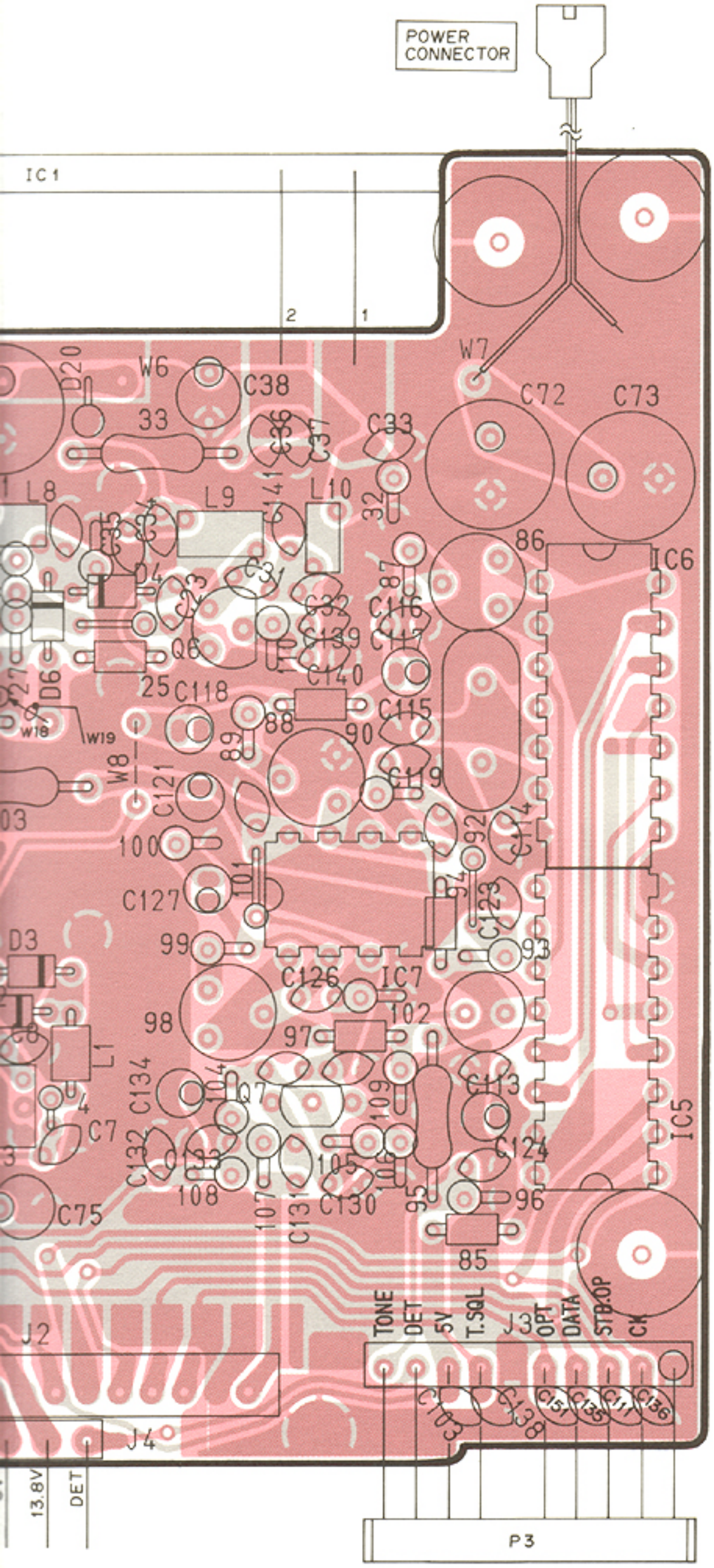


NJM4558D IC7
(DUAL NOISE LOW AMP)



• MAIN UNIT (IC-228A/E)





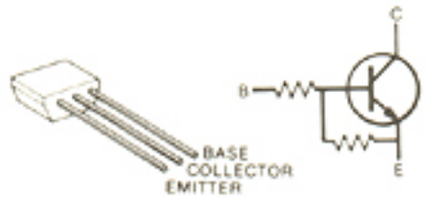
OPTION
UT-40

2SA1048 GR
Q13, Q15
Q16, Q19

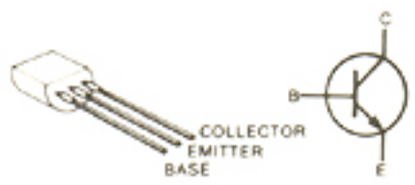
2SC3776 D
Q3, Q4
Q5

2SA1359 Y
Q8

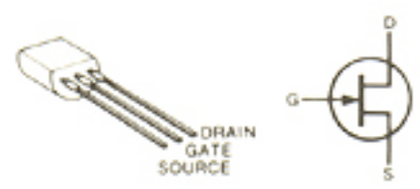
RN1204
Q10



2SC2407
Q6

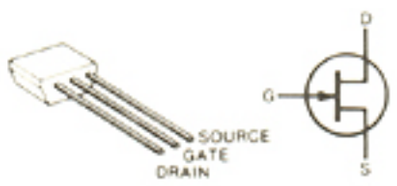


2SK125
Q2



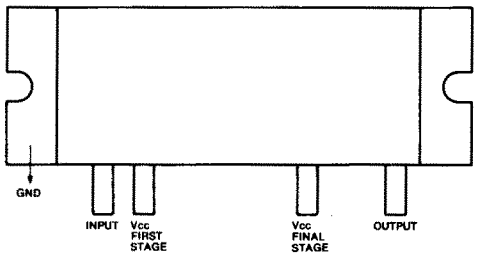
2SC2458 GR
Q1, Q9
Q12, Q17
Q18, Q20
2SC2458L G
Q7

2SK184 Y
Q11, Q14

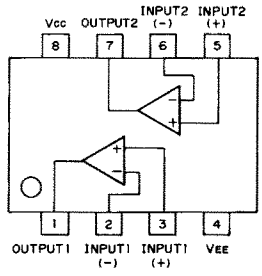


• IC-228H

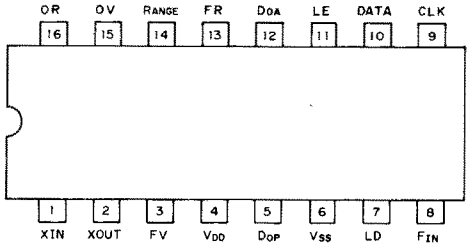
SC-1022 IC1
(45W VHF RF POWER AMP)



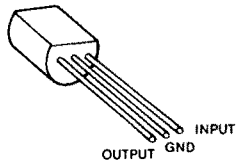
µPC358C IC2
(DUAL DRIVER)



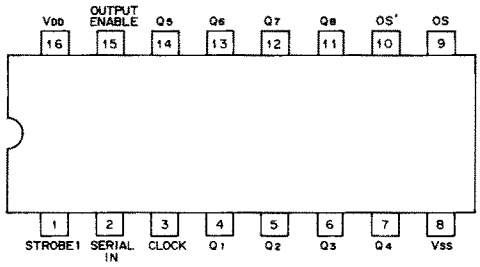
PLL2001 IC3
(PLL IC)



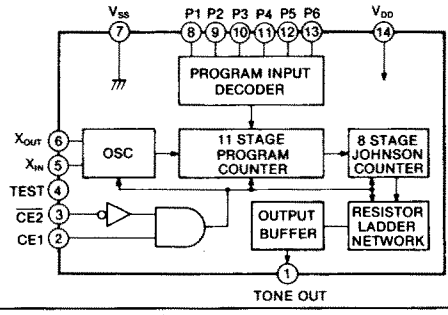
TA78L005AP IC4
(3-TERMINAL 5V REGULATOR)



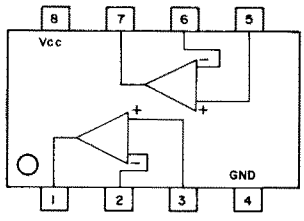
µPD4094BC (IC-228H: U.S.A., Asia) IC5
(8-STAGE SHIFT REGISTER)



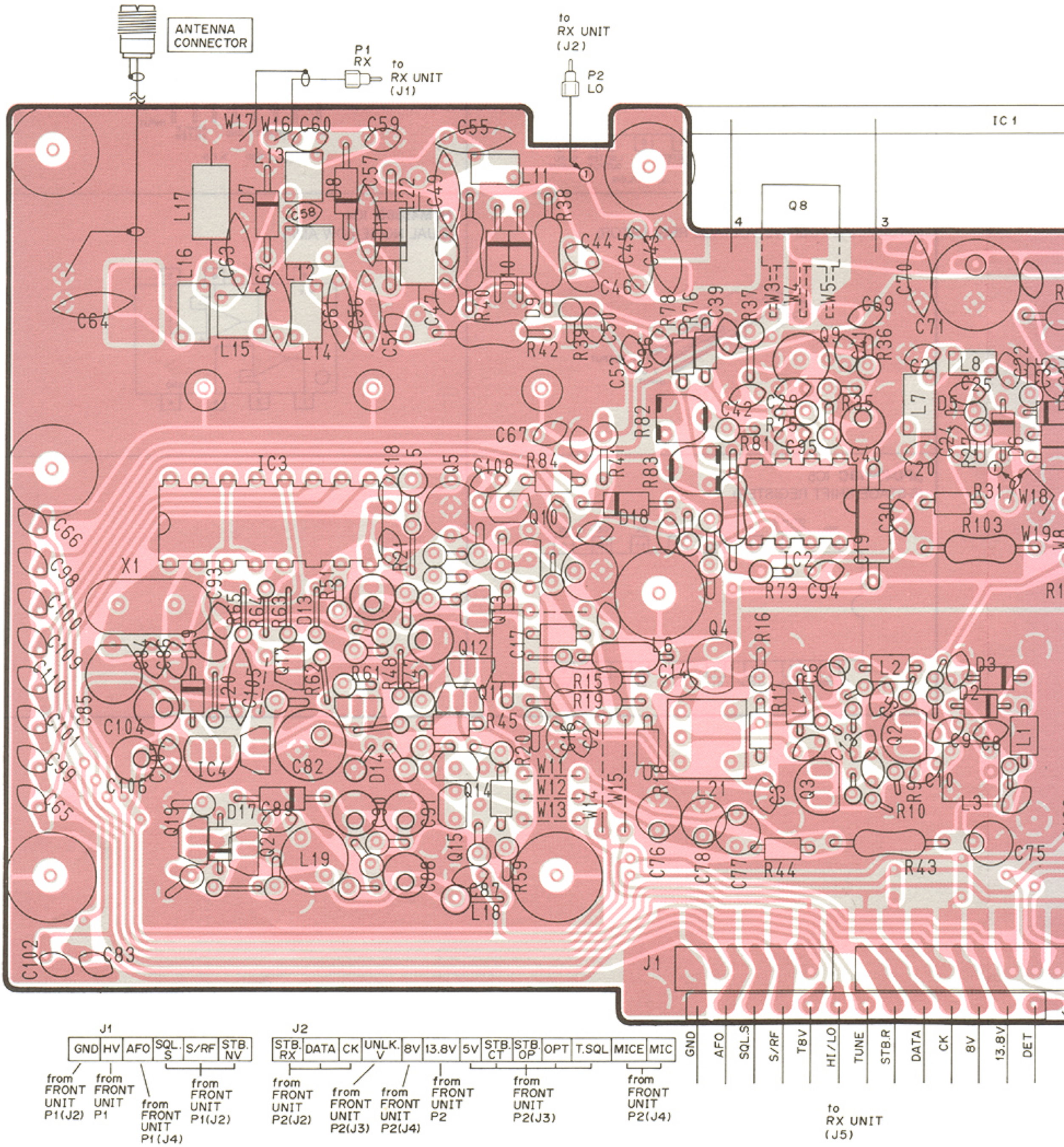
S7116A (IC-228H: U.S.A., Asia) IC6
(PROGRAMMABLE TONE GENERATOR)



NJM4558D IC7
(DUAL NOISE LOW AMP)



• MAIN UNIT (IC-228H)

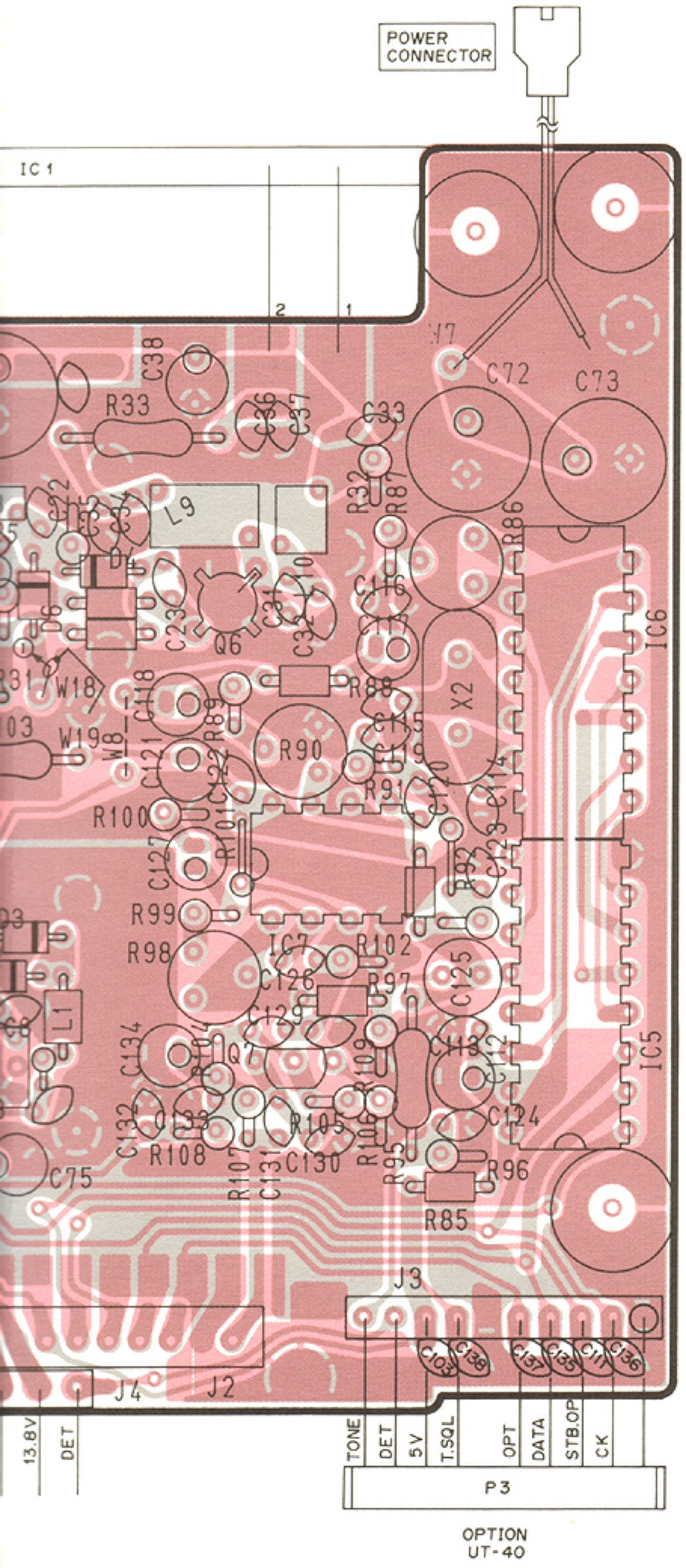


J1

GND	HV	AFO	SQL. S	S/RF	STB. NV
from FRONT UNIT P1(J2)	from FRONT UNIT P1	from FRONT UNIT P1(J4)	from FRONT UNIT P1(J2)		

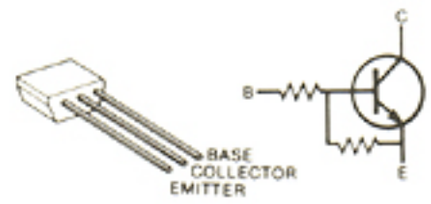
J2

STB. RX	DATA	CK	UNLK. V	8V	13.8V	5V	STB. CT	STB. OP	OPT	T.SQL	MICE	MIC
from FRONT UNIT P2(J2)		from FRONT UNIT P2(J3)	from FRONT UNIT P2(J4)		from FRONT UNIT P2			from FRONT UNIT P2(J3)			from FRONT UNIT P2(J4)	

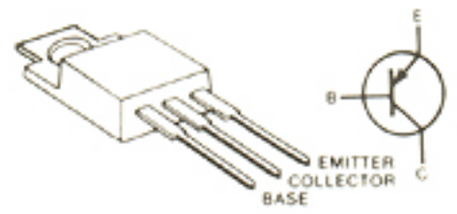


2SA1048 GR
Q13, Q15
Q16, Q19

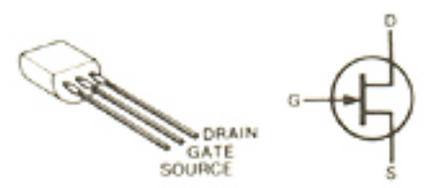
RN1204
Q10



2SB1019
Q8

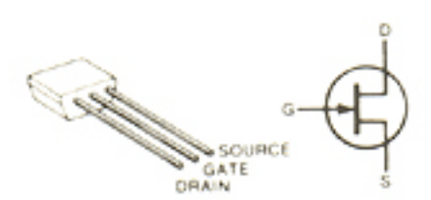


2SK125
Q2



2SC1645 B
Q9

2SK184 Y
Q11, Q14



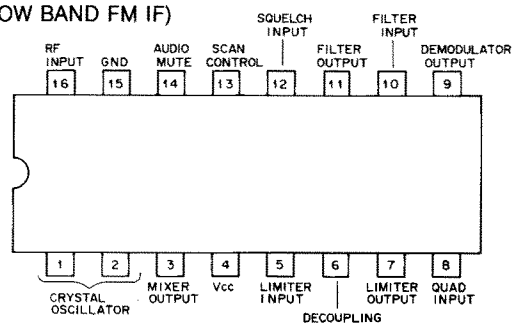
2SC2458 GR
Q1, Q12
Q17, Q18
Q20
2SC2458L G
Q7

TRF559
Q6

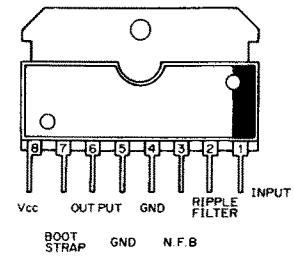
2SC3776 D
Q3, Q4
Q5

7-3 RX UNIT

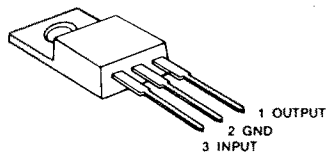
MC3357P IC1
(NARROW BAND FM IF)



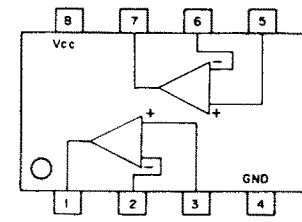
μPC1242H IC2
(AUDIO POWER AMP)



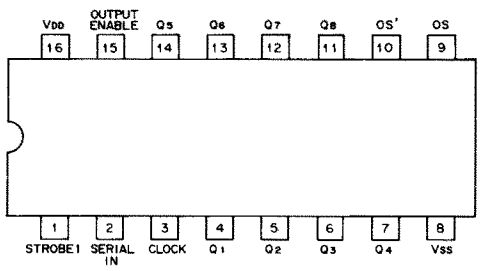
AN6541 IC3
(3-TERMINAL POSITIVE VOLTAGE REGULATOR)



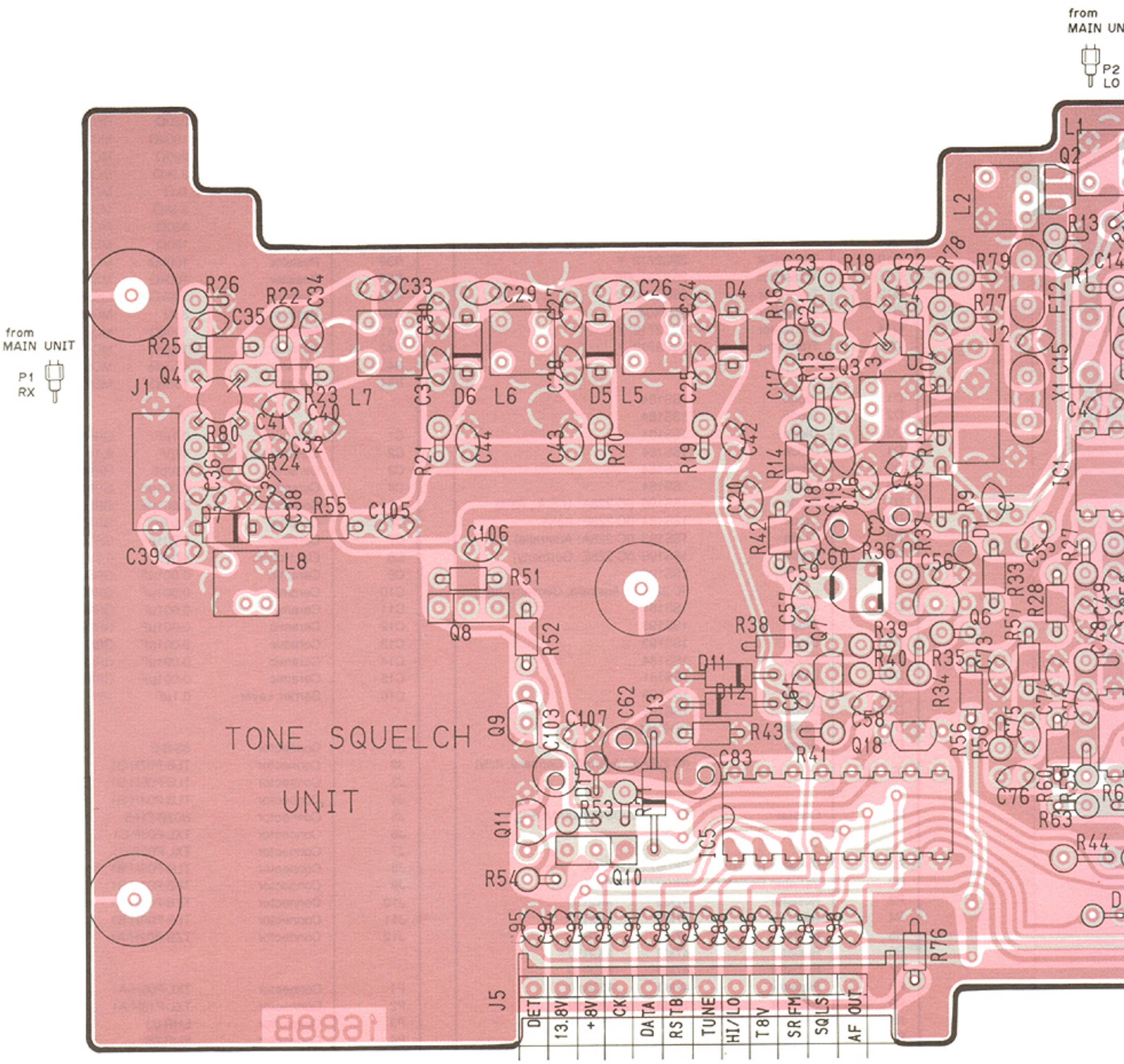
NJM4558D IC4
(DUAL NOISE LOW AMP)

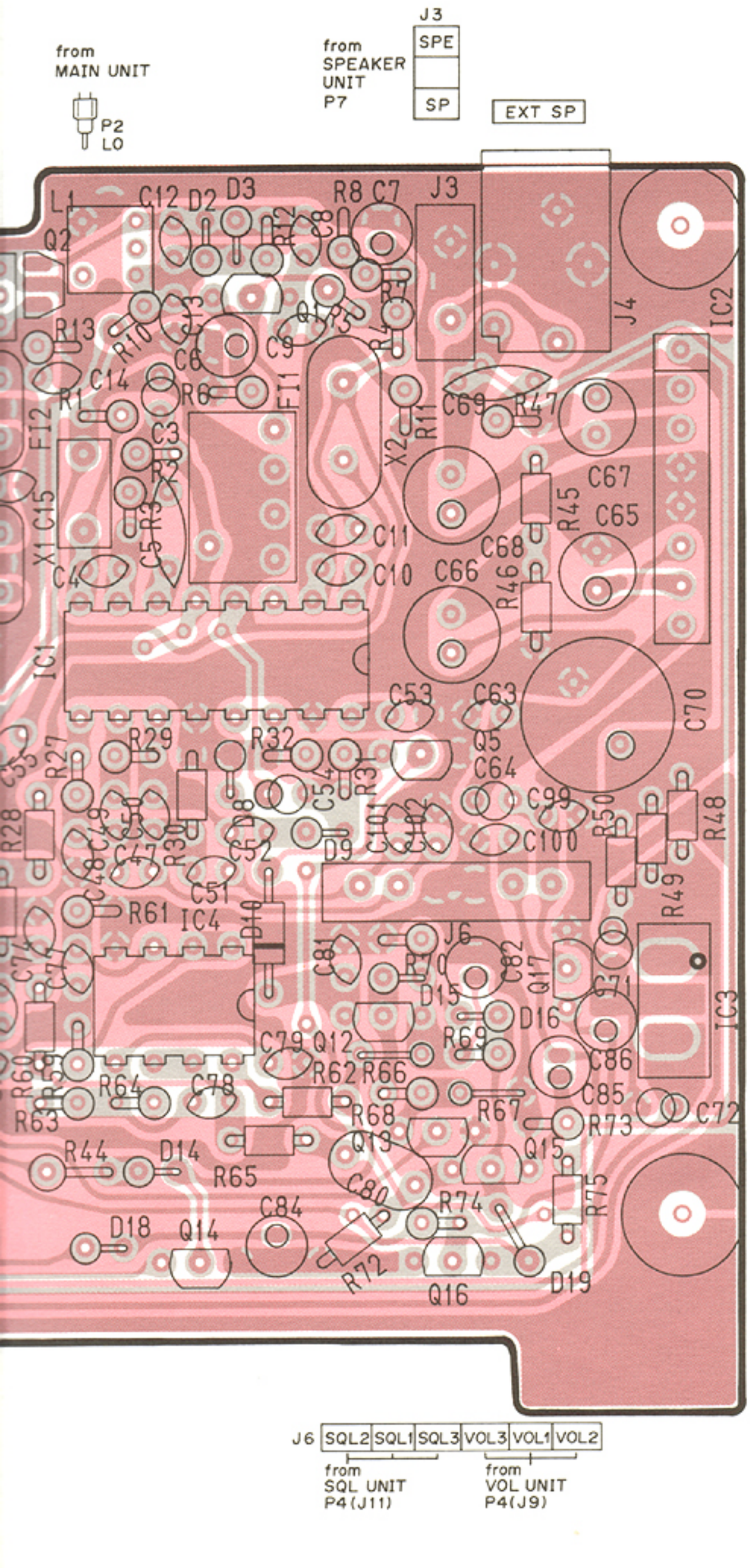


μPD4094BC IC5
(8-STAGE SHIFT REGISTER)



• RX UNIT


from
MAIN UNIT
P1
RX
J1
L8
L7
L6
L5
D6
D5
D4
L1
L2
L3
L4
Q2
Q3
Q4
Q6
Q7
Q8
Q9
Q10
Q11
Q18
D1
D11
D12
D13
IC1
IC5
X1
J2
J5
TONE SQUELCH
UNIT
DET
13.8V
+8V
CK
DATA
RSTB
TUNE
HI/LO
T8V
SRFM
SQLS
AF OUT
to
MAIN UNIT
(J4)



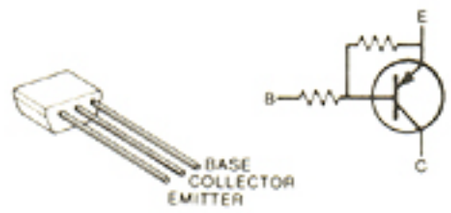
J6 | SQL2 | SQL1 | SQL3 | VOL3 | VOL1 | VOL2

from SQL UNIT P4(J11)

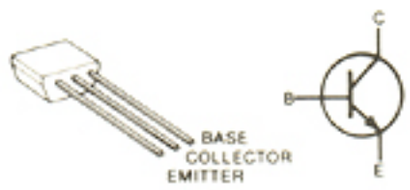
from VOL UNIT P4(J9)

2SB909M Q/R
Q8, Q10

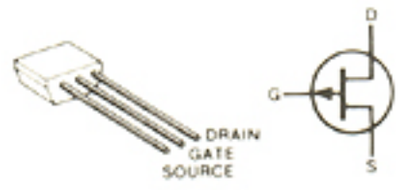
RN2204
Q12, Q18



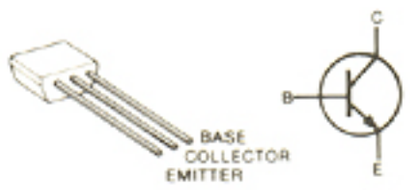
2SC2458 GR
Q5, Q6
Q7, Q13



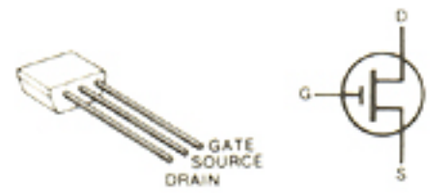
2SJ105 GR
Q15



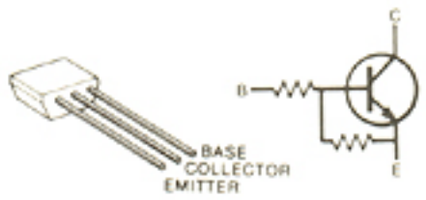
2SC2668 O
Q1



2SK241 GR
Q2



RN1204
Q9, Q11
Q14, Q16
Q17



3SK174 L
Q3, Q4

SECTION 8 PARTS LIST

[EF UNIT]

REF. NO.	DESCRIPTION	PART NO.
IC1	IC	μPD75308GF-101-3B9
IC2	IC	M51943BML
IC3	IC	LA6393M
IC4	IC	TC4S81F
Q1	Transistor	2SC2712 Y
Q2	Transistor	2SC2712 Y
Q3	Transistor	RN2404
Q4	Transistor	2SC2712 Y
Q5	Transistor	2SC2712 Y
Q8	Transistor	RN2404
Q9	Transistor	RN2404
Q10	Transistor	2SC2712 Y
Q11	Transistor	2SB798 DK
Q12	Transistor	2SC2712 Y
Q13	Transistor	RN2404
Q14	Transistor	2SC2712 Y
Q15	Transistor	2SC2712 Y
D1	Diode	1SS184
D2	Diode	1SS184
D3	Diode	1SS184
D4	Diode	1SS184
D5	Diode	1SS184
D6	Diode	1SS184
D7	Diode	1SS196 (IC-228A: U.S.A., Asia)
D8	Diode	1SS184 (IC-228E: Italy)
D8	Diode	1SS193 (IC-228A: Australia)
D8	Diode	1SS196 (IC-228E: Germany)
D9	Diode	1SS193 (IC-228A/E: Australia, Germany, Italy)
D11	Diode	1SS184
D12	Diode	1SS193
D13	Diode	1SS193
D14	Diode	1SS184
D15	Diode	1SS181
D16	Diode	1SS193
D17	Diode	1SS181
D18	Zener	RD9.1M B2
D19	Diode	1SS254 (IC-228A/E: Australia, Germany, Italy)
X1	Crystal	FAR-C4CA-04194000-M01
R1	Variable Resistor	RK097111200BA
R2	Variable Resistor	RK0971114005A
R3	Resistor	47kΩ MCR10
R4	Resistor	47kΩ MCR10
R5	Resistor	47kΩ MCR10
R6	Resistor	47kΩ MCR10
R7	Resistor	47kΩ MCR10
R8	Resistor	47kΩ MCR10
R9	Resistor	15kΩ MCR10
R10	Resistor	1MΩ MCR10
R11	Resistor	8.2kΩ MCR10
R12	Resistor	100kΩ MCR10
R13	Resistor	1.2MΩ MCR10
R14	Resistor	1kΩ MCR10
R15	Resistor	100kΩ MCR10
R16	Resistor	100kΩ MCR10
R17	Resistor	100kΩ MCR10
R18	Resistor	4.7kΩ MCR10
R19	Resistor	220kΩ MCR10
R20	Resistor	3.3kΩ MCR10
R21	Resistor	2.7kΩ MCR10
R22	Resistor	82kΩ MCR10

[EF UNIT]

REF. NO.	DESCRIPTION	PART NO.
R23	Resistor	27kΩ MCR10
R24	Resistor	56kΩ MCR10
R25	Resistor	27kΩ MCR10
R26	Resistor	1.2kΩ MCR10
R27	Resistor	1.8kΩ MCR10
R28	Resistor	220Ω R50X
R29	Resistor	100kΩ MCR10
R30	Resistor	220Ω MCR10
R31	Resistor	3.9kΩ MCR10
R32	Resistor	1kΩ MCR10
R33	Resistor	3.3kΩ MCR10
R34	Resistor	330Ω MCR10
R35	Resistor	180Ω MCR10
R36	Resistor	100kΩ MCR10
R37	Resistor	100kΩ MCR10
R39	Resistor	100kΩ MCR10
R40	Resistor	33Ω MCR10
R41	Resistor	100kΩ MCR10
R42	Resistor	100kΩ MCR10
R43	Resistor	470kΩ MCR10
R44	Resistor	150kΩ MCR10
C1	Ceramic	0.1μF GRM40 F
C2	Electrolytic	47μF 6.3V MS7
C3	Ceramic	330pF GRM40 CH
C4	Ceramic	0.001μF GRM40
C5	Ceramic	0.001μF GRM40
C6	Ceramic	0.01μF GRM40 F
C7	Ceramic	0.001μF GRM40
C8	Electrolytic	47μF 6.3V MS7
C9	Ceramic	0.001μF GRM40
C10	Ceramic	0.001μF GRM40
C11	Ceramic	0.001μF GRM40
C12	Ceramic	0.001μF GRM40
C13	Ceramic	0.001μF GRM40
C14	Ceramic	0.001μF GRM40
C15	Ceramic	0.001μF GRM40
C16	Barrier Layer	0.1μF 16V
J1	Connector	8S-S-E
J2	Connector	TLB-P07H-B1
J3	Connector	TLB-P06H-B1
J4	Connector	TLB-P04H-B1
J5	Connector	B03B-EH-S
J6	Connector	TXL-P03P-C1
J7	Connector	TXL-P03P-C1
J8	Connector	TLB-P03H-B1
J9	Connector	TLB-P03H-B1
J10	Connector	TZB-P02H-A1
J11	Connector	TLB-P03H-B1
J12	Connector	TZB-P02H-A1
P1	Connector	TXL-P06H-A1
P2	Connector	TXL-P13H-A1
P3	Connector	EHR-03
P4	Connector	EHR-06
P5	Connector	TXL-P03H-A1
P6	Connector	TXL-P03H-A1
P7	Connector	EHR-03
DS1	LCD	LCD-9811J
DS2	Lamp	HRS-7219A-Y2 30
DS3	Lamp	HRS-7219A-Y2 30
DS4	Lamp	HRS-7219A-Y2 30
DS5	LED	SLP-251B
DS6	LED	SLP-151B

[EF UNIT]

REF. NO.	DESCRIPTION	PART NO.
S1	Switch	SKHHAK013A
S2	Switch	HKW0270-01-300
S3	Switch	SKHLAB064A
S4	Switch	HKW0270-01-300
S5	Switch	HKW0270-01-300
S6	Switch	HKW0270-01-300
S7	Switch	SKHLAB064A
S8	Switch	HKW0270-01-300
S9	Switch	SKHLAB064A
S10	Switch	HKW0270-01-300
S11	Rotary Encoder	SRBM1L038A
SP1	Speaker	57S38-1
BT1	Lithium Battery	BR2032-1T2
EP1	P.C. Board	B-1655B (LOGIC)
EP2	P.C. Board	B-1694B (VOLUME)
EP3	P.C. Board	B-1695B (SQUELCH)
EP4	P.C. Board	B-1696A (SENSOR)
EP5	LCD Contact Strip	SRCN543

[MAIN UNIT]

REF. NO.	DESCRIPTION	PART NO.
IC1	IC	SC-1019 (IC-228A/E) SC-1022 (IC-228H)
IC2	IC	µPC358C
IC3	IC	PLL2001
IC4	IC	TA78L005AP
IC5	IC	µPD4094BC (IC-228A: U.S.A., Asia)
IC6	IC	S7116A (IC-228A: U.S.A., Asia)
IC7	IC	NJM4558D
Q1	Transistor	2SC2458 GR
Q2	FET	2SK125
Q3	Transistor	2SC3776 D
Q4	Transistor	2SC3776 D
Q5	Transistor	2SC3776 D
Q6	Transistor	2SC2407 (IC-228A/E) TRF559 (IC-228H)
Q7	Transistor	2SC2458L G
Q8	Transistor	2SA1359 Y (IC-228A/E) 2SB1019 (IC-228H)
Q9	Transistor	2SC2458 GR (IC-228A/E) 2SC1645 B
Q10	Transistor	RN1204
Q11	FET	2SK184 Y
Q12	Transistor	2SC2458 GR
Q13	Transistor	2SA1048 GR
Q14	FET	2SK184 Y
Q15	Transistor	2SA1048 GR
Q16	Transistor	2SA1048 GR
Q17	Transistor	2SC2458 GR
Q18	Transistor	2SC2458 GR
Q19	Transistor	2SA1048 GR
Q20	Transistor	2SC2458 GR
D1	Diode	1SS53
D2	Varicap	1SV50E
D3	Varicap	1SV50E
D4	Diode	1SS265
D5	Diode	1SS53

[MAIN UNIT]

REF. NO.	DESCRIPTION	PART NO.
D6	Diode	1SS265
D7	Diode	MI308
D8	Diode	MI308
D9	Diode	1SS97
D10	Diode	1SS97
D11	Diode	MI308 (IC-228A/E) MI407 (IC-228H)
D12	Diode	15CD11
D13	Diode	1SS53
D14	Zener	RD20E B2
D15	Diode	1SS133
D16	Diode	1S953
D17	Zener	RD30E B2
D18	Diode	1SS53
D19	Diode	1SS133
X1	Crystal	CR-69
X2	Crystal	RF4A3FAA (IC-228A: U.S.A., Asia)
L1	Coil	3.3µH LAL02KR 3R3K
L2	Coil	3.3µH LAL02KR 3R3K
L3	Coil	LB-167
L4	Coil	3.3µH LAL02KR 3R3K
L5	Coil	3.3µH LAL03NA 3R3K
L6	Coil	3.3µH LAL03NA 3R3K
L7	Coil	LA-244
L8	Coil	LA-234
L9	Coil	LA-244 (IC-228A/E) LA-254 (IC-228H)
L10	Coil	LA-233 (IC-228A/E) LA-235 (IC-228H)
L11	Coil	LA-234
L12	Coil	LA-235
L13	Coil	LA-235
L14	Coil	LA-243
L15	Coil	LA-236
L16	Coil	LA-244
L17	Coil	LW-19
L18	Coil	1mH LAL03NA 102K
L19	Coil	LW-30
L20	Coil	100µH LAL03NA 101K
L21	Coil	LR-116
L22	Coil	LW-19
R1	Resistor	4.7kΩ ELR20
R2	Resistor	2.7kΩ ELR20
R3	Resistor	470Ω ELR20
R4	Resistor	470Ω ELR20
R5	Resistor	47Ω ELR20
R6	Resistor	47Ω ELR20
R7	Resistor	100Ω ELR20
R8	Resistor	4.7kΩ ELR20
R9	Resistor	220Ω ELR20
R10	Resistor	680Ω ELR20
R11	Resistor	47Ω ELR20
R12	Resistor	100Ω R20
R13	Resistor	100Ω ELR20
R14	Resistor	47Ω ELR20
R15	Resistor	4.7kΩ R25
R16	Resistor	680Ω ELR20
R17	Resistor	47Ω R20
R18	Resistor	270Ω R20
R19	Resistor	18Ω R25
R20	Resistor	270Ω ELR20
R21	Resistor	47Ω ELR20
R22	Resistor	4.7kΩ ELR20
R23	Resistor	680Ω ELR20
R24	Resistor	3.3kΩ ELR20
R25	Resistor	1kΩ R20
R26	Resistor	47Ω ELR20
R27	Resistor	2.2kΩ ELR20
R31	Resistor	390Ω R20

[MAIN UNIT]

REF. NO.	DESCRIPTION	PART NO.	
R32	Resistor	150Ω	ELR20
R33	Resistor	10Ω	R25
R34	Resistor	10kΩ	ELR20
R35	Resistor	47kΩ	ELR20
R36	Resistor	33kΩ	ELR20
R37	Resistor	330Ω	R50X (IC-228A/E)
		220Ω	R50X (IC-228H)
R38	Resistor	4.7kΩ	R20
		4.7kΩ	CRB25FX (IC-228H)
R39	Resistor	4.7kΩ	ELR20
R40	Resistor	4.7kΩ	R20 (IC-228A/E)
		4.7kΩ	CRB25FX (IC-228H)
R41	Resistor	47Ω	R50X (IC-228A/E)
		33Ω	R50X (IC-228H)
R42	Resistor	47Ω	R50X (IC-228A/E)
		33Ω	R50X (IC-228H)
R43	Resistor	2.2kΩ	R25
R44	Resistor	270Ω	R20
R45	Resistor	10kΩ	R20
R46	Resistor	1kΩ	ELR20
R47	Resistor	100kΩ	ELR20
R48	Resistor	270kΩ	ELR20
R49	Resistor	220kΩ	ELR20
R50	Resistor	4.7kΩ	ELR20
R51	Resistor	15kΩ	ELR20
R52	Resistor	56kΩ	ELR20
R53	Resistor	270kΩ	ELR20
R55	Resistor	220kΩ	ELR20
R56	Resistor	2.2MΩ	ELR20
R57	Resistor	10Ω	R20
R58	Resistor	150kΩ	ELR20
R59	Resistor	100kΩ	ELR20
R60	Resistor	6.8kΩ	ELR20
R61	Resistor	220kΩ	ELR20
R62	Resistor	56kΩ	ELR20
R63	Resistor	47kΩ	ELR20
R64	Resistor	220kΩ	ELR20
R65	Resistor	100kΩ	ELR20
R66	Resistor	47kΩ	ELR20
R67	Resistor	15kΩ	ELR20
R68	Resistor	2.2kΩ	ELR20
R69	Resistor	68kΩ	ELR20
R70	Resistor	10kΩ	ELR20
R71	Resistor	470Ω	ELR20
R72	Resistor	470Ω	ELR20
R73	Resistor	100Ω	ELR20
R74	Resistor	15kΩ	R25
R75	Resistor	2.2MΩ	ELR20
R76	Resistor	56kΩ	R20
R77	Resistor	680Ω	ELR20
R78	Resistor	10kΩ	R20
R79	Resistor	100kΩ	ELR20
R80	Resistor	180kΩ	ELR20
R81	Resistor	1.2kΩ	ELR20 (IC-228A/E)
		1kΩ	ELR20 (IC-228H)
R82	Trimmer	3.3kΩ	RH0421CN3J01A
R83	Trimmer	2.2kΩ	RH0421CJ3J09A
R84	Resistor	390Ω	R20 (IC-228A/E)
		47Ω	R20 (IC-228H)
R85	Resistor	10Ω	R20
		(IC-228A: U.S.A., Asia)	
R86	Resistor	47kΩ	RH0651CS4J25A
		(IC-228A: U.S.A., Asia)	
R87	Resistor	47kΩ	ELR20
		(IC-228A: U.S.A., Asia)	
R88	Resistor	47kΩ	R20
		(IC-228A: U.S.A., Asia)	
R89	Resistor	5.6kΩ	ELR20
R90	Trimmer	10kΩ	RH0651C14J2WA
R91	Resistor	82kΩ	ELR20
R92	Resistor	82kΩ	ELR20
R93	Resistor	82kΩ	ELR20
R94	Resistor	150kΩ	R20
R95	Resistor	47kΩ	R25
R96	Resistor	100kΩ	ELR20

[MAIN UNIT]

REF. NO.	DESCRIPTION	PART NO.	
R97	Resistor	150kΩ	R20
R98	Trimmer	100kΩ	RH0651C15J1UA
R99	Resistor	1.5kΩ	ELR20
R100	Resistor	100Ω	ELR20
R101	Resistor	220kΩ	ELR20
R102	Resistor	270kΩ	ELR20
R103	Resistor	100Ω	R25
R104	Resistor	5.6kΩ	ELR20
R105	Resistor	1.2MΩ	ELR20
R106	Resistor	330Ω	ELR20
R107	Resistor	1kΩ	ELR20
R108	Resistor	100Ω	ELR20
R109	Resistor	4.7kΩ	ELR20
R110	Resistor	10Ω	ELR20 (IC-228A/E only)
R111	Resistor	330Ω	ELR20 (IC-228A/E only)
C1	Electrolytic	100µF	10V SS
C2	Ceramic	470pF	50V
C3	Ceramic	0.001µF	50V
C4	Ceramic	470pF	50V
C5	Ceramic	470pF	50V
C6	Tantalum	4.7µF	16V DN
C7	Ceramic	470pF	50V
C8	Ceramic	1pF	50V
C9	Ceramic	0.001µF	50V
C10	Ceramic	0.001µF	50V
C11	Ceramic	1pF	50V
C12	Ceramic	100pF	50V
C13	Ceramic	470pF	50V
C14	Ceramic	22pF	50V
C15	Ceramic	470pF	50V
C16	Ceramic	470pF	50V
C17	Cylinder	22pF	UP125 SL 220J
C18	Ceramic	5pF	50V
C19	Cylinder	5.6pF	UP125 SL 5R6K
C20	Ceramic	10pF	50V
C21	Ceramic	22pF	50V
C22	Ceramic	12pF	50V
C23	Ceramic	20pF	50V (IC-228A/E)
		30pF	50V (IC-228H)
C24	Ceramic	470pF	50V
C25	Ceramic	470pF	50V
C26	Ceramic	470pF	50V
C29	Ceramic	470pF	50V
C30	Ceramic	470pF	50V
C31	Ceramic	22pF	50V
C32	Ceramic	10pF	50V
C33	Ceramic	22pF	50V
C34	Ceramic	470pF	50V
C35	Ceramic	0.001µF	50V
C36	Ceramic	470pF	50V
C37	Ceramic	0.001µF	50V
C38	Tantalum	10µF	35V DN
C39	Ceramic	470pF	50V
C40	Electrolytic	10µF	16V MS7
C41	Ceramic	0.001µF	50V
C42	Ceramic	0.001µF	50V
C43	Ceramic	22pF	500V (IC-228A/E)
		12pF	500V (IC-228H)
C44	Ceramic	1pF	50V (IC-228A/E)
		2pF	50V UJ (IC-228H)
C45	Ceramic	2pF	500V (IC-228H only)
C46	Ceramic	20pF	50V CH (IC-228A/H)
		27pF	50V CH (IC-228H)
C47	Ceramic	20pF	50V CH (IC-228A/H)
		27pF	50V CH (IC-228H)
C48	Ceramic	1pF	50V (IC-228A/E)
		2pF	50V UJ (IC-228H)
C49	Ceramic	2pF	500V (IC-228H only)
C50	Ceramic	0.001µF	50V
C51	Ceramic	0.001µF	50V
C52	Ceramic	470pF	50V
C53	Ceramic	0.001µF	50V
C54	Ceramic	470pF	50V

[MAIN UNIT]

REF. NO.	DESCRIPTION	PART NO.
C55	Ceramic	12pF 500V
C56	Ceramic	0.001µF 500V
C57	Ceramic	22pF 500V (IC-228A/E)
		18pF 500V (IC-228H)
C58	Ceramic	39pF 50V
C59	Ceramic	20pF 50V
C60	Ceramic	100pF 50V
C61	Ceramic	15pF 500V
C62	Ceramic	30pF 500V
C63	Ceramic	30pF 500V
C64	Ceramic	10pF 500V
C65	Ceramic	0.001µF 50V
C66	Ceramic	470pF 50V
C67	Ceramic	0.001µF 50V
C68	Ceramic	470pF 50V
C69	Ceramic	0.001µF 50V
C70	Ceramic	220pF 50V
C71	Electrolytic	330µF 16V SS
C72	Electrolytic	330µF 16V SS
C73	Electrolytic	330µF 16V SS
C74	Feed Through	0.001µF TF318-450E 102GMV
C75	Tantalum	0.1µF 35V DN
C76	Tantalum	10µF 35V DN
C77	Tantalum	2.2µF 35V DN
C78	Tantalum	10µF 35V DN
C79	Electrolytic	4.7µF 25V MS7
C80	Electrolytic	1µF 50V MS7
C81	Ceramic	0.001µF 50V
C82	Electrolytic	47µF 25V MS9
C83	Ceramic	22pF 50V
C84	Ceramic	18pF 50V
C85	Trimmer	20pF CV05D2001
C86	Ceramic	27pF 50V
C87	Ceramic	0.001µF 50V
C88	Electrolytic	10µF 16V MS7
C89	Ceramic	100pF 50V
C90	Electrolytic	3.3µF 50V MS7
C91	Electrolytic	3.3µF 50V MS7
C92	Ceramic	0.001µF 50V
C93	Barrier Layer	0.01µF 25V
C94	Ceramic	0.001µF 50V
C95	Ceramic	0.001µF 50V
C96	Ceramic	470pF 50V
C97	Ceramic	0.001µF 50V
C98	Ceramic	0.001µF 50V
C99	Ceramic	470pF 50V
C100	Ceramic	0.001µF 50V
C101	Ceramic	470pF 50V
C102	Ceramic	47µF 50V
C103	Ceramic	0.001µF 50V
C104	Electrolytic	22µF 6.3V MS7
C105	Barrier Layer	0.1µF 16V
C106	Electrolytic	10µF 16V MS7
C107	Ceramic	0.001µF 50V
C108	Ceramic	0.001µF 50V
C109	Ceramic	470pF 50V
C110	Ceramic	0.001µF 50V
C111	Ceramic	47pF 50V
C112	Electrolytic	2.2µF 50V MS7
		(IC-228A: U.S.A., Asia)
C113	Ceramic	0.001µF 50V
		(IC-228A: U.S.A., Asia)
C114	Ceramic	39pF 50V
		(IC-228A: U.S.A., Asia)
C115	Ceramic	39pF 50V
		(IC-228A: U.S.A., Asia)
C116	Barrier Layer	0.01µF 25V
		(IC-228A: U.S.A., Asia)
C117	Electrolytic	0.1µF 50V MS7
		(IC-228A: U.S.A., Asia)
C118	Electrolytic	4.7µF 25V MS7
C119	Ceramic	120pF 50V
C120	Barrier Layer	0.0022µF 25V
C121	Electrolytic	4.7µF 25V MS7
C122	Ceramic	0.001µF 50V

[MAIN UNIT]

REF. NO.	DESCRIPTION	PART NO.
C123	Barrier Layer	0.001µF 25V
C124	Ceramic	470pF 50V
C125	Electrolytic	1µF 50V BP
C126	Ceramic	470pF 50V
C127	Electrolytic	0.22µF 50V MS7
C128	Ceramic	470pF 50V
C129	Barrier Layer	0.01µF 25V
C130	Ceramic	470pF 50V
C131	Barrier Layer	0.01µF 25V
C132	Ceramic	0.001µF 50V
C133	Ceramic	0.001µF 50V
C134	Electrolytic	10µF 16V MS7
C135	Ceramic	22pF 50V
C136	Ceramic	47pF 50V
C137	Ceramic	47pF 50V
C138	Ceramic	47pF 50V
C139	Ceramic	470pF 50V (IC-228A/E only)
C140	Ceramic	470pF 50V (IC-228A/E only)
C141	Ceramic	22pF 50V (IC-228A/E only)
J1	Connector	TXL-P06P-A1
J2	Connector	TXL-P13P-A1
J3	Connector	PD09A10M
J4	Connector	SB13P-HVQ-24
P1	Connector	TMP-P01X-A1
P2	Connector	TMP-P01X-A1
P3	Connector	PI28A10F
W1	Cable	OPC-186
W2	Cable	OPC-143
W3	Jumper	JPW-01 R01
W4	Jumper	JPW-01 R01
W5	Jumper	JPW-01 R01
W6	Jumper	JPW-01 R01
W7	Jumper	JPW-01 R01
W8	Jumper	JPW-01 R01
W9	Jumper	JPW-01 R01
W10	Jumper	JPW-01 R01
W11	Jumper	JPW-01 R01
W12	Jumper	JPW-01 R01
W13	Jumper	JPW-01 R01
W14	Jumper	JPW-02A
W15	Jumper	JPW-02A
W16	Shield Cable	61/99/170/C31/W13A
W17	(with P1 assembly)	08 A
W18	Shield Cable	61/99/170/C31/W13A
W19	(with P2 assembly)	08 A
W20	Wire	23/00/070/D02/D22
W21	Wire	23/01/070/D02/D22
W22	Wire	23/02/070/D02/D22
W23	Wire	23/03/065/D02/D22
W24	Wire	23/04/065/D02/D22
W25	Wire	23/05/065/D02/D22
W26	Wire	23/06/060/D02/D22
W27	Wire	23/07/060/D02/D22
W28	Wire	23/08/060/D02/D22
W29	Jumper	JPW-02A (IC-228A/E only)
EP1	Ferrite Bead	DL2-OP2.6-3-1.2H
EP2	Ferrite Bead	DL2-OP2.6-3-1.2H
EP9	Crystal	Crystal Seat 4124
EP10	Crystal	Crystal Seat 4124
EP11	P.C. Board	B-1680B (MAIN) (IC-228A/E)
		B-1653B (MAIN) (IC-228H)

[RX UNIT]

REF. NO.	DESCRIPTION	PART NO.
IC1	IC	MC3357P
IC2	IC	μPC1242H
IC3	IC	AN6541
IC4	IC	NJM4558D
IC5	IC	μPD4094BC
Q1	Transistor	2SC2668 O
Q2	FET	2SK241 GR
Q3	FET	3SK174 L
Q4	FET	3SK174 L
Q5	Transistor	2SC2458 GR
Q6	Transistor	2SC2458 GR
Q7	Transistor	2SC2458 GR
Q8	Transistor	2SB909M Q/R
Q9	Transistor	RN1204
Q10	Transistor	2SB909M Q/R
Q11	Transistor	RN1204
Q12	Transistor	RN2204
Q13	Transistor	2SC2458 GR
Q14	Transistor	RN1204
Q15	FET	2SJ105 GR
Q16	Transistor	RN1204
Q17	Transistor	RN1204
Q18	Transistor	RN2204
D1	Zener	RD6.2E B2
D2	Diode	1S953
D3	Diode	1S953
D4	Varicap	1SV50E
D5	Varicap	1SV50E
D6	Varicap	1SV50E
D7	Varicap	1SV50E
D8	Diode	1S953
D9	Diode	1S953
D10	Zener	RD6.2E B2
D11	Diode	1S953
D12	Diode	1S953
D13	Diode	1SS53
D14	Diode	1SS53
D15	Diode	1SS53
D16	Diode	1SS53
D17	Zener	RD5.1E B2
D18	Diode	1SS53
D19	Diode	1SS53
FI1	Ceramic	CFW455E
FI2	Crystal	17M15B
X1	Discriminator	CDB455C7A
X2	Crystal	CR-166
L1	Coil	LS-331
L2	Coil	LS-331
L3	Coil	LS-331
L4	Coil	0.22μH LAL02KR R22M
L5	Coil	LS-291
L6	Coil	LS-291
L7	Coil	LS-291
L8	Coil	LS-291
R1	Resistor	1.5kΩ ELR20
R2	Resistor	1.5kΩ ELR20
R3	Resistor	47kΩ ELR20
R4	Resistor	100Ω ELR20
R5	Resistor	1.5kΩ ELR20
R6	Resistor	1kΩ ELR20
R7	Resistor	56kΩ ELR20
R8	Resistor	18kΩ ELR20
R9	Resistor	100Ω R20

[RX UNIT]

REF. NO.	DESCRIPTION	PART NO.
R10	Resistor	100Ω ELR20
R11	Resistor	22kΩ ELR20
R12	Resistor	10kΩ ELR20
R13	Resistor	2.2kΩ ELR20
R14	Resistor	100Ω R20
R15	Resistor	3.9kΩ ELR20
R16	Resistor	270Ω ELR20
R17	Resistor	820Ω R20
R18	Resistor	3.3kΩ ELR20
R19	Resistor	100kΩ ELR20
R20	Resistor	100kΩ ELR20
R21	Resistor	100kΩ ELR20
R22	Resistor	47Ω ELR20
R23	Resistor	22Ω R20
R24	Resistor	82Ω ELR20
R25	Resistor	47kΩ R20
R26	Resistor	10kΩ ELR20
R27	Resistor	470Ω ELR20
R28	Resistor	470Ω R20
R29	Resistor	330kΩ ELR20
R30	Resistor	5.6kΩ R20
R31	Resistor	100kΩ ELR20
R32	Resistor	100kΩ ELR20
R33	Resistor	15kΩ R20
R34	Resistor	180kΩ ELR20
R35	Resistor	47kΩ ELR20
R36	Trimmer	4.7kΩ RH0421CS3J08A
R37	Resistor	2.7kΩ ELR20
R38	Resistor	47kΩ R20
R39	Resistor	100kΩ ELR20
R40	Resistor	1.5kΩ ELR20
R41	Resistor	1kΩ ELR20
R42	Resistor	100Ω R20
R43	Resistor	22kΩ R20
R44	Resistor	47kΩ ELR20
R45	Resistor	1kΩ R20
R46	Resistor	3.3Ω R20
R47	Resistor	2.2Ω ELR20
R48	Resistor	1Ω R20
R49	Resistor	1Ω R20
R50	Resistor	1Ω R20
R51	Resistor	10kΩ R20
R52	Resistor	1kΩ R20
R53	Resistor	10kΩ ELR20
R54	Resistor	1kΩ ELR20
R55	Resistor	100kΩ R20
R56	Resistor	470Ω R20
R57	Resistor	27kΩ R20
R58	Resistor	27kΩ ELR20
R59	Resistor	5.6kΩ ELR20
R60	Resistor	1.2MΩ R20
R61	Resistor	1.2MΩ ELR20
R62	Resistor	100Ω R20
R63	Resistor	12kΩ ELR20
R64	Resistor	12kΩ ELR20
R65	Resistor	2.7kΩ R20
R66	Resistor	100Ω ELR20
R67	Resistor	100kΩ ELR20
R68	Resistor	10kΩ ELR20
R69	Resistor	100kΩ ELR20
R70	Resistor	4.7kΩ ELR20
R71	Resistor	220Ω ELR20
R72	Resistor	4.7kΩ R20
R73	Resistor	10kΩ ELR20
R74	Resistor	220kΩ ELR20
R75	Resistor	470kΩ R20
R76	Resistor	27kΩ R20
R77	Resistor	270Ω ELR20
R78	Resistor	18Ω ELR20
R79	Resistor	270Ω ELR20
R80	Resistor	10kΩ ELR20
C1	Ceramic	0.001μF 50V
C2	Electrolytic	4.7μF 25V MS7

[RX UNIT]

REF. NO.	DESCRIPTION	PART NO.		
C3	Tantalum	0.1μF	35V	DN
C4	Ceramic	82pF	50V	
C5	Barrier Layer	0.1μF	16V	
C6	Electrolytic	4.7μF	25V	MS7
C7	Electrolytic	0.1μF	50V	MS7
C8	Ceramic	120pF	50V	
C9	Ceramic	5pF	50V	
C10	Ceramic	47pF	50V	
C11	Ceramic	120pF	50V	
C12	Ceramic	47pF	50V	
C13	Barrier Layer	0.01μF	25V	
C14	Ceramic	68pF	50V	
C15	Ceramic	3pF	50V	
C16	Ceramic	68pF	50V	
C17	Ceramic	0.001μF	50V	
C18	Ceramic	0.001μF	50V	
C19	Barrier Layer	0.01μF	25V	
C20	Ceramic	0.001μF	50V	
C21	Ceramic	0.5pF	50V	
C22	Ceramic	7pF	50V	
C23	Ceramic	2pF	50V	
C24	Ceramic	0.35pF	50V	
C25	Ceramic	10pF	50V	
C26	Ceramic	0.5pF	50V	
C27	Ceramic	1pF	50V	
C28	Ceramic	10pF	50V	
C29	Ceramic	0.5pF	50V	
C30	Ceramic	1pF	50V	
C31	Ceramic	10pF	50V	
C32	Ceramic	0.001μF	50V	
C33	Ceramic	0.001μF	50V	
C34	Ceramic	0.001μF	50V	
C35	Ceramic	0.001μF	50V	
C36	Ceramic	68pF	50V	
C37	Ceramic	0.5pF	50V	
C38	Ceramic	22pF	50V	
C39	Ceramic	6pF	50V	
C40	Ceramic	0.001μF	50V	
C41	Ceramic	470pF	50V	
C42	Ceramic	0.001μF	50V	
C43	Ceramic	0.001μF	50V	
C44	Ceramic	0.001μF	50V	
C45	Ceramic	470pF	50V	
C46	Ceramic	0.001μF	50V	
C47	Ceramic	0.001μF	50V	
C48	Ceramic	47pF	50V	
C49	Barrier Layer	0.0015μF	25V	
C50	Ceramic	33pF	50V	
C51	Barrier Layer	0.0015μF	25V	
C52	Barrier Layer	0.01μF	25V	
C53	Ceramic	0.001μF	50V	
C54	Tantalum	1μF	35V	DN
C55	Ceramic	0.001μF	50V	
C56	Barrier Layer	0.01μF	25V	
C57	Barrier Layer	0.01μF	25V	
C58	Barrier Layer	0.01μF	25V	
C59	Ceramic	0.001μF	50V	
C60	Electrolytic	1μF	50V	MS7
C61	Barrier Layer	0.01μF	25V	
C62	Electrolytic	10μF	10V	MS5
C63	Ceramic	470pF	50V	
C64	Tantalum	0.1μF	35V	DN
C65	Electrolytic	47μF	16V	SS
C66	Electrolytic	220μF	16V	SS
C67	Electrolytic	47μF	16V	SS
C68	Electrolytic	220μF	16V	SS
C69	Barrier Layer	0.1μF	16V	
C70	Electrolytic	470μF	16V	SS
C71	Tantalum	1μF	35V	DN
C72	Tantalum	4.7μF	16V	DN
C73	Ceramic	0.001μF	50V	
C74	Barrier Layer	0.01μF	25V	
C75	Barrier Layer	0.01μF	25V	
C76	Barrier Layer	0.01μF	25V	
C77	Barrier Layer	0.01μF	25V	

[RX UNIT]

REF. NO.	DESCRIPTION	PART NO.		
C78	Barrier Layer	0.01μF	25V	
C79	Barrier Layer	0.0047μF	25V	
C80	Mylar	0.056μH	563K 50V F2D	
C81	Ceramic	0.001μF	50V	
C82	Electrolytic	10μF	16V	MS7
C83	Electrolytic	4.7μF	25V	MS5
C84	Electrolytic	4.7μF	25V	MS7
C85	Electrolytic	1μF	50V	MS7
C86	Electrolytic	1μF	50V	MS7
C87	Ceramic	0.001μF	50V	
C88	Ceramic	0.001μF	50V	
C89	Ceramic	47pF	50V	
C90	Ceramic	47pF	50V	
C91	Ceramic	0.001μF	50V	
C92	Ceramic	47pF	50V	
C93	Ceramic	0.001μF	50V	
C94	Ceramic	0.001μF	50V	
C95	Ceramic	0.001μF	50V	
C96	Ceramic	0.001μF	50V	
C97	Ceramic	0.001μF	50V	
C98	Ceramic	0.001μF	50V	
C99	Ceramic	0.001μF	50V	
C100	Ceramic	0.001μF	50V	
C101	Ceramic	0.001μF	50V	
C102	Ceramic	0.001μF	50V	
C103	Electrolytic	3.3μF	50V	MS7
C104	Ceramic	0.001μF	50V	
C105	Ceramic	0.001μF	50V	
C106	Ceramic	0.001μF	50V	
C107	Ceramic	0.001μF	50V	
J1	Connector	TMP-J01X-A2		
J2	Connector	TMP-J01X-A2		
J3	Connector	B3B-EH-S		
J4	Connector	HSJ0836-01-010		
J5	Connector	5124-13BH		
J6	Connector	B6B-EH-S		
EP1	P.C. Board	B-1688B (RX)		

SECTION 9 OPTIONAL UNITS

9-1 UT-40 TONE SQUELCH UNIT CIRCUIT DESCRIPTION

9-1-1 GENERAL DESCRIPTION

IC1 is a tone encoder/decoder IC chip that outputs and detects 37 different kinds of tones. A tone is set by serial data from IC1 on the EF UNIT in the IC-228A/E/H transceiver.

IC2 functions as a serial/parallel converter, applying 6-bit parallel data to IC1. The following table shows the relation between frequency and input data in IC1.

OUTPUT FREQUENCY [Hz]	IC1 INPUT PIN NUMBER						OUTPUT FREQUENCY [Hz]	IC1 INPUT PIN NUMBER						OUTPUT FREQUENCY [Hz]	IC1 INPUT PIN NUMBER					
	3	4	5	6	7	8		3	4	5	6	7	8		3	4	5	6	7	8
67.0	H	L	H	H	H	L	110.9	H	L	H	L	H	H	173.8	L	L	L	H	L	H
71.9	L	L	H	H	H	L	114.8	L	L	H	L	H	H	179.9	H	H	H	L	L	H
74.4	H	H	L	H	H	L	118.8	H	H	L	L	H	H	186.2	L	H	H	L	L	H
77.0	L	H	L	H	H	L	123.0	L	H	L	L	H	H	192.8	H	L	H	L	L	H
79.7	H	L	L	H	H	L	127.3	H	L	L	L	H	H	203.5	L	L	H	L	L	H
82.5	L	L	L	H	H	L	131.8	L	L	L	L	H	H	210.7	H	H	L	L	L	H
85.4	H	H	H	L	H	L	136.5	H	H	H	H	L	H	218.1	L	H	L	L	L	H
88.5	L	H	H	L	H	L	141.3	L	H	H	H	L	H	225.7	H	L	L	L	L	H
91.5	H	L	H	L	H	L	146.2	H	L	H	H	L	H	233.6	L	L	L	L	L	H
94.8	H	L	L	H	H	H	151.4	L	L	H	H	L	H	241.8	H	H	H	H	H	L
100.0	L	L	L	H	H	H	156.7	H	H	L	H	L	H	250.3	L	H	H	H	H	L
103.5	H	H	H	L	H	H	162.2	L	H	L	H	L	H	—	—	—	—	—	—	—
107.2	L	H	H	L	H	H	167.9	H	L	L	H	L	H	—	—	—	—	—	—	—

H: HIGH L: LOW

9-1-2 ENCODER CIRCUIT

Pin 26 in IC1 outputs a programmed tone frequency when pin 12 in IC1 becomes "L."

Q4 functions as a buffer amplifier. The collector of Q4 outputs the tone signal and the signal is applied to the VCO circuit to be modulated.

Tone deviation can be adjusted by R10.

9-1-3 DECODER CIRCUIT

Detected signals from pin 9 in IC1 on the RX UNIT of the IC-228A/E/H are applied to pin 29 in IC1 on the UT-40 through the DET line. When the signals have a tone modulated and the tone is matched with the programmed tone frequency by IC2, pin 23 in IC1 changes from "HIGH" to "LOW."

• When the tone squelch function is turned OFF:

Both pins 11 and 12 in IC2 are "HIGH" and +5V are not applied to IC1. Q2 and Q3 turn OFF and the TSQL line is "HIGH."

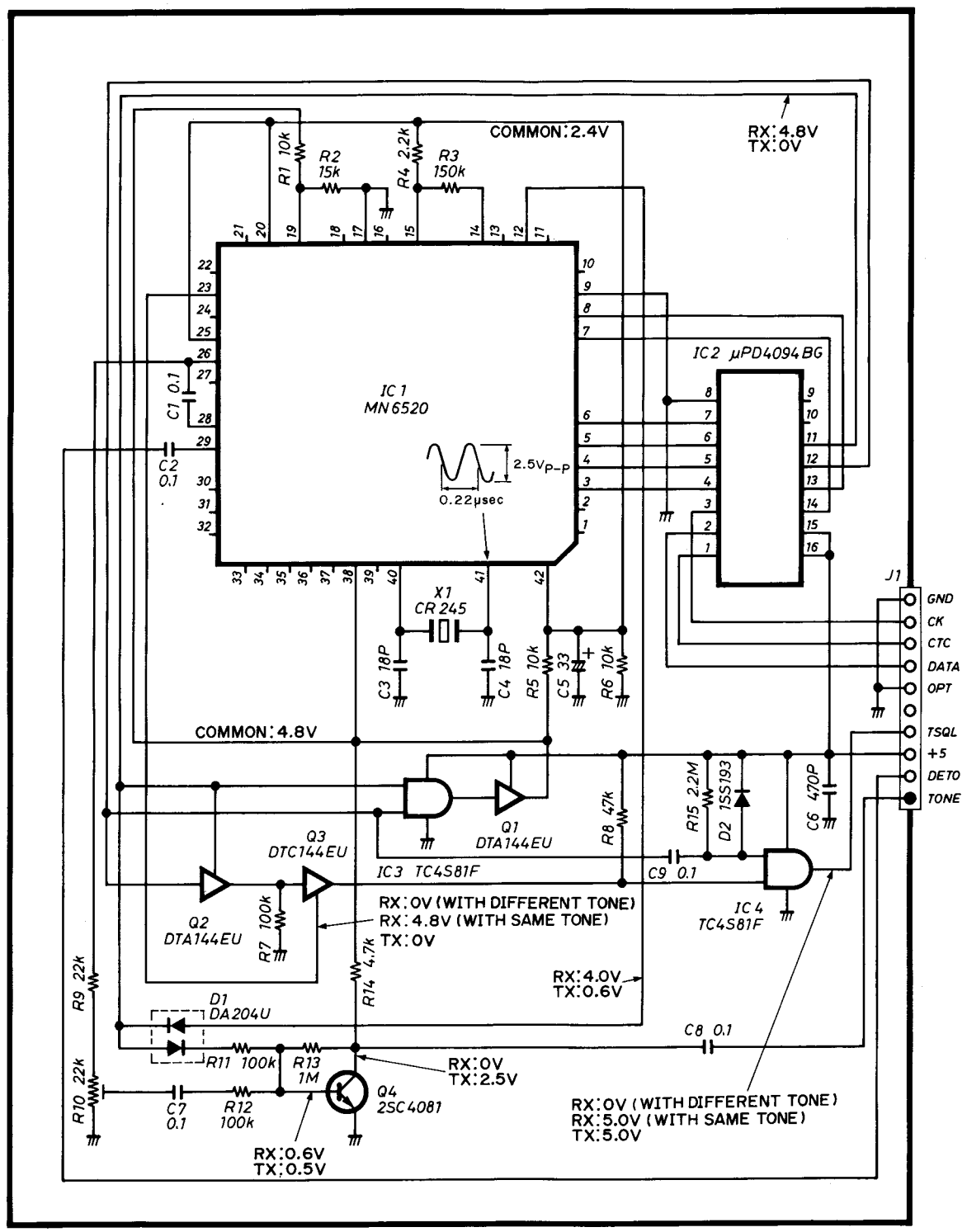
• When the tone squelch function is turned ON:

Pin 11 of IC2 is "HIGH" and pin 12 of IC2 is "LOW." Both Q2 and Q3 turn ON.

When the received tone frequency is not matched with the programmed tone frequency, pin 23 of IC1 is "LOW" and the TSQL line is "LOW."

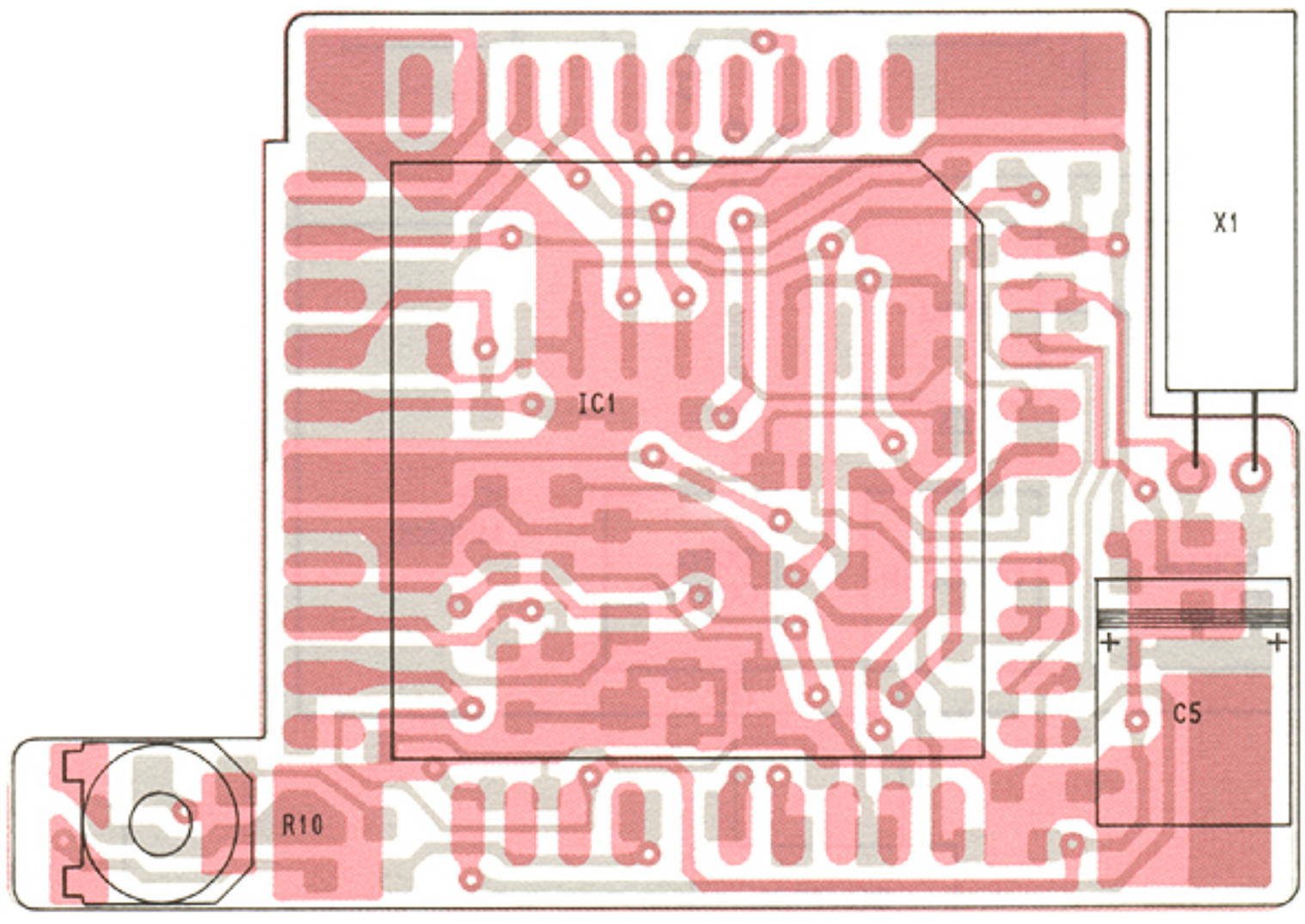
When the received tone frequency is matched with the programmed tone, pin 23 becomes "HIGH" and the TSQL line becomes "HIGH."

9-2 UT-40 VOLTAGE/CIRCUIT DIAGRAM

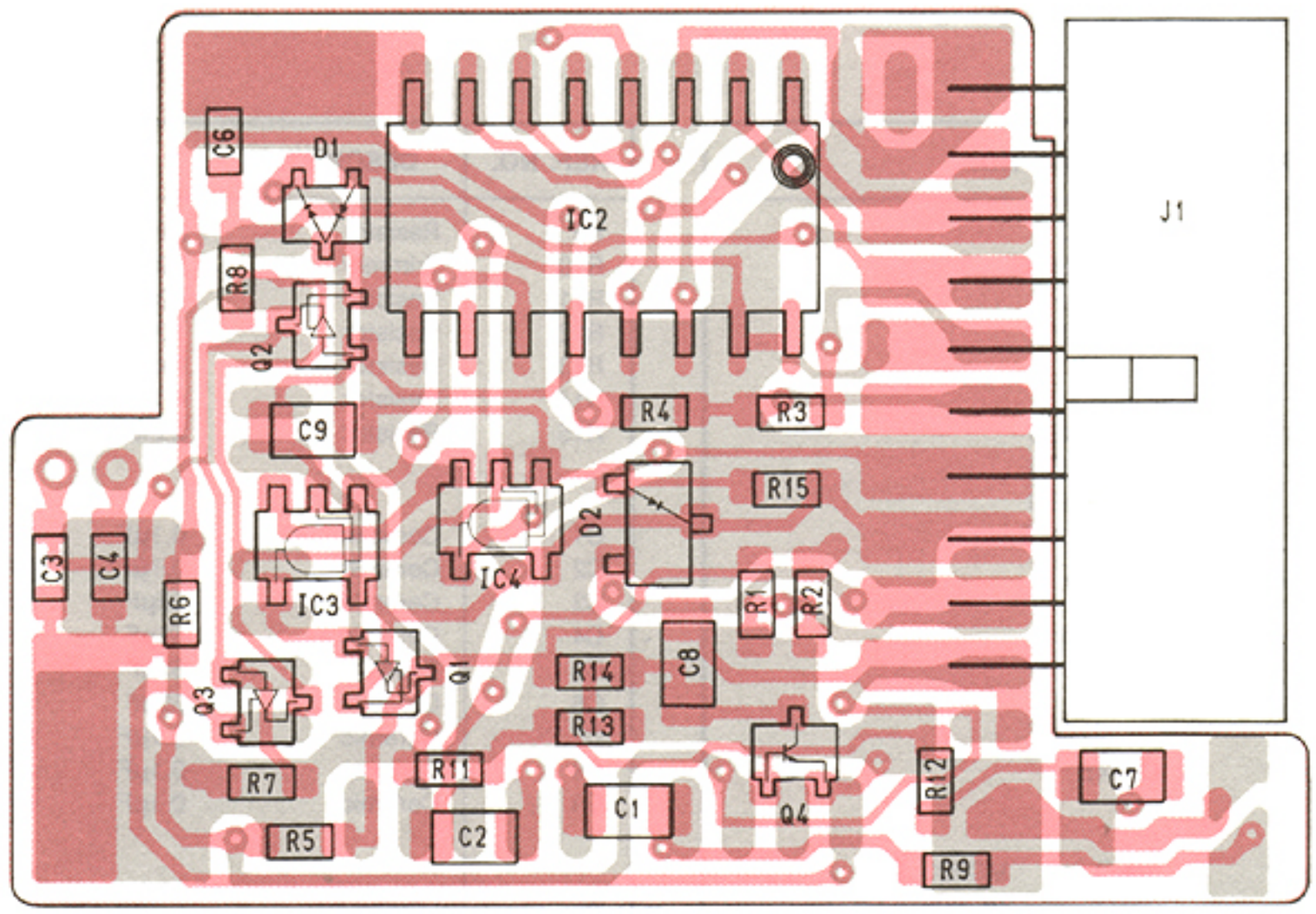


9-3 UT-40 BOARD LAYOUTS

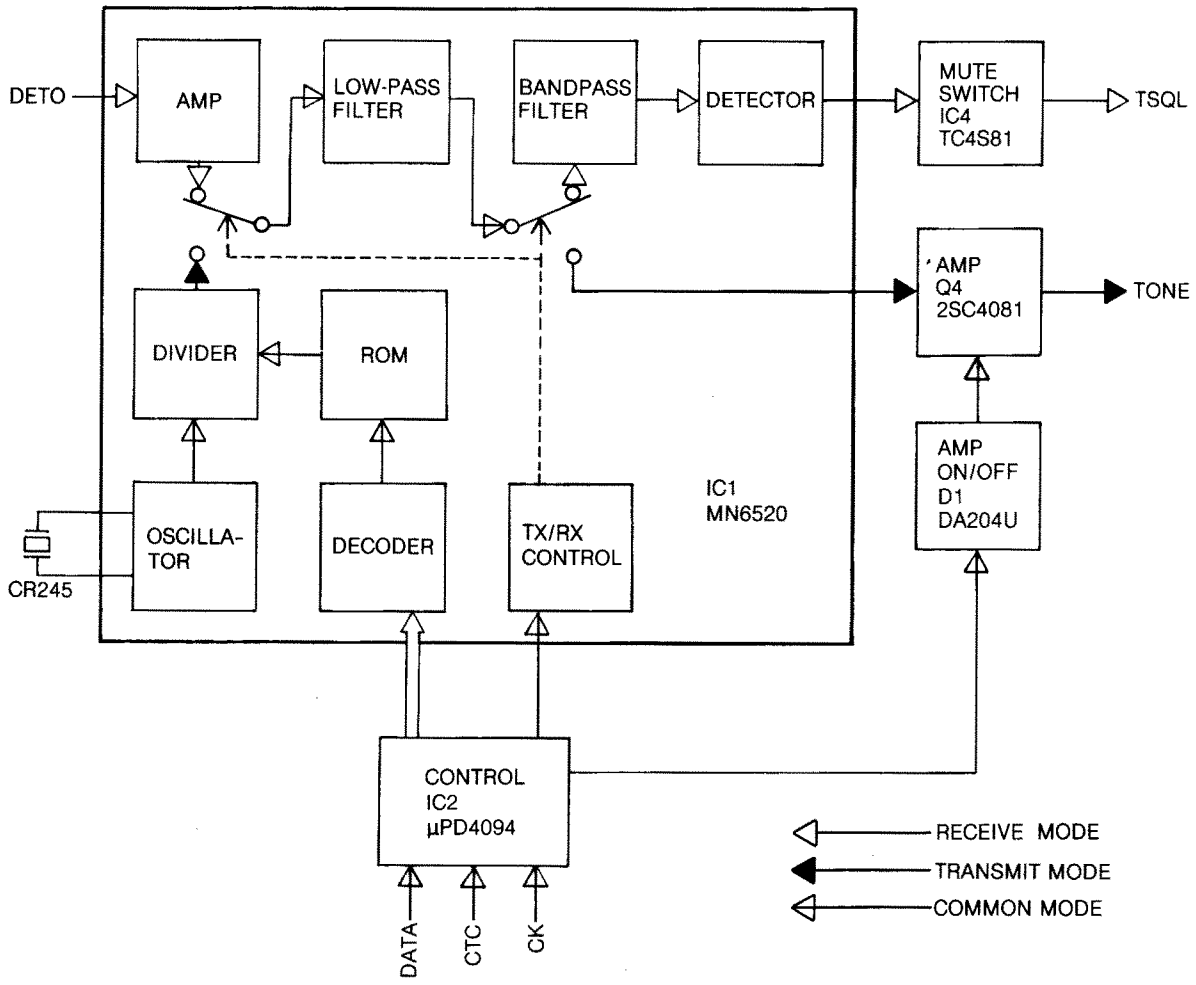
COMPONENT SIDE



FOIL SIDE



9-4 UT-40 BLOCK DIAGRAM



9-5 UT-40 PARTS LIST

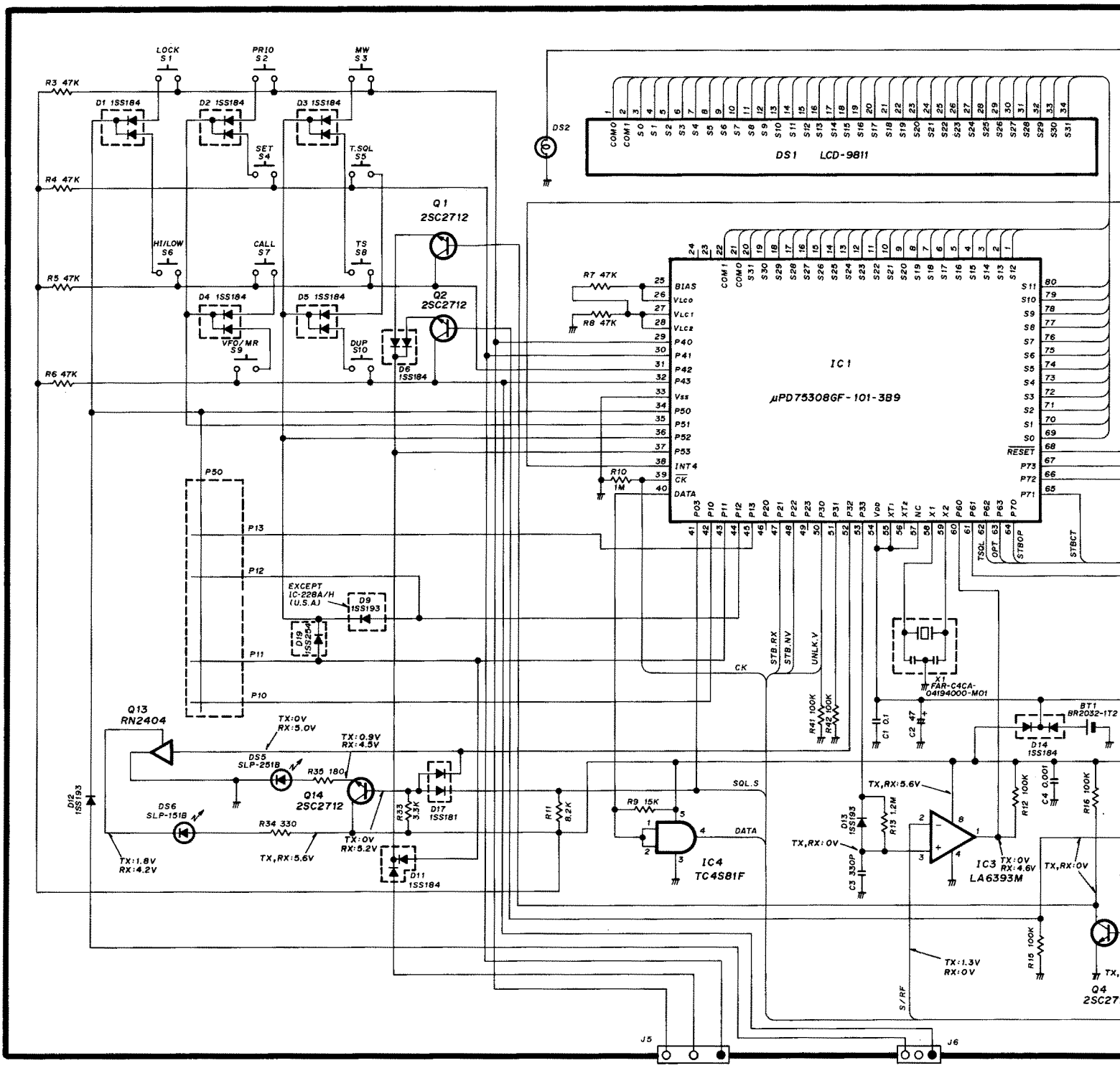
[T. SQL UNIT]

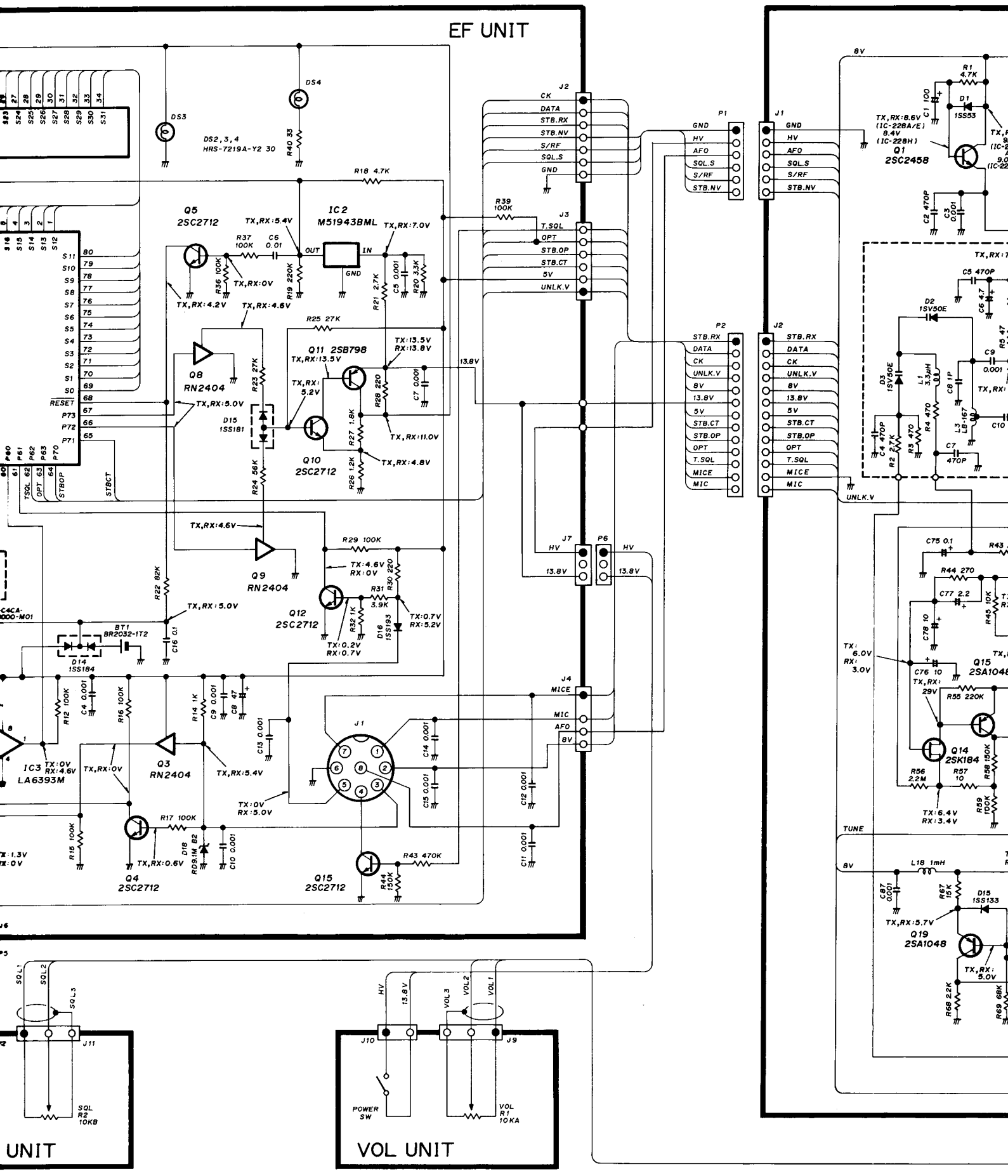
REF. NO.	DESCRIPTION	PART NO.	
IC1	IC	MN6520	
IC2	IC	µPD4094BG	
IC3	IC	TC4S81F	
IC4	IC	TC4S81F	
Q1	Transistor	DTA144EU	
Q2	Transistor	DTA144EU	
Q3	Transistor	DTC144EU	
Q4	Transistor	2SC4081 R	
D1	Diode	DA204U	
D2	Diode	1SS193	
X1	Crystal	CR245	
R1	Resistor	10kΩ	MCR03 EZH J
R2	Resistor	15kΩ	MCR03 EZH J
R3	Resistor	150kΩ	MCR03 EZH J
R4	Resistor	2.2kΩ	MCR03 EZH J
R5	Resistor	10kΩ	MCR03 EZH J
R6	Resistor	10kΩ	MCR03 EZH J
R7	Resistor	100kΩ	MCR03 EZH J
R8	Resistor	47kΩ	MCR03 EZH J

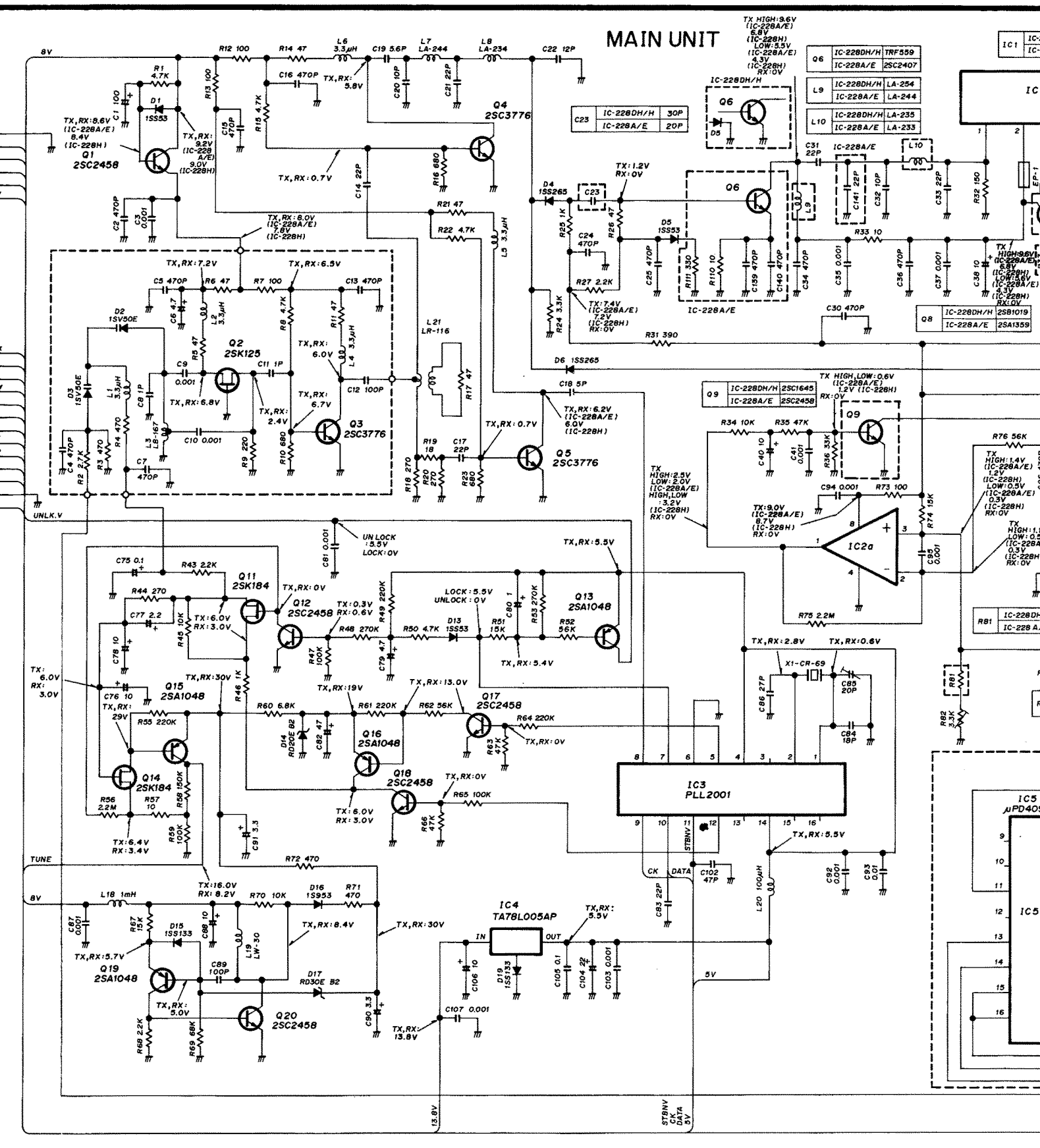
REF. NO.	DESCRIPTION	PART NO.	
R9	Resistor	22kΩ	MCR03 EZH J
R10	Trimmer	22kΩ	RH04A3AJ4J
R11	Resistor	100kΩ	MCR03 EZH J
R12	Resistor	100kΩ	MCR03 EZH J
R13	Resistor	1MΩ	MCR03 EZH J
R14	Resistor	4.7kΩ	MCR03 EZH J
R15	Resistor	2.2MΩ	MCR03 EZH J
C1	Ceramic	0.1µF	GRM40 F
C2	Ceramic	0.1µF	GRM40 F
C3	Ceramic	50µF	GRM39 SL 180J
C4	Ceramic	50µF	GRM39 SL 180J
C5	Tantalum	33µF	TESVC0G336M12L
C6	Ceramic	50µF	GRM39 B 471K
C7	Ceramic	0.1µF	GRM40 F
C8	Ceramic	0.1µF	GRM40 F
C9	Ceramic	0.1µF	GRM40 F
J1	Connector	PI28A10M	
EP1	P.C. Board	B-1577C	

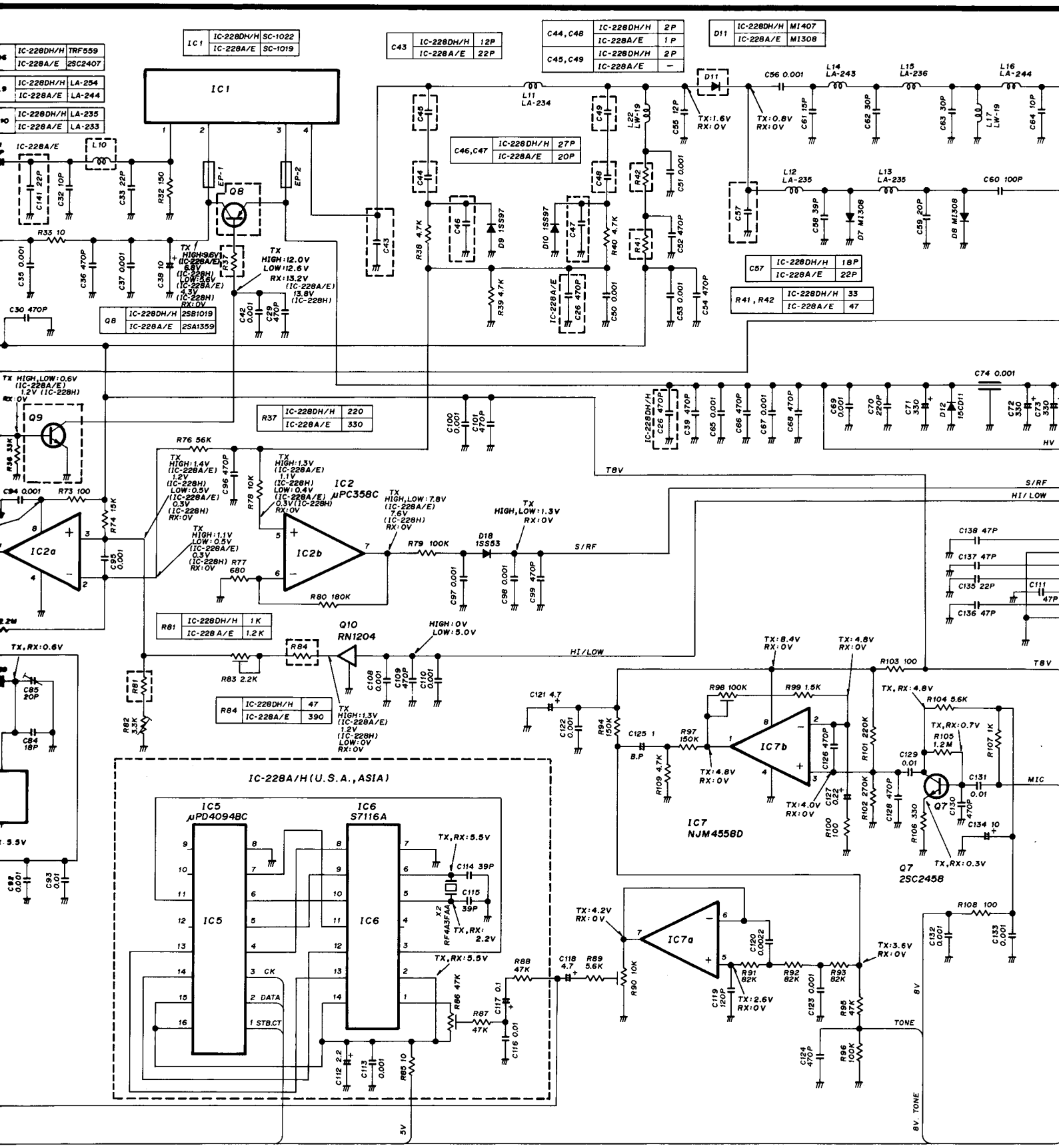
SECTION 10 VOLTAGE DIAGRAM

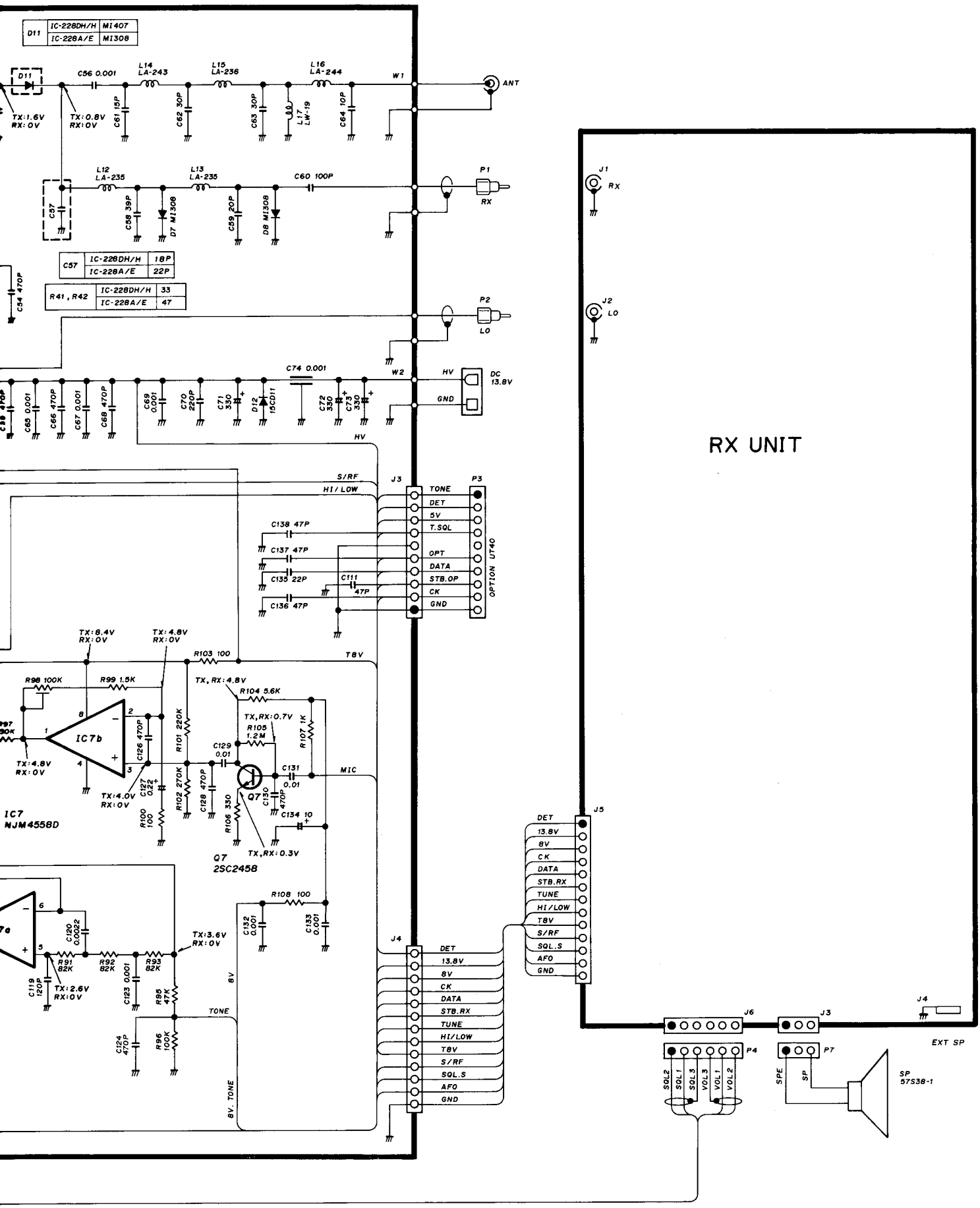
• EF AND MAIN UNITS



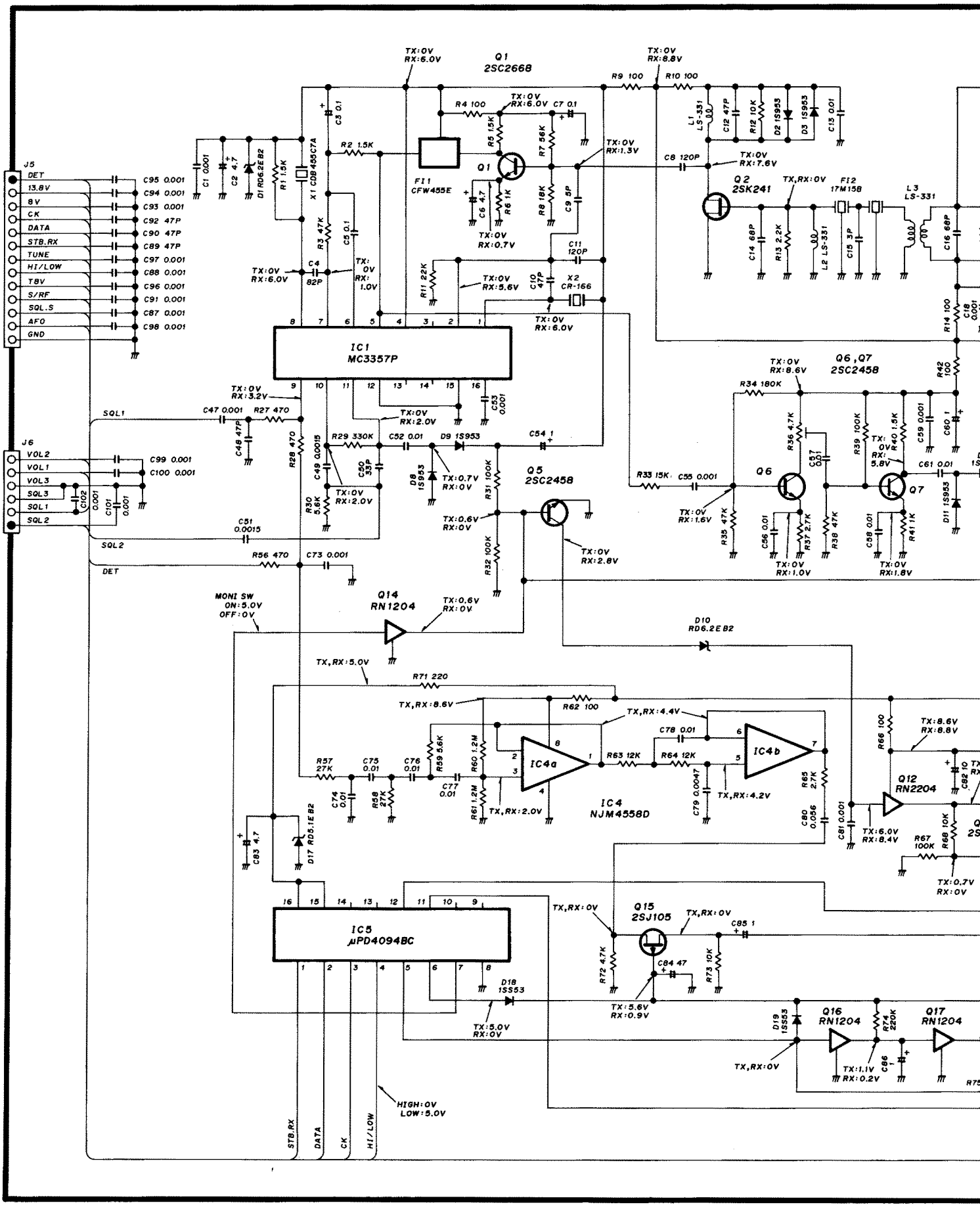

EF UNIT
DS3
DS4
DS2,3,4
HRS-7219A-Y2 30
R40 33
R18 4.7K
Q5
2SC2712
TX,RX:5.4V
IC2
M51943BML
TX,RX:7.0V
R37 100K
C6 0.01
OUT
IN
GND
R36 100K
TX,RX:0V
R19 220K
C5 0.001
R20 3.3K
R21 2.7K
TX,RX:4.2V
TX,RX:4.6V
R25 27K
Q11 2SB798
TX,RX:13.5V
TX:13.5V
RX:13.8V
13.8V
Q8
RN2404
R23 27K
R28 220
C7 0.001
TX,RX:
5.2V
TX,RX:5.0V
D15
1SS181
R27 1.8K
TX,RX:11.0V
Q10
2SC2712
TX,RX:4.8V
R24 56K
R26 1.2K
RESET
P73
P72
P71
TSQL
OPT
STBOP
STBCT
TX,RX:4.6V
R29 100K
TX:4.6V
RX:0V
Q9
RN2404
R22 82K
R30 220
R31 3.9K
TX,RX:5.0V
Q12
2SC2712
R32 1K
TX:0.7V
RX:5.2V
TX:0.2V
RX:0.7V
D16
1SS193
C16 0.1
BT1
BR2032-1T2
D14
1SS184
R12 100K
C4 0.001
R16 100K
R14 1K
C9 0.001
C8 47
C13 0.001
IC3
LA6393M
TX:0V
RX:4.6V
TX,RX:0V
Q3
RN2404
TX,RX:5.4V
J1
C14 0.001
C15 0.001
TX:0V
RX:5.0V
R17 100K
R15 100K
TX,RX:0.6V
D18
RD9.1M B2
C10 0.001
Q4
2SC2712
Q15
2SC2712
R43 470K
R44 150K
C12 0.001
C11 0.001
J2
CK
DATA
STB.RX
STB.NV
S/RF
SQL.S
GND
J3
T.SQL
OPT
STB.OP
STB.CT
5V
UNLK.V
J7
HV
13.8V
P6
J4
MICE
MIC
AFO
8V
P1
P2
J1
J2
8V
R1 4.7K
C1 100
D1
1SS53
TX,RX:8.6V
(IC-228A/E)
8.4V
(IC-228H)
Q1
2SC2458
C2 470P
C3 0.001
C5 470P
C6 4.7
D2
1SV50E
D3
1SV50E
L1 3.3μH
C8 1P
C9 0.001
R4 470
L3 LB-167
C4 470P
R2 2.7K
R3 470
C7 470P
C10
UNLK.V
C75 0.1
R43
R44 270
C77 2.2
R45 10K
C78 10
TX:
6.0V
RX:
3.0V
Q15
2SA1048
C76 10
TX,RX:
29V
R55 220K
Q14
2SK184
R56 2.2M
R57 10
R58 150K
TX:6.4V
RX:3.4V
R59 100K
TUNE
8V
L18 1mH
C87 0.001
R67 15K
D15
1SS133
TX,RX:5.7V
Q19
2SA1048
TX,RX:
5.0V
R68 2.2K
R69 68K
SQL1
SQL2
SQL3
J11
SQL
R2
10KB
UNIT
HV
13.8V
VOL3
VOL2
VOL1
J10
J9
POWER
SW
VOL
R1
10KA
VOL UNIT


MAIN UNIT
8V
UNLK.V
TUNE
13.8V
STBNV
CK
DATA
5V
Q1 2SC2458
Q2 2SK125
Q3 2SC3776
Q4 2SC3776
Q5 2SC3776
Q6
Q8
Q9
Q10
Q11 2SK184
Q12 2SC2458
Q13 2SA1048
Q14 2SK184
Q15 2SA1048
Q16 2SA1048
Q17 2SC2458
Q18 2SC2458
Q19 2SA1048
Q20 2SC2458
IC1
IC2a
IC3 PLL2001
IC4 TA78L005AP
IC5 µPD405
Q6 IC-228DH/H TRF559 IC-228A/E 2SC2407
L9 IC-228DH/H LA-254 IC-228A/E LA-244
L10 IC-228DH/H LA-235 IC-228A/E LA-233
C23 IC-228DH/H 30P IC-228A/E 20P
Q8 IC-228DH/H 2SB1019 IC-228A/E 2SA1359
Q9 IC-228DH/H 2SC1645 IC-228A/E 2SC2458
R81 IC-228DH/H IC-228A/E
IC-228DH/H
IC-228A/E

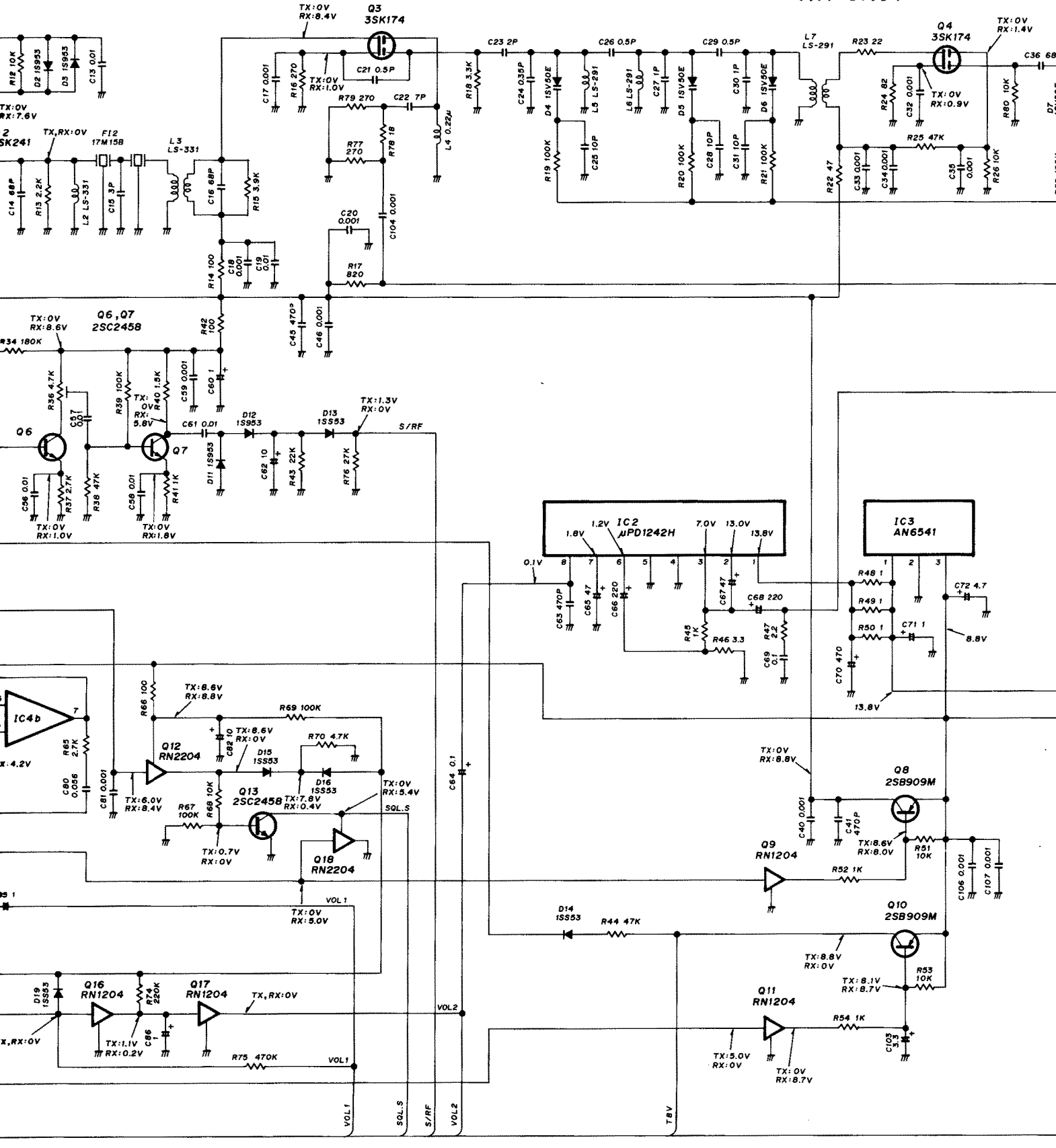

IC1
IC-228DH/H SC-1022
IC-228A/E SC-1019
C43 IC-228DH/H 12P
IC-228A/E 22P
C44,C48 IC-228DH/H 2P
IC-228A/E 1P
C45,C49 IC-228DH/H 2P
IC-228A/E –
D11 IC-228DH/H MI407
IC-228A/E MI308
C46,C47 IC-228DH/H 27P
IC-228A/E 20P
C57 IC-228DH/H 18P
IC-228A/E 22P
R41,R42 IC-228DH/H 33
IC-228A/E 47
Q8 IC-228DH/H 2SB1019
IC-228A/E 2SA1359
R37 IC-228DH/H 220
IC-228A/E 330
R61 IC-228DH/H 1K
IC-228A/E 1.2K
R84 IC-228DH/H 47
IC-228A/E 390
IC-228A/H(U.S.A.,ASIA)
IC5 μPD4094BC
IC6 S7116A
IC2 μPC358C
IC7 NJM4558D
Q10 RN1204
Q7 2SC2458
L10
L11 LA-234
L12 LA-235
L13 LA-235
L14 LA-243
L15 LA-236
L16 LA-244
L17 LW-19
L22 LW-19
EP-1
EP-2
D9 1SS97
D10 1SS97
D7 M1308
D8 M1308
D12 1SC101
D18 1SS53
X2 RF443FAA
T8V
5V
8V
S/RF
HI/LOW
MIC
TONE
HV
8V. TONE

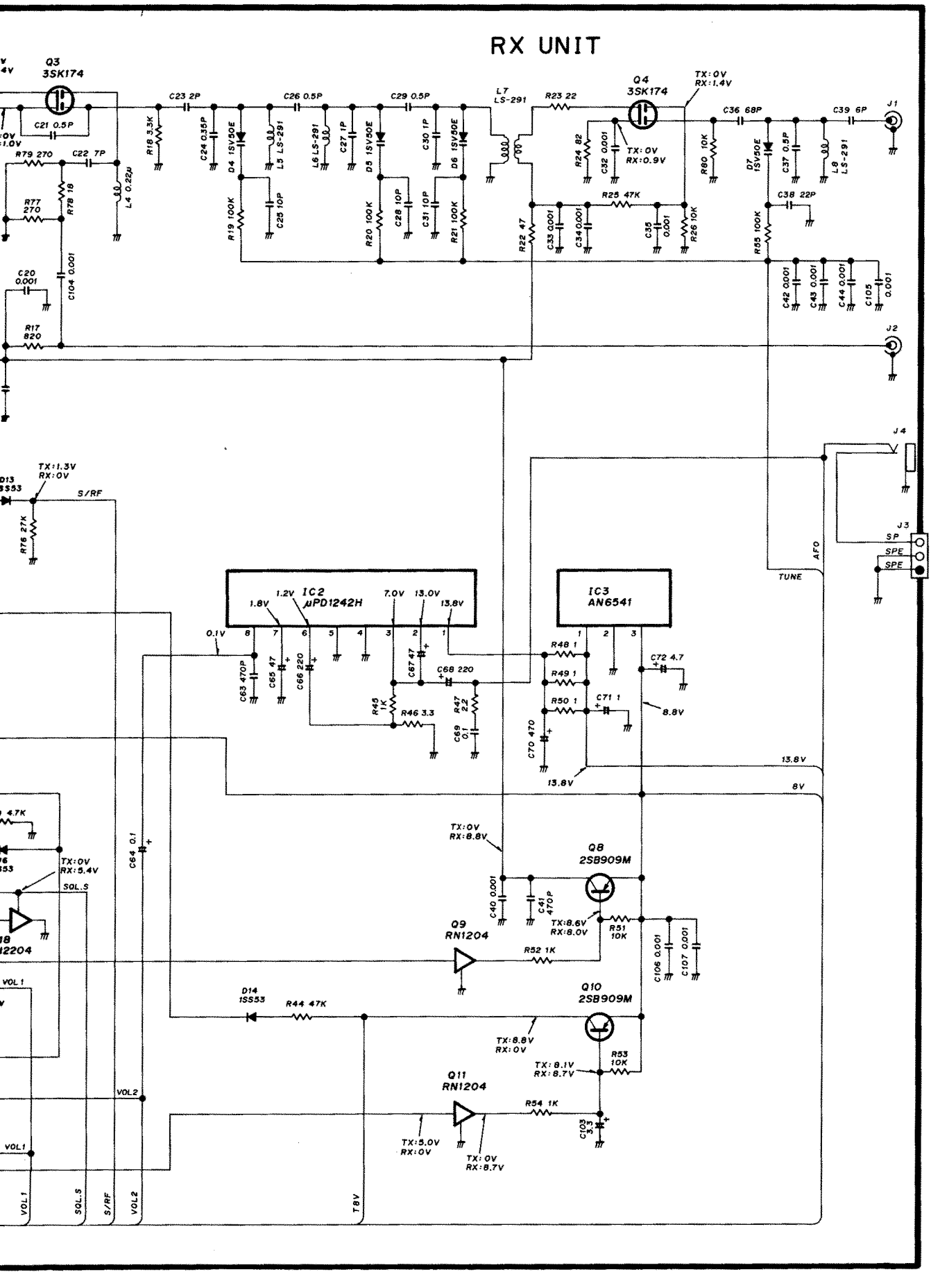

D11 IC-228DH/H MI407
IC-228A/E MI308
C57 IC-228DH/H 18P
IC-228A/E 22P
R41, R42 IC-228DH/H 33
IC-228A/E 47
RX UNIT
ANT
P1 RX
P2 LO
J1 RX
J2 LO
HV
DC 13.8V
GND
S/RF
HI/LOW
J3
P3
TONE
DET
5V
T.SQL
OPT
DATA
STB.OP
CK
GND
OPTION UT40
IC7b
IC7 NJM4558D
Q7 2SC2458
MIC
T8V
8V
TONE
8V, TONE
J4
J5
J6
P4
P7
SQL2
SQL1
SQL3
VOL3
VOL1
VOL2
SPE
SP
SP 57S38-1
EXT SP

• RX UNIT


MAIN UNIT J4
EF UNIT P4
J5
DET
13.8V
8V
CK
DATA
STB.RX
TUNE
HI/LOW
T8V
S/RF
SQL.S
AFO
GND
J6
VOL2
VOL1
VOL3
SQL3
SQL1
SQL2
Q1 2SC2668
Q2 2SK241
Q5 2SC2458
Q6,Q7 2SC2458
Q14 RN1204
Q12 RN2204
Q15 2SJ105
Q16 RN1204
Q17 RN1204
IC1 MC3357P
IC4 NJM4558D
IC5 μPD4094BC
X1 CDB455C7A
X2 CR-166
F11 CFW455E
F12 17M158
D1 RD6.2EB2
D2 1S953
D3 1S953
D8 1S953
D9 1S953
D10 RD6.2EB2
D11 1S953
D17 RD5.1EB2
D18 1SS53
D19 1SS53
L1 LS-331
L2 LS-331
L3 LS-331
MONI SW ON:5.0V OFF:0V
HIGH:0V LOW:5.0V
STB.RX
DATA
CK
HI/LOW
SQL1
SQL2
DET

RX UNIT


Q3 3SK174
Q4 3SK174
L7 LS-291
L3 LS-331
F12 17M15B
Q6,Q7 2SC2458
Q6
Q7
IC2 μPD1242H
IC3 AN6541
IC4b
Q12 RN2204
Q13 2SC2458
Q18 RN2204
Q8 2SB909M
Q9 RN1204
Q10 2SB909M
Q11 RN1204
Q16 RN1204
Q17 RN1204
TX,RX:0V
TX:0V RX:8.4V
TX:0V RX:7.6V
TX:0V RX:8.6V
TX:0V RX:1.0V
TX:0V RX:1.8V
TX:0V RX:1.4V
TX:0V RX:0.9V
TX:1.3V RX:0V
TX:8.6V RX:8.8V
TX:8.6V RX:0V
TX:6.0V RX:8.4V
TX:7.8V RX:0.4V
TX:0V RX:5.4V
TX:0.7V RX:0V
TX:0V RX:5.0V
TX:8.8V RX:0V
TX:8.6V RX:8.0V
TX:8.1V RX:8.7V
TX:5.0V RX:0V
TX:0V RX:8.7V
TX:1.1V RX:0.2V
S/RF
SQL.S
VOL1
VOL2
T8V


RX UNIT
Q3 3SK174
Q4 3SK174
TX:0V RX:1.4V
TX:0V RX:0.9V
L7 LS-291
C23 2P
C26 0.5P
C29 0.5P
C21 0.5P
C24 0.5P
C27 1P
C30 1P
C36 68P
C39 6P
C38 22P
R18 3.3K
R19 100K
R20 100K
R21 100K
R22 47
R23 22
R24 82
R25 47K
R26 10K
R79 270
C22 7P
R77 270
R78 18
L4 0.22μ
C20 0.001
C104 0.001
R17 820
C28 10P
C31 10P
C25 10P
C32 0.001
C33 0.001
C34 0.001
C35 0.001
R80 10K
R55 100K
C37 0.5P
C42 0.001
C43 0.001
C44 0.001
C105 0.001
J1
J2
P1
P2
MAIN UNIT
MAIN UNIT
J4
EXT SP
J3
SP
SPE
SPE
P7
SP
SPE
SP 57S38-1
AFO
TUNE
TX:1.3V RX:0V
S/RF
R76 27K
IC2 μPD1242H
1.8V
1.2V
7.0V
13.0V
13.8V
0.1V
IC3 AN6541
C63 470P
C65 47
C66 220
C67 47
C68 220
R45 1K
R46 3.3
R47 2.2
C69 0.1
R48 1
R49 1
R50 1
C71 1
C72 4.7
8.8V
C70 470
13.8V
13.8V
8V
TX:0V RX:8.8V
Q8 2SB909M
C40 0.001
C41 470P
TX:8.6V RX:8.0V
R51 10K
Q9 RN1204
R52 1K
C106 0.001
C107 0.001
D14 1SS53
R44 47K
Q10 2SB909M
TX:8.8V RX:0V
TX:8.1V RX:8.7V
R53 10K
Q11 RN1204
R54 1K
C103 33
TX:5.0V RX:0V
TX:0V RX:8.7V
TX:0V RX:5.4V
SOL.S
C64 0.1
VOL1
VOL2
VOL1
VOL1
SOL.S
S/RF
VOL2
T8V

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