TECHNICAL MANUAL

OPERATION, MAINTENANCE, INSTALLATION INSTRUCTIONS AND ILLUSTRATED PARTS BREAKDOWN

HF DSP RECEIVER
MODEL RX-331

TEN-TEC, INC.
1185 DOLLY PARTON PARKWAY
SEVIERVILLE, TN 37862

THIS MANUAL WAS PREPARED IN ACCORDANCE WITH MIL-M-7298C

1) EXTERNAL FREQUENCY STANDARD

Please reference manual page 1-1 regarding *External Frequency Standard* and page 2-1 section *2-9 Ext Ref*

Input Level: 500mV p-p minimum
2V p-p maximum.
1.0 - 1.5V p-p typical

Input impedance exceeds 200 Ohms so that multiple RX-331 can be connected in parallel (daisy-chained with BNC T-connectors) and driven from a 50 Ohm source. Installations with long runs of coax may need a 50 Ohm termination at the end of the run.

Ten-Tec Part No. 74263-Addendum   April 2009

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INTRODUCTION

This technical manual provides operation and maintenance instructions for the RX-331 HF DSP Receiver. The manual was prepared in accordance with MIL-M-7298C, "Manuals, Technical: Commercial Equipment". This manual is organized into nine chapters along with a Table of Contents and lists of tables and illustrations.

Chapter 1 presents general information about the Receiver, which includes functional capabilities, performance specifications, and physical dimensions. Chapter 2 provides information concerning the unpacking and initial installation of the receiver. A general theory of operation is provided in Chapter 3 which describes the functioning of the Receiver's individual circuit boards. Chapter 4 contains information on operation of the multi-drop RS-232 Interface and the parallel data output.

Chapter 5 provides information on maintenance and troubleshooting measures to be employed at the user's level. Instructions pertaining to the reshipment or long term storage are provided in Chapter 6. A detailed list of unique single source parts is provided in Chapter 7. In addition, Chapter 7 contains a list of manufacturers for these parts and their addresses. Chapter 8 provides a listing of replaceable modules and parts. Chapter 9 contains detailed parts lists for each of the replaceable modules. Chapter 9 also contains schematic diagrams for the electronic circuits.
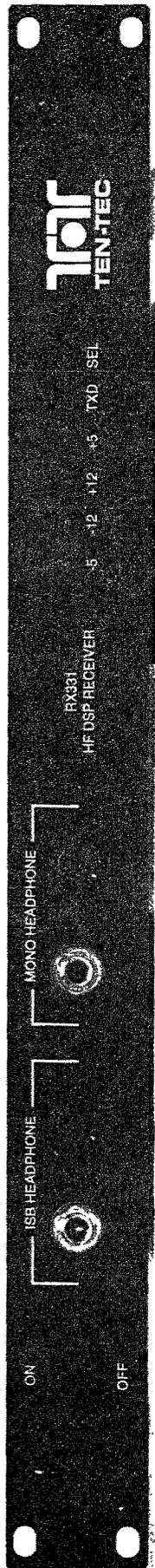
FIGURE I. RX-331 FRONT VIEW
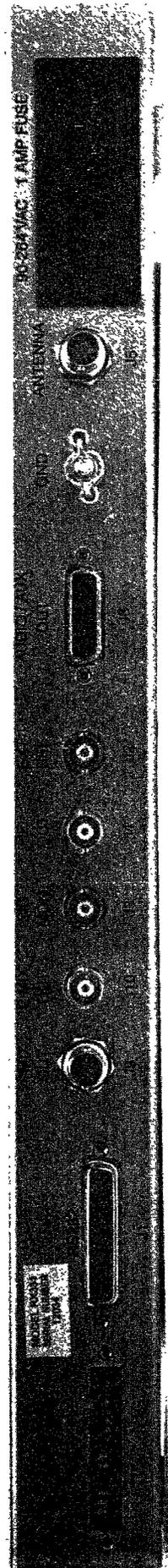
FIGURE II. RX-331 REAR VIEW

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CHAPTER 1

GENERAL INFORMATION

1-1 PURPOSE AND FUNCTION: The TEN-TEC RX-331 is a remotely controlled Monitor Receiver capable of tuning the 0 to 30 MHz range in 1 Hz steps. The Control Interface is Multi-drop RS-232, allowing multiple receivers to be addressed on one RS-232 line. Available detection modes are: USB, LSB, ISB, CW, AM, Synchronous AM, and FM. IF Bandwidth is selectable in 57 steps from 100 Hz to 16 KHz. Both manual (MAGC) and automatic (AGC) gain control modes are provided. AGC parameters may be custom programmed. In CW mode, the adjustable BFO has a range of $\pm$ 8000 Hz. In CW, LSB and USB modes, a passband tuning function allows simultaneous adjustment of BFO and receiver tuning over a $\pm$ 2000 Hz range. Three Audio and four IF outputs are provided.

1-2 SPECIFICATIONS: Applicable from 500 KHz - 30 MHz unless otherwise stated.

Power Supply:
Internal, accepts 48-440 Hz line power, 90-264 VAC. 30 watts nominal.

Frequency tuning system:
Tuning Range: 50 KHz to 30 MHz at typical sensitivity. Tunable to 0 MHz with degraded performance.
Tuning Increment: 1 Hz minimum.
Synthesizer lock time: 10 mS nominal.
BFO: Tunable in CW mode only, $\pm$ 8 KHz, 10 Hz steps. Fixed frequency in SSB and ISB modes, disabled in AM and FM modes.
Accuracy: All internal oscillators can be locked to either internal or external frequency standards. The internal reference is adjustable by a continuously variable trimmer to allow calibration to any desired accuracy.
Stability (internal standard): $\pm$ 1 ppm per degree C within the operating range of 0 to 50 degrees C. An optional TCVCXO provides $\pm$ 1 ppm over entire range (0 to 50 degrees C).
External Frequency Standard: 1, 2, 5, or 10 MHz $\pm$ 1 ppm, 200 mV p-p, high impedance load. The receiver automatically detects and uses the

external standard upon application, at power-up, or after any serial link activity. If the external standard input slews far outside the $\pm$ 1 ppm specified, the internal circuitry will lose lock until the input returns to within spec, or will re-lock at the next power-up or serial activity if the input is within specification at a valid reference frequency (1, 2, 5, or 10 MHz). A frequency-out-of-lock condition is always reported over the serial link. Removal of the external frequency standard input immediately returns the receiver to the internal standard.

Tuning Method: Remote control via multi-drop RS-232.
Frequency Indication: None visible. Frequency status reported by the RS-232 serial link.

Interface connections:
RF Input:

Impedance:	50 Ohms, nominal.
VSWR:	2.5 : 1 maximum in preselector passband.
Connector:	rear panel BNC.
Protection:	internal surge protector.

Audio Outputs:
Two 600 Ohm lines

Level:	0 dBm nominal, center-tapped, ungrounded.
Connector:	3 pins of rear panel DA-15 connector, each line.
Function:	Upper and lower sideband audio on separate lines in ISB mode. Same signal on both lines in other modes.

Stereo Headphone:

Level:	10 mW maximum into 600 Ohm load. Front panel volume control.
Connector:	Front panel 1/4" stereo phone jack.
Function:	Upper and lower sidebands in ISB mode. Monaural output in other modes.

Single-ended Audio: (Both AC and DC coupled outputs available)

Level:	10 mW maximum into 600 Ohm load.

Connector: 2 pins of rear panel DA-15 connector, one grounded
Function: Upper, lower, or both sidebands in ISB mode, software configured.

Mono Headphone:
Level: 10 mW maximum into 600 Ohm load. Front panel volume control.
Connector: Front panel 1/4" mono phone jack.
Function: Upper, lower, or both sidebands in ISB mode, software configured.

Signal Monitor:
Frequency: 455 KHz center. (inverted)
Bandwidth: 16 KHz (-6 dB).
Level: -10 dBm nominal. AGC delayed 40 dB.
Impedance: 50 ohms nominal.
Connector: Rear panel BNC.

IF Output:
Frequency: 455 KHz center. (inverted)
Bandwidth: Determined by IF filter selection.
Level: -10 dBm nominal (AGC leveled).
Impedance: 50 ohms nominal.
Connector: Rear panel BNC.

1st Mixer Out:
Frequency: 45.455 MHz Center frequency (inverted)
Bandwidth: Determined by preselector filter
Level: -16 dB rel. to RX input (PREAMP/ATTN off)
Impedance: 50 ohms nominal
Connector: Rear panel BNC

2nd Mixer Out:
Frequency: 455KHz center frequency (inverted)
Bandwidth: 16 KHz (-6 dB)
Level: 0 dB rel to RX input (PRESEL/ATTN off)
Impedance: 50 ohms nominal.
Connector: Rear panel BNC.

Sensitivity:
Noise Figure: 10 dB typical, 14 dB maximum - preamp on.
17 dB typical, 19 dB maximum - preamp off.

<u>VLF Sens.</u>, Typ, .3 KHz bandwidth preamp off.

	16 dB SINAD
>500 KHz	-116 dBm (.35uV)
100 KHz	-115 dBm (.4uV)
50 KHz	-114 dBm (.45uV)
20 KHz	-107 dBm (1 uV)
15 KHz	-104 dBm (1.4uV)
10 KHz	-94 dBm (4.5 uV)
5 KHz	-82 dBm (18uV)

Spurious Responses: All spurious less than -119 dBm equivalent input - preamp on.

Control Interface:
Standard: Multi-drop RS-232.
Config: Dipswitch programmable, 300 to 19200 baud, 7 or 8 data bits, even, odd, or no parity.
Connector: DB-25 female.

Sensitivities by mode:

	BW	SINAD	PREAMP OFF TYP	MAX	PREAMP ON TYP	MAX
AM: (50% Mod @ 400 Hz)	6 KHz	10 dB	-103 dBm 1.6 uV	-101 dBm/ 2.0 uV	-112dBm/ 0.56 uV	-108dBm/ 0.9 uV
FM: (6 KHz dev @ 1 KHz)	16 KHz	16 dB	-102 dBm/ 1.8 uV	-100 dBm/ 2.2 uV	-108dBm/ 0.9 uV	-104dBm/ 1.4 uV
USB/LSB/ISB:	3.2 KHz	10 dB	-112 dBm/ 0.6 uV	-110 dBm/ 0.7 uV	-119dBm/ 0.25 uV	-115dBm/ 0.4 uV
CW:	300 Hz	16 dB	-116 dBm/ 0.35 uV	-114 dBm/ 0.45 uV	-124dBm/ 0.14 uV	-120dBm/ 0.22 uV

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Gain Characteristics:

Gain control:
The receiver can operate with automatic (AGC) or manual (MAGC) gain control. Manual gain control reduces receiver gain and increases the AGC threshold by up to 120 dB.

AGC:
Range: 90 dB minimum
Threshold: 3 uV typical
Attack Time: 15 mS typical, to within ±3dB of a 20 dB step.
Release Time:
  Fast   25 mS for 30 dB recovery (1200 dB/s)
  Medium   .5 second for 50 dB recovery (100 dB/s)
  Slow   4 seconds for 100dB recovery (25dB/s)

Manual AGC:
Range: 120 dB. Controlled through the RS-232 interface.
Attack/Release Times: Limited only by RS-232 serial transfer rate.

Programmable AGC:
Setting Ranges:
  Attack: 0.01-1.0 dB/ms
  Hang: 0.01-99.9 seconds
  Decay: 0.01-99.9 dB/s

Signal handling characteristics: - preamp off
Image Rejection: 90 dB typical, 80 dB minimum (all mixers).
IF Rejection: 90 dB typical, 80 dB minimum (all IFs).
Third order intercept point: 30 dBm typical, 25 dBm minimum.
Second order intercept point: +75 dBm, typ, 60 min.

Selectivity: 57 bandwidths selectable from 0.1 to 16 KHz. Shape factor better than 1.5:1 (6 to 60 dB): 100, 120, 150, 170, 200, 220, 250, 300, 350, 400, 450, 500, 600, 700, 800, 900 Hz, 1, 1.1, 1.2, 1.3,1.4, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.2, 2.4, 2.6, 2.8, 3.0, 3.2, 3.4, 3.6, 3.8, 4.0, 4.4, 4.8, 5.2, 5.6, 6.0, 6.4, 6.8, 7.2, 7.6, 8.0, 8.8, 9.6, 10.4, 11.2, 12.0, 12.8, 13.6, 14.4, 15.2, 16.0 KHz.
The receiver automatically selects the best match greater than or equal to the requested bandwidth. Bandwidth is fixed at 3.2 KHz in ISB mode, and at 6 KHz in SAM mode. Minimum band width is 600 Hz in FM mode.

Blocking on tune: <5% THD: -6 dBm input 30% AM 1 KHz
Blocking off tune: 200 KHz offset. 15dBm typ. 10 dBm min for 3 dB desense
Ultimate Rejection: Greater than 70 dB regardless of filter selected.
Group Delay: No more than .1 ms variation over passband of 300 Hz to 3050 Hz.
Lo Phase noise: -120 dBc/Hz @ 20 KHz offset typ., -110 dBc/Hz max.

1-3 ENVIRONMENTAL CONDITIONS

Normal Operating:
Temperature: 0 to 50 deg C (32-122F)
Humidity: Up to 95% Rel, non-cond.
Altitude: Up to 10,000 feet MSL
Shock: Not applicable
Vibration: Not applicable

Storage/Transport:
Temperature: -46 to 71 deg C (-50-160F)
Humidity: Up to 95% Rel, non-cond.
Altitude: Up to 15,000 feet MSL
Shock: 10 G, 11 mS duration
Vibration: 1-1/2 G, 5 to 200 Hz

Specifications subject to change without notice.

1-4 MECHANICAL

Size: 1.75H x 19W x 21.31D inches
          44.45H x 482.6W x 541.4D mm
Weight: 11.24 lbs. (5.10 kg)
Cooling: Air convection cooled within fan
          ventilated rack cabinet. Units are
          directly stackable with no fillers
          required between chassis.

Mounting: Model RX-331 conforms to
          EIA standard 19 inch rack mount
          panel space and is 1 U (1.75)
          high. Slide mechanism attach
          ment points (10-32 thread) are
          compatible with Jonathan slide
          type 375 QD.

Cable connectors Rear panel:
          Receiver RF input: BNC female
          IF output 455 KHz: BNC female
          1st Mixer Out: BNC female
          2nd Mixer Out: BNC female
          Signal Monitor: BNC female
          External Reference: BNC female
          Remote Control: (Multi-drop RS-232)
                    DB 25, female
          Main Power: Detachable 3 conductor ac
                    cord
          Audio/Aux: 15 pin D connector, female
Front Panel:
          Mono headphone: 1/4" mono jack
          Stereo headphone: 1/4" stereo jack

1-5 EQUIPMENT/PARTS SUPPLIED

1   HF DSP RECEIVER MODEL RX-331
1   AC POWER CORD
1   FUSE - 1A, GDC-1A, 5 X20 mm
     (Spare in power entry module)
1   TECHNICAL MANUAL

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CHAPTER 2

PREPARATION FOR USE AND INSTALLATION

2-1 UNPACKING AND INSPECTION: Examine the shipping carton for damage before unpacking the unit. If the carton is damaged, open the carton in the presence of an agent of the shipping carrier if possible. If the carton is not damaged, retain the carton and packing materials for inspection if damage is found after the unit is unpacked.

Open the carton and remove the foam packing materials on top of the unit. Lift the unit free of the carton. No packing materials are required or provided inside the unit. Replace the foam packing material in the carton. The carton may be saved for possible re-shipment if required.

Upon unpacking, inspect the unit for obvious external damage. Pay particular attention to dents or bent sheet metal. If damage is evident, remove the top cover of the unit and inspect for further damage such as damaged circuit boards. Do not attempt to operate the unit if such damage is noted until further checks are made.

2-2 MOUNTING: RX-331 is designed for EIA standard 19 inch panel space rack. Slide mechanism attachment points (10-32 thread) are compatible with Jonathan slide type 375QD.

2-3 POWER: The RX-331 is designed to operate from 90-264 VAC, without setting any switches or jumpers.

2-4 ANTENNA: Connect the antenna to the BNC connector on the RX-331 labeled antenna (J5 in Figure II).

2-5 IF OUT: A 455 KHz signal with bandwidth dependent on IF selectivity filter selected (120 dB AGC range) (J4 in Figure II). 1 Hz tuning step.

2-6 SIG MON: A 455 KHz signal with a fixed bandwidth of 16 KHz after AGCed IF amplifier, in-

verted (80 dB AGC range) (J3 in Figure II). 1KHz tuning step.

2-7 1ST MIXER OUT: A 45.455 MHz signal with bandwidth determined by preselector selection, J9. Non-AGC'd, inverted. 1KHz tuning step.

2-8 2ND MIXER OUT: A 455 KHz signal with fixed 16 KHz bandwidth. Before AGC'd IF amplifier. Non-AGC'd, J10, inverted. 1KHz tuning step.

2-9 EXT REF: Automatically turns off the internal 10 MHz reference if a 1 MHz, 2 MHz, 5 MHz or 10 MHz 200 mV p-p signal is applied (J2 in Figure II).

2-10 RS-232: The RS-232 will accept a standard DB-25 connector (J1 in Figure II).

2-11 LINE A: Provides a 600 Ω balanced center tapped output (J8 in Figure II).

2-12 LINE B: Provides a 600 Ω balanced center tapped output (J8 in Figure II).

2-13 AUDIO: Provides a 600 Ω unbalanced AC coupled output (J8 in Figure II).

2-14 DC COUPLED AUDIO: Provides a 600 Ω unbalanced DC coupled output (J8 in Figure II).

2-15 AUX OUTPUT: 4 digital level "user" outputs which can be controlled by RS-232 command (J8 in Figure II).

2-16 MONO HEADPHONE: Provides a 600 Ω unbalanced output controlled by a front panel volume control (shown in Figure I).

2-17 ISB HEADPHONE: Provides both sidebands controlled by front panel volume control (shown in Figure I).

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CHAPTER 3

GENERAL THEORY OF OPERATION

3-1 INTRODUCTION: The TEN-TEC Model RX-331 receiver combines a high dynamic range front end with a versatile DSP back end to provide extraordinary performance and flexibility. Refer to the overall block diagram Figure 9-1 and interconnect diagram Figure 3-2.

The RF signals applied to the receiver Antenna Input (J5) are bandpass filtered in one of eight bands of approximately one-half octave bandwidth. Balanced amplifiers and a high level first mixer stage preserve the second and third order intercept points during conversion to the first IF of 45.455 MHz. Two 2-pole crystal filters provide first IF selectivity of 16 KHz bandwidth to reject 1st mixer spurious products and the 2nd mixer image (at -910 KHz). Both mixer outputs are available at rear panel connectors J9 and J10.

After conversion to the second IF of approximately 455 KHz in the second mixer stage, the signal is bandpass filtered to 16 KHz bandwidth and applied to an AGC'd 2nd IF amplifier with up to 80 dB gain. After post-filtering (again 16 KHz bandwidth), the signal is made available at the Signal Monitor output (J3) and also applied to the third mixer stage.

The third mixer converts the signal to a center frequency of 16 2/3 KHz where it is low pass filtered and applied to an analog to digital converter. The A/D converter produces a serial data stream at a 66 2/3 KHz sample rate for input to the Digital Signal Processor.

Serial data from the DSP at a 133 1/3 KHz sample rate is applied to a digital to analog converter. The D/A output samples are time de-multiplexed into two or three output channels, depending on the mode selection. Half of the D/A output time is devoted to the DSP'd IF output which is first converted back to 455 KHz by mixing with the third LO, then bandpass filtered to 16 KHz bandwidth, and finally made

available at the IF Output connector (J4).

The other half of the D/A bandwidth is separated into USB and LSB audio channels in Independent Sideband mode, or into a single audio channel in all other modes.

3-2 PRESELECTOR (81727): Eight bandpass filters covering the frequency range of 500 KHz to 30 MHz are controlled by the DSP/CPU Board (81721). A six FET push-pull amplifier makes up for loss in the bandpass filter.

3-3 PREAMP/ATTN: Refer to Preselector schematic diagram Fig. 9-6. The normal signal path is through pin diode D19 and D20. For weak signal reception, diodes D17 and D18 and preamplifier Q7 may be enabled. For very strong signals, a 15 dB attenuator may be inserted in the signal path by diodes D21 and D22.

3-4 FIRST MIXER (81773): The input signal passes through a 30 MHz low pass filter to a diode mixer and mixes with the amplified first LO to produce an IF frequency of 45.455 MHz. This signal is available at rear panel connector J9. The signal is applied to a six FET push-pull amplifier, then two 45.455 MHz crystal filters, producing an overall 4 pole response at the 1st IF to reject the 2nd mixer image. The 45.455 MHz signal is amplified again for use in the second mixer.

3-5 SECOND MIXER / 3RD LO (81817): The 2nd mixer / 3rd LO board handles the conversion of the first IF of approximately 45.455 MHz to the second and third IFs of 455 KHz and 16 2/3 KHz respectively. It provides outputs to the 2nd Mixer output connector J10, the Signal Monitor connector (J3 #56), the A/D converter (#51), AGC DET (#16), AGC control (#74) and LO3 (#52). Required inputs are: 1st IF (#54), LO2 (#55), 10 MHz reference (#57), PLL data (#12), AGC DAC (#17), and power of ±5 (#20) and +12V (#23).

The 1st IF input (45.455 MHz) is applied to a high level diode ring mixer along with the amplified 2nd LO (45.0 MHz) from Q1. The mixer output at 455 KHz is buffered, bandpass filtered and then amplified by controlled-gain IF amplifier U1. The IF amplifier output is post-filtered and then splits three ways: (1) AGC detector Q2/Q3 pulls the voltage on AGC integrating capacitor C52 low at a rate of 31.25 mV per dB when the output signal exceeds a threshold set by AGC ADJ pot R64. (2) Opamp U2a buffers the IF output and applies it to Signal Monitor connector J3. (3) The IF output is applied to third mixer U3 along with the 471 2/3 KHz 3rd Local Oscillator signal from U4b to produce the third IF of 16 2/3 KHz.

The 3rd IF signal from U3 passes through anti-aliasing lowpass filter U5 to the IF3 output connector #51. DC OSET pot R50 nulls any DC offset at the A/D input (connector #51).

The AGC detector voltage on capacitor C52 is buffered by opamp U2b and output to AGC DET connector #16. Opamp U6B provides a means for setting the IF gain externally via AGC DAC connector #17. The D/A converter connected to AGC DAC pulls the AGC detector voltage low, overriding the AGC detector output, and reducing IF gain at a rate of 32 dB/Volt. A high level output from Q17 to pin D of connector #74 indicates that the DAC is overriding the AGC detector. A high level output from U6A to pin A of connector #74 indicates that the AGC detector is overriding the DAC. The combination of U6A and Q17 can be thought of as a 2-bit ADC with 1dB of hysteresis.

Phase locked loop U7, charge pump and VCO transistors Q4-Q8, and divider U8/U4 develop the third Local Oscillator frequency of 471 2/3 KHz. This signal drives the third mixer U3 and the 3rd LO output connector #52. On receive frequencies above 20 KHz, the PLL is fixed programmed by the CPU for a reference frequency of 66 2/3 KHz and a VCO frequency of 37 11/15 MHz.

3-6 CONVERTER-I/O BOARD (81790): The
Converter-I/O board contains the main A/D and D/A converters that provide the interface to the Digital

Signal Processor, timing and multiplexing circuits that separate D/A data into the various audio and IF channels, and analog reconstruction filters and audio drivers that form the final audio outputs of the receiver. This board also contains the mixer and filter used to convert baseband IF signals back to 455 KHz for the DSP'd IF output.

Refer to the Converter Board schematic diagram Fig. 9-14. Connectors #4, #5 and #64 carry the serial data to and from the DSP. Word framing signals for the A/D and D/A converters (CVST and LDAC), and timing signals for the analog switch de-multiplexers (AF, IF, USB, and LSB) are formed by the dividers and combinational logic circuits U1-U5. Refer to the timing diagram part of Fig. 9-1 for the timing relationships between the converters and de-multiplexers.

The 3rd IF signal at 16 2/3 KHz is applied to the sampling input of A/D converter U7. On command of CVST from U4b, the analog input voltage is converted to a serial bit stream and transferred to the DSP via connector #4.

Serial data from the DSP is transferred to D/A converter U8 via connectors #5 and #64, and, under control of LDAC from U4a, output as discrete voltage samples at V out. Each voltage sample from the D/A converter is steered to the proper audio or IF channel by analog switch de-multiplexers U9 and U10, timed by AF/IF and USB/LSB signals from U4c, d and U5b, c.

Reconstruction filters U11-U14 attenuate the sample clock frequencies (66 2/3 or 33 1/3 KHz) and present a smoothed analog voltage to mode switches U9z and U10z or, in the case of the IF channel, to switching mixer U14b/U15x. The 471 2/3 KHz LO3 from connector #52 mixes with the 16 2/3 KHz baseband IF signal in section x of U15 to produce a 455 KHz component. This component is selected by 16 KHz wide bandpass filter FL1, buffered by opamp U18b, and output to connector #53 and the DSP'd IF Output connector J4.

Based on the mode selected by the CPU/DSP via connector #5, the z sections of U9 and U10 connect the appropriate reconstruction filter outputs to the audio and

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line drivers U16 and U17. Connector #8 carries both audio channels to the front panel ISB level control and stereo phone jack J6. Connector #9 supplies transformer coupled audio to the 600 Ohm line connections on rear panel J8. All audio outputs and the IF output at J4 can be muted by a connection to ground at connector #68, which is available at rear panel J8 pin 11.

Controlled by SB select lines from connector #18, U15 sections y and z connect either one or both audio channels to the monaural audio driver U18a and to audio connectors #7, 10 and 34, rear panel J8, CPU/DSP Board and front panel mono level control and phone jack J7.

3-7 FIRST LO SYNTHESIZER (p/o 81772):

Refer to the synthesizer block diagram Fig. 9-3, and the schematic Fig.9-21. The 1st LO synthesizer is a three loop architecture. Fine Loop (PLL3) U1 and charge pump U2 steer VCO Q1/D5/D6 over a range of 80 to 99.6 MHz in 400 KHz steps. This VCO output is buffered by common base amplifiers Q3 and Q4 and then divided by 400 in the N divider of the Mixing Loop (U7) to produce a fine tuning loop output of 200 to 249 KHz in 1 KHz steps.

Coarse Loop (PLL1) U4 and charge pump U5 steer VCO Q5/D13/D14 over a range of 45.7 to 75.7 Mhz in 50 KHz steps. This VCO output is buffered by common base amplifiers Q7 and Q8 and then applied to a phase shift circuit L25-L27 / C91-C93 to form quadrature inputs to the mixing loop mixers U9 and U10.

Mixing Loop (PLL2) U7 and charge pump U8 steer VCO Q9/D19/D20 over the 1st LO frequency range of 45.455 to 75.455 Mhz in 1 KHz steps. The mixing loop is programmed with a fixed N divider of 400 and fixed R divider of 1 so that it's VCO runs at the VCO frequency of the Coarse Loop (PLL1), offset by the divided down VCO frequency of the Fine Loop (PLL3). This VCO output is buffered by common base amplifiers Q11/Q12, amplified by Q13/Q14, bandpass filtered by L20-L22, C78-C80, and applied to connector #61. The output of Q11 provides an input to both mixers U9/U10 for transla-

tion to quadrature intermediate frequencies of 200 to 249 KHz.

Mixing Loop acquisition is aided by phase detector U11, comparator U6, and charge sink circuit U3. During certain transient conditions (such as power-up and large negative frequency steps), when the Mixing Loop VCO frequency is temporarily **above** the Coarse Loop VCO frequency, the output of U11 drops below the comparator threshold, and the charge sink ramps the Mixing Loop control voltage lower, steering the Mixing Loop VCO toward the correct offset.

Presteer circuit U6/U3 forces the Mixing Loop control voltage to within ±1V of the Coarse Loop control voltage. This ensures the **maximum** Mixing Loop offset is less than 5 MHz, and the U9/U10 mixer outputs are always below cutoff of lowpass filters L23/L24, C83-C85, and L28/L29, C99-C101.

3-8 SECOND LOCAL OSCILLATOR (p/o 81772):

The 45 MHz injection frequency required by the second conversion mixer circuit is developed by first dividing the 10 MHz reference by 2 in U15 to produce a 5 MHz square wave, and then selecting the 9th harmonic with 45 MHz monolithic filter FL1. The resulting 45 MHz sine wave is amplified by Q28/Q29, bandpass filtered by L34-L36, C136-C138, and applied to connector #55.

3-9 10 MHz REFERENCE OSCILLATOR (p/o 81772):

The main frequency standard for the RX330B is a 10 MHz voltage-controlled crystal oscillator (or optional high stability TCVCXO) that can be locked to an external reference of 1, 2, 5, or 10 MHz. Refer to the synthesizer schematic diagram Fig. 9-21. Differential amplifier Q21/Q22 presents a high impedance to board connector #63 and rear panel external reference connector J2. A sample of Q22's output is detected by diode D25 and compared to a threshold voltage by U14. When the external reference amplitude exceeds the threshold set by U14, transistors Q23-Q25 turn off, allowing the gate of FET switch Q26 to pull high. This condition connects the output of PLL U13, filtered by U14, to VCO tuning diode D26, completing the loop and

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locking the VCXO Y1/Q27 to 10 MHz. When no external reference is applied to J2 and connector #63, transistors Q23-Q25 conduct, holding the gate of FET switch Q26 low. In this condition the bias on tuning diode D26 is set by trimpot R106, and crystal Y1 is the frequency standard for the receiver.

3-10 DSP/CPU (81821): The DSP/CPU board contains two separate processor systems; the MAIN CPU (U1) which controls the RX-331's interface and the DSP CPU which performs the signal processing functions. The two system's busses integrate through an I/O expansion IC (U11). Communication between the MAIN CPU and the DSP CPU is handled by a combination of hardware and software, providing bi-directional data capability.

The MAIN CPU system consists of CPU (U1), CPLD (U4), ROM (U12) and battery backed RAM(U3). Latches U5 and U6 buffer rear panel switch settings while a portion of CPLD U4 is used for address control. Serial/parallel converter U28 adds additional output capability to the system. RS-232 interface controller chip (U2) handles buffering and level translation for the MULTI-DROP network. This is a special RS-232 IC that allows its output to be completely turned off when not active. It is this feature of U2 that permits multiple connects to a common RS-232 bus. Audio outputs are monitored by U1 via an internal A/D converter.

U17, U23 and U24 process the DSP digital output. A Programmable Logic device, U17, converts the DSP serial output data to a dual byte parallel output and creates the HIBYTE/LOWBYTE, STROBE, IFAF and USB/LSB control signals. Latches U23 and U24 provide output buffering for the data and control signals. In addition U23 and U24 add tri-state capability to the interface which can be selected under via software command.

The DSP system core consists of the DSP PRO-CESSOR (U15), ROM(U30), and AGC DAC (U18). The DSP system is connected to the I/O CONVERTER BOARD via connectors 4,5,18 and 64. Serial data travels from the CONVERTER BOARD to the DSP CPU at a 66 2/3 kHz sample rate. After signal processing, serial data travels to the CONVERTER BOARD at twice the input rate or 133 1/3 kHz. The DSP output data is multiplexed to provide AUDIO and IF data to the CONVERTER BOARD which demultiplexes the data and directs it to the proper output.

The RX-331 provides a programmable AGC response which is implemented as a combination of hardware and DSP software. The DSP system provides an analog AGC control voltage output on connector J17 which is delivered to the SECOND MIXER BOARD. Circuitry on the SECOND MIXER BOARD compares the voltage to the received signal level and provides feedback to the DSP via connector J74. The two signals on J74 tell the DSP if the applied AGC voltage is greater than or less than an AGC voltage derived from the received signal. The DSP then uses this information to control shaping of the analog AGC response.

Four user programmable control outputs are provided on the rear panel and are programmed by commands sent from a controller or PC. These logic level outputs are capable of providing approximately 10 ma of current. External circuitry should be added if additional power is required. They may be connected to external devices to provide additional control capability to the system. See Chapter 4 for additional information.

3-11 LED BOARD (81788): Voltage from the four power supply outputs is applied to four individual LEDs. These LEDs offer a visual indication that the power supply is operating. Two additional LED's indicate receiver address selection and data transmit status of the RS-232 interface.

LED BOARD   SYNTHESIZER   POWER SUPPLY
(81788)   (81772)   (81825)

DSP/CPU BOARD   1ST MIXER   CONVERTER (I/O)   2ND/3RD MIXER   RX PRESELECTOR
(81821)   (81823)   (81790)   (81817)   (81727)
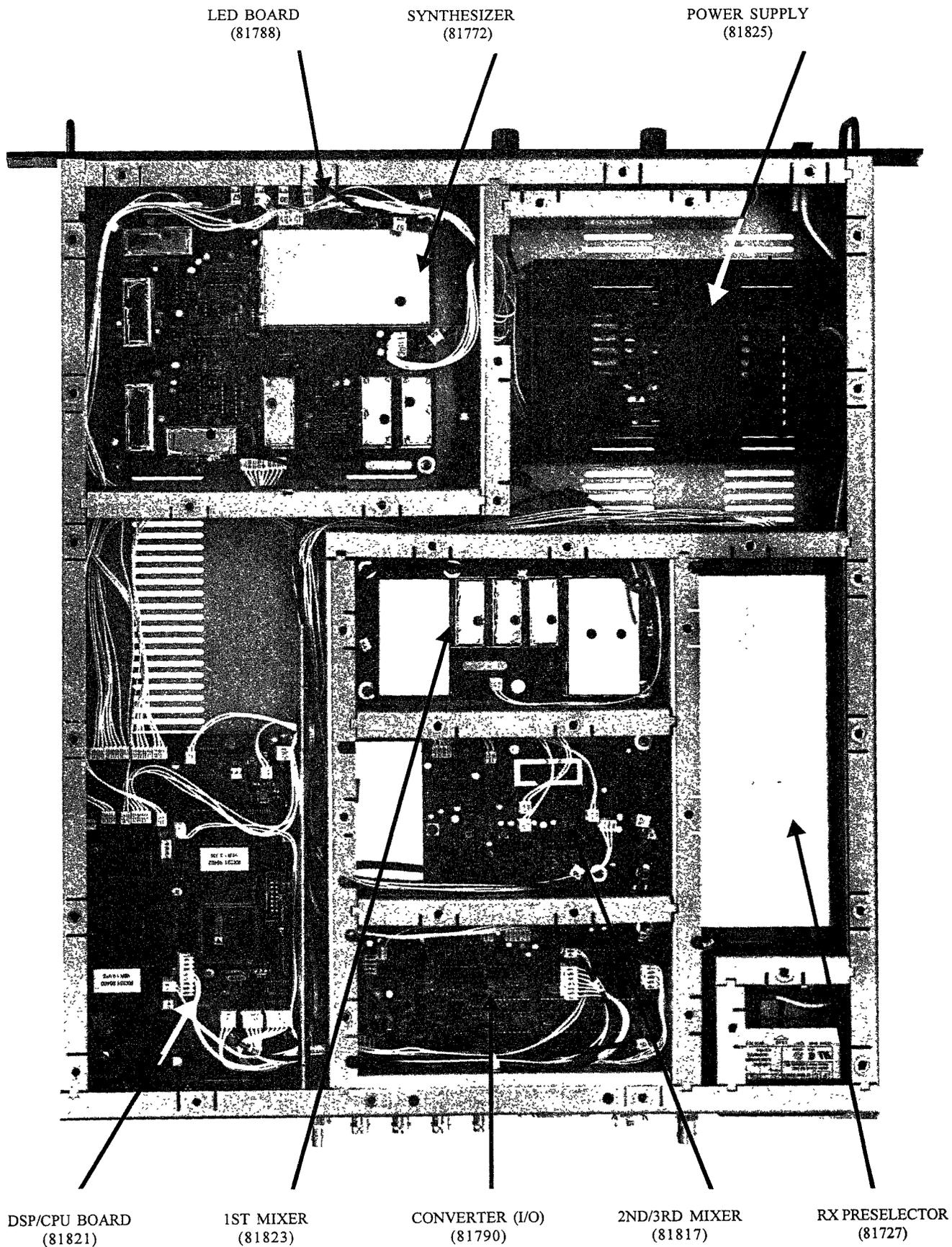
FIGURE 3-1 RX-331 TOP VIEW

3-5
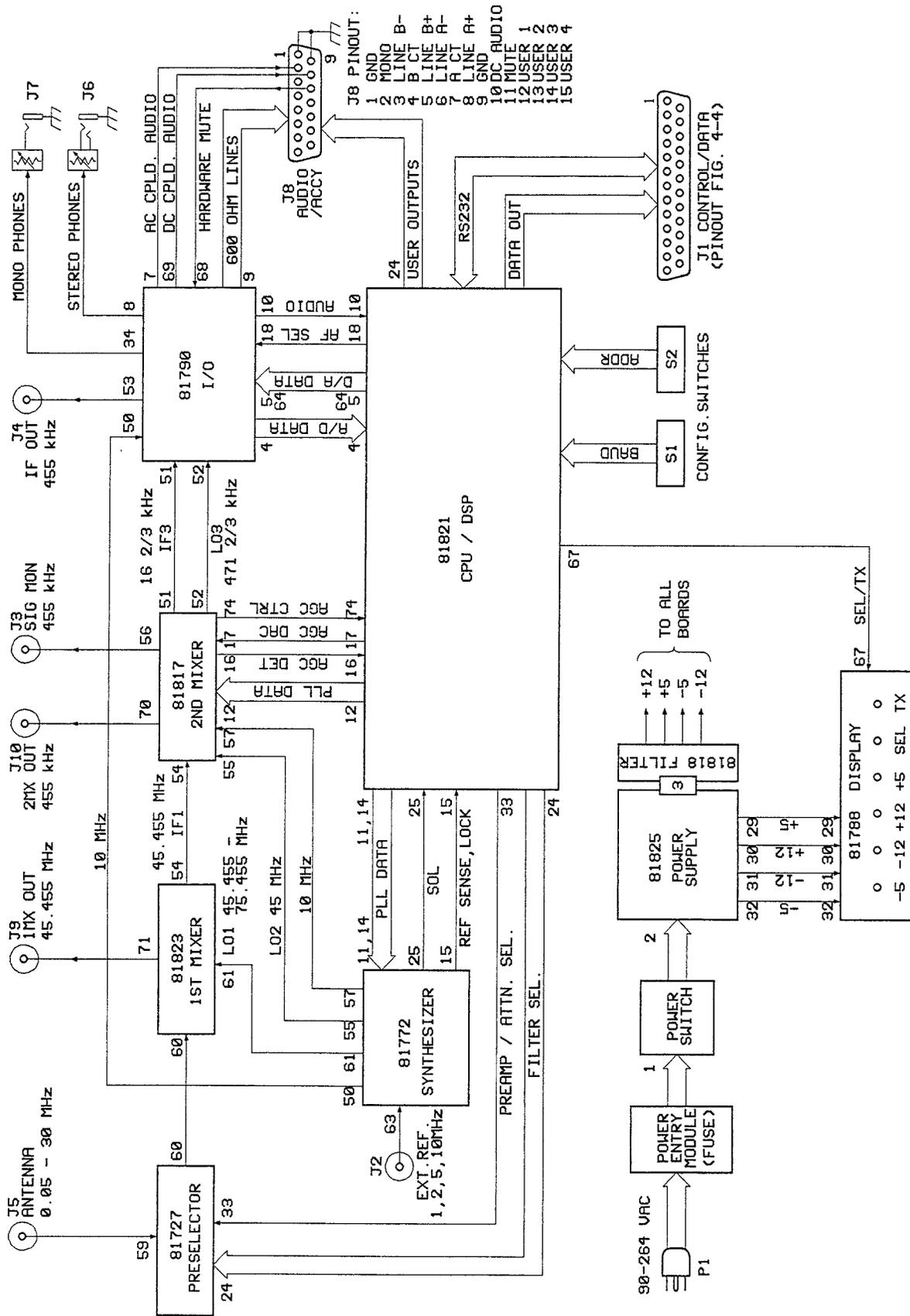
FIGURE 3-2 RX-331 INTERCONNECT DIAGRAM

DETAILED OPERATING INSTRUCTIONS

4-1 MULTI-DROP NETWORK: The RX-331 has no front panel operating controls and thus must be controlled remotely via its MULTI-DROP RS-232 interface. A Personal Computer or similar controller may be used to control the receiver. It will be necessary to acquire or design control software appropriate to the intended application of the receiver. The RX-331 Interface is based on plain text (ASCII) codes and strings which reduces the software design burden. An ASCII based interface allows an operator to exercise the RX-331 via a simple terminal or PC running terminal emulation software. In this way, software designers can quickly become familiar with commands and responses of the RX-331.

The first step in hooking up the RX-331 to a controller is to construct or purchase the proper cable. The RX-331 receiver has been designed as a DCE device for serial interface applications. A 3 wire interface is required to connect the RX-331 to the proper controller (TXDATA, RXDATA and GND). When connecting multiple RX-331's to a single controller, all units are wired in a parallel fashion to the cable. In this way, all receivers share a single TXDATA line, RXDATA line and GND line. See figure 4-1. After the receivers have been wired, they must be configured. Dipswitches S1 and S2 located on the rear panel allow users to set serial interface parameters and receiver addresses. Dip switch S1 is used to select serial interface parameters (see figure 4-2). Dip switch S2 is used to set the receivers address (range 0 to 127). Switch S2-1 is not used for address selection and should be left in the down position for normal operation. This switch is used to activate a FACTORY TEST/SERVICE MODE which is explained later.

The RX-331 receiver is interfaced to a PC or other suitable controller via a multi-drop serial network. Signal levels for the network are RS-232 compatible. However, unlike conventional RS-232 systems which allow only a single connection, the RX-331 has been designed to allow multiple connections. While any number of receivers may be interconnected at one time, the number of simultaneous connections is limited by line capacitance. Total capacitance should not exceed 2500 pF. However, the Baud rate and RS-232 drive delay may be adjusted to allow operation with a less than perfect installation. (See "H" command section 4-5)

The multi-drop feature may be disabled by sending the "U5" command. After this command is received, the interface becomes standard RS-232C (single receiver system.)
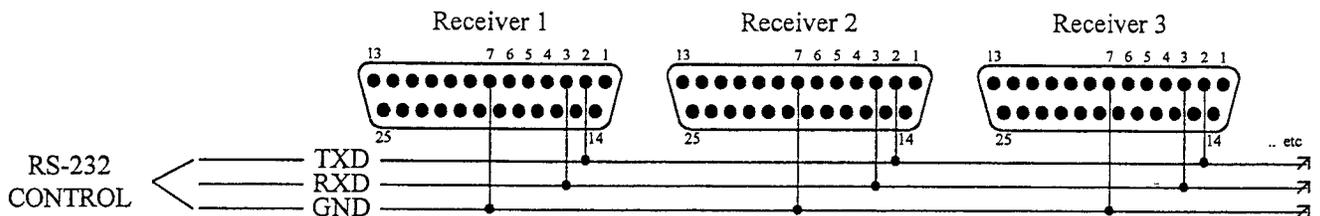
FIGURE 4-1 CONNECTION DIAGRAM

4-2 RECEIVER CONTROL: Control of the RX 331 is achieved through plain text (ASCII) command codes. The command codes are sent to a receiver from a remote PC or other control unit. Command codes provide control of Frequency, Mode, etc. as well as others such as B.I.T.E. (Built In Test Equipment) and memory functions. All command codes are a single ASCII letter. The comma (,) and dollar sign ($) are also used in receiver addressing operations. In addition to a command code letter, many commands require that additional information be provided immediately following the command code (see specific codes). All command strings must be terminated by a carriage return ASCII 13 (hex 0D) and only capital letters are allowed in command strings.

Before commands can be issued to a receiver, or group of receivers, the receiver(s) must first be selected or addressed. Dipswitch S2 provided on the rear panel of each receiver, allows a receiver's address to be set from 0 to 127 (see figure 4-2). In order for a receiver to be selected it must be sent a $ (dollar sign) followed by its particular address. For example: to select a receiver that has its address set to 15, $15 would be sent over the interface. Likewise, multiple receivers may be addressed by listing more than one receiver in the command line separating each address by a "," comma. For example, to select receiver 15, receiver 9 and receiver 22 the command would be $15,9,22. Receivers remain addressed until another addressing command is issued.

Once a receiver(s) is addressed, additional receiver commands may be sent to control Frequency, Mode, etc. Some receiver commands are single character, such as "X" which causes a receiver to return current signal level. Others require that additional information follow the command code such as "F10.12345" to set frequency or "D3" to set detection mode to CW. It is important for receiver operation, that proper syntax be followed for these commands. Receiver's that are not addressed will ignore commands intended for other receivers. An error in a command sent to a receiver(s) will cause the receiver to ignore the command and de-select itself as a safegaurd against data errors.

Multiple addressing and mutiple receiver commands may be placed in the same command string as long as the total command string length does not exceed 256 characters (including terminating carriage return). For example, $0,2F10. D1M4A100 <CR> would command receivers #0 and #2 to tune to 10.1 mHz, AM detection mode, Manual AGC with attenuation set to 100 dB.

4-3 RECEIVER RESPONSE: Some commands result in a receiver sending information back to the controller. This response will generally follow a format that is much like the format for issuing a command. For example: if a receiver is asked to tell its current operating frequency, it will respond with the format "F10.12345". In addition, whenever a receiver sends information, a status code is appended to the end of each response. The status code is the letter S followed by a number such as "S1" which indicated that the receiver is operating in remote mode (which is always true of the RX-331). The status number is encoded as follows:

1	Receiver is in remote control mode
2	Synthesizer is out of lock
4	not used
8	last string had character transmission error
16	last string had data error
32	last string had lost data
64	external reference applied
128	receiver in mute (activated by command)

With a properly operating receiver and interface a receiver would have a status code of 'S1' or 'S65' if using an external reference. A receiver response will be terminated with a carriage return ASCII 13 (hex 0D). **NOTE:** Any command that would generate a response from a receiver will be ignored if multiple receivers have been addressed. In order for these commands to operate properly a single receiver must be selected.

4-4 RECEIVER CONTROL COMMANDS: The group of receiver control commands consists of commands that affect the operating status of the receiver. Commands to control frequency, mode and filter selection fall into this group. All commands in

4-2

this group require that additional data follow a command code to complete the operation. If a command code is sent to a receiver without the proper data the receiver will ignore the command code and become deselected. The receiver will then ignore any characters until it receives a carriage return (ASCII 13) at which point it may again be re addressed.

The following text describes individual commands and the type and range of data that is to follow any given command. The format description for a command, such as Fnn.nnnnnn for example, describes a command, in this case the set frequency command, which is to be followed by up to 2 digits, a decimal point and then 6 digits. In most commands, a decimal point is required and any exceptions are noted below.

4-5 RX-331 RECEIVER CONTROL COMMAND SET: (Listed in Alphabetical Order)

COMMAND	DESCRIPTION	VALID RANGE
Annn	**MANUAL AGC ATTENUATION** Selects the amount of AGC Attenuation to use when in manual AGC mode. Setting covers 120 dB range. Attenuation may be set in any AGC mode. Example: A30 (Set Attenuation to 30 dB)	0 - 120 dB
B+n.nnn (B-n.nnn)	**BFO FREQUENCY** +/- 8000 Hz Allows setting the receiver BFO frequency when receiver is in CW mode. BFO is fixed in sideband modes and not operational in others. In CW mode, BFO frequencies are relative to receiver tuned frequency which is also passband center if passband tuning is off. Example: B200 (Set BFO to 200 Hz) B-2000 (Set BFO to -2000 Hz)	+/- 8000 Hz
Dn	**DETECTION MODE** This command allows setting of the receiver detection mode. Detection mode designators are: 1 AM 2 FM 3 CW (with variable BFO) 4 CW1 (BFO fixed at 0 Hz) 5 ISB (both sidebands, 3.2 kHz fixed BW) 6 LSB 7 USB 8 SAM (Synchronous AM, 6kHz fixed BW) Example: D3 (Set receiver to CW mode) D1 (Set receiver to AM mode)	1 - 8

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4-3

| E[U,L,B,M] | **AUDIO / IF SELECT** | E, U or B |
| | Allows AUDIO / IF Selection and receiver muting. Affects the IF output and AUDIO outputs. Either Upper, Lower or both ISB audio channels may be selected for output. Either Upper or Lower IF may be selected for output. If BOTH is selected IF selection remains at last setting. Also, receiver may be muted by using the "M" selection. A receiver which is muted will set the mute flag in the status byte. | |

Example: EU (Select Upper IF and Upper AUDIO)
          ELEB (Select Lower IF and Both AUDIO)

| Fnn.nnnnnn | **FREQUENCY** | 0 - 30 MHz |
| | 0 - 30 MHz This command allows setting of the receiver frequency to a resolution of 1 Hz. Least Significant digits may be dropped (assumed 0). A decimal point is required except when frequency is 0 Hz, in which case it is not necessary to have any frequency data in the command string. Receiver tuned frequency is suppressed carrier frequency in sideband modes and passband center in all other modes. | |

Example: F14.123456 (set frequency to 14.123456 MHz)
          F14.1   (set frequency to 14.100000 MHz)
          F<CR>   (set frequency to 0 Hz)

| Hnnn | **SET RS-232 DELAY** | 0 - 255 ms |
| | Controls the time between tx output enable and the occurrence of the first transmitted bit on the RS-232 transmit line. This command may be used to overcome an RS-232 controller with a slow response. Units are milliseconds. | |

Example: H40 (Set delay to 40 Milliseconds)

| Inn.nn | **IF FILTER** | .1 - 16 KHz |
| | This command selects the IF filter bandwidth. Bandwidths allowed are 100 Hz to 16 KHz in all detection modes except FM in which 600 Hz is the narrow filter limit. If an operator requests a filter that is not available, the receiver will use a close but wider filter. Units are in KHz. Appending a 'C' to the I command will access a secondary filter set when using filters below 4 KHz in width. This alternate filter set exhibits reduced delay times with degraded shape factors. These filters should only be used in systems sensitive to filter delay. | (FM .6 - 16 KHz) |

4-4

Example: I3.2 (Set IF Bandwidth to 3.2 KHz)
I0.5 (Set IF Bandwidth to 500 Hz)

Kn **PRE-AMP/ATTENUATOR**
Allows control of pre-amp and attenuator
  1 Normal - Preamp off, attenuator off
  2 Preamp on, attenuator off
  3 Attenuator on, preamp off

Mn **AGC OPERATING MODE**   1 - 4
Selects the AGC operating mode. Where n is one of the
following:
  1 Fast AGC
  2 Medium AGC
  3 Slow AGC
  4 Programmable AGC

Example: M1 (Set Fast AGC mode)
         M4 (Set Programmable AGC mode)

note: The receiver will accept and execute a manual 'A'
      setting in any of the modes.

PROGRAMMABLE MODE SETTINGS

note: The receiver will accept new settings for these
      parameters at any time but will only be using them
      when operating in programmable AGC mode
      (command 'M4').

MA Program ATTACK RATE in dB/msec.   Range: 00.01 to 01.00
     Example: MA0.40 Set ATTACK RATE to 0.4
         dB/msec

MD Program DECAY RATE in dB/sec.   Range: 00.01 to 99.99

MH Program HANG TIME in seconds.   Range: 00.01 to 99.99

Dump current AGC state and restart AGC
     process.

TM Query the PROGRAMMED AGC settings. The
     receiver will respond with a string similiar to:

           M1MA00.90MD75.00MH02.00S1
             | | | - |
             | | | |_Hang time (sec)
             | | |_Decay rate (dB/sec)
             | |_Attack rate (dB/msec)
             |_AGC mode (1,2,3 or 4)

The pre-programmed AGC modes, FAST, MEDIUM, AND SLOW have the following characteristics:

AGC mode	attack	decay	hang
FAST (M1)	0.8 dB/msec	1200 dB/sec	0
MED (M2)	0.8 dB/msec	100 dB/sec	0
SLOW (M3)	0.8 dB/msec	25 dB/sec	0

Nnn.nnn

NOTCH FREQUENCY
Allows tuning of the receiver's Notch Filter. The Notch filter is operational in CW,CW1,LSB and USB modes for IF Filter Bandwidths of 4 KHz or less. The Notch filter may be tuned +/- 2 KHz (around passband center). A notch frequency of 0 Hz effectively turns the notch filter off. The frequency data indicates the audio tone to be notched. Notch frequencies are relative to BFO frequency.

+/- 2000 Hz
(around passband center)

Example: N500   (Notch 500 Hz Audio Tone)
            N1000 (Notch 1000 Hz Audio Tone)

Onn

NOISE BLANKER WIDTH
Allows setting of the Noise Blanker Width. Range is 0 (off) to 10 ms in 1 ms increments.

0-9

Example: 05 (Set Blanker width to 6 ms)
            00 (Set Blanker to OFF)
NOTE!!
This command is provided here for reference only and will be a future option to the RX-331. While the current version of RX-331 firmware will accept and reapportion the parameter it will not affect receiver operations.

Pnn.nnn

PASS BAND TUNING
Allows setting of the pass band tuning feature. This feature is available in CW and SSB modes. Passband tuning shifts passband center frequency without affecting receiver tuned frequency or BFO. The effective SSB BFO offset may be adjusted with this command.

+/- 2000 Hz

Example: P2.20   (Shift passband 2.2 KHz)
            P-1.0   (Shift passband - 1 KHz)

Qnnn

SQUELCH

Allows setting of the FM squelch control. Allowable range is 0 (off) to 120 covering a range of 0-120 dB.

0 - 120 dB

Example: Q50 (Set Squelch to 50 dB)

Un

DIGITAL DSP INTERFACE CONTROL

Allows setting operational status of DSP digital output.

1   Interface off
2   Interface on - no control flags in serial data
3   Interface on - control bits included in serial data
4   Enable multi-drop interface (default)
5   Disable multi-drop interface (single receiver system)

Z

MASTER RESET

This command forces all receiver parameters back to factory default conditions. All memories are cleared. The receiver requires about 3 seconds to complete the process.

!n[+/-]

USER OUTPUT CONTROL

Sets the state of each User Output provided on the rear panel of the RX-331. Outputs are programmed individually by setting **n** to 1,2,3 or 4 (See Discussion of User Outputs Section 3-10). Outputs are programmed to be ON (+5v) by appending a '+' sign to the command. Appending a '-' sign will program the output to the OFF state (0v). All User Outputs are programmed to the OFF state at Power-On and after a Reset.

Example: !1+ Turns on user output 1.
          !3- Turns off user output 3.

4-6 RX-331 RECEIVER MEMORY COMMAND SET

The RX-331 command set provides two commands that access the 100 memories contained in the receiver. The 100 memories are stored in the battery backed ram contained in the receiver and will remain stored during power down and storage. A master reset however, will clear any stored memories.

Wnn	**WRITE MEMORY**	0 - 99

Write current operating parameters to memory number nn. Memory channels 00-99 may be used. The memory will contain all receiver settings such as frequency, mode, filter selection, etc.

Example: W20 (Write parameters to memory # 20)

Rnn	**RECALL MEMORY**	0 - 99

Recall memory nn to main operating parameters. Memory channels 00-99 may be used.

Example: R20 (recall memory # 20)

4-7 RX-331 RECEIVER QUERY COMMAND SET

Some commands result in a receiver sending information back to the controller. This response will generally follow a format that is much like the format for issuing a command. For example: if a receiver is asked to tell its current operating frequency, it will respond with the format "F10.12345". In addition, whenever a receiver sends information, a status code is appended to the end of each response. The status code is the letter S followed by a number such as "S1" which indicates that the receiver is operating in remote mode (which is always true of the RX-331). The status number is encoded as follows:

    1   Receiver is in remote control mode
    2   Synthesizer is out of lock
    4   not used
    8   last string had character transmission error
    16 last string had data error
    32 last string had lost data
    64 external reference applied

With a properly operating receiver and interface a receiver would have a status code of "S1". A receiver response will be terminated with a carriage return ASCII 13 (hex 0D).

G	**REPORT STATUS**

Receiver responds with all operating parameters relevant to the current operating mode. Parameters that are OFF or are not relevant to the current mode will not be included in the response. See also command "J".

Example:
    Command: G
    Response: F15.010000D2B-1800...etc...\<CR>

4-8

Tx(xxx)

REPORT SPECIFIC STATUS
The receiver responds with the operating data as specified along with the command.

Example:
    Command: TF - Request receiver operating frequency.
    Response: F15.0100000 <CR>
    For: frequency = 15.01 MHz

    Command: TFBNX - Request F,B,N settings and S-meter level
    Response: F15.010000B-1800N0.00X020 <CR>
    For: frequency = 15.01 MHz
        BFO = -1800 Hz
        Notch = 0.00 Hz (OFF Position)
        S-meter = 20 db Signal

X

REPORT SIGNAL LEVEL
This command forces the receiver to report the signal level or S-meter reading. Range is 0-120 covering the 120 dB range of the receiver.

Example:
    Command: X - request S-meter reading.
    Response: X015
    For: S-meter = 15 dB signal level

V

REPORT FIRMWARE REVISION NUMBER
The receiver will respond with a number indicating the revision level of the firmware.

Example:
    Command: V - Request firmware revision number.
    Response: V1.90
    For: Firmware revision number of 1.90

J

REPORT ALL OPERATING PARAMETERS
The receiver responds with all operating parameters regardless of their current use or relation to the current operating modes. See command G for additional information.

4-8 RX-331 RECEIVER B.I.T.E. (Built in test equipment)
The TEN-TEC model RX-331 Receiver contains BITE firmware routines to assist in field level troubleshooting and repair. Three levels of testing are provided. Although each level executes the identical test routines the data are interpreted and processed differently. Accordingly, each BITE LEVEL has its own particular responses. BITE LEVEL 1 provides a simple PASS/FAIL response. BITE LEVEL 2 provides a

BOARD LEVEL diagnosis and responds with one or more RX-331 sub-assembly numbers representing likely failures. BITE LEVEL 3 provides PASS/FAIL results on individual internal tests.

Control codes to initiate the different levels of BITE are:

S3   -   Initiate LEVEL 1 BITE
           Responses:
               A LEVEL 1 BITE will respond with either PASS or FAIL.

S4   -   Initiate LEVEL 2 BITE
           Responses:
               A LEVEL 2 BITE will respond with PASS or FAIL followed by
               one or more of the following sub-assembly numbers:

                         81821   81823
                         81817   81790
                         81772

S5   -   Initiate LEVEL 3 BITE
           Responses:
               A LEVEL 3 BITE will respond with PASS or FAIL followed by
               two decimal numbers separated by a colon. For example: 127:64.
               These numbers represent the individual test results encoded into
               two bytes. The 8 bits of each byte represent different BITE tests.
               If the bit is set (1) the corresponding BITE test failed. A clear bit
               (0) indicates that the particular test has passed. The two bytes are
               encoded as follows:

First byte:
            d0   Generate Audio Tone and Measure with CPU A/D
            d1   Check LO1 Lock Status
            d2   Check LO2 Lock Status
            d3   Check LO3 Lock Status
            d4   Check REF Lock Status
            d5   Check LO1 Loop Lock Time
            d6   Check LO2 Loop Lock Time
            d7   Check Last Power Up For Battery Failure

Second byte:
            d0   Check CPU/DSP Interface
            d1   Check I.F. for high noise level
            d2   Check I.F. for normal signal levels
            d3   Check S-Meter Level
            d4   Apply Manual AGC and Measure
            d5   Remove Manual AGC and Measure
            d6   DSP RESET FAILURE FLAG
            d7   not assigned

4-10

4-9 FACTORY SERVICE/FIELD TEST MODE

The RX-331 firmware also contains a special program for FACTORY/FIELD testing of the receiver. In this mode, the RX-331 runs an internal program in which it will directly control a dumb terminal and most receiver functions are available through on-screen controls. A PC running a terminal emulation program provides easy access to the FACTORY/FIELD test features. It is required that the Terminal or Terminal Emulation Software be capable of emulating a WYSE 50 or DEC VT-100 terminal.

While the FACTORY/FIELD TEST MODE is a powerful testing tool, it is also simple to use. Keys for each function are designated by a single character contained in brackets, such as (I) for IF Bandwidth selection. Two other keys have meaning in this mode. Pressing 'Z' will initiate a MASTER RESET while pressing 'V' will cause the program to be restarted.

To enter FACTORY/FIELD TEST MODE set dipswitch S2-1 to the up position before applying power to the receiver. When the receiver is turned on, it will begin displaying information on the terminal. To exit FACTORY/FIELD TEST MODE, return S2-1 to its down position and cycle the power.

CAUTION!!! FACTORY/FIELD TEST MODE is intended to be used in a one receiver setup. It is not possible to operate multiple receivers in FACTORY/FIELD TEST MODE at once.

4-10 DSP DATA OUTPUT

The RX-331 receiver contains a digital output interface providing POST DSP I.F. & A.F. data from the Digital Signal Processor. This output may be interfaced with user supplied equipment for additional signal processing. Signal quality between the RX-331 and external devices is maintained since D/A and A/D stages are eliminated. In addition, the data streams may be turned on or off as needed by remote command.

Since the RX-331 provides both audio and I.F. outputs, the data streams available have control signals associated with each. As the Serial and Parallel interfaces are implemented quite differently, the control signals associated with each are also quite different.
The SERIAL INTERFACE provides SERIAL CLOCK, SERIAL DATA and FRAME START signals. The SERIAL DATA output provides a 14 bit signed sample. Additional control signals are provided to indicate the origin of the sample. The IF/AF line indicates if a sample is I.F. DATA or A.F. DATA. The U/L line indicates if the A.F. sample is from the UPPER SIDEBAND or LOWER SIDEBAND. In all receiver modes except ISB the UPPER and LOWER samples will be the same. When in ISB mode UPPER and LOWER samples can be selected by remote commands.

The PARALLEL DATA stream consists of a 14 bit signed sample embedded in a 16 bit word with the upper two bits providing additional information about the sample. These two bits are encoded to indicate the origin of the sample. Bit 15 indicates if the sample is an I.F. or A.F. sample. If bit 15 indicates an A.F. sample, bit 14 will indicate either UPPER SIDEBAND or LOWER SIDEBAND sample. In all modes except ISB the UPPER SIDEBAND and LOWER SIDEBAND samples will be the same. When in ISB mode, UPPER SIDEBAND and LOWER SIDEBAND samples can be controlled by remote commands. Also the control bits (bits 14 & 15) can be turned off (forced to logic 0) by remote command.

SERIAL INTERFACE

S1 IS USED TO SELECT SERIAL INTERFACE SETTINGS

BAUD RATE

S1

Setting	DIP switch
75 BAUD	
150 BAUD	
300 BAUD	
1200 BAUD	
2400 BAUD	
4800 BAUD	
9600 BAUD	
19,200 BAUD	
38,400 BAUD	

DATA BITS

S1

Setting	DIP switch
7 BITS	
8 BITS	

PARITY

S1

Setting	DIP switch
NONE	
EVEN	
ODD	

STOP BITS

S1

Setting	DIP switch
TWO	
ONE	

RECEIVER ADDRESS

S2

Setting	DIP switch
ADDRESS 1	
ADDRESS 2	
ADDRESS 3	
ADDRESS 4	
ADDRESS 5	
ADDRESS 6	
ADDRESS 7	
ADDRESS 8	

•
•
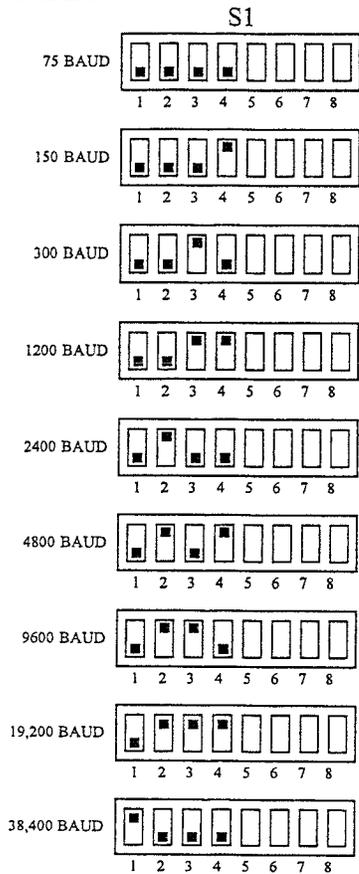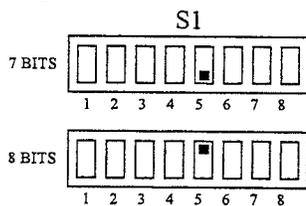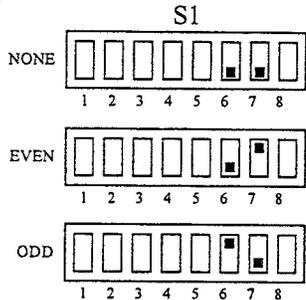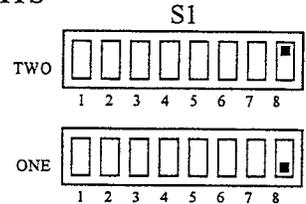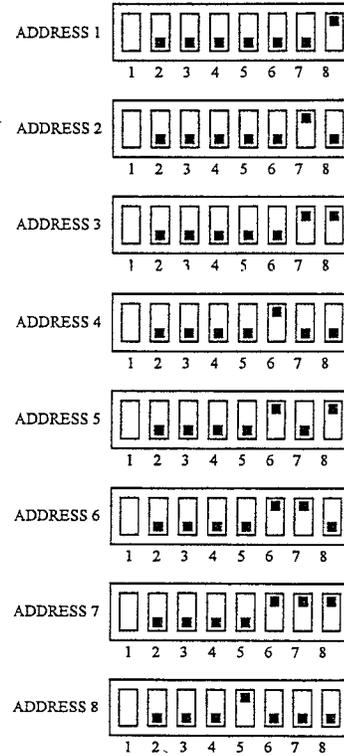
Address range 0 - 127

binary sequence

•
•

Setting	DIP switch
ADDRESS 124	
ADDRESS 125	
ADDRESS 126	
ADDRESS 127	

FACTORY TEST

S2

Setting	DIP switch
FACTORY TEST MODE	
OPERATING MODE	
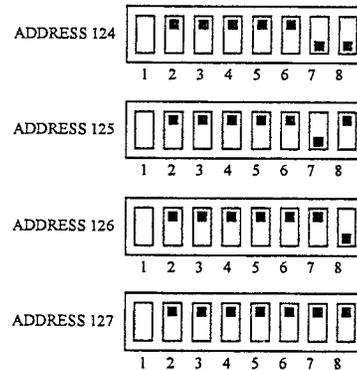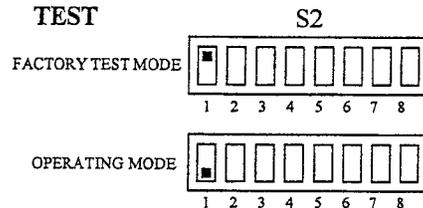
FIGURE 4-2 CONFIGURATION DIAGRAM

4-13

FRAME SYNC

SERIAL CLOCK

SERIAL DATA

IF/AF FLAG

U/L FLAG

REQUEST

HI BYTE
LO BYTE

DATA D0-D7

STROBE

7.5 µS

D13 D12 D11 D10 D9 D8 D7 D6 D5 D4 D3 D2 D1 D0

D13 D12 D11 D10 D9 D8 D7 D6 D5 D4 D3 D2 D1 D0
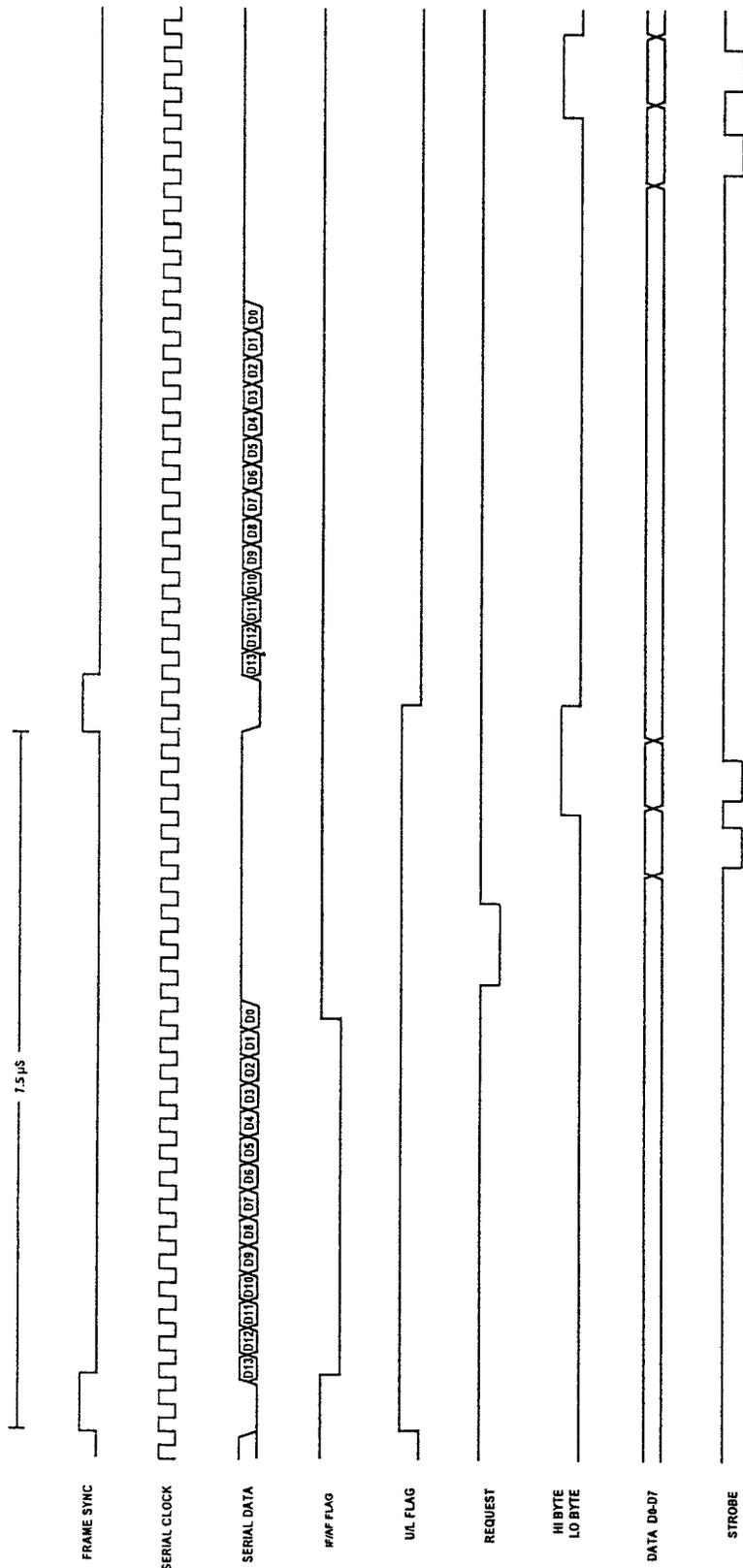
PARALLEL OUTPUT BIT POSITIONS

LSB

LOW BYTE   D7 D6 D5 D4 D3 D2 D1 D0

MSB

HIGH BYTE   A7 U/L D13 D12 D11 D10 D9 D8
                        SIGN

NOTE:

1) U/L & I/A FLAGS MAY BE FORCED TO LOGIC 0
   VIA SOFTWARE COMMAND.

2) SERIAL & PARALLEL DATA OUTPUTS MAY BE
   DISABLED AT DB25 CONNECTOR BY SOFTWARE
   COMMAND. RS-232 WILL REMAIN ACTIVE

FIGURE 4-3 RX-331 SERIAL/PARALLEL INTERFACE
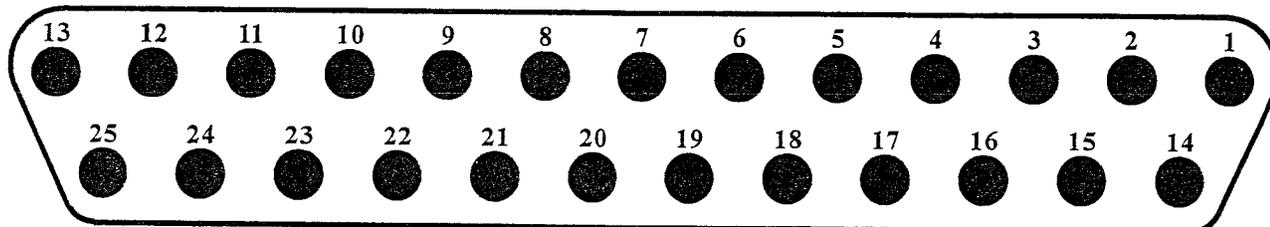
1	GND		14	DSP SERIAL	FRAME SYNC
2	RS232 TXO		15	DSP SERIAL	SERIAL DATA
3	RS232 RXO		16	DSP SERIAL	SERIAL CLOCK
4	DSP PARALLEL	HI/LO BYTE INDICATOR	17	DSP PARALLEL	DATA D1
5	DSP PARALLEL	DATA D0	18	DSP PARALLEL	DATA D3
6	DSP PARALLEL	DATA D2	19	DSP PARALLEL	DATA D4
7	GND		20	DSP PARALLEL	DATA D6
8	DSP PARALLEL	DATA D5	21	GND	
9	DSP PARALLEL	DATA D7	22	+5V	
10	DSP PARALLEL	REQUEST	23	DSP PARALLEL	DATA STROBE
11	GND		24	GND	
12	DSP PARALLEL	IF/AF INDICATOR	25	DSP PARALLEL	U/L INDICATOR
13	GND				

FIGURE 4-4 RX-331 DB25 PIN ASSIGNMENTS

> # WARNING
> # HIGH VOLTAGE
> is used in the operation of this equipment
> ## DEATH ON CONTACT
> may result if personnel fail to observe safety precautions.
> Learn the areas containing high voltage within the equipment.
> Be careful not to contact high voltage connections when installing,
> operating or maintaining this equipment.
> Before working inside the equipment, turn power off
> and ground points of high potential before touching them.

5-1 INTRODUCTION: To perform maintenance tasks on the Model RX-331 the technician shall identify faulty modules or subassemblies. The faulty module or subassembly shall be replaced with a known good one.

5-2 CLEANING AND LUBRICATION: There are no cleaning or lubrication requirements for the Model RX-331.

5-3 TROUBLESHOOTING: Troubleshooting the Model RX-331 consists of identifying faulty modules or subassemblies by running the bite tests (section 4-8). Level 2 and 3 bite tests list symptoms and the probable module or modules associated with the fault.

5-4 INSPECTION: There are no parts in the Model RX-331 that are subject to wear. Rear panel connectors should be inspected for damage whenever the unit is removed.

5-5 PERFORMANCE VERIFICATION TEST FOR MODEL RX-331: The following performance verification tests may be performed if there is a suspected failure. Perform the verification tests in the order listed, as previous tests may contain test setup procedures required for succeeding tests. The technician will need the following test equipment to perform the verification tests.

5-5.1 TEST EQUIPMENT REQUIRED FOR MODEL RX-331:
• Signal generator, HP8656A or equivalent.
• Signal generator, HP8640B or equivalent (16 MHz phase noise less than -130 dBc @ 10 KHz offset), or 16.208 MHz crystal oscillator with +15 dBm output level.
• RF Two-Tone test setup consisting of generators above, hybrid combiner (Anzac HH-107 or equivalent) and fabricated lowpass filters, amplifiers and pads to provide two 0 dBm tones at 16.208 and 16.308 MHz and at 16.208 and 16.2085 MHz with all intermodulation and harmonic outputs less than -80 dBm.
• Audio analyzer, HP8903B or equivalent: AC Level, SINAD, and %THD capabilities.
• Audio spectrum analyzer, HP141T/8852B/8553B or equivalent.
• Step attenuator, 10 dB steps, 0-120 dB, HP355B or equivalent.
• Step attenuator, 1 dB steps, 0-12 dB, HP355C or equivalent.
• Directional coupler, 20 dB, Anzac CD-920-4 or equivalent.
• Computer terminal with RS-232 interface, Wyse 50, DEC VT-100, or equivalent.

5-5.2 FUNCTIONAL TESTS FOR MODEL RX-331:

Specification	Test Setup	TYP.	MIN/MAX
SENSITIVITY Preamp Off Attenuator Off	Connect a signal generator to the receiver RF input. Connect an audio analyzer with SINAD measurement capability to the Mono Audio output. Set receiver tuned frequency to 15.01 MHz, preamp off.		
(Noise Fig. 18 dB typ. 20 dB max.)	USB MODE: IF BW 3.2 KHz MAGC = 0. Apply -109 dBm, 15.011 MHz. Adjust level for 10 dB SINAD.	-112 dBm	-110 dBm MAX
	CW MODE: IF BW 300 Hz. BFO -1000. Apply -113 dBm, 15.01 MHz. Adjust level for 16 dB SINAD.	-116 dBm	-114 dBm MAX
	AM MODE: IF BW 6 KHz Apply -100 dBm, 15.01 MHz, 50% modulation @ 400 Hz. Adjust level for 10 dB SINAD.	-103 dBm	-101 dBm MAX
	FM MODE: IF BW 16 KHz Apply -99 dBm, 15.01 MHz, 6 KHz Peak Deviation @ 1 KHz Adjust level for 16 dB SINAD.	-102 dBm	-100 dBm MAX
Preamp on (Noise Fig. 10 dB typ. 14dB max.)	USB MODE: Preamp ON IF BW 3.2 KHz MAGC = 0 Apply -119 dBm, 15.011 MHz Adjust level for 10 dB SINAD.	-119 dBm (.25 uV)	-115 dBm MAX
IMAGE REJ. (90 dB typ. 80 dB min.)	FIRST MIXER: Receive frequency 15.01 MHz., preamp OFF USB Mode IF BW 3.2 KHz BFO -1800 Hz		

Specification	Test Setup	TYP.	MIN/MAX
	MAGC = 0 Apply 105.924 MHz, -50 dBm Increase level for 10 dB SINAD.	>10 dBm	-32 dBm MIN
	SECOND MIXER: Receive frequency 15.01 MHz. USB Mode IF BW 3.2 KHz BFO -1800 Hz MAGC = 0 Apply 15.923 MHz, -50 dBm Increase level for 10 dB SINAD.	-25 dBm	-32 dBm MIN
IF REJECTION (90 dB typ. 80 dB min.)	FIRST IF: Receive frequency 29.995 MHz, preamp OFF USB Mode IF BW 3.2 KHZ BFO -1800 Hz MAGC = 0 Apply 45.456 MHz, -50 dBm Increase level for 10 dB SINAD.	>10 dBm	-32 dBm MIN
	SECOND IF: Receive frequency 0.500 MHz. Apply 456 KHz -50 dBm Increase level for 10 dB SINAD.	>10 dBm	-32 dBm MIN

3RD ORDER
INTERCEPT
POINT
 	
(+30 dBm typ.
+25 dBm min.)
	Configure the two-tone test set to produce
	    a lowpass filtered 16.208 MHz. / 16.308 MHz
	    two-tone output with each tone at 0 dBm (6 dBm PEP).
	    Third order products and harmonics at the
	    combiner output must be less than -80 dBm.
	Connect the two-tone output through a 1 dB
	    step attenuator to the receiver RF input.
	    Receive frequency 16.1072 MHz, preamp OFF
	    Set MAGC to 65 dB
	Note audio output level in dBv. Reduce the
	    two-tone level by 3 dB and observe a 9 dB
	    drop in audio output.
	Remove the two-tone generator and step attenuator.
	Connect a 16.1082 MHz. generator to RF input.
	Adjust generator level for the same audio
	    level noted above.
	Generator level should be:
		-60 dBm	-50 dBm MAX

5-3

Specification	Test Setup	TYP.	MIN/MAX

SECOND ORDER INTERCEPT POINT

Receive frequency 26.005 MHz, preamp OFF.
MAGC = 0.
Set generator to 22.728 MHz.
Connect sufficient lowpass filtering to
generator output to reduce 2nd harmonic
(+75 dBm typ. +60 dBm min.) to -100 dBc at -30 dBm output.
Connect filtered generator to RF input.
Adjust generator level for 10 dB SINAD.

Generator level should be: — -17 dBm -26dBm MIN

INBAND IMD

Configure the two-tone test set to produce
a lowpass filtered 16.208/16.2085 MHz
two-tone with each tone at -16 dBm (-10
(-55 dB typ. -50 dB max.) dBm PEP). Third order products and
harmonics must be less than -80 dBm.
Connect the two-tone to the receiver RF input.
Receive frequency 16.207 MHz, USB, AGC=SLOW,
preamp OFF.
Send a status request command to the receiver
and note the received signal level. Add 10
to the signal level, and set the Manual Gain (Attenuation)
to this number.
Connect the audio spectrum analyzer to the MONO
AUDIO output.

Analyzer settings: 1250 Hz CF
30 Hz RBW
10 Hz VBW
200 Hz/div
0 dBm Input Level
20 dBm Log Reference
1 sec/div Scan Time

Adjust Display Reference to place each main tone at
-6 dB.

Third order products should be: — -55 dB -50 dB MAX
Turn attenuator ON
Each main tone should drop to: — -20 dB +/- 3 dB

LO PHASE NOISE @ 20 KHz offset

Connect a 16.208 MHz / 15 dBm crystal
oscillator thru 10 dB and 1 dB step
attenuators to RF in.
Connect audio analyzer to MONO AUDIO output.
Receive frequency 16.227 MHz, USB, preamp OFF.

5-4

Specification	Test Setup	TYP.	MIN/MAX
(120 dB/Hz typ. -110 dB/Hz max.)	Set attenuator to 80 dB MAGC = 20. Note audio noise level in dBm. Decrease attenuator setting for a 10 dB rise in noise level.		
	Attenuator setting should be:	42 dB	52 dB MAX

Note: 10 dB rise above typical receiver noise floor of -122 dBm/3.2 KHz is -147 dBm/Hz. Subtract RF input level from this to obtain dBc/Hz phase noise. Phase noise of the xtal oscillator or signal generator used must be at least 20 dB better than the expected measurement.

BLOCKING ON TUNE (<5% THD: 0 dBm input 30% AM 1 KHz)	AM Mode, 6 KHz BW. Receive frequency 15.01 MHz, preamp OFF. Connect signal generator to RF input. Set signal generator to 15.01 MHz, 30% AM/ 1 KHz, -6 dBm MAGC = 0. AGC Mode = Slow. Set audio analyzer to read % distortion.		
	Distortion should be less than:	2.5%	5% MAX

BLOCKING
OFF TUNE
 	
(200 KHz offset
15 dBm typ.
10 dBm min.)
	Receive frequency 16.408 MHz, preamp OFF.
	Connect a +15 dBm 16.208 MHz crystal
	   oscillator through a step attenuator to a
	   directional coupler input.
	Connect the direct output of the directional
	   coupler to the receiver RF input.
	Terminate the forward port of the coupler.
	Connect a -40 dBm, 16.408 MHz, 30% AM/
	1 KHz, signal generator to the reverse
	   port of the directional coupler.
	Set step attenuator to 50 dB
	Set audio analyzer to read AC Level in dBm.
	Increase MAGC setting until the AC Level
	   reading drops by 10 dBm
	Reduce attenuator setting until blocking
	   begins (3 dB drop in AC Level).		

	RF input level should be:	> 15 dBm	10 dBm MIN

CHAPTER 6

PREPARATION FOR SHIPMENT OR STORAGE

6-1 PREPARATION FOR RESHIPMENT: If the Model RX-331 ever needs to be packaged for reshipment, it is recommended that the following steps be taken.

1. Remove all cords or cables attached to the unit.

2. Ensure that there is sufficient foam packing material in the shipping carton to protect the unit from any hard impact that may occur during shipment.

3. Place the unit in the center of the shipping carton.

4. Cover the unit with foam packing material.

5. If using a cardboard packing carton, securely tape the seams of the carton's top cover, bottom cover and side flaps with reinforced tape.

6. Fasten labels or stamp with indelible ink the word FRAGILE on the top, bottom, and all sides of the carton.

6-2 PREPARATION FOR STORAGE: If the Model RX-331 is not going to be used for a long period of time, it should be stored in its shipping case or some other suitable carton. The unit is rated for storage at temperatures from -50° F to 160° F. To prepare the unit for storage perform the following steps.

1. Remove all cords or cables attached to the unit.

2. Ensure that there is sufficient foam packing material in the container.

3. Place the unit in the center of the packing container.

4. Cover the unit with foam packing material.

5. If using a cardboard packing carton, securely tape the container with reinforced packing tape.

6. Fasten labels or stamp with indelible ink the word FRAGILE on the top, bottom, and all sides of the container.

7. Write the Model No. and quantities in large characters on top of the carton.

CHAPTER 7

SINGLE SOURCE PARTS LIST

7-1 INTRODUCTION: Table 7-1 is a listing of all the parts available from only one unique manufacturer or source. The table lists the Sub-Assembly Number, component ID, Manufacturer Part Number, Manufacturer Code, Part Description, and the Ten-Tec Part Number.

TABLE 7-1 MODEL RX-331 SINGLE SOURCE PARTS LIST

S/A NO.	MFGR. PART No.	MFGR. CODE	DESCRIPTION	TEN-TEC PART No.
81727	UCN5895A	ALLEGRO	IC-8 CHANNEL SERIAL DRIVER	25344
81727	KS4522	FSI	DIODE-PIN-25 WATTS	28103
81727	85413-10	TT	COIL-RF 5 TURNS #28 BIFILAR ON 21167	85413-10
81727	85413-11	TT	COIL-RF 5 TURNS #28 BIFILAR 5 TURNS #24 ON 21037 AND 21167	85413-11
81823	2SC1971	MITI	VHF TRANSISTOR	25337
81823	BLBC-2TX2-4P	CTC	TRANSFORMER-BIFILAR BALUN	21152
81823	BLBC-2TX3-4P	CTC	TRANSFORMER-TRIFILAR BALUN	21153
81823	85134	TT	TRANSFORMER-TRIFILAR	85134
81823	85149	TT	TRANSFORMER-RF 1:1 BALUN	85149
81823	85419-1	TT	COIL - 14 3/4 TURNS #30 ON 91566	85419-1
81823	85419-2	TT	COIL - 9 3/4 TURNS #30 ON 91566	85419-2
81823	5082-2835	HP	DIODE - HOT CARRIER	28013
81823	91744	TT	VCO - ENCLOSURE	91744
81823	456PS-1011	TOKO	TRANSFORMER, DIRECTIONAL COUPLER	21191
81823	85414-11	TT	TRANSFORMER, TRIFILAR	85414-11
81823	8390B	PTI	FL-1 MONOLITHIC FILTER PAIR 45,455 MHz	48226

TABLE 7-1 MODEL RX-331 SINGLE SOURCE PARTS LIST (cont.)

S/A NO.	MFGR. PART NO.	MFGR. CODE	DESCRIPTION	Ten-Tec PART NO.
81817	BLBC-2TX2-4P	CTC	TRANSFORMER - BIFILAR BALUN	21152
81817	BLBC-2TX3-4P	CTC	TRANSFORMER - TRIFILAR BALUN	21153
81817	MCI2019P	RCA	IC ÷20/21 PRESCALER	25354
81817	2SC1971	MITI	VHF TRANSISTOR	25337
81817	MC145170P	MOT	IC - PLL	25296
81817	AD600JN	AD	IC - DUAL AMPLIFIER	25322
81817	7MM	AURA	SHIELD CAN-COIL, 7MM NI PLATED	38131
81817	85413-03	TT	COIL - 12 TURNS #30 BIFILAR ON 21175	85413-03
81817	160-0021-020	DAYSTAR	PRINTED CIRCUIT BOARD TERMINAL	41003
81817	85413-12	TT	COIL - 9 TURNS #30 TRIFILAR ON 21175	85413-12
81817	MBD301	MOT	DIODE - HOT CARRIER	28110
81817	CFW455D	MURATA	455 KHz FILTER	48203
81772	85134	TT	TRANSFORMER - TRIFILAR BALUN	85134
81772	MC145170P	MOT	PLL FREQUENCY SYNTHESIZER SERIAL INTERFACE	25296
81772	KV3902	FSI	DIODE - VARACTOR	28075
81772	CA3096E	RCA	IC - TRANSISTOR ARRAY	25345
81772	85419-3	TT	COIL 8 3/4 TURNS #30 ON 91566 FORM	85419-3
81772	85419-6	TT	COIL 15 3/4 TURNS #30 ON 91566 FORM	85419-6
81772	93365	TT	ENCLOSURE-COVER-SOLID	93365
81772	91744	TT	ENCLOSURE - VCO	91744
81772	93368	TT	ENCLOSURE-VCO BOTTOM	93368
81772	91745	TT	ENCLOSURE-COVER	91745
81772	85419-5	TT	INDUCTOR - AIR, 4T #22	85419-5
81772	85419-8	TT	INDUCTOR - AIR, 5T #22	85419-8
81772	85419-4	TT	INDUCTOR - AIR, 8T #24	85419-4

7-2

TABLE 7-1 MODEL RX-331 SINGLE SOURCE PARTS LIST (cont.)

S/A NO.	MFGR. PART NO.	MFGR. CODE	DESCRIPTION	TEN-TEC PART NO.
81772	85419-7	TT	INDUCTOR - AIR, 11T #24	85419-7
81772	3132B	PTI	MONOLITHIC FILTER 45 MHz	48202
81772	NE612AN	SG	IC - MIXER	25319
81772	BB911	PHILLIPS	DIODE - VARACTOR	28123
81772	10 MHz HC 18 32P	FM	CRYSTAL 10 MHz .002% HC 18 32 PF	48112
81772	93352	TT	SHIELD TOP	93352
81772	93362	TT	SHIELD BOTTOM	93362
81772	50CBS	LEADER	SHIELD FENCE	38255
81772	751A	FOX	TCVCXO OPTION	48255
81821	80C552	SG	CPU - U1	25331
81821	MAX242	MAX	IC - CONVERTER SMD - U2	25415
81821	M48Z58SO	SGS	IC - SRAM SMD - U3	25401
81821	XC9536VQ44	XIL	IC - PROGRAMMED - U4	25416
81821	XC9536VQ44	XIL	IC - PROGRAMMED - U17	25416
81821	98400	TT	IC - PROGRAMMED - U12	25423
81821	98402	TT	IC - PROGRAMMED - U30	25423
81821	ADSP2181KS	AD	IC - DSP CPU SMD - U15	25362
81790	42XLO16	MOUSER	TRANSFORMER 600Ω CT.	21185
81790	AD7872JN	AD	IC - ANALOG TO DIGITAL CONVERTER	25348
81790	AD7840JN	AD	IC - DIGITAL TO ANALOG CONVERTER	25349
81790	CFU455D2	MURATA	455 KHz FILTER	48198
81825	PSA-4541	PHIHONG	SWITCHING POWER SUPPLY	21200

TABLE 7-2 PART MANUFACTURER'S INFORMATION

MFGR'S CODE	MANUFACTURER NAME AND ADDRESS
AD	ANALOG DEVICES INC., ONE TECHNOLOGY WAY, PO BOX 9106, NORWOOD, MA 02060-9106
ALLEGRO	ALLEGRO MICROSYSTEMS INC., 115 NORTHEAST CUTOFF BOX 15036, WORCESTER, MA 01615
AURA	AURA MRG. COMPANY, 50 MC DERMATT RD., NORTH HAVEN, CT 06473
CSF	TOMPSON-CSF COMPONENTS CORPORATION, SEMICONDUCTOR DIVISION 6660 VARIEL AVE., CANOGA PARK, CA 91303
CTC	CTC COILS LTD FLAT L-M, 141 F HARIBEST IND'L BLDG., 45-47 AU PUI, WAM STREET FO-TAN, SHATIN, NT HONG KONG
DALLAS	DALLAS SEMICONDUCTOR CORP., 4401 SOUTH BELTWOOD PARKWAY, DALLAS, TX 75244-3292
DAYSTAR	DAYSTAR MFG. INC., 11535 FRANKLIN AVE, FRANKLIN PARK, IL 60131
FSI	FREQUENCY SOURCES INC., SEMICONDUCTOR DIVISION, 16 MAPLE RD, CHELMS FORD, MA 01824
HARRIS	HARRIS CORP, SEMICONDUCTOR PRODUCTS DIV., PO BOX 883, MELBOURNE, FL 32902
HP	HEWLETT PACKARD CO., PO BOX 10301, PALO ALTO, CA 94303-0890
LEADER	LEADER TECH, 14100 MC CORMICK DRIVE, TAMPA, FL 33626
MAX	MAXIM INTEGRATED PRODUCTS INC., 120 SAN GABRIEL DR., SUNNYVALE, CA 94086
MITI	MITSUBISHI ELECTRONICS AMERICA, INC. 1050 EAST ARQUES AVENUE, SUNNYVALE, CA 94086
MOT	MOTOROLA SEMICONDUCTOR PRODUCTS INC., 3501 ED BLUESTEIN BLVD., AUSTIN, TX 78721
MOUSER	MOUSER ELECTRONICS INC., 1175 N.E. 24 STREET, PO BOX 5727 FORT LAUDERDALE, FL 33310
MURATA	MURATA ERIE NORTH AMERICA INC., 1148 FRANKLIN RD S.E., MARIETTA, GA 30067

TABLE 7-2 PART MANUFACTURER'S INFORMATION (cont.)

MFGR'S CODE	MANUFACTURER NAME AND ADDRESS
PHIHONG	PHIHONG USA, 374 S. MILPITAS BLVD. MILPITAS, CA 95035
PHILLIPS	SIGNETICS/PHILLIPS SEMICONDUCTORS, 811 EAST ARQUES AVE, SUNNYVALE, CA 94088-3409
PTI	PIEZO TECHNOLOGY INC., 2525 SHADER RD., PO BOX 547859, ORLANDO, FL 32854-7859
RCA	RCA/HARRIS CORP. SEMICONDUCTOR PRODUCT DIV., PO BOX 883 MELBOURNE, FL 32902
FM	FREQUENCY MANAGEMENT, 15302 BOLSA CHICA ST., HUNTINGTON BEACH, CA 92649
SG	SIGNETICS/PHILIPS SEMICONDUCTORS, 811 EAST ARQUES AVE, SUNNYVALE, CA 94088-3409
SGS	SGS-THOMSON, 55 OLD BEDFORD ROAD, LINCOLN, MA 01773
TT	TEN-TEC, INC., 1185 DOLLY PARTON PARKWAY, SEVIERVILLE, TN 37862
TOKO	TOKO AMERICA, 1250 PEEHANVILLE DRIVE, MOUNT PROSPECT, IL 60056
XIL	XILINX, 2100 LOGIC DRIVE, SAN JOSE, CA 95124-3400
FOX	FOX ELECTRONICS, 5570 ENTERPRISE PKY., FT. MYERS, FL 33905

CHAPTER 8

FINAL ASSEMBLY

8-1 INTRODUCTION: Table 8-1 is a listing of all the modules in the RX-331 that can be replaced in corrective maintenance procedures. Figure 3-1 illustrates where the modules are located in the chassis. Table 8-2 is a listing of additional small parts which may need to be replaced if the receiver has been damaged.

TABLE 8-1 RX-331 MODULES

DESCRIPTION	TT PART NO.
RX PRESELECTOR	81727
1ST MIXER	81823
2ND MIXER/3RD LO	81817
SYNTHESIZER	81772
POWER SUPPLY	81825
LED BOARD	81788
DSP/CPU BOARD	81821
CONVERTER (I/O)	81790

TABLE 8-2 FINAL ASSEMBLY REPLACEABLE PARTS

DESCRIPTION	TT PART NO.
FUSE, 1A GDC-1A, 5 x 20 mm	27071
RES-VAR 1K LIN	30087
RES-VAR 1K DUAL GANGED	30621
SWITCH DPDT	32087
JACK - PHONE 1CKCT	35008
BNC CONNECTOR CHASSIS MOUNT	35134
JACK - PHONE STEREO	35144
POWER ENTRY MODULE	35299
EMI/RFI GASKET FOR DB-25	35282
D-CONNECTOR 15 PIN	35287
SHIELDED BNC CONNECTOR	35286
1.5" RACK HANDLES, 3/16" DIA	38213
DETACHABLE AC CORD/3COND.	46138
SHIELD 1	93168-1
SHIELD 2	93168-2
SHIELD 3	93168-3
SHIELD 4	93168-4
SHIELD 5	93168-5
SHIELD 6	93168-6
SHIELD 7	93168-7
SHIELD 8	93168-8
SHIELD 10	93168-10
SHIELD 11	93168-11
SHIELD 12	93328-12
SHIELD 13	93168-13
SHIELD 14	93168-14
CHASSIS	93413-1A
TOP	93332
LEFT SIDE	93326
RIGHT SIDE	93327
SUB-PANEL	93329
FRONT PANEL	93414 DP1A
ADDRESS/DATA COVER	93170
KNOB ASSEMBLY .250 ID	81724
POWER SUPPLY SHIELD TOP	93369-CN
POWER SUPPLY SHIELD BOTTOM	93370-CN
INSULATOR FOR - 12	93363

8-2

CHAPTER 9

ILLUSTRATIONS

9-1 INTRODUCTION: This chapter contains the detailed illustrations for the manual. This includes the block and schematic diagrams, parts lists, component location illustrations, and in some cases circuit board trace views.
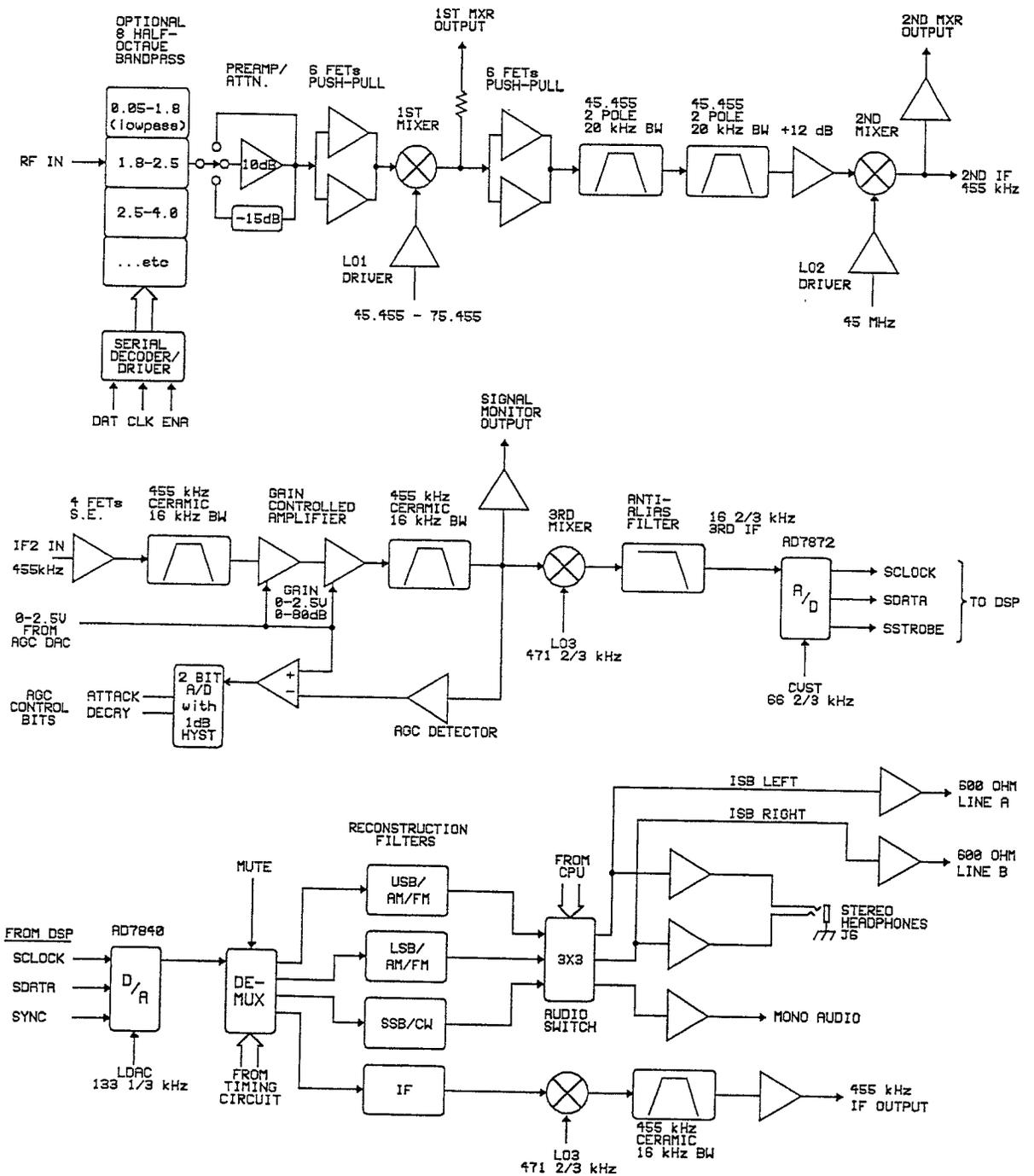
FIGURE 9-1. MODEL RX-331 BLOCK DIAGRAM

LO1, LO2, LO3   PRESELECTOR

RS-232
INTERFACE

(U2)

MAIN CPU
SYSTEM

(U1,U3,U4,U5,U6,U7,
U8,U9,U11,U12,U29)

USER OUTPUTS

AGC
DAC

(U18)

AGC FORCE

DSP SYSTEM

(U15,U17,U19,U21,U22,U30,U31)

DATA
A/D
&
D/A

2ND IF AND
I/O CONVERTER BOARD

DIGITAL
OUTPUT
U17
U23
U24

SERIAL
PARALLEL
DSP DATA

AGC CONTROL BITS
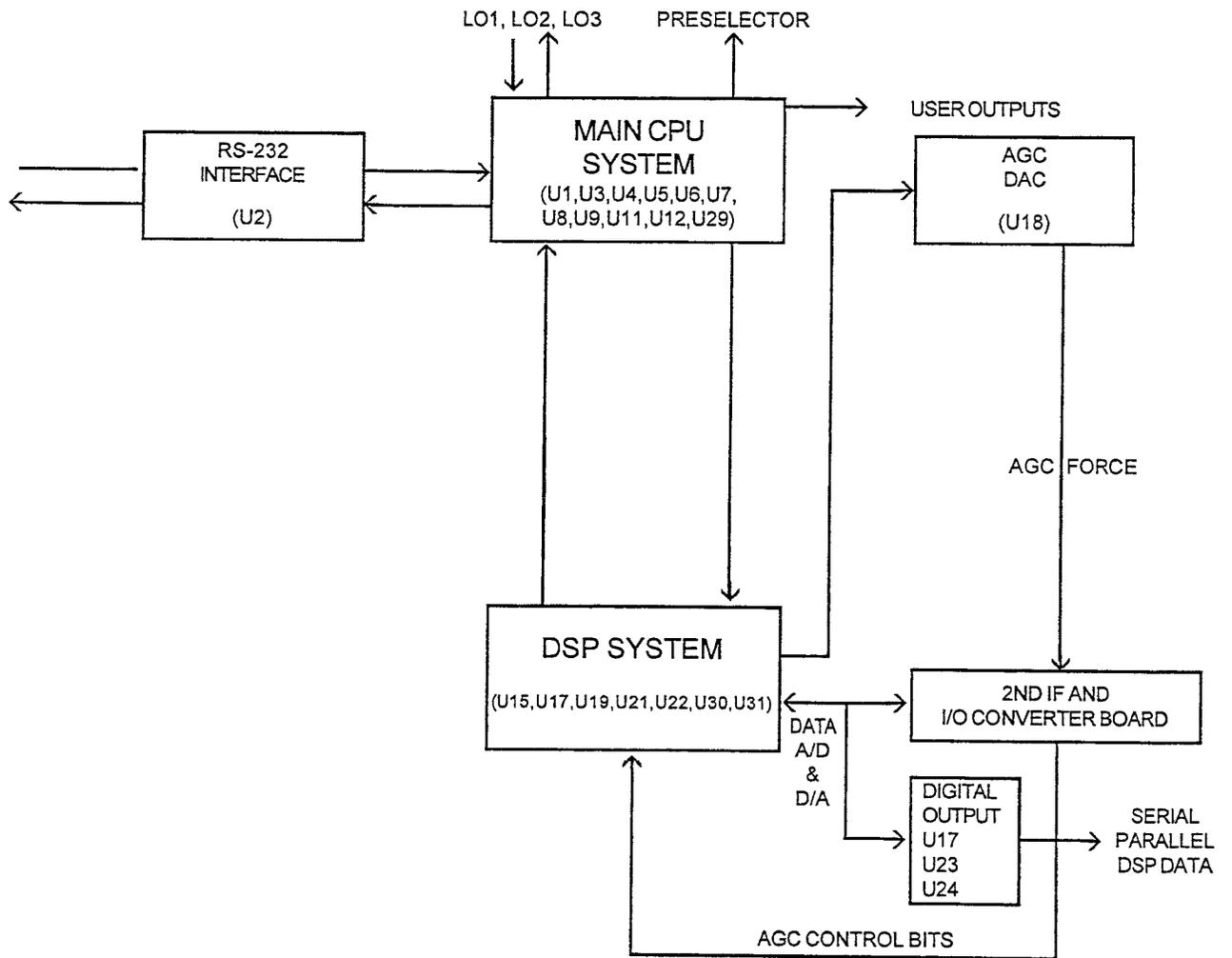
FIGURE 9-2 LOGIC BOARD BLOCK DIAGRAM

FIGURE 9-3 SYNTHESIZER BLOCK DIAGRAM

FIGURE 9-4. 81727 CIRCUIT TRACE

FIGURE 9-5. 81727 RX PRESELECTOR COMPONENT LAYOUT

9-5/9-6 BLANK

FIGURE 9-6. 81727 RX PRESEL

FIGURE 9-6. 81727 RX PRESELECTOR SCHEMATIC

9-7/9-8 BLANK

TABLE 9-1. 81727 RX PRESELECTOR PARTS LIST

ID	Description	Part No.
R1	47	30289
R2	100	30309
R3	47	30289
R4	100	30309
R5	47	30289
R6	100	30309
R7	47	30289
R8	100	30309
R9	47	30289
R10	100	30309
R11	47	30289
R12	100	30309
R13	47	30289
R14	100	30309
R15	150	30438
R16	100	30309
R17	1K	30333
R18	220	30290
R19	1K	30333
R20	1K	30333
R21	1K	30333
R22	1K	30333
R23	1K	30333
R24	1K	30333
R25	1K	30333
R26	220	30290
R27	3.3K	30294
R28	1K	30333
R29	220	30290
R30	22K	30298
R31	22K	30298
R32	10	30314
R33	100	30309
R34	150	30438
R35	22K	30298
R36	22K	30298
R37	47K	30291
R38	33	30434
R39	33	30434
R40	22	30433
R41	22K	30298
R42	22K	30298
R43	82	30437

ID	Description	Part No.
R44	4.7K	30305
R45	33K	30299
R46	4.7K	30305
R47	4.7K	30305
R48	47K	30291
R49	33K	30299
R50	4.7K	30305
R51	4.7K	30305
R52	4.7K	30305
R53	4.7K	30305
R54	33K	30299
R55	4.7K	30305
R56	4.7K	30305
R57	100	30309
R58	100	30309
R59	100	30309
R60	100	30309
R61	100	30309
R62	100	30309
R63	1K	30333
R64	4.7	30624
R65	100	30309
R66	100	30309
R67	100	30309
R68	2.2K	30293
C1	0.1	23261
C2	1/50V	23264
C3	56	23379
C4	180	23389
C5	220	23396
C6	5.0	23249
C7	10	23251
C8	220	23396
C9	180	23389
C10	56	23379
C11	1.0/50V	23264
C12	.01	23260
C13	.01	23262
C14	1.0/50V	23264
C15	120	23386
C16	220	23396
C17	180	23389
C18	12	23370

TABLE 9-1. 81727 RX PRESELECTOR PARTS LIST (continued)

ID	Description	Part No.
C19	220	23396
C20	180	23389
C21	120	23386
C22	1.0/50V	23264
C23	.01	23260
C24	.01	23260
C25	1.0/50V	23264
C26	270	23397
C27	270	23397
C28	270	23397
C29	27	23303
C30	270	23397
C31	270	23397
C32	270	23397
C33	1.0/50V	23264
C34	.01	23260
C35	.01	23260
C36	1.0/50V	23264
C37	270	23397
C38	470	23400
C39	470	23400
C40	33	23246
C41	470	23400
C42	470	23400
C43	270	23397
C44	1.0/50V	23264
C45	.01	23260
C46	.01	23260
C47	1.0/50V	23264
C48	560	23401
C49	750	23148
C50	560	23401
C51	39	23377
C52	560	23401
C53	750	23148
C54	560	23401
C55	1.0/50V	23264
C56	0.1	23261
C57	0.1	23261
C58	1.0/50V	23264
C59	.001	23282
C60	.0012	23283
C61	.001	23282

ID	Description	Part No.
C62	75	23382
C63	.001	23282
C64	.001	23282
C65	.0012	23283
C66	1.0/50V	23264
C67	0.1	23261
C68	0.1	23261
C69	1.0/50V	23264
C70	.001	23245
C71	680	23402
C72	150	23388
C73	.0012	23282
C74	120	23386
C75	150	23388
C76	.001	23245
C77	.001	23245
C78	680	23402
C79	.0012	23283
C80	1.0/50V	23264
C81	0.1	23261
C82	1.0/50V	23264
C83	.0018	23285
C84	.0039	23334
C85	.0039	23334
C86	.0018	23285
C87	.1	23262
C88	1.0/50V	23264
C89	.1	23261
C90	1.0/50V	23264
C91	1.0/50V	23264
C92	.1	23261
C93	1.0/50V	23264
C94	.1	23261
C95	.1	23261
C96	1.0/50V	23264
C97	.1	23261
C98	1.0/50V	23264
C99	1.0/50V	23264
C100	.1	23261
C101	.1	23261
C102	.1	23261
C103	1.0/50V	23264
C104	.1	23261

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TABLE 9-1. 81727 RX PRESELECTOR PARTS LIST (continued)

ID	Description	Part No.
C105	1.0/50V	23264
C106	.1	23261
C107	1.0/50V	23264
C108	.1	23261
C109	.1	23261
C110	.1	23261
C111	1.0/50V	23264
C112	.1	23261
C113	.1	23261
C114	.1	23261
C115	.1	23261
C116	.1	23261
C117	.1	23261
C118	.1	23261
C119	.1	23261
C120	1.0/50V	23264
C121	.1	23261
C122	.1	23261
C123	.001	23282
C124	.001	23282
C125	.001	23282
C126	.01	23260
C127	470/16V	23228
D1	KS4522	28103
D2	KS4522	28103
D3	KS4522	28103
D4	KS4522	28103
D5	KS4522	28103
D6	KS4522	28103
D7	KS4522	28103
D8	KS4522	28103
D9	KS4522	28103
D10	KS4522	28103
D11	KS4522	28103
D12	KS4522	28103
D13	KS4522	28103
D14	KS4522	28103
D15	KS4522	28103
D16	KS4522	28103
D17	KS4522	28103
D18	KS4522	28103
D19	KS4522	28103
D20	KS4522	28103

ID	Description	Part No.
D21	KS4522	28103
D22	KS4522	28103
D23	IN751	28041
L1	100	21060
L2	1.0	21112
L3	.39	21107
L4	2.7	21117
L5	.39	21107
L6	1.0	21112
L7	100	21060
L8	100	21060
L9	1.0	21112
L10	.82	21111
L11	5.6	21121
L12	.82	21111
L13	1.0	21112
L14	100	21060
L15	100	21060
L16	1.2	21113
L17	1.5	21114
L18	6.8	21122
L19	1.5	21114
L20	1.2	21113
L21	100	21060
L22	100	21060
L23	2.7	21117
L24	2.2	21116
L25	15	21126
L26	2.2	21116
L27	2.7	21117
L28	100	21060
L29	100	21060
L30	3.3	21118
L31	3.9	21119
L32	27	21129
L33	3.9	21119
L34	3.3	21118
L35	100	21060
L36	100	21060
L37	4.7	21120
L38	5.6	21121
L39	39	21159
L40	5.6	21121

TABLE 9-1. 81727 RX PRESELECTOR PARTS LIST (continued)

ID	Description	Part No.
L41	4.7	21120
L42	100	21060
L43	820	21095
L44	12	21125
L45	100	21164
L46	58	21162
L47	27	21129
L48	12	21125
L49	820	21196
L50	1mh	21007
L51	4.7	21120
L52	4.7	21120
L52	4.7	21120
L53	4.7	21120
L54	NOT USED	
L55	NOT USED	
L56	NOT USED	
L57	1mh	21196
L58	1mh	21196
L59	1mh	21196
L60	1mh	21196
L61	NOT USED	
L62	1mh	21196

ID	Description	Part No.
L63	1.2	21113
L64	1.2	21113
L65	6-HOLE BEAD	21179
SP1	SPARK GAP	27040
T1	TOROID	85414-10
T2	TOROID	85414-10
T3	TOROID	85414-11
T4	TOROID	85414-10
Q1	J310	25115
Q2	J310	25115
Q3	J310	25115
Q4	J310	25115
Q5	J310	25115
Q6	J310	25115
Q7	2N5109	25079
Q8	2N5087	25001
Q9	MPS6514	25054
Q10	2N5087	25001
Q11	MPS6514	25054
Q12	2N5087	25001
Q13	MPS6514	25054
U1	UCN5895A	25344
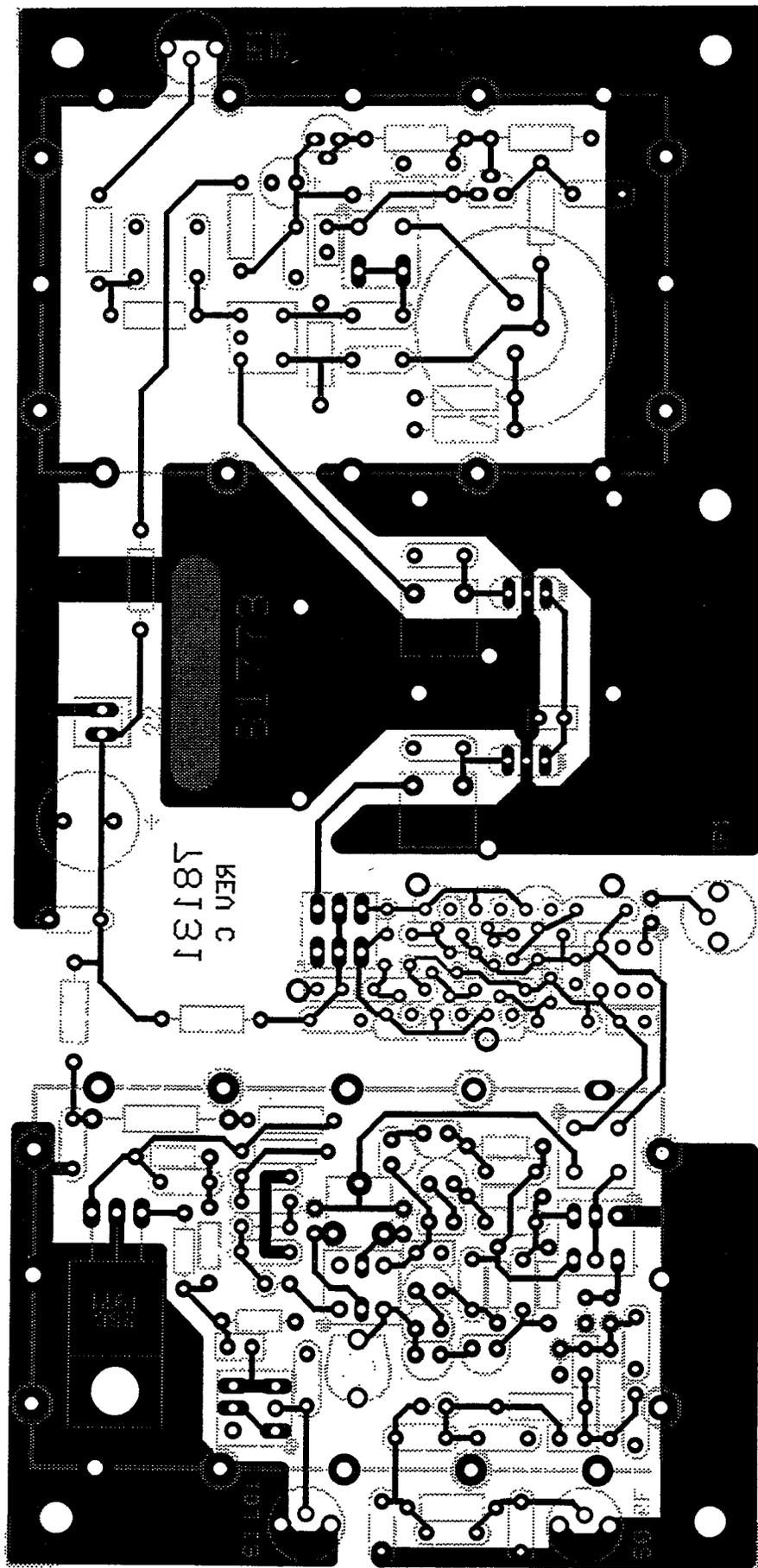
FIGURE 9-7. 81823 BOTTOM CIRCUIT TRACE
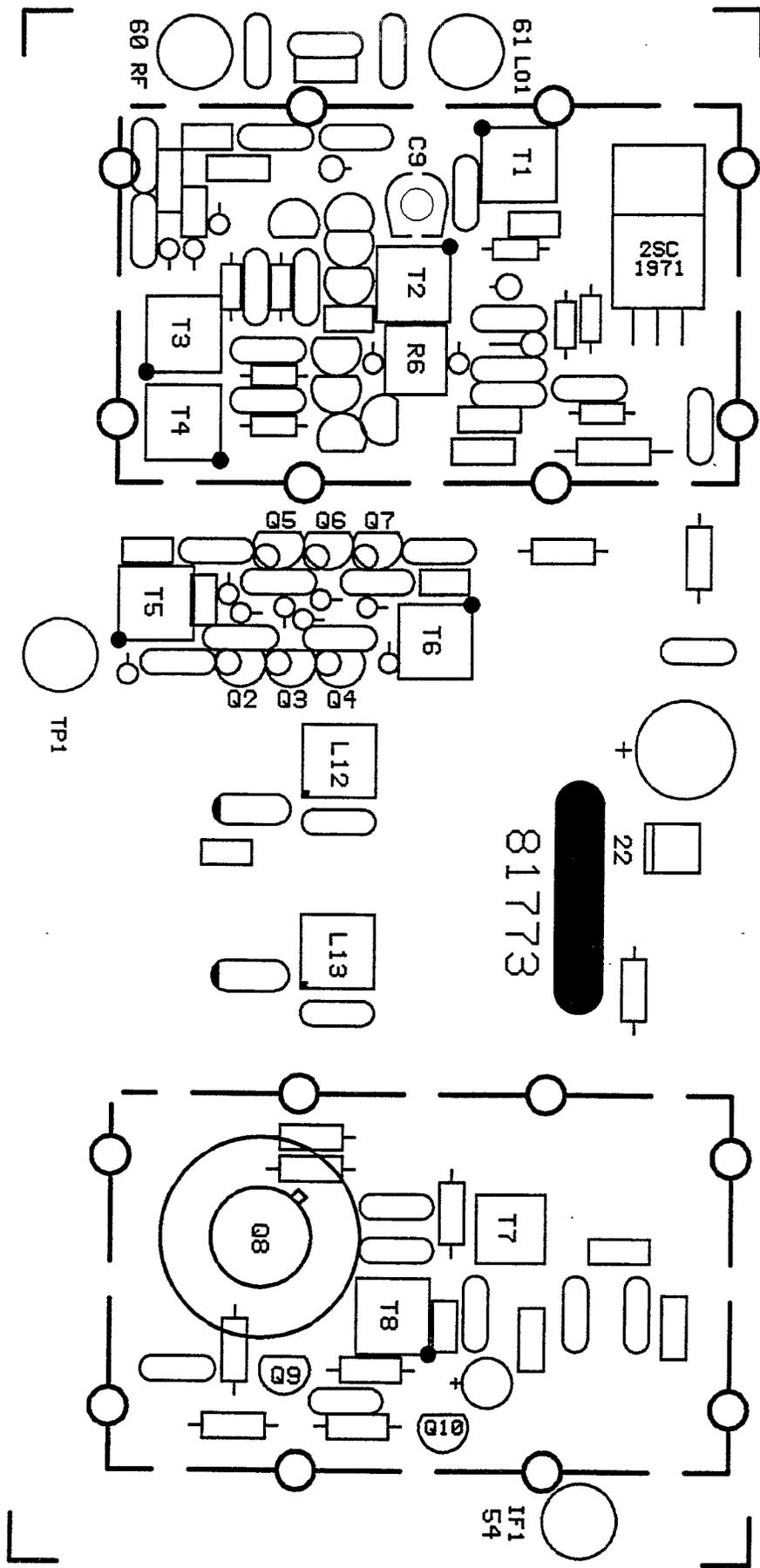
FIGURE 9-8. 81823 1st MIXER COMPONENT LAYOUT
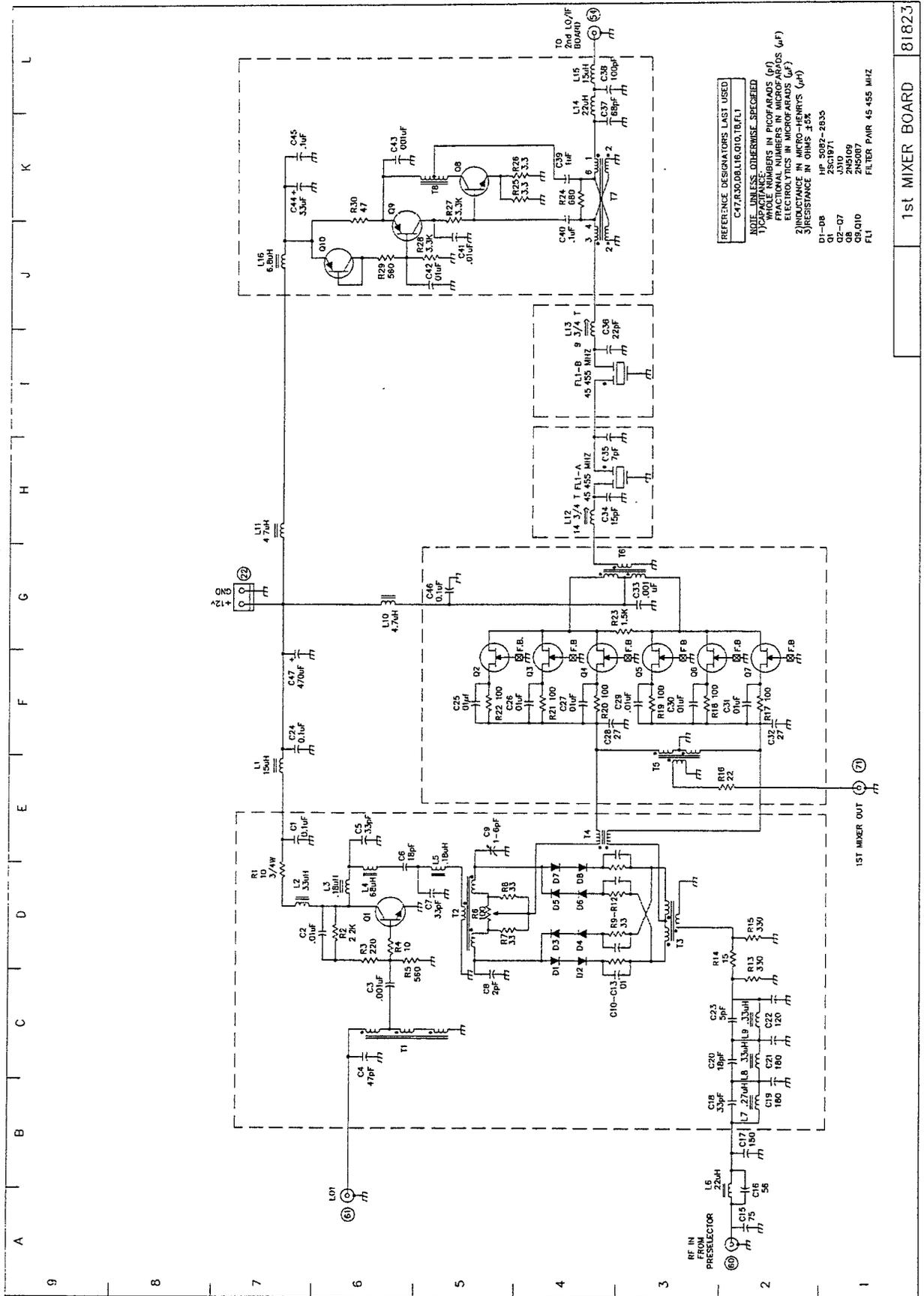
FIGURE 9-9. 81823 1st MIXER SCHEMATIC

TABLE 9-2. 81823 1st MIXER PARTS LIST

ID.	Description	Part No.
R1	10 3/4W	30022
R2	2.2K	30293
R3	220	30290
R4	10	30314
R5	560	30440
R6	100 VAR.	30617
R7	33	30428
R8	33	30428
R9	33	30434
R10	33	30434
R11	33	30434
R12	33	30434
R13	330	30241
R14	15	30431
R15	330	30241
R16	22	30432
R17	100	30318
R18	100	30318
R19	100	30318
R20	100	30318
R21	100	30318
R22	100	30318
R23	1.5K	30245
R24	680	30136
R25	3.3	30109
R26	3.3	30109
R27	3.3K	30144
R28	3.3K	30144
R29	560	30135
R30	47	30122
C1	.1	23261
C2	.01	23260
C3	.001	23245
C4	47pF	23378
C5	33pF	23376
C6	18pF	23302
C7	33pF	23376
C8	2pF	23301
C9	1-6pF VAR	23244
C10	.01	23260
C11	.01	23260
C12	.01	23260
C13	.01	23260

ID.	Description	Part No.
C14	470, 16V	23228
C15	75pF	23382
C16	56pF	23379
C17	150pF	23388
C18	33pF	23376
C19	180pF	23389
C20	18pF	23373
C21	180pF	23389
C22	120pF	23386
C23	5pF	23249
C24	.1	23261
C25	.01	23260
C26	.01	23260
C27	.01	23260
C28	27pF	23303
C29	.01	23260
C30	.01	23260
C31	.01	23260
C32	27pF	23303
C33	.001	23245
C34	15pF	23372
C35	7pF	23269
C36	22pF	23374
C37	68pF	23381
C38	100pF	23385
C39	.1	23261
C40	.1	23261
C41	.01	23260
C42	.01	23260
C43	.001	23245
C44	33μF	23308
C45	.1	23261
C46	.1	23261
D1	HP 5082-2835	28013
D2	HP 5082-2835	28013
D3	HP 5082-2835	28013
D4	HP 5082-2835	28013
D5	HP 5082-2835	28013
D6	HP 5082-2835	28013
D7	HP 5082-2835	28013
D8	HP 5082-2835	28013
Q1	2SC1971	25337
Q2	J310	25115

TABLE 9-2. 81823 1st MIXER PARTS LIST (continued)

ID.	Description	Part No.
Q3	J310	25115
Q4	J310	25115
Q5	J310	25115
Q6	J310	25115
Q7	J310	25115
Q8	2N5109	25079
Q9	2N5087	25001
Q10	2N5087	25001
T1	XFMR, TRIFILAR	85134
T2	XFMR, TRIFILAR	85134
T3	XFMR, TRIFILAR	85414-11
T4	XFMR, BIFILAR	85149
T5	XFMR, TRIFILAR	85134
T6	XFMR, TRIFILAR	85134
T7	DIRECTIONAL COUPLER	21191
T8	XFMR, BIFILAR	85149
FL1	FILTER PAIR 45.455 MHz	48226

ID.	Description	Part No.
L1	15μh	21126
L2	.33μh	21106
L3	.18μh	21103
L4	.68μh	21110
L5	.18μh	21103
L6	.22μh	21104
L7	.27μh	21105
L8	.33μh	21106
L9	.33μh	21106
L10	4.7μh	21120
L11	4.7μh	21120
L12	14 3/4 T	85419-1
L13	9 3/4 T	85419-2
L14	.22μh	21104
L15	.15μh	21102
L16	6.8μh	21122
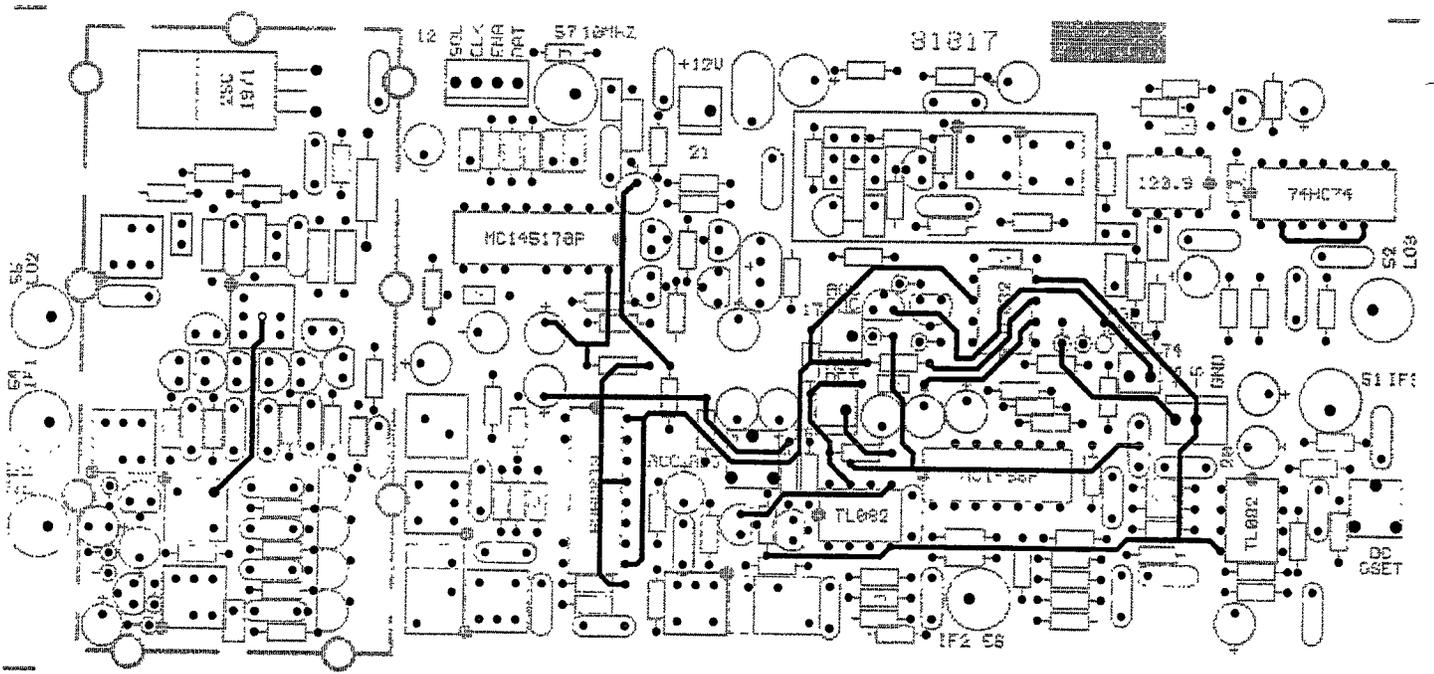
FIGURE 9-10. 81817 TOP CIRCUIT TRACE
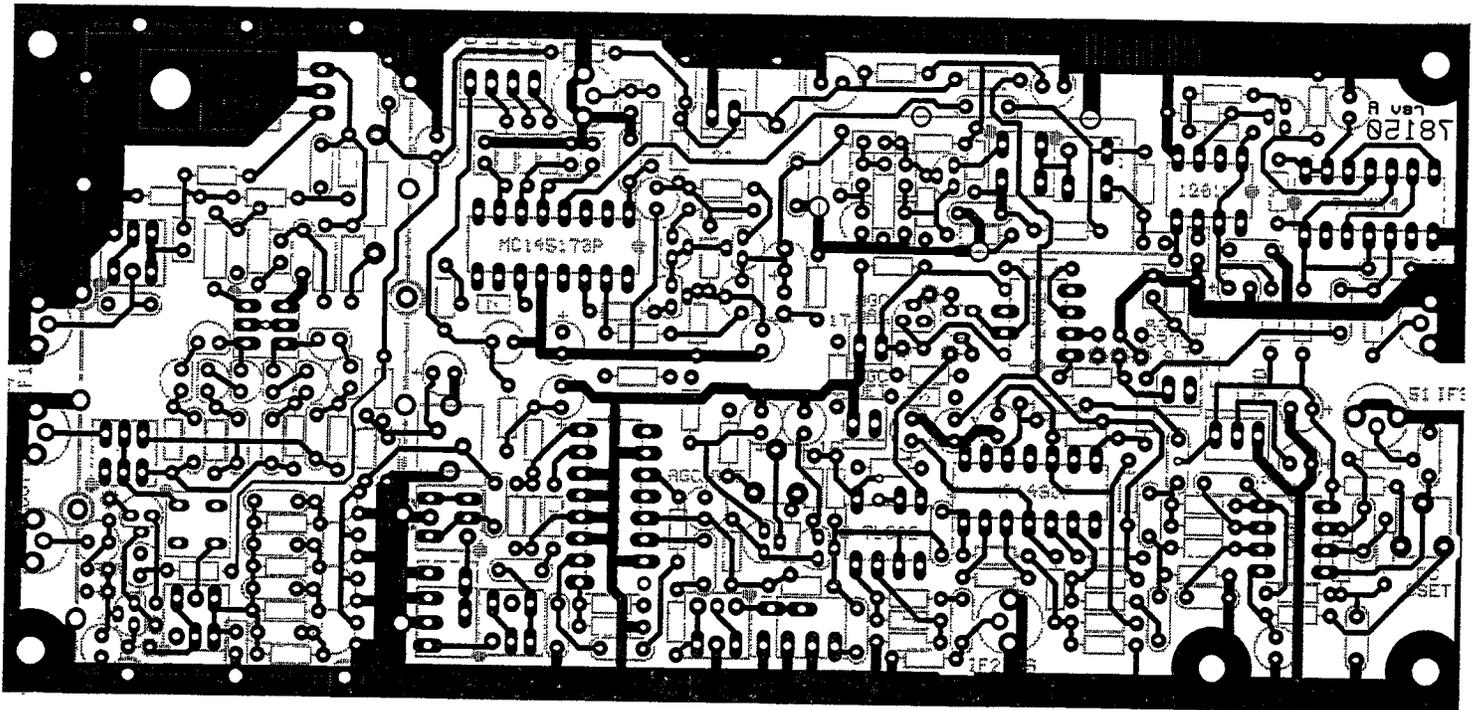
FIGURE 9-11. 81817 BOTTOM CIRCUIT TRACE
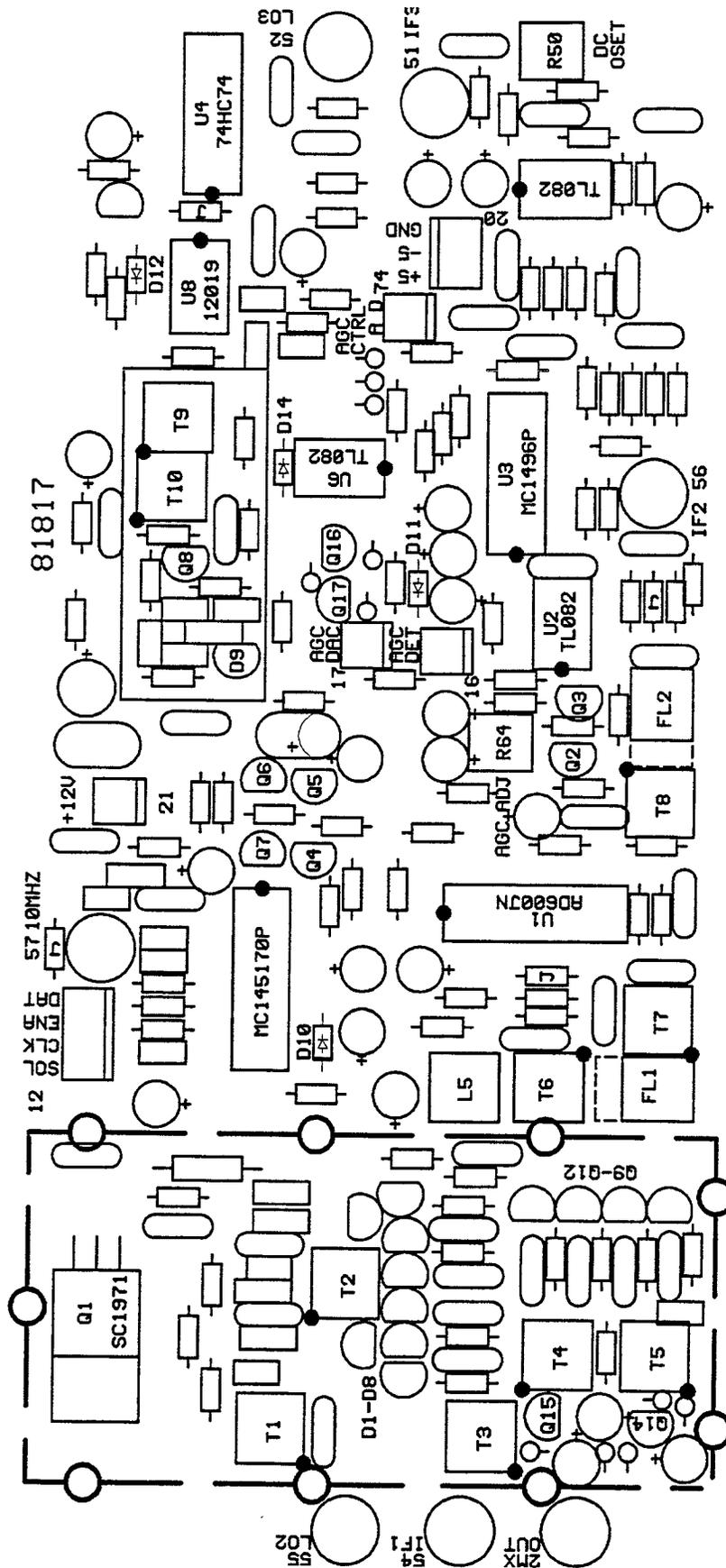
FIGURE 9-12. 81817 2nd MIXER / IF COMPONENT LAYOUT
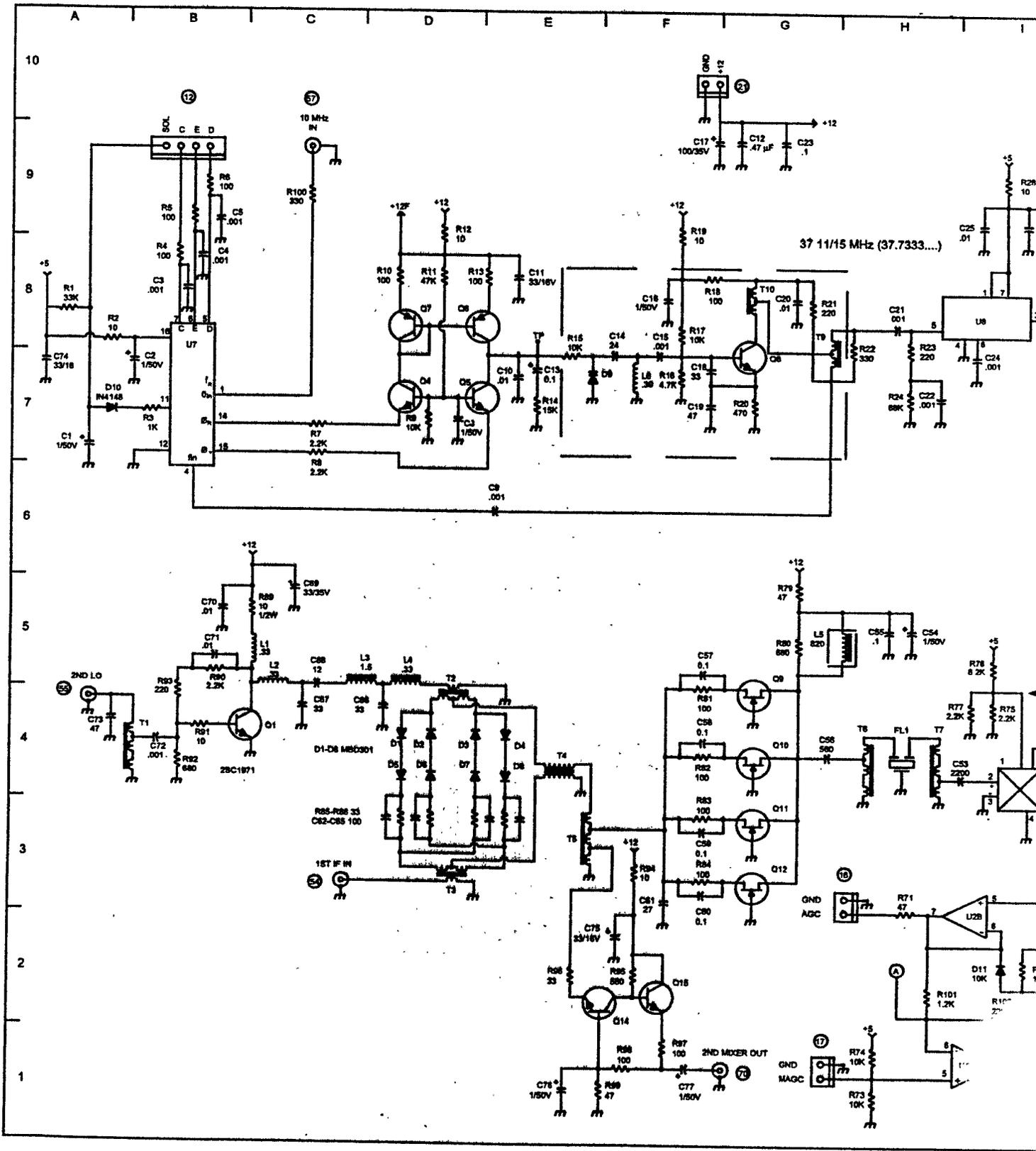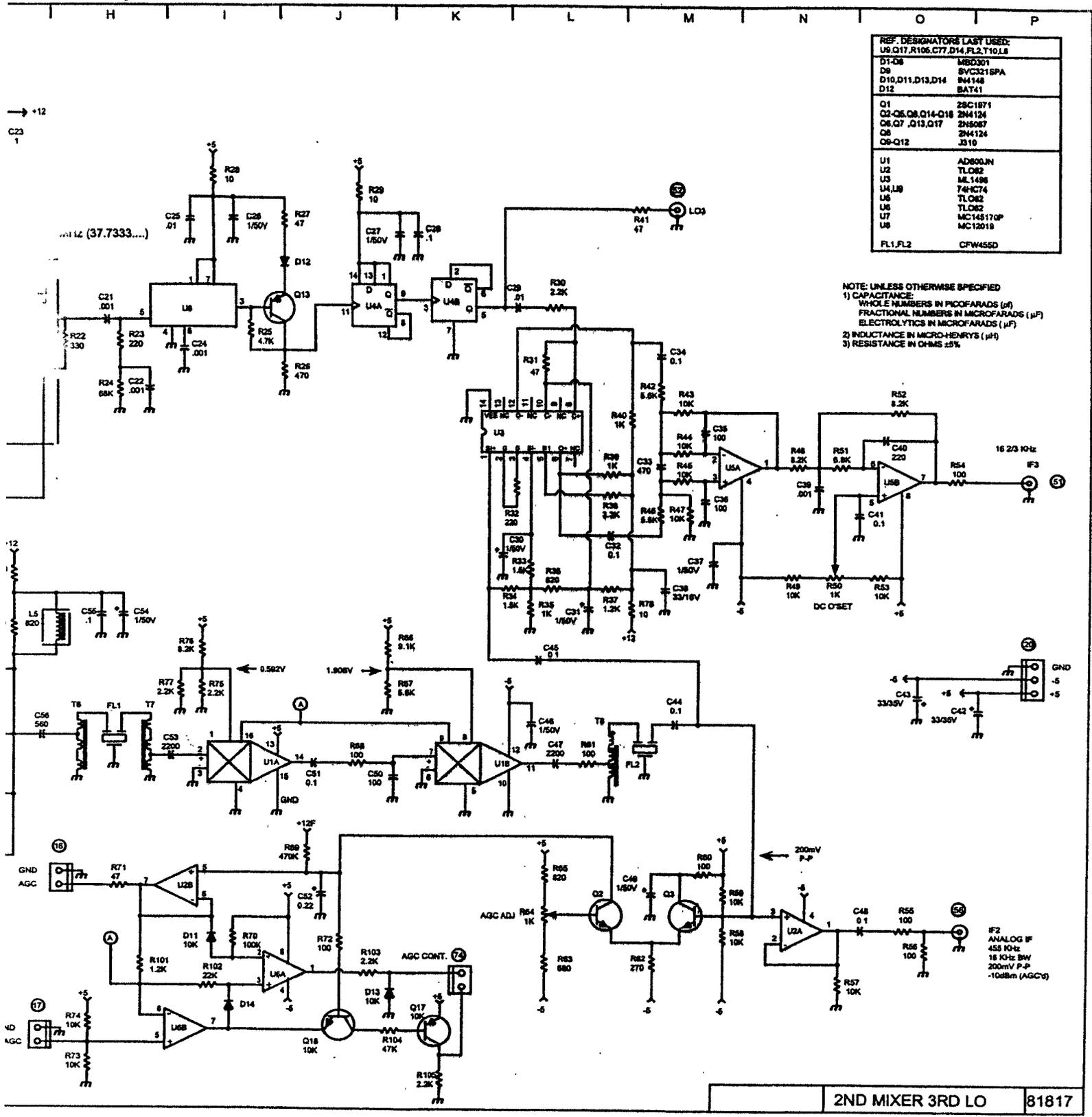
FIGURE 9-13. 81817 2nd MI

FIGURE 9-13. 81817 2nd MIXER / IF SCHEMATIC

2ND MIXER 3RD LO | 81817

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TABLE 9-3. 81817 3RD LO/2ND MIXER PARTS LIST

ID.	Description	Part No.
R1	33K	30299
R2	10	30314
R3	1K	30333
R4	100	30309
R5	100	30309
R6	100	30309
R7	2.2K	30293
R8	2.2K	30293
R9	10K	30296
R10	100	30309
R11	47K	30300
R12	10	30314
R13	100	30309
R14	15K	30297
R15	10K	30296
R16	4.7K	30305
R17	10K	30296
R18	100	30309
R19	10	30314
R20	470	30291
R21	220	30290
R22	330	30316
R23	220	30290
R24	68K	30303
R25	4.7K	30305
R26	470	30291
R27	47	30298
R28	10	30314
R29	10	30314
R30	2.2K	30293
R31	47	30289
R32	220	30290
R33	1.5K	30322
R34	1.5K	30322
R35	1K	30333
R36	820	30442
R37	1.2K	30623
R38	3.3k	30294
R39	1K	30333
R40	1K	30333
R41	47	30298
R42	5.6K	30295
R43	10K	30296

ID.	Description	Part No.
R44	10K	30296
R45	10K	30296
R46	5.6K	30295
R47	10K	30296
R48	8.2K	30402
R49	10K	30296
R50	1K VAR	30337
R51	6.8K	30332
R52	8.2K	30402
R53	10K	30296
R54	100	30309
R55	100	30309
R56	100	30309
R57	10K	30296
R58	10K	30296
R59	10K	30296
R60	100	30309
R61	100	30309
R62	270	30131
R63	680	30292
R64	1K	30333
R65	820	30442
R66	9.1K	30622
R67	5.6K	30295
R68	100	30309
R69	470K	30448
R70	100K	30301
R71	47	30289
R72	100	3039
R73	10K	30296
R74	10K	30296
R75	2.2K	30293
R76	8.2K	30402
R77	2.2K	30293
R78	10	30314
R79	47	30289
R80	680	30292
R81	100	30309
R82	100	30309
R83	100	30309
R84	100	30309
R85	33	30434
R86	33	30434

TABLE 9-3. 81817 3RD L0/ 2ND MIXER PARTS LIST (continued)

ID.	Description	Part No.
R87	33	30434
R88	33	30434
R89	10½W	30022
R90	2.2K	30293
R91	10	30314
R92	680	30292
R93	220	30290
R94	10	30314
R95	560	30439
R96	33	30438
R97	100	30318
R98	100	30318
R99	47	30238
R100	330	30316
R101	1.2K	30623
R102	22K	30298
R103	2.2K	30293
R104	47K	30256
R105	2.2K	30246
C1	1/50V	23264
C2	1/50V	23254
C3	.001	23245
C4	.001	23245
C5	.001	23245
C6	NOT USED	
C7	NOT USED	
C8	1/50V	23264
C9	.001	23282
C10	.01	23340
C11	33/16V	23308
C12	.47µF	23330
C13	0.1	23328
C14	24	23255
C15	.001	23245
C16	1/50V	23264
C17	100/35V	23189
C18	33	23246
C19	47	23257
C20	.01	23260
C21	.001	23245
C22	.001	23245
C23	.1	23261
C24	.001	23245

ID.	Description	Part No.
C25	.01	23260
C26	1/50V	23264
C27	1/50V	23264
C28	.1	23361
C29	.01	23260
C30	1/50V	23264
C31	1/50V	23264
C32	0.1	23261
C33	470	23400
C34	0.1	23261
C35	100	23385
C36	100	23385
C37	1/50V	23264
C38	33/16V	23308
C39	.001	23282
C40	220	23396
C41	0.1	23261
C42	33/16V	23308
C43	33/16V	23308
C44	0.1	23261
C45	0.1	23261
C46	1/50V	23264
C47	2200	23286
C48	0.1	23261
C49	1/50V	23264
C50	100	23385
C51	0.1	23261
C52	0.22	23262
C53	220	23286
C54	1/50V	23264
C55	.1	23261
C56	560	23401
C57	0.1	23261
C58	0.1	23261
C59	0.1	23261
C60	0.1	23261
C61	27	23303
C62	100	23385
C63	100	23385
C64	100	23385
C65	100	23385
C66	33	23376
C67	33	23376

TABLE 9-3. 81817 3RD LO / 2ND MIXER PARTS LIST (continued)

ID.	Description	Part No.
C68	12	23370
C69	33/16V	23308
C70	.01	23260
C71	.01	23260
C72	.001	23245
C73	47	23378
C74	33/16V	23308
C75	33/16V	23308
C76	1/50V	23264
C77	1/50V	23264
D1	MBD301	28110
D2	MBD301	28110
D3	MBD301	28110
D4	MBD301	28110
D5	MBD301	28110
D6	MBD301	28110
D7	MBD301	28110
D8	MBD301	28110
D9	SVC321SPA	28099
D10	IN4148	28001
D11	IN4148	28001
D12	BAT41	28071
D13	IN4148	28001
D14	IN4148	28001
L1	.33	21106
L2	.33	21106
L3	1.5	21114
L4	.33	21106
L5	820	21095
L6	.39	21107
T1	TRIFILAR	21153
T2	TRIFILAR	21153
T3	TRIFILAR	21153

ID.	Description	Part No.
T4	COIL	85413-03
T5	TRIFILAR	21153
T6	TOROID	85413-12
T7	TOROID	85413-12
T8	TOROID	85413-12
T9	BIFILAR	21152
T10	BIFILAR	21152
Q1	2SC1971	25337
Q2	MPS6514	25054
Q3	MPS25054	25054
Q4	MPS25054	25054
Q5	MPS6514	25054
Q6	2N5087	25001
Q7	2N5087	25001
Q8	MPS6514	25054
Q9	J310	25115
Q10	J310	25115
Q11	J310	25115
Q12	J310	25115
Q13	2N5087	25001
Q14	2N4124	25258
Q15	2N4124	25258
U1	AD600JN	25322
U2	TL082	25321
U3	ML1496	25047
U4	74HC74	25178
U5	TL082	25321
U6	TL082	25321
U7	MC145170P	25296
U8	MC12019	25354
U9	74HC74	25178
FL1	CFW455D	48203
FL2	CFW455D	48203
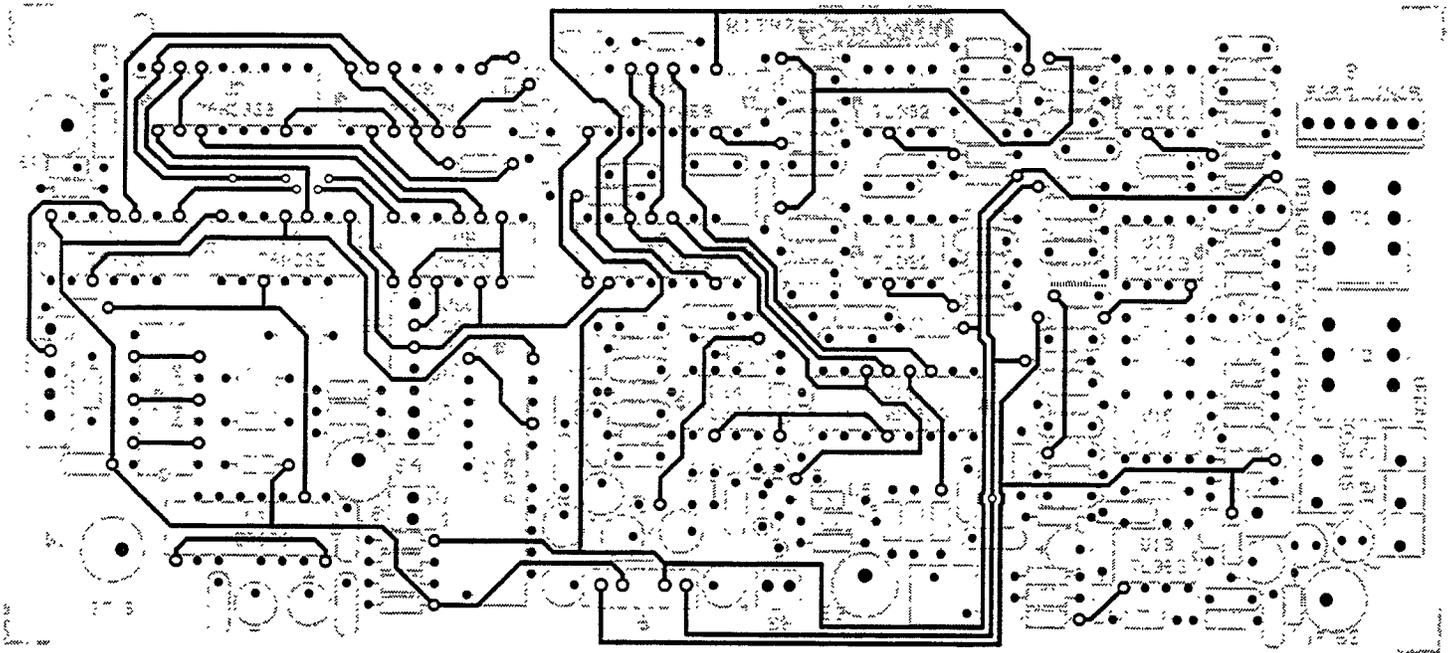
FIGURE 9-14. 81790 TOP CIRCUIT TRACE
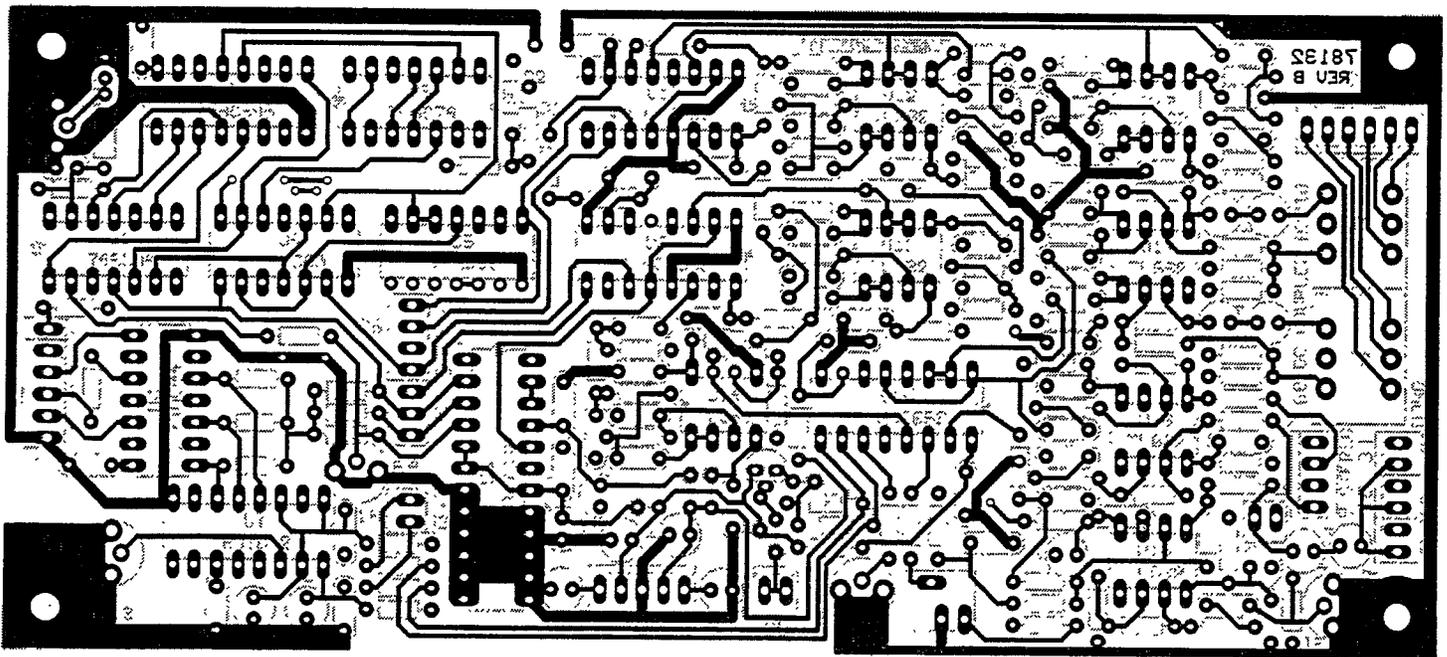
FIGURE 9-15. 81790 BOTTOM CIRCUIT TRACE
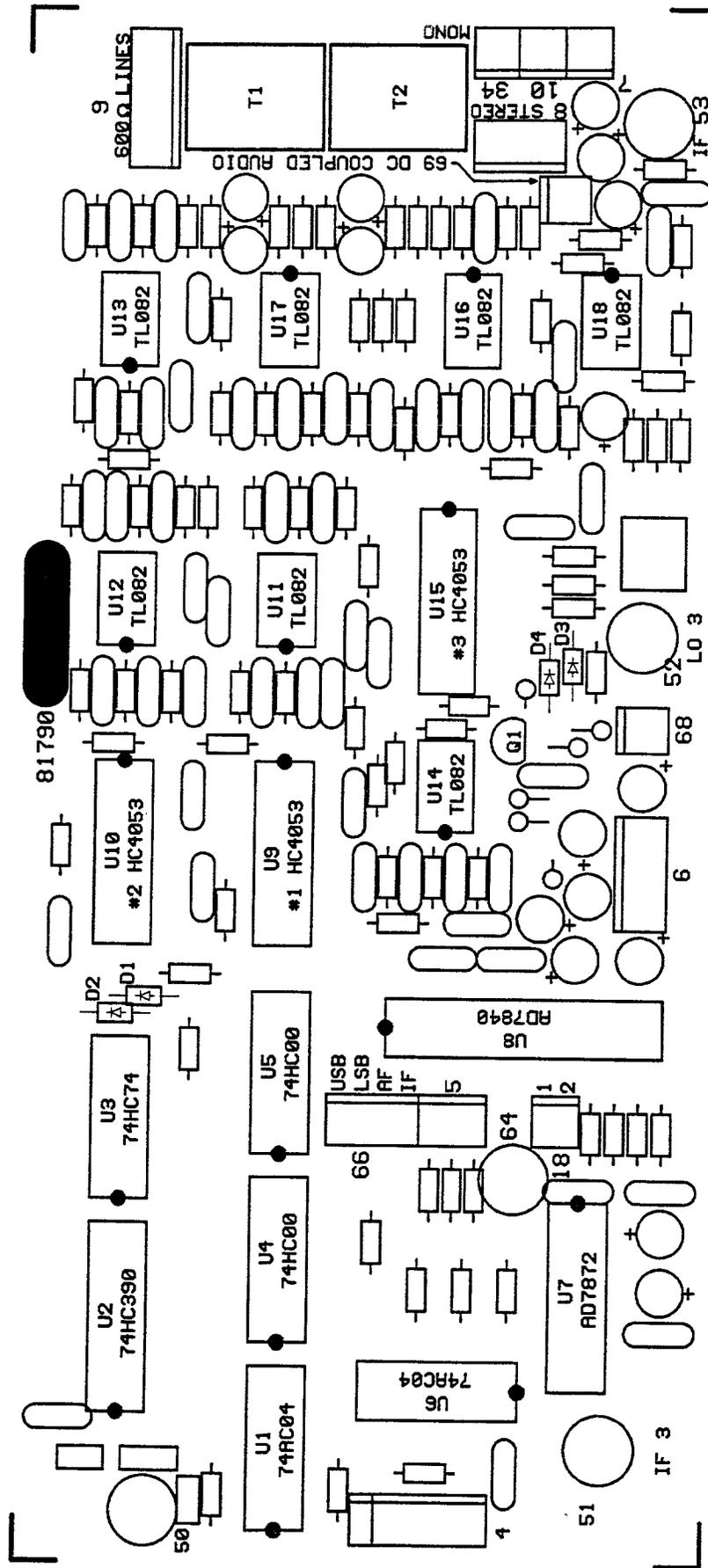
FIGURE 9-16. 81790 CONVERTER-I/O BOARD COMPONENT LAYOUT

9-27/9-28 BLANK

FIGURE 9-17. 81790 CONVERTI

NOTE: UNLESS OTHERWISE SPECIFIED
1) CAPACITANCE:
WHOLE NUMBERS IN PICOFARADS (pf)
FRACTIONAL NUMBERS IN MICROFARADS (µF)
ELECTROLYTICS IN MICROFARADS (µF)
2) INDUCTANCE IN MICRO-HENRYS (µH)
3) RESISTANCE IN OHMS ±5%

REFERENCE DESIGNATORS LAST USED: C71, R92, U18, T2, D4	
U1, U6	74AC04
U2	74HC390
U3	74HC74
U4, U5	74HC00
U7	AD7872
U8	AD7840
U9 U10 U15	74HC4053
U11-U14, U16, U17 U18	TL082
D1-D2	BAT 41
D3-D4	1N4148
Q1	2N5087

Figure 9-17. 81790 CONVERTER-I/O BOARD SCHEMATIC

INPUT/OUTPUT 81790

9-29/9-30 BLANK

TABLE 9-4. 81790 CONVERTER-I/O BOARD PARTS LIST

ID.	Description	Part No.	ID.	Description	Part No.
R1	330	30316	R46	82K	30446
R2	100K	30301	R47	2.2K	30293
R3	47	30289	R48	33K	30299
R4	4.7K	30305	R49	82K	30446
R5	47	30289	R50	2.2K	30293
R6	2.2K	30293	R51	68K	30303
R7	4.7K	30305	R52	68K	30303
R8	10	30314	R53	1K	30333
R9	10	30314	R54	47	30289
R10	2.2K	30293	R55	22K	30298
R11	150	30438	R56	10K	30296
R12	150	30438	R57	47	32089
R13	150	30438	R58	10K	30296
R14	3.3K	30294	R59	10K	30296
R15	22K	30298	R60	47	30289
R16	100K	30301	R61	10K	30296
R17	47	30289	R62	10K	30296
R18	3.3K	30294	R63	1K	30333
R19	150	30438	R64	1K	30333
R20	22K	30298	R65	100K	30301
R21	100K	30301	R66	1K	30333
R22	47	30289	R67	1K	30333
R23	100K	30301	R68	3.3K	30294
R24	470	30291	R69	22K	30298
R25	470	30291	R70	3.3K	30294
R26	470	30291	R71	47	30289
R27	47	30289	R72	10K	30296
R28	100K	30301	R73	47	30289
R29	47	30289	R74	10K	30296
R30	100K	30301	R75	10	30314
R31	10K	30296	R76	10	30314
R32	47	30289	R77	1.5K	30322
R33	10K	30296	R78	1.5K	30322
R34	10K	30296	R79	47	30289
R35	10K	30296	R80	3.3K	30294
R36	10K	30296	R81	3.3K	30294
R37	10K	30296	R82	2.2K	30293
R38	1K	30333	R83	4.7K	30305
R39	47	30289	R84	4.7K	30305
R40	47	30289	R85	47	30289
R41	1K	3033	R86	100	30309
R42	47	30289	R87	100	30309
R43	47	30289	R88	47	30238
R44	47	30289	R89	3.3K	30247
R45	33K	30299	R90	10K	30252

TABLE 9-4. 81790 CONVERTER-I/O BOARD PARTS LIST (continued)

ID.	Description	Part No.	ID.	Description	Part No.
R91	470K	30448	C44	.1	23261
R92	4.7K	30248	C45	750	23403
C1	NOT USED		C46	470	23400
C2	NOT USED		C47	.1	23261
C3	.1	23261	C48	.01	23340
C4	10μF	23266	C49	47	23378
C5	.1	23261	C50	.1	23261
C6	10μF	23266	C51	470	23400
C7	.1	23261	C53	.1	23261
C8	.01	23340	C54	470	23400
C9	.1	23261	C55	470	23400
C10	.1	23261	C56	0.1	23261
C11	10μF	23266	C57	1μF	23264
C12	.1	23261	C58	33	23308
C13	10μF	23266	C59	33	23308
C14	0.1	23328	C60	.1	23261
C15	0.1	23261	C61	0.1	23328
C16	1μF	23264	C62	.1	23261
C17	.1	23261	C63	0.1	23328
C18	10μF	23266	C64	0.1	23328
C19	10μF	23266	C65	.1	23261
C20	10μF	23266	C66	33	23308
C21	10μF	23266	C67	33	23308
C22	.1	23261	C68	0.1	23328
C23	100	23385	C69	.1	23261
C24	.001	23282	C70	33	23308
C25	:001	23282	C71	33	23308
C26	.01	23340	D1	BAT41	28071
C27	.1	23261	D2	BAT41	28071
C28	.1	23261	D3	1N4148	28001
C29	.1	23261	D4	1N4148	28001
C30	.1	23261	T1	CT-600CT	21185
C31	.001	23282	T2	CT-600CT	21185
C32	1500	23284	U1	74AC04	25340
C33	.01	23340	U2	74HC390	25347
C34	470	23400	U3	74HC74	25178
C35	470	23400	U4	74HC00	25161
C36	.1	23261	U5	74HC00	25161
C37	.1	23261	U6	74AC04	25340
C38	470	23400	U7	AD7872	25348
C39	.1	23261	U8	AD7840	25349
C40	470	23400	U9	74HC4053	25350
C41	.01	23340	U10	74HC4053	25350
C42	1500	23284	U11	TL082	25321
C43	.001	23282	U12	TL082	25321

TABLE 9-4. 81790 CONVERTER-I/O BOARD PARTS LIST (continued)

| ID.	Description	Part No.
U13	TL082	25321
U14	TL082	25321
U15	74HC4053	25321
U16	TL082	25321
U17	TL082	25321
U18	TL082	25321
Q1	2N5087	25001
FL1	CFU455D2	48198
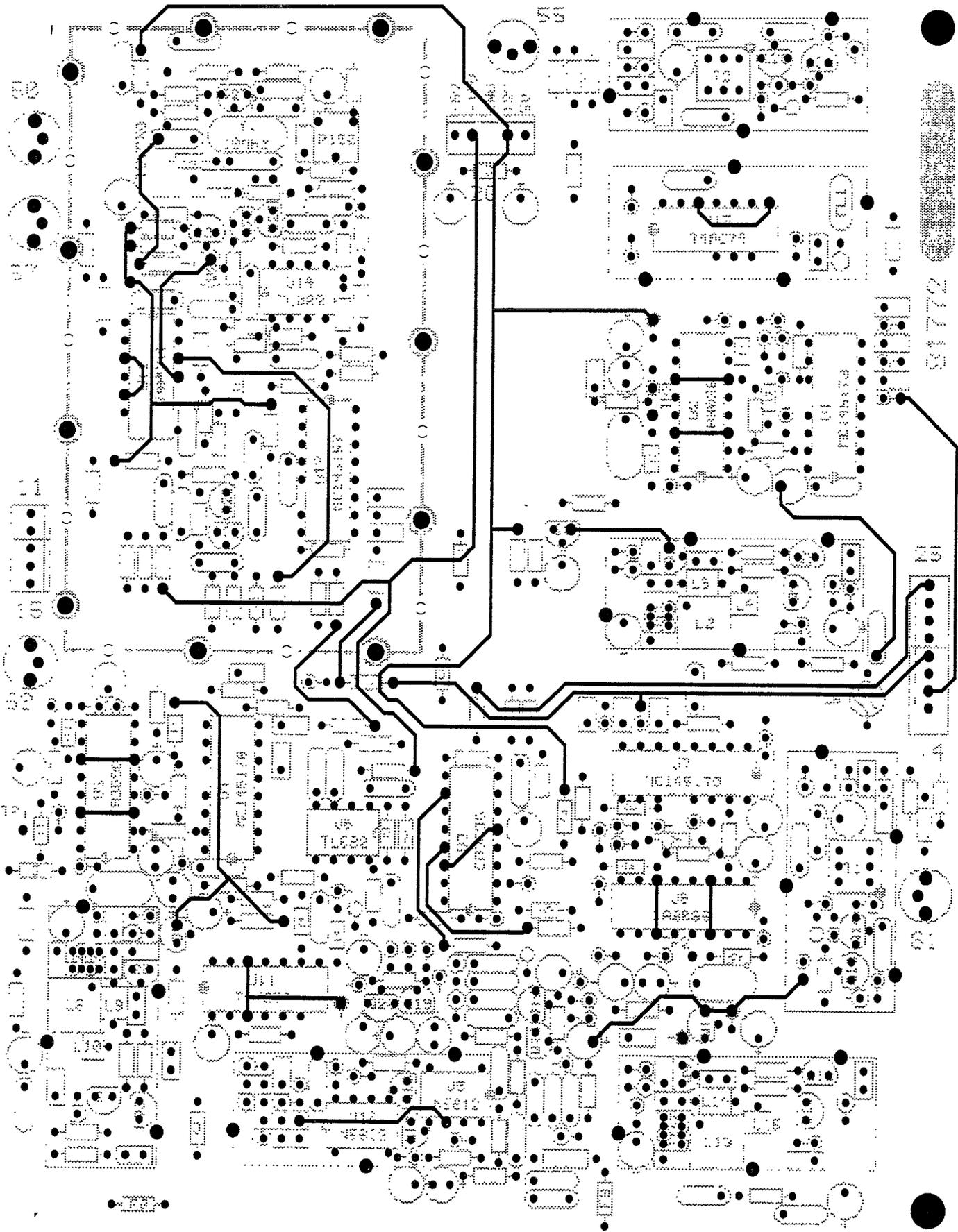
**FIGURE 9-18. 81772 SYNTHESIZER TOP CIRCUIT TRACE**
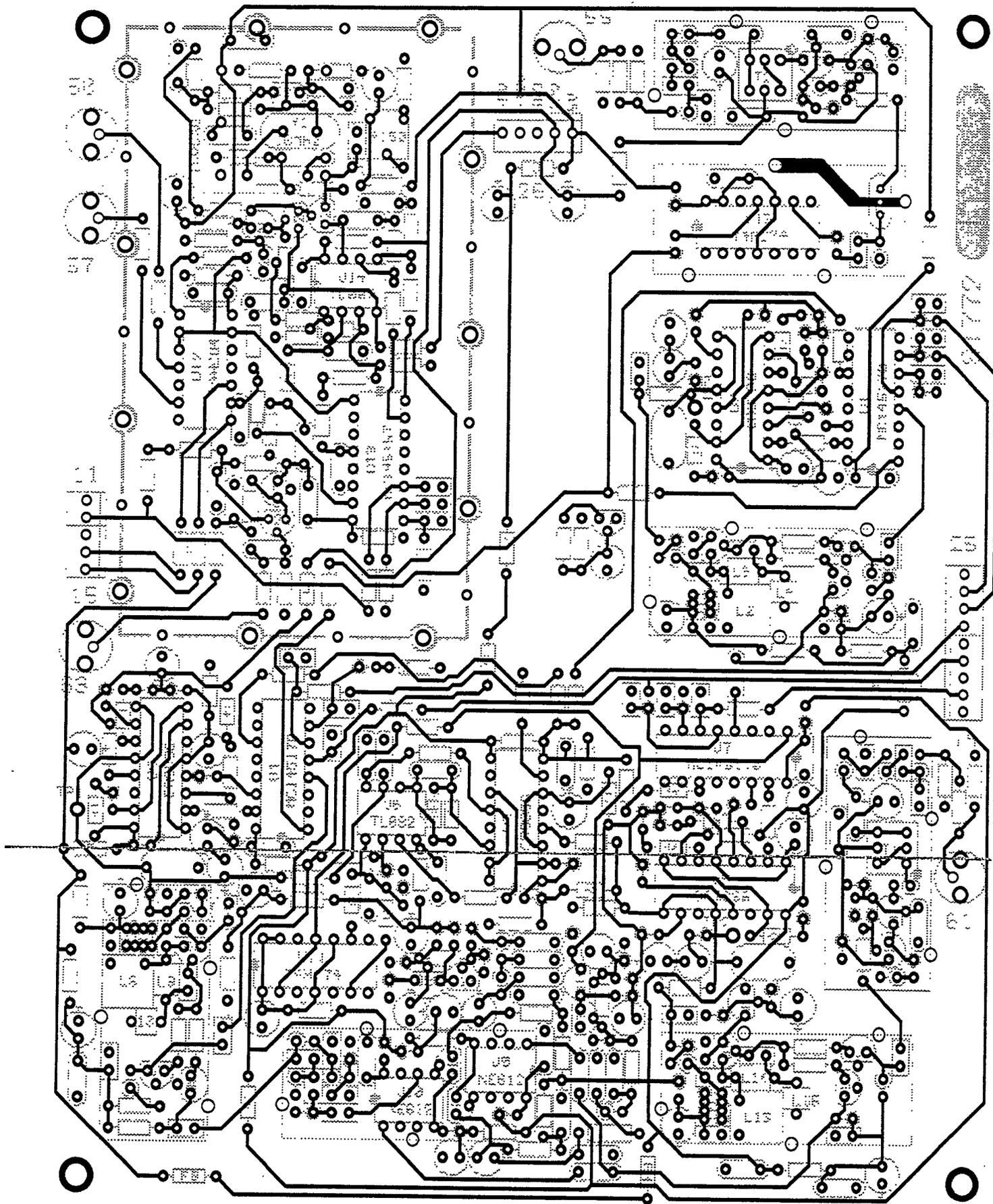
FIGURE 9-19. 81772 SYNTHESIZER BOTTOM CIRCUIT TRACE

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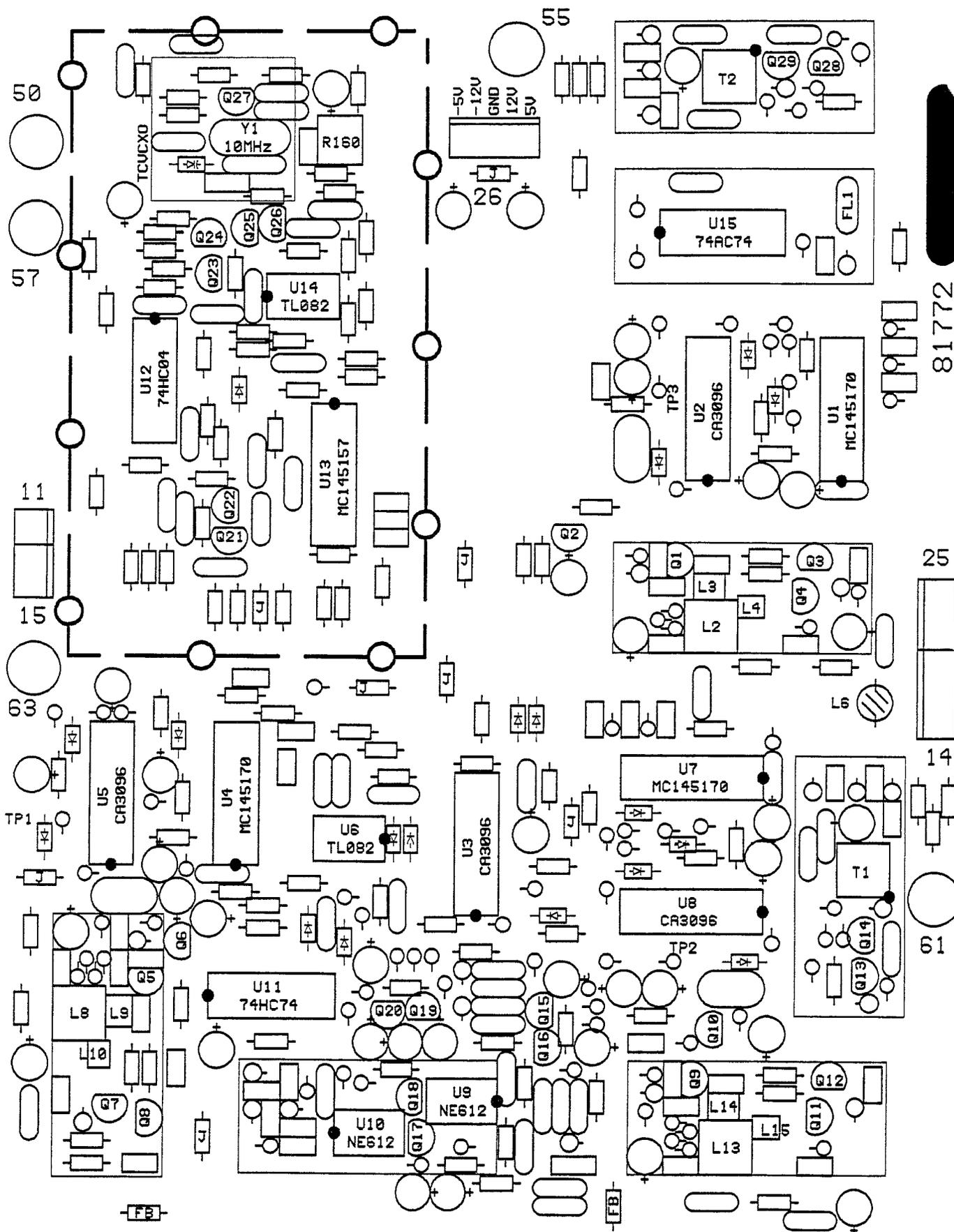
**FIGURE 9-20. 81772 SYNTHESIZER COMPONENT LAYOUT**

FIGURE 9-21 81772 SYNTHES

FIGURE 9-21 81772 SYNTHESIZER SCHEMATIC

SYNTHESIZER   81772

9-37/9-38 BLANK

TABLE 9-5. 81772 SYNTHESIZER PARTS LIST

ID.	Description	Part No.	ID.	Description	Part No.
R1	47	30238	R44	100	30309
R2	47	30238	R45	220	30240
R3	47	30238	R46	100	30318
R4	10	30314	R47	680	30243
R5	1K	30333	R48	100	30309
R6	330	30316	R49	47	30289
R7	47K	30256	R50	47	30289
R8	470	30242	R51	100	30309
R9	100	30309	R52	1K	30244
R10	10K	30252	R53	1K	30244
R11	220	30240	R54	100K	30301
R12	220	30290	R55	82K	30446
R13	220	30240	R56	680K	30452
R14	100	30318	R57	330	30316
R15	220	30240	R58	330	30316
R16	100	30309	R59	470	30291
R17	680	30243	R60	100	30309
R18	1K	30333	R61	47	30289
R19	1K	30244	R62	47	30238
R20	100K	30301	R63	47	30289
R21	82K	30446	R64	47	30238
R22	680K	30452	R65	10	30319
R23	330	30316	R66	1K	30333
R24	330	30316	R67	330	30241
R25	470	30242	R68	82	30427
R26	100	30318	R69	47K	30256
R27	47	30289	R70	10K	30252
R28	47	30289	R71	2.2K	30246
R29	47	30289	R72	1.2K	30623
R30	47	30238	R73	330	30241
R31	10	30314	R74	100	30318
R32	10K	30296	R75	220	30240
R33	1K	30333	R76	100	30309
R34	100	30309	R77	4.7	30624
R35	100K	30301	R78	2.2K	30293
R36	330	30316	R79	1K	30244
R37	47K	30256	R80	100K	30258
R38	470	30242	R81	82K	30445
R39	47	30238	R82	680K	30451
R40	10K	30296	R83	330	30316
R41	220	30240	R84	330	30316
R42	220	30290	R85	150	30240
R43	220	30290	R86	100	30309

TABLE 9-5. 81772 SYTHESIZER PARTS LIST (continued)

ID.	Description	Part No.	ID.	Description	Part No.
R87	22	30433	R130	47	30289
R88	470	30242	R131	47	30289
R89	220	30240	R132	47	30289
R90	1.5K	30245	R133	2.2K	30293
R91	1.2K	30623	R134	10	30314
R92	10	30319	R135	680	30292
R93	470	30291	R136	47	30289
R94	10	30314	R137	1K	30333
R95	470	30291	R138	680	30292
R96	220	30240	R139	2.2K	30293
R97	1.5K	30245	R140	4.7K	30305
R98	1.5K	30245	R141	100K	30301
R99	220	30240	R142	10M	30321
R100	1K	30333	R143	100K	30301
R101	220K	30260	R144	2.2M	30625
R102	22	30433	R145	100K	30301
R103	4.7K	30305	R146	22K	30298
R104	3.3K	30294	R147	1M	30360
R105	470	30291	R148	10	30314
R106	10	30319	R149	68K	30303
R107	100	30318	R150	68K	30303
R108	220	30240	R151	10K	30296
R109	220	30240	R152	1.5M	30626
R110	100	30318	R153	1.5M	30626
R111	10	30314	R154	10	30314
R112	470	30242	R155	22K	30298
R113	4.7K	30305	R156	1K	30333
R114	3.3K	30294	R157	22K	30298
R115	22	30432	R158	100K	30301
R116	220K	30260	R159	10K	30296
R117	1K	30333	R160	10K VAR.	30619
R118	220	30240	R161	2.2K	30293
R119	1.5K	30245	R162	2.2K	30293
R120	220	30240	R163	10K	30296
R121	1.5K	30245	R164	10	30314
R122	10	30314	R165	10K	30296
R123	10K	30252	R166	4.7K	30305
R124	10K	30296	R167	560	30440
R125	10K	30252	R168	470	30291
R126	47	30289	R169	680	30292
R127	2.2K	30293	R170	100K	30301
R128	10K	30252	R171	4.7	30624
R129	47	30289	R172	330	30316

TABLE 9-5. 81772 SYNTHESIZER PARTS LIST (continued)

ID	Description	Part No.
R173	330	30316
R174	680	30243
R175	4.7	30624
R176	10	30319
R177	22	30433
R178	27	30119
R179	220	30240
R180	10	30314
R181	1.2K	30623
R182	1.5K	30245
R183	150	30438
R184	47	30289
R185	150	30438
R186	680	30292
R187	1K	30333
C1	.001	23245
C2	.001	23245
C3	.001	23245
C4	.01	23260
C5	.01	23260
C6	1/50	23264
C7	3.3/50	23265
C8	3.3/50	23265
C9	.15	23343
C10	.001	23245
C11	4.7/50	23310
C12	.001	23245
C13	33/16	23308
C14	.001	23245
C15	.001	23245
C16	33/16	23308
C17	.1	23261
C18	.001	23245
C19	.001	23245
C20	.001	23245
C21	33/16	23308
C22	.01	23260
C23	.001	23245
C24	.001	23245
C25	.001	23245
C26	.01	23260
C27	4.7/50	23310
C28	1/50	23264

ID	Description	Part No.
C29	3.3/50	23265
C30	3.3/50	23265
C31	.15	23343
C32	.01	23340
C33	.1	23261
C34	.1	23261
C35	.001	23245
C36	4.7/16	23310
C37	.001	23245
C38	33/16	23308
C39	.001	23245
C40	.001	23245
C41	33/16	23308
C42	33/16	23308
C43	33/16	23308
C44	.001	23245
C45	.001	23245
C46	.001	23245
C47	33/16	23308
C48	.01	23260
C49	.001	23245
C50	.001	23245
C51	.001	23245
C52	.001	23245
C53	.01	23260
C54	NOT USED	
C55	1/50	23264
C56	10/50	23266
C57	10/50	23266
C58	.47	23330
C59	.001	23245
C60	4.7/50	23310
C61	.001	23245
C62	33/16	23308
C63	.001	23245
C64	.001	23245
C65	33/16	23308
C66	.1	23261
C67	.001	23245
C68	.01	23260
C69	.01	23260
C70	33/50	23308
C71	.001	23245

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TABLE 9-5. 81772 SYNTHESIZER PARTS LIST (continued)

ID	Description	Part No.
C72	.01	23260
C73	.001	23245
C74	.01	23260
C75	.1	23261
C76	4.7/50	23310
C77	.01	23260
C78	33pF	23246
C79	15pF	23253
C80	33pF	23246
C81	33/16	23308
C82	33/16	23308
C83	120pF	23386
C84	180pF	23389
C85	120pF	23386
C86	1/50	23264
C87	.1	23261
C88	.001	23245
C89	3.3/50	23265
C90	.1	23261
C91	10pF	23251
C92	39pF	23304
C93	39pF	23304
C94	.001	23245
C95	.1	23261
C96	3.3/50	23265
C97	.1	23261
C98	1/50	23264
C99	120pF	23386
C100	180pF	23389
C101	120pF	23386
C102	33/16	23308
C103	33/16	23308
C104	4.7/50	23310
C105	.01	23340
C106	.1	23261
C107	.001	23245
C108	.001	23245
C109	.001	23245
C110	.01	23260
C111	.01	23260
C112	.01	23260

ID	Description	Part No.
C113	.1	23328
C114	.01	23260
C115	.01	23260
C116	.01	23260
C117	.01	23260
C118	.01	23260
C119	.1	23328
C120	.1	23328
C121	.01	23260
C122	10/50V	23266
C123	.001	23245
C124	18pF	23444
C125	.1	23261
C126	.01	23260
C127	100pF	23385
C128	100pF	23385
C129	.01	23260
C130	.01	23260
C131	.1	23261
C132	10pF	23251
C133	.1	23261
C134	4.7/50	23310
C135	.01	23260
C136	27pF	23303
C137	5pF	23249
C138	27pF	23303
C139	.01	23260
C140	33/16	23308
C141	33/16	23308
Q1	J310	25115
Q2	MPSA14	25253
Q3	2N5087	25001
Q4	2N5087	25001
Q5	J310	25115
Q6	MPSA14	25253
Q7	2N5087	25001
Q8	2N5087	25001
Q9	J310	25115
Q10	MPSA14	25253
Q11	2N5087	25001
Q12	2N5087	25001
Q13	MPS3866	25263
Q14	MPS3866	25263

TABLE 9-5. 81772 SYNTHESIZER PARTS LIST (continued)

ID	Description	Part No.
Q15	2N5087	25001
Q16	2N5087	25001
Q17	2N5087	25001
Q18	2N5087	25001
Q19	2N5087	25001
Q20	2N5087	25001
Q21	2N4124	25258
Q22	2N4124	25258
Q23	2N4124	25258
Q24	2N5087	25001
Q25	2N4124	25258
Q26	2N7000	25351
Q27	2N4124	25258
Q28	MPS3866	25263
Q29	MPS3866	25263
U1	MC145170P1	25296
U2	CA3096	25345
U3	CA3096	25345
U4	MC145170P1	25296
U5	CA3096	25345
U6	TL082	25321
U7	MC145170P1	25296
U8	CA3096	25345
U9	NE612	25319
U10	NE612	25319
U11	74HC74	25178
U12	74HC04	25399
U13	MC145157	25213
U14	TL082	25321
U15	74AC74	25346
D1	1N4148	28001
D2	1N4148	28001
D3	1N4148	28001
D4	1N4148	28001
D5	BB911	28123
D6	BB911	28123
D7	1N4148	28001
D8	1N4148	28001
D9	1N4148	28001
D10	1N4148	28001
D11	1N4148	28001
D12	1N4148	28001
D13	BB911	28123

ID	Description	Part No.
D14	BB911	28123
D15	1N4148	28001
D16	1N4148	28001
D17	1N4148	28001
D18	1N4148	28001
D19	BB911	28123
D20	BB911	28123
D21	1N4148	28001
D22	1N4148	28001
D23	1N4148	28001
D24	1N4148	28001
D25	1N4148	28001
D26	KV3902	28075
L1	47	21160
L2	10T	85419-3
L3	8T	85419-4
L4	4T	85419-5
L5	4.7	21120
L6	6 HOLE BEAD	21179
L7	47	21160
L8	15T	85419-6
L9	11T	85419-7
L10	5T	85419-8
L11	4.7	21120
L12	47	21160
L13	15T	85419-6
L14	11T	85419-7
L15	5T	85419-8
L16	4.7	21120
L17	2-BEADS	21027
L18	4.7	21120
L19	1.0	21113
L20	.18	21103
L21	.68	21110
L22	.18	21103
L23	18	21127
L24	18	21127
L25	.22	21104
L26	.22	21104
L27	.82	21111
L28	18	21127
L29	18	21127
L30	12	21125

TABLE 9-5. 81772 SYNTHESIZER PARTS LIST (continued)

ID	Description	Part No.
L31	1.2	21113
L32	4.7	21120
L33	.68	21110
L34	.39	21107
L35	2.7	21117
L36	.39	21107
L37	BEAD	21090
L38	BEAD	21090
T1	TRIFILAR	85134
T2	TRIFILAR	85134
FL1	FILTER 45 MHz	48202
Y1	10 MHz	48112
TCVCXO OPTION		48255
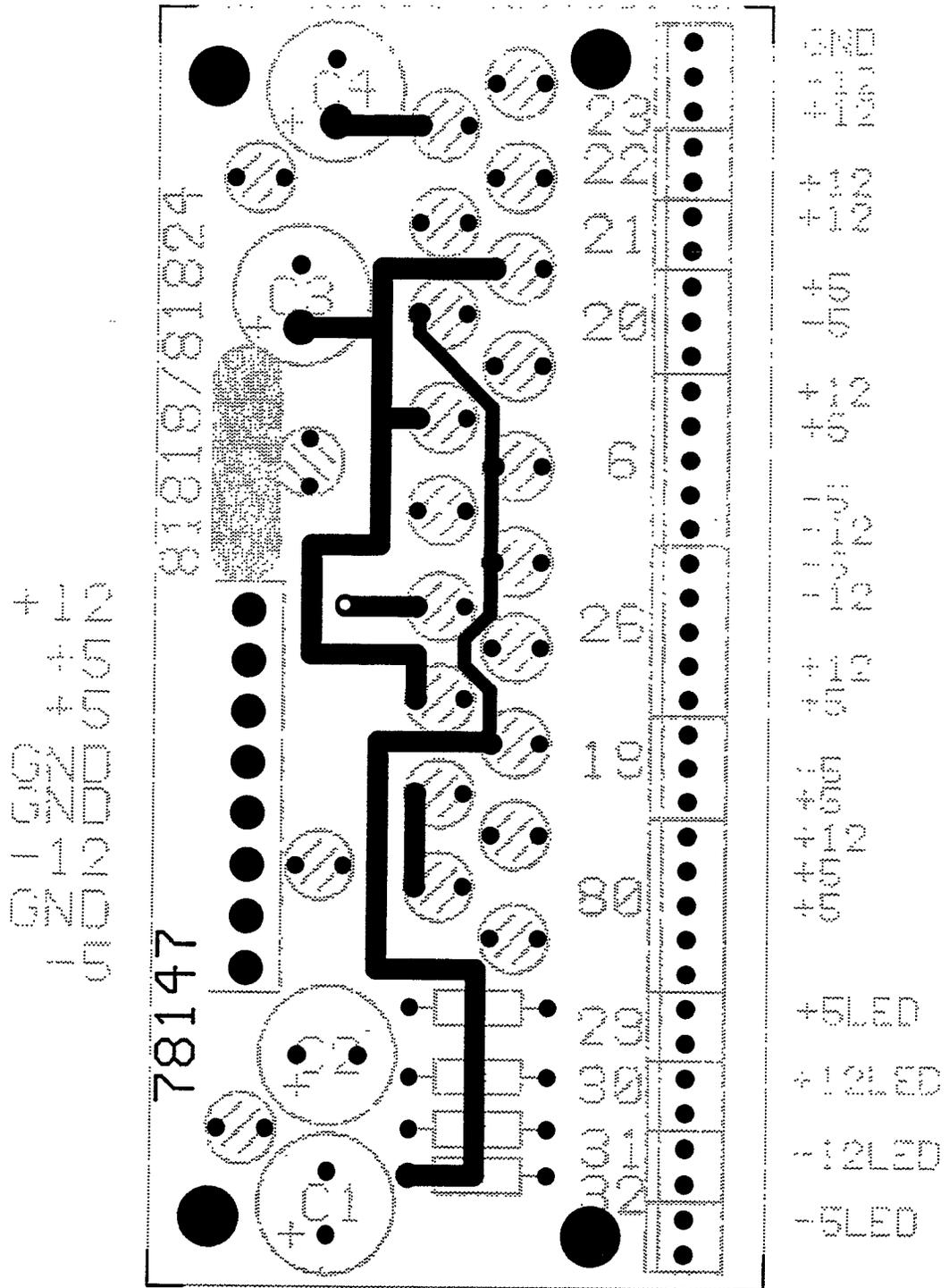
FIGURE 9-22. 81818 POWER SUPPLY FILTER TOP CIRCUIT TRACE
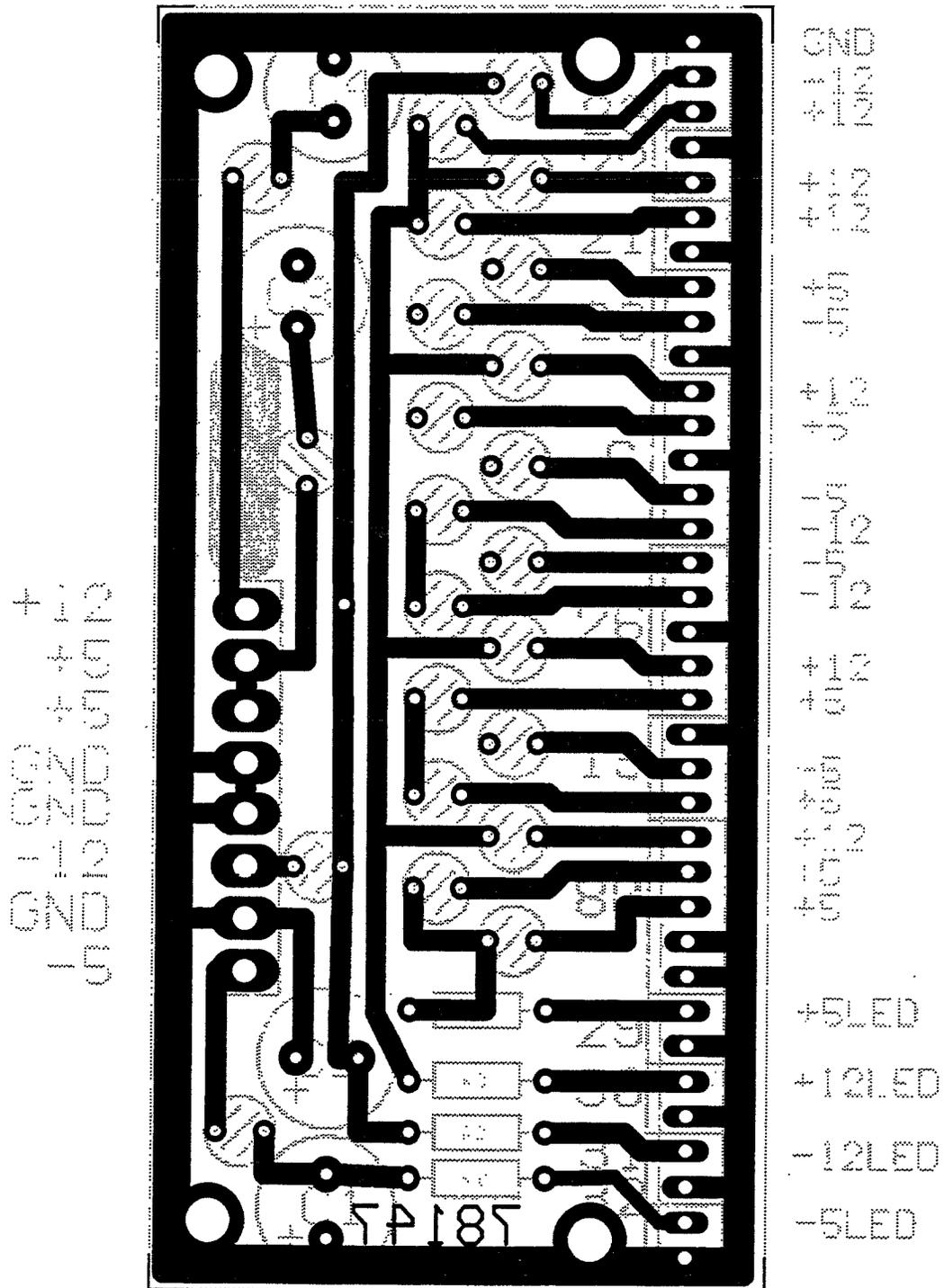
FIGURE 9-23. 81818 POWER SUPPLY FILTER BOTTOM CIRCUIT TRACE
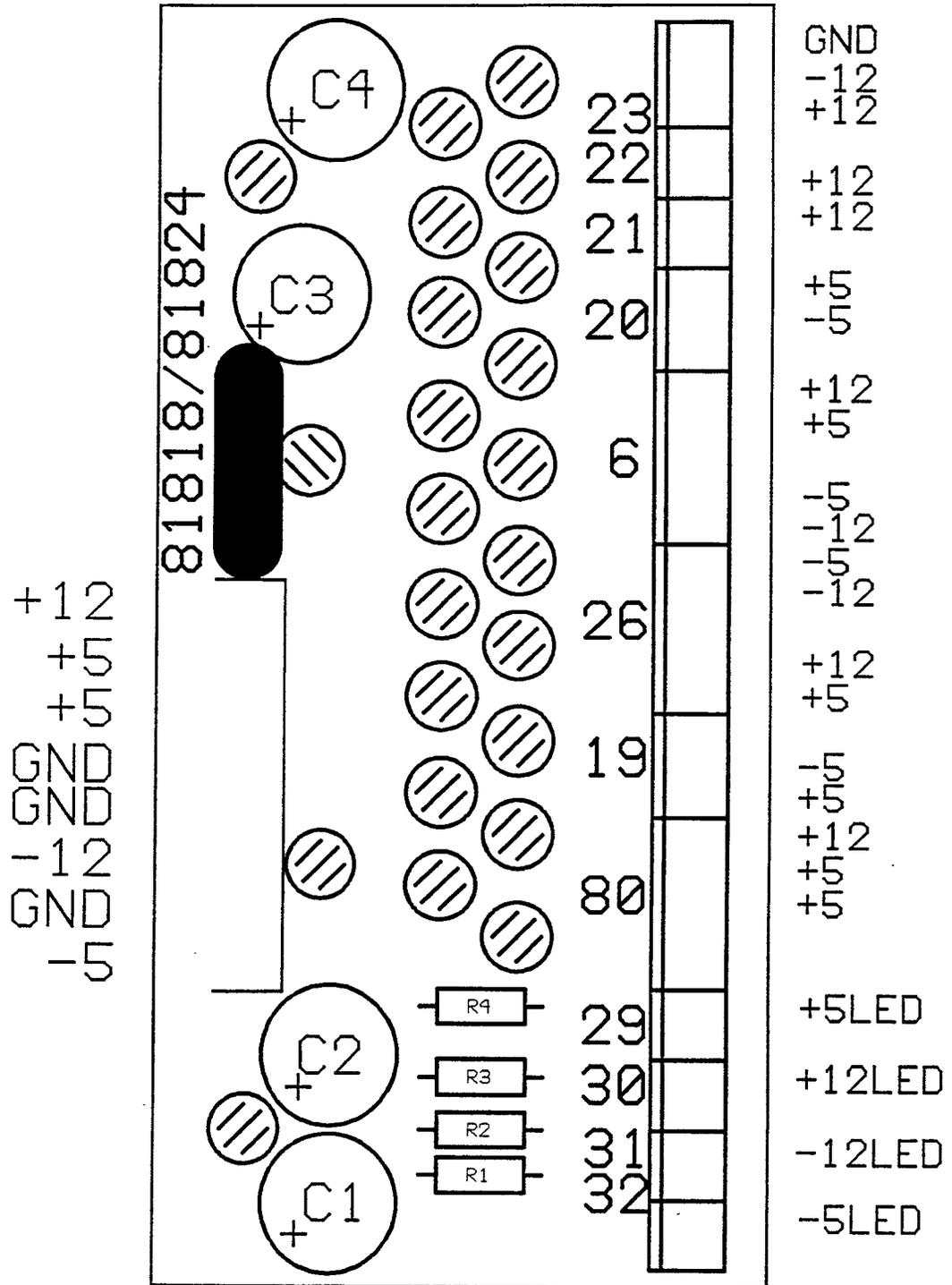
FIGURE 9-24. 81818 POWER SUPPLY FILTER COMPONENT LAYOUT

9-47
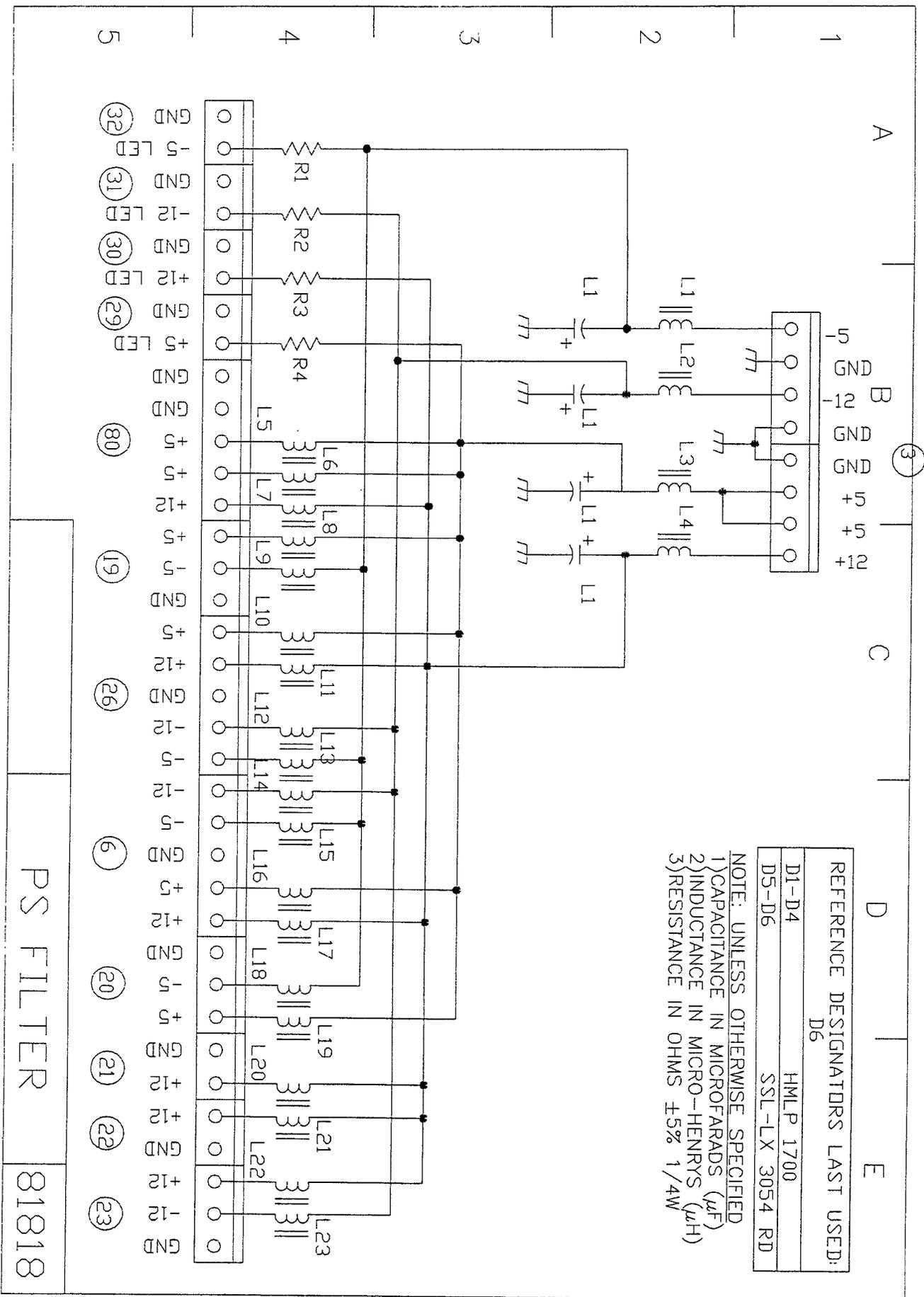
FIGURE 9-25. 81818 POWER SUPPLY FILTER SCHEMATIC

TABLE 9-6. 81818 POWER SUPPLY FILTER PARTS LIST

ID.	Description	Part No.
R1	470	30134
R2	1.2 K	30139
R3	1.2 K	30139
R4	470	30134
C1	470/16V	23228
C2	470/16V	23228
C3	470/16V	23228
C4	470/16V	23228
L1	CHOKE	21179
L2	CHOKE	21179
L3	CHOKE	21179
L4	CHOKE	21179
L5	CHOKE	21179
L6	CHOKE	21179
L7	CHOKE	21179
L8	CHOKE	21179
L9	(NOT USED)	
L10	CHOKE	21179
L11	CHOKE	21179
L12	CHOKE	21179
L13	CHOKE	21179
L14	CHOKE	21179
L15	CHOKE	21179
L16	CHOKE	21179
L17	CHOKE	21179
L18	CHOKE	21179
L19	CHOKE	21179
L20	CHOKE	21179
L21	CHOKE	21179
L22	CHOKE	21179
L23	CHOKE	21179
U1	7805	25095
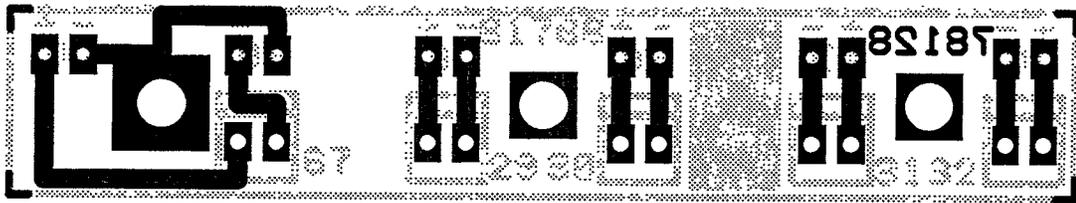
FIGURE 9-26. 81788 BOTTOM CIRCUIT TRACE *
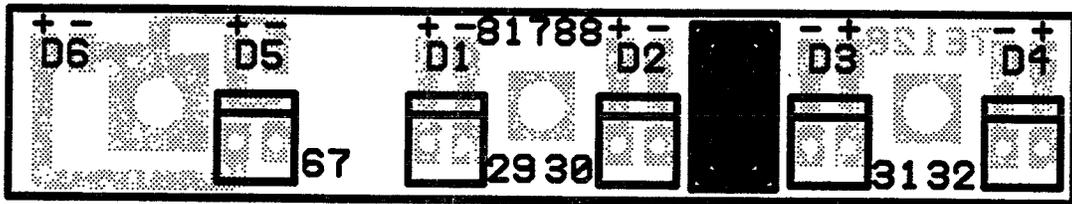
FIGURE 9-27. 81788 LED BOARD COMPONENT LAYOUT *

* Drawing is magnified twice the original size

9-50

REFERENCE DESIGNATORS LAST USED:
D6

D1-D4	HMLP 1700
D5-D6	SSL-LX 3054 RD

NOTE: UNLESS OTHERWISE SPECIFIED
1) CAPACITANCE IN MICROFARADS (μF)
2) INDUCTANCE IN MICRO-HENRYS (μH)
3) RESISTANCE IN OHMS ±5% 1/4W
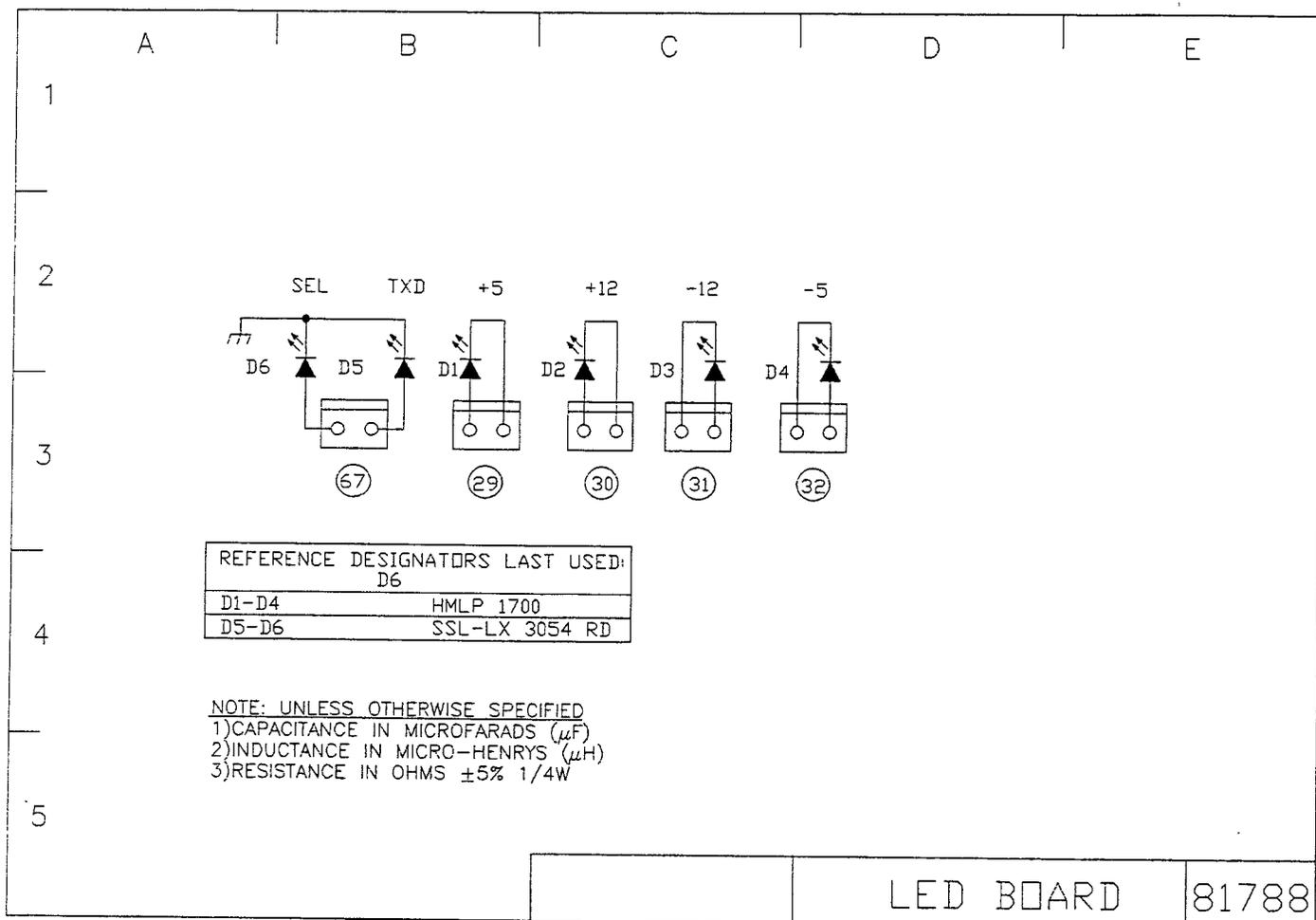
LED BOARD 81788

FIGURE 9-28. 81788 LED BOARD SCHEMATIC

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TABLE 9-7. 81788 LED BOARD PARTS LIST

ID.	Description	Part No.
D1	HMLP 1700	28066
D2	HMLP 1700	28066
D3	HMLP 1700	28066
D4	HMLP 1700	28066
D5	SSL-LX 3054RD	28024
D6	SSL-LX 3054RD	28024
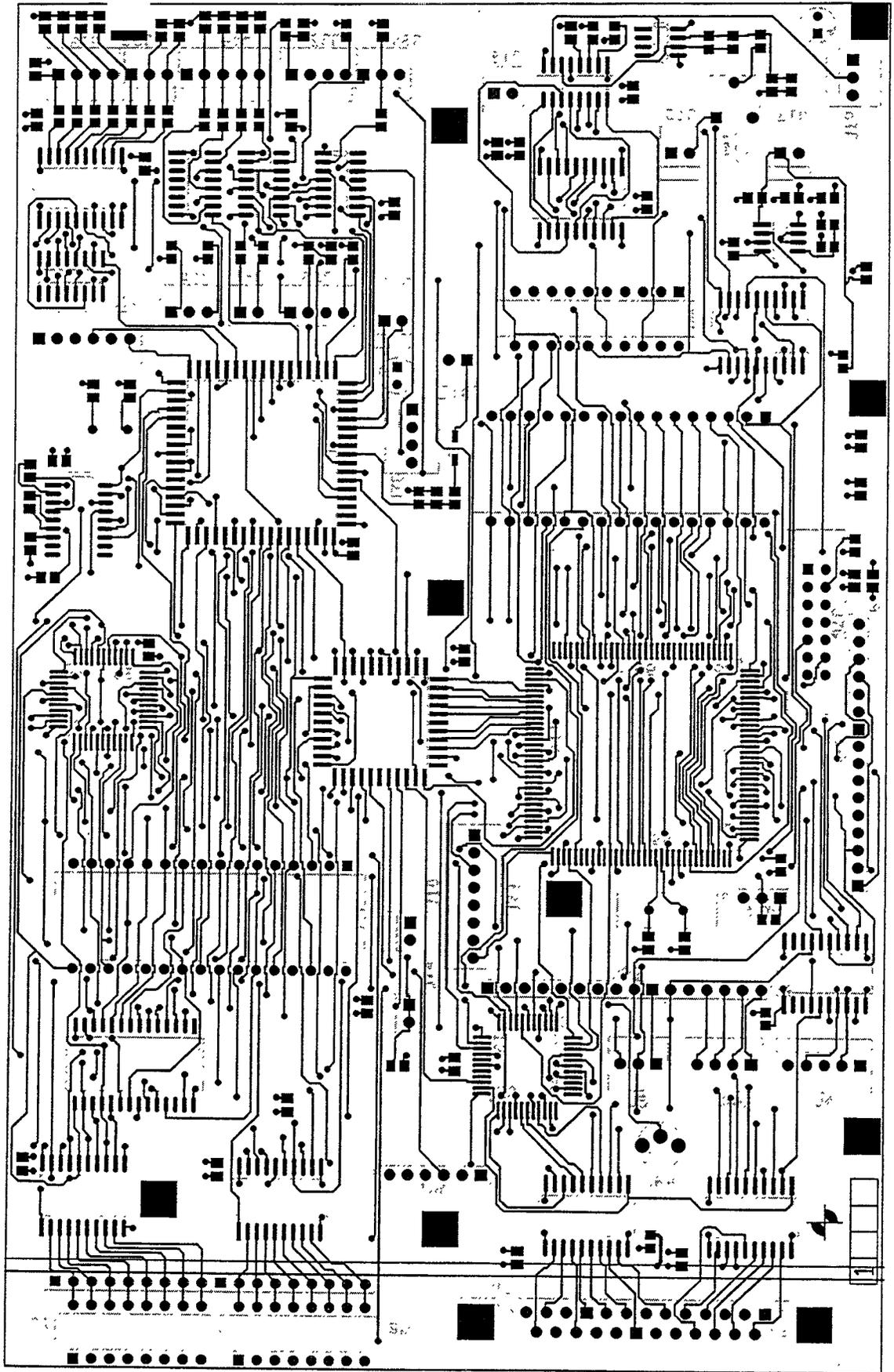
**FIGURE 9-29. 81821 DSP/CPU TOP CIRCUIT TRACE**

9-53

FIGURE 9-30. 81821 DSP/CPU BOTTOM CIRCUIT TRACE

FIGURE 9-31. 81821 DSP/CPU COMPONENT LAYOUT

FIGURE 9-32. 81821 DSP/CPU

Part No 74263
2nd Printing - 11/99
Printed in U S A
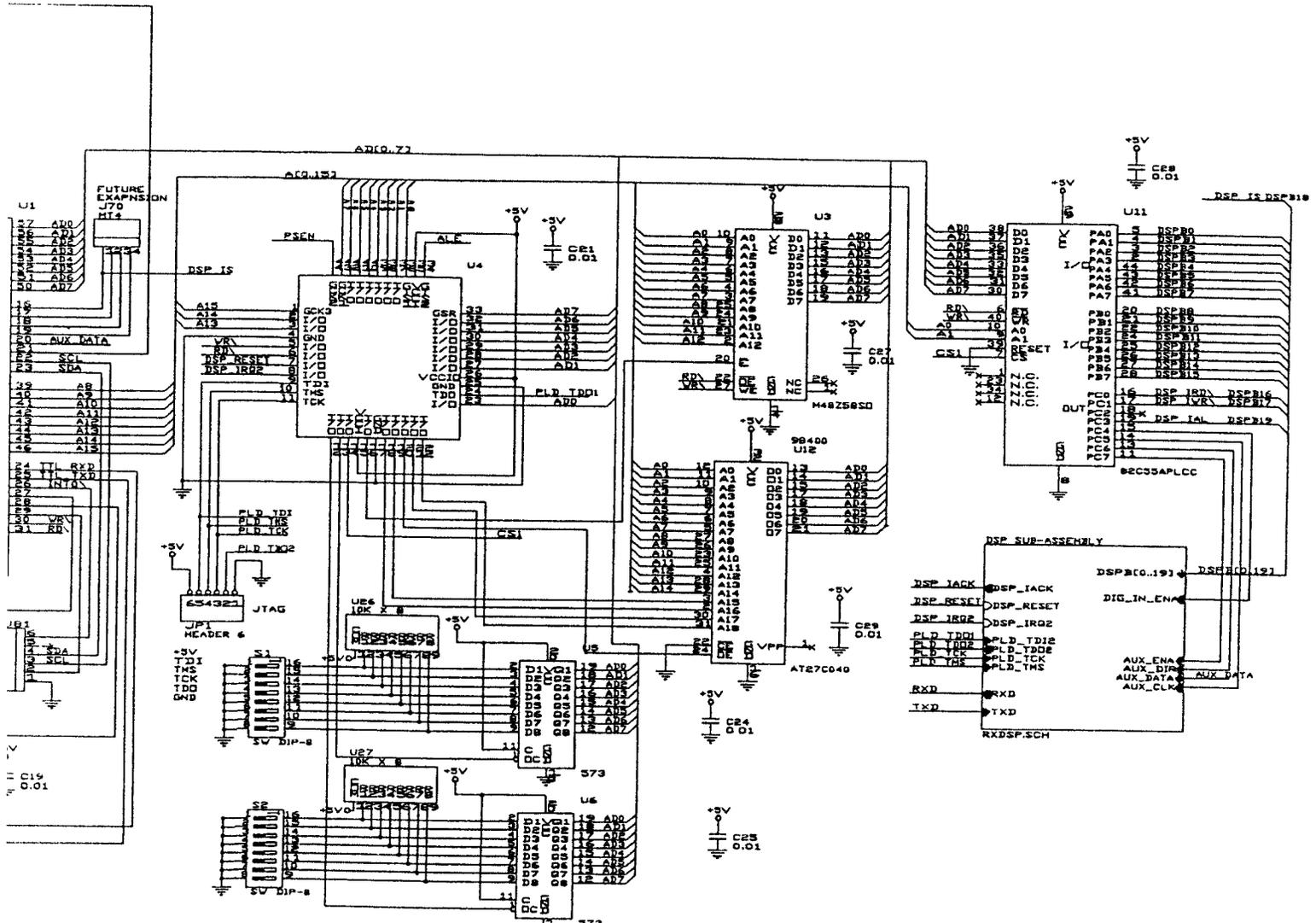
E 9-32. 81821 DSP/CPU SCHEMATIC

| pg 1 | DSP/CPU | 81821 |

9-57/9-58 BLANK
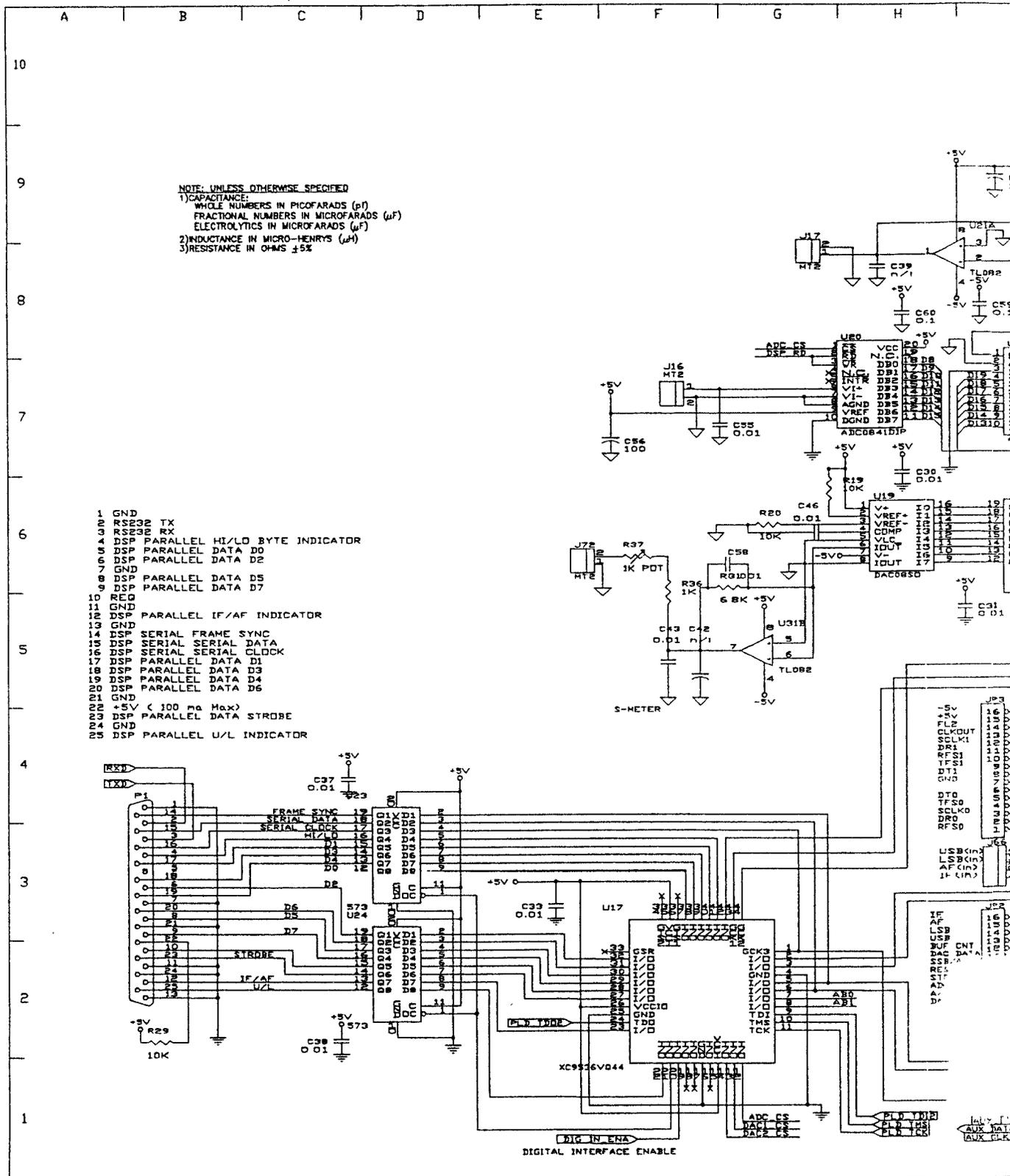
FIGURE 9-33.

FIGURE 9-33.

9-59/9-60 BLANK
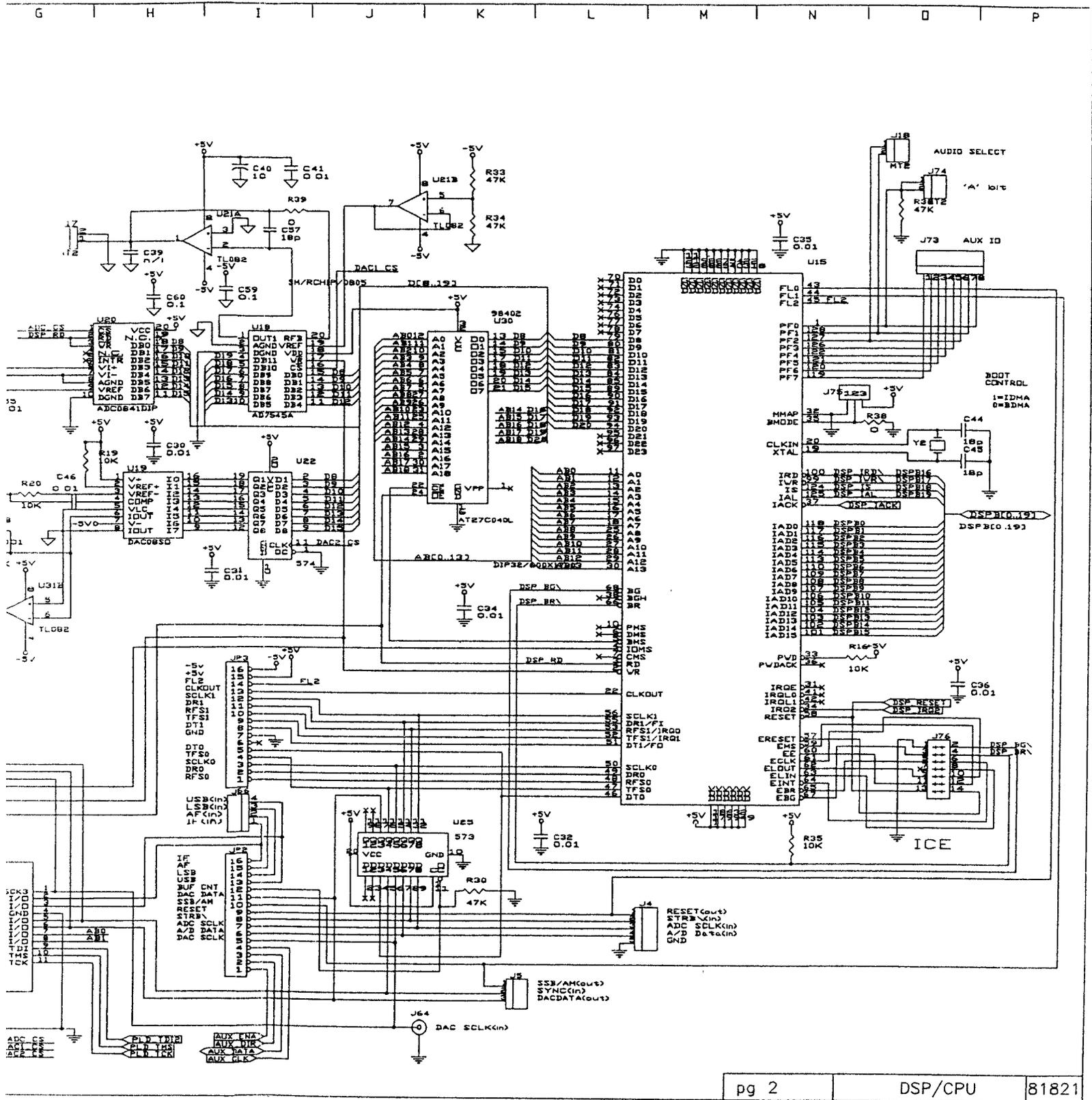
TABLE 9-8. 81821 DSP/CPU BOARD PARTS LIST

ID	Description	Part No.
C1	0.01μF	23487
C2	0.001μF	23486
C3	0.001μF	23486
C4	0.001μF	23486
C5	0.001μF	23486
C6	0.001μF	23486
C7	0.001μF	23486
C8	0.001μF	23486
C9	0.01μF	23487
C10	0.01μF	23487
C11	0.01μF	23487
C12	20pF	23465
C13	20pF	23465
C14	0.1μF	23488
C15	0.1μF	23488
C16	0.1μF	23488
C17	0.1μF	23488
C18	0.1μF	23488
C19	0.01μF	23487
C20	3.3uF	23265
C21	0.01μF	23487
C24	0.01μF	23487
C25	0.01μF	23487
C27	0.01μF	23487
C28	0.01μF	23487
C29	0.01μF	23487
C30	0.01μF	23487
C31	0.01μF	23487
C32	0.01μF	23487
C33	0.01μF	23487
C34	0.01μF	23487
C35	0.01μF	23487
C36	0.01μF	23487
C37	0.01μF	23487
C38	0.01μF	23487
C39	0.1μF	23488
C40	10uF	23266
C41	0.01μF	23487
C42	100	30650
C43	0.01μF	23487

ID	Description	Part No.
C44	20pF	23465
C45	20pF	23465
C46	0.01μF	23487
C47	0.001μF	23486
C48	0.001μF	23486
C49	0.001μF	23486
C50	0.001μF	23486
C51	0.001μF	23486
C52	0.001μF	23486
C53	0.001μF	23486
C54	0.01μF	23487
C55	0.01μF	23487
C56	100	30650
C57	20pF	23488
C58	0.001μF	23486
C59	0.1μF	23488
C60	0.1μF	23488
D1	1N4148	28124
R1	470	30658
R2	470	30658
R4	100	30650
R5	100	30650
R6	100	30650
R7	100	30650
R8	100	30650
R9	100	30650
R10	100	30650
R11	220K	30690
R12	1K	30662
R13	4.7K	30670
R14	10K	30674
R15	10K	30674
R16	10K	30674
R19	10K	30674
R20	10K	30674
R22	100	30650
R23	100	30650
R24	100	30650
R25	100	30650
R26	100	30650

TABLE 9-8. 81821 DSP/CPU BOARD PARTS LIST

ID	Description	Part No.
R27	100	30650
R28	100	30650
R29	10K	30674
R30	47K	30682
R31	6.8K	30672
R32	47K	30682
R33	47K	30682
R34	47K	30682
R35	10K	30674
R36	1K	30662
R37	1K POT	30618
R38	0	30629
R39	0	30629
R40	47K	30300
U1	80C552	25331
U2	MAX242	25415
U3	M48Z58SO	25401
U4	XC9536VQ44	25416
U5	573	25413
U6	573	25413
U7	74HC4050	25414
U8	74HC4050	25414

ID	Description	Part No.
U9	74HC4050	25414
U11	82C55APLCC	25417
U12	AT27C040	27065
U15	ADSP2181KS	25362
U17	XC9536VQ44	25416
U18	AD7545A	25424
U19	DAC08SO	25418
U20	ADC0841DIP	25332
U21	TL082	25406
U22	574	25404
U23	573	25413
U24	573	25413
U25	573	25413
U26	10K X 8	30404
U27	10K X 8	30404
U28	14094	25422
U29	573	25413
U30	AT27C040L	27065
U31	TL082	25406
Y1	22.1184 MHZ	48201
Y2	16.667 MHZ	48209

RECORD OF CHANGES

CHANGE NO.	DATE	TITLE OR BRIEF DESCRIPTION	ENTERED BY

WARNING

HIGH VOLTAGE

is used in the operation of this equipment.

DEATH ON CONTACT

may result if personnel fail to observe safety precautions.
Learn the areas containing high voltage within the equipment.
Be careful not to contact high voltage connections when installing,
operating or maintaining this equipment.
Before working inside the equipment, turn power off
and ground points of high potential before touching them.

Ten-Tec, Inc.
1185 Dolly Parton Parkway
Sevierville, TN 37862
Repair Service: (865) 428-0364

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

Ten-Tec, Inc., warrants this product to be free from defects in material and workmanship for a period of one (1) year from the date of purchase, under these conditions:

1. THIS WARRANTY APPLIES ONLY TO THE ORIGINAL OWNER. It is important that the warranty registration card be sent to us promptly.

2. READ THE MANUAL THOROUGHLY. This warranty does not cover damage resulting from improper operation. Developing a thorough understanding of this equipment is your responsibility.

3. IF TROUBLE DEVELOPS we recommend you contact our customer service group direct at the address or phone number shown above. It has been our experience that factory direct service is expeditious and usually results in less down-time on the equipment. Some overseas dealers do offer warranty service and, of course, have our complete support.

4. EQUIPMENT RETURNED TO THE FACTORY must be properly packaged, preferably in the original shipping carton(s). You pay the freight to us and we prepay surface freight back to you. Canadian customers must have proper customs documentation sent with incoming repair equipment. Duties or fees charged due to improper documenting are the responsibility of the owner of the equipment.

5. EXCLUSIONS. This warranty does not cover damage resulting from misuse, lightning, excess voltages, polarity errors or damage resulting from modifications not recommended or approved by Ten-Tec. In the event of transportation damage, a claim must be filed with the carrier. Under no circumstances is Ten-Tec liable for consequential damages to persons or property caused by the use of this equipment.

6. TEN-TEC RESERVES the right to make design changes without any obligation to modify equipment previously manufactured, or to notify owners of changes to existing equipment.

7. THIS WARRANTY is given in lieu of any other warranty, expressed or implied.

SERVICE OUTSIDE OF THE U.S.A. OR CANADA

Many of our international dealers provide warranty service on the equipment they sell. Many of them also provide out of warranty service on all equipment whether they sold it or not. If your dealer does not provide service or is not conveniently located, follow the procedure outlined above. Equipment returned to us will be given the same attention as domestic customers but roundtrip freight expense, customs and broker fees will be paid by you.

Part no. 74244