
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

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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.

TABLE OF CONTENTS

PARAGRAPH	PAGE
LIST OF ILLUSTRATIONS	iii
LIST OF TABLES	iv
INTRODUCTION.....	v
1. GENERAL INFORMATION	
1-1 PURPOSE AND FUNCTION	1-1
1-2 SPECIFICATIONS	1-1
1-3 ENVIRONMENTAL CONDITIONS	1-3
1-4 MECHANICAL	1-4
1-5 EQUIPMENT/PARTS SUPPLIED	1-4
2. PREPARATION FOR USE AND INSTALLATION	
2-1 UNPACKING AND INSPECTION	2-1
2-2 MOUNTING	2-1
2-3 POWER	2-1
2-4 ANTENNA	2-1
2-5 IF OUT	2-1
2-6 SIG MON	2-1
2-7 1ST MIXER OUT	2-1
2-8 2ND MIXER OUT	2-1
2-9 EXT REFERENCE	2-1
2-10 RS232	2-1
2-11 LINE A	2-1
2-12 LINE B	2-1
2-13 AUDIO	2-1
2-14 DC DOUPLED AUDIO	2-1
2-15 AUX OUTPUT	2-1
2-16 MONO HEADPHONE	2-1
2-17 ISB HEADPHONE	2-1
3. GENERAL THEORY OF OPERATION	
3-1 INTRODUCTION	3-1
3-2 PRESELECTOR (81727)	3-1
3-3 PREAMP/ATTN	3-1
3-4 FIRST MIXER (81823)	3-1
3-5 SECOND MIXER/THIRD LOCAL OSCILLATOR (81817)	3-1
3-6 CONVERTOR-I/O BOARD (81790).....	3-2
3-7 FIRST LO SYNTHESIZER (P/O 81772)	3-3

TABLE OF CONTENTS

PARAGRAPH	PAGE
3. GENERAL THEORY OF OPERATION (CONTINUED)	
3-8 2ND LOCAL OSCILLATOR (P/O 81772)	3-3
3-9 10 MHZ REFERENCE OSCILLATOR (P/O 81772)	3-3
3-10 DSP/CPU (81821)	3-4
3-12 LED BOARD (81788)	3-4
4. DETAILED OPERATING INSTRUCTIONS	
4-1 MULTI-DROP NETWORK	4-1
4-2 RECEIVER CONTROL	4-2
4-3 RECEIVER RESPONSE	4-2
4-4 RECEIVER CONTROL COMMANDS	4-2
4-5 RX-331 RECEIVER CONTROL COMMAND SET	4-3
4-6 RX-331 RECEIVER MEMORY COMMAND SET	4-8
4-7 RX-331 RECEIVER QUERY COMMAND SET	4-8
4-8 RX-331 RECEIVER BITE	4-9
4-9 FACTORY SERVICE/FIELD TEST MODE	4-11
4-10 DSP DATA OUTPUT	4-11
5. MAINTENANCE INSTRUCTIONS	
5-1 INTRODUCTION	5-1
5-2 CLEANING AND LUBRICATION	5-1
5-3 TROUBLESHOOTING	5-1
5-4 INSPECTION	5-1
5-5 PERFORMANCE VERIFICATION TEST FOR MODEL RX-331	5-1
5-5.1 TEST EQUIPMENT REQUIRED FOR MODEL RX-331	5-1
5-5.2 FUNCTIONAL TESTS FOR MODEL RX-331	5-2
6. PREPARATION FOR SHIPMENT OR STORAGE	
6-1 PREPARATION FOR RESHIPMENT	6-1
6-2 PREPARATION FOR STORAGE	6-1
7. SINGLE SOURCE PARTS LIST	
7-1 INTRODUCTION	7-1
8. FINAL ASSEMBLY MODEL RX-331	
8-1 INTRODUCTION	8-1
9. ILLUSTRATIONS	
9-1 INTRODUCTION	9-1

LIST OF ILLUSTRATIONS

FIGURE		PAGE
I	RX-331 FRONT VIEW	vi
II	RX-331 REAR VIEW	vi
3-1	RX-331 TOP VIEW	3-5
3-2	RX-331 INTERCONNECT DIAGRAM	3-6
4-1	CONNECTION DIAGRAM.....	4-1
4-2	CONFIGURATION DIAGRAM	4-12
4-3	SERIAL/PARALLEL INTERFACE	4-13
4-4	DB25 PIN ASSIGNMENTS	4-14
9-1	MODEL RX-331 BLOCK DIAGRAM	9-2
9-2	LOGIC BOARD BLOCK DIAGRAM	9-3
9-3	SYNTHESIZER BLOCK DIAGRAM.....	9-4
9-4	81727 CIRCUIT TRACE	9-5
9-5	81727 RX PRESELECTOR COMPONENT LAYOUT	9-5
9-6	81727 RX PRESELECTOR SCHEMATIC	9-7
9-7	81823 1ST MIXER BOTTOM CIRCUIT TRACE	9-13
9-8	81823 1ST MIXER COMPONENT LAYOUT	9-14
9-9	81823 1ST MIXER SCHEMATIC	9-15
9-10	81817 2ND MIXER/IF TOP CIRCUIT TRACE	9-18
9-11	81817 2ND MIXER/IF BOTTOM CIRCUIT TRACE	9-18
9-12	81817 2ND MIXER/IF COMPONENT LAYOUT	9-19
9-13	81817 2ND MIXER/IF SCHEMATIC	9-21
9-14	81790 CONVERTER/IO TOP CIRCUIT TRACE	9-26
9-15	81790 CONVERTER/IO BOTTOM CIRCUIT TRACE	9-26
9-16	81790 CONVERTER/IO BOARD COMPONENT LAYOUT	9-27
9-17	81790 CONVERTER/IO BOARD SCHEMATIC	9-29
9-18	81772 TOP CIRCUIT TRACE - SYNTHESIZER	9-34
9-19	81772 BOTTOM CIRCUIT TRACE - SYNTHESIZER	9-35
9-20	81772 COMPONENT LAYOUT - SYNTHESIZER	9-36
9-21	81772 SYNTHESIZER SCHEMATIC	9-37
9-22	81818 POWER SUPPLY FILTER TOP CIRCUIT TRACE	9-45
9-23	81818 POWER SUPPLY FILTER BOTTOM CIRCUIT TRACE	9-46
9-24	81818 POWER SUPPLY FILTER COMPONENT LAYOUT	9-47
9-25	81818 POWER SUPPLY FILTER SCHEMATIC	9-48
9-26	81788 LED BOARD BOTTOM CIRCUIT TRACE	9-50
9-27	81788 LED BOARD COMPONENT LAYOUT	9-50
9-28	81788 LED BOARD SCHEMATIC	9-51
9-29	81821 DSP/CPU TOP CIRCUIT TRACE.....	9-53
9-30	81821 DSP/CPU BOTTOM CIRCUIT TRACE.....	9-54
9-31	81821 DSP/CPU COMPONENT LAYOUT.....	9-55
9-32	81821 DSP/CPU SCHEMATIC (page 1 of 2)	9-57
9-33	81821 DSP/CPU SCHEMATIC (page 2 of 2)	9-59

LIST OF TABLES

TABLE		PAGE
7-1	MODEL RX-331 SINGLE SOURCE PARTS LIST	7-1
7-2	PART MANUFACTURER'S INFORMATION	7-4
8-1	RX-331 MODULES	8-1
8-2	FINAL ASSEMBLY REPLACEABLE PARTS	8-2
9-1	81727 RX PRESELECTOR PARTS LIST	9-9
9-2	81823 1ST MIXER PARTS LIST	9-16
9-3	81817 2ND MIXER/IF PARTS LIST	9-23
9-4	81790 CONVERTER/IO BOARD PARTS LIST	9-31
9-5	81772 SYNTHESIZER PARTS LIST	9-39
9-6	81818 POWER SUPPLY FILTER PARTS LIST	9-49
9-7	81788 LED BOARD PARTS LIST	9-52
9-8	81821 DSP/CPU BOARD PARTS LIST	9-61

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.

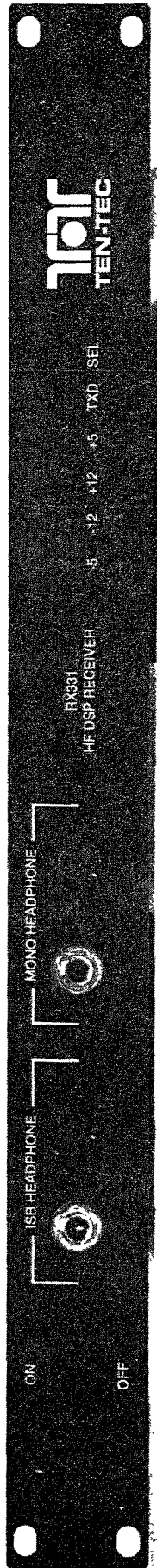


FIGURE I. RX-331 FRONT VIEW

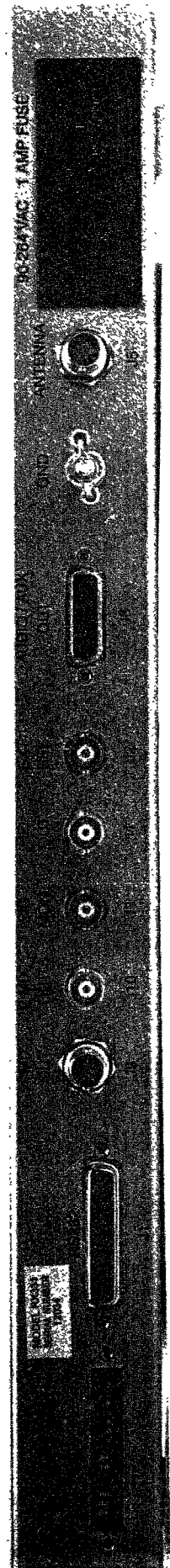


FIGURE II. RX-331 REAR VIEW

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 ± 8000 Hz. In CW, LSB and USB modes, a passband tuning function allows simultaneous adjustment of BFO and receiver tuning over a ± 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, ± 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): ± 1 ppm per degree C within the operating range of 0 to 50 degrees C. An optional TCVCXO provides ± 1 ppm over entire range (0 to 50 degrees C).

External Frequency Standard: 1, 2, 5, or 10 MHz ± 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 ± 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.

VLF Sens., 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		PREAMP ON	
			TYP	MAX	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

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 ± 3 dB 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 attachment 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

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 AGC'd 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).

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 $16 \frac{2}{3}$ 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 $66 \frac{2}{3}$ KHz sample rate for input to the Digital Signal Processor.

Serial data from the DSP at a $133 \frac{1}{3}$ 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 $16 \frac{2}{3}$ 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