

March 5, 1990

**PROTOTYPE**

**TECHNICAL MANUAL**

**FOR**

**R110 RECEIVER**

THIS MANUAL IS INTENDED FOR USE WITH  
THE FOLLOWING SERIAL NUMBERS:

\_\_\_\_\_ thru \_\_\_\_\_

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## 1. GENERAL INFORMATION

### 1.1 Description and Purpose

The R-110 receiver, shown in the frontispiece, is a solid-state multiple-conversion receiver that provides a means of detecting and measuring signals associated with electromagnetic analysis, TEMPEST, spectrum analysis, and frequency surveillance, in the range of 1 KHz to 1 GHz. Three basic modes of operation are incorporated into the instrument: manual operation, automated sweeping, and remote operation controlled by a host computer. The receiver will also work with various accessories such as the R-1180 Microwave Downconverter, which extends the frequency range to 18 GHz.

### 1.2 Equipment Description

The R-110 receiver consists of modularly-constructed electronic circuits integrated with a front panel assembly containing operator controls and indicators. RF, video, and analog signals are interconnected by dedicated connectors located on the front and back panels of the instrument. Function control signals and interface data used by separately mounted equipment are provided through multi-contact connectors that use distinctive configurations to prevent improper positioning when mated.

### 1.3 Physical Characteristics

The characteristics of the R-110 are shown in Table 1-1.

Table 1-1 Physical Characteristics

Input Power	115/230 vac $\pm$ 10%
Power Dissipation	100 watts
Mechanical Dimensions	
Standard Height	5.22 in (133 mm)
Standard Width	17.00 in (432 mm)
Standard Depth	18.00 in (457 mm)
Rack Mount Height	5.22 in (133 mm)
Rack Mount Width	19.00 in (483 mm)
Rack Mount Depth	18.00 in (457 mm)
Weight	39.0 lbs (18 kg)
Volume	0.6 cu.ft.
Cooling	Free and forced convection (internal fans)
Temperature Range	
Operating	40 to 105 F (5 to 40 C)
Storage	-40 to 167 F (-40 to 75 C)
Relative Humidity	
Operating	0 - 90% non condensing
Storage	0 - 95% non condensing

## 1.4 Specifications

The detailed electrical and performance specifications of the R-110 receiver are shown in Table 1-2. Each entry is prefaced with the applicable paragraph number from Section 4.3.3 of the SOW or a "DSI", indicating that the item is in addition to the specified requirements. An "\*" indicates that the specification paragraph has been revised. The "As Designed" entries show the anticipated operation/performance of the prototype and production receivers; a "Same" means "same as specified requirement". The "Specification" entries are from the SOW and approved revisions.

**Table 1-2 Specifications**

SOW PARA.	AS DESIGNED	SPECIFICATION
(4.3.3.1) Modes of Operation	Same plus Scan and Downconverter Modes	Manual (standard) and Remote (optional)
(4.3.3.3)* RF Inputs	Same	Two inputs, remote or locally selectable, break-before-make switching
(4.3.3.4) Frequency Range:	Same	Both inputs tunable over range of 1 KHz to 1 GHz
(4.3.3.5) Noise Figure:	10 dB	Less than 15 dB
(4.3.3.5) Spurious-free Dynamic Range :	70 dB	Not less than 60 dB between RF input and AM video output, and between RF input and IF output
(4.3.3.3) Input VSWR:	Same	Less than 2:1 over full freq. range
(4.3.3.3) Input Impedance:	Same	50 ohms nominal
(4.3.3.3)* Maximum Tolerated RF Input:	1 watt average CW	
(4.3.3.3) Isolation between inputs:	80 dB	At least 60 dB
(4.3.3.8) LO Leakage at Input Connector:	Same	Less than -90 dBm
(4.3.3.8) Residual Spurious Responses:	< -120 dBm	Less than -107 dBm
(4.3.3.6) IF Rejection:	Same	At least 80 dB
(4.3.3.6) Image Rejection:	Same	At least 80 dB

SOW PARA.	AS DESIGNED	SPECIFICATION
(DSI) Input Attenuator: Range: Operation: Switching Time:	0-70 dB in 10 dB steps Manual and auto.selection Less than 30 ms	
(4.3.3.5,.6)* Gain:	Quasi-continuous, 50 dB range. RF, IF, pre-detection gains optimally adjusted	
(DSI) Bands:	Three bands cover the frequency range; the bands are automatically selected as a function of input frequency	
(DSI) Band Switching/Settling Time:	30 msec typical	
(DSI) Band Frequency Ranges: (hysteresis provided across band breaks)	Band 1: 1 KHz to 249.99..KHz Band 2: 250 KHz to 14.99..MHz Band 3: 15 MHz to 999.99..MHz	
(4.3.3.4)* Tuning:	Single knob tuning with selectable tuning rate; dual switches for pushbutton tuning; switches for automatic scan	
(4.3.3.4)* Tuning Resolution:	0.1 Hz below 250 KHz 1.0 Hz from 250 KHz to 15 MHz 100 Hz above 15 MHz	
(4.3.3.3) Tuning interference:	Same	No detectable tuning interference in video and audio outputs
(DSI) Reference Oscillator Type:	100 MHz oven-controlled, Quartz oscillator (TCXO); adjustable frequency	
(DSI) Ref. Oscillator Aging:	1 PPM per year	
(DSI) Ref. Oscillator Temperature Stability:	0.05 PPM, 0 to 60 C	
(4.3.2.2) Reference Oscillator Output:	> 0 dBm	Level not defined



SOW PARA.	NOMINAL	SPECIFICATION
(4.3.3.4) Receiver Frequency Stability:	Same as Ref.Osc. after 30 min.	1 PPM after 30 minutes
(4.3.3.4) Receiver Frequency Accuracy:	Same as Ref.Osc. after 30 min.	1 PPM after 30 minutes warm-up
(DSI) Frequency Display:	12 digit alphanumeric character, LED, adjustable intensity	
(4.3.3.4) Frequency Display Readability:	Same	Readable with/without backlighting
(DSI) Wide-BW IF Output Frequency:	1450 MHz nominal	
(DSI) Wide-BW IF Output Level:	At least -30 dBm into 50 Ohms	
(4.3.3.7) Signal Monitor Center Frequency:	Same	21.4 MHz
(4.3.3.7) Signal Monitor Output Bandwidth:	Same	4 MHz minimum
(4.3.3.7) Signal Monitor Output Level:	at least 100 uV	At least 10 uV peak into 50 Ohms with RF input of -107 dBm and full RF gain
(4.3.3.7) IF Center Frequency:	Same	21.4 MHz
(4.3.3.6)* IF Bandwidths (default set):	500 Hz to 100 KHz (in 1-2-5 sequence), 300 KHz, 1 MHz, 4 MHz, 15 MHz	
(DSI) IF Bandwidths (alternate set):	50 Hz to 100 KHz (in 1.0-1.25-1.6-2.0-2.5-3.2-4.0-5.0-6.4-8.0 sequence), 300 KHz, 1 MHz, 4 MHz, 15 MHz	
(4.3.3.6) IF Bandwidth Impulse Response:	Less than 5%	Overshoot less than 8% for BW <150 KHz, 12 % for BW >150 KHz
(4.3.3.6) IF Selectivity:	4:1 typical	Shape Factor better than 10:1 (60 to 6 dB)
(4.3.3.7) IF Output Level:	At least 10 dBm	At least 0 dbm into 50 Ohms

SOW PARA.	AS DESIGNED	SPECIFICATION
(DSI) AGC:	Selectable with keyboard	
(4.3.3.2) Detection Modes:	Same	AM, CW
(DSI) Detection Type:	AM peak	
(4.3.3.7) Video Output Modes:	Same	AM (Linear), Log, Z-axis
(DSI) Optional AM Video Functions:	Slideback, pulse stretch	
(4.3.3.7)* Video Bandwidths:	Not less than 1/2 selected IF bandwidth	
(4.3.3.7) AM Video Dynamic Range:	At least 35 dB	At least 30 dB
(4.3.3.7) Log Dynamic Range:	At least 70 dB	At least 60 dB
(4.3.3.7) AM, Log and Z-Axis Impedances:	Same	50 Ohms nominal
(4.3.3.7) AM, Log Output Levels:	At least 3 volts	At least 2 Volts (into 50 Ohms)
(4.3.3.7) Z-axis Operation:	Same with 3 volts	Output adjustable to 2 Vrms and reversible
(4.3.3.7) Audio 3 dB Freq. Response:	20 Hz to 20 KHz	30 Hz to 12 KHz
(4.3.3.7) Audio Output Level:	At least 8 V rms	At least 1 Vrms into 8 Ohms
(4.3.3.6) BFO Tuning Range:	Same	At least 4 KHz
(4.3.3.6) BFO Tuning Resolution:	Continuous	At least 10 Hz steps
(4.3.3.8) IEEE-488 Codes:	Same	SH1, AH1, T6, L4, SR1, RL1, PP0, DC1, DT1, C0
(DSI) Remotely Controllable Functions:	Frequency, Input attenuation, IF bandwidth, detection mode/gain, RF gain, AGC mode, RF input select, Step Size, Step Up, Step Down, plus Calibration and Service functions	
(4.3.3.8) Power cord:	Same	Shielded cord
(4.3.3.8) Protection from power damage:	Same	No damage when improperly powered
(4.3.3.8) Line voltage select:	Rotary switch	Slide switch

### 2.6.1 Power Settings and Connections

The instrument is shipped from the factory preset to operate from a power source of 115 volts, 50/60 Hz, single phase. For operation using a different voltage range, select the proper fuse rating from Table 2-4, and proceed as follows:

1. Place the line voltage select switch located on the rear panel of the instrument in the proper position.
2. Select and install the proper line fuses for the input voltage to be used.
3. Set the line voltage range switch to the required position as shown in Table 2-5. When both the PWRHI and PWRLO LED lightbars on the front panel are unlit, the range selected is acceptable.

**Table 2-4 Fuse Selection**

VOLTAGE	FUSE RATING
115 V Range	2 Amp, 2ASB slo-blo, Little -Fuse 213002
230 V Range	2 Amp, 1ASB slo-blo, Little -Fuse 213001

**Table 2-5 Line Voltage Range Selection**

SELECT SWITCH	RANGE SWITCH	INPUT VOLTAGE RANGE
115 V	Low	95 - 105 VAC
	Norm	105 - 115 VAC
	High	115 - 126 VAC
230 V	Low	190 - 210 VAC
	Norm	210 - 231 VAC
	High	231 - 253 VAC

The instrument has a 3 conductor power cord which, when connected to an appropriate receptacle, grounds the instrument chassis for safety.

#### WARNING

**The AC power cord should only be connected to receptacles that have active protected earth ground contacts. Bypassing or defeating the earth ground protection can result in injury to operating personnel.**

### 2.7 External Interfaces

Pin numbers and signal identification for the IEEE-488 bus interface connector are listed in Table 2-6.

The signal identification for the internally mounted RS-232 service connection is listed in Table 2-7.

The R-110 comes factory-set to IEEE-488 bus address 12, and with the RS-232 interface to a baud rate of 4800. To change either of them, perform the following steps.

- 1) Unplug the receiver. Remove the front panel assembly.
- 2) Open the front panel assembly to gain access to the Processor board.
- 3) There is one dip-switch visible on the bottom edge of this board. Switches 1 - 5 determine the bus address. The desired address must be set in binary, with switch 5 considered to be the MSB. "On" generates a zero, "Off" a one. Table 2-7 lists the setting for each available address. Switches 6 - 8 determine the baud rate for the RS-232 interface. Table 2-8 lists the setting for each available baud rate.
- 4) When the dipswitch is set to the desired value, replace the cover and reassemble the receiver. The new setting will be read on power-up.

**Table 2-6 IEEE-488 Bus**

<b>Pin No.</b>	<b>Signal</b>	<b>Pin No.</b>	<b>Signal</b>
1	DIO1	13	DIO5
2	DIO2	14	DIO6
3	DIO3	15	DIO7
4	DIO4	16	DIO8
5	EOI	17	REN
6	DAV	18	GND (6)
7	NRFD	19	GND (7)
8	NDAC	20	GND (8)
9	IFC	21	GND (9)
10	SRQ	22	GND (10)
11	ATN	23	GND (11)
12	SHIELD	24	GND, LOGIC

Note: Numbers in parenthesis identify the signal line associated with the indicated ground.

**Table 2-7 RS-232 Interface (Internal Connector)**

<b>Pin No.</b>	<b>Signal</b>	<b>Pin No.</b>	<b>Signal</b>
1	GND (Shield)	14	(spare)
2	RXD	15	(spare)
3	TXD	16	(spare)
4	RTS	17	(spare)
5	CTS	18	(spare)
6	DSR	19	(spare)
7	GND (Signal)	20	DTR
8	(spare)	21	(spare)
9	(spare)	22	(spare)
10	(spare)	23	(spare)
11	(spare)	24	(spare)
12	(spare)	25	(spare)
13	(spare)		

**Table 2-8 Dipswitch Settings for IEEE-488 Bus Address**

Address	Switch Position				
	5	4	3	2	1
0	on	on	on	on	on
1	off	on	on	on	on
2	on	off	on	on	on
3	off	off	on	on	on
4	on	on	off	on	on
5	off	on	off	on	on
6	on	off	off	on	on
7	off	off	off	on	on
8	on	on	on	off	on
9	off	on	on	off	on
10	on	off	on	off	on
11	off	off	on	off	on
12	on	on	off	off	on
13	off	on	off	off	on
14	on	off	off	off	on
15	off	off	off	off	on
16	on	on	on	on	off
17	off	on	on	on	off
18	on	off	on	on	off
19	off	off	on	on	off
20	on	on	off	on	off
21	off	on	off	on	off
22	on	off	off	on	off
23	off	off	off	on	off
24	on	on	on	off	off
25	off	on	on	off	off
26	on	off	on	off	off
27	off	off	on	off	off
28	on	on	off	off	off
29	off	on	off	off	off
30	on	off	off	off	off
31	off	off	off	off	off

**Table 2-9 Dipswitch Settings for RS-232 Baud Rate**

Baud Rate	Switch		
	6	7	8
110	on	on	on
150	off	on	on
300	on	off	on
600	off	off	on
1200	on	on	off
2400	off	on	off
4800	on	off	off
9600	off	off	off

**2.7.1 Discrete Status/Control Interface**

In addition to the IEEE-488 interface, there is also a connector on the rear panel of the receiver which contains discrete, dedicated status and control lines intended for interfacing to various associated hardware. The signals on the various connector pins are listed in Table 2-10.

**Table 2-10 Discrete Status/Control Interface**

Pin	Signal	Used With	Pin	Signal	Used With
TO BE REVISED:					
1	DETOL	System Interface	14	GND	All
2	RFOL	System Interface	15	(Spare)	
3	LSTAT	System Interface	16	(Spare)	
4	PRE01	Preselector	17	(Spare)	
5	PRE02	Preselector	18	(Spare)	
6	PRE03	Preselector	19	(Spare)	
7	PRE04	Preselector	20	(Spare)	
8	IFOL	System Interface	21	(Spare)	
9	CSA	Audio Processor	22	(Spare)	
10	(Spare)		23	(Spare)	
11	(Spare)		24	(Spare)	
12	(Spare)		25	(Spare)	
13	(Spare)				

### 3. OPERATION

#### 3.1 Introduction

This section provides instructions for the operation of the receiver. The section begins with identification of the various controls, displays and connectors. The modes of operation and the default settings are then presented, along with a list of condensed operating instructions. More detailed discussions follow, providing an in-depth understanding of the receiver's operational features.

#### 3.2 Identification of Controls, Displays, and Connectors

Figure 3-1 is a front view of the receiver with numerical designators that are referenced to the identification list of Table 3-1. Figure 3-2 provides a back view of the instrument and is referenced to the nomenclature listed in Table 3-2. The tables provides a short explanation of function and purpose for each designated item; more detailed explanations are given later.

Table 3-1 Front Panel Nomenclature

##### CONNECTORS:

- |                |   |
|----------------|---|
| 1. RF Input #1 | Female BNC connector for input of RF signals.         |
| 2. RF Input #2 | Female BNC connector for input of RF signals.         |
| 3. X-Axis      | Female BNC connector for output of X-Axis scan signal |
| 4. Video       | Female BNC connector for output of video signal       |
| 5. Audio Jack  | Phone jack for output of audio signal                 |

##### PUSHBUTTONS AND SWITCHES:

- |                        |   |
|------------------------|---|
| 6. Power               | Two position rocker switch that controls the input power to the receiver.   |
| 7. RF Input #1         | Pushbutton switch to select RF Input #1; includes light emitting diode (LED) which lights when RF Input #1 connector is selected. |
| 8. RF Input #2         | Pushbutton switch to select RF Input #2; includes indicator LED   |
| 9. Input Attenuation   | Dual pushbutton switches to select input signal attenuation level.  |
| 10. Bandwidth          | Dual pushbutton switches to select bandwidth  |
| 11. Keypad             | 15 pushbutton switches used to enter frequencies and rates, decimal point location, tuning resolution, and repetition modes.      |
| 12. Alt                | Pushbutton switch (nested with keypad) (with LED indicators) used to select secondary modes and functions                         |
| 13. Tuning resol./scan | Three pushbutton switches (with LED indicators) used to select display resolution and to control the scan mode                    |
| 14. Tuning             | Dual pushbutton switches for tuning   |
| 15. AM slideback       | Pushbutton switch (with LED indicator) to activate optional slideback   |
| 16. Pulse stretch      | Pushbutton switch (with LED indicator) to activate optional pulse stretch   |
| 17. BFO                | Pushbutton switch (with LED indicator) to activate BFO  |



- |                  |   |
|------------------|---|
| 18. Z-Axis (on)  | Pushbutton switch (with LED indicator) to activate Z-axis output    |
| 19. Z-Axis (inv) | Pushbutton switch (with LED indicator) to invert Z-axis output      |
| 20. Log          | Pushbutton switch (with LED indicator) to select log detection mode |

**ALPHANUMERIC LED DISPLAYS:**

- |                       |  |
|-----------------------|--|
| 21. Tuning            | 12-character display for frequency presentation            |
| 22. Input Attenuation | 4-Character display indicating attenuator setting          |
| 23. Gain              | 4-Character display indicating receiver gain or delta gain |
| 24. Bandwidth         | 4-Character display indicating bandwidth setting           |

**LED LIGHT-BAR INDICATORS:**

- |                 |  |
|-----------------|--|
| 25. Unlock      | Synthesizer unlocked                                   |
| " RFOVL         | Front-end overload                                     |
| " IF/DET OL     | IF or video overload                                   |
| " PwrHi         | Power line voltage higher than nominal                 |
| " PwrLo         | Power line voltage lower than nominal                  |
| " Unreg         | Power supply out of regulation                         |
| " $\Delta$ GAIN | Differential gain mode or alt. gain (CW vs. Impulsive) |
| " AGC           | AGC on   |
| " Alt BW        | Alternative set of narrow BW selected                  |
| " Thresh        | Slideback threshold indication                         |
| 26. Start       | Entering scan mode start frequency                     |
| " Stop          | Entering scan mode stop frequency                      |
| " Step          | Entering step size                                     |
| " Rate          | Entering step rate                                     |
| " Scan          | Scan mode  |
| " Tune          | Tune mode  |
| " Bright        | Brightness control mode                                |
| " Beep          | Beeper level control mode                              |
| " Addr          | IEEE-488 address display mode                          |
| " Remote        | Remote control enabled; most controls disabled         |

**ROTARY CONTROLS:**

- |                   |                                 |
|-------------------|---------------------------------|
| 27. Tuning        | Tunes receiver                  |
| 28. Gain          | Sets receiver gain              |
| 29. Audio         | Adjusts audio output level      |
| 30. BFO           | Adjusts BFO frequency           |
| 31. Z-Axis        | Adjusts Z-axis output amplitude |
| 32. Slideback     | Adjusts AM slideback threshold  |
| 33. Pulse-stretch | Adjusts Pulse stretch           |

**AUDIBLE ALARM:**

- |            |  |
|------------|--|
| 34. Beeper | Sounds when operational limit is exceeded. |
|------------|--|

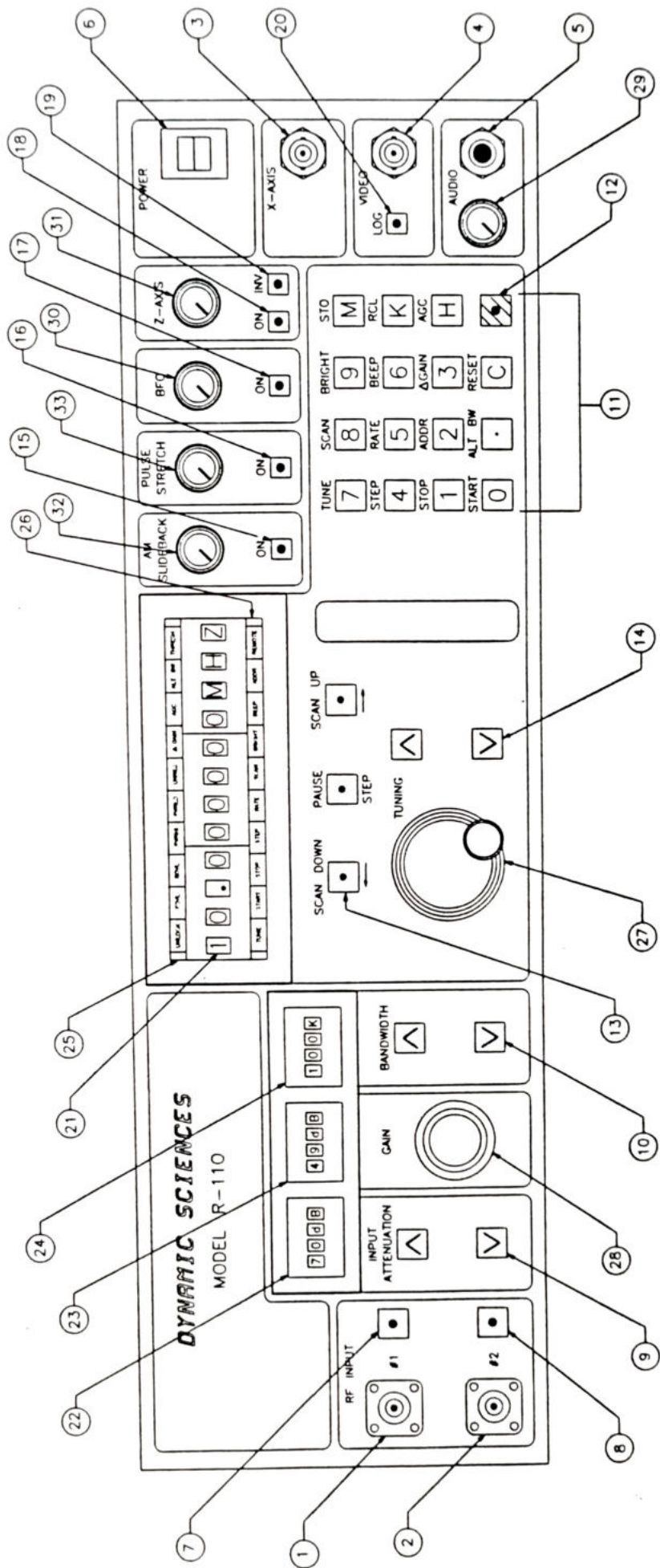


FIGURE 3-1 FRONT PANEL

**Table 3-2 Rear Panel Nomenclature**

**CONNECTORS:**

A	Ref.Oscillator	Female BNC for frequency reference
B	Signal Monitor	Female BNC for IF monitor (prior to BW filtering)
C	Z-Axis	Female BNC for Z-axis monitoring
D	IF Output	Female BNC for IF output (after BW filtering)
E	1450 MHz IF Output	Female BNC for Wide BW IF (1450 MHz) (optional)
F	IEEE-488 Interface	Std. IEEE-488 Bus Conn.
G	Status/Control	Female 25D Conn. for Status/Control discretes
H	AC Input	3-contact NEMA Receptacle with line fuses
I	Ground Stud	1/4"x20 Single-point ground for receiver

**SWITCHES:**

J	Line Voltage Range	115/230 vac select
K	Line Voltage Adjust	Line voltage adjustment switch

### 3.3 Modes of Operation

The primary modes of operation of the R-110 are "Tune", "Scan", "Downconverter", and "Remote".

**Tune:** The tune mode is the normal mode of operation. In this mode the receiver is tuned using the rotary tuning control (27) or the pushbuttons (14). The TUNE lightbar is illuminated in this mode.

**Scan:** In the scan mode, the receiver automatically scans a preset frequency range, using preselected step size and rate. The SCAN lightbar is illuminated in this mode.

**Downconverter:** This mode is enabled when the R-110 is integrated with the R-1180 Microwave Downconverter. Tuning and gain control are accomplished with the Microwave Downconverter's controls and displays, with the R-110 automatically tracking to receive and process the downconverted signal. All of the other R-110 functions are available, including bandwidth and detection mode selection. Communication between the units is via the IEEE-488 bus. The REMOTE lightbar is illuminated in this mode.

**Remote:** In the remote mode the R-110 is under control of a host processor. Control is accomplished via the IEEE-488 bus. The REMOTE lightbar is illuminated in this mode.

In addition to these primary modes, additional modes are provided for entry of parameters and control, including selection of display brightness and beep loudness, storage and recall of panel settings, AGC activation, and IEEE-488 address display/selection.

The modes are summarized in the condensed procedures in Para. 3.5 and discussed in detail in Para. 3.6, below.

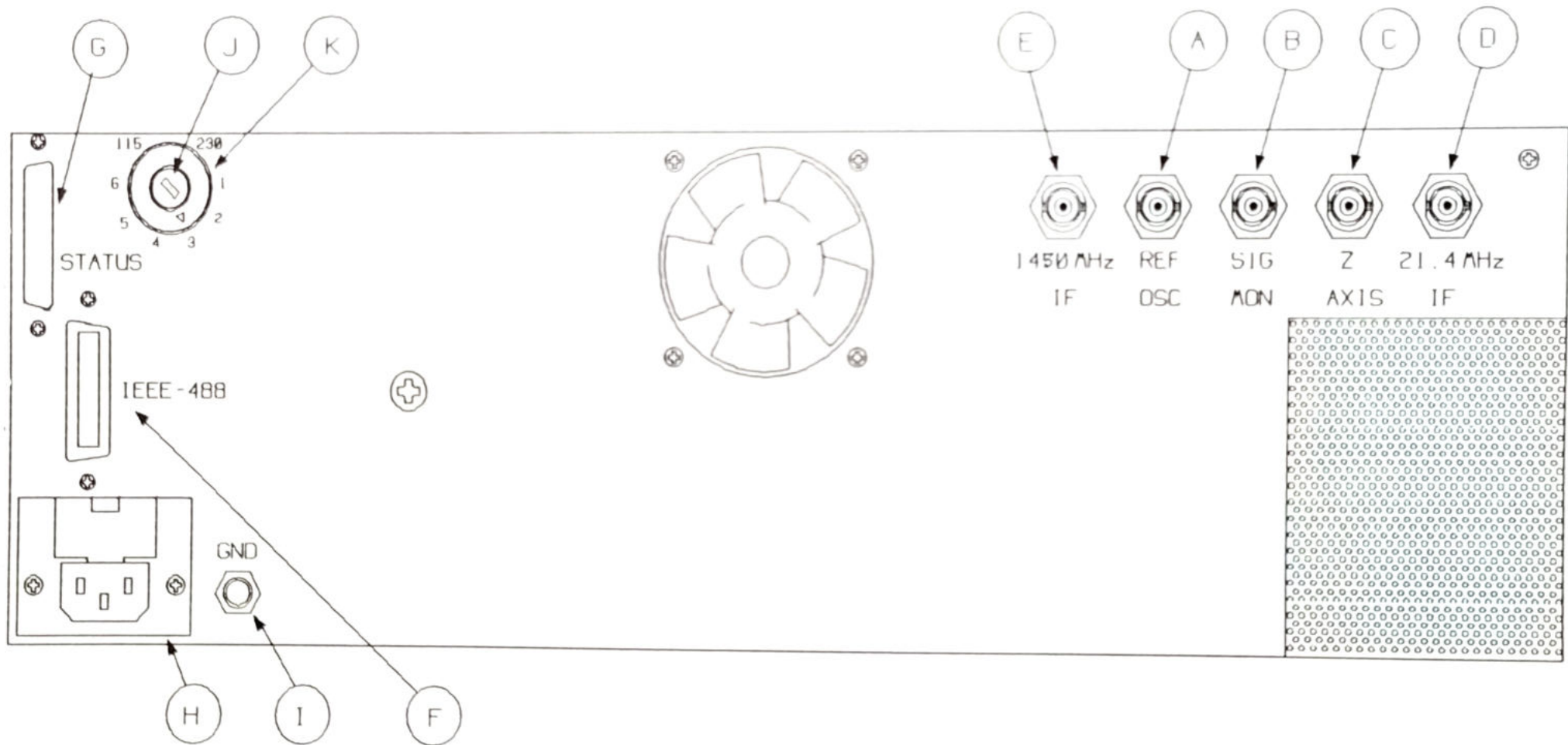


FIGURE 3-2 REAR PANEL

### 3.4 Default Settings

When the receiver is first energized, default modes and conditions are automatically selected, and the front panel indicators and displays are activated accordingly. The default conditions are as noted in Table 3-3.

**Table 3-3 Default Settings**

<b>MODE</b>	<b>DEFAULT SETTING</b>
Tune	Selected; TUNE lightbar illuminated
Video	Normal (Log not selected)
Scan	Not-selected
△Gain/Alt. Gain	Not-selected
AGC	Not-selected
Alt. Bandwidths	Not-selected
<b>CONTROLS/DISPLAYS</b>	<b>DEFAULT SETTING</b>
RF Input #1	Selected (LED illuminated)
Input Attenuation	20 dB
Gain	Maximum
Bandwidth	1 MHz
Tuned Frequency	100 MHz
Tuning resolution	1 MHz digit
BFO	Off
Z-Axis	Off
Z-Axis (inv)	Off
Log	Off
Optional AM slideback	Off
Optional Pulse stretch	Off
Display Brightness	Setting when last used (or mid-point) **
Audio Beep level	Setting when last used (or mid-point) **

### 3.5 Condensed Operation Instructions

#### **NORMAL OPERATIONS:**

Preparation for use	Verify that the receiver RF input connectors (1)(2) are not connected to a high voltage/energy source (e.g. a PLISN)
Energize the Receiver	Turn on power switch (6). The receiver will power-up and will switch to the default settings
Select tuned frequency	Enter frequency (with decimal point) using keypad (11), followed by H, K, or M (Hz, KHz, or MHz)

## Condensed Operation Instructions, continued

Adjust tuned frequency	Select tuning resolution and use rotary tuning control (27) or pushbuttons (14).
Select tuning resolution	Press left (13L) or right (13R) arrow pushbuttons; observe dimmed/brightened digit in frequency display (21)(see detailed discussion in "Tune Mode" paragraph for additional procedures)
Select input	Press RF Input #1 (7) or #2 (8) pushbutton
Set Input Attenuation	Use pushbuttons (9) and display (22)
Use Auto Attenuation	Increase Atten. past 70 dB
Set Receiver Gain	Use gain knob (28) and display (23)
Set bandwidth	Use pushbuttons (10) and display (24)
Use audio output	Connect headphone or speaker to phone jack (5)
Adjust audio level	Use control (29)
Use video output	Connect cable to Video Connector (4)
Select Log detection	Press pushbutton (20)
Use Z-axis output	Connect cable to Z-axis connector (C) on rear panel; activate Z-axis by pressing pushbutton (18)
Adjust Z-axis output	Rotate control (31)
Invert Z-axis	Press pushbutton (19)
Use BFO	Press pushbutton (17); monitor audio output
Adjust BFO frequency	Rotate control (30)

## Condensed Operation Instructions, continued

### SPECIAL MODES:

Use DELTA-GAIN mode	Use ALT key (12) and press $\Delta$ GAIN key (key 3); use same keys to return to normal operation
Use ALT-GAIN mode	Use ALT key (12) and press <i>TO BE DEFINED</i> key (key TBD); use same keys to return to normal operation
Use SCAN mode:	
Enter Start freq.	Use ALT key (12) and press START key (key 0); enter freq. with keypad
Enter Stop freq.	Use ALT key (12) and press STOP key (key 1); enter freq.
Enter Step size	Use ALT key (12) and press STEP key (key 4); enter step size (1 Hz to 1 GHz)
Enter Rate	Use ALT key (12) and press RATE key (key 5); enter rate (0.01 to 10 steps per sec.; enter "0" for max rate)
Select SCAN mode	Use ALT key (12) and press SCAN key (key 8)
Control scan	Use SCAN DOWN, PAUSE, and SCAN UP keys (13)
Adjust scan rate	Press SCAN DOWN or UP keys (13) while scanning to increase/decrease scan rate
Return to TUNE mode	Use ALT key (12) and press TUNE key (key 7)
Use X-axis output	Set up Scan mode; connect to X-axis connector (3); 0-2 vdc output provided while scanning
Store panel settings	Use ALT key (12) and press STO key (key M)
Recall panel settings	Use ALT key (12) and press RCL key (key K)
Use AGC	Use ALT key (12) and press AGC key (key H); use same keys to return to normal operation **

## Condensed Operation Instructions, continued

Display/Set IEEE-488 address	Use ALT key (12) and press ADDR key (key 2); use up/down keys (14) or tuning knob (27) to adjust
Adjust display brightness	Use ALT key (12) and press BRIGHT key (key 9); use up/down keys (14) or tuning knob (27) to adjust
Adjust Beep loudness	Use ALT key (12) and press BEEP key (key 6); use up/down keys (14) to adjust or tuning knob (27) to adjust

### WARNING INDICATIONS (lightbars):

UNLOCK	Blinks when tuning; if the lightbar stays on the radio must be serviced.
RFOVL	Flashes for short overload; for long overload increase input attenuation
IF/DET OL	Flashes for short overload; for a long overload decrease gain setting
PWRHI	Indicates AC line voltage is too high; check input voltage selection (J); change the line voltage range to the next higher setting using switch (K)
PWR LO	Indicates AC line voltage is too low; check input voltage selection (J); change the line voltage range to the next lower setting using switch (K)
UNREG	Check if PWRHI and PWRLO lightbars are on; otherwise indicates problem in the receiver

## 3.6 Detailed Operation Discussions

The following paragraphs describe the various receiver functions and their associated operational procedures. The reference numbers in the text are defined in Tables 3-1 and 3-2, and are shown in the illustrations of the receiver's front and rear panels.



The receiver includes audible alarms which sound when an operational limit is exceeded. A beeper is provided behind the front panel, and a beep tone is injected into the audio (headphone) output. Occasions when the alarms are sounded occur are noted in the descriptions.

### **3.6.1 RF Input Controls, Indicators, and Connectors**

The user may select one of two available RF inputs. Each input is provided with a connector (1)(2) on the front panel. Next to each connector is a pushbutton switch, and in the middle of each button is an indicator LED. In order to select an input the operator presses the adjacent pushbutton (7)(8). When this is done the pushbutton's LED will be illuminated and the LED of the other pushbutton extinguished. The input selection is also a remotely controllable function, with selection via the IEEE-488 interface; the appropriate indicator LED will be illuminated to show which input is currently selected. When in the remote and downconverter modes the pushbuttons will have no effect. When the remote or downconverter modes are terminated, any selection made in remote will be maintained until changed by the operator using the pushbuttons.

### **3.6.2 Input Attenuation Control and Display**

The user may select one of eight available input attenuation settings from 0 dB to 70 dB in 10 dB steps; the selected attenuation is shown on the four-character alphanumeric Input Attenuation display (22). Selection is made by means of a pair of pushbuttons (9), one with an "up" arrow and the other a "down" arrow. Pressing the up arrow button increases the attenuation by 10 dB while pressing the down arrow decreases it by 10 dB. When an attempt is made to go below 0 dB of attenuation then the selection will stay at 0 dB and a beep will be sounded on the audible alarm and through the headphone jack. When an attempt is made to go above 70 dB of attenuation the "auto" attenuation mode is selected. In this mode a pair of limit detectors are used to keep the input attenuation at such a level that attenuation is kept to a minimum without allowing front-end overload to occur. When this mode is selected a beep is also issued. When an attempt is made to select past this mode with the up arrow key the "auto" attenuation mode will be maintained and a beep sounded.

The current attenuation setting is shown on the display in dB, for example, "40dB". In "auto" attenuation mode the attenuation in dB is shown in the two leftmost characters as before, but now a blank and an "A" are shown in the rightmost characters, for example "20 A".

Input attenuation is settable over the IEEE-488 interface. When in remote and downconverter modes "auto" attenuation is disabled and the last selected value of attenuation maintained until changed by an IEEE-488 interface command. In remote and downconverter modes the up and down arrow pushbuttons are disabled. The display will indicate all new selections made over the bus. When these modes are terminated the last attenuation setting will be maintained until the operator changes it with the arrow pushbuttons.

### 3.6.3 Gain Control and Display

Gain is settable from 0 to 50 dB, using the gain control and the its display. When the control is used, with are adjustments made to several areas of the radio. The gain control is a high-resolution shaft encoder, but the gain display indicates the set value only to the nearest dB.

Rotating the control clockwise will increase the gain, and counterclockwise reduces the gain. When the end of the adjustable range is reached the fianl value will be maintained and a beep will sound both on the front panel and at the headphone output.

The gain display consists of four alphanumeric characters. The gain is shown in dB, for example "12dB".

Gain is a remotely controllable function. The same resolution that is available to the control is available over the bus, but again the display only indicates it to the nearest 1 dB. When in remote mode the gain control is disabled, while the display updates on any settings made over the bus. When remote operation is terminated the last setting made is maintained until the operator changes it with the gain control.

In addition to the normal gain adjustment, there are "Delta-Gain" and "Alternate Gain" modes available. In the Delta-Gain mode the gain is displayed in relative rather than absolute form, and in the Alternate Gain mode the receiver's gain is distributed to optimize performnace for either CW or impulsive signals. These modes are described in the operating modes discussion, Para. 3.7.1 below.

### 3.6.4 Bandwidth Controls and Display

Receiver bandwidth is selected using a pair of pushbuttons (10), one with an up arrow and the other a down arrow. The display consists of four alphanumeric characters. Typical bandwidth displays would be "500H", "20K", and "1M". Pressing the up arrow key selects the next broader available bandwidth while pressing the down arrow key selects the next narrower available bandwidth. When the broadest bandwidth is already selected and the up arrow key is pressed, the selection will be maintained and a beep will sound on the front panel and also at the headphone jack. A similar action will occur when the narrowest bandwidth is selected and the down arrow key is pressed.

Bandwidth is a remotely controllable function. When in the remote mode the arrow pushbuttons are disabled (operation is normal in the downconverter mode). The display, however, is updated when bandwidth bus commands are received, so the display remains current. When remote mode is terminated the current bandwidth is maintained until the operator changes it with the arrow keys.

The set of bandwidths normally selectable is called the "default" set. The bandwidths in this set are those most commonly used. There are additional narrow bandwidths (less than 40 KHz) available in the receiver. An alternate, expanded set of bandwidths may be selected using the procedures described in Operating Modes paragraphs, Para. 3.7.1 below.

### 3.6.5 BFO Controls and Indicator

BFO ("beat frequency oscillator") is used to detect CW signals. If the BFO is set a little off of the IF frequency then a "beat frequency" occurs at a frequency equal to the difference of the two. This beat frequency may be heard through the headphone jack. The BFO is settable over a +/- 4 KHz range by the BFO panel potentiometer (30).

The associated pushbutton (17) is used to enable/disable the BFO function. BFO takes the place of the normal AM detection link to the audio output, so that pressing the button to enable BFO takes the AM detector output off of the audio circuit. Pressing the pushbutton again restores the AM detector and turns off the BFO. A LED indicator located in the pushbutton illuminates when BFO is selected and is extinguished otherwise.

BFO is not a remotely settable or selectable function, and is disabled in the remote mode. It stays off when remote mode is exited, so the operator must then press the button to reselect it if it is desirable to do so. The button is disabled during remote mode. In the downconverter mode, operation is normal.

### 3.6.6 Video Output, Control, and Indicator

The video output can be produced by either a log or a linear detector (the linear detector is normally used). The LOG pushbutton (20) selects one or the other. The linear mode is selected when the receiver is turned-on, and the LED in the pushbutton is extinguished. Pushing the button will cause the log detector to be selected and the LED will illuminate.

Both selections are allowed in remote mode, although the linear detector is generally used. In the remote mode the pushbutton is disabled, but if the selection is changed by a bus command then the LED will be updated to indicate the current selection. When remote is exited any changes made while in remote will be maintained until the operator changes the selection again with the pushbutton.

### 3.6.7 Z Axis Controls and Indicators

The Z axis output is similar to the video output, but is located on the rear panel and has different controls. The output is intended for driving the Z axis (intensity) input of an oscilloscope. The Z-Axis potentiometer (31) adjusts the level, pushbutton (19) inverts the signal, and pushbutton (18) turns the signal on and off. LEDs in the pushbuttons illuminate to indicate the state. When the transition from "off" to "on" is made, the normal, rather than inverted, mode is always selected.

The amplitude setting is not remotely controllable, but the two pushbutton settings are. The LEDs always reflect the current settings. If a setting is changed in remote mode, the change is maintained when remote is exited until the operator changes it again with the pushbuttons. The pushbuttons are disabled in remote mode. Operations are normal in the downconverter mode.

### **3.6.8 X Axis Output**

The X axis output produces a 0 - 2 volt DC ramp signal during automatic scans. The signal is available on the front panel X-Axis connector (3). It is intended to be connected to the horizontal input of an oscilloscope or X-axis of a plotter, to implement spectral presentations. It has no associated controls or indicators. The output is enabled only during scan operations, and never otherwise, including remote mode. Operations are normal in the downconverter mode.

### **3.6.9 Audio Output**

The audio output will drive headphones or a speaker, or any reasonable load down to a few Ohms, using the phone-jack (5). The Audio level potentiometer (29) sets the gain. At the counterclockwise end there is zero output. The audio output signal includes an audible warning "beep" when an operational limit is exceeded; adjustment of this level is discussed in the Para. 3.7, below.

#### **3.6.9.1 Audio Warning**

The beep which occurs when an operational limit is exceeded is simultaneously presented by a sonic alarm (34) on the front panel, and mixed into the audio output. The amplitude of the warning signal is adjustable independently of the audio signal level. Adjustment of beep amplitude is done via one of the "Alt" functions of the keypad, described in Para. 3.7, below.

### **3.6.10 Status Indicators**

The status indicators are LED lightbars (26) located in the upper portion of the tuning display window. Lightbars are provided for synthesizer, overload, and power supply status. Note that the audible alarm does not beep for bad status indications. All status information is available at the rear panel status connector and over the IEEE-488 interface.

The "UNLOCK" lightbar illuminates when one or more of the synthesizer's phase-locked-loops (PLL) is out of lock. When all PLL are in lock the lightbar goes out. If one PLL is out-of-lock for just an instant the lightbar will give a quick flash. If the lightbar stays on the radio must be serviced.

The "RF OVL" lightbar illuminates when an RF overload is detected. For a short overload it gives a flash. For a long overload the input attenuation must be increased.

The "IF/V OVL" lightbar illuminates when an IF or video overload is detected. For a short overload it gives a flash. For a long overload the gain setting must be decreased.

The "PWRHI" lightbar illuminates when AC line voltage is too high for the current power supply input voltage selection. Change the line voltage range to the next higher setting using the switch (\*\*\*) on the rear panel (e.g. switch from NORM to HI).

The "PWR LO" lightbar illuminates when AC line voltage is too low for the current power supply input voltage selection. Change the line voltage range to the next lower setting using the switch (\*\*\*) on the rear panel (e.g. switch from NORM to LO).

The "UNREG" lightbar illuminates when one or more of the power supply regulators is out of tolerance. It can be caused by the power line being out of tolerance (indicated by the PWRHI and PWRLO lightbars), or a problem in the receiver.

### 3.7 Keypad and Tuning Control Operations

Control of the receiver also involves keypad-selected operations. The keypad is used in conjunction with the tuning controls to select modes and vary operating parameters. The tuning controls include the tuning shaft encoder and the associated up and down arrow keys. For most operations the tuning display is also involved.

#### 3.7.1 Operating Modes

The operating modes selected with the keypad are listed below. Many of these modes have a LED lightbar (25)(26) to indicate when they are enabled.

- Tune mode
- Delta-Gain mode
- Alternate-Gain mode
- Alternate-Bandwidth mode
- Store settings
- Recall settings
- Start frequency entry mode
- Stop frequency entry mode
- Step size entry mode
- Step rate entry mode
- Scan mode
- AGC on/off
- IEEE-488 address display/setting mode
- Display brightness setting mode
- Beep amplitude setting mode
- Reset the radio
- Test mode

The operating modes and non-mode keypad functions are all selected by pressing the Alt (12) key and then some other keypad key. If instead of another key the Alt key is pressed again the "Alt" operation will be canceled and the receiver will resume its previous operating mode.

All of the modes and functions will be discussed individually in the paragraphs which follow.

Note that the keypad and all of the tuning controls are disabled in remote mode, and certain functions are not available during the downconverter mode. In remote mode the tuning display always shows the currently tuned frequency, while in the downconverter mode the display shows the downconverter's output frequency (the signal ranges between 800 and 900 MHz).

### **3.7.1.1 Tune Mode**

The tune mode is the primary mode of operation of the receiver. The Tune mode is entered by pressing the Alt key (12) so that the LED in the pushbutton is illuminated, and then pressing the "7" key with "TUNE" marked above it. The lightbar marked "TUNE" (26) will be illuminated while the LED in the Alt key goes out.

In this mode the tuned frequency may be entered via the keypad, or adjusted by means of the tuning controls (27, 14) and the three resolution select keys (13a,b,c). The procedure for entering a frequency via the keypad is described below.

Adjustment of the tuned frequency using the tuning controls may be done with two different selections of tuning resolution. Firstly, the "step" key (13b) may be pressed to select the stored step size (entered in Step Mode, described in the Scan Operations paragraphs, below) as the adjustment size. When the key is pressed the LED in the key is illuminated. In this mode each time the up or down arrow key (14) is pressed, or for each pulse produced by a rotation of the tuning knob (27), the tuned frequency will be incremented or decremented by the stored value.

The other adjustment size involves selection of a digit for tuning on the frequency display. The left and right arrow keys (13a,c) are used to accomplish this. Pressing the left arrow key (13a) will select successive digits on the tuning display, starting with the rightmost digit and proceeding leftward. When the selection reaches the left end it starts over at the right end, with a null selection intervening. The selection is indicated by making the selected digit a different intensity. The right arrow key (13c) does the same thing only in the other direction.

Once a digit and resolution is selected the up and down arrow keys and the tuning knob can be used to increment or decrement the tuned frequency starting with the selected resolution at the selected digit. Pressing the up or down arrow key will increment or decrement the selected digit by one. Each increment from the tuning knob will do the same thing. Holding down an arrow key will cause adjustment to go on automatically after a short delay, at about a 2-per-second rate.

If an attempt is made to adjust the frequency beyond the limits of the receiver then the adjustment is rejected and a beep sounded on the front panel and at the audio output.

Pressing the "C" key will cancel any digit selection currently enabled. If the stored step size mode is selected then it is deselected and the LED in the pushbutton goes out.

This mode is executed until another operating mode (start, stop, step, scan, tune, bright, beep, address, remote, or test) is selected.

#### **3.7.1.1.1 Entering Frequencies Via the Keypad**

Frequencies are entered into the receiver via the keypad in the tune, start, stop, step, and rate modes using the following procedure.

Firstly, the LED in the Alt (12) key must NOT be illuminated. If it is lit, pressing a keypad key will select an Alt function. If the LED is out, enter the digits of the desired frequency, with the decimal point in the proper place for either Hz, KHz, or MHz. When the digits are entered press the "H" key for Hz, the "K" key for KHz, or the "M" key for MHz. If an error is made while entering the digits (before one of the terminator keys has been pressed), press the "C" key to recall the last selected value.

If a value outside of the legal range is entered then the nearest legal value will be substituted when the terminator key is pressed, and a beep will sound on the front panel and at the audio output.

### 3.7.1.2 Delta-Gain Mode

The Delta-Gain mode displays the gain changes made after an initial setting. The initial gain setting becomes a "zero reference" in this differential mode, and further adjustments are displayed in dB. To use the feature, set the gain control (28) to the desired position. Select the Delta-Gain mode by pressing the Alt key (12) so that the LED in its pushbutton is illuminated. Then press the "3" key with " $\Delta$ GAIN" marked above it. The  $\Delta$ GAIN lightbar will be illuminated and the LED in the Alt key will extinguish. The currently selected operating mode is resumed. The gain display will indicate 0 dB. Changing the gain control or the attenuator from their positions from this time on will increase or decrease the display in accordance with the changes made in gain and attenuation. If an attempt is made to increment or decrement past the settable range of gain the last legal value will be maintained and a beep will sound on the front panel and at the audio output.

To exit the Delta-Gain mode repeat the Alt key and  $\Delta$ GAIN key sequence.

The Delta-Gain mode is not selectable in remote mode. It will be exited automatically during the transition to remote. Operations are normal in the downconverter mode.

### 3.7.1.3 Alternate-Gain Mode

This mode permits optimization of the receiver's gain distribution for either impulsive or CW signals. The default condition is impulsive, and the gains are set so that maximum performance is obtained with impulsive signals. With this settings, performance remains satisfactory for CW signals, but can be improved by selecting the CW setting.

Select the Alternate-Gain mode by pressing the Alt key (12) so that the LED in its pushbutton is illuminated. Then press the "TBD" key with "TBD" marked above it. The TBD lightbar will be illuminated and the LED in the Alt key will extinguish. The currently selected operating mode is resumed.

To exit the Alternate-Gain mode repeat the Alt key and TBD key sequence.

The Alternate-Gain mode is selectable in remote and downconverter modes.

### 3.7.1.4 Alternative Bandwidth Set

More bandwidths can be selected than the set that is normally available. To make all of them available first press the "Alt" key (12) so that the LED in the Alt pushbutton is illuminated. Then press the "." key with the "ALT BW" legend marked above it. All of the settable bandwidths will now be available in order, using the bandwidth up and down arrow buttons. To resume using the limited bandwidth selection mode, repeat the selection operation.

All bandwidths are available in remote mode, and as usual the bandwidth up and down arrow buttons are disabled. If the enhanced mode is enabled prior to transition to remote, it will still be enabled when the remote mode is exited. Operations are normal in the downconverter mode.

### 3.7.1.5 Store Settings

To store the current front panel settings, first press the Alt (12) key so that the LED in the Alt pushbutton is illuminated. Then press the "M" key with "STO" marked above it. Finally, press a digit key to indicate the memory location to be used for storage. The following settings will be stored in non-volatile memory:

- Current tuned frequency
- Stored start frequency (normally volatile)
- Stored stop frequency (normally volatile)
- Stored step size (normally volatile)
- Stored step rate (normally volatile)
- Current input selection
- Current input attenuation (auto mode ignored)
- Current gain setting
- Current bandwidth
- Current AGC setting
- Current gain mode
- Current bandwidth mode
- Current slideback on/off state (not the adjustment)
- Current pulse stretch on/off state (not the adjustment)
- Current BFO on/off state (not the adjustment)
- Current Z axis on/off and invert states (not the adjustment)
- Current log/lin detector selection
- Current display brightness selection
- Current IEEE-488 address selection

The following are NOT stored:

- Slideback threshold setting
- Pulse stretch adjustment
- BFO frequency adjustment
- Z axis output amplitude adjustment
- Audio output amplitude adjustment
- Beep amplitude

Once the operation has been completed the LED in the Alt key will go out and the keypad/display will resume their previously selected operating mode.

### 3.7.1.6 Recall Settings

This does the opposite of the preceding function. The stored settings are recalled and set into the receiver. The operator first presses the Alt (12) key so that the LED in the Alt pushbutton is illuminated. The operator then presses the "K" key with "RCL" marked above it, and finally the digit key which indicates the memory location where the settings were stored. The stored settings are then recalled, the displays are updated, and the settings are applied to the receiver hardware. The list of settings recalled is the same list as were stored, as described in the preceding section.



Once the operation has been completed the LED in the Alt key will go out and the keypad/display will resume their previously selected operating mode.

### **3.7.1.7 Scan Operations**

The Scan Mode encompasses five separate modes: Start, Stop, Step, Rate, and Scan. The Step mode is also utilized in conjunction with the Tune mode, discussed above. The Scan-related modes are discussed below.

#### **3.7.1.7.1 Start Mode**

Start mode is used to enter one of the scan parameters, the scan start frequency. Other required parameters are the stop frequency, the step size, and the step rate. To enter start mode first press the Alt key so that the LED in the pushbutton is illuminated. Then press the key with "START" marked above it. The display will be updated with the last stored start frequency. The keypad digit and terminator keys may now be used to enter any start frequency from 1 KHz to 1 GHz. Entry of frequencies via the keypad is covered in a previous section.

The entered frequency will be stored for use by scan mode. It is stored in non-volatile memory by the store command.

This mode is executed until another operating mode (stop, step, rate, scan, tune, bright, beep, address, remote or test) is selected.

#### **3.7.1.7.2 Stop Mode**

Stop mode is used to enter one of the scan parameters, the scan stop frequency. It is entered just like the start frequency described in the section above, with the same range limits (1 KHz to 1 GHz) except that the key with "STOP" marked above it is pressed to enter the mode (after the Alt key is pressed) and the "STOP" lightbar is illuminated. Note that the stop frequency need not be higher than the start frequency. If it is lower then the scan using those parameters will proceed from the higher to the lower frequency (actually, scans can go in either direction anyway, either from start to stop or vice versa, so the order in which the limits are entered really doesn't matter a whole lot).

The entered frequency will be stored for use by scan mode. It is stored in non-volatile memory by the store command.

This mode is executed until another operating mode (start, step, rate, scan, tune, bright, beep, address, remote, or test) is selected.

### **3.7.1.7.3 Step Mode**

Step mode is used to enter one of the scan/tune parameters, the step size, which is the number of Hz the tuned frequency is incremented or decremented for each scanning or tuning step. It is entered just like the start and stop frequencies described in the preceding sections, but with different limits (1 Hz to 1 GHz), and with the exceptions that the key with "STEP" marked above it is pressed to enter the mode (after pressing the Alt key) and the "STEP" lightbar is illuminated.

The entered frequency will be stored for use by both scan mode and tune mode. It is stored in non-volatile memory by the store command.

This mode is executed until another operating mode (start, stop, rate, scan, tune, bright, beep, address, remote, or test) is selected.

### **3.7.1.7.4 Rate Mode**

Rate mode is used to enter one of the scan parameters, the step rate, which is number of times per second that a scan step is executed. It is entered just like the start, stop, and step frequencies described in the preceding sections, but with different limits (.01 - 10 steps per second calibrated, around 100 steps per second maximum), and with the exceptions that the "5" key with "RATE" marked above it is pressed to enter the mode and that the "RATE" lightbar (26) is illuminated. If a value of 0 is entered then the "maximum rate" option is selected and the scan will proceed at whatever rate the microprocessor is capable of. This rate is neither calibrated nor necessarily constant over the duration of the scan. The X axis output will still track it, however.

The entered rate will be stored for use by the scan mode. It will be stored in non-volatile memory by the store command.

This mode is executed until another operating mode (start, stop, step, scan, tune, bright, beep, address, remote, or test) is selected.

### **3.7.1.7.5 Scan Mode**

Scan mode is used to automatically step from one frequency to another, using preselected values for start frequency, stop frequency, step size, and step rate. All of these are initialized to default values at powerup, but it is usually desirable to set each of them in their respective entry operating modes before entering scan mode.

Scan mode is entered by pressing the Alt (12) key so that the LED in the pushbutton is illuminated and then pressing the "8" key with "SCAN" marked above it. This will cause the "SCAN" lightbar (26) to be illuminated while the LED in the Alt key goes out.

In this mode the three tune/scan control keys (13a,b,c) are used to control the scan, or the tuning controls (tuning knob (27), up and down arrow keys (14)) can be used to step the frequency manually. To do it automatically, the right arrow key (13c) can be pressed to execute the scan from the start frequency to the stop frequency. Alternatively, the left arrow key (13a) can be used to execute the scan from the stop frequency to the start frequency. For each step the stored step size will be added to or subtracted from the current frequency. Pressing the right or left arrow key to start a scan will cause the LED in the pressed pushbutton to be illuminated to indicate the selection.

The pause key (13b) can be used to halt the scan at any point. The right and left arrow keys can then be used to restart it in the desired direction, or the pause key can be pressed again to continue the scan in the original direction, whichever it was. When the pause key is pressed to halt a scan, the LED in the pushbutton is illuminated.

Pressing the right or left arrow key once from the halted condition will cause a scan to be executed at the preset scan rate. Pressing one of these keys while the scan is executing will affect the scan rate. For instance, if the scan is running upward (start to stop) and the right arrow key is pressed again, then the scan rate will approximately double. This will happen every time the right arrow key is pressed until the microprocessor's limit is reached. Note that only the base rate is calibrated, however. Alternatively, if the scan is running upward and the left arrow key is pressed, then the scan rate will be approximately halved. This too will continue until the timer generating the scan rate runs out of bits. Again, only the base rate is calibrated. If the pause key is hit while executing one of these adjusted rates, then the adjusted rate will be recalled when the scan is resumed.

In scan mode the tuning display always indicates the currently tuned frequency.

Normally the scan proceeds from one limit frequency to the other and then stops. It is possible to make the scan operate in two different ways. In one mode the scan runs from one limit to the other and then automatically starts over. In the other mode the scan runs from one limit to the other and then continues back the other way. To enter the first mode, press the "M" key before or during the scan. To enter the second mode, press the "G" key before or during the scan. To revert to the normal operating mode, press the "H" key before or during the scan.

If you are in the middle of a scan and want to start over, press the "C" key on the keypad. This will reset the scan to its starting conditions (except that currently tuned frequency will remain at whatever it was when the scan was cleared, until the scan is started again).

When the scan is running the tuning controls (tuning knob, up and down arrow keys) are disabled. However, before or after the scan, or during a pause, the tuning controls can be used to increment or decrement the tuned frequency by the amount of the stored step size. This is convenient, because the operator can buzz past something interesting during a scan, hit the pause button, and then tune back manually with the knob to check it out. Tuning in this mode is similar to tuning in tune mode with stored step size selected as the increment/decrement value. You can go beyond the preset scan limits if you haven't started the scan yet, but during a pause these limits are in force. If the attempt is made then the step that would put it past the limit is rejected and a beep sounded on the front panel and at the audio output.

This mode is executed until another operating mode (start, stop, step, scan, tune, bright, beep, address, remote, or test) is selected. If a scan is in progress at the time then it will be terminated.

In this mode the three tune/scan control keys (13a,b,c) are used to control the scan, or the tuning controls (tuning knob (27), up and down arrow keys (14)) can be used to step the frequency manually. To do it automatically, the right arrow key (13c) can be pressed to execute the scan from the start frequency to the stop frequency. Alternatively, the left arrow key (13a) can be used to execute the scan from the stop frequency to the start frequency. For each step the stored step size will be added to or subtracted from the current frequency. Pressing the right or left arrow key to start a scan will cause the LED in the pressed pushbutton to be illuminated to indicate the selection.

The pause key (13b) can be used to halt the scan at any point. The right and left arrow keys can then be used to restart it in the desired direction, or the pause key can be pressed again to continue the scan in the original direction, whichever it was. When the pause key is pressed to halt a scan, the LED in the pushbutton is illuminated.

Pressing the right or left arrow key once from the halted condition will cause a scan to be executed at the preset scan rate. Pressing one of these keys while the scan is executing will affect the scan rate. For instance, if the scan is running upward (start to stop) and the right arrow key is pressed again, then the scan rate will approximately double. This will happen every time the right arrow key is pressed until the microprocessor's limit is reached. Note that only the base rate is calibrated, however. Alternatively, if the scan is running upward and the left arrow key is pressed, then the scan rate will be approximately halved. This too will continue until the timer generating the scan rate runs out of bits. Again, only the base rate is calibrated. If the pause key is hit while executing one of these adjusted rates, then the adjusted rate will be recalled when the scan is resumed.

In scan mode the tuning display always indicates the currently tuned frequency.

Normally the scan proceeds from one limit frequency to the other and then stops. It is possible to make the scan operate in two different ways. In one mode the scan runs from one limit to the other and then automatically starts over. In the other mode the scan runs from one limit to the other and then continues back the other way. To enter the first mode, press the "M" key before or during the scan. To enter the second mode, press the "G" key before or during the scan. To revert to the normal operating mode, press the "H" key before or during the scan.

If you are in the middle of a scan and want to start over, press the "C" key on the keypad. This will reset the scan to its starting conditions (except that currently tuned frequency will remain at whatever it was when the scan was cleared, until the scan is started again).

When the scan is running the tuning controls (tuning knob, up and down arrow keys) are disabled. However, before or after the scan, or during a pause, the tuning controls can be used to increment or decrement the tuned frequency by the amount of the stored step size. This is convenient, because the operator can buzz past something interesting during a scan, hit the pause button, and then tune back manually with the knob to check it out. Tuning in this mode is similar to tuning in tune mode with stored step size selected as the increment/decrement value. You can go beyond the preset scan limits if you haven't started the scan yet, but during a pause these limits are in force. If the attempt is made then the step that would put it past the limit is rejected and a beep sounded on the front panel and at the audio output.

This mode is executed until another operating mode (start, stop, step, scan, tune, bright, beep, address, remote, or test) is selected. If a scan is in progress at the time then it will be terminated.

### **3.7.1.8 AGC On/Off Toggle**

To set AGC (automatic gain control) on or off, first press the Alt (12) key so that the LED in the Alt pushbutton is illuminated. Then press the "H" key with "AGC" marked above it. There is an associated lightbar (25) marked "AGC". Pressing the button will cause AGC to be enabled and the lightbar to be illuminated if it was off before, or will cause AGC to be disabled and the lightbar to be extinguished if it was on before. Once the AGC button is pushed the LED in the Alt key will go out and the keypad will resume its previously selected operation.

AGC is allowed in remote mode, but is not normally used. When a change in AGC selection is made in remote mode the lightbar is updated to show the change. Changes made in remote mode are maintained upon exiting to local, until the operator uses the keypad to change its selection.

### **3.7.1.9 IEEE-488 Address Display/Selection**

The currently selected bus address can be displayed by pressing the Alt (12) key so that the LED in the pushbutton is illuminated and then pressing the "2" key with "ADDR" marked above it. The lightbar marked "ADDR" will be illuminated while the LED in the Alt key will go out. The currently selected address will be shown on the tuning display. Note that this value can range from 0 - 31 and is automatically set to the setting of a dipswitch on the processor board every time the receiver is powered up.

Once the address is displayed the tuning arrow keys can be used to increment or decrement it. Pressing the up arrow key will increment it while pressing the down arrow key will decrement it. The tuning knob may also be used to perform the selection but it is not as convenient. The operator must be sure not to choose an address occupied by another instrument on the bus. When the operator attempts to select an address beyond 0 or 31 the address will remain at the limit value and a beep will sound on the front panel and at the audio output.

This mode will be executed until another operating mode is selected (start, stop, step, rate, scan, tune, bright, beep, remote, or test).

### **3.7.1.10 Display Brightness Selection**

The alphanumeric displays are capable of four brightness levels, one of which is "off". To change the current brightness setting, press the Alt (12) key so that the LED located in the pushbutton is illuminated. Then press the "9" key with "BRIGHT" marked above it. The "BRIGHT" lightbar will be illuminated while the LED in the Alt key goes out. The tuning display will continue to indicate whatever was there before. The tuning arrow keys may then be used to increment or decrement the brightness selection of all of the alphanumeric displays simultaneously. Unlike most functions, the selection here wraps around, so that the selection using the up arrow key is, starting at the bright selection, off, dim, medium, and bright, and repeat. Using the down arrow key it is the other way around. The tuning knob may also be used to perform the selection, but it is not as convenient.

The mode will be executed until another operating mode is executed (start, stop, step, rate, scan, tune, beep, address, remote, or test).

### **3.7.1.11 Audio Output Beep Level Adjustment**

To adjust the audio output beep level, first press the Alt key (12). The LED in the button will illuminate. Then press the "6" keypad key with the "BEEP" label above it. The light bar marked "BEEP" (26) will illuminate and the LED in the Alt key will go out. As with all of the "Alt" functions, the tuning arrow keys (14) may now be used to increase or decrease the beep amplitude. Pressing the up arrow key will produce a beep at the next higher amplitude level so the operator can determine a comfortable level for the current headphones/speaker in use. Pressing the down arrow key will produce a beep at the next lower amplitude level. Rotation of the tuning control (27) will have the same effect. A total of 128 steps cover the full range. When either end of the available adjustment range is reached the beep amplitude will stay at that limit. The last level set will be stored and remembered.

The mode will be executed until another operating mode is executed (start, stop, step, rate, scan, tune, beep, address, remote, or test).

### **3.7.1.12 Reset the Receiver**

To reset the receiver, first press the Alt (12) key so that the LED in the pushbutton is illuminated. Then press the "C" key with "RESET" marked above it. The receiver will be reset to its power-on settings. This will get the receiver out of an IEEE-488 hang-up but not an internal processor hang-up. If a processor hang-up is encountered then it will be necessary to turn off the receiver unless the top cover happens to be off of the receiver. In that case a reset button is available under the switch access cover in the top of the shield behind the front panel.

Once the operation has been completed the LED in the Alt key will go out and the receiver will enter its powerup operating mode, which is tune mode.

### **3.7.1.13 Test Mode**

The Test mode is executed automatically on powerup. The displays are cycled and the processor memory is checked. If the memory is OK then the receiver enters the tune mode to complete the powerup cycle. Note that this cycle can be re-run at any time via the reset function.

## **3.7.2 AM Slideback Controls and Indicators (optional)**

The optional AM slideback function is a threshold gate in the AM detector. The slideback potentiometer (32) sets a threshold level, so that signals above this level cause the associated "THRESH" lightbar (25) to light, while signals below the set level do not. In use the radio is tuned to a signal of interest and the slideback control is set to just detect its peaks. The signal can then be replaced by a calibrated, adjustable source and the source set to exactly the same level, using the "THRESH" indicator as a reference. This permits an accurate estimate of the strength of the signal of interest without requiring a perfectly calibrated radio.

A pushbutton (15) associated with the slideback function acts as an on/off switch. A LED indicator in the button indicates the current state. Press the button to enable slideback, press it again to disable it. The LED is illuminated when slideback is enabled.

Slideback is not a remotely settable function. However, it is automatically disabled when the transition to remote is made. It stays off when remote is exited, so the operator must then push the

button to re-enable it, if it is desirable to do so. The button is disabled in remote mode. Operations are normal in the downconverter mode.

### **3.7.3 Pulse Stretch Controls and Indicator (optional)**

The optional pulse stretch function, as its name implies, stretches narrow pulses while maintaining their amplitude, in order to make them easier to detect. The Pulse Stretch potentiometer (33) adjusts the amount of stretching. All inputs receive the selected amount of stretching, not just narrow pulses, but on all but narrow pulses the effect is negligible.

An associated pushbutton (16) acts as an on/off switch. A LED indicator located in the button indicates the current state. Press the button to enable pulse stretching, press it again to disable it. The LED is illuminated when pulse stretching is enabled.

Pulse stretch is not a remotely settable function, and is automatically disabled when the transition to remote is made. It stays off when the remote mode is terminated, so the operator must then push the button to re-enable it, if it is desirable to do so. The button is disabled in remote mode. Operations are normal in the downconverter mode.

## **4. TEST AND INSPECTION**

### **4.1 Introduction**

The tests outlined below will verify that the receiver is functioning properly. The test sequence consists of applying either a CW signal or a modulated input signal to the receiver and monitoring the output while activating each appropriate front panel function to determine proper operation.

### **4.2 Test Equipment**

The test equipment required for the tests are listed in Table 4-1. Equipment with compatible specifications may be substituted.

### **4.3 Data Sheet**

A sample of the data sheet to be used with the tests is shown in Figure 4-1. The data sheet includes acceptable test limits.

### **4.4 Performance Test**

The performance test sequence requires the utilization of the specific items of test equipment, listed in Table 4-1, connected to the receiver as shown in Figure 4-2.

Connect the test equipment and set the controls as outlined in the following paragraphs. If a receiver junction is inoperable or out of tolerance, then locate the malfunction from the list in Section 6, which will direct the operator to the applicable fault isolation procedure.

- a. Connect a signal generator to the desired receiver input connector.
- b. Set the signal generator for a frequency within the range of the desired band, at an output level of -20 dBm.
- c. Set the signal generator for modulation with a frequency of 1000 Hz adjusted to modulate at 30% of the carrier level.
- d. Connect a spectrum analyzer to the desired monitor point depending on the type of input signal selected. For audio output signals, connect an audio monitor to the appropriate output jack.
- e. Verify that the receiver functions are operational based on the frequency range and mode selected. For instructions regarding receiver operation, refer to the Chapter 3 of this manual.
- f. A complete performance test consists of providing input signals within the frequency range of each band (1 - 3), using each type of carrier (CW and AM), and checking each control, selector, or indicator associated with the applied signal.



**Table 4-1 Test Equipment**

<b>Instrument</b>	<b>Specifications</b>	<b>Make, Model</b>
Signal Generator	10 Hz - 1280 MHz AM, CW	Hewlett Packard 8662A
RMS Voltmeter	30 $\mu$ V - 3 V.F.S. 10 KHz - 2 GHz	Racal-Dana 9303
Spectrum Analyzer	10 KHz - 1.8 GHz	Tektronix 7L14
Oscilloscope	300 MHz BW	Tektronix 2465
Frequency Counter	10 Hz - 3 GHz	Hewlett Packard 5386A
Microwave Power Meter	10 $\mu$ W - 10 mW F.S.	Hewlett Packard 432B
Digital Multimeter	0 - 1000 vdc 0 - 2 Amp dc 0 - 750 vac rms 0 - 2 Amp ac rms 0 - 20 Mohm	Fluke 8012A

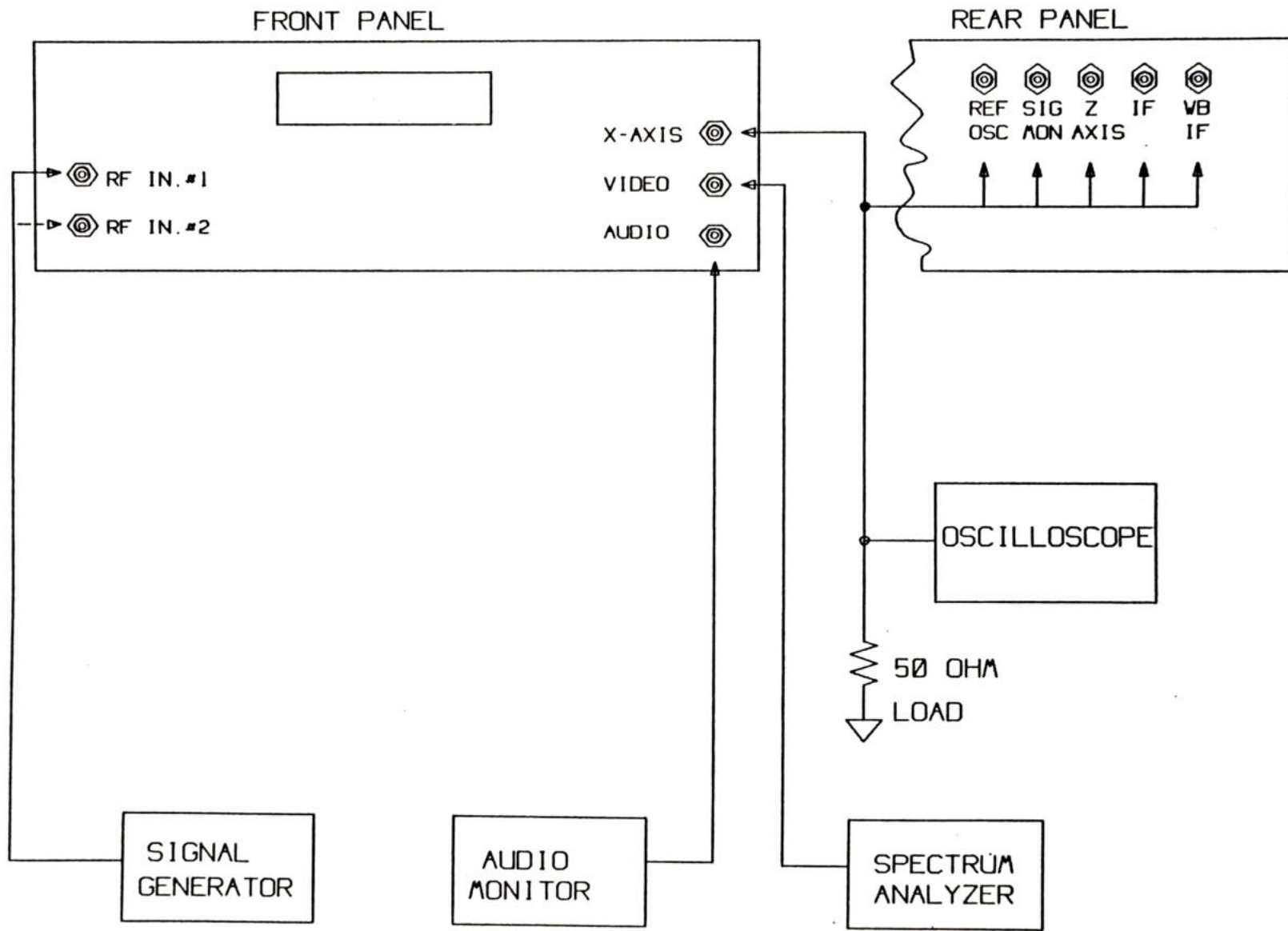


FIGURE 4-2 TEST EQUIPMENT CONNECTION

## 5. PRINCIPLES OF OPERATION

### 5.1 Introduction

The model R-110 is a wide range superheterodyne receiver that is continuously tunable, covering the frequency range from 1 KHz to 1 GHz in three bands. The receiver detects RF signals in the form of continuous wave (CW) or modulated carriers.

The major sections of the receiver and their functions are:

- |              |   |   |
|--------------|---|---|
| RF           | - | Processes RF inputs; converts to 21.4 MHz IF; implemented with three modules plus front-panel components  |
| IF           | - | Performs bandpass filtering and AGC; consists of two modules (IF1 and IF2)  |
| DC IF        | - | Performs narrow-band filtering; implemented on single board   |
| Video        | - | Detects IF; provides buffered video and audio outputs; implemented on single board. Optional pulse stretch and slide-back available on second board |
| Synthesizer  | - | Provides LO signals for frequency conversion; consists of three boards plus components in RF section  |
| Control      | - | Controls operation of all modules; includes front panel; contained in front panel assembly  |
| Power Supply | - | Provides regulated power to receiver circuits (uses linear design to minimize EMI); contained in rear panel assembly                                |

The simplified block diagram of Figure 5-1 shows how the sections are interconnected (a detailed block diagram is included in Section 7). The RF Section uses three signal paths that divide the input range into specific frequency bands. The paths contain mixer circuits used to heterodyne the tuned input signal to the 21.4 MHz intermediate frequency. The IF Section provides amplification and selectable bandpass filtering. For the wider bandwidths, the IF Section's output is routed to the Detector Section which provides the audio and video output signals. For narrow bandwidths, the IF signal goes to the DC-IF Section where it is processed and detected.

The Synthesizer Section utilizes precision direct-digital-synthesis (DDS) and phase-locked-loop (PLL) circuits to create the required local oscillator signals, thus providing accurate frequency control and high resolution.

The power supply section of the receiver provides individually regulated DC voltages from a selection of six ranges of AC input power.

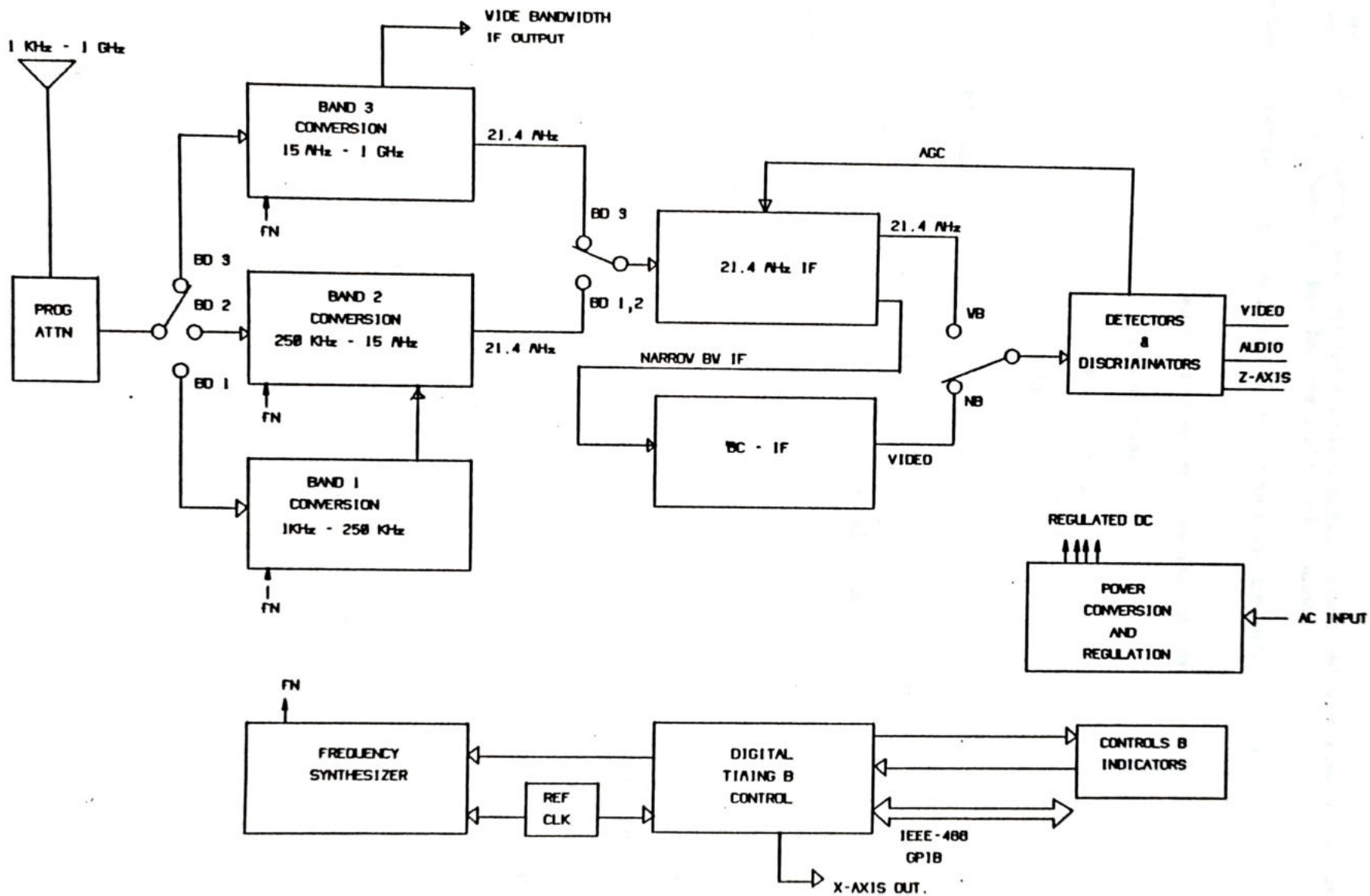


FIGURE 5-1 R-110 RECEIVER BLOCK DIAGRAM

## 5.2 RF Section

The RF Section is made up of the RF front-end components (contained in the Front Panel Assembly), the RF Preselector board, the MW Module, and the LF Module.

The three conversion stages used to cover the tuning range are listed in Table 5-1.

**Table 5-1 Receiver Frequency Bands**

<b>Band</b>	<b>Tuning Range</b>
1	1 KHz - 250 KHz
2	250 KHz - 15 MHz
3	15 MHz - 1 GHz

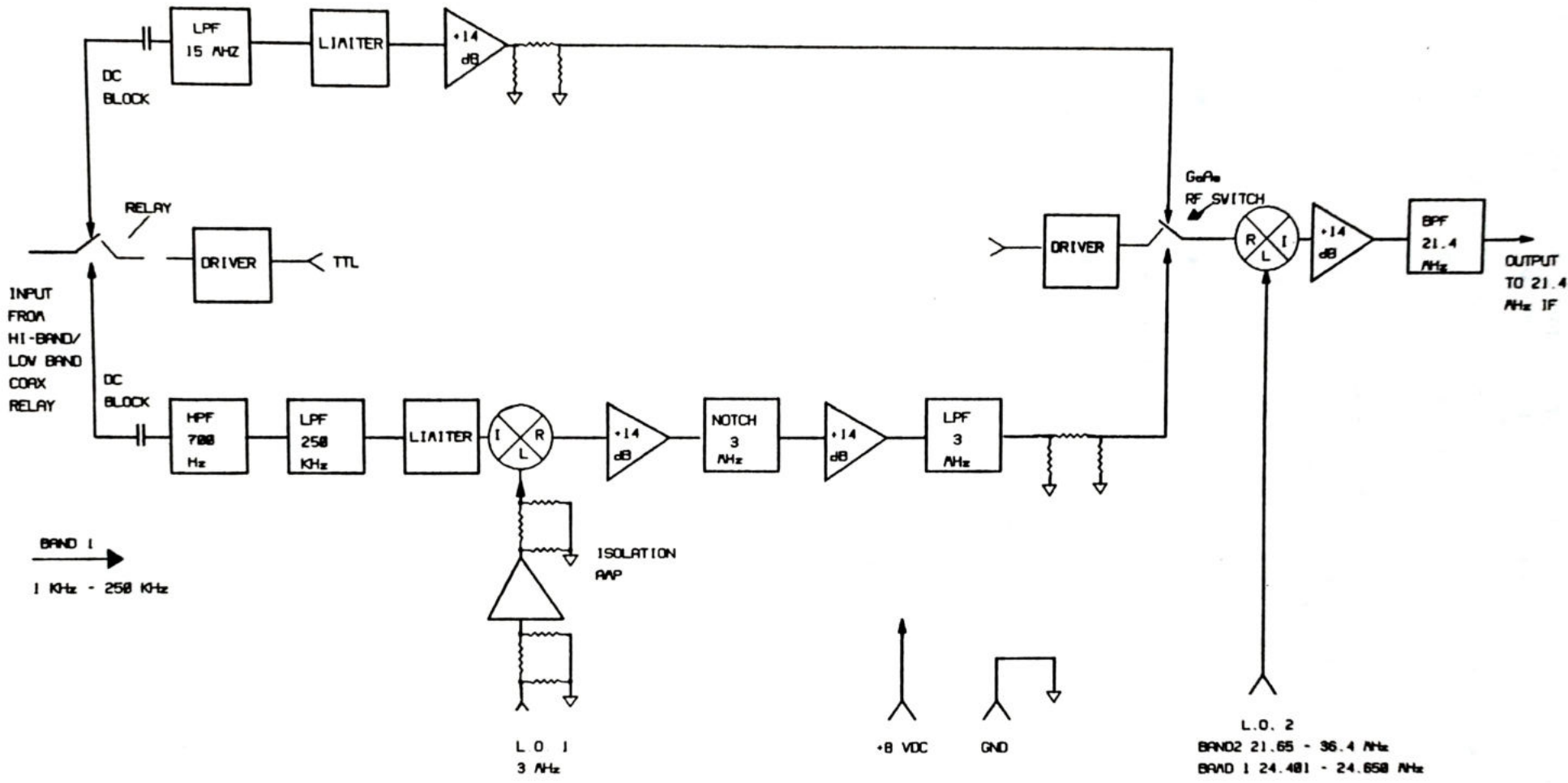
### 5.2.1 RF Front-End

There are two signal inputs to the receiver: RF Input #1 and RF Input #2. The two inputs are received with BNC connectors; these are connected to a latching RF relay (K\*) which performs selection between them. The relay is actuated by a pulse command from the Control Section. The output of the relay is connected to a programmable attenuator, AT\*, which ranges from 0 - 70 dB in 10 dB steps. The attenuator's output is routed to the appropriate conversion stage by another RF relay which set according to the tuned frequency.

### 5.2.2 Band 1 and 2 Processing

Band 1 and 2 signals go to the LF Module for processing and conversion. Figure 5-2 is a simplified schematic of the module showing the circuit functions and the LO frequencies utilized. Band 1 signals are converted to the 21.4 MHz intermediate frequency using two mixer stages. The first mixer is an up-converter that produces the sum of the band 1 received frequency and a 3 MHz LO signal. The first mixer stage output is routed to a second converter where it is mixed with a variable LO to produce the fixed 21.4 MHz intermediate frequency. This second converter is shared by both Band 1 and Band 2. Band 2 signals are processed using a single up-conversion stage. The signals are amplified, filtered, and then up-converted to the 21.4 MHz intermediate frequency.

The LF Module is implemented with a latching RF relay which selects Band 1 or Band 2 signals depending on the tuned frequency. The Band 1 signal goes to a 1 KHz high-pass pass filter which attenuates power-line-related noise, and then to a limiter for protection against transient spikes. The output of the limiter is amplified and filtered, and then drives a double-balanced mixer. The other input of the mixer is fed by a 3 MHz fixed frequency LO from the Synthesizer Section. Since the mixer is used for up-conversion, the mixer input connections are reversed from the usual practice in order to allow the low frequency portions of the Band 1 tuning range to pass through.



The output of the mixer feeds an amplifier which has two outputs. One supplies the Band 1 overload detector circuit and the other drives a bandpass filter and a 3 MHz crystal notch filter circuit which is used to suppress the local oscillator frequency component coming from the mixer. The bandpass filter passes frequencies from 3 MHz to 3.25 MHz, suppressing the difference output of the mixer while retaining the sum. The output signal at this point is not IF yet: it is merely the Band 1 input range, up-converted.

The signal then goes to a GaAs FET switch which feeds one input of another double-balanced mixer. The other input of the mixer is driven by a 24.2 to 24.65 MHz local oscillator signal which provides frequency tuning for Band 1. The output of the mixer feeds an amplifier and a low pass filter, which suppresses everything but the difference signal, thus producing a 21.4 MHz IF frequency signal.

### 5.2.3 Band 3 Processing

Band 3 circuitry is contained in the MW Module. Figure 5-3 is a block diagram of this module. The Band 3 signal from the front-end first passes through a high-pass filter located on the Preselector board. The filtered signal then goes to the MW Module. The RF module processes frequencies in Band 3, using up-conversion to a 1450 MHz IF stage, and two downconversions (550 MHz and 21.4 MHz) to provide the 21.4 MHz IF output. A wide bandwidth 1450 MHz IF signal is also provided from the module for external processing. The MW Module contains portions of the synthesizer circuitry, as indicated in Figure 5-2.

When the signal enters the MW Module it passes through a wideband limiter (A1) for protection against transient spikes, and drives an amplifier (A2U1) with wide dynamic range and a low noise figure. The amplifier's output goes to a double-balanced mixer (A2U2) for up-conversion. A stepped local oscillator (A2U3) and a buffer amplifier (A2U4) supply the 1470 - 2450 MHz LO to the mixer; the LO steps in 5 MHz increments as the receiver is tuned. The mixer produces a 1450 MHz (nominal) IF signal. This signal goes to a GaAs FET switch (A2K1) which switch routes the 1450 MHz IF signal to either the next conversion stage or to a connector at the rear of the receiver for external use. During normal operation, the output of the switch goes through a 1450 MHz bandpass filter (A3) to an amplifier (A4U1), and then to mixer A4U2.

A 2 GHz fixed LO signal developed by a fixed-frequency oscillator (A4U3) and buffered by amplifier A4R3 drives mixer A4U2, which mixes the two signals to produce a 550 MHz difference frequency. This signal passes through a 550 MHz bandpass filter (A5), is amplified by A6U1, and goes to mixer A6U2. A 528.6 to 533.6 MHz variable LO signal from VCO A6U4 drives mixer A6U2. The mixer produces an output difference frequency of 21.4 MHz which is routed to the IF section.

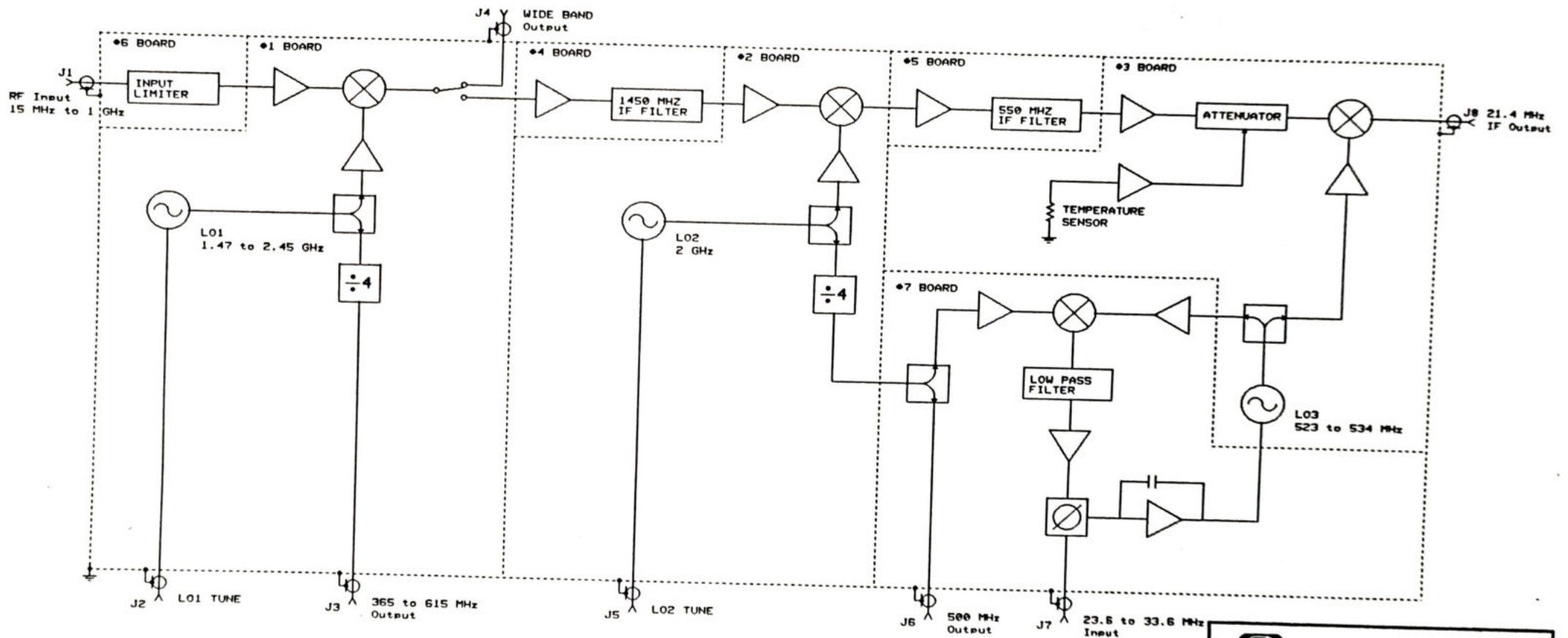



FIGURE 5-3

 <b>Dynamic Sciences, Inc</b>			
<b>MW MODULE BLOCK DIAGRAM</b>			
D	CODE INENT 6-1962	DWG NO 4935XX	REV X1
DATE: Feb 9 1990		SHEET 1 OF 1	



### 5.3 IF Section

The IF Section is implemented with two modules IF1 (A6) and IF2 (A8). Figure 5-4 is a schematic of the section. The following discussion will be based on this diagram.

The signal path in the IF section begins with the IF1 module. The 21.4 MHz IF signal inputs are received from the LF Module and the MW Module. A GaAs FET switch (S1) at the input selects either the Band 1-2 or Band 3 IF signals. The output of the switch goes to a low-noise, wide-dynamic-range, two-stage amplifier. The output of this amplifier is monitored by the first 21.4 MHz IF overload detector. This signal is used to derive the control signals for the auto-attenuation function, and eventually to drive the front panel front-end overload indicator (RF OVL) and rear panel status line. The amplifier also drives the first 21.4 MHz AGC circuit through a gain-setting pad.

There are three stages of AGC; three stages are used in order to preserve the sensitivity and dynamic range of the receiver. The first AGC circuit consists of an attenuator which is controlled by a voltage developed by the Video Section (A1A9 board). The output of the first AGC circuit supplies an input signal to an amplifier, which in turn drives a power splitter; one output of the splitter goes to the second AGC circuit (the other output goes to the Signal Monitor connector on the rear panel of the receiver, allowing monitoring of the 21.4 MHz IF signal prior to bandpass filtering).

The second AGC circuit is similar in design to the first, and is also controlled by the video board, although not by the same signal that controls the first AGC stage. This AGC circuit supplies the input signal to another amplifier, which drives the five 21.4 MHz IF bandwidth filters and the second IF overload detector.

This overload detector passes the IF signal through a transformer to a full-wave peak detector. This detector's output voltage is compared with a DC reference set by a potentiometer. When the detected signal exceeds the reference, the output of the comparator triggers a one-shot which produces a pulse of about 25 milliseconds. Thus, no matter how short the duration of the signal that caused the overload may have been, the detector output will always generate at least a 25 millisecond pulse to indicate it. This output is sent to the control/status connector on the rear panel of the receiver, and is intended for use with automated systems.

The prototype receiver contains four bandwidth filters (provisions are included for expansion) with bandwidths ranging from 300 KHz to 15 MHz. Each filter consists of a solid-state switch, amplifier, and the filter itself. The solid-state switches are used in lieu of relays for increased reliability. The control voltages for switches are supplied by the bus control circuitry which decodes commands from the Control Section. The gain of each filter stage is progressively reduced to compensate for the increase in noise that the increase in bandwidth allows. Attenuation increases at a rate of ten times the log of the bandwidth.

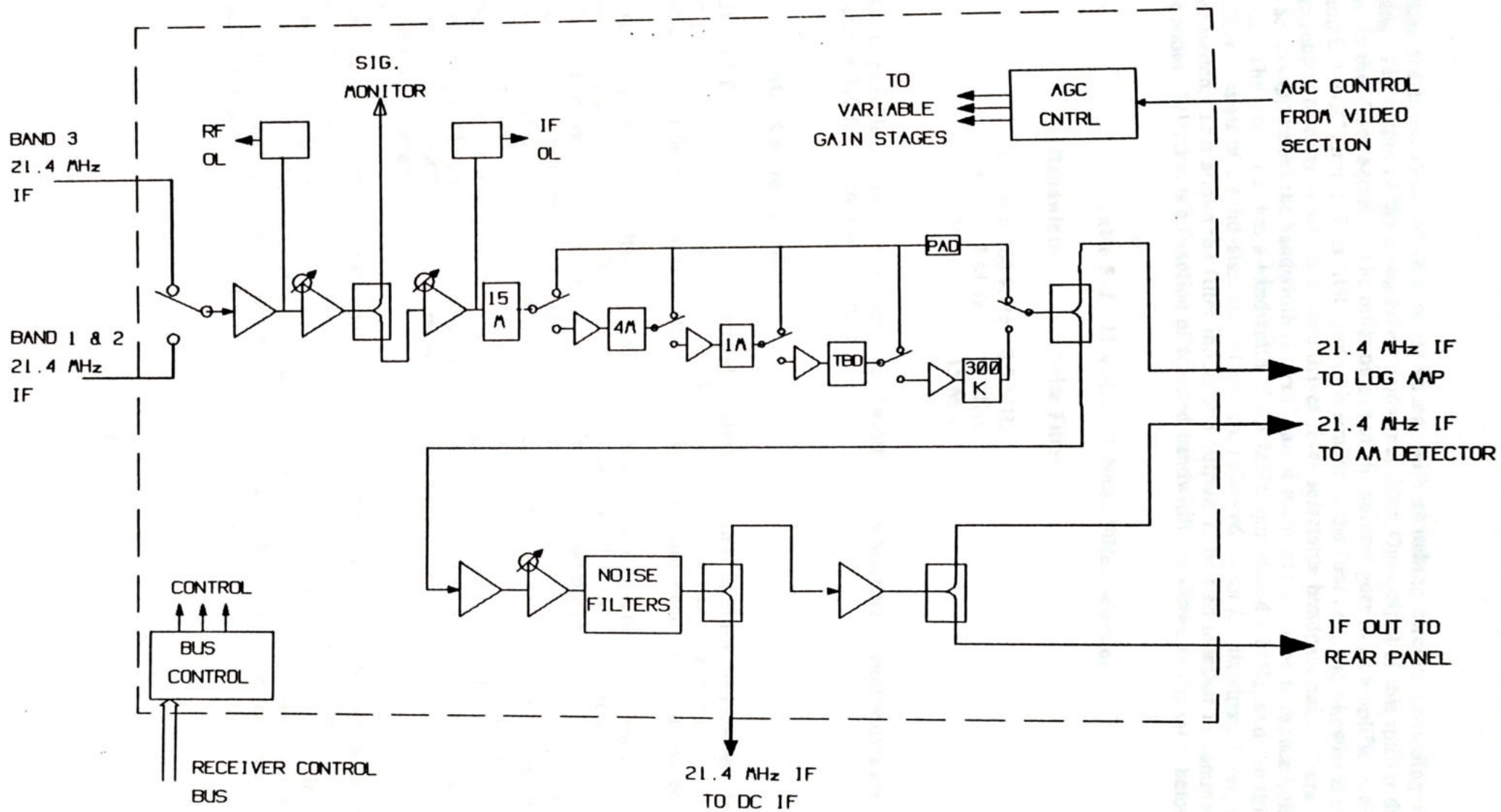


FIGURE 5-4 IF SECTION BLOCK DIAGRAM

The filter are interconnected in a series string, with switching circuits providing the required bypassing. The output of the string drives a power splitter. One output of this splitter drives the log detector in the Video Section. The other output of the splitter goes to an amplifier whic drives the third and last AGC circuit. This AGC circuit is similar to the first two, and likewise is controlled by the bus control circuits. is which in turn drives three selectable bandpass noise filters. These noise filters act to supplement the bandwidth filters ahead of them, and are used to reduce noise out of the passband. The first filter has a bandwidth of 0.8 MHz, the second 4 MHz, and the third 15 MHz. Each filter consists of a solid-state on/off switch, followed by an LC bandpass filter, followed by another switch. This allows the filter inputs and outputs to be tied together in common input and output nodes. Selection is a function of selected bandwidth, as shown in the table below.

**Table 5-2 21.4 MHz IF Noise Filter Selection**

<b>Bandwidth</b>	<b>Noise Filter</b>
Up thru 500 KHz	0.8 MHz
1 MHz - 2 MHz	4 MHz
5 - 15 MHz	15 MHz

The DC IF provides the receiver's narrow bandwidths, and when narrow bandwidths are selected, the IF Section's 300 KHz bandwidth is used.

### 5.3.1 AGC Control Circuit

TO BE REVISED: The AGC circuit provides automatic gain control for the receiver. In the remote mode power the AGC is disabled. The detected AM video signal from the Video Section, in conjunction with the receiver gain setting, controls the IF gain when AGC is activated.

The receiver gain control voltage is provided by the front-end gain control on the front panel or by a digital-to-analog converter (DAC) in the Control Section; the DAC is controlled by the IEEE-488 interface during remote mode operation. The gain voltage and the processed AM video voltage are summed so that the larger the output of the AM detector is, the more the front-end gain of the receiver is reduced. Since the output of the circuit is applied to PIN diode attenuators, the gain control voltage that is mixed with it is actually a control of attenuation as well, although there is a tendency to think of it as gain. The combined signals feed an amplifier which produces the AGC2 control voltage. The output of this amplifier also drives a second amplifier which produces the AGC1 control voltage. AGC2 drives the first AGC circuit in the IF section, and AGC1 drives the second and third AGC circuits.

Again, note that whereas the gain control provides a fixed bias to the PIN diode attenuators in the IF section to provide a fixed attenuation, or, in effect, a fixed gain, the AGC, when enabled, provides a variable attenuation which increases with increasing output from the AM detector circuitry. Also, while the gain control operates over a 50 dB range, the AGC range is only about 30 dB, so that if the AGC provides inadequate automatic adjustment of gain, then the gain control may be adjusted manually to accommodate additional control.

#### 5.4 DC IF Section

The DC IF Section provides narrow-bandwidth IF processing for the R-110 receiver. The DC IF is implemented on a single plug-in board and provides selectable filtering for bandwidths up to 100 KHz. Figure 5-5 is a block diagram of the DC IF.

The DC IF uses a set of programmable filters to replace the fixed LC and crystal filters normally used for narrowband IF filtering. The programmable filters are lowpass in nature, rather than the bandpass normally required, so it is necessary to employ processing prior to filtering.

The 21.4 MHz signal from the IF Section is converted down to baseband using a I-Q mixer and a 21.4 MHz local oscillator. Two outputs are taken from from the mixer, in quadrature. Since the two signals always differ in phase by  $90^\circ$ , their vector sum will reproduce the incoming signal at baseband.

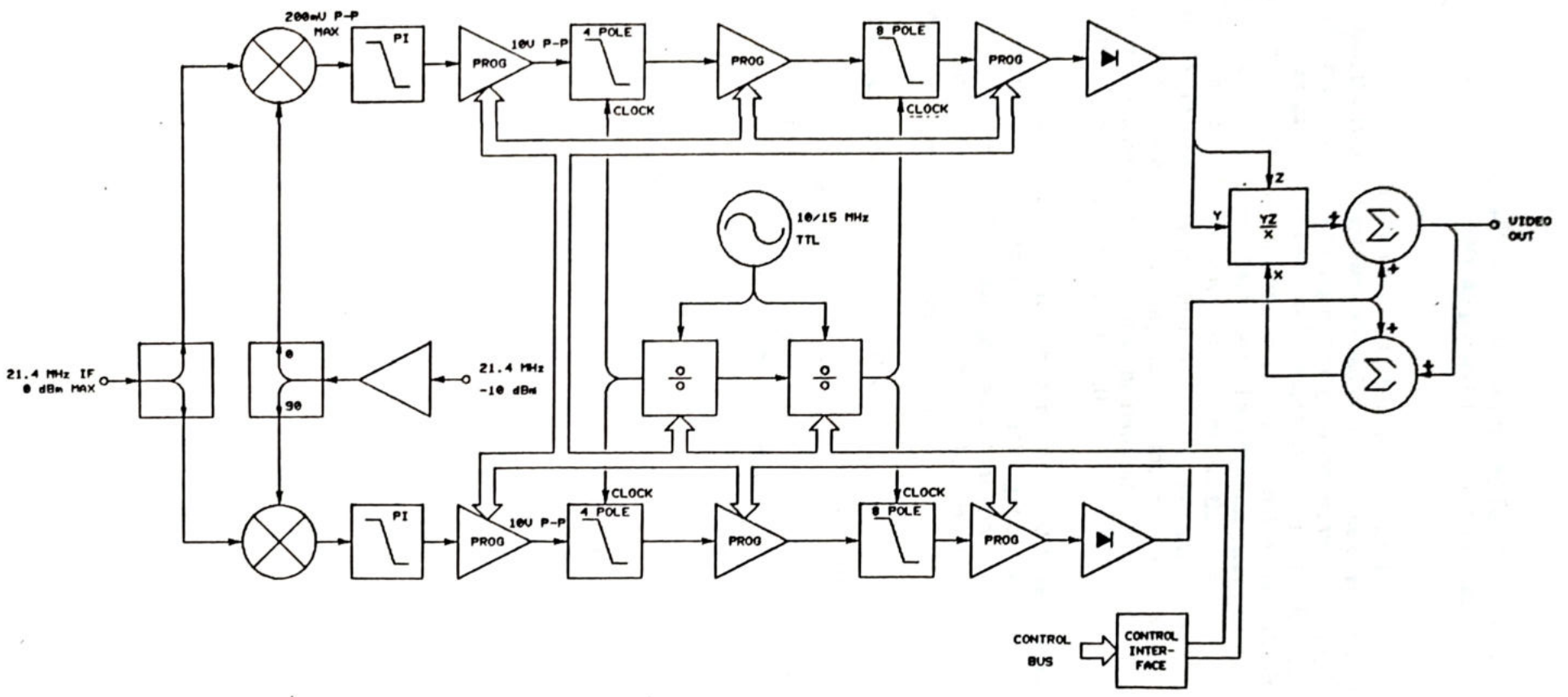


FIGURE 5-5 DC IF BLOCK DIAGRAM

The circuit consists of a mixer/quadrature splitter module, a preamp for the 21.4 MHz LO coming from the synthesizer section, and a pair of post-amplifiers to recover the amplitude lost coming through the mixer/splitter.

Each leg receives identical processing with tolerances maintained to within 1%, since any mismatch will show up as distortion when the two legs are recombined at the end the chain. The signal in each leg is passed through a pair of circuits, each consisting of an eighth-order, switched-capacitor lowpass filter followed by a programmable gain stage. The cutoff frequency of the filter depends on the clock rate supplied to it, whereas the gain of the following amplifier is settable via a 12 bit multiplying digital-to-analog converter (MDAC) in the feedback loop. Two of these circuits are used because a considerable amount of loss can occur for narrow bandwidths, so that for signal-to-noise ratio considerations it is necessary to filter partway and then recover the lost amplitude, and then repeat the process. This need can be seen when considering that the incoming bandwidth, which has a bandwidth of 150 KHz after conversion to baseband, may be reduced to below 500 Hz by the DCIF, and the resulting loss to an impulsive signal can exceed 60 dB.

The switched capacitor filters require a clock that is either 75 or 150 times the desired cutoff frequency. The same clock is applied to the matching filter in each leg, but the clocks to the first and second filter in each leg are separate. A timebase generator consisting of a phase-locked-loop referenced to the 21.4 MHz LO provides the two clocks. The timebase can produce clock frequencies allowing cutoff frequencies from above 50 KHz to below 50 Hz.

Following filtering and gain recovery the signals in the two legs must be recombined. This recombination must be performed as a vector sum, while maintaining a 60 dB SNR. An integrated circuit called an "analog processing unit" is used which contains log and antilog amplifiers; for vector summing an additional pair of opamps are used to form a feedback loop with the processing unit. The end result is to produce the square root of the sum of the squares of two inputs. A passive delay, buffered by a third opamp, is used to compensate for the propagation delay of one signal through the processing unit, versus the other which is fed through one side of the opamps.

The analog processing unit only accommodates positive-going signals. The signal in each leg is therefore full-wave rectified after gain recovery but before recombination. The precision rectifier circuit consists of a fast voltage-mode opamp with diodes in the feedback loops. This configuration eliminates the turn-on curve of the diodes but also produces positive and negative outputs with high and nonlinear impedance. The two outputs are buffered and then recombined using a current-mode opamp. A voltage mode amplifier is necessary for the rectification itself due to the fact that the feedback impedance is also nonlinear.

Overload detection is provided by means of comparators which sense the levels of the rectified signals in each leg of the DCIF. All comparator outputs are combined into a single overload line which drives both the combined IF/Video overload status line and a separate status line on the cardcage backplane.

## 5.5 Video Section

The Video Section is contained on a single board (A1A10) and provides AM linear and log detection, BFO, automatic gain control, and Z-axis output. The board outputs detected AM and detected BFO. The AM output feeds the optional pulse stretch and slideback circuits and the AGC circuits. The audio output goes to the front panel of the receiver, where it is buffered by the audio amplifier circuit for output to the audio jack. Figure 5-6 is a block diagram of the board.

Three inputs are used by the video board "IF-B" (the 21.4 MHz IF signal from first splitter in the IF Section), the final IF output "IF-A", and the DC-IF output signal. These signals are processed depending upon the combined modes of operation: wideband, narrowband, linear, and log. The modes are defined as follows:

Mode	Receiver Control Settings
Wideband	Bandwidths of 100KHz or larger
Narrowband	Bandwidths of 40KHz or less
Linear	Normal AM detection
Log	Logarithmic detection

The inputs are switched to the various circuits with three relays: K1, K2, and K3. K1 selects wideband or narrowband inputs for log amplification. K2 is the linear/log mode relay. K3 selects either wideband or narrowband video signals. The relays are activated as follows

Combined Mode	K1	K2	K3
Wideband-Linear	not energized	not energized	not energized
Narrowband-Linear	not energized	not energized	energized
Wideband-Log	energized	energized	not energized
Narrowband-Log	not energized	energized	not energized

**Wideband-Linear:** During wideband operation with linear detection, the IF-A signal is used (the output of the log amp is disabled by K2). The IF-A signal goes to the detector circuit where it is detected and buffered. The detected signal passes through K2's contacts to an envelop filter, and then through K3 to the video noise filters. The filtered signal then goes to the main video amplifier, where it is buffered, outputted to the front panel connector, and used to perform AGC, create the audio and Z-axis outputs, and used with the optional pulse stretch and slideback circuits.

**Narrowband-Linear:** In this mode the DC-IF signal is used rather than the 21.4 MHz IF signal. The DC-IF is a base-band signal and detection is not required, so the signal passes through K2 and K3 contacts directly to the video noise filter. Other functions are the same as in the Wideband-Linear mode.

**Wideband-Log:** For this mode the IF-B signal is used rather than the IF Section's main output (IF-A). This 21.4 MHz IF signal is tapped off of a middle stage in the IF Section because the final IF output has too much gain for log processing. The signal goes through K1's contacts to the log amplifier circuit, where it is detected and amplified. The amplified signal passes through K2 to the envelop filter, and then through K3 to the video noise filter.

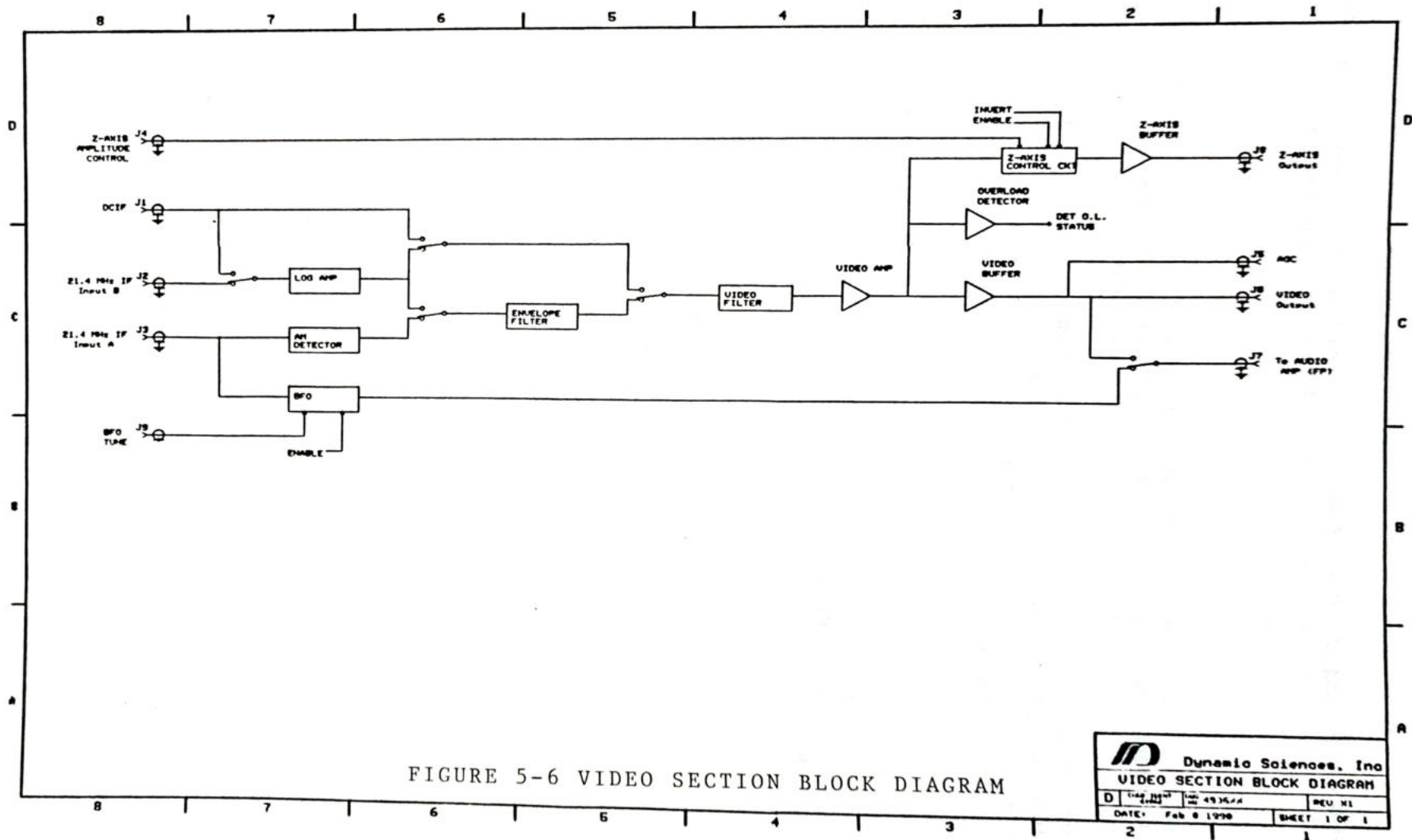



FIGURE 5-6 VIDEO SECTION BLOCK DIAGRAM

 <b>Dynamic Sciences, Inc</b>		
<b>VIDEO SECTION BLOCK DIAGRAM</b>		
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**Narrowband-Log:** The DC-IF signal is used. The signal goes through K1 to the log amp circuit, then through K2 to the envelop filter, and then through K3 to the video noise filter.

### 5.5.1 Detector Circuit

The detector circuit consists of a double-tuned RF amplifier stage and a rectifier diode, driving into the summing junction of a wide-band isolation amplifier. The amplifier provides temperature compensation and drives an asymmetrical eight-section low-pass envelope filter.

The detector circuit is based on transistor Q1 and diode CR1. Temperature compensation is provided by an unbypassed resistor on the emitter of Q1. Q1 and its associated components are supplied with 15 volts, yielding a large linear range. The AM detector output goes to amplifier U4, which is temperature compensated by diode CR2. The output is supplied to relay K2 and then envelop filtered before going to relay K3.

### 5.5.2 Video Amplifier and Noise Filters

The video amplifier's first stage drives the video noise filters. These are a set of programmable low pass filters consisting of a single-stage RC networks with selectable capacitors. Each capacitor provides a different cutoff frequency, stepped by an order of magnitude, and selected based on the currently selected bandwidth. The selection is as follows:

**Table 5-3 Video Filter Selection**

<b>Bandwidth</b>	<b>Filter Cutoff</b>
50 Hz - 2 KHz	3.8 KHz
5 KHz - 20 KHz	38 KHz
50 KHz - 200 KHz	380 KHz
500 KHz - 2 MHz	3.8 MHz
5 MHz - 15 MHz	(None)

The main video amplifier follows the noise filters and consists of three parts: a voltage amplifier followed by a current amplifier, and also another low-speed amplifier connected to provide offset stabilization for the main amplifier. The video amplifier drives several other parts of the board, mostly from the output of the current driver. One output, however, is taken from the output of the voltage amplifier. This is the output that drives the Z-axis output circuit. It was taken from the output of the voltage amplifier in order to take full advantage of its large bandwidth.

The current driver output of the main video amplifier also drives the AGC output to the IF Section, and the AM detector overload sensing circuit. The overload output is sent to the Control Section, where it is buffered to drive the front panel detector overload LED, and is placed in one of the bus readback status words.

### 5.5.3 Z-Axis Circuit

The Z-axis circuit provides an auxiliary output to enable Z-axis modulation of an X-Y display or oscilloscope. The signal from the video amplifier goes to a four-quadrant multiplier (U16), which is used as the control element for both level and polarity. Discrete signals from the Control Section activate the circuit and select the polarity. An analog signal from a potentiometer on the front panel sets the level. The differential outputs of the multiplier are fed to an op-amp for conversion to a single-ended output, and are buffered by a non-inverting unity-gain amplifier (U18) capable of driving 50 ohm loads.

### 5.5.4 BFO Detector Circuit

The BFO detector consists of a voltage-controlled crystal oscillator, centered at 21.4 MHz and tunable over a  $\pm 4$  KHz range. The oscillator is implemented with Q2, crystal Y1, and varactor diodes CR3 and 4. The varactor diodes allow fine frequency setting via the front panel BFO control. The oscillator is activated when the BFO switch on the front panel is selected, and is shut down when the receiver is in remote mode, using the remote status line. The output of the oscillator is coupled into double-balanced modulator U5 where it is mixed with the 21.4 MHz IF input (IF-A). The output of the modulator is the mixed product of the 21.4 MHz IF and the BFO oscillator frequency. This output is lightly low-pass filtered and then buffered by amplifier U6. The BFO output is supplied to the front panel audio circuit during BFO operation.

### 5.5.5 Optional Pulse Stretch and Slideback

The pulse stretch function extends the width of a short pulse. This is useful when pulses are small compared to the time between them, so that stretching them allows them to be more easily seen on an oscilloscope, or more easily heard through the audio output. There are two stages of pulse stretch, one in the AM video signal path and one in the audio signal path. The one in the video path is adjustable, whereas the one in the audio signal path is fixed. The audio signal path is picked off of the video after the video pulse stretch circuit, making video and audio pulse stretch additive.

The slideback function establishes a level against which the video signal is compared. If the video signal exceeds the threshold, then an indicator on the front panel illuminates. This is useful in establishing a limit reference for incoming signals. The limit may be set by connecting a CW source to one of the calibrate inputs of the receiver, setting it to a known value, and then setting the various receiver gain controls and the slideback control so that the indicator barely lights. This provides a known reference threshold for incoming signals, so that when a signal which is connected to one of the signal inputs of the receiver, with the same control settings, and it causes the indicator to light, then the incoming signal has exceeded the calibrated reference. Also, the circuit overlays this reference onto the input. This can act as a noise limiter at the audio output, since it is AC coupled, so that the only output that appears is only that which exceeds the reference, and anything that is below it is suppressed.

Operation of the optional circuits are as follows. The output of the video amplifier is fed to the pulse stretch/slideback circuit. There are two stages to this circuit, a video stage followed by an audio stage. The video stage is connected to the output of the video amplifier through a capacitor bypassed by a FET. The FET is controlled by the switch on the pulse stretch control, so that the input is AC coupled when pulse stretch is turned on. The video stage of the circuit consists of an amplifier similar to the video amplifier but with added components to perform the video pulse stretch and slideback functions. The initial voltage amplifier output is peak detected with a diode and a

capacitor, and the voltage on the capacitor is buffered by the current driver. There are actually two capacitors, a large one and a small one. The large capacitor is switched in and out using a PIN diode biased by a current source. The current source is controlled by the same signal as the card input relay, so that the large capacitor is switched out when the input is from the wideband section of the receiver. This is because the rise time during pulse stretch needs to be not greater than the reciprocal of the IF bandwidth, approximately, and a smaller capacitor is needed for the wider bandwidths. A side circuit biases the voltage amplifier to temperature compensate and reduce the threshold voltage of the diode.

Also connected to the diode-capacitor node is a circuit which forms a voltage-dependent resistor and biasing network. This is the heart of the pulse stretch and slideback circuit in that the effective value of the VDR is settable via the pulse stretch control, and the bias is settable via the slideback control. The resistance is formed by a FET which is controlled by the front panel pulse stretch control. This creates a settable discharge rate for the peak detect capacitor. The control is driven by a constant current source, so that the voltage developed across the control, which is applied to the gate of the FET, is proportional to the resistance setting of the control. It was necessary to do it this way because the whole FET floats above ground by the amount of the slideback setting, so that a simple voltage divider on the control would not work. An high-frequency bypass capacitor is placed on the gate of the FET as well to reduce scratchiness from the wiper of the control. When pulse stretch is disabled the current from the current source is diverted, so that no voltage is developed at the gate of the FET and the FET is completely on.

For slideback, the front panel slideback control provides a settable bias voltage to the low side of the voltage dependent resistor. This point has a very low AC impedance to ground, so that the only effect to the other side of the FET is a DC bias which is applied directly to the capacitor on the diode-capacitor node. This bias provides a back-bias to the diode, so that only signal levels above the bias will appear on the capacitor. DC coupling is provided from the capacitor through the current driver, so that the bias appears at the output as well.

The output of the video pulse stretch/slideback circuit is sent to a relay and to the slideback indicator circuit. The relay is controlled by the pulse stretch and slideback switches on the respective front panel controls and by the remote enable line. It selects the output of the pulse stretch/slideback circuit when either of those functions is enabled, and the output of the video amplifier otherwise or when remote mode is enabled. The relay feeds the video output of the board, which is sent to the front panel AM video connector, and also to the audio pulse stretch circuit.

The slideback indicator circuit consists of two AC-coupled gain stages followed by a fast comparator. The comparator outputs when the input signal to the pulse stretch/slideback circuit rises above the bias level set by the front panel slideback control, as determined by a trimpot setting on the other input of the comparator. The output of the comparator triggers a one-shot, which in turn drives the front panel slideback indicator. When slideback is disabled via the front panel switch, the one-shot is disabled as well.

Power to the entire video pulse stretch/slideback circuit is removed when neither function is enabled, or when the receiver is in remote mode. This is done by combining the three enable lines in a diode junction which controls a relay. One section of the relay, described above, selects the signal driving the video output of the card. The other section controls a pair of power transistors which supply positive and negative supply voltages to the pulse stretch/slideback circuitry.

The audio pulse stretch circuit provides a fixed amount of pulse stretch. It takes the signal present at the video output of the card and AC couples it into another diode-capacitor node. A fixed discharge resistor is connected at this node, providing a fixed decay rate for incoming pulses. The

signal on the node is buffered by an opamp and passed through a trimpot to set the gain. Switching is provided to select the output of the circuit when pulse stretch is enabled, and the input otherwise. The output of the switching goes to the audio output, which is sent to the front panel audio circuit.

## 5.6 Synthesizer Section

The Synthesizer Section produces the fixed and tuneable local oscillator frequencies used for converting the signal at the receiver's input to the various intermediate frequencies. The section is implemented on cards A1A4, A5, and A6, and part of the MW Module circuitry. Local oscillator (LO) outputs of the Synthesizer Section drive conversion circuits in the RF and DC-IF sections of the receiver.

### 5.6.1 Local Oscillator Usage

The receiver uses three different conversion schemes and a total of six intermediate-frequency stages. The synthesizer generates the local oscillators used for these stages, as follows:

	<u>IF Frequency</u>	<u>LO Frequencies</u>
BAND 1 (receive frequency 1 KHz to 250 KHz)		
First IF	3.1245 MHz	3.0 MHz
Second IF	21.4 MHz	24.401 - 24.650 MHz
BAND 2 (receive frequency 250 KHz to 15 MHz)		
First IF	21.4 MHz	21.650 - 36.400 MHz
BAND 3 (receive frequency 15 MHz to 1.0 GHz)		
First IF	1447.5 MHz	1470 - 2450 MHz
Second IF	550 MHz	2.0 GHz
Third IF	21.4 MHz	523.600 - 533.600 MHz

In order to reduce the LO bleed-thru in the front end of the receiver when tuned to 15 MHz (bottom end of Band 3), the first and third Band 3 LO frequencies are adjusted when the receiver is tuned between 15 MHz and 20 MHz. When tuning the receiver below 20 MHz the first LO is moved up 5 MHz and the third ("back-end") LO is tuned 5 MHz lower. This puts the L.O. bleed-thru after the upper break frequency of the 1447.5 IF and before the lower break frequency of the 550 MHz IF. As a result, when the receiver is tuned below 20 MHz the 1470 MHz L.O. is well out-of-band for the first and second IF, providing maximum LO rejection.

The Synthesizer Section is divided into the following major sub-sections:

- Reference Clock
- Direct Digital Synthesis
- Microwave Multiplier
- Bands 1 - 2 Synthesizer/Mixer

2 GHz Multiplier  
3 MHz Multiplier  
21.4 MHz DC-IF Clock  
523-533 MHz Mixer

These sub-sections are implemented on three printed circuit boards. The block diagram of the section is shown in Figure 5-7.

### **5.6.2 Reference Clock**

The reference clock is derived from a 100 MHz temperature-compensated crystal oscillator (TCXO). The TCXO output is divided by 5 to produce the 20 MHz reference clock used throughout the synthesizer. The internal reference can be monitored using the Frequency Reference connector on the rear of the receiver.

### **5.6.3 Direct-Digital-Synthesizer**

The direct-digital-synthesizer (DDS) provides a 1.0 MHz to 2.0 MHz output with adequate frequency resolution to yield (at the receiver level) a 0.1 Hz resolution for tuned frequencies up to 1 MHz, 1 Hz for frequencies from 1 MHz up to 100 MHz, and 100 Hz for frequencies above 100 MHz. The output of the DDS is fed to the Band 1-2 synthesizer circuits.

The DDS is implemented around a Qualcomm Q2334-20MHz Dual Direct Digital Synthesizer integrated circuit in a 68 pin PLCC package. The only support circuits required are a 12 bit latch, digital-to-analog converters (DAC), a lowpass filter to remove the clock frequency from the DAC outputs, and a buffer amplifier.

### **5.6.4 Microwave Multiplier**

The microwave multiplier is a fundamental phase-locked-loop with a bus controlled programmable divider as the feedback element. The input to the microwave multiplier is the 20 MHz reference frequency. The 20 MHz input is divided by 16 to produce a 1.25 MHz signal. This signal is the reference frequency input to the phase/frequency comparator. The variable frequency input to the phase/frequency comparator comes from the bus controlled programmable divider. This divider is programmed to cause a 5 MHz step resolution at the output of the MW multiplier. The output of the microwave multiplier is the first L.O. for Band 3, and has a frequency range of 1470 MHz to 2450 MHz.

### **5.6.5 Bands 1 - 2 Synthesizer/Mixer**

The Band 1 and 2 Synthesizer/Mixer is a dual phase-locked-loop. The operation of both loops is similar to that of the MW Multiplier section, the differences being the feedback elements and the ultimate input and output frequencies. The 1 MHz input reference frequency is supplied by the 20 MHz reference clock after a division of 20. The synthesizer portion of the circuit is responsible for the coarse tuning, and the total frequency range is 22 to 37 MHz in 1 MHz steps. Frequency selection is through programming of the feedback divider via the computer bus.

The output of the synthesizer portion of this section is fed to the mixer loop. In the mixer subsection the synthesizer's output is combined with the mixer VCO in a double-balanced mixer. The difference frequency is selected by a 2.5 MHz lowpass filter. The difference output is fed to the variable frequency input of the phase detector, and the reference input to the phase detector is fed from the DDS. The output of the mixer section's phase detector is filtered by the loop filter and

applied to the mixer VCO. The resulting mixer VCO frequency is the synthesizer frequency minus the DDS frequency. The output from the DDS is thus not multiplied but instead subtracted from the synthesizer output. This allows a very fine tuning without multiplication of the DDS phase noise. The DDS supplies from 1 to 2 MHz with a minimum step resolution of 10 or 100 Hz as required (10 Hz up to 100 MHz receive frequency and 100 Hz above 100 MHz receive frequency). The output of the Band 1 - 2 Synthesizer/Mixer is fed through a buffer to the 528-533 MHz Mixer loop phase detector and is also fed through another buffer to be output as the Band 1 - 2 L.O. An additional Band 1 - 2 enable line is applied to this last buffer to allow disabling of the output when the receiver is in Band 3. This reduces the possibility of residual responses caused by the Band 1 -2 LO. The output frequency range as a function of band is as follows:

BAND 1 ----- 24.401-24.650 MHz in 10 Hz steps  
BAND 2 ----- 21.650-36.400 MHz in 10 Hz steps  
BAND 3 ----- 23.600-33.600 MHz in 10 Hz steps < 100 MHz rec. freq.  
100 Hz steps > 100 MHz rec. freq.

#### **5.6.6 2 GHz Multiplier**

The 2 GHz Multiplier circuit generates the fixed second LO required in Band 3 and the fixed 500 MHz for the 523-533 MHz Mixer. The 2 GHz Multiplier is a fundamental phase-locked-loop very much like the MW Multiplier loop. In this circuit the total divide-by in the feedback element is a fixed 100. The input reference frequency to this loop comes from the 20 MHz Reference Clock, which produces a 2 GHz output frequency (20 MHz multiplied by 100). In addition, the feedback divider is tapped at the output of the first divide by 4, filtered, and buffered to produce the 500 MHz for output to the 523-533 MHz Mixer.

#### **5.6.7 3 MHz Multiplier**

The 3 MHz Multiplier derives the Band 1 fixed 3 MHz first LO by simply dividing the 20 MHz Reference Clock by 20 and multiplying that resultant by 3 in a varactor-type multiplier. The divide-by-20 output is tapped off and divided by 5 to produce the 200 KHz reference for the DC IF Clock circuit. Enable and disable signals are provided by the Control Section to turn off these circuits when not in use.

#### **5.6.8 21.4 MHz DC-IF Clock**

The 21.4 MHz DC IF Clock circuit is a single phase-locked-loop similar in operation to the MW Multiplier and Band 1 - 2 Multiplier sections; the primary differences are the feedback element divide-by number and the input and output frequencies. The input reference frequency of 200 KHz is multiplied by 107 to produce 21.4 MHz. This 21.4 MHz LO is enabled only when the DC-IF is in use.

### 5.6.9 523-533 Mixer

The 523-533 MHz Mixer is a phase-locked-loop that creates the Band 3 variable back-end LO. The feedback element in this loop is a double balanced mixer. The basic configuration of this loop is very similar to that of the mixer loop used in the BAND 1 - 2 Synthesizer/Mixer circuit, with the main differences being the input and output frequencies. This loop combines the Band 3 output of the Band 1 - 2 Synthesizer/Mixer with the filtered fixed 500 MHz from the 2 GHz Multiplier circuit. The result is an output frequency range from 523.6 to 533.6 MHz. This output is used as the last LO in Band 3 with a tuning resolution of 10 Hz up to a receiver tuned-frequency of 100 MHz, and 100 Hz above 100 MHz. This circuit generates the fine-tune resolution necessary for selecting receive frequencies that lie between the coarse 5 MHz steps of the front-end tuning.

# R110 SYNTHESIZER BLOCK DIAGRAM

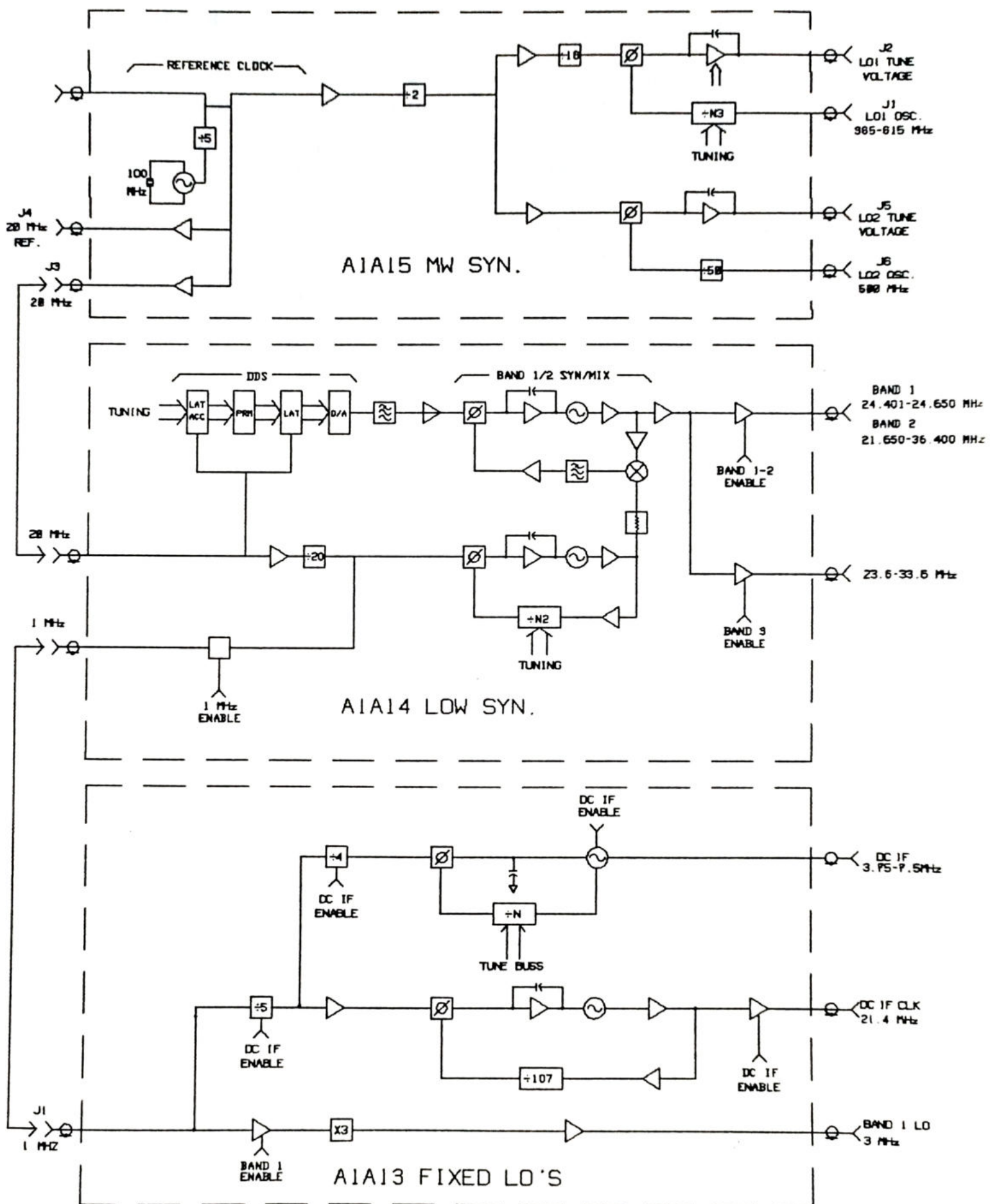


FIGURE 5-7 SYNTHESIZER BLOCK DIAGRAM



## 5.7 Control Section

The Control Section administers the operation of the receiver. Taking its inputs from the front panel and the IEEE-488 interface, it supplies control signals to the receiver's relays, switches, attenuators, and synthesizers, and status information to the front panel displays and the outputs of the discrete interface. Physically, the control circuitry resides on the Processor board, Front Panel I/O board, and the Front Panel board, all located in the Front Panel assembly. Figure 5-8 is a block diagram of the section.

The receiver has three control modes: manual mode, in which all functions are controlled by the front panel; remote mode, in which tuned frequency, IF bandwidth, input attenuation, gain, AGC mode, and log/linear detector selection are controlled by the IEEE-488 interface; and the MDC mode, provided for operation in conjunction with the companion R-1180 microwave downconverter, in which the tuned frequency, input attenuation, and front-end gain only are controlled by the IEEE-488 interface. In the last two modes the remote indicator on the front panel is illuminated.

*NOTE: microwave downconverter mode to be added later*

Following is a general description of the IEEE-488 interface and descriptions of the circuitry on the individual control boards. Descriptions of bus commands are given in the chapter on receiver operation.

### 5.7.1 IEEE-488 Interface

The IEEE-488 bus is a digital data communications interface consisting of eight parallel data lines, eight control lines, and eight ground lines. A double-row 24 pin connector is specified for the interface, along with jackscrew retainers. The complete specification is given by the Institute of Electrical and Electronics Engineers (IEEE) as their specification number 488, copies of which are available from them.

The specification defines three sorts of devices which may be connected to the bus. These are controllers, talkers, and listeners, and a particular piece of hardware may be any or all of these. There may be multiple controllers on the bus, but only one may be active at any given time. A protocol is defined whereby active control may be passed from one to another. One of the controllers is considered to be "controller in charge", meaning that it may regain control of the bus whenever it wants to without resorting to the normal protocol.

The controller assigns other devices on the bus as active talkers or listeners. There may be only one active talker at a time, whereas there may be multiple listeners. The active talker drives the eight bus data lines, and the listeners sense them. The controller assigns devices as talkers and listeners, and may make itself a talker or listener as well.

Three of the control lines act as handshaking for transfers on the data lines. The active talker drives Data Available (DAV) and the listeners share control of Not Ready for Data (NRFD) and Not Data Accepted (NDAC). Each byte transferred across the data lines goes through a handshaking protocol in which the talker signals that data is available and all listeners must acknowledge when they receive it. The speed of the transfer is therefore determined by the response time of the last listener to acknowledge.

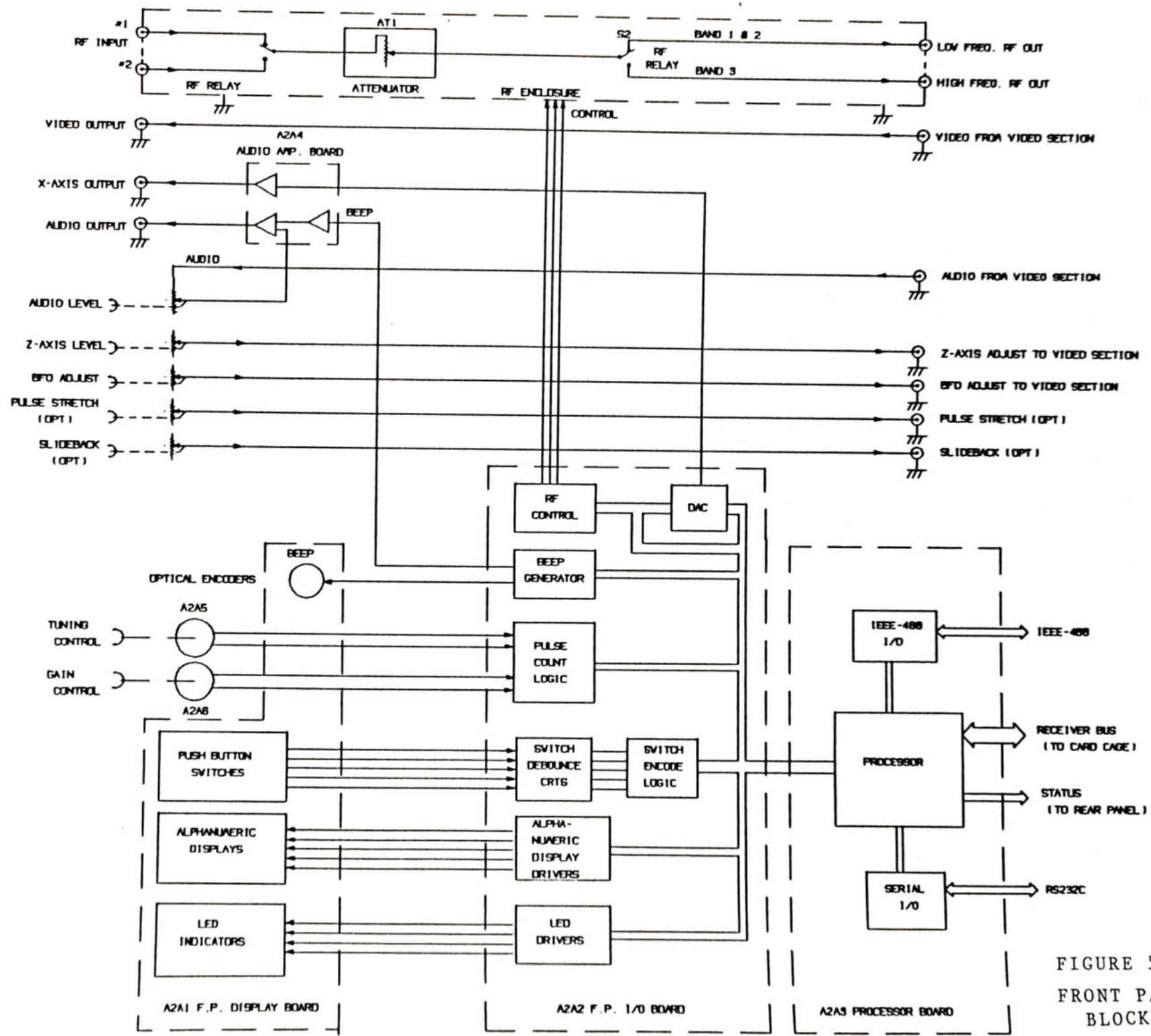


FIGURE 5-8  
FRONT PANEL BOARD  
BLOCK DIAGRAM

There remain five other control lines. These are described as follows:

**Attention.** The ATN line is used by the controller to interrupt the currently active talker. When ATN is asserted the talker stops driving the data and DAV lines and everybody waits for the controller to send a command. With ATN asserted the controller can then drive the data and DAV lines and issue commands. Commands are received by all devices on the bus, regardless of their currently assigned state. When the controller stops asserting ATN it also stops driving the data and DAV lines, and any assigned talker can then resume driving them.

**Remote Enable.** The REN line is driven by the controller in charge and allows devices on the bus to be placed under control of the bus when it is asserted. When the controller stops asserting it, all devices on the bus return to local (manual) control.

**Interface Clear.** The IFC line is strobed by the controller in charge when it wants to reset the system to its base state. It acts as a master reset.

**End or Identify.** The EOI line is unique in that it is the only line with more than one function. In conjunction with a command state (ATN asserted) it triggers parallel polling. In conjunction with a data state (ATN unasserted) it can be used to indicate the last character of a data string.

**Service Request.** The SRQ line is the only control line other than handshaking that is driven by the bus slave devices rather than the controller. The line is used as an interrupt request and is shared by all devices on the bus not in control. When the controller senses it being asserted it must serially poll the devices on the bus which may be responsible for asserting it. Several devices may assert it simultaneously.

### 5.7.2 Front Panel Board

The Front Panel board is an irregular-shaped PC board which is attached directly to the back of the receiver's front panel. Most of the switches, controls, displays, and indicators are directly connected to this board.

The tuning and gain controls attached to the board with 4-conductor ribbon cables. Each control is an optical shaft encoder that requires four connections in order to operate. Two of these are +5V and ground. The other two are the encoder outputs, and the relationship in which pulses occur on them determines the direction of rotation of the shaft. The encoder produces about 200 pulses on each line per rotation of the shaft.

The LED displays and lightbars are mounted on the board, along with the pushbutton switches. Each LED lightbar is controlled separately by the Front Panel I/O board. The displays are "intelligent" and are driven using data, address, and control discretetes from the I/O board. The audible alarm (beeper) is also attached to the board.

The board is interfaced with the Front Panel I/O Board via two 50-conductor stacking connectors.

### 5.7.3 Front Panel I/O Board

The function of the Front Panel I/O board is to interface and process signals between the Front Panel board and the Processor board, control the RF front-end components, to supply the X-axis ramp output. The interface with the Processor board consists of power and a control bus. The bus has eight bidirectional data lines, eight unidirectional address lines, and separate read, write, and clear lines.

Signals from each of the panel's 33 SPST momentary-contact pushbuttons pass through a debounce circuit before being processed. The keypad switches are priority encoded in such a way that if no button is pushed the output code is zero. These four bits are buffered onto the bus. The signals from the remaining 18 switches are buffered and also supplied to the bus.

The X-axis output is implemented with latches feeding a 16-bit digital-to-analog converter (DAC) which provides an output signal with a  $\pm 10$  volt DC range.

The audio warning is implemented with a tone generator and a piezoelectric transducer. The tone generator supplies an audio signal which is mixed with the receiver's audio output. The signal amplitude is adjusted using a digitally-controlled potentiometer, which has a 128 step range.

### 5.7.4 Processor Board

The Processor board contains an 80C31 microcontroller, static RAM, EPROM, EEPROM, IEEE-488 and RS-232C interfaces circuits, and support devices. The board manages all receiver operations and provides outputs for display and control. Figure 5-9 is a block diagram of the board.

The processor operates with a 11.0592 MHz clock. The clock rate provides a basic instruction cycle of 1.1 microseconds, and provides a reference for the RS-232C baud rates. The processor responds to interrupts from the external counter/timer; the scan function uses this for its operation. In addition, interrupts are serviced from the external data busses, and from the other boards in the control section via request lines in the interconnecting bus.

A separate 5 MHz clock supplies the IEEE-488 interface controller IC and the counter-timer circuitry.

The RS-232C interface is used for factory service. When used, the normal receiver control functions are interrupted, and a control program is enabled which permits rudimentary control of the receiver via the interface.

A dip-switch is provided on the board for set-up of the IEEE-488 and RS-232C interfaces. Five of the eight switches of the dip-switch set the IEEE-488 address, and the other three switches select the baud rate. The settings are described in Section 3.

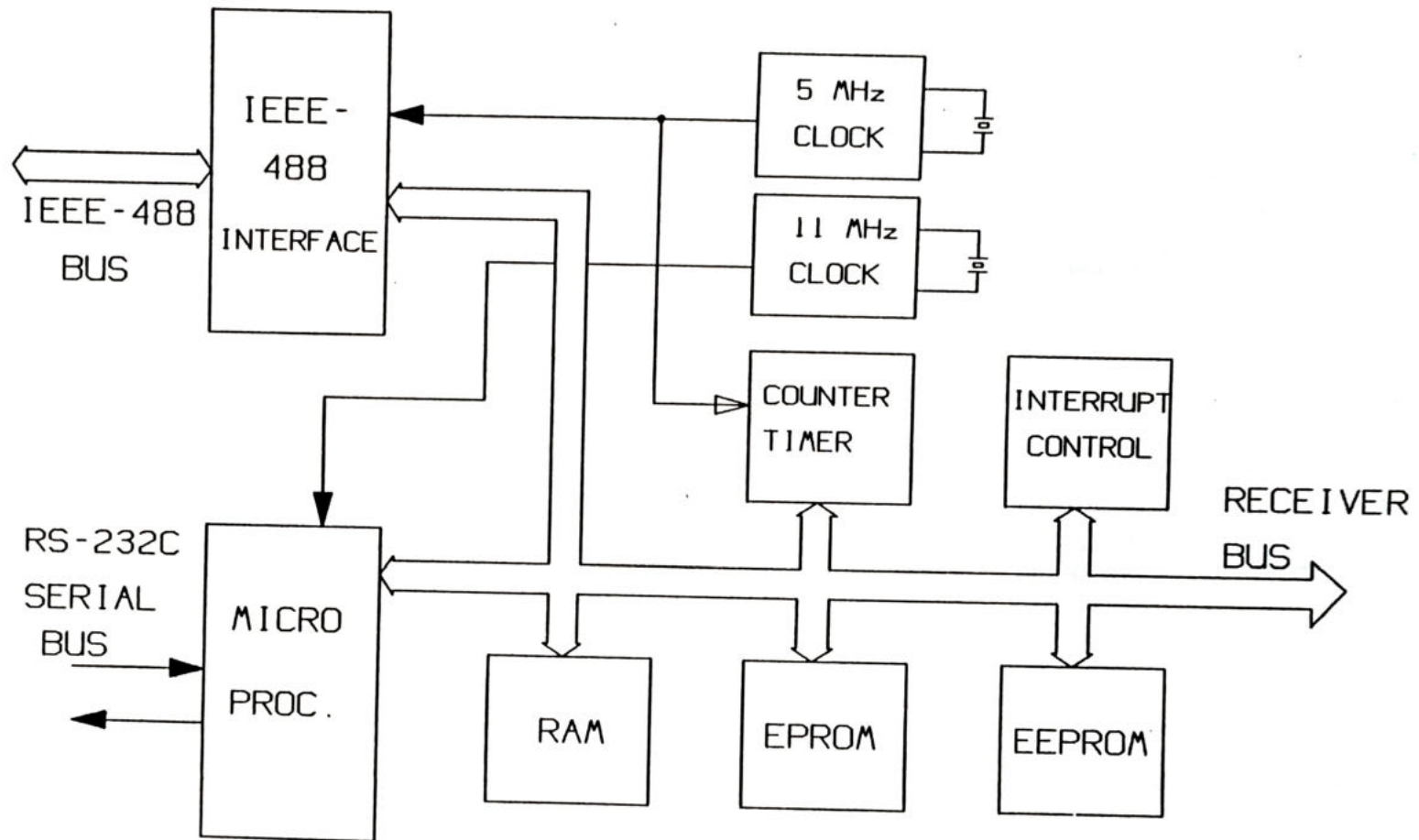


FIGURE 5-9 PROCESSOR BOARD BLOCK DIAGRAM

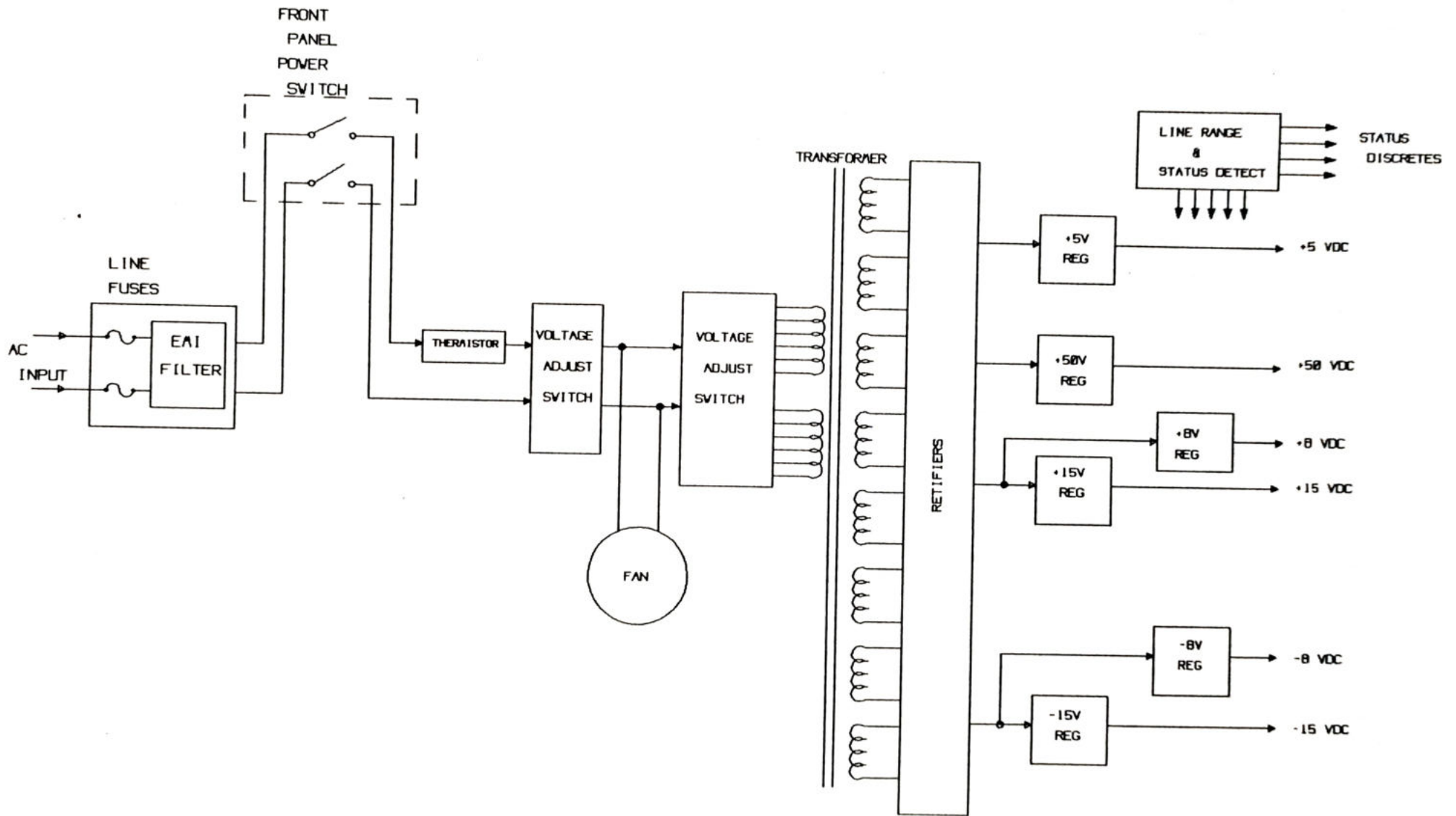


FIGURE 5-10

POWER SUPPLY BLOCK DIAGRAM

The power transformer has eight secondary windings. Two are used as a center-tapped source for the rectifiers supplying the +5 vdc regulator. The other six windings are "stacked" to yield a multiple-tapped secondary feeding the rectifiers for the +60, +24, and  $\pm 15$  vdc outputs.

Rectifying and filtering circuits are mounted on the rectifier/regulator printed circuit board. Diode packs (SR1600 series) with dual rectifiers are used for all circuits except the +60 VDC; the +60 VDC supply uses separate 1N4003 diodes mounted on the PC board. Full-wave rectification with capacitor filtering is used in all cases. The transformer windings, harness, and circuitry are specially configured to reduce noise caused by high crest-factor currents: each winding on the transformer terminates at the same point (no hybrid connections within the transformer), twisted-pairs attach to the terminations, harness geometry is controlled, rectifiers are located close to their power source, diode packs are used to reduce wire length, etc.

### **5.8.2 Regulated Supply**

The regulated portion of the power supply consists of a portion of the printed circuit board plus a heat sink which is integral with the rear panel. The board contains the +60 VDC regulator components, AC line-range detector, and the power supply status detector.

The regulators are implemented with low-dropout integrated circuit regulator devices which operate with minimal headroom; these improve the efficiency of the power supply, cutting both power consumption and power dissipation. Each regulator incorporates short circuit protection and thermal overload protection, and provides a fault status indication to the status detector circuit.

All regulated outputs except the +60 VDC have fixed outputs, as does the unregulated +24 Volt output. The +60 VDC output is adjustable using a potentiometer located on the board.

### **5.8.3 Power Supply Monitoring**

TO BE REVISED: The power supply monitor circuits check for AC line high and low, and regulated output high and low for each of the DC outputs. Most of the checking is done with a pair of power supply monitor chips (ULN-8130A). One chip monitors the +5V, +50V, and -15V outputs, while the other one monitors the +24V, and +15V outputs, and also the AC line. The DC outputs are compared to both high and low thresholds, the high side set by a reference in the monitor chip and the low by a fixed fraction of the reference. The second chip only checks for a low AC line, so a separate comparator is provided to check for AC line high.

All of this is powered as follows. The monitor chips are powered by the +20V unregulated supply. The added comparator is powered by +5V. The input for the AC line sense function of the second monitor chip is derived from the +20V unregulated supply, adjustable via a trimpot. The input for the AC line high comparator is derived from the +20V unregulated supply as well, again adjustable via a trimpot. The reference for the comparator is taken from the reference provided by the second monitor chip.

The reference is leaked into the two +5V sense inputs via resistors in order to increase the allowable tolerance on these two inputs. Once in the chip, the reference, supplied at 2.5 VDC, sets the high level for comparison, and the divided reference supplies the low level. The various regulator outputs are divided with resistor networks in order to fit into this range. Timing capacitors are provided on the monitor chips so that momentary fluctuations will not cause a glitch at the output.

Each of the three monitor chips has three outputs: undervoltage, overvoltage, and line fault. The over- and under- outputs from both chips are combined into a single node using open-collector drivers, along with the line low output of the second chip. This means that either line low or any DC out-of-tolerance will pull the node low. This node is output as the PSTAT#2 signal. The line low output from the second chip and the line high output of the comparator are also combined into a second node using open-collector drivers. This means that for any line fault the node will be pulled low. This node is output as PSTAT#1. The two nodes also feed a third node through open-collector drivers. This node is therefore pulled low for any power supply fault at all and is designated PSTAT#3.





**Table 6-7 Fault Isolation, RF Section**

Ensure that properly operating test equipment is correctly connected and applicable to the test sequence.

Apply a CW signal of 550 MHz frequency at a level of -20 dBm.

Refer to Figure 6-1 for the locations of test points. Verify the presence of a signal of 21.4 MHz frequency and approximately -9 dBm amplitude.

A normal signal indicates that the malfunction is related to external cable connections or test equipment operation.

Refer to Figure 6-1 for the locations of test points. Verify the presence of a signal of 1450 MHz frequency and approximately -8 dBm amplitude.

## 7. SCHEMATICS

The schematics for the R-110 are attached.

These schematics are drawn in accordance with the following standards and specifications which govern the symbols, designations and abbreviations used:

**\*\* TBD \*\*** (all schematics are drawn with Schema: list Schema standards)

The assemblies and their schematics are identified in Table 7-1

**Table 7-1 List of Schematics**

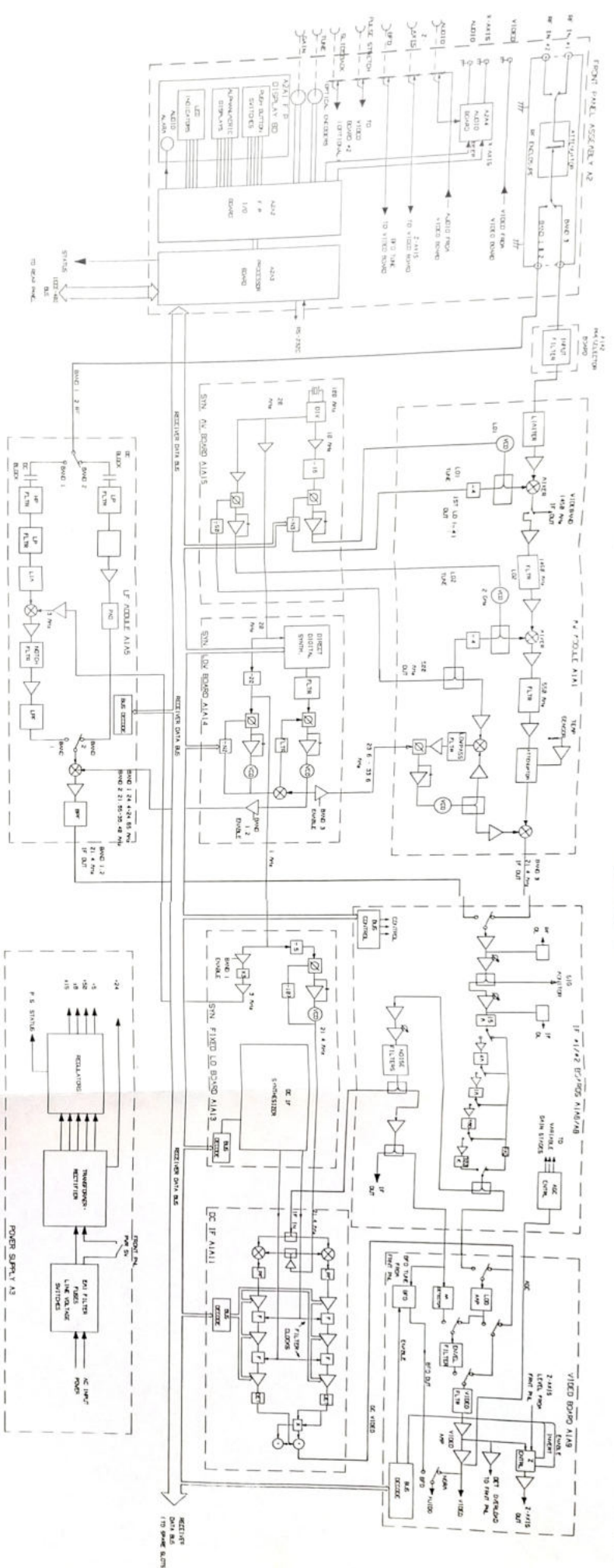
DSI PART NUMBER	REF. DESIG.	TITLE
493001		R-110 Receiver
493101	A1A1	MW Module
493191	A1A2	Preselector Board
493181	A1A3	LF Module
493302	A1A4	Synthesizer MW Board
493332	A1A5	Synthesizer Fixed LO Board
493352	A1A6	Synthesizer Low Freq. Board
493202	A1A7	IF-1 Board
493252	A1A8	IF-2 Board
493502	A1A9	DC IF Board
493402	A1A10	Video Board
493601	A2	Front Panel Assy.
493622	A2A1	F.P. Display Board
493632	A2A2	F.P. I/O Board
493641	A2A3	Processor Board
493651	A2A4	Audio Board
493701	A3	Rear Panel Assy.
493722	A3A1	PS Regulator Board

## 8. PARTS LISTS

The parts lists for the receiver and its various assemblies are attached. The assemblies and the lists are identified in Table 8-1. Please refer to Table 7-2 in the previous section for a definition of the designations used in the parts lists.

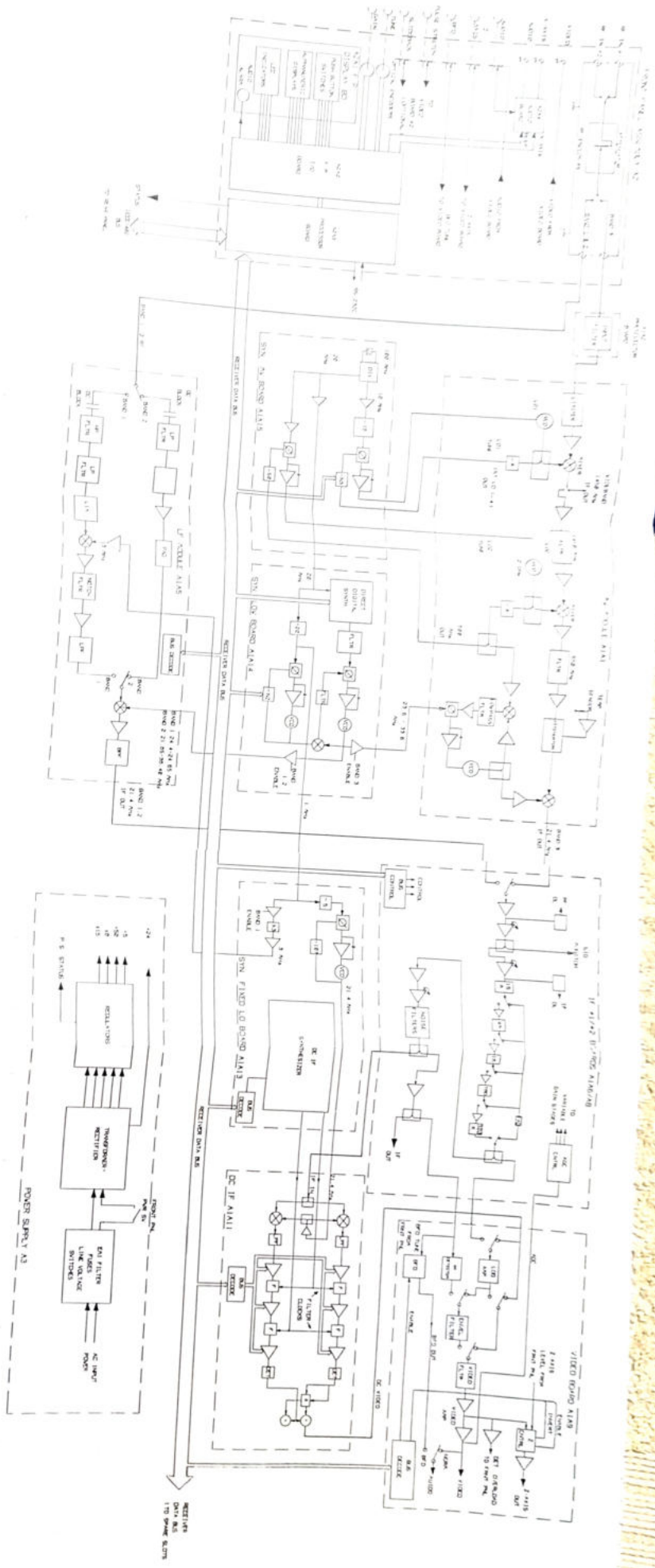
Table 8-1 List of Parts Lists

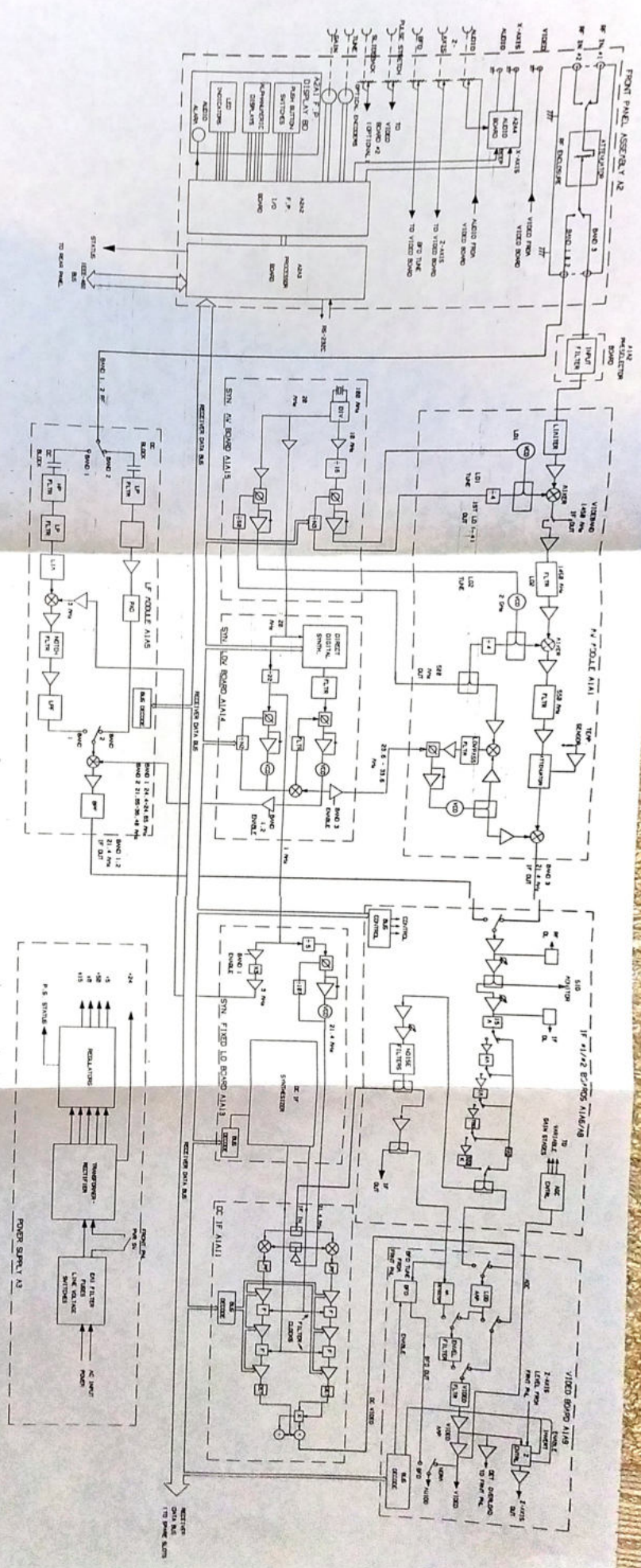
DSI PART NUMBER	REF. DESIG.	TITLE
493000 PL		R-110 Receiver
493100 PL	A1A1	MW Module
493190 PL	A1A2	Preselector Board
493180 PL	A1A3	LF Module
493300 PL	A1A4	Synthesizer MW Board
493330 PL	A1A5	Synthesizer Fixed LO Board
493350 PL	A1A6	Synthesizer Low Freq. Board
493200 PL	A1A7	IF-1 Board
493250 PL	A1A8	IF-2 Board
493500 PL	A1A9	DC IF Board
493400 PL	A1A10	Video Board
493600 PL	A2	Front Panel Assy.
493620 PL	A2A1	F.P. Display Board
493630 PL	A2A2	F.P. I/O Board
493640 PL	A2A3	Processor Board
493650 PL	A2A4	Audio Board
493700 PL	A3	Rear Panel Assy.
493000 SK		Service Kit



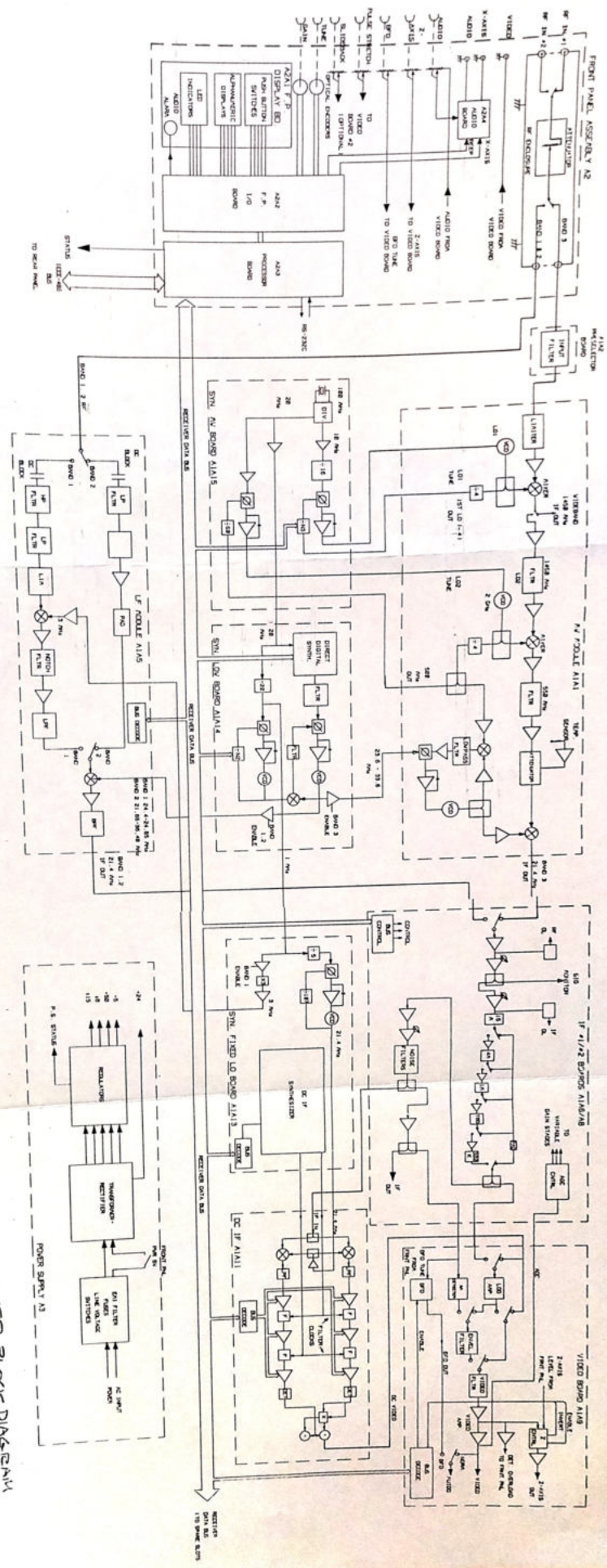
RIIO RECEIVER BLOCK DIAGRAM  
2/15/90

R110 RECEIVER BLOCK DIAGRAM  
2/15/95





VIDEO RECEIVER BLOCK DIAGRAM  
2/15/90



R110 RECEIVER BLOCK DIAGRAM  
2/15/90