HF RADAR MANUAL

VOLUME 2

Low Power RF System

Prepared by

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LOW POWER RF SYSTEM

1. INTRODUCTION

The low power RF system for the HF sounder system is shown in block diagram form in Figure 1. A receiver channel consists of the Antenna multiplexer, RF, mixer, IF, detector, and Analog convertor modules. A complete dual channel receiver contains two of each of these modules, with the exception of the analog converter module which itself is implemented for dual channel operation. In principle, additional receiver channels can be added if required.

Two oscillator sources are used. One is a general purpose commercial synthesizer which is used as the receiver local oscillator source. The receiver is a single up conversion type with a 40.625 MHz IF frequency. For signal inputs from 0.1-30 MHz, the synthesizer is digitally controlled to generate frequencies from 40.725 to 70.625 MHz. The second oscillator is a fixed frequency crystal oscillator at the IF center frequency of 40.625 MHz. This is used as the reference for quadrature detection and, using a down converter in the transmitter mixer module, to coherently generate the sounder transmitter frequency. Keying of the transmitted signal is carried out at 40.625 MHz by a composite on/off quadraphase modulator followed by a bandpass filter after which the signal is down converted to the system operating frequency. Two outputs are provided. One for the high power transmitter itself at a level of -3 dBm and a second, controllable in level from -30 to -150 dBm is used as a calibration signal source for the receiver.

Calibration signal level and IF gain are set by relay switched attenuators which are digitally controlled. In the IF amplifier, there is, in addition, a diode attenuator to provide range dependent fast gain control if required.

The antenna multiplexer and the diode attenuator in the IF both have off positions in which the control current is switched to zero to desensitize the receiver during transmission. The antenna multiplexer has the additional capability of providing phase reversal for use in decoding pulse-to-pulse code sequences.

2. DESIGN DISCUSSION AND SPECIFICATIONS

2.1 Receiver Front End Intermodulation

A critical performance parameter in a frequency agile system is the linearity of the front end RF amplifier and mixer section. Nonlinearities cause the generation of intermodulation products between signals in the pass band which can reach this section of the receiver before a particular signal is selected by the IF amplifier. Ideally, for maximum simplicity and frequency agility, we would like to leave the receiver front end open to the whole 0.1-30 MHz pass band. This requires a high order of linearity if the intermodulation products are not to seriously degrade the system performance. The effects are a strong function of the RF spectrum environment in which the receiver operates. One or two very local transmitters will dominate the cross products produced. Second order responses $f_1 + f_2$, $f_1 - f_2$, $2\ f_1$, $2\ f_2$, etc., cause a single strong transmission to produce sum and difference signals with every other signal in the spectrum, and, depending on their intensity compared with the other signal, cause a significant increase in interference level. On the other hand, since these products are generally well separated in frequency from the sources, relatively simple (< 1 octave) band pass filters can be used to remove them. Third order products of the type $2\ f_1 - f_2$ generally lie close to the sources if they themselves are close together and cannot be removed except by individual signal filtering. The receiver uses balanced RF amplifiers and a double balanced first mixer so that second order products are very well suppressed.

The approach taken in this system was to build the best possible front end system and make provision for the insertion of selected filters under computer control if these prove to be necessary at a particular site. Filters have not proved to be necessary when working in the RF environment at the Boulder Laboratories.

The mixer selected for the receiver is a high level double balanced diode unit (M9E) rated for operation at +27 dBm oscillator level. With sinusoidal drive the mixer has a third order intercept* of +29 dBm. This has been improved to ≈ +39 dB by using a square wave drive at a level of ≈ +30 dBm with transition times of ≈ 2 ns. This improvement means that at a given signal level input, the third order products are reduced by 20 dB, or conversely, the input signal can be 10 dB higher for a given third order product ratio (all intercepts are quoted with respect to the single tone power).

The overall receiver performance is determined by the additional components in front of the mixer. These are (as shown) the two 10 dB gain blocks, the low pass filter and the antenna multiplexer. This configuration is necessary if small aperture

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*The intercept is the hypothetical signal level at which the output level of the input frequencies and the distortion products are equal. It is obtained by extrapolating the rate of change of distortion product versus output level.

array antennas are used with appreciable transmission line losses. The 10 dB gain blocks used (AM109) have a 6 dB noise figure and third order intercept of +45 dBm. The electronic switches used in the antenna multiplexer are claimed to have a +42 dBm intercept. However, measurements in the laboratory show that this is only achieved at high frequencies, presumably because the carrier lifetime in the diodes used becomes a factor in the linearity at low frequencies. The laboratory measurements show intercepts for the multiplexer of +20 dBm at 100 kHz, +28 dBm at 1 MHz, and +45 dBm at 30 MHz.

In the complete receiver with zero dB RF attenuation, the intermodulation performance is limited by the mixer performance. As the RF attenuation increases, the multiplexer switches become the limiting factor.

If the receiver is to be used on a large aperture antenna, then the RF preamplifier should not be used. It would not be needed to improve the receiver noise performance and would only degrade the intermodulation performance. Indeed input attenuation may be desirable to optimize the performance.

2.2 Receiver Noise Performance

Assuming no excess noise in the first mixer, the noise figure at the mixer input is calculated to be ≃10 dB. This would then be reduced to ≃6 dB by the RF amplifier and then degraded again by the image rejection RF filter loss and the antenna multiplexer loss, a total of ≃4 dB. In practice, the mixer when driven from the synthesizer is up to 6-8 dB worse than this, depending on the frequency. This is due to noise present at the synthesizer output at the IF frequency. (A filter is used to remove the image noise.) Allowing for the synthesizer excess noise and the improvement due to the antenna preamplifier, the calculated noise figure of the receiver is 10.5 dB. The typical noise performance of the receiver prototype, including the antenna preamplifier but with negligible cable loss, is shown in Figure 2. The data are presented as the tangential threshold sensitivity, i.e., that rms input signal required to just separate the noise plus signal from the noise on an oscilloscope display. Between 1 and 30 MHz, the sensitivity is $<$0.4 µV. This is consistent with an effective noise figure of ≃10 dB assuming that the tangential condition is met for equal signal and noise powers, e.g.,

Boltzman's Constant	-198.6 dBm/Hz/°K
300°K	24.8 dB°K
50 kHz Noise BW	47.0 dB Hz
Thermal Noise Power	-127.0 dBm
Noise Figure	10.0 dB
Total Noise Power	-117.0 dBm

or ≃ 0.3 µV in 50 Ω.

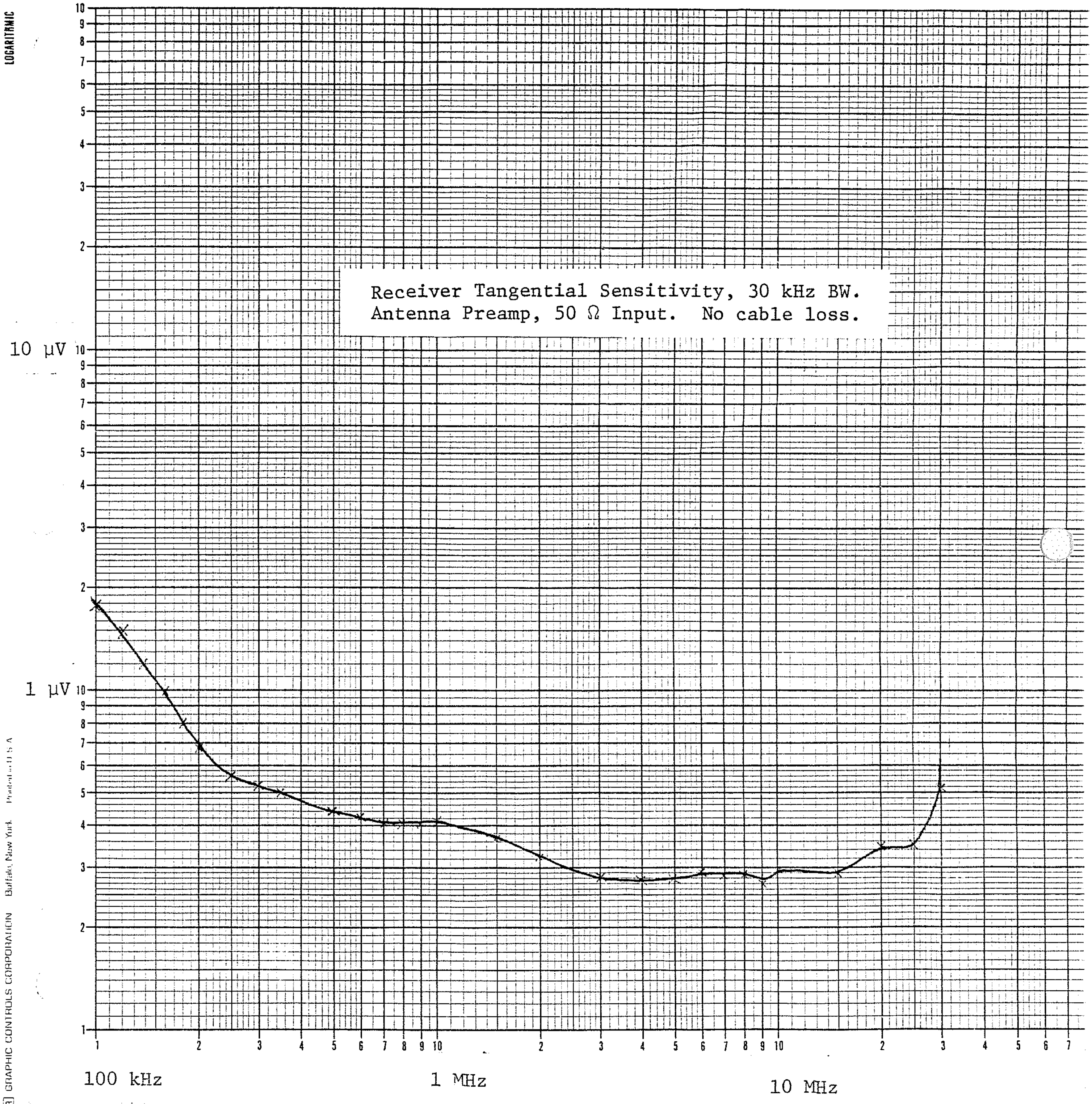

Receiver Tangential Sensitivity, 30 kHz BW.
Antenna Preamp, 50 Ω Input. No cable loss.

Figure 2

The higher threshold at frequencies below 1 MHz is caused by the drop in gain of the RF amplifier modules which causes the mixer noise to predominate. The latter also increases somewhat below 500 kHz as the synthesizer frequency approaches the IF frequency.

2.3 Receiver Gain

The measured gain of the prototype receiver with zero IF and RF attenuation is shown versus frequency in Figure 3. The gain is constant within ±1 dB between 400 kHz and 28 MHz. The rolloff above 28 MHz is due to the image protection 30 MHz low pass filter (≃-3 dB at 30 MHz). At frequencies below 400 kHz, the gain drops due to the low frequency rolloffs of the transformers in the RF preamplifiers and the antenna multiplexer switches. Table 2 shows the low frequency performance of the three units concerned. The actual low frequency performance of the AM109 amplifiers below their specified 500 kHz low frequency cutoff units varies considerably between units.

Table 2

Frequency (kHz)	AM109 RF Preamp	Ant. MUX	AM109 RF Amp
1000	0	0	0
500	0	0	0
200	- 0.5 dB	- 1 dB	0
120	- 1 dB	- 1 dB	0
100	- 5 dB	- 2 dB	- 3 dB
60	-11 dB	- 5 dB	-11 dB

2.4 Transmitter Gain

The variation of the transmitter drive (upper) and calibration signal outputs versus frequency are shown in Figure 4. The calibration output is flat ± 1 dB from 100 kHz to 30 MHz. The transmitter output is similarly flat from 200 kHz to 30 MHz and is 5 dB down at 100 kHz. The latter is due to the low frequency performance of the AM110 +30 dB amplifier in the transmitter drive module.

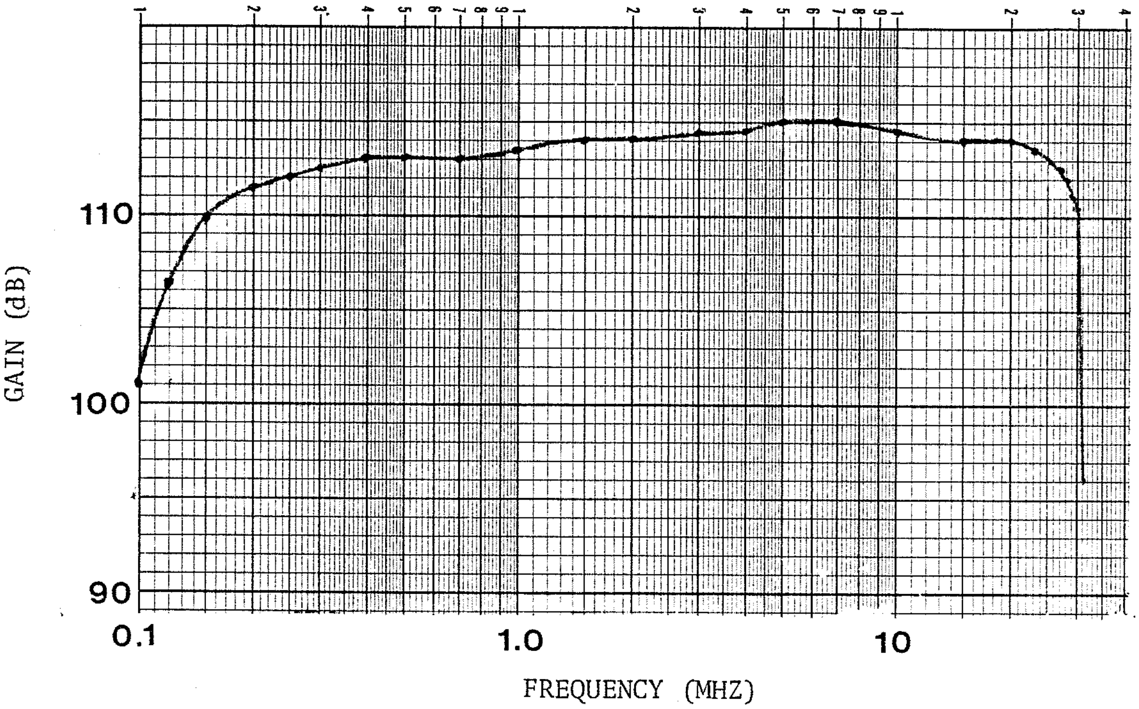


Figure 3.

Overall receiver gain (including 10 dB preamp) measured at detector module outputs. Output amplitude constant at +20 dBm (2.25 V).

Variation of TX Drive Module Outputs with Frequency

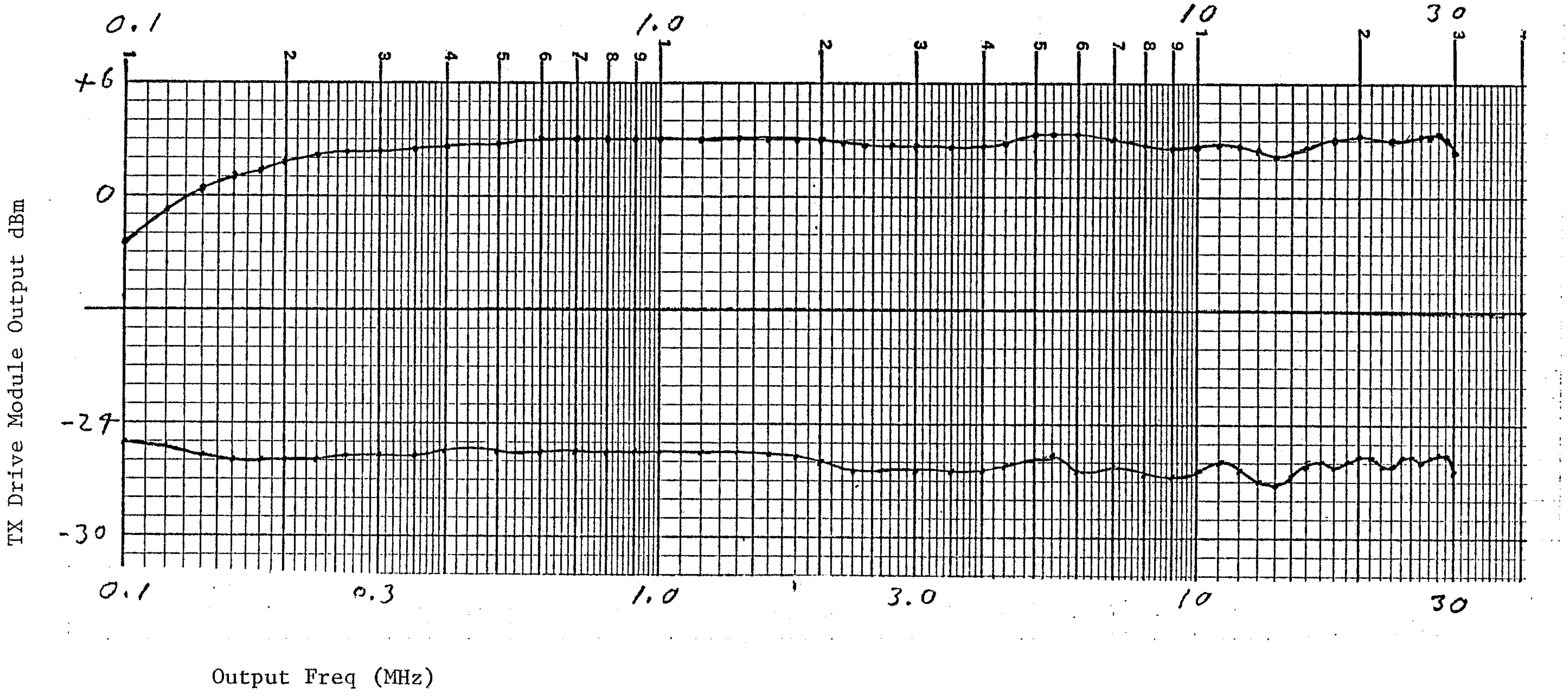


Figure 4

2.5 Receiver Gain Control

The receiver gain, the calibration signal output, and (in the transmitter) the transmitter drive are controlled by attenuators which are under digital control. Control is exercised by the computer via a DIO interface or by manual control from the front panel. In each receiver channel "slow" attenuation is exercised by two relay switched attenuators, one in the RF module prior to the AM109 10 dB wide band amplifier and a second in the IF module prior to the second IF filter. Both these provide 0-60 dB of attenuation in 4 dB steps. The relay switching time is ≤ 6 ms making them suitable for overall gain setting between groups of pulses.

A separate diode attenuator is provided in the IF module with nominal 0, 20, or 40 dB attenuation. This is controlled by the Timing Sequence Generator. The switching time of the attenuator is less than the transient response of the IF amplifier making this attenuator suitable for range dependent gain switching or gain changes between groups of pulses. The actual gain control element is a double balanced PIN diode quad configuration (Minicircuits PAS 1). The control current is supplied by electronically switched resistors selected to give the desired attenuation steps. Figure 5 shows the characteristics of the attenuator. The critical performance parameter is the output limiting which occurs, for 40 dB attenuation, at above +10 dBm input. This leads to a restriction on the gain management of the receiver to avoid operation close to the region of nonlinearity where third order products of signals within the IF pass band might become significant.

The diode attenuator is used in two auxiliary roles. Firstly, it is provided with an off position which is utilized to desensitize the receiver during transmissions. Secondly, it is used with a local level detector and latch to protect the second IF crystal filter from input signals above +10 dB which might damage the filter. This might occur if the receiver where turned, at high gain, to a strong local signal or to zero frequency. The latch is reset by the system transmitter enable line.

2.6 Receiver Dynamic Range

2.6.1 In Band Signals

The dynamic range of the receiver at its output is determined ultimately by the DC uncertainties in the quadrature detector zeros at the low end and by the quadrature detector overload

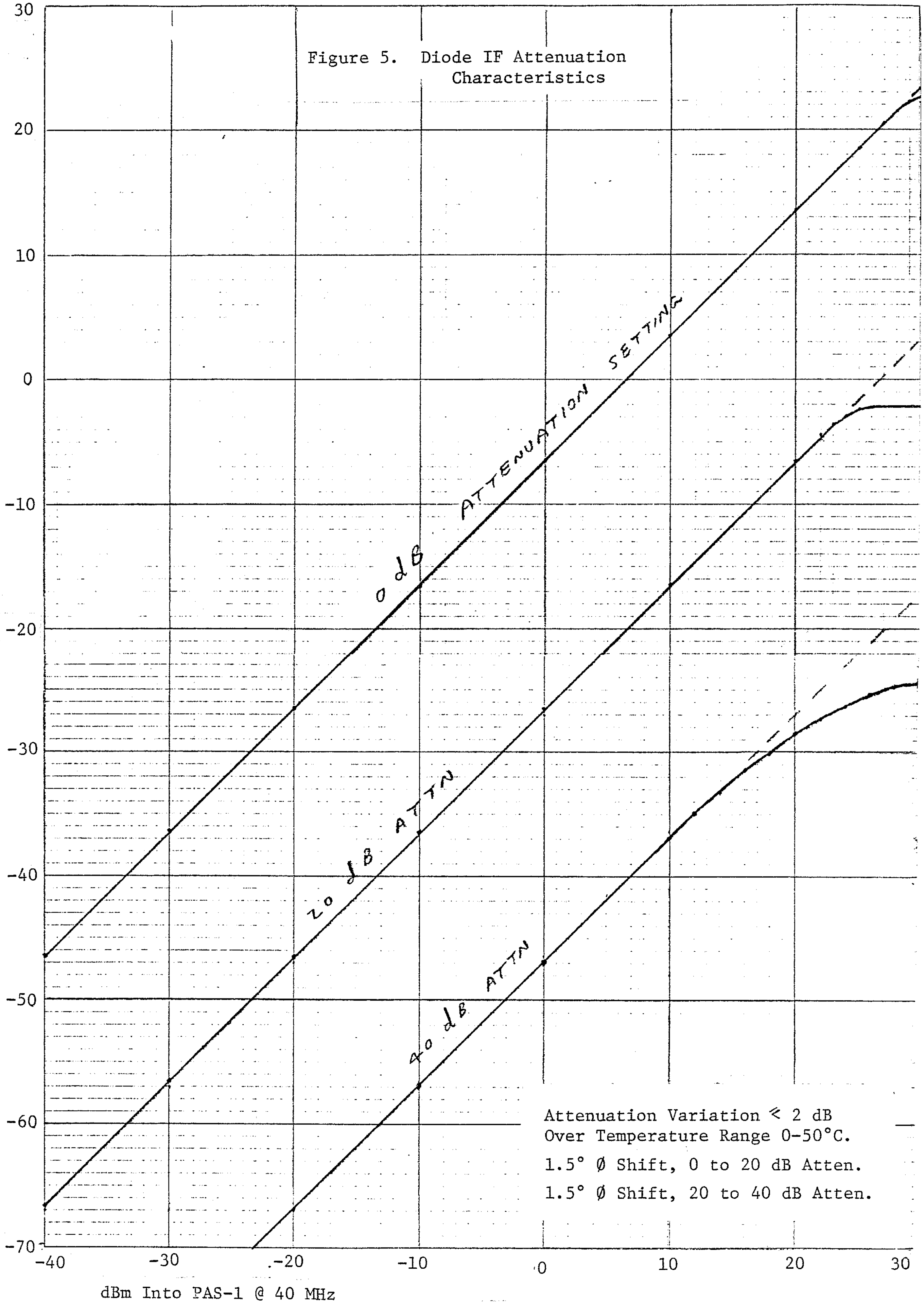


Figure 5. Diode IF Attenuation Characteristics

Attenuation Variation ≤ 2 dB
Over Temperature Range 0-50°C.

1.5° Ø Shift, 0 to 20 dB Atten.

1.5° Ø Shift, 20 to 40 dB Atten.

at the high end. The gain of the output DC amplifier/filter has been chosen so that the detector overload occurs just outside the nominal 10 V maximum output of the receiver XY channels.

The phase detector zero uncertainty is primarily due to the temperature coefficient of matching in the detector diode quad. The drift due to warm-up is about 50 mV at the output of the receiver. After warm-up, the drift is of the order of 10 mV per day. Another contributor to DC offset and drift is coupling within the receiver giving rise to a leakage of a coherent signal into the detectors. Under normal conditions of operation, this has been held to < 2 mV. In order to avoid thermal and other DC drifts from degrading the accuracy and dynamic range, an auto zero correction program is utilized in the digital data system. This reads the phase detector zeros periodically with all receiver attenuators set to maximum and store these values as a subsequent zero correction to all measured XY values. By this means, the detector zero uncertainties can be held to ± 2 quantization levels or ± 10 mV.

The dynamic range afforded by the detectors can be maintained throughout the receiver providing the correct gain control philosophy is adopted. The criterion for the distribution of RF and IF gain is to run at the minimum RF attenuation consistent with maintaining headroom prior to the IF attenuator. The headroom must be at least 40 dB if the fast attenuator is to be used without restriction. A 50 dB headroom is maintained and optimum noise performance if the IF step attenuator is used initially for the first 20 dB of gain reduction and the RF and IF attenuators are then increased in step. Figures 6 and 7 show the input, output relations for the receiver under various attenuation conditions in which the IF step attenuator is also used to simulate the use of the fast diode attenuator.

2.6.2 Out-of-Band Signals

The receiver performance, when receiving a wanted small signal in the presence of large out-of-band signals which are allowed to reach the mixer, is influenced by three effects:

1. Receiver intermodulation products may fall in the pass band with the wanted signal (see 2.1).

2. Gain modulation may occur.

3. The receiver noise level may be increased by mixing between the out-of-band signals and the synthesizer local oscillator phase noise.

Receiver
Dynamic Range

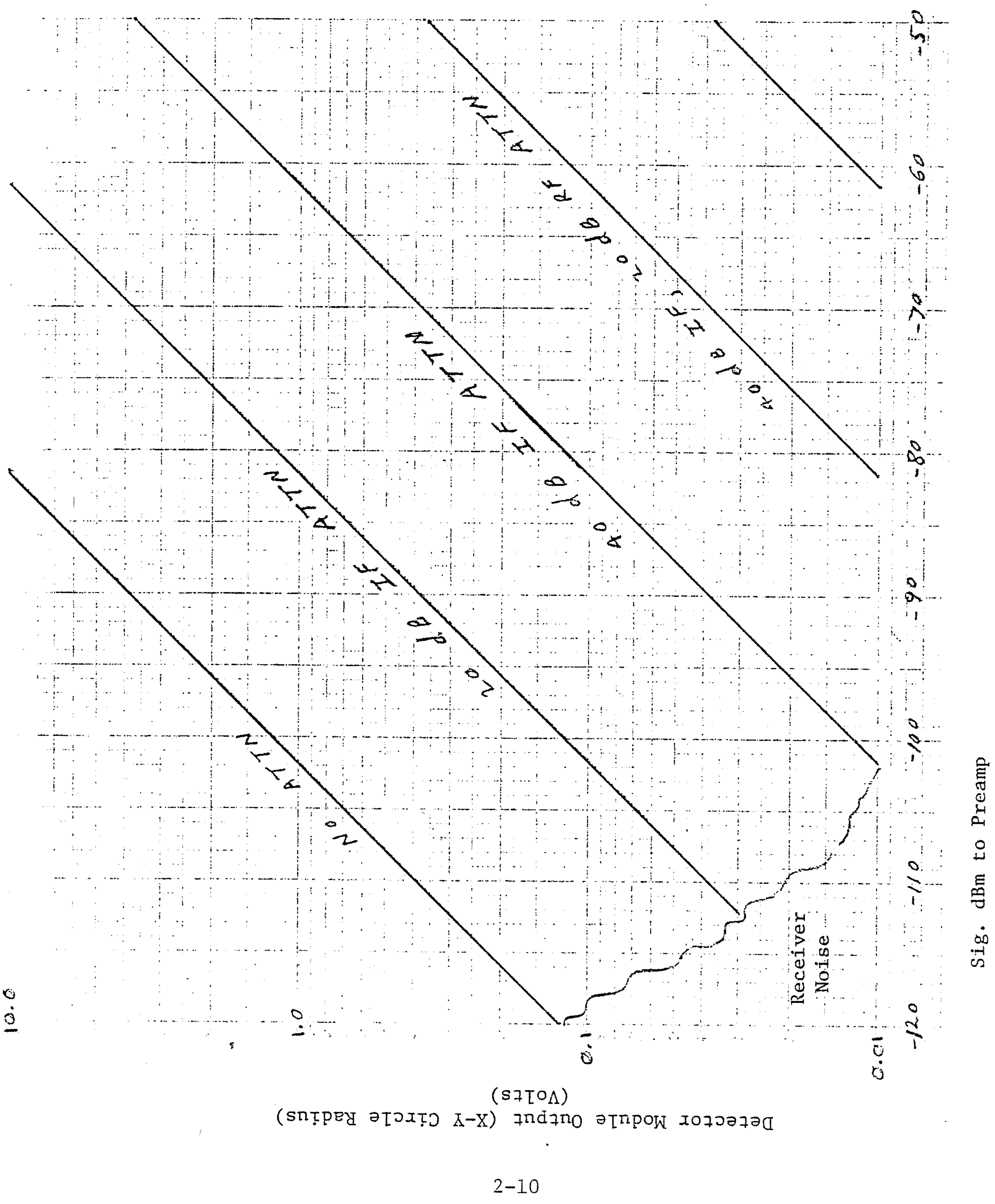


Figure 6

Receiver
Dynamic Range

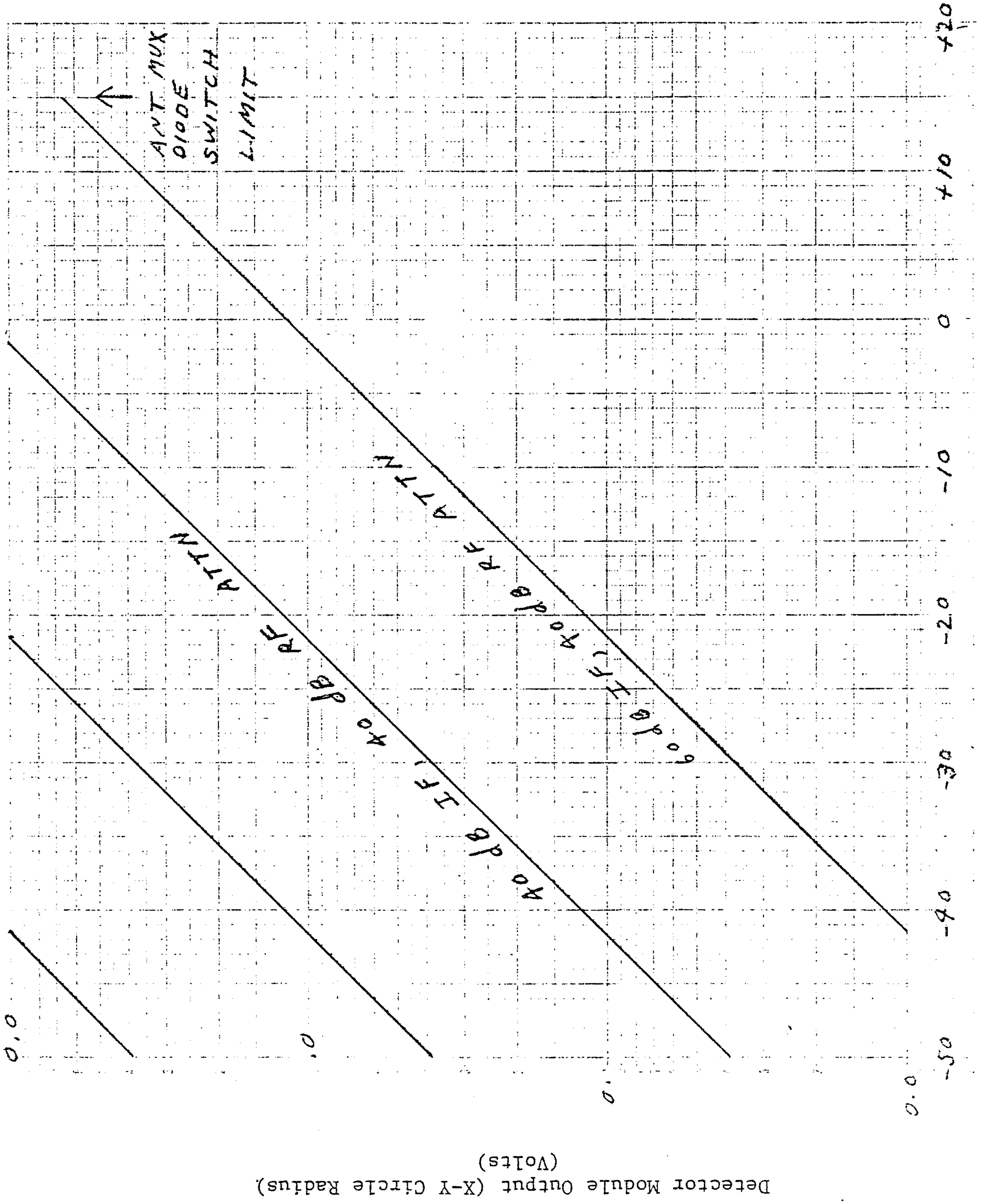


Figure 7

Gain modulation is usually expressed as the out-of-band signal required to reduce the receiver sensitivity ("desense") by 1 dB. Tests on the mixer configuration alone showed that this was > + 25 dBm at the mixer input. In the complete receiver including the RF preamplifier, which separately measures > + 20 dBm at its input, it is difficult to measure this quantity because effect 3 dominates for a genuinely low level signal. However, on the basis of the gain in front of the mixer (≈ 16 dB in this test), the overall receiver would be expected to be limited by the mixer and have a 1 dB desense level of ≈ + 11 dBm.

The noise level increase due to out-of-band signals is determined by the synthesizer local oscillator. In the band in which it is used, the source, an AILTECH 360, has a phase noise level of ≈ -135 dBc/Hz. This corresponds to -88 dB in the 50 kHz noise bandwidth of the receiver. Because the receiver mixer does not suppress the phase noise side bands, this means that every signal present at the mixer input produces a noise power increase of -88 dB with respect to its own level. For the simple case of a single high level signal, the effect and magnitude can be verified in Figure 8 which shows the receiver pass band measured by adjusting the strength of an input signal to maintain a constant receiver output. When the input signal is increased to ≈ 88 dB above its center frequency level, the apparent receiver output ceases to reduce as the input signal is moved further from center frequency due to the noise side bands falling in the pass band of the receiver. Substituting a HP 606 signal generator for the synthesizer, local oscillator produces about a 10 dB improvement showing that the signal source, also an HP 606, is not contributing significantly to the observed noise floor.

2.7 Receiver Pass Band

The receiver pass band is determined by two 4-pole maximally flat time delay filters with center frequencies of 40.625 MHz. The nominal -3 dB bandwidth of each filter is 30 kHz and the - 60 dB bandwidth 206 kHz. The filters are manufactured to our specification by a contractor using quartz crystal elements. The practical filters approach the theoretical transfer function quite closely and have an ultimate rejection of > 60 dB and spurious responses < - 60 dB.

An important reason for using this type of filter response function is that when executed by a carrier step function at the filter center frequency, the locus of output phase is a radial (i.e., constant phase) straight line. In the practical filters, this has been found to be a more sensitive indication

Total Receiver Freq. Response: RF sig freq = 10 MHz. Measurement obtained by varying input sig. amplitude to maintain constant analog converter output. RX setting constant; vary freq. of sig gen.

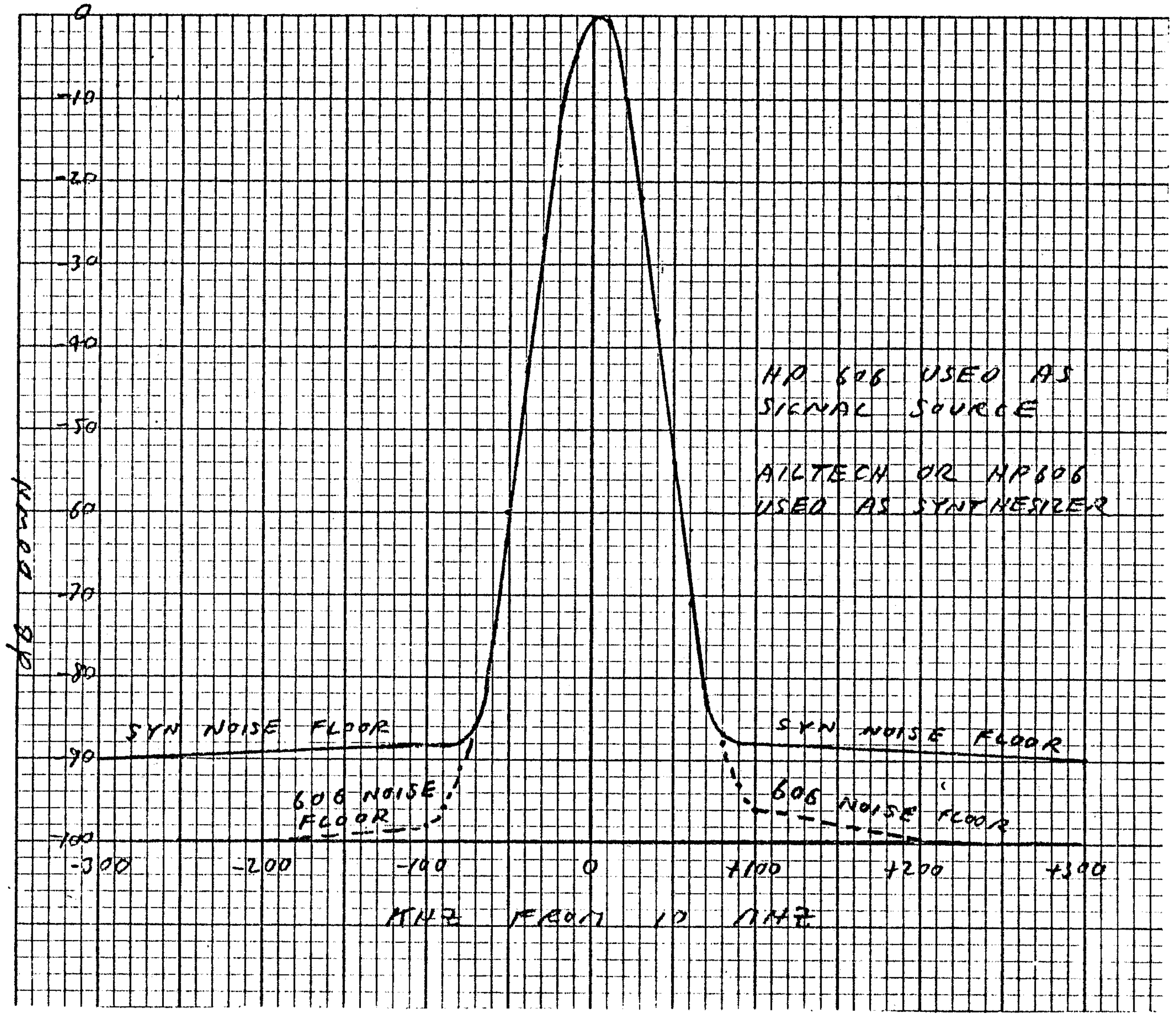


Figure 8

of correct alignment and matching than the envelope transient response or the steady state frequency response. It is important practically that the observed phase of ionospherically reflected signals is not sensitive to the exact timing of the measurement within the envelope. In practice by choosing filters in pairs for best compensation of errors, the phase locus can be held to ≈ ±2° for amplitudes above 10%.

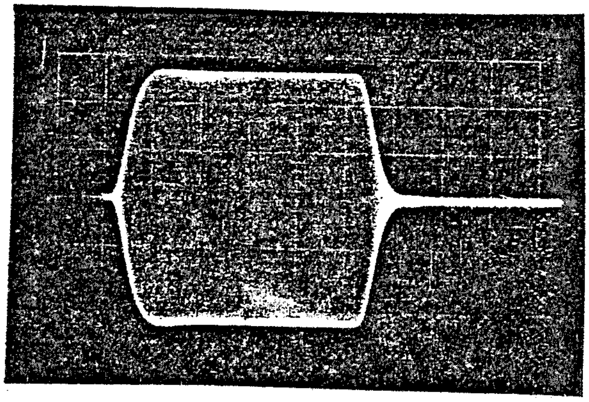
The overall receiver pass band frequency response measured through the mixer is shown in Figure 8. The 6 dB bandwidth is 32 kHz and the - 60 dB bandwidth 105 kHz. Measured in this manner, it is not possible to measure below the noise floors shown as was explained in the previous section. Measurements of the IF amplifier alone confirm that the pass band slope is maintained down to at least -120 dB. Figure 9 shows the pulse response of two representative filters, the two filters cascaded through resistive pads and the two filters in the receiver. Figure 10 shows a comparison of the calculated and measured pulse response. As can be seen from this, the receiver is essentially matched to a nominal 60 μs rectanglar pulse. The 10-90% rise time is ≈ 34 μs.

2.8 Output Low Pass Filter Response

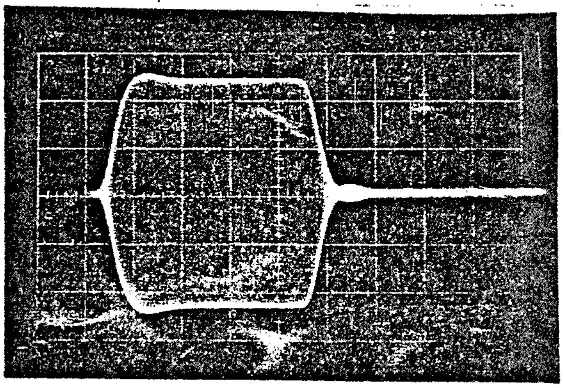
Active low pass filters are provided at the output of each of the quadrature detectors to permit bandwidth reduction when the receiver is used in a spectrum surveillance, or general purpose reception mode. The filters are two pole maximally flat time delay type so that they can also be used for pulse filters if desired. Bandwidth selection is accomplished by digital control. Nominal 3 dB low pass bandwidths are 30 kHz, 10 kHz, 3 kHz, and 1 kHz. The equivalent band pass responses are twice these. Figure 11 shows the receiver band pass responses plotted as a function of input signal offset. The 30 kHz position is intended merely to improve the skirt selectivity of the IF filters and does not modify the upper portion of the receiver response. The offset in the 30 kHz position response curve is due to a real center frequency offset of the IF filters themselves. (The band pass response imposed by the low pass filters must, of course, be completely symmetrical.) Work is at present in progress to reduce the IF filter offset both in the prototype and future production If amplifiers.

2.9 $\sqrt{X^2 + Y^2}$ Module

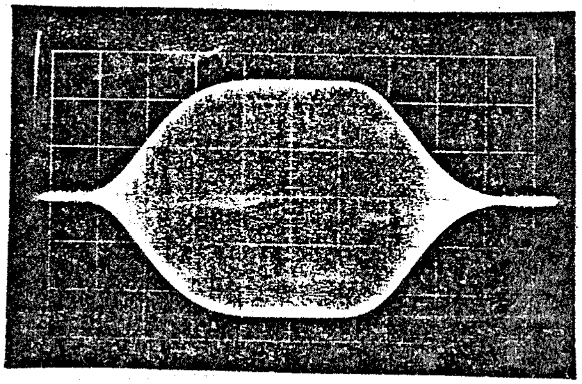
This module is a commercial building block using transconductance multipliers. Its purpose is to provide a convenient analog receiver amplitude output for operator CRT display, monitoring of AM modulated transmissions such as WWV, and in the spectrum surveillance mode, to provide the computer with a convenient, fast, single value amplitude through the housekeeping ADC.



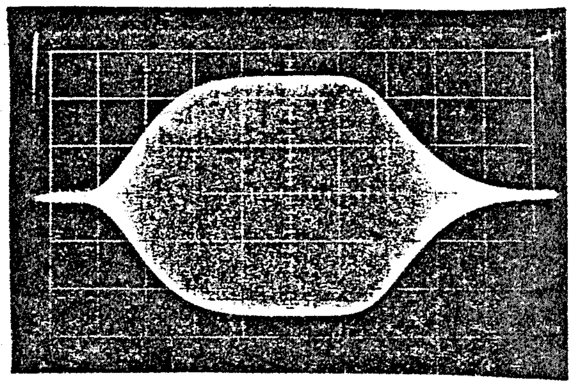
Filter #4
5 mV, 50 μs/Div



Filter #5
5 mV, 50 μs/Div

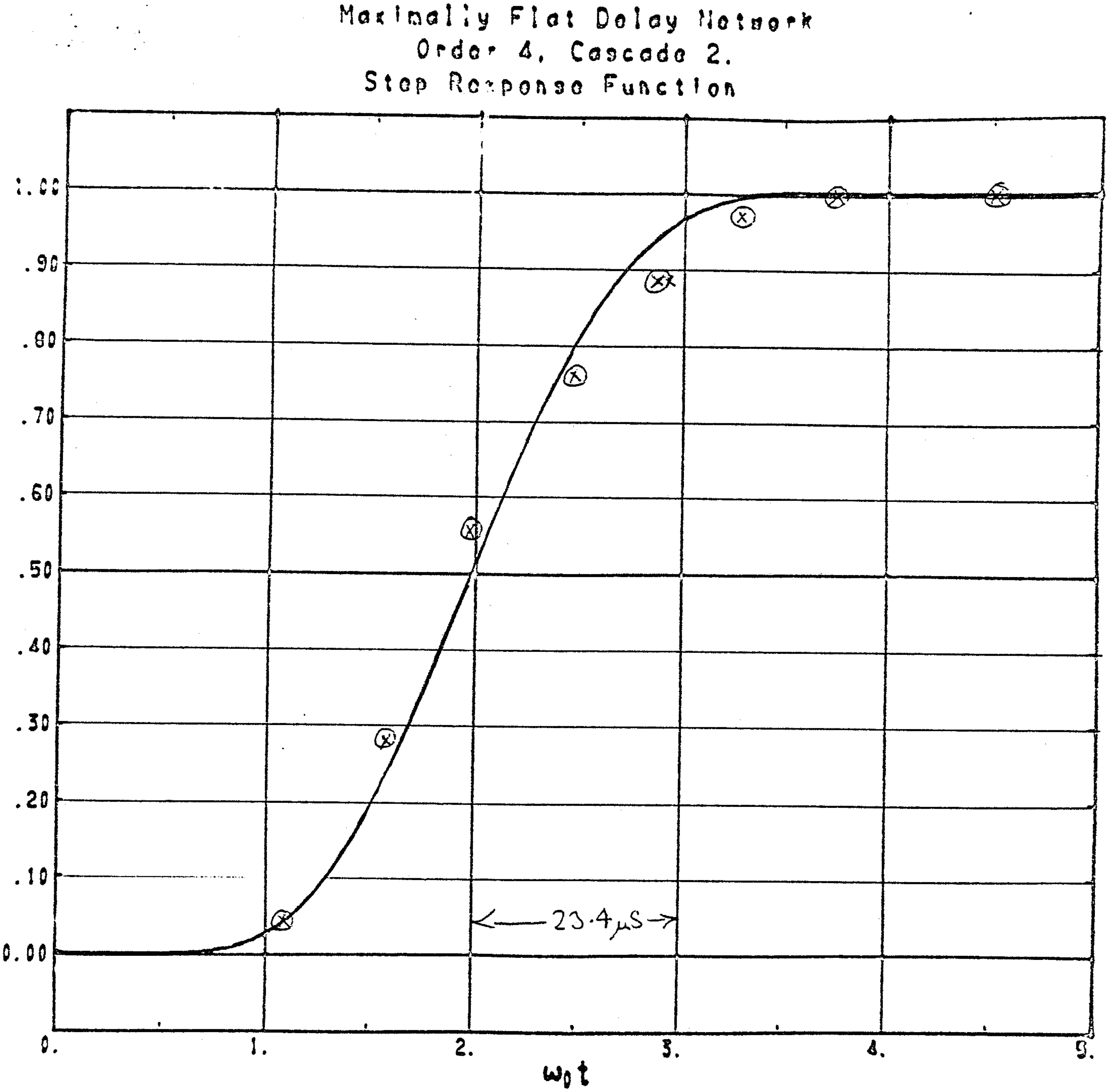


Two filters cascaded.
50 Ω Term.
50 mV, 20 μs/Div



Two filters cascaded.
Normal Receiver Circuit.
50 mV, 20 μs/Div

Figure 9



Comparison of Observed and Calculated IF Step Response
(Time Displacement 0.26)

Filter: $f_{-3\ dB}$, 15 kHz; f_0 = 6.8 kHz;
$\omega_0 = 42.8 \times 10^3$ rad/sec; t_0 = 23.4 μs

Figure 10

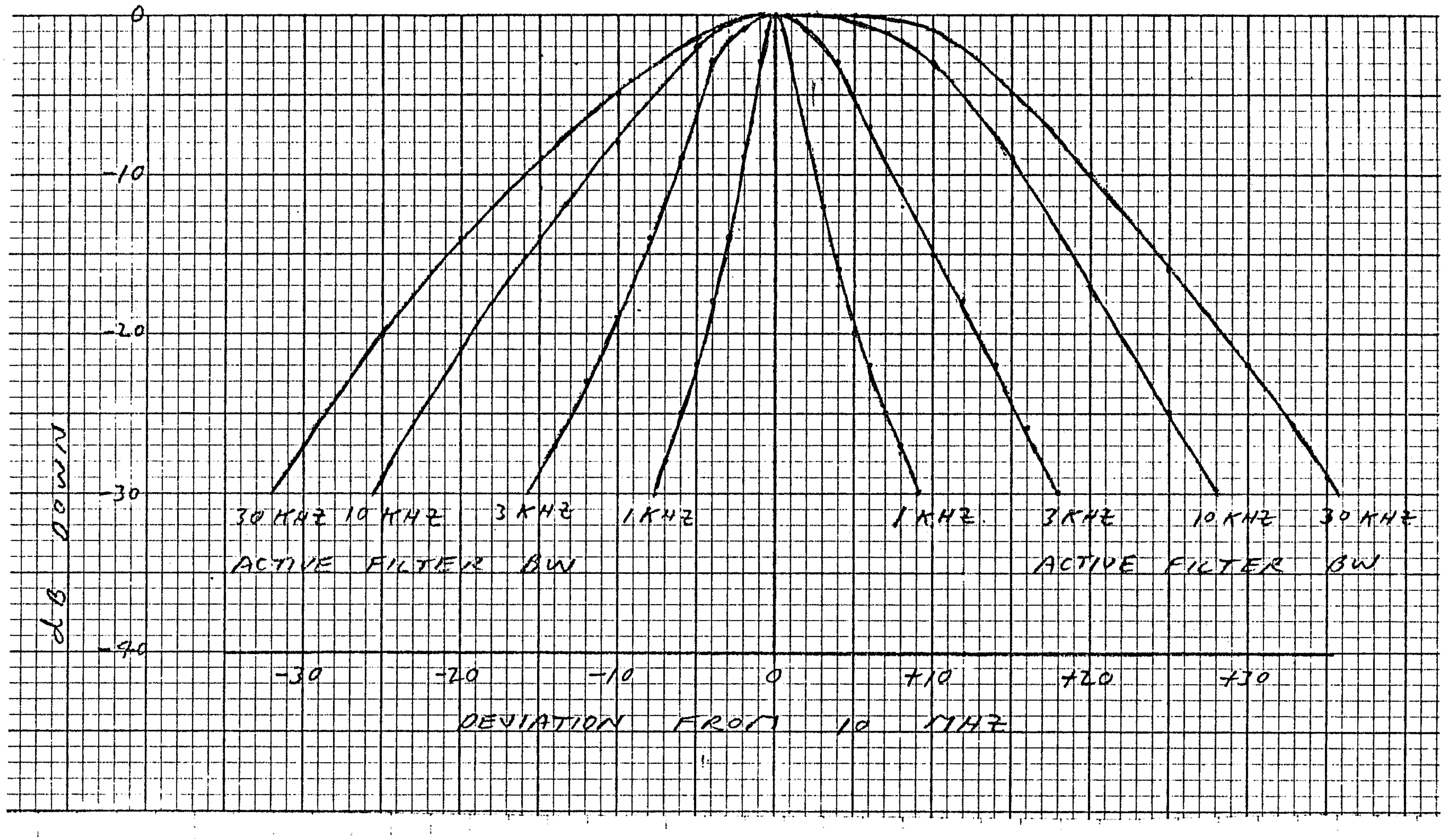


Figure 11. Overall receiver selectivity including output active filter

2.10 Logarithmic Amplifier

A video logarithmic amplifier is provided to give a wide dynamic range operator display. The logarithmic amplifier uses the log characteristic of the reverse turn-on of a backward diode. This characteristic is independent of temperature. The amplifier characteristic is shown in Figure 12.

2.11 Specification

2.11.1 System Type

Frequency agile receiver--coherent low power transmitter drive source, 4 way input multiplexer.

2.11.2 Frequency Range (R_X and T_X)

0.1-30 MHz.

2.11.3 Receiver Gain (Including Preamp)

113 dB ± 2 dB 0.2-29 MHz

+2 -11 dB, 0.1-30 MHz.

2.11.4 Receiver Output: XY Quadrature Components 0-10 V

(Primary)

$\sqrt{X^2 + Y^2}$ 0-10 V

Log $\sqrt{X^2 + Y^2}$ 0-6 V, 0.1 V/db

(Secondary)

2.11.5 IF Selectivity

-6 dB, 30 kHz

-60 dB, 150 kHz.

Maximally flat time delay response.

2.11.6 Post Detector Filters

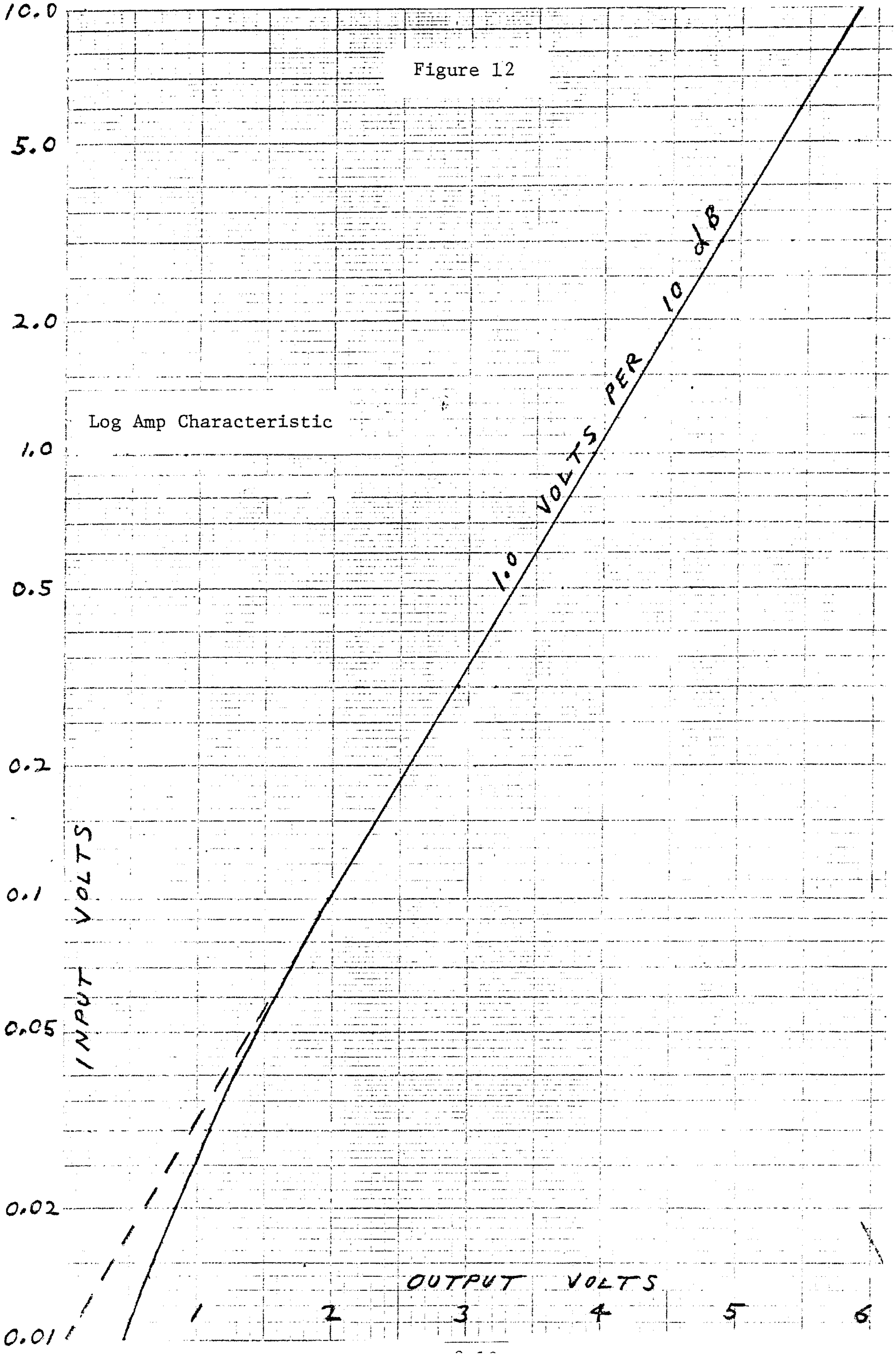
30, 10, 3, 1 kHz nominal 2-pole maximally flat time delay.

2.11.7 Pulse Rise Time

34 μs, 10-90%.

Figure 12

Log Amp Characteristic



2.11.8 Third Order Intercept, 0 dB RF Attenuation

With AM109 Preamp: ≃ + 16 dBm

Without Preamp: ≃ + 26 dBm.

2.11.9 1 dB Desense

With Preamp: ≃ + 11 dBm

Without Preamp: ≃ + 15 dBm.

2.11.10 IF Rejection: ≥ 120 dB

2.11.11 Other Spurious Response Rejection: ≥ 70 dB

2.11.12 Spurious Outputs

From receiver input ≤ -116 dBm.

From transmitter drive output ≤ -50 dB.

2.11.13 Receiver Sensitivity: 300 kHz-30 MHz, ≤ 0.5 μV
100 kHz, ≤ 2 μV

(Measured Tangentially.)

2.11.14 Calibration Signal Output

-26 dBm, ± 1 dB, 100 kHz-30 MHz.

2.11.15 Transmitter Drive Output

-3 dBm, ± 1 dB, 200 kHz-30 MHz

- 6 dB, 100 kHz.

3. RECEIVER MODULE SPECIFICATIONS

3.1 Antenna Multiplexer Module

3.1.1 FUNCTIONAL DESCRIPTION

The antenna multiplexer selects one antenna out of four for connection to the receiver. The single pole four-position diode switch is controlled either locally from a front panel switch or remotely by the computer through the control module. Front panel LED indicators show which antenna is selected and whether it is selected locally or remotely. In addition, the polarity of the signal can be shifted 180° in the diode switch by TSG control. The resulting positive or negative polarity of the output signal is indicated by a LED on the front panel.

3.1.2 MECHANICAL

The module is a single width NIM module with standard power and control interface. The four signal inputs and one signal output are BNC jacks on the back panel. Ambient temperatures range from 0° to 40°C operating, and -20 to +60 nonoperating.

3.1.3 ELECTRICAL INTERFACE

Power Requirements:

± 15 V @ 100 mA

+ 5 V @ 100 mA.

DIO Specification

Device Address:

Channel 1: 10 (Hex)
Channel 2: 11 (Hex)

Control Functions

One out of four antennas is selected by the eight bit control word from the DIO as follows:

Hex Control Word	Flag Word	Antenna	
00	00	#1	Remote
01	01	#2	
02	02	#3	
03	03	#4	
1X	10	#1	Local
1X	11	#2	
1X	12	#3	
1X	13	#4	

X = Don't Care

The flag word to the DIO is the same as the control word when control is remote but can be different when control is local.

Control can be changed from local to remote by the computer regardless of front panel settings, but it can be changed from remote to local with a front panel pushbutton only when local control is enabled through the DIO.

The connection between the antenna preamps and the RF amplifier is keyed by the diode switches in the antenna MUX module, which are controlled by the TSC. One bit of the 7-bit TSC control word switches the antennas on or off, and another bit switches the phase of the RF signal through 180°, as shown below:

Control Word	RX Phase Code	RX Disable
X X 0 X X X 0	+	No
0 1	+	Yes
1 0	-	No
1 1	-	Yes

Signal Input-Output: 50 Ω Unbalanced

3.1.4 PERFORMANCE SPECIFICATIONS

VSWR

Selected Signal Input: < 1.5:1 (output terminated in 50 Ω).

Nonselected Signal Input: Open Circuit.

Feedthrough

From one nonselected input to a selected channel source and sink terminated in 50 Ω:

1 MHz:	> 50 dB
30 MHz:	> 50 dB.

Insertion Loss (Selected Channel):

100 kHz:	< 6 dB
1 MHz:	< 2 dB
30 MHz:	< 2 dB.

Intermodulation

Third order products for two tones each + 10 dBm at input:

100 kHz, 150 kHz:	20 dB down
1 MHz, 1.1 MHz:	36 dB down
29 MHz, 30 MHz:	70 dB down.

Switching Speed:

< 10 μs to reach equilibrium within 1 dB.

Transient Feedthrough: Negligible

3.1.5 DOCUMENTATION

	Drawing No.
Block Diagram	HFS 111
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Module Interconnections	HFS 102
Parts List	HFS 151
Internal Connections	

3.2 FILTER MODULE

Specifications are to be determined.

3.3 RF MODULE

3.3.1 FUNCTIONAL DESCRIPTION

The RF module contains a 30 MHz low pass filter, 0 to 120 dB step attenuator, and a 10 dB amplifier. The filter suppressed all signals outside the operating range of the receiver. The amplifier and attenuator give a combined gain of from + 10 to -50 dB in 4 dB steps.

Attenuation is controlled either locally from a front panel switch or remotely by the computer through the control module. Front panel LED indicators show how much attenuation is selected and whether it is selected locally or remotely.

3.3.2 MECHANICAL

The module is a double width NIM module with standard power and control interface. The RF input and output connections are BNC jacks on the back panel.

3.3.3 ELECTRICAL INTERFACE

Power Requirements

+ 28 V @ 300 mA

+ 5 V @ 100 mA.

DIO Specification

Device Address --

Channel 1: 14 (Hex)

Channel 2: 15 (Hex)

Control Functions--

Attenuation from zero to 60 dB in 4 dB steps is selected by the eight bit control word from the DIO as follows:

X = Don't Care

Hex Control Word	Flag Word	Attenuation	
00	00	60 dB	Remote
01	01	56 dB	
--		--	
--		--	
OE	OE	4 dB	
OF	OF	0 dB	
1X	10	60 dB	Local
1X	11	56 dB	
--	--	--	
--	--	--	
1X	IE	4 dB	
1X	IF	0 dB	

The flag word to the DIO is the same as the control word when control is remote but can be different when control is local. Control can be changed from local to remote by the computer through the DIO regardless of front panel settings, but it can be changed from remote to local with a front panel pushbutton only when local control is enabled through the DIO.

Signal Input-Output: 50 Ω Unbalanced

3.3.4 PERFORMANCE SPECIFICATIONS

VSWR: < 1.5:1 at input with 50 Ω source or at output with 50 Ω sink.

Intermodulation:

Third order products at output for two tones each 10 dB at input:

> 75 dB down, 2-30 MHz

>   dB down @ 500 kHz

>   dB down @ 100 kHz.

Gain:

10 dB, 0.5-30 MHz

8 dB @ 200 kHz

6 dB @ 100 kHz.

Noise Figure:

< 6 dB @ 30 MHz

1 dB Compression Point:

> 28 dBm.

3.3.5 DOCUMENTATION:

	Drawing No.
Block Diagram	HFS 113
Schematic Diagram	HFS 114
Subcircuit Diagrams	HFS 131
Assembly Drawing	HFS 162
Front View	HFS 104
Rear View	HFS 106
Module Interconnections	HFS 102
Parts List	HFS 152
Internal Connections	

3.4 MIXER MODULE

3.4.1 FUNCTIONAL DESCRIPTION

The mixer module contains a double balanced mixer, crystal filter, and 33 dB amplifier. RF signals in the range of zero to 30 MHz are mixed with the synthesizer frequency in the range of 40 to 70 MHz to give an IF signal at 40.625 MHz, which is then filtered and amplified. The signal from the synthesizer is squared and amplified to 27 dBm at the LO input to the double balanced mixer. There are no controls in this module.

3.4.2 MECHANICAL

The module is a double width NIM module with standard power and control interface. The RF input, synthesizer input, and IF output connections are BNC jacks on the back panel.

3.4.3 ELECTRICAL INTERFACE

Power Requirements

+28 V @ 700 mA

+ 5 V @ 100 mA.

DIO Specification

Device Address: None

Control Functions: None

Signal Input-Output: 50 Ω Unbalanced.

3.4.4 PERFORMANCE SPECIFICATIONS

VSWR: < 1.5:1

Intermodulation:

Third order products at output for two tones each + 10 dBm at input:

0.5, 0.7 MHz:	53 dB down
29, 30 MHz:	60 dB down.

Gain: 24 dB.

Bandwidth:

30 kHz @ 3 dB down

240 kHz @ 60 dB down.

Spurious Rejection:

> 60 dB.

1 dB Compression Point:

+ 27 dBm.

3.4.5 DOCUMENTATION

	Drawing No.
Block Diagram	HFS 115
Schematic Diagram	HFS 116
Subcircuit Diagrams	HFS 132
Assembly Drawing	HFS 163
Front View	HFS 104
Rear View	HFS 106
Module Interconnections	HFS 102
Parts List	HFS 153
Internal Connections	

3.5 IF MODULE

3.5.1 FUNCTIONAL DESCRIPTION

The IF module contains a diode fast attenuator, a relay operated slow attenuator, a crystal filter, and a 33 dB amplifier. The diode attenuator is used for fast gain changes, with settings of 20 and 40 dB, and to disable the receiver when the input to the crystal filter approaches its damage threshold. The diode attenuator setting is controlled locally from a front panel switch, or remotely by the TSG. When the receiver is disabled, it remains disabled until reset locally from a front panel switch, or remotely from the computer. The receiver cannot be reset as long as the signal exceeds the disable threshold. An interrupt output goes to the computer whenever the receiver is disabled.

The slow attenuator can be set between zero and 60 dB in 4 dB steps locally from a front panel switch or remotely by the computer through the control module. The status of both attenuators and the disabled condition are shown by front panel LED indicators. The indicators also show whether control is from the TSG, computer, or front panel switch.

3.5.2 MECHANICAL

The module is a double width NIM module with standard power and control interface. The IF input and output connections are BNC jacks on the back panel.

3.5.3 ELECTRICAL INTERFACE

Power Requirements

+28 V @ 400 mA

+ 5 V @ 200 mA.

DIO Specification

Device Address:

Channel 1:	16 (Hex)
Channel 2:	17 (Hex)

Control Functions:

Attenuation from zero to 60 dB in 4 dB steps is selected by the 8-bit control word as follows:

Hex Control Word	Flag Word X = Don't Care	Attenuation	
00	00	60 dB	Remote
01	01	56 dB	
--	--	--	
--	--	--	
OE	OE	4 dB	
OF	OF	0 dB	
1X	10	60 dB	Local
1X	11	56 dB	
--	--	--	
--	--	--	
1X	IE	4 dB	
1X	IF	0 dB	

The flag word to the DIO is the same as the control word when control is remote but can be different when control is local.

Control can be changed from local to remote by the computer regardless of front panel settings, but it can be changed from remote to local with a front panel pushbutton only when local control is enabled through the DIO.

When the IF module is under remote control, the diode attenuator is controlled by the 7-bit word from the TSG, as shown below.

Control Word	Fast Attenuation
0 0 X X X X X	0 dB
0 1	20 dB
1 0	Not Used
1 1	40 dB

The TSC control word also disables the IF amplifier:

Control Word	Reset
X X X X X X 0	No
1	Yes

If the IF amplifier has become disabled by an overload, it can be reset by the TSG. In this situation, the control bit will have been zero before the disability occurred. A positive pulse will reset to the enabled condition if the overloading signal is no longer present.

Signal Input-Output: 50 Ω Unbalanced

3.5.4 PERFORMANCE SPECIFICATIONS

VSWR: < 1.5:1

Gain: 24 dB

Bandwidth:

30 kHz @ 3 dB down

240 kHz @ 60 dB down.

Spurious Rejection: > 60 dB

1 dB Compression Point: + 27 dBm

3.5.5 DOCUMENTATION

	Drawing No.
Block Diagram	HFS 117
Schematic Diagram	HFS 118
Subcircuit Diagrams	HFS 129, 131
Assembly Drawing	HFS 164
Front View	HFS 104
Rear View	HFS 106
Module Interconnections	HFS 102
Parts List Internal Connections	HFS 154

3.6 DETECTOR MODULE

3.6.1 FUNCTIONAL DESCRIPTION

The detector splits the IF signal into two quadrature components and mixes the components with the reference signal from the local oscillator. The difference frequency components are then low-pass filtered by second order constant delay active filters. The filter cutoff frequencies can be set at 1, 3, 10, or 30 kHz locally from a front panel switch, or remotely by the computer through the control module. Front panel LED indicators show which bandwidth is selected and whether it is selected locally or remotely.

3.6.2 MECHANICAL

The module is a double width NIM module with standard power and control interface. The IF input, reference oscillator input, and X-Y quadrature output connections are BNC jacks on the rear panel.

3.6.3 ELECTRICAL INTERFACE

<u>Power Requirements</u>

+ 28 V @ 700 mA

± 15 V @ 100 mA

+ 5 V @ 300 mA.

<u>DIO Specification</u>

Device Address:

Channel 1:	18 (Hex)
Channel 2:	19 (Hex)

Control Functions

Bandwidth between 1 kHz and 30 kHz is selected by the 8-bit control word from the DIO as follows:

Hex Control Word	Flag Word	Bandwidth	
	X = Don't Care		
00	00	1 kHz	Remote
01	01	3 kHz	
02	02	10 kHz	
03	03	30 kHz	
1X	10	1 kHz	Local
1X	11	3 kHz	
1X	12	10 kHz	
1X	13	30 kHz	

Control can be changed from local to remote by the computer regardless of front panel settings, but it can be changed from remote to local with a front panel pushbutton only when local control is enabled through the DIO.

The flag word to the DIO is the same as the control word when control is remote but can be different when control is local.

Signal Input-Output

IF and synthesizer inputs are 50 Ω unbalanced. Quadrature outputs are 100 Ω DC unbalanced, but to avoid excessive voltage drop, they are connected only to devices having input impedances of at least 50 kΩ.

3.6.4 PERFORMANCE SPECIFICATION

Gain: 48 dB

Maximum Output Voltage: ± 10 volts

Output Zero Stability

< 1 mV per sec
< 5 mV per hour
< 10 mV per day.

Phase Error Over 60 dB Range, with Correction for DC Offset: ± 1°.

VSWR: < 2:1 at input

Dynamic Range from Noise Threshold to Saturation: > 60 dB.

3.6.5 DOCUMENTATION

	Drawing No.
Block Diagram	HFS 119
Schematic Diagram	HFS 120
Subcircuit Diagrams	HFS 130, 131
Assembly Drawing	HFS 165
Front View	HFS 104
Rear View	HFS 106
Module Interconnections	HFS 102
Parts List	HFS 155
Internal Connections	

3.7 ANALOG CONVERTER MODULE

3.7.1 FUNCTIONAL DESCRIPTION

The analog converter contains a vector operator and a log amplifier. The vector performs a $\sqrt{X^2 + Y^2}$ operation on the quadrature inputs, X and Y, giving an output proportional to the amplitude of the received signal. The amplitude voltage is the input to the log amplifier, whose output is proportional to the log of the signal amplitude. The amplitude voltage also goes to a threshold detector which sends an interrupt to the computer and indicates on a front panel LED when the signal is overloading the vector module.

There is also an audio amplifier with speaker and a front panel voltmeter, which are connected in parallel and can be switched to monitor the X and Y detector outputs and the amp and log analog converter outputs.

3.7.2 MECHANICAL

The module is a triple width NIM module with standard power and control interface. The X-Y quadrature inputs, amplitude output, and log output for two channels are BNC jacks on the back panel. There are two jacks in parallel for each of the four inputs, so that one can be used as an analog data connection to the computer interface.

3.7.3 ELECTRICAL INTERFACE

Power Requirements

+ 28 V @ 100 mA

± 15 V @ 100 mA

+ 5 V @ 100 mA

DIO Specification

Device Address: None

Control Functions: None

Signal Input-Output

The quadrature input impedances are 1 MΩ. The amplitude and log output impedances are 100 Ω DC to ground, but to avoid excessive voltage drop, the outputs are connected only to devices having input impedances of 50 kΩ or more.

3.7.4 PERFORMANCE SPECIFICATIONS

Amplitude Output Dyanmic Range: 40 dB

Log Output Dynamic Range: 40 dB

Amplitude Output Accuracy: ± 100 mV over dynamic range

Log Output Accuracy: ± 2 dB over dynamic range

3.7.5 DOCUMENTATION

	Drawing No.
Block Diagram	HFS 121
Schematic Diagram	HFS 122
Subcircuit Diagrams	None
Assembly Drawing	HFS 166
Front View	HFS 104
Rear View	HFS 106
Module Interconnections	HFS 102
Parts List	HFS 156
Internal Connections	

3.8 TRANSMITTER MIXER MODULE

3.8.1 FUNCTIONAL DESCRIPTION

The transmitter mixer module contains the reference oscillator, a dual bipolar switch, a band pass filter, and a double balanced mixer. An output of the 40.625 MHz reference oscillator is mixed with an output of the synthesizer to produce the frequency in the zero to 30 MHz range which is transmitted. The bipolar switch pulse modulates the oscillator output and varies its phase from zero to 270° in 90° increments. Phase and amplitude are controlled by the TSC, with LED indicators on the front panel. The square pulses are gaussian-shaped by the band pass crystal filter between the switch and the mixer.

3.8.2 MECHANICAL

The module is a triple width NIM module with standard power and control interface. The synthesizer input, RF output, and three reference oscillator output connections are BNC jacks on the back panel.

3.8.3 ELECTRICAL INTERFACE

<u>Power Requirements</u>

+ 28 V @ 600 mA

± 15 V @ 100 mA

+ 5 V @ 100 mA

<u>DIO Specification</u>

Device Address: None

Control Functions

Transmitter keying and the phase of the transmitted signal are controlled remotely by three bits of the TSG control word as shown below:

Control Word	TX Phase Code	TX Pulse Keying
X X X 0 0 0 X	0	On
0 0 1	0	Off
0 1 0	270	On
0 1 1	270	Off
1 0 0	90	On
1 0 1	90	Off
1 1 0	180	On
1 1 1	180	Off

Signal Input-Output: 50 Ω Unbalanced

3.8.4 PERFORMANCE SPECIFICATION

VSWR: < 1:5:1 at input with 50 Ω source or at output with 50 Ω sink.

Insertion Loss: 29 dB

Bandwidth:

30 kHz @ 3 dB down

240 kHz @ 60 dB down

Switching Speed:

< 5 μs to reach equilibrium within 1 dB. Pulse envelope rise time is mainly determined by 30 μs rise time of filter response.

Feedthrough

Output in keyed-off condition 50 dB below output in keyed-on condition.

3.8.5 DOCUMENTATION

	Drawing No.
Block Diagram	HFS 123
Schematic Diagram	HFS 124
Subcircuit Diagrams	HFS 133
Assembly Drawing	HFS 167
Front View	HFS 104
Rear View	HFS 106
Module Interconnections	HFS 102
Parts List	HFS 157
Internal Connections	

3.9 TRANSMITTER DRIVE MODULE

3.9.1 FUNCTION DESCRIPTION

The transmitter drive module removes the unwanted frequency components generated in the double balanced mixer of the transmitter mixer module. The resulting signal is then amplified and becomes the output to the high power transmitter. A diode switch turns the transmitter off and on, either by local control from a front panel switch or by remote control from the computer. The status is shown by an LED indicator on the front panel.

There is also a calibration output through a step attenuator. Attenuation is controlled locally from a front panel switch or remotely from the computer, and can be varied from zero to 120 dB in 8 dB steps. Front panel LED indicators show how much attenuation is selected and whether it is selected locally or remotely.

3.9.2 MECHANICAL

The module is a double width NIM module with standard power and control interface. The RF input, RF output, and calibration output connections are BNC jacks on the rear panel.

3.9.3 ELECTRICAL INTERFACE

Power Requirements

+ 28 V @ 200 mA

+ 5 V @ 100 mA

DIO Specification

Device Address: 1A (Hex)

Control Functions

Attenuation from zero to 120 dB in 8 dB steps is selected by the 8-bit control word from the DIO as follows:

Hex Control Word	Flag Word	Attenuation	
00	00	120 dB	Remote
01	01	112 dB	
--	--	--	
--	--	--	
OE	OE	8 dB	
OF	OF	0 dB	
1X	10	120 dB	Local
1X	11	112 dB	
--	--	--	
--	--	--	
1X	IE	8 dB	
1X	IF	0 dB	

X = Dont't Care

Control can be changed from local to remote by the computer regardless of front panel settings, but it can be changed from remote to local with a front panel pushbutton only when local control is enabled through the DIO.

The flag word to the DIO is the same as the control word when control is remote, but can be different when control is local.

The transmitter is keyed on or off by one bit of the 7-bit TSG control word as shown below:

Control Word	TX Enable
X X X X X X 0	No
1	Yes

Signal Input-Output: 50 Ω Unbalanced

3.9.4 PERFORMANCE SPECIFICATIONS

VSWR: < 1.5:1 at input with 50 Ω source or at output with 50 Ω sink.

Feedthrough

Output in disabled condition 50 dB below output in enabled condition.

Gain: 24 dB

RF Output: ≈ 0 dBm.

3.9.5 DOCUMENTATION

	Drawing No.
Block Diagram	HFS 125
Schematic Diagram	HFS 126
Subcircuit Diagrams	HFS 131
Assembly Drawing	HFS 168
Front View	HFS 104
Rear View	HFS 106
Module Interconnections	HFS 102
Parts List Internal Connections	HFS 158

3.10 SYNTHESIZER DISTRIBUTION MODULE

3.10.1 FUNCTION DESCRIPTION

The synthesizer distribution module contains a four-way power splitter to distribute the synthesizer output to the mixer modules, the transmitter mixer module, and a test port. It also contains a low pass filter to remove any spurious outputs above 73 MHz and a 3 dB coaxial attenuator to reduce the power at the outputs to 0 dBm.

3.10.2 MECHANICAL

The module is a single width NIM module with standard power and control interface. The signal input and four signal outputs are BNC sockets attached to the low pass filter and power splitter, respectively, and accessed through holes in the back panel.

3.10.3 ELECTRICAL INTERFACE

Power Requirements: None

DIO Specification: None

Signal Input-Output

Input: +10 dBm, 50 Ω unbalanced
Output: 0 dBm, 50 Ω unbalanced

3.10.4 PERFORMANCE SPECIFICATION

The output signals are down 3 dB at 73.0 MHz, 20 dB at 76.7 MHz, and 40 dB at 80.3 MHz.

3.10.5 DOCUMENTATION

Synthesizer distribution module drawing no. 163.

3.11 CONTROL MODULE

3.11.1 FUNCTION DESCRIPTION

The control module controls attenuation, bandwidth, and antenna selection in the receiver. The address of the device being controlled and the data corresponding to the setting are received from the computer. The data word is sent to the device and a flag word is received from the device. Under remote control, the flag word is the same as the data word, but under local control, it may be different.

3.11.2 MECHANICAL

The module is a single width NIM module with standard power and control interface. The standard NIM plug connects the control module with the other receiver modules. An additional 25 pin plug connects it to the computer I/O interface.

3.11.3 ELECTRICAL INTERFACE

Power Requirements

+ 5 V @ 1000 mA

3.11.4 DOCUMENTATION

	Drawing No.
Block Diagram	HFS 127
Schematic Diagram	None
Subcircuit Diagrams	HFS 134, 135
Assembly Drawing	HFS 169
Front View	HFS 104
Rear View	HFS 106
Module Interconnections	HFS 102
Parts List	HFS 159
Internal Connections	

3.12 CONTROL/ADDER MODULE

3.12.1 FUNCTION DESCRIPTION

The control/adder module consists of a control module plus an adder and a LED display. In addition to the functions of a control module, it adds the RF frequency data from the computer to the fixed 40.625 MHz IF frequency and outputs the sum to the synthesizer. The RF frequency when remotely selected is shown by the LED display on the front panel.

3.12.2 MECHANICAL

The module is a double width NIM module with standard power and control interface. The standard NIM plug connects the control/ adder module with the other receiver modules. An additional 25 pin plug connects it to the computer I/O interface, and a 50 pin plug connects it to the synthesizer.

3.12.3 ELECTRICAL INTERFACE

Power Requirements

+ 5 V @ 1800 mA

3.12.4 DOCUMENTATION

	Drawing No.
Block Diagram	HFS 128
Schematic Diagram	
Subcircuit Diagrams	HFS 134, 135, 136, 137
Assembly Drawing	HFS 170
Front View	HFS 104
Rear View	HFS 106
Module Interconnections	HFS 102
Parts List Internal Connections	HFS 160

4. SUBMODULE CIRCUITS

4.1 Dual Bipolar Switch

One circuit is used in the transmitter mixer module and two are used in the antenna multiplexer module. The circuit diagram is shown in drawing no. 103.

The function of the dual bipolar switch is to pass or stop two RF signals at diode attenuators M2 and M3 (the component designations refer to the switch in the transmitter mixer module). In addition, when the signal is passed through each attenuator, its phase at the output can be 0° or 180° relative to the input, depending on the DC voltage applied to the control terminals of the attenuator.

In the transmitter mixer module, the dual bipolar switch keys the transmitter and varies the phase of the transmitted signal from 0° to 270° in 90° steps. This is done by splitting the signal into quadrature components through quadrature hybrid QH1. The two components are connected to the inputs of M2 and M3, and the outputs are recombined in power splitter PS2. The status of the PS2 output as a function of the M2 and M3 control voltages is tabulated below.

M2 Control Voltage	M3 Control Voltage	Output Signal
Zero	Zero	Off
-	-	0°
-	+	90°
+	+	180°
+	-	270°

In the antenna multiplexer module, two dual bipolar switches are used to select one of four receiving antennas, and to set the phase of the signal from the selected antenna at 0° or 180°. Positive or negative control voltage is selected simultaneously for all four attenuators, but only one at a time is enabled by the output of decoder U8.

The diode control voltages are supplied by operational amplifiers U1 and U2. The status of each attenuator as a function of the inputs to its op amp driver is tabulated below.

Op Amp Inputs		
Direct (Pin 10)	Inverting (Pin 11)	Attenuator Output
Zero	Zero	Off
+	Zero	On @ 0°
Zero	+	On @ 180°

The condition where both inputs are positive would be redundant and is not used. The required combination is encoded for both attenuators by quad NOR gate U3. Amplitude and phase are controlled independently unless the U3 inputs for common on/off or for common +/- are jumpered. When the dual bipolar switch is used in the transmitter mixer module, common on/off is jumpered, and when it is used in the transmitter mixer module, common +/- is jumpered.

A control current of 20 mA is required for full conduction in the diode attenuator. This current does not have to be precise, and variations caused by differences in the high output levels of U3 are not critical. For the off condition, the control current must be less than one μA, but since there is no conduction when the control voltage is below 100 mV, variations in the U3 low output levels do not have to be compensated. Output DC offset voltages from op amps U1 and U2 are nulled by potentiometers R49 and R50. The switching time of 10 μs is determined by the capacitance of C10-C13.

The low pass filters consisting of inductors L5 and L6, and capacitors C30-C33, prevent spurious RF voltages from modulating the signals in the diode attenuators.

4.2 Squarer

One circuit is used in the mixer module. Its circuit diagram is shown in drawing no. 132. The purpose of the squarer is to increase the third order intercept point of the double-balanced mixer (M1) in the mixer module by reducing the time required to switch the diodes from fully conducting in one direction to fully conducting in the opposite direction. Using this circuit, the transition time is reduced to 4 ns. The 2 ns rise time of the square wave is obtained by operating transistors Q1-Q4 as linear push-pull amplifiers and clipping the sine wave with Schottky diodes between the two stages.

Transistors Q1-Q4 must be matched pairs (Q1 with Q2, and Q3 and Q4) to obtain a symmetric waveform at the output. A curve tracer, such as the Tektronix 577, can be used to match the common emitter collector characteristics.

4.3 Fast Attenuator

One circuit is used in the IF module. The circuit diagram is shown in drawing no. 129.

The attenuation of the diode attenuator M1 is controlled by the total current through the three resistive branches: Branch 1 = (R15 + R16 + R18); Branch 2 = (D4 + R17 + R19); Branch 3 = (D3 + R20). Outputs of hex inverter U4 selectively pull these branches to ground, varying the current to the attenuator according to the table below:

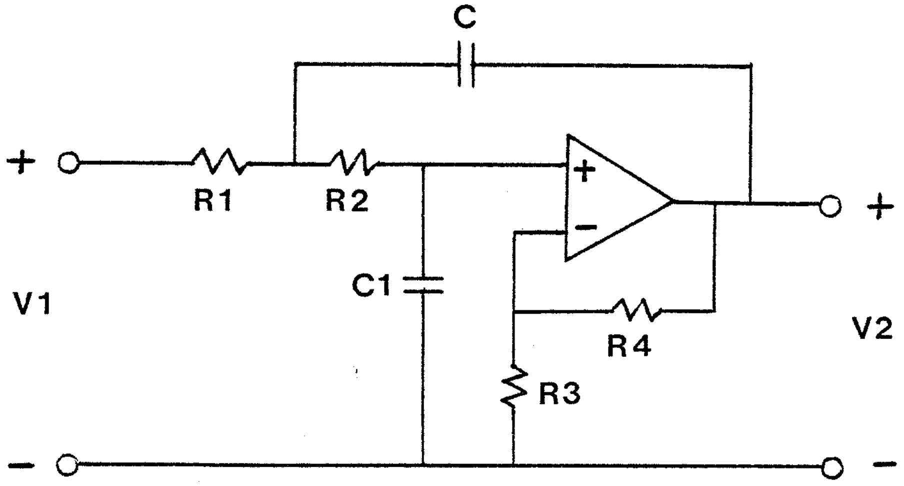
U4 Output Low	Branch Supplying Current	Current to Attenuator	Attenuation
None	1, 2, 3	20 mA	3 dB (min.)
Pin 2	1, 2	72 μA	23 dB
Pins 2, 4	1	6.0 μA	43 dB
Pins 8, 10, 12	None	Zero	> 50 dB (max.)

The maximum attenuation is used to disable the IF amplifier when the input signal to the crystal filter F1 exceeds the safe operating limit of +15 dBm. One of the outputs of power splitter PS1 is rectified, and the resulting DC level is applied to the input of voltage comparator U1. When the input to PS1 exceeds +18 dBm and each output exceeds +15 dBm, the output of U1 goes low, setting an RS flip-flop (½ U2) at the S input (Pin 4). The $\overline{Q}$ output (Pin 11) then goes high, setting the U4 outputs (Pins 8, 10, and 12) low, and cutting off all control current to the attenuator. The IF amplifier remains disabled until the flip-flop is reset either locally or remotely by a negative pulse at the R input (U2, Pin 12).

4.4 Active Filter

Two circuits are used in the detector module. The circuit diagram is shown in drawing no. 130.

The filter type is second order low pass Bessel, or constant time delay. It's basic circuit (Reference Data For Radio Engineers, 6th Ed, Page 10-3) is given below



The transfer function of a second order approximation to an ideal low pass filter with cutoff frequency ω_o is given by:

$$\frac{V_2}{V_1} = \frac{k\, b\, \omega_o^{\,2}}{s^2 + a\, \omega_o\, s + b\, \omega_o^{\,2}} \qquad (1)$$

where k is the zero frequency gain. For frequencies up to ω_o, the time delay through the filter is nearly constant.

The values of resistance and capacitance are related by:

$$R_1 = \frac{2}{(aC + \{[a^2 + 4b\ (k-1)]\ C^2 - 4bCC_1\}^{\frac{1}{2}})\ \omega_o}$$

$$R_2 = \frac{1}{bCC_1\ R_1\ \omega_o{}^2}$$

$$R_3 = \frac{K\ (R_1 + R_2)}{K - 1}$$

$$R_4 = K\ (R_1 + R_2)$$

For the Bessel filter used in the detector module, the chosen values are

$$f_d = \frac{\omega_o}{2\pi} = 1 \text{ kHz, } 3 \text{ kHz, } 10 \text{ kHz, and } 30 \text{ kHz}$$

$C_1 = 2C = .05\ \mu F$ for $f_d = 1$ kHz

$a = b = 3$

$K = 15.$

The other values are calculated from (2) through (5).

Bandwidths are switched by DPST reed relays S4, S5, and S6. Resistance is held constant and capacitance is varied. The switch status and corresponding capacitors which set the bandwidth are given below:

Bandwidth	Switch Status	Bandwidth Determined By
1 kHz	All Open	C14 and C16
3 kHz	S6 Closed	C10 + C14 and C12 + C16
10 kHz	S5 Closed	C6 + C14 and C8 + C16
30 kHz	S4 Closed	C2 + C14 and C4 + C16.

Potentiometer R20 adjusts the zero output. While it is not necessary that the gain be exact, it is necessary that the gains of both the "X" and "Y" outputs be equal. For this reason, the gain of the "Y" filter is constant and the gain of the "X" filter can be adjusted by potentiometer R34 to match it.

For both filters to have the same characteristics over the entire frequency range, the resistors and capacitors must be closely matched between filters. The resistors are 1% tolerance, but since precision is more difficult to obtain in capacitors, 5% or 10% capacitors are used. Each capacitor in the "X" filter is matched to the corresponding capacitor in the "Y" filter within 5%.

4.5 Local/Remote Controller

One circuit is used in the antenna multiplexer, RF, and detector modules. Two circuits are used in the IF and transmitter drive modules. A block diagram and wiring diagram are shown in drawing no. 131. Each controller consists of one 7400 quad NAND gate and one 9322 quad two-input multiplexer. The control word is inputed either remotely, or locally from front panel switches. Selection is controlled by the level of the Q output of an RS flip-flop (½ of the 7400). A negative level at the R input from the DIO always forces remote control, since it is also connected to the S input via a NAND gate. When the R input is high, local control can be obtained by a negative pulse at the local enable input, from a front panel pushbutton.

4.6 Log Amplifier

Two log amplifiers are used in each detector module. The circuit diagram is contained in drawing no. 122. Each amplifier consists of two LM 531 operational amplifiers (U1 and U2, using the designations of the channel A amplifier). The logarithmic feedback element is D1, a forward biased BD-7 back diode. Since the amplifier is used only for positive gain, another diode connected in the opposite direction is not needed. R38 limits the gain near zero, where the diode resistance is very high, and improves its stability in that region. D5, an HP 2800 hot carrier diode in the second (linear) stage, limits the negative output voltage to about 300 mV. Potentiometer R15 adjusts the output to zero when the input is zero. Maximum output is +5 volts, and the output is proportional to the logarithm of the input over at least a 40 dB range (50 mV to 5 V).

4.7 DIO Strobe Buffer Circuit

One strobe buffer circuit is used in each control module and in the control/adder module. A block diagram is contained in drawing no. 134, and a wiring diagram is contained in drawing no. 135.

The buffer consists of one DM8836N quad NOR gate (U1 in the control module), plus R1-R3 and C7-C9. Its function is to buffer and distribute the address and data strobe pulses to the data circuits in the control and control/adder modules.

The function of R3 and C9 is to hold the address strobe to the address comparator low for 60 ms after power turn-on. This prevents the situation where both the tri-state buffer and tri-state latch in the data circuits output data simultaneously at power turn-on.

4.8 DIO Data Circuit

Five data circuits are used in each control module and in the control/adder module. A block diagram is contained in drawing no. 134 and a wiring diagram is contained in drawing no. 135. The circuits are grouped in five vertical rows on one PC board, the row nearest the strobe buffer circuit consisting of:

U2	DM8131N	Bus Comparator
U7, U12	DM81LS95N	Tri-State Buffer
U17	DM8553N	Tri-State Latch

Each device (such as an attenuator) is selected by the 6-bit address input to U2. On the falling edge of the address strobe, U2 compares the input word with the 6-bit word set by the address links, which are jumpered to either +5 volts or ground. If they are identical, it outputs a true level to enable U7, U17, and U12. On the falling edge of the data strobe, U2 transfers the data bits from the DIO bus to U17, where they are latched and sent to the device being controlled. Flags from the device return to U12, which transfers them to the flag bits of the DIO bus as long as the data circuit is addressed.

4.9 Adder Circuit

One adder is used in the control/adder module. Its block diagram is contained in drawing no. 136, and a wiring diagram is contained in drawing no. 137. It consists of five 82S83 BCD adder chips on a 7.35 inch by 9.25 inch PC board and is mounted in the NIM module beside the control board. One input to the adder is the constant five digit BCD IF frequency word (40625). The other input is a six digit BCD RF frequency word from the DIO bus via three eight bit DIO data circuits. The 24 lines are wired from the "control to device" pads on the control board to the frequency inputs of the adder. The hundreds digit in the RF frequency is not added to anything, and is connected directly to the output. The sum output of the adder is the synthesizer frequency, and is connected to the 50 pin synthesizer connector at the module back panel.

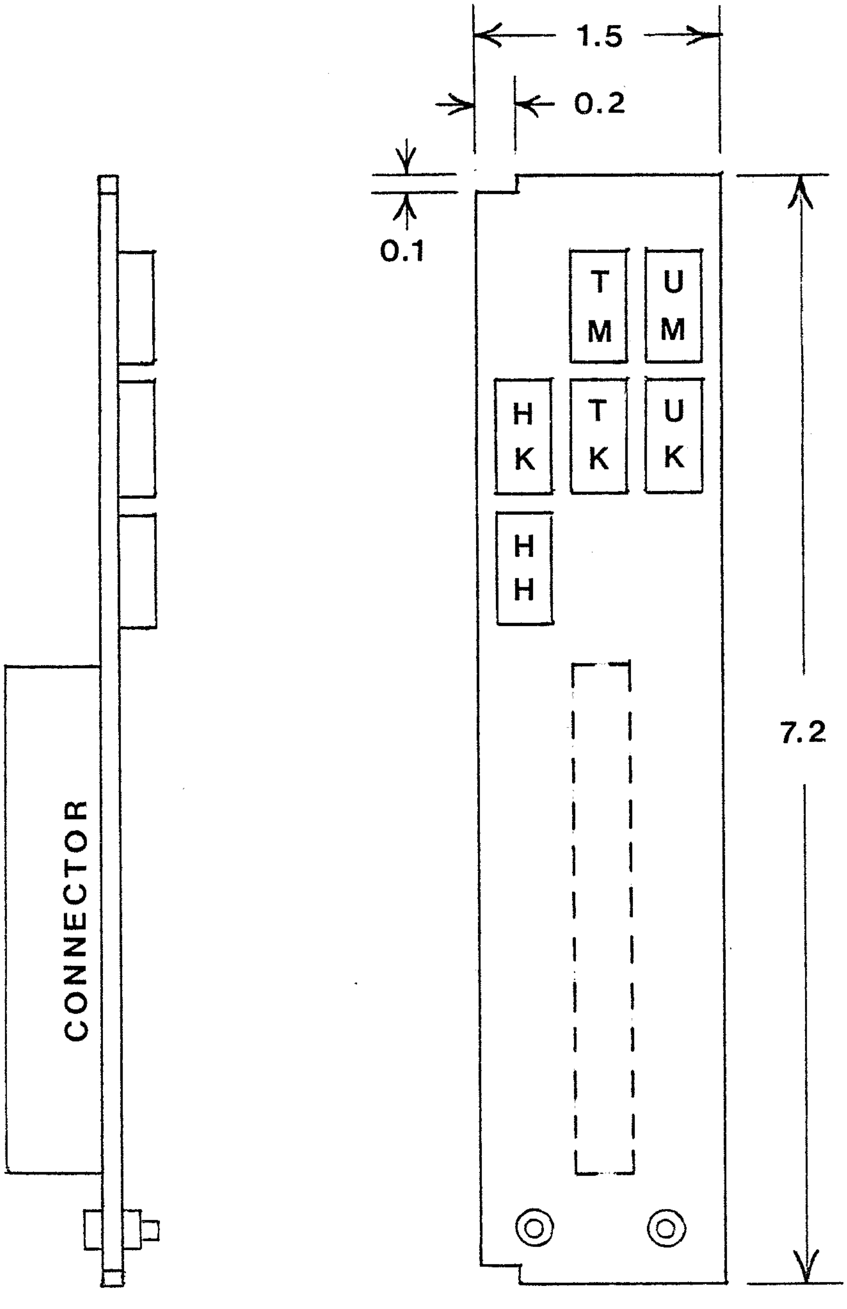
4.10 Frequency Display Circuit

One circuit is constructed on a 1.5 inch x 7.2 inch PC board which is mounted behind the front panel of the control/adder module. A block diagram is contained in drawing no. 136 and a wiring diagram is contained in drawing no. 137. The frequency display board is attached to the front edge of the adder board by a 60 pin wire-wrap edge connector (Amphenol part no. 261-10030-2). The mounting lugs on the connector are cut off and the wire wrap pins are soldered to the circuit side of the board.

The function of the frequency display is to display six digits of the RF frequency (hundreds Hz to tens MHz). The six TIL 308 decoder display chips are connected to the frequency inputs of the adder board through the 60 pin connector.

The front surfaces of the LED display chips are flat against the back surface of the module front panel, so that there is 0.2 inches spacing between the back of the front panel and the back side of the board. This spacing is maintained at the bottom end of the board by two 4-40 x ¼ inch screws through the board. The nut and lock washer are on the front side.

Two corners of the board are notched to accommodate the corner rails of the NIM module. The mechanical details of the frequency display are shown in the figure 4-1.



SIDE VIEW

FRONT VIEW

Figure 4-1 Frequency Display Mechanical Details

5. COMPONENT DESCRIPTIONS AND SPECIFICATIONS

5.1 General

The components used in the receiver are divided into three groups:

(1) Components which are constructed from materials by the receiver builder (for example, the heat sinks)

(2) Components specified in terms of their characteristics (for example, a 7400 quad NAND gate) which could be supplied by various manufacturers

(3) Components specified by manufacturer and model number (for example, Anzac AM-109 RF amplifier). In this group substitution of equivalent components made by other manufacturers may not be possible because of incompatibility in physical dimensions or pin configurations.

5.2 Group 1 Components

1. Air Core Inductor

Air core coils are used in low pass filters at the outputs of the mixer and IF modules. The inductance, as given in the parts lists, is calculated from

$$L = \frac{a^2 n^2}{9a + 10b} \quad \mu H$$

where a = coil radius in inches,

b = coil length in inches

n = number of turns.

2. Heat Sink

The TRW amplifiers, RF amplifiers used in the mixer, IF, detector, and transmitter mixer modules consume 8 watts of power (330 mA at 24 V). Heat sinks are required to dissipate this power into the air which circulates through the module and into the outside surface of the module. Dimensions and construction details of the different heat sink designs are shown in drawing no. 163. To insure good thermal contact between the heat sinks and the module front and back panels, the ends of the 0.375 inch square bars which run the length of the modules must be flat and square at the ends. Silicone grease is used where surfaces join to improve thermal conductivity.

3. RFI Strip

To prevent RF leakage between modules, the side panels of the RF, mixer, IF, detector, transmitter mixer, and transmitter drive modules are electrically connected to the front and back panels with aluminum 0.25 or 0.375 inch square strips. The dimensions of these strips and their locations are listed below. The type column refers to drawing no. 164 which shows the dimensions and hole locations. The strips are attached to the front and back panels with 4-40 screws.

Location	Size	Length	Type
Circuit side and component side of RF, Mixer, Transmitter Mixer, and Transmitter Drive Module Front Panels	0.25 inches square	7.00 inches	A
Circuit Side of IF and Detector Module Front Panels	0.25 inches square	7.00 inches	A
Component Side of IF and Detector Module Front Panels (connected to Heat Sinks)	0.375 inches square	7.00 inches	B
Circuit Side of RF, Mixer, IF Detector, Transmitter Mixer, and Transmitter Drive Module Back Panels	0.25 inches square	7.00 inches	A
Component Side of RF, Mixer, IF, Detector, Transmitter Mixer, and Transmitter Drive Module Back Panels	0.25 inches square	4.50 inches	C

4. Electromagnetic Shield

Shielding is required around the low pass filters at the output of the mixer and IF modules. The shields are made from one inch inside diameter copper tubing, one inch long with a copper disk soldered to one end. The construction procedure is to cut the tubing to one inch and then cut a flat piece of 0.030 inch copper 1.5 inches square. Solder the flat square to one end of the tubing, soldering around the inside edge. Then trim the square to the outside edge. Place the shield over the filter and solder in four places to the PC board ground plane.

5. Internal RF Cables

RF-174/U 50 ohm coaxial cable is used for RF connections between components where the connections are not made via the PC board striplines. Depending on what the cable connects to, the end connectors are as follows:

Straight SMA Cable Plug

E. F. Johnson Part No. 142-0221-006

Angle SMA Cable Plug

E. F. Johnson Part No. 142-0221-006

Straight BNC Cable Plug

Trompeter Electronics Type PL20-5

6. PC Boards

All the modules use 1/16 inch double-sided fiberglass PC boards, cut to 7.35 x 9.55 inches, except for the following:

A. The adder board is 7.35 x 9.35 inches.

B. The frequency display board is 1.5 x 7.20 inches.

C. The synthesizer distribution module uses a board made of 1/16" aluminum, cut to 7.35 x 9.55 inches, since there is no electrical connection to the board.

Since the PC board dimensions must be accurate for a secure fit in the NIM modules, the boards are trimmed to the correct dimensions, rather than to the borders of the printed circuits. The tolerance is ± 0.02 inches on the 7.35 inch dimension and +0.00, -0.05 inches on the 9.55 inch dimension.

5.3 Group 2 Components

1. Resistors

Metal oxide film resistors are used in the receiver construction because of their low variation of resistance with age, temperature, and frequency. Except where specified otherwise, resistors are 1/4 watt, 5%. Where space is limited, or in high frequency circuits, 1/8 watt resistors may be specified. In circuits where accuracy is required, such as the matched pair of active filters in the detector module, 1% resistors are used. Resistors of more than 1/4 watt dissipation are used only in the analog converter module, where R36 is 1 W and may be composition or wire wound.

2. Capacitors

Capacitors in high frequency shunt applications are ceramic disk types. Low inductance to ground is important, and leads should be as short as possible.

In low frequency bypass applications, such as in power supply lines, either solid tantalum or tantalum foil electrolytics are used. Tantalum electrolytics are preferred over aluminum electrolytics because of their lower series impedence, smaller size, and higher reliability.

Where precision is required, as in the active filter, plastic film capacitors are used. The bandwidth of the filter depends on the time constant of the capacitors and 1% precision resistors. Since 1% capacitors are not generally available, 5% or 10% capacitors can be used if the capacitors in the two active filters of the detector module are matched within 5%. For temperature stability, the preferred material is polycarbonate, but polystyrene and polyester (such as Mylar) are acceptable.

Silvered mica capacitors are used where low values of capacitance (< 100 pF) are required, such as in the L-C output filter of the IF module.

3. Ferrite Inductors

All power, control, flag, and interrupt lines between the 50 pin back panel plug and the circuit board of each module are filtered with three beads of type Q2 ferrite. (Indiana General CF-101-Q2). Ferrite core inductors are used where greater inductance is required, such as in the low pass filters in the dual bipolar switches. The coil resistance should be small compared to the resistors in series with the inductors; otherwise the resistors should be modified to compensate.

4. Diodes

The types of diodes used for various applications in the receiver are listed below.

Front Panel Indicators:

Light Emitting Diode, Red, Monsanto MV 5023.

Low Frequency, Low Current:

Silicon Diode, Type IN4053.

Low Frequency, High Curent:

Silicon Diode, Type IN4004.

High Frequency:

Schottky Diode, Type HP2800.

Log Amplifier Feedback:

Back Diode, General Electric BD-7.

5. Transistors

Characteristics of types 2N3959 and 2N4260 are given in Appendix A.

6. Digital Integrated Circuits

Pinouts for the following types of standard TTL logic used in the receiver are shown in Appendix A.

7400 Quad NAND gate
7402 Quad NOR gate
7406 Hex Inverter-Buffer
7407 Hex Buffer
7442 One-of-Ten Decoder
9321 Dual One-of-Four Decoder
9322 Quad Two Bit Multiplexer

7. Voltage Regulators

7824, +24 Volt, 3 Terminal
7720, +20 Volt, 3 Terminal
7812, +12 Volt, 3 Terminal
7912, +12 Volt, 3 Terminal

5.4 Group 3 Components

Information about the components listed below is given in Appendix A in the form of manufacturers specifications. Equivalent components by other manufacturers can be used in the receiver, but the PC boards layouts might have to be modified to accommodate different dimensions and pin configurations.

1. RF Amplifiers

   Anzac AM-109 (RF Module)
   Anzac AM-110 (Transmitter Drive Module)
   TRW CA2810 (Mixer, IF, Detector, Transmitting Mixer Modules)

2. Filters

   Allen Avionics 40 MHz High Pass (Mixer Module)
   Allen Avionics 30 MHz Low Pass (RF, Transmitter Drive Module)
   Allen Avionics 73 MHz Low Pass (Synthesizer Distribution Module)

3. Mechanical Attenuators

   Alan Industries 50 DA 60-S (RF, IF Modules)
   Alan Industries 50 DA 120-S (Transmitter Drive Module)

4. Electronic Attenuators

   Minicircuits Laboratories PAS-1 (IF Module)
   Minicircuits Laboratories PAS-3 (Antenna Multiplier, Transmitter Mixer, Transmitter Drive Modules)

5. Double-Balanced Mixers

   Watkins-Johnson M9-E (mixer Module)
   Minicircuits Laboratories RAY-1 (Detector, Transmitter Mixer Modules)

6. Power Splitters

   Minicircuits Laboratories PSC-2-1 (Detector, Transmitter Mixer, Transmitter Drive Modules)

   Minicircuits Laboratories PSC-4-3 (Transmitter Mixer Module)
   Merrimac PD40-55 (Synthesizer Distribution Module)

7. Quadrature Hybrid

   Merrimac QHS-3 (Detector, Transmitter Mixer Modules)

8. Reed Relay

   Grigsby-Barton GB822A-2 (Detector Module)

9. Binary Coded Switch

   Electronic Engineering Company of California 1B177633G (Detector Module)

10. Transformers

    Vari-L HF-122, HF-128 (Mixer Module)

11. Crystal Oscillator

    Greenray YH-980 (Transmitter Mixer Module)

12. Digital Integrated Circuits

    National Semiconductor DM8131N, DM81LS95N, DM8553N, DS8836N (Control, Control/Adder Modules)
    Signetics 82S83-B (Control/Adder Module)
    Texas Instruments TIL-308 (Control/Adder Module)

13. Analog Integrated Circuits

    Operational Amplifier, RCA 3047 (Antenna Multiplexer, Transmitter Mixer Modules)
    Voltage Comparator, National Semiconductor LM 311 (Mixer, Analog Converter Modules)
    Audio Amplifier, National Semiconductor LM 380 (Analog Converter Module)
    Operational Amplifier, National Semiconductor LM 531 (Analog Converter Module)

14. Hybrid Circuits

    Vector Module, Intronics VM-101 (Analog Converter Module)
    Operational Amplifier, Optical Electronics 9817 (Detector Module)

15. NIM Hardware

    NIM Module, Single Width, Vector NIM-1387-CPA-14
    NIM Module, Double Width, Vector NIM-2787-CPA-14
    NIM Module, Triple Width, Vector NIM-4087-CPA-14
    NIM Bin, Vector CN-87A-14

6. COMPONENT TEST PROCEDURES

6.1 RF Amplifier, Anzac AM-109

With the input connected to a signal generator and the output connected to an RF voltmeter or oscilloscope, measure the gain over the range of 100 kHz to 30 MHz. Verify that it is within the manufacturer's specifications of 10.7 ± 0.5 dB from 0.5 to 30 MHz. The gain is not specified below 500 kHz and varies among units. With a 10 μF capacitor connected across the power terminals of the amplifier (as in the RF module circuit), the gain from 100-500 kHz should approximate the typical results given below.

Frequency (kHz)	Gain (dB)
500	11
200	10.5
150	10
120	8
100	6

Measure the maximum output power and DC supply current and compare them with the specifications (+28 dBm for 1 dB compression, and 180 mA at 20 V).

RF Amplifier, Anzac AM-110

Measure the gain, maximum output power, and supply current, and compare with the specifications as with the AM-109 (30 dB gain, +23 dBm for 1 dB compression, 120 mA at 20 V).

6.2 RF Amplifier, TRW CA 2810

Testing of the TRW amplifier prior to installation on the module PC board must be done before the pins are bent at a 90° angle. When the pins are bent, they are easily rotated and loosened. Also, since the pin bond is weakened at soldering temperature, it is undesirable to solder the amplifier to the module PC board more than once. A test jig which does not damage the pins can be made using standard IC sockets.

Using a +24 V supply, measure the gain (33 dB), output power at 1 dB compression (+26 dBm), and power consumption (330 mA at 24 V). The entire frequency range of 350 MHz is required only in the mixer module, where the amplifier drives the M9E mixer with a +27 dBm square wave. With a square wave input, the amplifier output should have the positive and negative half-cycles identical in shape at 10 V PP into 50 ohms. The rise time should be approximately 1 ns.

6.3 L-C Filter, Allen Avionics

Three types are used in the receiver: low pass, shape factor H, 3 dB at 30 MHz; low pass, shape factor H, 3 dB at 73 MHz; high pass, shape factor F, 3 dB at 40 MHz.

Using a network analyzer (HP8407A with HP8601A sweep generator) measure the insertion loss within the pass band (2 dB maximum) and the frequencies at which the response is down 3 dB, 20 dB, and 40 dB. These are tabulated below, based on the manufacturer's specifications.

Filter	3 dB Down (MHz)	20 dB Down (MHz)	40 dB Down (MHz)
30 MHz low pass	30.0	31.5	33.0
73 MHz low pass	73.0	76.7	80.3
40 MHz high pass	40.0	36.4	33.3

6.4 Crystal Filter, Damon 7118A

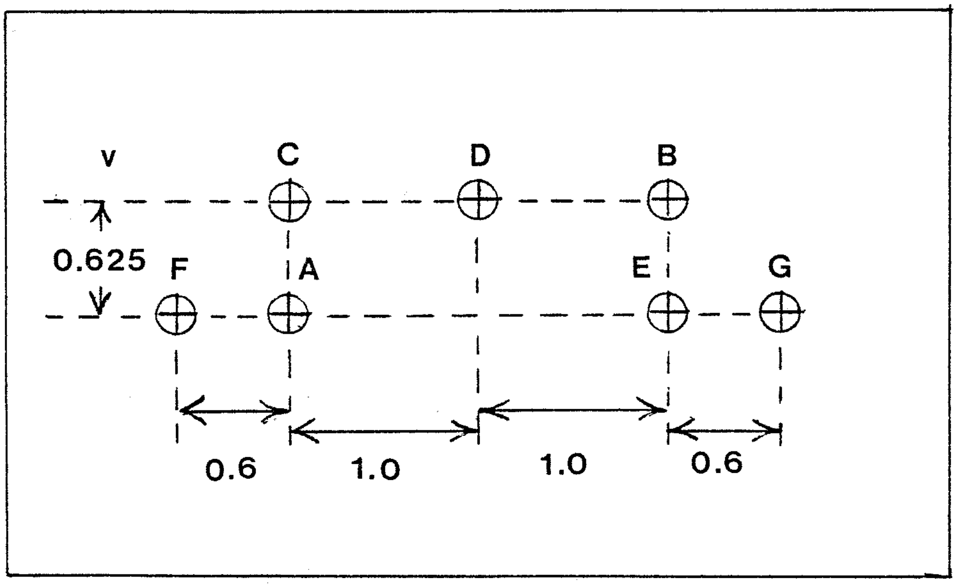
For testing the crystal filters, a holder is required which adapts the filter input and output pins to BNC connectors without soldering to the pins. The holder is made from a 3 inch by 5 inch PC board, two BNC panel jacks, and three single pin sockets to slip over the filter pins. The PC board is drilled as shown in Figure 6-1.

The BNC sockets are soldered to the ground plane and connected to the filter sockets with short stranded wires. A third wire connects the socket for the filter ground pin to the ground plane.

Initial tests in the holder verify that the filters have not been damaged in shipment. Using a network analyzer (HP8407A with HP8601A sweep generator), each filter is tested for center frequency, insertion loss, shape of response curve near center frequency, rejection far from center freqeuncy, and spurious responses. The test results are compared with the manufacturer's test data for each filter.

Typical results are shown in Figure 6-2.

Further testing under conditions which simulate the receiver operation are done in a test jig as described in Appendix D. This test jig is used by the manufacturer in the filter construction.



HOLE	DIAMETER	PURPOSE
A, B	0.125"	Filter Screw Mounts
C, D, E	0.250"	Filter Pins
F, G	0.375"	BNC Panel Jacks

Figure 6-1

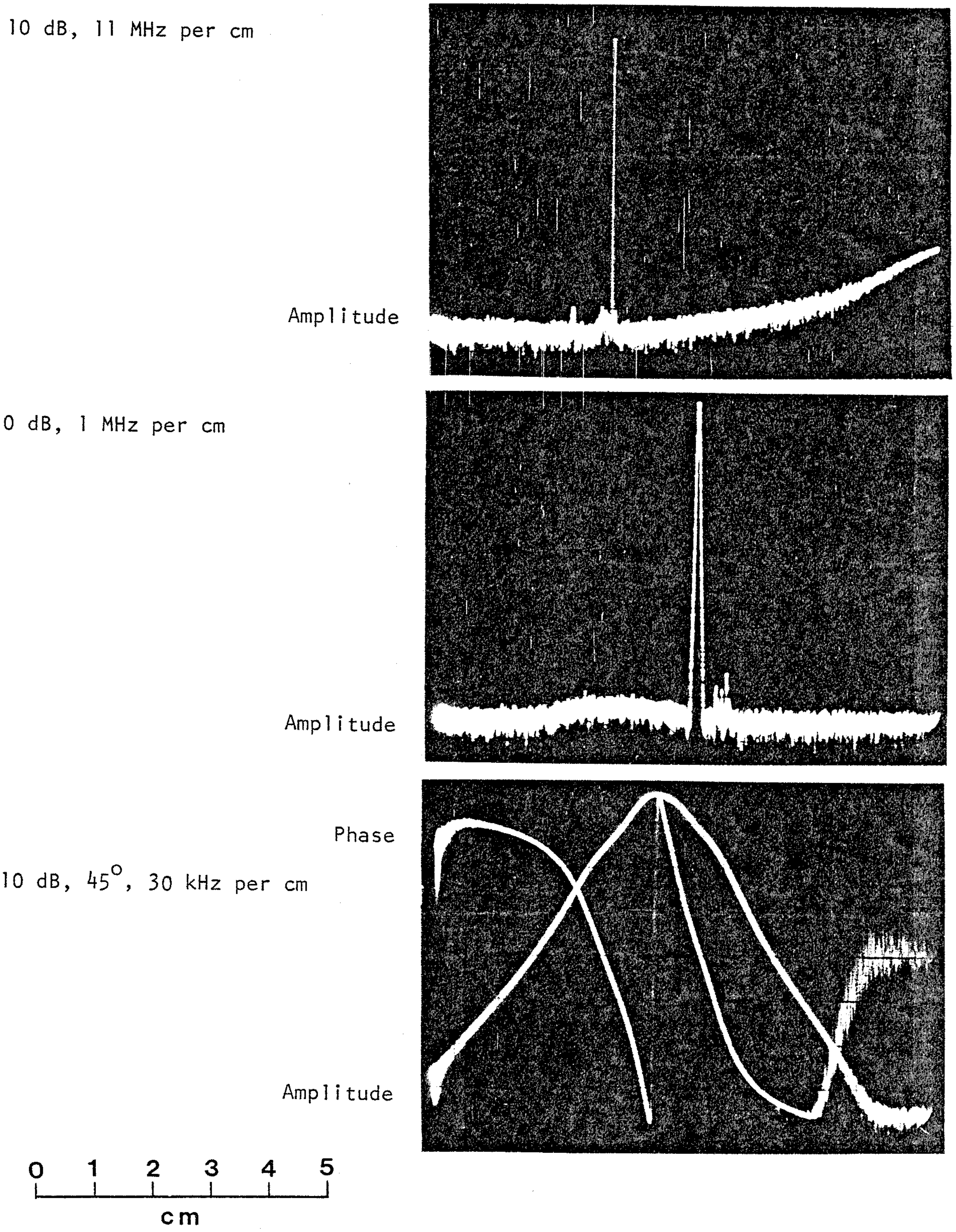

10 dB, 11 MHz per cm
Amplitude
10 dB, 1 MHz per cm
Amplitude
Phase
10 dB, 45°, 30 kHz per cm
Amplitude
0 1 2 3 4 5
cm

Figure 6-2

6.5 Mixer, Watkins-Johnson M9E

Before installation on the PC board, the mixer is tested for third order intercept and isolation.

Two inputs to the double-balanced mixer are:

f_L = frequency of the synthesizer signal at the L input

f_{R1} = frequency of the RF signal to which the receiver is set and which appears at the R input.

If an unwanted RF signal at a frequency f_{R2} close to f_1 also appears at the R input, then the mixer generates sums and differences of harmonics of f_{R1} and f_{R2}. The most troublesome combinations are the third order products ($2\ f_{R2}-f_{R1}$) and ($2\ f_{R1}-f_{R2}$) which when mixed with the synthesizer signal generate outputs from the mixer I port at frequencies within the pass band of the IF amplifier.

Figure 6-3 shows the M9E normal conversion product and third order product output levels as a function of input level, for two input signals of equal amplitude at f_{R1} and f_{R2}. When both inputs are at zero dBm, the third order product is 65 dB below the normal conversion product. For each dB that the input signals increase, the third order output products increase by 2 dB, so that at some input level the power in each third order product equals that of the normal product. This is called the third order intercept, which for the M9E is specified at +32.5 dBm. This specification is for a sinusoidal drive at +27 dBm. In the receiver, the mixer is driven by a +27 dBm square wave, which increases the intercept to approximately +40 dBm.

The intercept is measured with the test circuit of Figure 6-4. One signal generator is set at 1.0 MHz and the other at 1.1 MHz with both at zero dBm. At the power combiner output, each signal is at -3 dBm, so that the total signal power into the mixer is zero dBm. The synthesizer output is set at 40 MHz and zero dBm. For up-conversion, the normal products appear on the spectrum analyzer at 41.0 and 41.1 MHz with the third order products at 40.9 and 41.2 MHz. The intercept is given by

$$P_I = P_N + \frac{(P_N - P_3)}{2} \quad \text{dBm}$$

where P_I = power (in dBm) at intercept

P_N = Power (in dBm) of each normal conversion product

P_3 = power (in dBm) of each third order product.

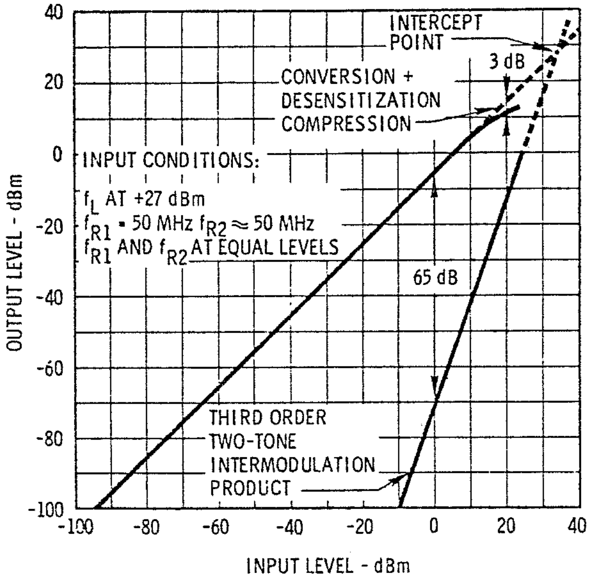

INTERCEPT POINT
3 dB
CONVERSION + DESENSITIZATION COMPRESSION
INPUT CONDITIONS:
f_L AT +27 dBm
f_R1 = 50 MHz f_R2 ≈ 50 MHz
f_R1 AND f_R2 AT EQUAL LEVELS
65 dB
THIRD ORDER TWO-TONE INTERMODULATION PRODUCT
OUTPUT LEVEL - dBm
INPUT LEVEL - dBm
40
20
0
-20
-40
-60
-80
-100
-100
-80
-60
-40
-20
0
20
40

Figure 6-3

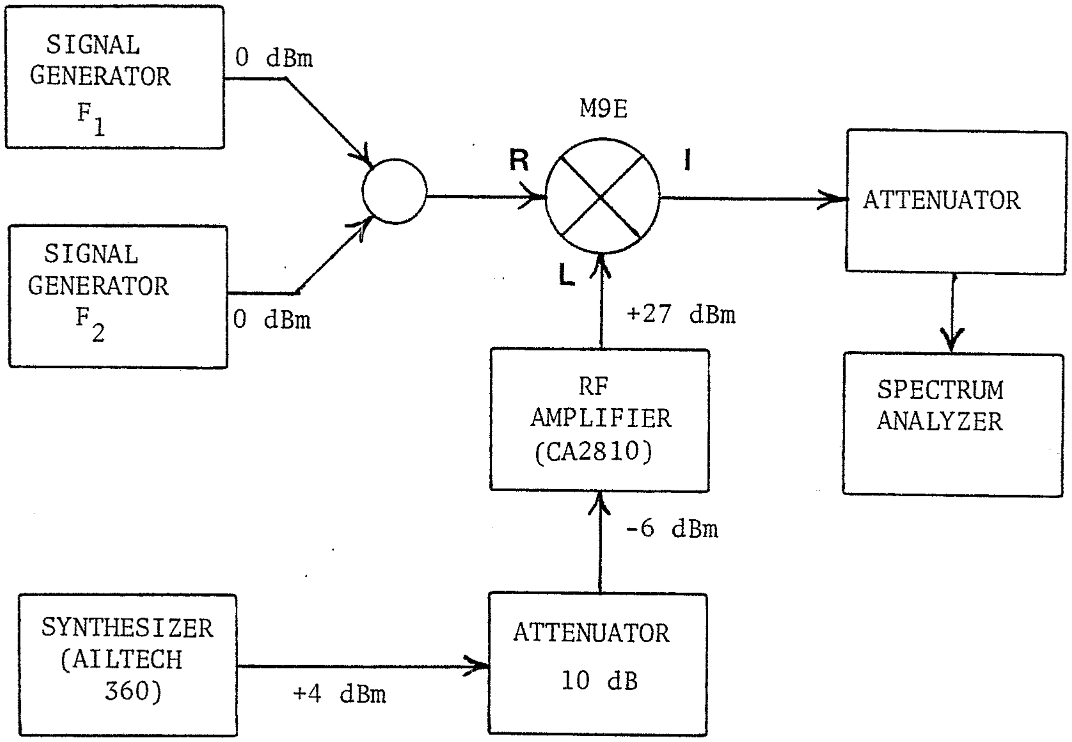

SIGNAL GENERATOR F1
0 dBm
SIGNAL GENERATOR F2
0 dBm
M9E
R
I
L
ATTENUATOR
+27 dBm
RF AMPLIFIER (CA2810)
SPECTRUM ANALYZER
-6 dBm
SYNTHESIZER (AILTECH 360)
+4 dBm
ATTENUATOR 10 dB

Figure 6-4

Isolation is specified as follows for the M9E:

f_L at R port	35 dB	$30 < f_L < 100$ MHz
f_L at I port	40 dB	$30 < f_L < 100$ MHz
f_R at I port	25 dB	$1 < f_L < 400$ MHz.

The isolation of f_R at the I port is not specified in the range of $100 < f_R < 500$ kHz.

To measure the isolation of f_L at the R port, for example, the L port is driven at +27 dBm and the I port is terminated with 50 ohms. The R port is connected to the spectrum analyzer, and its level is measured and compared with the specifications.

6.6 Transistors, 2N3959 and 2N4260

Transistor matching in both amplifier stages of the squarer is necessary in order to obtain a symmetric output waveform. Matching is done by testing the stock of each transistor type on a curve tracer and grouping them in pairs having the most nearly identical collector output characteristics.

6.7 Oscillator, Greenray YH-980

After a one hour warm-up period, the oscillator ouput power is measured with an RF voltmeter and compared with the +10 dBm specification. Stability is then tested by connecting the oscillator to the R port of a double-balanced mixer through a 20 dB coaxial attenuator. The Ailtech synthesizer is connected to the L port and set at 40.625 MHz with the proper drive level. The I port is connected to an oscilloscope through a low pass filter. The synthesizer frequency is then adjusted until it equals the oscillator frequency. Stability is then measured from the variation in difference frequency and compared with the manufacturer's specifications.

7. MODULE ASSEMBLY

7.1 Circuit Board Assembly

The etched PC boards which have been cut to the dimensions given in section 5.2 are drilled to the hole sizes given in Table 7-1. If the holes are to be plated through, which is convenient but not necessary), the holes are drilled 0.010 inches larger in diameter.

The antenna multiplexer, control, and control adder modules require notches in the boards to allow space for connectors. The dimensions of the notches are shown in drawing no. 170.

Insulating washers are required between voltage regulators and ground planes, and between the mounting screw heads and the circuit sides of the boards, where there is close spacing between the mounting screws and the conductors.

The board for the synthesizer distribution module has no circuit etched on it, and can be made of either double copper-clad fiberglass or 0.063 inch aluminum. The locations and sizes of the holes which support a low pass filter and a power splitter are shown in Figure 7-1.

Table 7-1 PC Board Hole Sizes

Component Description	Hole Sizes in Milli-Inches	
	For Solder Leads or Pins	For Mounting Screws
1/8 W, 1/4 W Resistors	28	
Ceramic Disk, Mica Capacitors	28	
Integrated Circuits	28	
Transistors	28	
Diodes (Except IN4004)	28	
Diode, IN4004	38	
Jumpers	28	
Reed Relays	28	
Control Line Pads	28	
Power Line Pads	38	
RF Amp, Anzac AM109, 110	38	140
RF Amp, TRW CA 2810	28	140
Vector Module, Intronics VM-101	52	
Mechanical Attenuators		140
Allen L-C Filters		140
Damon Crystal Filters	52	113
OP Amp, Optical 9817	52	
Electronic Attenuators PAS-1, PAS-3	38	
Double Balanced Mixer, M9E, Ray-1	38	
Power Splitters, PSC-2, PSC-4	38	
Quad Hybrid QHS-3	38	
Transformer, HF 122, HF 128	38	
Oscillator, YH-980	38	140
Voltage Regulator	38	113
SMA Socket center	38	
SMA Socket shield	52	
Plastic Capacitors	38	
Potentiometers	38	

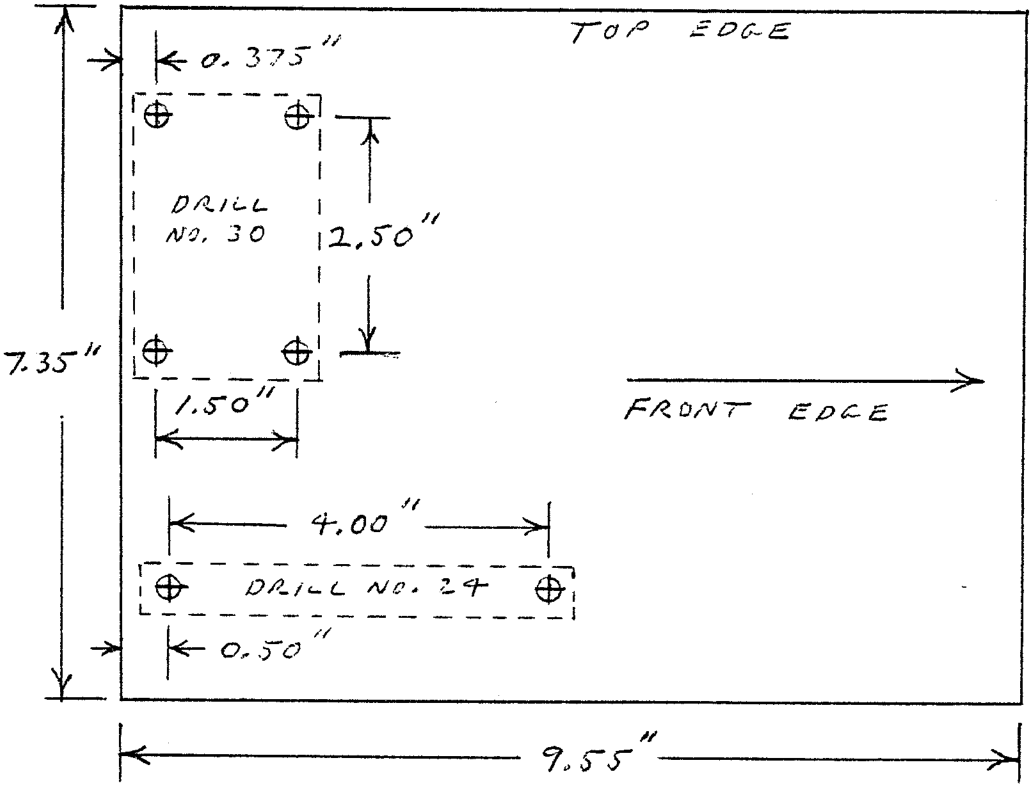


Figure 7-1 Synthesizer Distribution Module Board Dimensions

7.2 Front, Back, and Side Panel Assembly

Hole sizes and positions for mounting components on the front and back panels are shown in Appendix C. After the holes are punched, the lettering is silk-screened with black epoxy paint, and the components are mounted. The front, back, top, and bottom panels are assembled with the PC board, and connections are made from the board to the front and back panels. The side panels are then drilled to fit the RFI strips and installed.

8. LP RF SYSTEM ASSEMBLY

8.1 Chassis Connectors

The 50 pin Amp plugs on the NIM module back panels connect to sockets mounted on rails at the back of the NIM bins. The plugs and sockets have locating pins at diagonal corners, with the male pin at the corner nearest pin A on a plug and the female pin nearest pin A on a socket. The positions of the 50 pin sockets are shown in drawing no. HFS-162. A wiring table for the interconnections is shown in drawing no. 163, and in more detail in drawing no. HFS-163A. AWG 24 stranded wire is used for control and flag lines, and AWG 18 is used for power and ground.

Power lines are connected to the 6 pin Jones plugs (P9A, P9B, and P9C), and TSG control and interrupt lines go to the 25 pin delta sockets (J8A, J8B, and J8C).

8.2 Cables

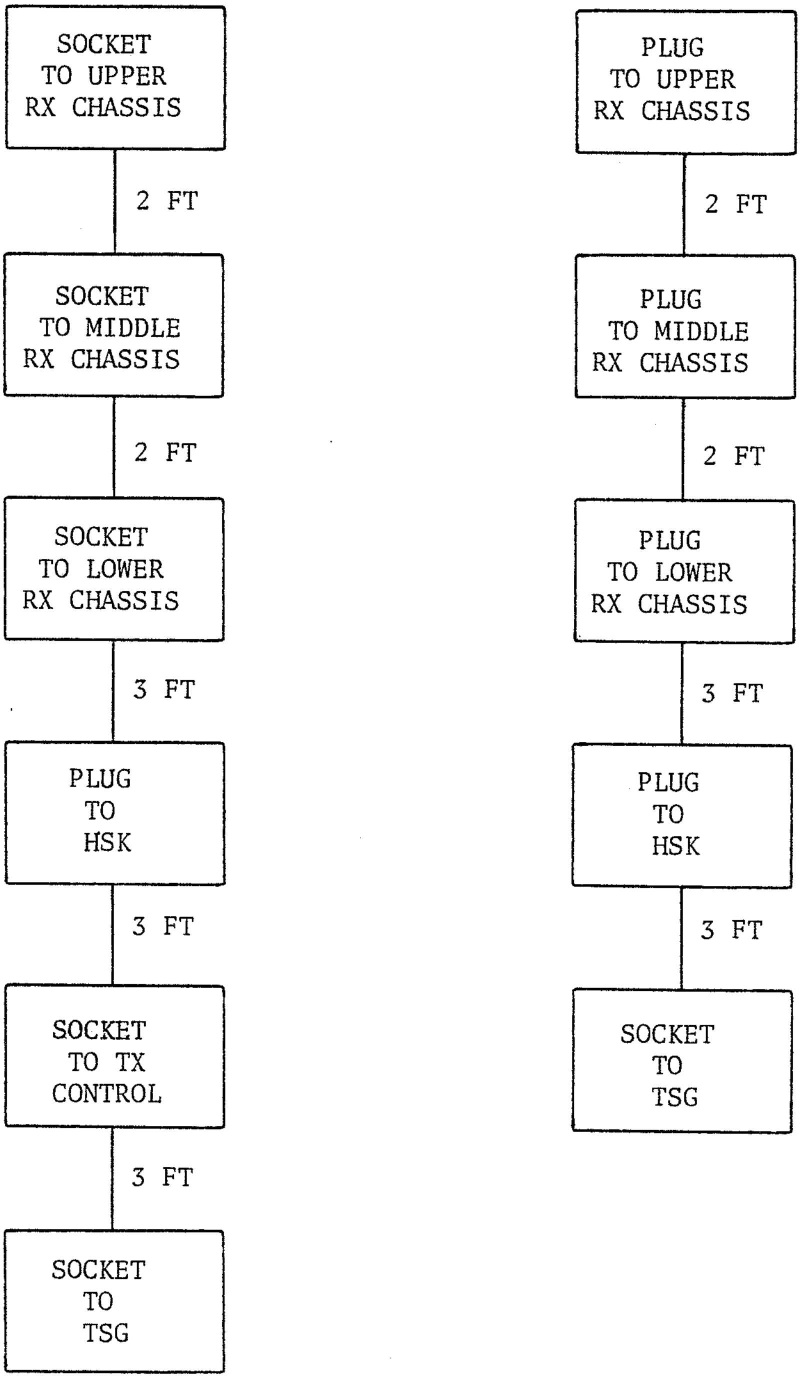
TSG control lines and interrupt lines from the 50 pin sockets connect to 25 pin delta sockets J8A, J8B, and J8C according to the wiring list in drawing no. 163.

The power cable from the receiver power supply is made with AWG 18 cable, using the same color convention as shown in the power connections of drawing no. 163. The following convention is followed everywhere in the receiver:

Voltage	Color
+28	Blue
+15	Red
-15	White
+ 5	Orange
Ground	Black

Note that both pins 1 and 6 of the 6 pin Jones connectors are connected to ground at the receiver and at the power supply. The power cable has two AWG 18 ground wires connected to these pins, since the ground line carries the combined current of the other lines.

The DIO and TSG buses are made with 25 line ribbon cable (3M type 3301, 28 AWG stranded) and delta connectors (3M type 3483-1000 socket, or 3M type 3482 plug). The connectors are always attached to the cables so that pin no. 1 coincides with the brown edge of the cable. Dimensions of the DIO and TSG buses are given at Figure 8-1. The synthesizer cable is made of stranded AWG 24 wires, connected at each end to a 50 pin AMP "champ" plug, made up of a cable half plug model 229974-1 and a 180° strain relief model 552008-1. This connector is



DIO BUS

TSG BUS

Figure 8-1 DIO and TSG Buses

designed for solid wire with the ends inserted into clips in the plug, but it appears that the best method is to use stranded wire and solder it into the clips. Both ends of the cable are wired to the plugs as shown in Table 8-1, although not all of the pins are used. Since there is no remote control of frequency digits below hundreds of Hz, pins 6, 7, 10, 11, 18, 19, 31, 32, 35, 36, 43, and 44 can be grounded at the synthesizer end of the cable.

RF cables which connect the modules together are made of RG58/U coax with BNC plugs at the ends. The cables which connect adjacent modules are 10 inches long.

Table 8-1 Ailtech 360 Synthesizer J5 Connections

FUNCTION			PIN
Frequency Decade	0.1 Hz	-1	32
		-2	7
		-4	31
		-8	6
	1 Hz	-1	36
		-2	11
		-4	35
		-8	10
	10 Hz	-1	19
		-2	44
		-4	43
		-8	18
	100 Hz	-1	23
		-2	48
		-4	22
		-8	49
	1 kHz	-1	27
		-2	26
		-4	28
		-8	29
	10 kHz	-1	3
		-2	2
		-4	4
		-8	5
	100 kHz	-1	34
		-2	33
		-4	8
		-8	9
	1 MHz	-1	40
		-2	39
		-4	41
		-8	42
	10 MHz	-1	46
		-2	20
		-4	21
		-8	47
	100 MHz	-1	45

FUNCTION	PIN
Logic Ground	25, 50
Power ON-OFF Flag (HI-ON, LO-OFF)	37
Remote/Local Flag (HI-Remote, LO-Local)	12
Out-of-Range Flag* (HI-In Band, LO-Out of Band)	1

*Indicates that a frequency beyond the range of the plug-in has been asked for.

NOTE: Load at each input equals one low power TTL load (low state sinks 0.8 ma.), Positive logic.

8.3 DIO-TSG Simulator

The DIO-TSG simulator is a group of switches and LED's built into a box and connected to the receiver via the TSG and DIO buses. It allows all DIO and TSG functions to be performed manually and all receiver flags and interrupt flags to be monitored. Its circuit diagram is shown in drawing no. 166.

8.4 Receiver Power Supply

The receiver power supply provides power to the receiver (+28 V, ±15 V, +5 V), the temperature monitor unit (±15 V), and the antenna preamps (+28 V). The position of the separate power supplies in the chasis and the wiring diagram are shown in drawing no. 167. The power supplies used in the prototype receiver are:

+28 V @ 8 A: Technipower LPC 28.0-8.0/2
±15 V @ 0.7A: Technipower NLPD 15-0.7/2
+ 5 V @ 10 A: Technipower LPC 5.0-10.0/2

The /2 at the end of the model number signifies operation on either 110 or 220 volts AC. The total current drawn from each power supply is approximately half of its current rating.

8.5 AILTECH Synthesizer

The first local oscillator source used is an AILTECH Model 360 Direct Synthesizer. This consists of:

Mainframe	360D11
Frequency Extender	3600E1
RF Plug-In	P360180E1
Modulator	PM3601 (includes leveling)

Option 003--High stability internal 10 MHz reference oscillator, oven controlled. Aging rate ± 1 x 10^{-9} in 24 hours.

In its normal configuration, the phase noise floor of the synthesizer increases by 6 dB at 60 MHz where the unit switches to a doubling mode. This is required in order to suppress a low level spurious signal which appears in the 60-70 MHz region in the nondoubling mode. For application in the HF Radar, the spurious signal is too low to be significant compared with the system noise in the 50 kHz noise bandwidth whereas the increase in phase noise floor does degrade the receiver performance above 20 MHz. The synthesizers are therefore modified before use to suppress the doubling mode until 80 MHz is reached (i.e., out of the operating range required by the radar). This is done by a simple modification to the control logic.

Referring to the manual for the P3601-180E1 plug-in section, the logic involved is shown in Figure 4-39, Logic Convertor A9 schematic diagram. The required changes are:

1. Disconnect pin 3, U19 from pin 12, U35

This can be done without cutting board PC traces by physically cutting 1CU35 pin 12 to isolate it and jumpering at the DIP pins to pin 13.

For normal operation, it is necessary that the synthesizer local/remote front panel switch be in the remote position and that the output level be set at +10 dBm. Neither of these functions is externally controllable by the computer system so that particular care must be taken to return them to these positions if they are changed for any reason.

It should also be noted that continuous power is necessary to the ovened reference oscillator if advantage is to be taken of its potential stability. If the rest of the system is to be powered down for an extended period, the synthesizer should if possible be left powered with the front panel switch in the "standby" mode. If the synthesizer is powered down completely, normal 10 MHz reference output to the TSG takes approximately 1 minute to achieve, and "correct" frequency requires approximately 60 minutes. If frequency accuracy to better than 1 part in 10^6 is required, the oscillator-frequency should be checked and reset if necessary about once every 100 days.

These warm-up considerations apply also to the 40.625 MHz oscillator contained in the Transmitter mixer module.

9. LP RF SYSTEM FUNCTION VERIFICATION

9.1 Cable Connections

Connect the receiver to the power supply, synthesizer, DIO bus, and TSG bus. Connect the coaxial cables between modules, and connect the DIO and TSG buses to the DIO-TSG similator. Connect a +5 V power supply to the simulator.

9.2 DIO-TSG Functions

Using the simulator, switch through all the control functions described in Section 5.3 and verify that each device status and flag corresponds to its control word.

9.3 Overload Circuits

Connect a 40.625 MHz signal source to the IF module input and an oscilloscope to the output. Set the module to local control with no attenuation and gradually increase the signal level. Verify that the output drops by at least 50 dB when the input reaches +18 dBm (+15 dBm into the crystal filter). The front panel indicator should show that the module is disabled, and the indicator on the simulator should show an interrupt. Reduce the signal level and verify that both indicators remain on until the module reset button is pushed.

Connect the IF module output to the detector input and connect a DC voltmeter to the test output of the analog converter. Set the meter function switch to read amplitude output from the channel being tested and gradually increase the signal level. Verify that the analog overload indicator shows an overload above 10 V and that the indicator on the simulator shows an interrupt.

9.4 Zero Adjustments

Disconnect the coaxial cables to the antenna multiplexer and slide it forward, using an extender cable to supply power and control. Set the simulator switches so that no antenna is selected and adjust potentiometers R71-R74 until the voltages measured at the control terminals (pins 3 and 4) of the diode switches (M1-M4) are within ± 1 mV of zero. Then switch the simulator to enable antenna no. 1 and verify that the voltage at pins 3 and 4 of M1 is approximately ± 0.7 volts when 0° or 180° phase is selected.

The bipolar switch in the transmitter mixer module is adjusted for zero by the same procedure.

To adjust the detector module, connect a 50 ohm termination to the input and adjust potentiometer R19 for zero DC volts at the X output. Adjust R20 for zero DC volts at the Y output.

The bipolar switch in the transmitter mixer module is adjusted for zero by the same procedure.

To adjust the detector module, connect a 50 ohm termination to the input and adjust potentiometer R19 for zero DC volts at the X output. Adjust R20 for zero DC volts at the Y output. Remove the termination and connect the synthesizer to the input through an attenuator. Connect the X and Y outputs to an X-Y oscilloscope. The detector bandwidth should be set for 30 kHz. Adjust the synthesizer frequency for a rotation of about 100 cycles per second and the attenuation for a radius of about 5 volts. The gain of the X channel in the detector is fixed but that of the Y channel can be varied ± 8% with R34. Adjust R34 until the X and Y outputs are equal (i.e., so that the horizontal and vertical diameters of the circle are equal). Since this adjustment should be made within 1%, it is necessary to calibrate the oscilloscope to remove any gain difference between the channels. This can be done by connecting one of the detector outputs to both inputs, one at a time, and adjusting the amplifier gains so that the horizontal and vertical deflections are equal.

To adjust the analogic converter, connect BNC shorting plugs to the X and Y inputs and a digital voltmeter to the test output. Set the meter function switch to amplitude output and adjust R31 and R32 for zero reading. Then set the meter function switch to log output and adjust R15 and R16 for zero output.

9.5 Synthesizer Frequency

Connect a 70 MHz counter to the synthesizer output and verify that the frequency is correct for all values of each digit. Switch the frequency control to remote and use the DIO-TSG simulator to set the frequency remotely. Verify that the digits displayed by the control/adder module are the same as those set with the switches and that the synthesizer frequency equals the displayed frequency plus 40.625 MHz through the range of 40.625 to 70.625 MHz.

10. MODULE TEST PROCEDURES

NOTE: THE RF AMPLIFIERS USED IN THE RECEIVER MODULES WILL PUT OUT A WATT OF POWER AT SATURATION, POSSIBLY CAUSING DAMAGE TO OTHER COMPONENTS. CARE SHOULD BE TAKEN TO AVOID EXCESSIVE TEST SIGNAL LEVELS.

10.1 General Description

Since most of the individual module tests are more conveniently done when the entire receiver is assembled, there is no clear distinction between module testing and receiver testing. In general, if the test measures the characteristics of a single module, it will be included under module testing. If it involves the interaction of modules, it will be included under receiver testing.

In the following test descriptions, unless specified otherwise, the tests start with the receiver modules connected for normal operation with local control. The DIO bus and the TSG bus from the receiver is connected to the DIO-TSG simulator, and the receiver is connected to its +5, +28, and ±15 volt power supply.

10.2 Antenna Multiplexer Module

1. Insertion Loss and Cross talk

Set the DIO-TSG switches for local control with antenna no. 1 selected. Disconnect the cable between the antenna multiplexer and RF modules, and connect a -20 dBm signal source to the RF module input. Set the attenuators for about 1 volt amplitude output from the analog converter, using a digital voltmeter connected to the test output. Read the voltage, then reconnect the antenna multiplexer to the RF module and connect the signal source to the antenna no. 1 input. The amplitude output should be no more than 2 dB down over the range of 1 to 30 MHz. Enable antenna no. 2 and decrease the receiver attenuation until the amplitude output is the same as when antenna no. 1 was selected. The difference should be at least 50 dB. Repeat the test for the other antenna combinations. The results of a cross talk test on the prototype receiver are shown in Figure 10-1.

Cross talk for all combinations, with -20 dBm signal level into multiplexer:

Frequency (MHz)	Input to Antenna No.	Output dB Down from Antenna No.			
		1	2	3	4
1.0	1	0	70+	70+	70+
	2	70+	0	70+	70+
	3	70+	70+	0	70+
	4	70+	70+	70+	0
30	1	0	58	58	58
	2	64	0	64	64
	3	(56)	56	0	56
	4	60	60	60	0

Above data to 2dB precision.

Frequency dependence of cross talk for above circled combination:

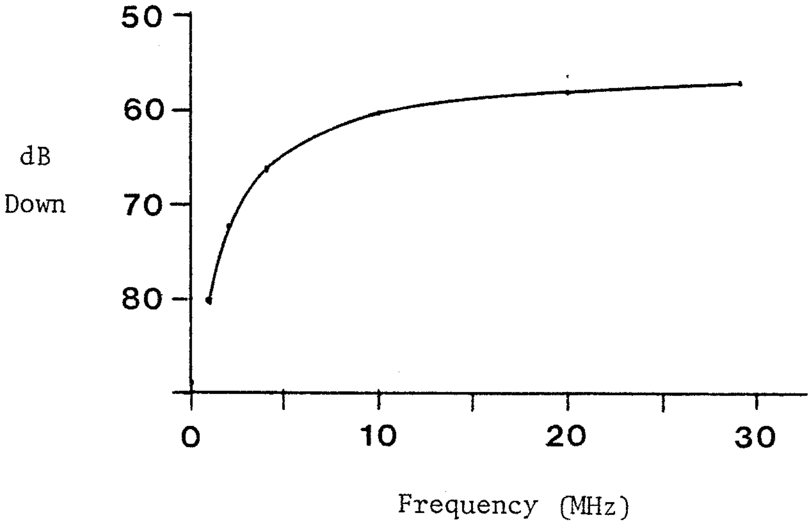


Figure 10-1 Antenna Multiplexer Cross Talk Test Results

10.3 RF Module

1. Module Gain

Connect a -40 dBm signal source to the RF input. Set the receivers for 1.0 volt amplitude output from the analog converter. Disconnect the RF output from the mixer input and connect the signal source to the mixer input. Increase the signal level until the amplitude output is the same as before. Compare the difference in signal levels with the gain specifications (Section 5.3) at 0.1, 0.2, and 0.5-30 MHz.

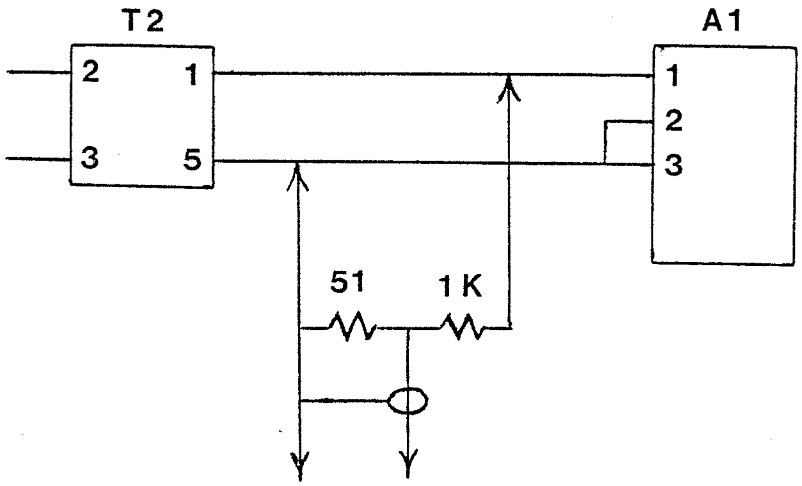
10.4 Mixer Module

1. Mixer Gain

Connect a 1.0 MHz signal source to the RF input and set the signal level and attenuation for 1.0 volt amplitude output. Disconnect the mixer module from the IF module and change the signal frequency to 40.625 MHz. Connect the signal to the IF module input and adjust the signal level to give 1.0 V amplitude output again. Compare the signal level difference with the gain specifications of Section 5.3.

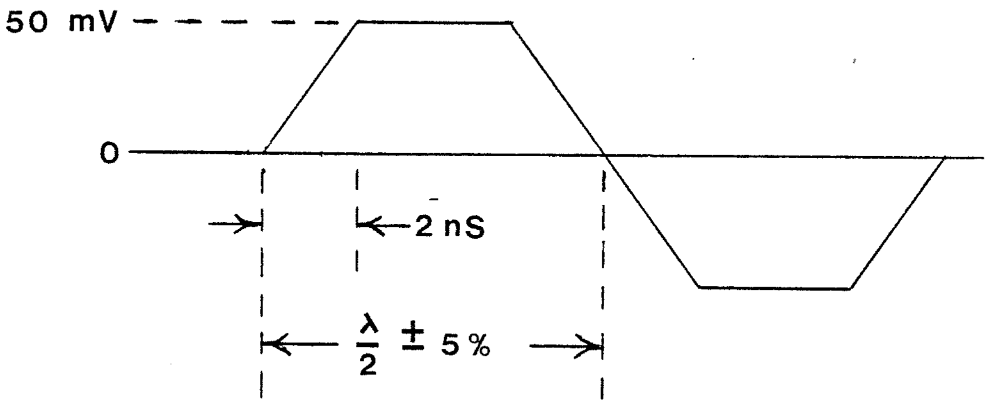
2. Squarer Waveform

Connect a coaxial cable from the squarer output to the 50 ohm input of a 500 MHz oscilloscope, using the resistive voltage divider shown in Figure 10-2A. The waveform should look like that of Figure 10-2B. The squarer output is 2 volts PP, which is reduced by 20:1 in the divider. The rise time should be 2 ns or less. If the positive and negative halves of the wave form are not within 10% of each other in duration, the transistors in the squarer should be matched more closely (see Section 6.6).



To 50 Ohm Scope Input

(A)



(B)

Figure 10-2 Squarer Output

10.5 IF Module

1. Module Gain

Connect a 40.625 MHz source to the input of the IF module. Set the level and attenuation for 1.0 volt amplitude output. Disconnect the IF module output from the detector module input and connect the source to the detector input. Adjust the source level to obtain 1 volt again. Compare the gain with the specifications of Section 5.3.

2. Fast Attenuator Accuracy

To check the accuracy of the fast attenuator, set up the receiver for normal operation with an RF signal that gives about a volt amplitude output when the IF slow attenuator is set at 40 dB and the fast attenuator is set at zero. Switch the fast attenuator from zero to 20 dB and the slow attenuator from 40 to 20 dB. There should be no change in amplitude output. Then switch the fast attenuator to 40 dB and the slow attenuator to zero. If there are significant changes, the resistors R16 and R17 which determine the current to diode attenuator M1 should be changed.

10.6 Detector Module

1. Gain at Center Frequency

Set the detector attenuation to zero and connect a 40.625 MHz signal source to the detector input. Adjust the source level for 2.25 volts at the amplitude output of the analog converter. The amplitude output is $\sqrt{X^2 + Y^2}$ and is therefore equal to the peak value of the X or Y outputs. The gain of the detector module is defined (in dB) by comparing the open circuit DC amplitude output as though it were a voltage into 50 ohms with the RMS IF voltage at the detector input. That is,

$$G = 20 \text{ Log} \left(\frac{V_{AMP\ out}}{V_{IF\ in}} \right) \quad \text{dB},$$

although this is not a true representation of power gain. Thus, in measuring the detector gain, an amplitude output of 2.25 volts is said to be +20 dBm. Read the signal source output dBm and compare the resulting dB gain of the detector with the specifications of Section 5.3.

2. Active Filter Frequency Response

With the 40.625 MHz signal source connected to the detector input, set the signal level so the amplitude output is about one volt. Set the detector bandwidth at 1 kHz. Increase the frequency in steps and at each step increase the signal level to keep the amplitude output constant and record the signal increase, which is equal to the active filter loss. Repeat for bandwidth settings of 3, 10, and 30 kHz. The resulting curves, when plotted on log scales, should look like Figure 10-3 which were obtained with the prototype receiver.

3. Active Filter Matching

If the components in both filters are perfectly matched, the output voltages of both filters will be equal throughout the pass band. Also, the phase between the X and Y outputs will be constant at 90°.

To test the filter matching, connect the X and Y outputs to a dual channel oscilloscope and connect the synthesizer to the detector module IF input. Set the detector bandwidth to 30 MHz and the synthesizer to 40.625 MHx. The quadrature outputs will

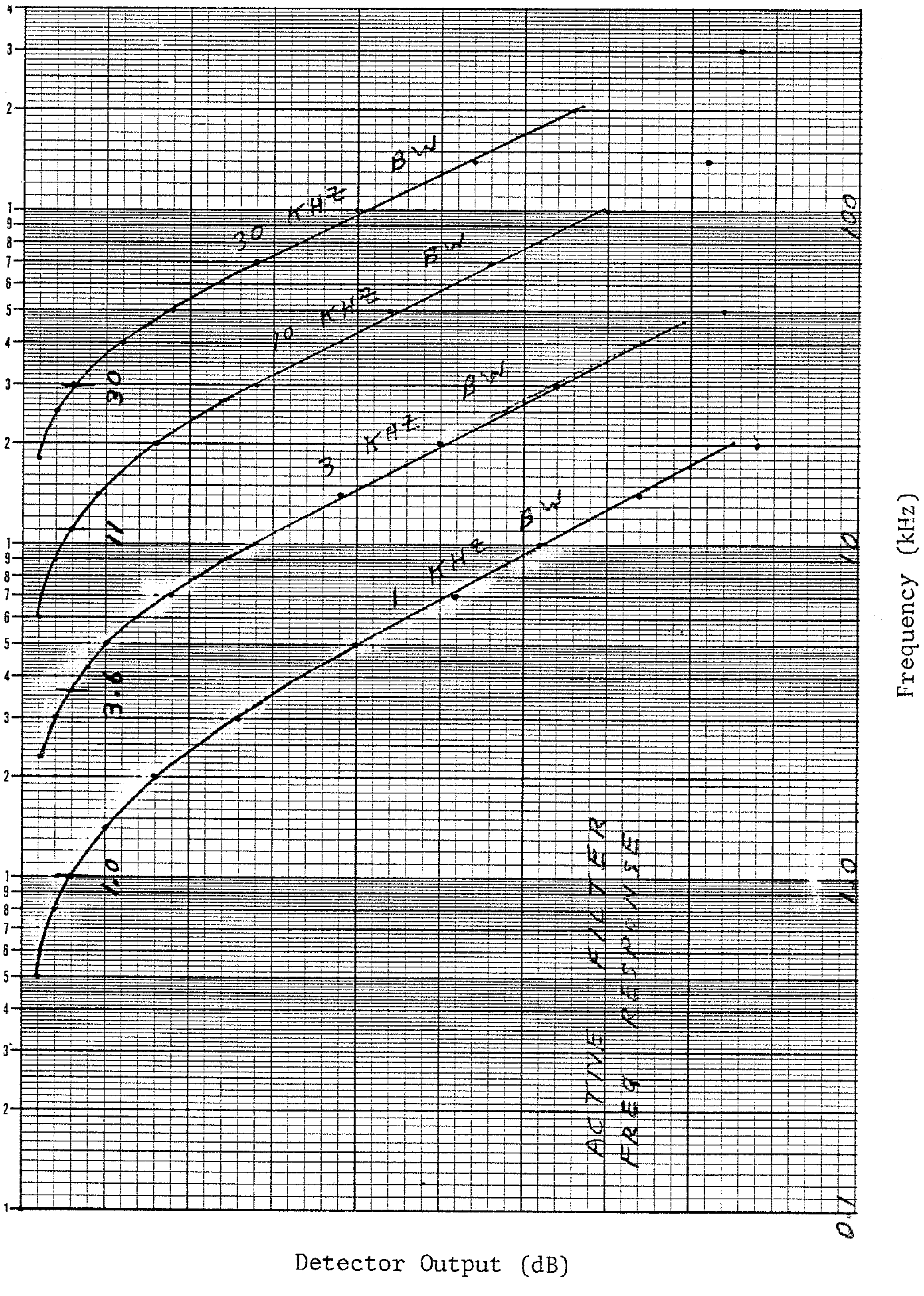


Figure 10-3 Active Filter Frequency Response

be at 1 kHz unaffected by the filter. Adjust the horizontal and vertical gains to that the quadrature outputs are equal, then increase the synthesizer frequency and verify that the outputs decrease equally in amplitude. Also verify that the 90° phase difference remains constant. Repeat the test for bandwidth settings of 3, 10, and 30 kHz.

If the quadrature outputs are connected to an X-Y oscilloscope for the same test, the result is a circle which should vary in radius but not in shape throughout the pass band.

10.7 Analog Converter Module

1. Log Amplifier

Set up the receiver for normal operation with a 1.0 MHz signal source and set the signal level for an output of +10 volts with no IF attenuation. The log output should be about +5 volts. Increase the IF attenuation in 4 dB steps and record the log output voltage for each step. The graph of log output voltage vs. input power in dB should be linear over a 40 dB range from 0.1 to 10 volts amplitude output. An example using data from the prototype received is shown in Figure 10-4.

2. Vector Module

Connect the cal output to the antenna multiplexer input and set the attenuators to give 1.0 volt amplitude output. Measure the X, Y, and amplitude outputs with a digital voltmeter for transmitter phase settings of 0°, 90°, 180°, and 270° and verify that the amplitude equals $\sqrt{X^2 + X^2}$ for all phase settings. Repeat the test at amplitudes of 100 mV and 10 V.

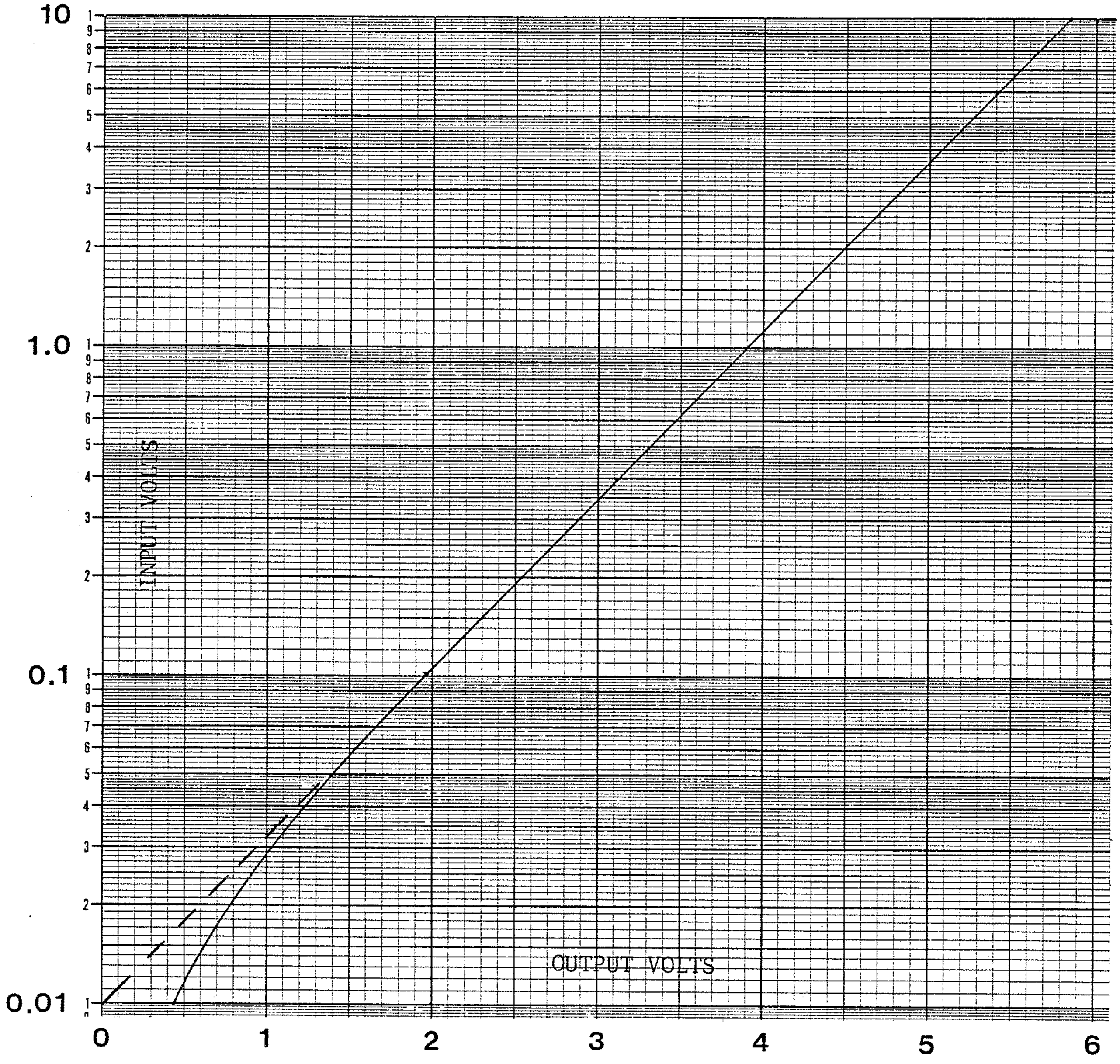


Figure 10-4 Prototype Logarithmic Amplifier Characteristic

10.8 Transmitter Mixer Module

1. Bipolar Switch

Connect an oscilloscope to the RF output of the transmitter mixer module and measure the output level. It should be approximately -3 dBm. Disable the output using the transmitter keying function on the DIO-TSG simulator. Measure the RF output again and verify that the power decreases by at least 50 dB.

10.9 Transmitter Drive Module

1. Diode Switch Attenuation

Connect an oscilloscope to the RF output of the transmitter drive module with the transmitter enabled and measure the output level when the RF input is connected to the transmitter mixer module RF output and the transmitter is keyed on. Measure the output again with the transmitter disabled and verify that the difference is at least 50 dB.

11. LP RF SYSTEM TEST PROCEDURES

11.1 Bandwidth

Curves of gain vs. frequency for the overall receiver are significantly different from those of the active filter alone (Section 10.6) at 10 and 30 kHz bandwidth settings because the crystal filter bandwidth is comparable to that of the active filter.

Connect a synthesizer to the input of the RF module, set at approximately 1 MHz. Proceed as in Section 10.6 for both positive and negative increments from center frequency. The resulting curves for the prototype receiver are shown in Figure 11-1.

11.2 Noise Floor

The receiver amplitude output voltage drops to the noise floor approximately 100 kHz from center frequency when the bandwidth is set at 30 kHz. With the RF signal at the antenna multiplexer input, the noise floor is determined by noise in the RF amplifier, mixer, or synthesizer. The synthesizer used as a signal source in the bandwidth test is replaced with a low noise signal generator, and the receiver is set to 10 MHz. Continue the 30 MHz frequency response curve to 1 MHz from center frequency. Repeat the test with the receiver set at 20 MHz. A higher noise floor indicates that the synthesizer noise increases at or above 60 MHz, where a frequency tripler is used. In this case, there is a step increase in noise floor if the synthesizer is switched from 59.999 to 60.000 MHz while the signal generator frequency is held constant at 10 MHz.

To determine whether the (receiver) synthesizer is the principle source of receiver noise, the noise floor test is repeated with a low noise signal generator connected to the syn input of the mixer module. Test results for the prototype receiver, using both the Ailtech synthesizer and an HP606 signal generator to drive the mixer, are shown in Figure 11-2. In this case, synthesizer noise exceeds mixer and RF amplifier noise by approximately 10 dB.

11.3 Intermodulation

To test the entire receiver, two signal sources having output power to +10 dBm are connected to the inputs of a two-way power combiner. The output of the power combiner is connected to an input of the antenna multiplexer. The signal sources are set at F1 = 1.0 MHz and F2 = 1.2 MHz, at -10 dBm each. Since each signal loses 3 dB in the power combiner, the total signal power is -10 dBm. Set the IF attenuation at 60 dB and the RF attenuation to give about 1 volt amplitude output at F1 and F2. Then set the receiver for $(2 F_1 - F_2) = 0.8$ MHz and decrease the IF

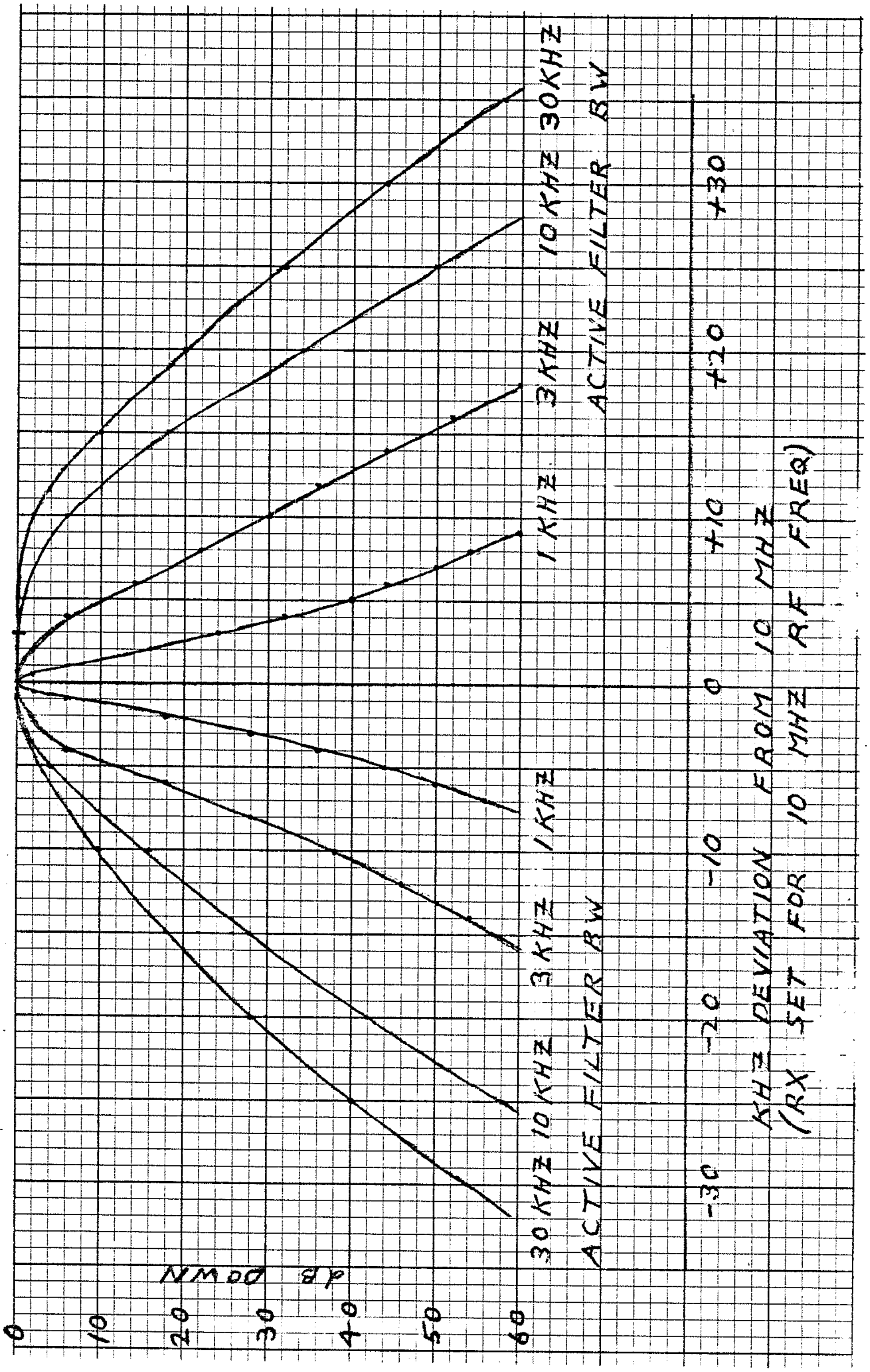


Figure 11-1 Receiver Frequency Response

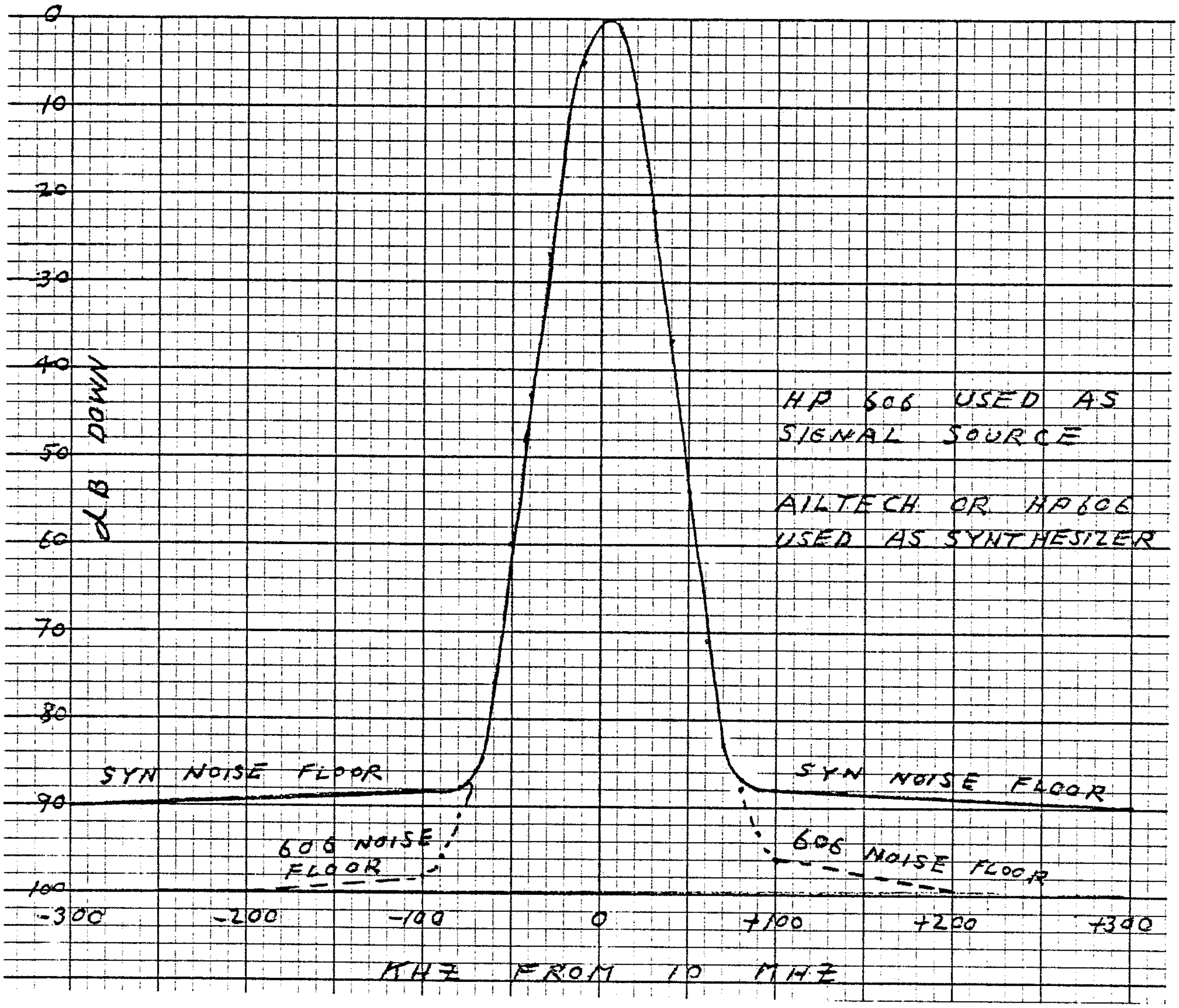


Figure 11-2 Receiver Noise Floor

attenuation until the amplitude output is again 1 volt. Repeat with the receiver set at 2 $F_2 - F_1$. The results should be nearly the same. Calculate the third order intercept as in Section 6. Repeat the test for signal levels of +10 dBm and also for F_1 = 20 MHz and F_2 = 21 MHz.

Typical results of tests on the prototype receiver are tabulated below.

F_1, F_2 (MHz)	Total Sig. Pwr. (dBm)	3rd Order dB Down	Upper or Lower	3rd Order Intcpt (dBm)
1.0, 1.2	-10	86	U	+33
	-10	80	L	+30
	+10	36	U	+28
	+10	44	L	+32
20, 21	-10	80	U	+30
	-10	86	L	+33
	+10	60	U	+40
	-10	64	L	+42

11.4 Gain Variation with Frequency

Connect a signal source to the antenna multiplexer input and set the level for an amplitude output of 2.25 V with no receiver attenuation. Vary the frequency over the range of 0.1 to 30.0 MHz, adjusting the signal level to keep the amplitude output constant. Record the signal levels and subtract them from +20 dBm to get the receiver gain. Results for the prototype receiver are shown in Figure 11-3.

11.5 Spurious Responses and Image Rejection

Connect a signal source to the receiver and slowly sweep the frequency from 100 kHz to 100 MHz. The receiver attenuation should be set at zero and the bandwidth at 30 kHz. Slowly search the frequency range from 100 kHz to 100 MHz. The signal

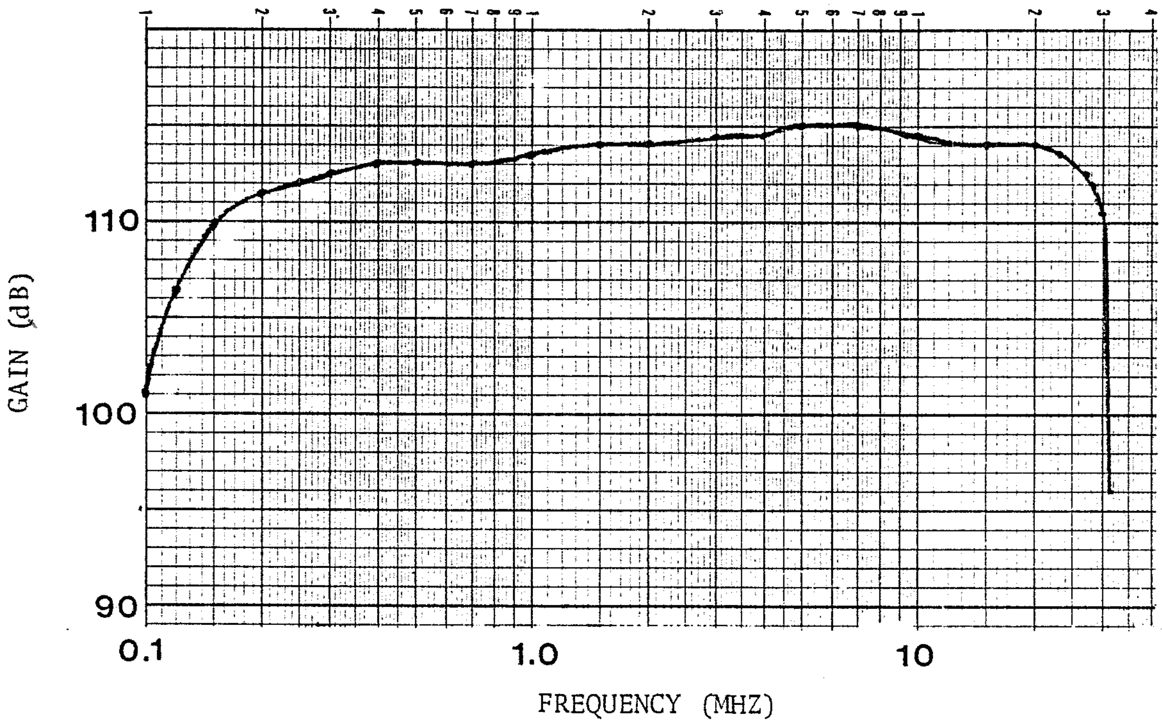


Figure 11-3 Receiver Gain
(Including 10 dB Preamplifier)

source should be set at about 0 dBm so that spurious responses be detected down to about 100 dB below the response to center frequency.

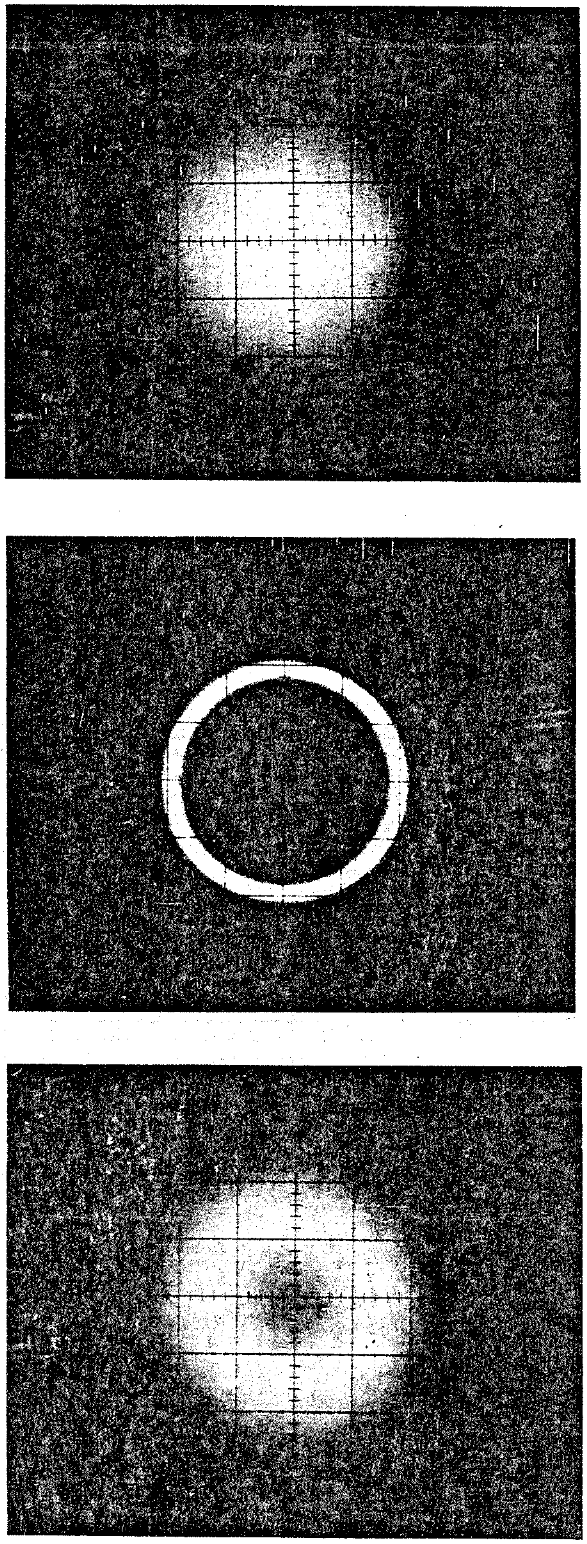
The frequencies at which spurious responses can be expected are listed below, based on data taken with the prototype receiver set at 1 MHz.

F (MHz)	dB Down	Significance
13.542	79	$3\ F = F_{IF}$
14.208	79	$2\ F_{SYN} -3\ F = F_{IF}$
20.3125	81	$2\ F = F_{IF}$
21.3125	79	$2\ F_{SYN} - 2\ F = F_{IF}$
27.415	81	Undertermined
28.0833	82	$3\ F_{SYN} - 3\ F = F_{IF}$
40.625	>100	$F = F_{IF}$
42.625	>100	$2\ F_{SYN} - F = F_{IF}$
82.250	> 85	$F - F_{SYN} = F_{IF}$ (Image)
84.250	>100	$3\ F_{SYN} - F = F_{IF}$

Other spurious responses occur at combinations of F and F_{SYN} which coincide with crystal filter spurs. In the prototype receiver, these responses were all more than 90 dB down.

11.6 Noise Thresholds

Set the receiver for normal operation with 30 kHz bandwidth and no attenuation. Connect the X and Y outputs from the analog converter to an X-Y oscilloscope. With no RF signal input, the gaussian distributed amplitude and phase noise looks like Figure 11-4A. Connect a low noise signal source to the antenna multiplexer. When the signal power is much greater than the noise power, a well defined circle is seen, as in 11-4B. Noise threshold is defined as the signal to noise ratio at which a hole can just be distinguished, as in 11-4C. Determine the signal power for this condition over the frequency range from 100 kHz to 30 MHz. Results for the prototype receiver are shown in Figure 11-5.



(A)

NO SIGNAL

(B)

STRONG SIGNAL

(C)

THRESHOLD SIGNAL

Figure 11-4 Receiver Threshold Measurement

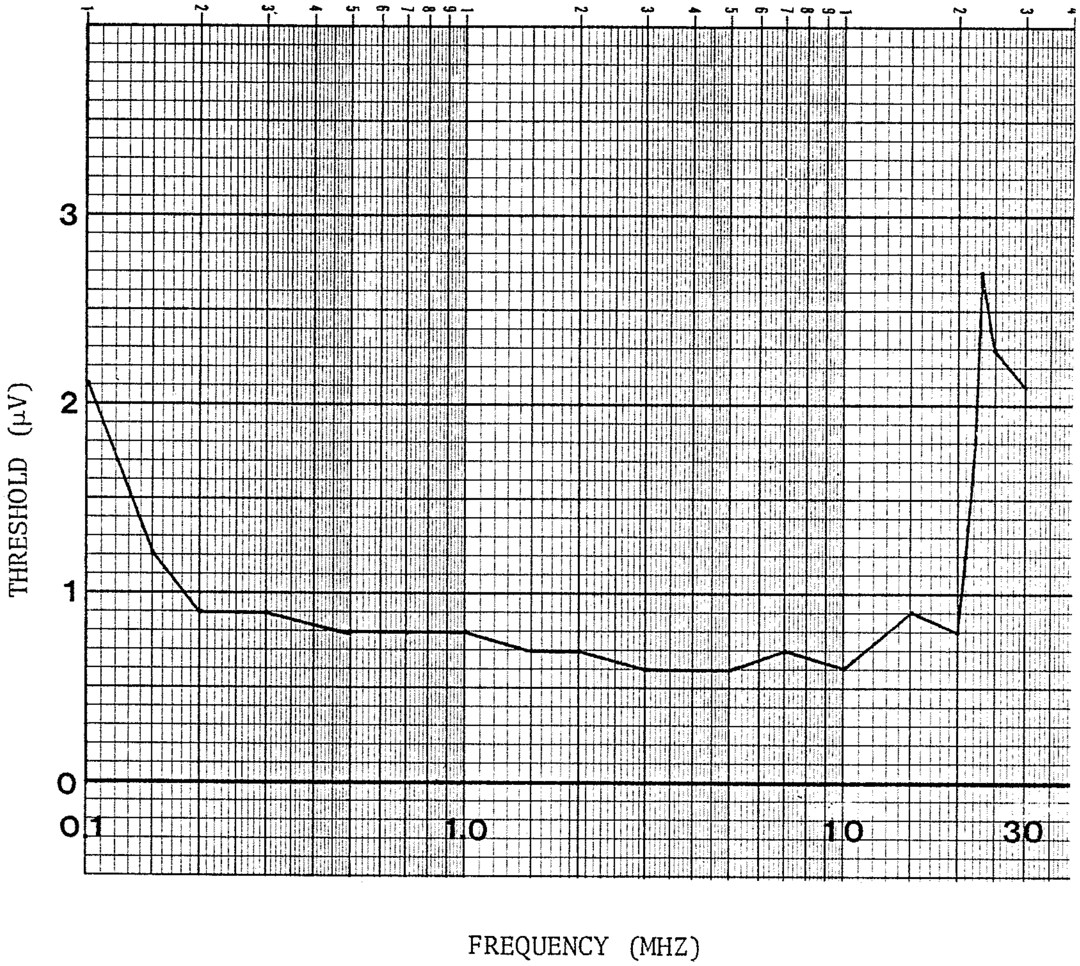


Figure 11-5 Receiver Noise Threshold

11.7 Reference Oscillator Leakage

While the receiver is set up for the noise threshold test, switch the bandwidth from 30 kHz to 1 KHz to reduce the diameter of the noise circle. Then switch the IF attenuation from 0 dB to 60 dB. If any power from the 40.625 MHz reference oscillator is coupled into the IF amplifier, it will cause a DC offset in the X-Y output. When 60 dB attenuation is switched in, both the noise circle and the DC offset approach zero. The change in DC offset should not exceed 5 mV.

11.8 Amplitude-Phase Conversion

Connect the cal output from the transmitter drive module to the antenna multiplexer input and set the transmitter phase to 0°. Set the cal attenuator, using an external pad if necessary to give an amplitude output of 10 volts when the RF and IF attenuators are set at zero. Increase the IF attenuation in 4 dB steps and record the X and Y outputs for each step. Then switch the RF attenuator to 60 dB and record X and Y. These last values are the zero offsets and should be only a few millivolts. To get the true values of X and Y, these zero offsets are subtracted from each of the X and Y values. For each corrected X-Y pair, the phase is calculated from $\phi = \tan^{-1} (Y/X)$ and plotted on a log linear scale. Repeat the measurements for phase settings of 90°, 180°, and 270°.

Typical data for the prototype receiver at 0° phase setting are tabulated below:

dB Below 10 Volts	Uncorrected Volts X	Uncorrected Volts Y	Corrected Volts X	Corrected Volts Y	Measured Phase (Degrees)
0	10.4	2.41	10.4	2.42	13.1
12	2.66	.339	2.65	.346	7.4
24	.685	.0889	.678	.0959	8.0
36	.177	.0168	.170	.0238	8.0
48	.0498	.0003	.0425	.0073	9.7
60	.0179	-.0062	.0106	.0008	7.6
120	.0073	-.0070			

It is the variation in measured phase rather than the difference between measured phase and phase setting which is significant. The accuracy of the phase switching is seen when the test is repeated for all four phase settings. Data from the prototype at mid range (≈ 5 V) values are tabulated below.

Phase Setting (Degrees)	Corrected Volts		Measured Phase (Degrees)	$\Delta \phi$ (Degrees)
	X	Y		
0	3.21	-1.51	- 25.2	
				91.1
90	-1.46	-2.96	-116.3	
				88.7
180	-3.17	-1.48	155.0	
				92.1
270	1.50	2.93	62.9	
				88.1
0	3.21	-1.51	- 25.2	

11.9 Transmitter Drive Output

Connect the RF output from the transmitter to an oscilloscope and measure the output voltage over the range of 0.1 to 30.0 MHz. Similarly, measure the cal output with the cal attenuation set at zero. The results of these tests on the prototype receiver are shown in Figure 11-6.

To test for spurious outputs, connect the RF output to a spectrum analyzer and step the synthesizer in random increments through the range of 40-70 MHz. All spurious outputs should be at least 60 dB down.

11.10 Cross Talk

Connect the cal output to the channel 1 antenna multiplexer input, and connect a 50 ohm termination to the channel 2 input. Set all receiver attenuators to zero and set the cal attenuator to give 10 V amplitude output when the transmitter keying is on. Read the channel 2 amplitude when the transmitter keying is off and again when it is on. Repeat with the cal signal to channel 2 and channel 1 terminated.

Results of this test on the prototype receiver showed no detectable cross talk. Since a change of 10 mV would be measurable, cross talk between channels is at least 60 db down.

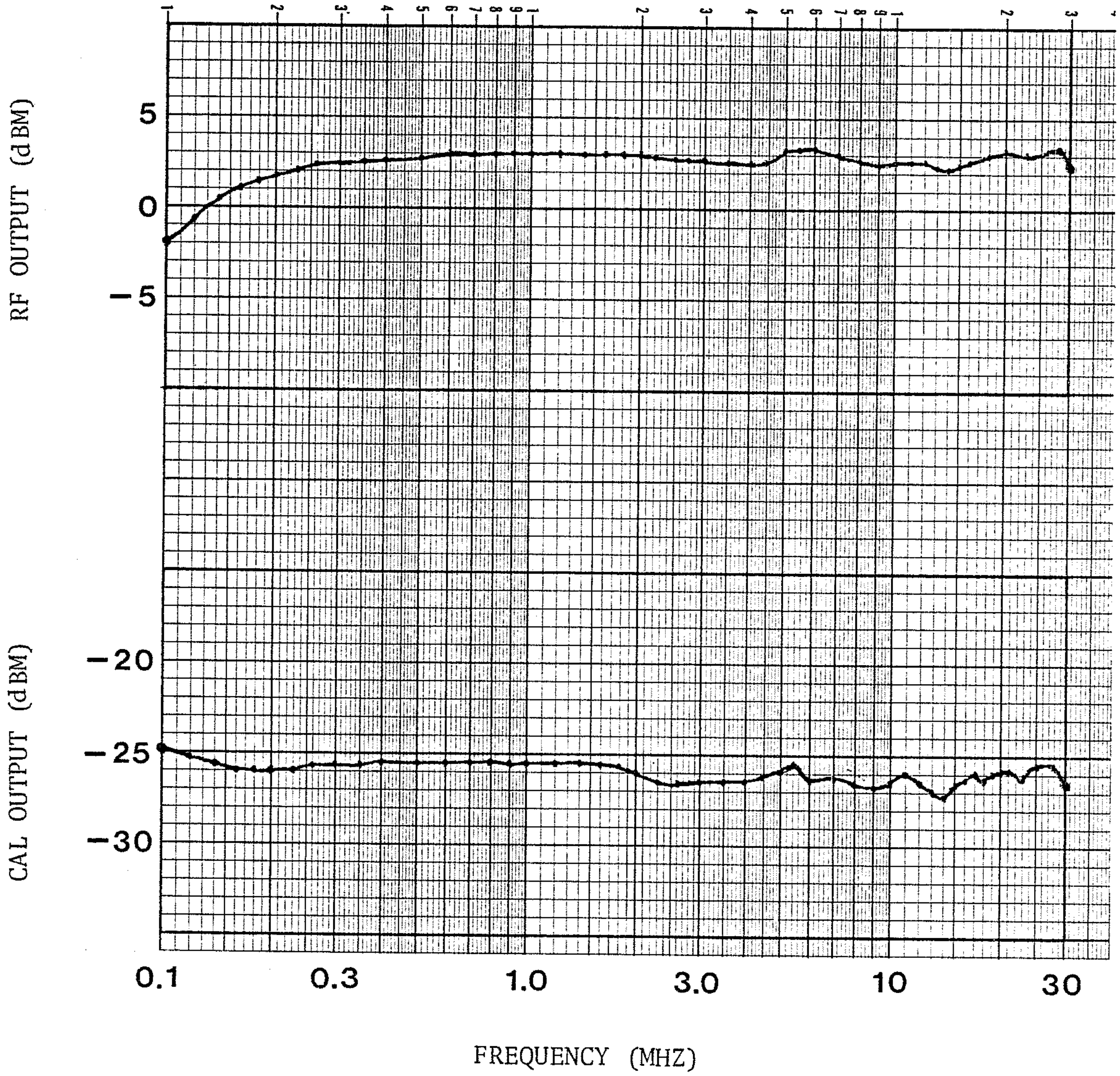
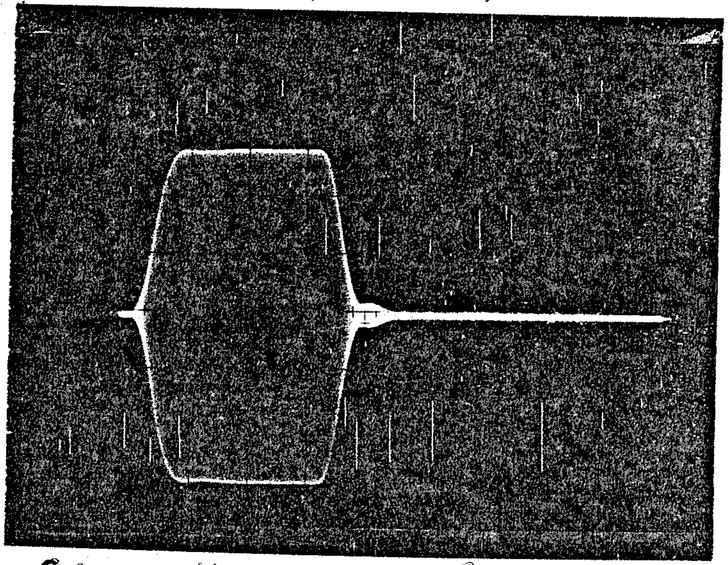


Figure 11-6 Transmitter Drive Output Levels

11.11 Pulse Envelopes

Connect a pulse generator to the TSG transmitter keying control. Connect the transmitter drive cal output to an oscilloscope, using the pulse generator for synchronization. Set the synthesizer for 10 MHz RF frequency. Set the pulse repetition rate at 1 kHz and the pulse duration at about 150 μs. The envelope is shown in Figure 11-7A. If the cal output is connected to the antenna MUX input and the oscilloscope is connected to the output of the IF module, the waveform will look like Figure 11-7B. If the detector X and Y outputs are connected to a dual channel oscilloscope, the result will be the waveform of Figure 11-8A. Finally, if the X and Y outputs are connected to X-Y oscilloscope, the trace shown in Figure 11-8B is obtained. In this figure, the zero axis is the point at the left end of the loop and the flat top of the waveform of 11-8A is the point at the right end. The sloping edges of the pulse envelope are the curved lines connecting the two points. Ideally, the lines joining the end points should be a single straight line. The curvature represents amplitude to phase conversion in the crystal filter which is caused by nonsymmetry of the frequency response curve about the IF frequency. The principal cause of nonsymmetry is an offset in the center frequency of the filter. This can be corrected by trimming the capacitor at the output terminal of the crystal filters in the mixer and IF modules. The purpose of the capacitor and the resistor in parallel with it is to correct the input impedence of the TRW amplifier, which is about 60 to 70 ohms and inductive. The capacitors should be trimmed for the straightest line between the end points. As the RF frequency of the receiver is varied, the loop rotates about the origin, because of the change in phase delay through the receiver. The shape of the loop changes with its rotation, so that the straightest line is a compromise.

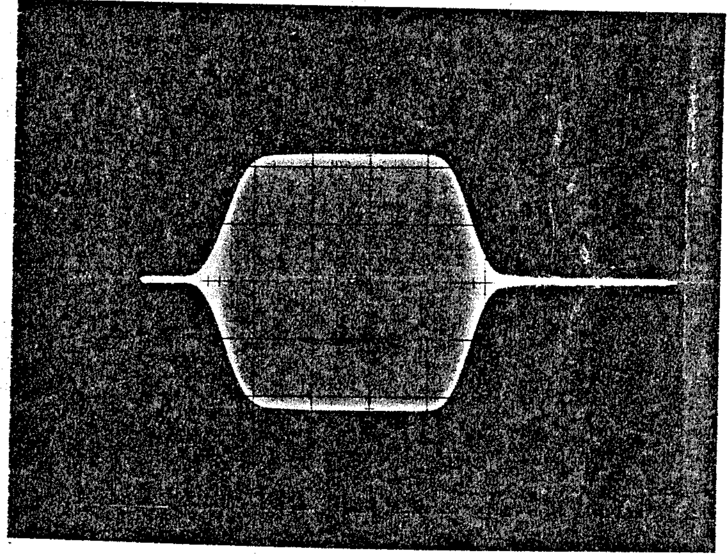
TX DRIVE RF OUTPUT



200 mV, 50 μS PER DIV

(A) Transmitter Drive Module Output

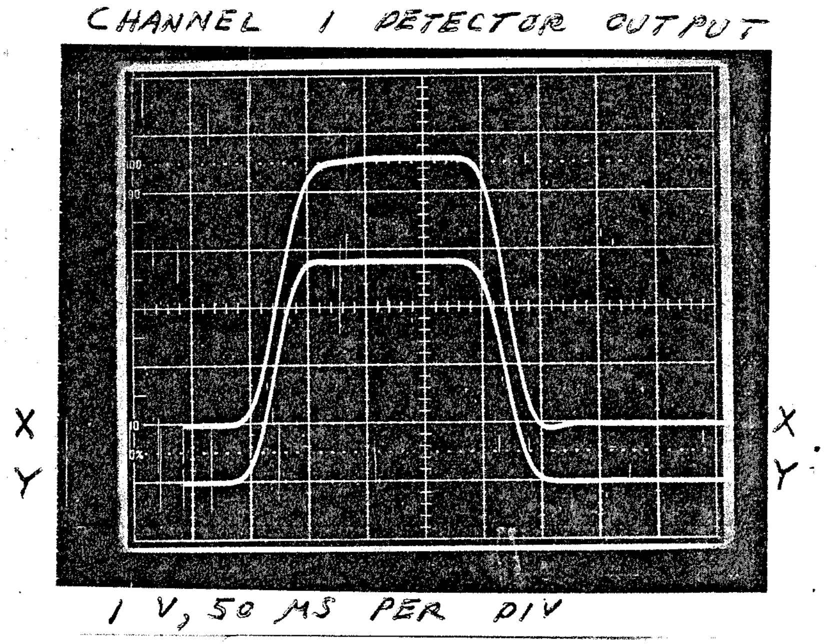
CHANNEL 2 IF OUTPUT



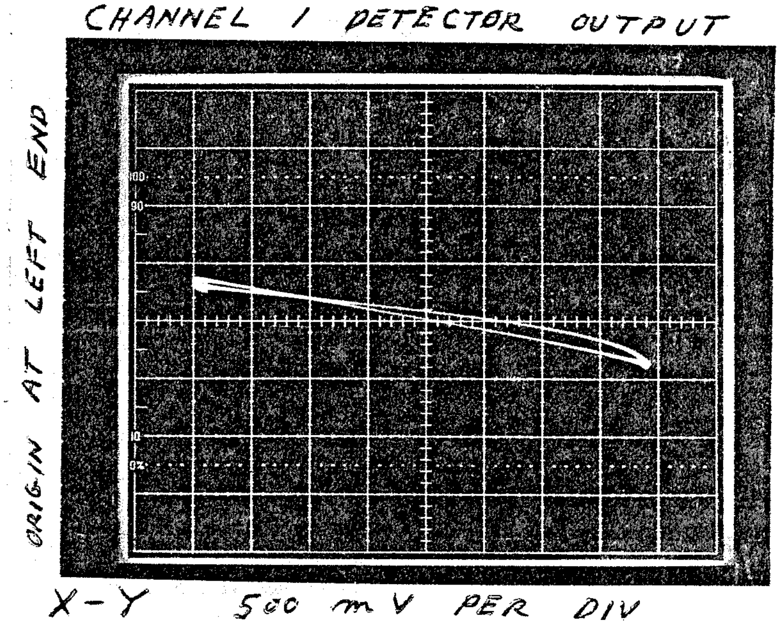
100 mV, 50 μS PER DIV

(B) IF Module Output

Figure 11-7 Pulse Envelopes



(A) X and Y Outputs



(B) X-Y Display

Figure 11-8 Detector Outputs

12. RECEIVING ANTENNA MATCHING AND CALIBRATION SYSTEM

The type of receiving antenna presently recommended for general purpose sounding and array measurements is an electrically short dipole (ideally < 0.1 λ at the highest frequency) placed about its own length above ground. Such an antenna appears capacitive in source impedance and for a flat transfer function frequency response must look into a high enough impedance to bring the input LF corner frequency below the band of interest. Although any arbitrary high balanced input impedance could be obtained with active devices in a matching amplifier, it could be difficult to maintain the receiver intermodulation performance and complex to protect against lightning damage. To minimize these problems, the present units employ a 1200 Ω to 50 Ω balance to unbalance transformer. This rather low impedance results in a corner frequency of ≈ 3 MHz depending on the dipole length. Below this frequency, the pick up factor drops at 6 dB/octave. The saving grace is that atmospheric noise levels rise at about 10 dB/octave, at least at mid latitudes, so that the real sensitivity remains constant or increases as the frequency is reduced.

The output from the transformer is amplified by an AM109 wide dynamic range 50 Ω amplifier. The output of the amplifier is converted to a 100 Ω balanced output with a second transformer to feed the transmission line to the main receiver. A balanced line is employed to eliminate common mode signal pick up problems which would otherwise cause measurement errors. Power for the AM109 is phantomed over the transmission line. Figure 12.1 shows the overall arrangement.

Following each transmitter pulse, the low power transmitter system generates a replica of the transmitter pulse for use as a system calibration. This pulse can be controlled in level from -30 dBm to < -120 dBm. As shown in Figure 12.1, this signal is distributed to the receiving antennas where it is coupled into the dipoles by small capacitors. This makes the calibration equivalent to a fixed RF field strength.

The ultimate controlling factor in system sensitivity is normally the atmospheric noise level at the site and frequency of interest. If maximum sensitivity is desired the receiving antenna system must be configured so that the atmospheric noise from the antenna is at least equal to or somewhat above the receiver generated noise. However the general signal level at the receiver input should not be increased beyond this point because of the rapid increase in third order products generated by the receiver from the man made radio spectrum.

The pick up factor (effective length) of the receiving dipoles can be adjusted within limits by changing their physical length. However the length cannot be increased indefinitely without violating the requirement for keeping the dipole electrically short at the highest frequency of interest and avoiding resonance effects which may make it difficult to keep the receiving antennas matched closely to each other. It has been found in practice that it is often not possible to meet both critera simultaneously with the present preamplifier gain and typical cable losses. The previously recommended overall dipole length of 5m for an upper sounding frequency of 20 MHZ does not provide enough pick up for the winter mid latitude atmospheric noise level to exceed the receiver noise. Experiment has shown however that operating the antenna through its resonance at a length of λ/2 does not produce any significant phase or amplitude anomoly because of the high (1200Ω) preamplifier input impedance. However operation through the resonance at a length of λ produces an amplitude null and should be avoided. Operation with a dipole length equal or somewhat greater than λ/2 at the highest frequency of interest eg. a 10m dipole for use up to 20MHZ, appears to be a safisfactory compromise. The receiving dipoles should be placed at a height not greater than λ/4 at the highest frequency of operation.

Operation with cable lengths greater than about 200m may require additional preamplification to offset cable losses and meet the atmospheric noise limit criteria even with the longer receiving dipoles.

Drawings HFS168, 169, 170, and 413 show the details of the antenna matching amplifier assembly.

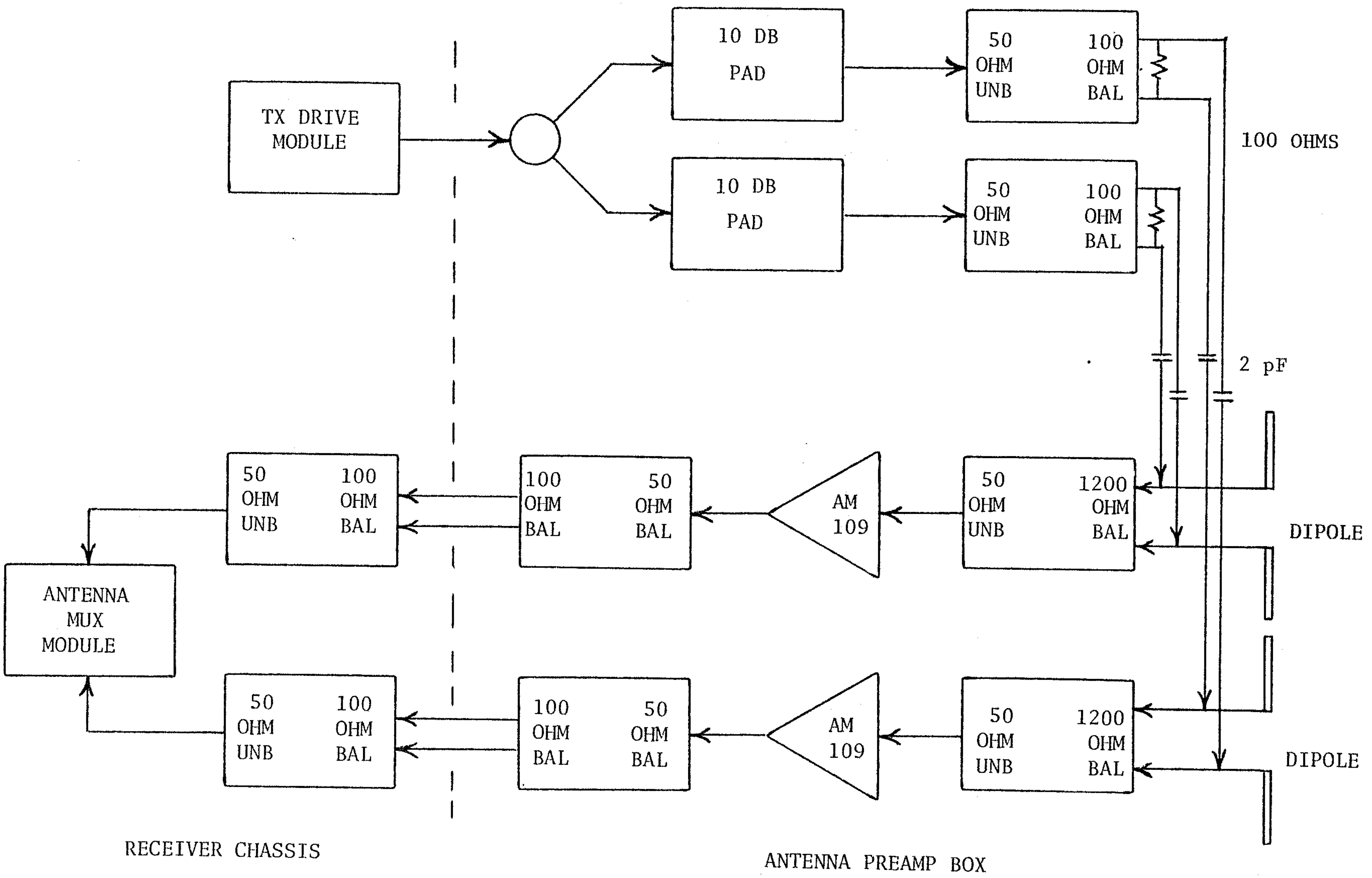


Figure 12.1 Receiving Antenna Matching and Calibration System (Two Channels Shown)

13. RECEIVER MODIFICATIONS

13.1 IF Bandwidth Selection

Drawing No. 138 shows a modification to the mixer, IF, and transmitter mixer modules. This modification allows a choice between two IF bandwidths, by switching between two crystal filters. The circuit is built on a ground plane printed circuit board, the layout of which is shown in drawing No. 139. A total of five boards is required for two receiver channels.

The modification boards are mounted on the component sides of the module boards, using one inch spacers. Space is provided along each end of the modification board for attaching the spacers. The position of the spacers relative to both boards, and the position of the modification board on the module board are chosen to avoid interference with the components and circuit on the module board. The crystal filter on each module board is removed and SMA sockets are attached at the IF input and output pads. If connections to the modification board are made through RG 174/U coaxial cable with SMA plugs.

13.2 QUADRATURE RF OUTPUTS

A modification to provide two simultaneous quadature low power RF outputs is shown in drawings HFS 123A and HFS 125A. This modification is used for circularly polarized transmissions. A dual bipolar switch is added to the transmitter mixer, and a second transmitter drive module is built. The dual bipolar switch is similar to that used in the original module and is built on a duplicate printed circuit board. The extra transmitter drive module can be inserted into the space originally provided for the synthesizer distribution module, which can be moved to one of the spaces allotted to the octave filters.

APPENDIX 1

RECEIVER MODULE PARTS LISTS Antenna Multiplexer MODULE

LABEL	PART NAME	DESCRIPTION
R1	Resistor	22 K 1/4 W 5% Metal Film
R2-R4	"	1.0 K 1/8 W " " "
R5-R10	"	220 ohms 1/4 W " " "
R11-R18	"	1.0 K 1/8 W " " "
R19-R34	"	2.2 K " " " "
R35-R42	"	4.7 K " " " "
R43-R50	"	27 K " " " "
R51-R54	"	470 ohms " " " "
R55-R58	"	10 K " " " "
R59-R62	"	220 ohms " " " "
R63-R66	"	100 ohms " " " "
R67-R70	"	330 ohms " " " "
R71-R74	Potentiometer	20 K, 10 turn
C1-C24	Capacitor	.05 µF 100 V Ceramic Disk
C25-C32	"	.005 " " " "
C33-C34	"	22 " 35 V Tantalytic
C35-C42	"	.01 " 100 V Ceramic Disk
C43-C46	"	0.1 " 100 V 10% Plastic
C47-C54	"	.001 " 100 V Ceramic Disk
L1-L2	Choke	220 µH 100 mA
L3	"	3 Ferrite Beads
D1-D6	LED	Monsanto MV 5023
U1-U4	Op Amp	RCA CA3047
U5-U6	Quad NOR	7402
U7	Hex Buffer	7407
U8	Dual Decoder	9321
U9	Quad NAND	7400
U10	Quad MUX	9322
VR1	Regulator	+ 12 V 7812
VR2	"	- 12 V 7912
M1-M4	Diode Attenuator	Minicircuits Lab PAS-3
J1-J5	Socket	Coaxial SMA
P1	Plug	50 pin AMP 200272-2
P2-P6	"	Coaxial SMA
P7-P11	"	Coaxial BNC
S1	Switch	2 Pole 5 POS Rotary
S2	"	Pushbutton N.O.
AD1-AD5	Adapter	Bulkhead BNC UG492
N1	NIM Module	Vector NIM 1387-CPA-14
B1	PC Board	7.35" x 9.55" Double Sided

PARTS LIST RF MODULE

LABEL	PART NAME	DESCRIPTION
R1-R5	Resistor	1.0 K 1/4 W 5% Metal Film
R6	"	22 K 1/4 W 5% Metal Film
C1-C4	Capacitor	.05 µF 100 V Ceramic Disk
C5-C14	"	.01 " 100 V Ceramic Disk
C15	"	0.33 " 35 V Tantalytic
C16	"	10 " 35 V Tantalytic
L1-L2	Choke	3 Ferrite Beads
D1-D5	LED	Monsanto MV 5023
U1	Quad NAND	7400
U2	Quad Multiplexer	9322
U3	Hex Buffer	7407
VR1	Regulator	+ 20 V Motorola MC 7820
P1	Plug	50 pin AMP 200272-2
P2-P5	"	Coaxial BNC
AD1-AD2	Adapter	Bulkhead BNC UG 492
S1	Switch	Binary coded EECO 177633G
S2	"	Pushbutton N.O.
F1	Low Pass Filter	Allen Avionics F301
A1	RF Amplifier	Anzac AM-109
AT1	Attenuator	Alan 50DA60-S
N1	NIM Module	Vector NIM 2787-CPA-14
B1	PC Board	7.35" x 9.55" Double Sided

PARTS LIST Mixer MODULE

LABEL	PART NAME	DESCRIPTION
R1-R2	Resistor	36 ohms 1/8 W 5% Metal Film
R3	"	150 " " " " "
R4	"	200 " " " " "
R5	"	270 " " " " "
R6	"	220 " " " " "
R7	"	47 " " " " "
R8-R9	"	100 " " " " "
R10	"	≃ 220 " 1/4 W 5% Metal Film (For best filter response.)
C1-C4	Capacitor	.01 μF 100 V Ceramic Disk
C5-C10	"	.05 " 100 V Ceramic Disk
C11-C12	"	22 pF Mica
C13	"	0.33 μF 35 V Tantalytic
C14	"	≃ 18 pF Mica (For best filter response.)
L1	Inductor	0.11 μH (0.4" dia, 0.4" length, 4 turns AWG 22)
L2-L7	Choke	3 Ferrite Beads
D1-D2	Diode	HP-2800
Q1-Q2	Transistor	2N3959
Q3-Q4	"	2N4260
VR1-VR2	Regulator	+24 V 7824
M1	Mixer	Watkins-Johnson M9E
F1	High Pass Filter	Allen Avionics F302
F2	Bandpass Filter	Damon 7118A
A1-A2	RF Amplifier	TRW CA 2810
T1	Transformer	Vari-L HF 128
T2	Transformer	Vari-L HF 122
J1-J3	Socket	Coaxial SMA
P1	Plug	50 pin AMP 200272-2
P2-P4	"	Coaxial SMA
P5-P7	"	Coaxial BNC
AD1-AD2	Adapter	Bulkhead BNC UG492
N1	NIM Module	Vector NIM 2787-CPA-14
B1	PC Board	7.35" x 9.55" Double Sided

PARTS LIST IF MODULE

LABEL	PART NAME	DESCRIPTION
R1	Resistor	10 K 1/4 W 5% Metal Film
R2-R8	"	1.0 K " " " "
R9	"	10 K " " " "
R10-R11	"	1.0 K " " " "
R12	"	4.7 K " " " "
R13	"	100 ohms 1/4 W 5% Metal Film
R14	"	1.0 K " " " "
R15-R16	"	≃ 2 M 1/4 W Metal Film (For 40 dB Attenuation)
R17	"	≃ 330 K 1/4 W Metal Film (For 20 dB Attenuation)
R18-R19	"	4.7 K 1/4 W 5% Metal Film
R20	"	1.2 K 1/2 W 5% Carbon
R21-R24	"	220 ohms 1/4 W 5% Metal Film
R25	"	22 K 1/4 W 5% Metal Film
R26	"	68 ohms 1/8 W 5% Metal Film
R27-R28	"	100 ohms 1/8 W 5% Metal Film
R29	"	≃ 220 ohms 1/4 W 5% Metal Film (For best filter response)
R30	"	1.0 K 1/4 W 5% Metal Film
C1	Capacitor	0.33 µF 35 V Tantalytic
C2-C8	"	.05 " 100 V Ceramic Disk
C9-C12	"	.001 " " " "
C13-C27	"	.01 " " " "
C28-C29	"	22 pF Mica
C30-C33	"	.05 µF 100 V Ceramic Disk
C34	"	≃ 18 pF Mica (For best filter response)
L1-L3	Choke	3 Ferrite Beads
L4	Inductor	0.11 µH (0.4" dia, 0.4" length, 4 turns AWG 22)
D1-D2	Diode	HP 2800
D3-D4	"	IN4004
D5-D12	LED	Monsanto MV5023
U1	Comparator	NS LM-311, 8 pin DIP
U2-U3	Quad NOR	7400
U4	Hex Inverter	7406
U5-U6	Quad Multiplexer	9322
U7	Dual Decoder	9321
U8	Hex Buffer	7407
UR1	Regulator	+24 V 7824
AT1	Attenuator	Alan 50 DA60-S
M1	Diode Attenuator	Minicircuits Lab PAS-1
PS	Power Splitter	Minicircuits Lab PSC-2
F1	Bandpass Filter	Damon 7118 A
J1-J4	Socket	Coaxial SMA
P1-P4	Plug	Coaxial SMA

PARTS LIST IF MODULE

LABEL	PART NAME	DESCRIPTION
P5-P8	Plug	Coaxial BNC
P9	Plug	50 pin AMP 200272-2
AD1-AD2	Adapter	Bulkhead BNC UG 492
S1	Switch	2 Pole 4 POS Rotary
S2	"	Binary coded EECO 177633G
S3-S4	"	Pushbutton N.O.
A1	RF Amplifier	TRW CA 2810
N1	NIM Module	Vector NIM 2787-CPA-14
B1	PC Board	7.35" x 9.55" Double Sided

PARTS LIST Detector MODULE

LABEL	PART NAME	DESCRIPTION
R1	Resistor	51 ohms 1/4 W 5% Metal Film
R2	"	68 " " " " "
R3-R4	"	100 " " " " "
R5-R6	"	50 " " " " "
R7-R10	"	200 " " " " "
R11-R12	"	4.2 K " " " "
R13-R14	"	4.8 K " " " "
R15-R16	"	1.0 K " " " "
R17-R18	"	1.0 M " " " "
R19-R20	Potentiometer	100 K 10 turn
R21	Resistor	65 K 1/4 W 1% Metal Film
R22	"	70 K " " " "
R23-R24	"	100 ohms " " " "
R25-R29	"	220 ohms 1/4 W 5% Metal Film
R30	"	22 K " " " "
R31-R33	"	1.0 K " " " "
R34	Potentiometer	10 K 10 turn
C1-C2	Capacitor	.047 µF 10% 100 V Plastic
C3-C4	"	0.1 " " " "
C5-C6	"	.015 " " " "
C7-C8	"	.033 " " " "
C9-C10	"	3300 pF " " "
C11-C12	"	6800 pF " " "
C13-C14	"	1500 pf " " "
C15-C16	"	3300 pf " " "
C17-C18	"	500 pf Mica
C19-C23	"	.05 µf 100 V Ceramic Disk
C24	"	4.7 " 35 V Tantalytic
C25	"	.05 " 100 V Ceramic Disk
C26	"	4.7 " 35 V Tantalytic
C27-C28	"	.05 " 100 V Ceramic Disk
C29-C42	"	.01 " 100 V Ceramic Disk
C43	"	0.33 " 35 V Tantalytic
L1-L4	Choke	3 Ferrite Beads
D1-D5	LED	Monsanto MV 5023
V1	Quad NAND	7400
U2-U3	Hex Buffer	7407
U4	Dual Decoder	9321
U5	Quad Multiplexer	9322
VR1-VR2	Regulator	+24 V 7824
J1-J4	Socket	Coaxial SMA
J5-J6	Socket	BNC Panel
P1-P2	Plug	Coaxial Cable SMA
P3-P4	Plug	Coaxial Cable BNC
P5	Plug	50 pin AMP 200272-2
AD1-AD2	Adapter	Bulkhead BNC UG 492
A1-A2	RF Amplifier	TRW CA 2810
A3-A4	Op Amp	Optical electronics 9817

PARTS LIST Detector MODULE

LABEL	PART NAME	DESCRIPTION
M1-M2	Mixer	Minicircuits Lab RAY-1
PS1	Power Splitter	Minicircuits Lab PSC-2
QH1	Quadrature Hybrid	Merrimac QHS-3, Model 3
S1-S6	Reed Relay	DPST Grigsby-Barton 822-A
S7	Switch	2 Pole 5 POS Rotary
S8	Switch	Pushbutton N.O.
N1	NIM Module	Vector NIM 2787-CPA-14
B1	PC Board	7.35" x 9.55" Double Sided

PARTS LIST Analog Converter MODULE

LABEL	PART NAME	DESCRIPTION
R1-R8	Resistor	100 ohms 1/4 W 5% Metal Film
R9-R10	"	10 K " " " "
R11-R14	"	1.5 K " 1% " "
R15-R16	Potentiometer	10 K 10 turn
R17-R18	Resistor	390 K 1/4 W 1% Metal Film
R19-R20	"	2.2 K " " " "
R21-R22	"	2.1 K " " " "
R23-R24	"	47 K " " " "
R25-R27	"	5.0 K " " " "
R28	"	13 K " " " "
R29	"	220 ohms 1/4 W 5% Metal Film
R30	"	1.0 M " " " "
R31-R32	Potentiometer	50 K 10 turn
R33	Resistor	4.5 K 1/4 W 1% Metal Film
R34	"	15 K " " " "
R35	"	195 K " " " "
R36	"	47 ohms 1 W 5% Carbon
R37	Potentiometer	100 K 1 turn (Audio)
R38-R39	Resistor	150 K 1/4 W 5% Metal Film
C1-C4	Capacitor	1000 pF 100 V Ceramic Disk
C5-C12	"	.05 pF 100 V Ceramic Disk
C13-C14	"	10 μF 35 V Tantalytic
C15-C16	"	1 " 25 V Tantalytic
C17-C20	"	1000 pF 100 V Ceramic Disk
C21-C25	"	.05 μF 100 V Ceramic Disk
C26-C29	"	27 pF Mica
C30	"	1000 μF 12 V Electrolytic
C31	"	50 " 25 V Electrolytic
C32	"	.02 " 100 V Plastic
C33	"	500 " 50 V Electrolytic
C34	"	.01 " 50 V Ceramic Disk
C35-C36	"	330 pF Mica
C37-C42	"	.05 μF 100 V Ceramic Disk
L1-L4	Choke	3 Ferrite Beads
D1-D2	Back Diode	General Electric BD-7
D3-D6	Diode	HP 2800
D7-D8	"	IN4004
D9	LED	Monsanto MV 5023
U1-U4	Op Amp	NS LM 531
U5	Audio Amp	NS LM 380
U6	Comparator	NS LM 311
VR1	Regulator	+12 V 7812
A1-A2	Vector Module	Intronics VM 101
SP1	Speaker	2.5" 4 ohms QUAM 25A07
S1	Switch	Spot Toggle
S2	Switch	1 Pole 10 POS Rotary
J1-J13	Socket	BNC Panel UG 1094
P1	Plug	50 pin AMP 200272-2
PM1	Panel Meter	50-0-50 μA Triplett 220G

PARTS LIST

Analog Converter MODULE

LABEL	PART NAME	DESCRIPTION
N1	NIM Module	Vector NIM 4087-CPA-14
B1	PC Board	7.35" x 9.55" Single Sided

PARTS LIST

Transmitter Mixer MODULE

LABEL	PART NAME	DESCRIPTION
R1-R8	Resistor	220 ohms 1/4 W 5% Metal Film
R9-R12	"	1.0 K " " " "
R13-R20	"	2.2 K " " " "
R21-R24	"	4.7 K " " " "
R25-R28	"	27 K " " " "
R29-R30	"	10 K " " " "
R31-R32	"	470 ohms " " " "
R33-R34	"	220 " " " " "
R35-R36	"	100 " " " " "
R37-R38	"	330 " " " " "
R39-R40	"	36 " 1/8 W 5% Metal Film
R41-R44	"	150 " " " " "
R45	"	68 " " " " "
R46-R47	"	100 " " " " "
R48	"	51 " 1/4 W 5% Metal Film
R49-R50	Potentiometer	20 K 10 turn
C1-C22	Capacitor	.05 µF 100 V Ceramic Disk
C23-C25	"	.01 " " " "
C26-C29	"	.001 µF " " "
C30-C33	"	.005 " " " "
C34-C35	"	100 " 25 V Electrolytic
C36	"	0.33 " 35 V Tantalytic
L1	Choke	3 Ferrite Beads
L2-L3	"	300 µH 10 ohms Max.
L4	"	3 Ferrite Beads
L5-L6	"	220 µH 110 mA
D1-D5	LED	Monsanto MV 5023
U1-U2	Op Amp	RCA CA 3047
U3	Quad NOR	7402
U4	Decoder	7442
VR1	Regulator	+24 V 7824
VR2	"	+12 V 7812
VR3	"	-12 V 7912
OSC 1	Oscillator	Greenray YH-980
QH1	Quadrature Hybrid	Merrimac QHS-3, Model 3
F1	Bandpass Filter	Damon 7118A
M1	Mixer	Minicircuits Lab RAY-1
M2-M3	Diode Attenuator	Minicircuits Lab PAS-3
PS1	Power Splitter	Minicircuits Lab PSC-4
PS2	Power Splitter	Minicircuits Lab PSC-2
A1	RF Amplifier	TRW CA 2810
J1-J6	Socket	Coaxial SMA
AD1-AD5	Adaptor	Bulkhead BNC UG 492
N1	NIM Module	Vector NIM 4087-CPA-14
B1	PC Board	7.35" x 9.55" Double Sided

PARTS LIST Transmitter Drive MODULE

LABEL	PART NAME	DESCRIPTION
R1-R3	Resistor	1/4 W 5% Metal Film for 50 ohm pad. Choose values for required attenuation.
R4	"	1 K 1/4 W 5% Metal Film
R5	"	22 K " " " "
R6-R10	"	1 K " " " "
R11	"	10 K " " " "
R12-R14	"	220 ohms 1/4 W 5% Metal Film
R15	"	100 " " " " "
C1-C10	Capacitor	.01 µF 100 V Ceramic Disk
C11-C14	"	.05 "
C15-C17	"	.001 µF
C18	"	.01 "
C19-C21	"	10 " 25 V Tantalytic
L1-L3	Choke	3 Ferrite Beads
L4	"	1 mH 250 mA
D1	Diode	Silicon 1N4153
D2-D7	LED	Monsanto MV 5023
U1	Quad NAND	7400
U2-U3	Quad Multiplexer	9322
U4-U5	Hex Buffer	7407
VR1	Regulator	+20 V Motorola MC 7820
F1	Low Pass Filter	Allen Avionics F301
AT1	Attenuator	Alan 50 DA120-S
A1	RF Amplifier	Anzac AM-110
PS1	Power Splitter	Minicircuits Lab PSC-2
M1	Diode Attenuator	Minicircuits Lab PAS-3
S1	Switch	Binary coded EECO 177633G
S2	"	N. O. Pushbutton
S3	"	SPDT Toggle
J1-J5	Socket	Coaxial SMA
P1-P5	Plug	Coaxial Cable SMA
P6-P14	"	Coaxial Cable BNC
P15	"	50 pin AMP 200272-2
AD1-AD3	Adapter	Bulkhead BNC UG 492
N1	NIM Module	Vector NIM 2787-CPA-14
B1	PC Board	7.35" x 9.55" Double Sided

PARTS LIST Control MODULE

LABEL	PART NAME	DESCRIPTION
R1-R2	Resistor	2.0 K 1/4 W 5% Metal Film
R3	"	4.7 K " " " "
C1-C6	Capacitor	.05 μF 100 V Ceramic Disk
C7-C8	"	47 pF Mica
C9	"	10 μF 25 V Tantalytic
L1	Choke	3 Ferrite Beads
U1	Quad NOR	NS DS8836N
U2-U6	Comparator	NS DM8131N
U7-U16	Tri-State Buffer	NS DM81LS95N
U17-U21	Tri-State Latch	NS DM8553N
P1	Plug	50 pin AMP 200272-2
N1	NIM Module	Vector NIM 1387-CPA-14
B1	PC Board	7.35" x 9.55" Double Sided

PARTS LIST Control/Adder MODULE

LABEL	PART NAME	DESCRIPTION
R1-R2	Resistor	2.0 K 1/4 W 5% Metal Film
R3	"	4.7 K " " " "
C1-C6	Capacitor	.05 μF 100 V Ceramic Disk
C7-C8	"	47 pF Mica
C9	"	10 μF 25 V Tantalytic
L1	Choke	3 Ferrite Beads
U1	Quad NAND	NS DS8836N
U2-U6	Comparator	NS DM8131N
U7-U16	Tri-State Buffer	NS DM81LS95N
U17-U21	Tri-State Latch	NS DM8553N
U22-U26	Adder	Signetics 82S83
U27-U32	Display	TI TIL 308
P1	Plug	50 pin AMP 200272-2
N1	NIM Module	Vector NIM 2787-CPA-14
B1	PC Board	7.35" x 9.55" Double Sided
B2	PC Board	7.35" x 9.25" Double Sided
B3	PC Board	1.50" x 7.20" Double Sided

PARTS LIST   Synthesizer Distribution MODULE

LABEL	PART NAME	DESCRIPTION
PS1	Power Splitter	Merrimac PD-40-55
F1	Low Pass Filter	Allen Avionics FC 73 MHz Z50
AT1	Attenuator	3 dB Coaxial
CC1	Coax Cable	8" RG58 with UG88 BNC Plug both ends
NIM1	NIM Module	Vector NIM 2787-CPA-14
B1	Mounting Board	7.35" x 9.55" x .062 Aluminum

PARTS LIST Power Supply MODULE

LABEL	PART NAME	DESCRIPTION
R1	Resistor	1 K 1/4 W 1% Metal Film
R2-R3	"	3 K " " " "
R4	"	5 K " " " "
R5-R6	"	1.5 K " " " "
R7	"	1.25 K 1/4 1% Metal Film
J1-J4	Socket	BNC Panel UG 1094
J5	"	2 pin Jones
J6	"	4 pin Jones
J7	"	6 pin Jones
P1	Plug	3 pin AC panel with filter
TS1	Terminal Strip	Phenolic with 6 standoff, 2 ground solder lugs
FU1	Fuse	3 AG 6A SB with panel mount holder
FP1	Panel	19" x 10.5" x .125" Relay Rack Front Panel
H1-H2	Hardware	4" Front Panel Handles

APPENDIX 2

MODULE INTERNAL CONNECTIONS Antenna Multiplexer MODULE

PC BOARD LABEL	DESCRIPTION		FRONT/BACK PANEL	
J1	1	Inputs from Antennas		Back Panel BNC
J2	2			
J3	3			
J4	4			
J5	Output to RF Amp			
A	0° Phase			
B	ANT 1	Indicator		Front Panel LED -
C	ANT 2			
D	ANT 3			
E	ANT 4			
F	L/R			
H	B	Antenna Local Control	B	Front Panel Binary Coded Switch
I	A		A	
J	+5 V		Front Panel LED's +	
K	Local Control		Front Panel Pushbutton	
L	B	Antenna DIO Control	B	Back Panel 50 Pin Connector
M	A		A	
N	DIO L/R Flag		L	
O	DIO L/R Control		E	
P	TSG RX Disable		N	
Q	A	DIO Flag	F	
R	B		H	
S	TSC RX Phase Code		P	

INTERNAL CONNECTIONS RF MODULE

PC BOARD LABEL	DESCRIPTION		FRONT/BACK PANEL	
A	DIO Remote Control		E	Back Panel 50 Pin Connector
B	DIO L/R Flag		L	
C	32 dB	DIO Control	D	
D	16 dB		C	
E	8 dB		B	
F	4 dB		A	
H	4 dB	DIO Flag	F	
I	8 dB		H	
J	16 dB		J	
K	32 dB		K	
L	4 dB	Indicator		Front Panel LED +
M	8 dB			
N	16 dB			
O	32 dB			
P	L/R	Indicator		Front Panel LED -
Q	16			
R	32			
S	8			
T	4			
U	L/R Indicator		Front Panel LED +	
V	Local Control		Front Panel Pushbutton	
W	32	Local Control		Front Panel Binary Coded Switch
X	16			
Y	8			
Z	4			

INTERNAL CONNECTIONS IF MODULE

PC BOARD LABEL	DESCRIPTION		FRONT/BACK PANEL		
J1	Fast Attn Out		Slow Attn In		
J2	IF Input		Back Panel BNC		
J3	Power Splitter Input		Slow Attn In		
J4	If Output		Back Panel BNC		
A	4 dB	Indicator		Front Panel LED +	
B	8 dB				
C	16 dB				
D	32 dB				
E	A	Fast Attn		Front Panel	
F	B	Local Control		Binary Coded Switch	
H	20 dB	Fast Attn		Front Panel LED -	
I	40 dB	Indicator			
J	Reset Indicator			Front Panel LED -	
K	L/R Indicator				
L	+5V		Front Panel LED +		
M	16	Indicator	Front Panel LED -		
N	32	Local Control		Front Panel	
O	16	(Slow Attn)		Binary Coded Switch	
P	32				
Q	8	Indicator		Front Panel LED -	
R	4				
S	Local Control		Front Panel Pushbutton		
T	4 dB	Local Control		Front Panel	
U	8 dB	(Slow Attn)		Binary Coded Switch	
V	8 dB	DIO Flag	H		V10
W	4 dB		F		BLU
X	32 dB		K		WHI
Y	16 dB		J		GRA
Z	8 dB	DIO Control	B		RED
AA	4 dB		A		BRN
AB	16 dB		C	Back Panel	BLK
AC	32 dB		D	50 Pin Connector	GRN
AD	DIO L/R Flag		L		YEL
AE	DIO Remote Control		E		ORA
AF	Reset	TSG	N		BRN
AG	A Fast	Control	P		RED
AH	B Attn		R		ORA
AI	Interrupt		T		YEL
AJ		Local Reset Control	N.C.	Front Panel	
AK			Common	Reset P. B.	

INTERNAL CONNECTIONS Mixer MODULE

PC BOARD LABEL	DESCRIPTION	FRONT/BACK PANEL
J1	RF Input	Back Panel BNC
J2	IF Output	
J3	Squarer Input	High Pass Filter Output

INTERNAL CONNECTIONS Detector MODULE

PC BOARD LABEL	DESCRIPTION	FRONT/BACK PANEL
J1	IF Input	Back Panel BNC
J2	Local Oscillator Input	
A	1 kHz	
B	3 kHz	
C	10 kHz Indicator	Front Panel
D	L/R	LED -
E	30 kHz	
F	Local Control	Front Panel Pushbutton
H	A Bandwidth	Front Panel
I	B Local Control	Binary Coded Switch
J	+5 V	Front Panel LED +
K	X Analog	Back Panel
L	Y Outputs	BNC Jacks
M	B DIO BW Flag	H
N	B Bandwidth	B
O	A DIO Control	A Back Panel
P	DIO L/R Flag	L 50 Pin Connector
Q	DIO L/R Control	E
R	A DIO BW Flag	F

INTERNAL CONNECTIONS Analog Converter MODULE

PC BOARD LABEL	DESCRIPTION			FRONT/BACK PANEL		
AX In	X	CH A	Inputs	A	Back Panel NIM Connector	*
AY In	Y			B		*
BX In	X	CH B		K		*
BY In	Y			L		*
A Amp	CH A Amp		Outputs	E		*
A Log	CH A Log			F		*
B Amp	CH B Amp			P		*
B Log	CH B Log			R		*
A Amp LPF	CH A	Low Pass Amp Out		H		
B Amp LPF	CH B			S		
A				Panel Meter +		
B				Center	Range Switch	
C	1.0 V FS			Down		
D	10 V FS			Up		
E	Volume			Volume Control Top		
F	Function			Function Switch Common		
H				Volume Control Center		
I		Overload Indicator		+	Front Panel LED	
J				-		
K	Overload Interrupt				Speaker, Back Panel 50 Pin Connector	
L						

INTERNAL CONNECTIONS Transmitter Mixer MODULE

PC BOARD LABEL	DESCRIPTION			FRONT/BACK PANEL
J1-J3	REF OSC Output			Back Panel BNC
J4	REF Input			
J5	Input From Syn			
B	0°	TX Phase Code Indicator		Front Panel LED -
C	90			
D	270			
E	180°			
F	Pulse Key Indicator			
A	+5 V			Front Panel LED +
H	Ø 1	Inputs From TSG	N	Back Panel 50 Pin Connector
J	Ø 2		P	
K	Key		R	
J6	RF Output			

INTERNAL CONNECTIONS Transmitter Drive MODULE

PC BOARD LABEL	DESCRIPTION		FRONT/BACK PANEL	
J1	RF Input		Low Pass Filter Output	
J2	CAL Input		Attn Input	
J3	RF Output		Back Panel BNC	
A	64 dB	Indicator		Front Panel LED +
B	32 dB			
C	16 dB			
D	8 dB			
E	+5 V		Front Panel LED + (REM, DIS)	
F	Local Control		Front Panel Pushbutton (N.O.)	
H	TX Enable Local Control		Front Panel Toggle Common	
I	64 dB	Local Control	8	Front Panel Binary Coded Switch
J	32 dB		4	
K	TX Enable Indicator		Front Panel LED -	
L	L/R	Indicator		Front Panel LED -
M	64 dB			
N	32 dB			
O	16 dB			
P	8 dB			
Q	8 dB	Local Control	1	Front Panel Binary Coded Switch
R	16 dB		2	
S	64 dB	DIO Flag	K	Back Panel 50 Pin Connector
T	32 dB		J	
U	16 dB		H	
V	8 dB		F	
W	8 dB	DIO Control	A	
X	16 dB		B	
Y	32 dB		C	
Z	64 dB		D	
AA	DIO L/R Flag		L	
AB	DIO L/R Control		E	
AC	TX Enable From TSC		N	
GND	Local Control		Pushbutton Common	
GND	TX Enable		F. P. Toggle (left)	
GND	Attenuation		Binary Coded Switch Common	
AD	TX Enable From TSG		F. P. Toggle (right)	

APPENDIX 3

CRYSTAL FILTER TEST SET

1. PURPOSE

It is important for the application of Damon filters (part number 7118A) that imperfections in the realization of the desired transfer function and, particularly, asymmetries in the response about the desired center frequency of 40.625 MHz do not cause AM to PM conversion. The test set to be GFE, in conjunction with the contractor's signal source, oscilloscope, and square wave modulation generator permits the filter response to an on/off modulated signal to be displayed on an X, Y oscilloscope in R, θ form. The ellipticity of the locus displayed shows directly the amount of AM to PM conversion and should permit quicker and more accurate center frequency and symmetry adjustment. In addition, the X or Y output displayed versus time on the oscilloscope can be used to verify that the envelope overshoot and undershoot specifications are met.

2. TEST SET DESCRIPTION

A block diagram of the filter test set is shown in Figure 1. A CW input signal at 40.625 MHz, +13 dBm is fed via power splitter PS1 to a modulator consisting of attenuator AT1, AT2, and diode switch M1. The other half of the signal is used as reference in a quadrature detector consisting of quadrature hybrid QH1, double balanced mixers M2 and M3, and power splitter PS2.

The modulator is driven by a contractor supplied square wave generator which can source 20 mA at TTL levels (such as the 50 Ω output of a Wavetek 183). The X and Y quadrature outputs when connected to the horizontal and vertical deflection of a contractor supplied X-Y oscilloscope show the amplitude of a signal at the detector input and its phase relative to that of the reference signal in R, θ form. The set also contains a 33 dB wide band amplifier.

The filter to be tested is inserted, with 10 dB isolation attenuators on both sides between the modulator output and the amplifier input, and the amplifier output is connected to the detector input. The test set requires a contractor supplied 20 V at 250 mA supply.

3. TEST PROCEDURE

Connect the test set to an RF signal generator supplying +13 dBm and a square wave generator (3-4 V at 50 Ω) as shown in Figure 2. Set the square wave generator for an offset square wave (+4 volts maximum, 0 volts minimum) at 10 kHz. Observe the modulated signal on the scope. The envelope should look like that shown in Figure 3.

After the proper waveform has been obtained, connect the test set as shown in Figure 4. With the scope in the X-Y mode, the amplitude A of the modulated signal and its phase Ø relative to that of the reference can be seen as in Figure 5. The two spots represent the maxima and minima of the envelope and the line joining them represents the rise and fall transitions. The amplitude should be about 70 mV, but the phase will depend on the total delay in the amplifier, attenuators, and their connecting cables. With no filter in the circuit, the transition line should be straight throughout the frequency range of 40.625 ± 1 MHz, indicating that the characteristics of the attenuators and amplifier are constant through the range. After this has been verified, insert the filter between the two 10 dB attenuators as shown in Figure 6. The envelope rise time will be longer (about 30 μs), so the modulating frequency should be reduced to 1 kHz.

The shape of the transition line will now be frequency dependent. It should be nearly straight at center frequency, and elliptical at several kHz above or below. The distance between the end points will also vary, corresponding to the change in amplitude of the filter response.

The desired result of the test is a filter whose maximum output amplitude and straightest transition line coincide at 40.625 MHz. The envelope transient response of the filter can also be observed by displaying the X or Y outputs versus time. Testing the existing set of filters shows that filters having the best gaussian envelope transient response also show the best straight line phase locus, although not necessarily at the nominal center frequency. The objective of the filter adjustment using the test jig is to permit transient response and center frequency to be optimized simultaneously on a best effort basis.

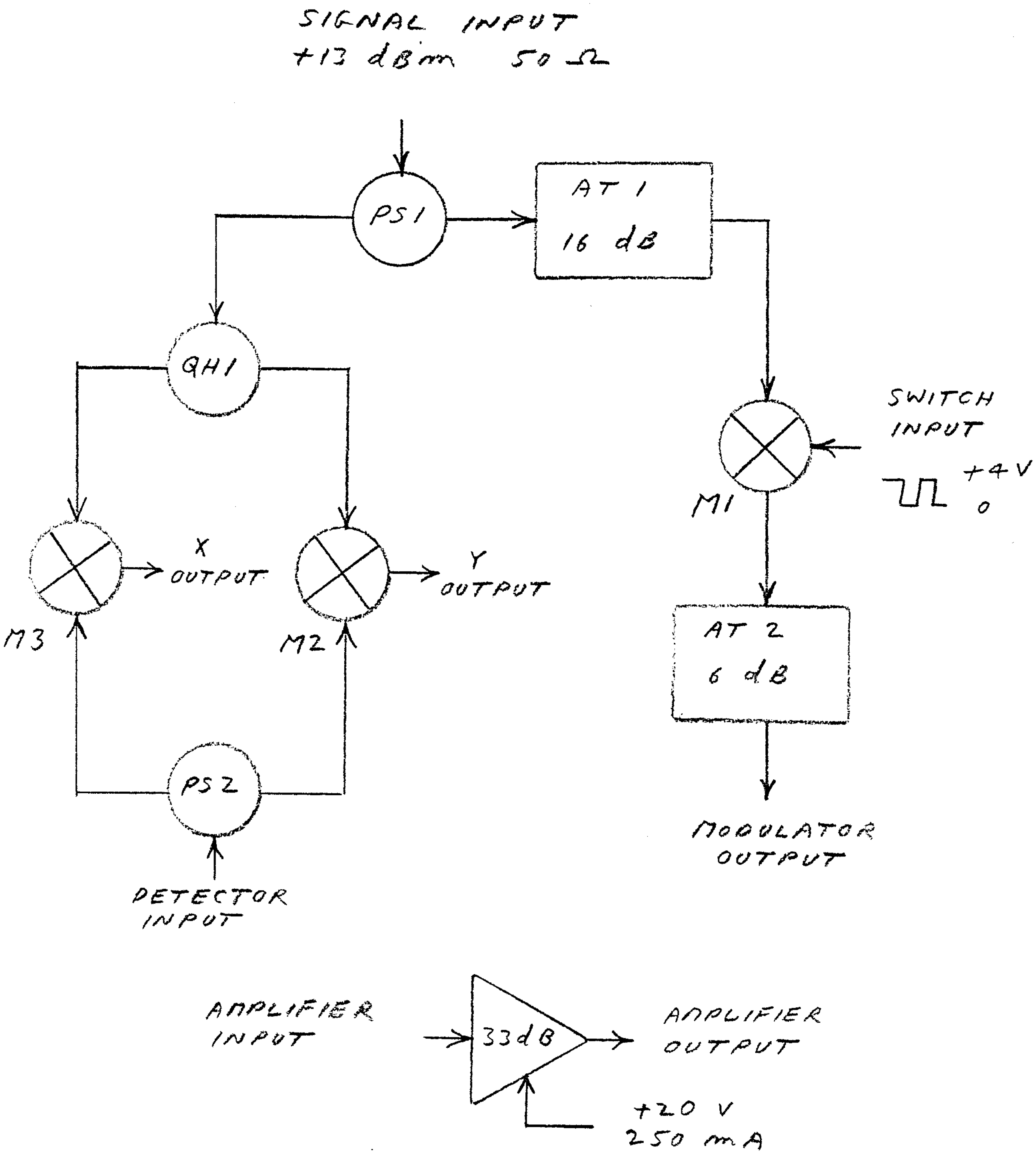


Figure 1. Filter Test Unit, Block Diagram

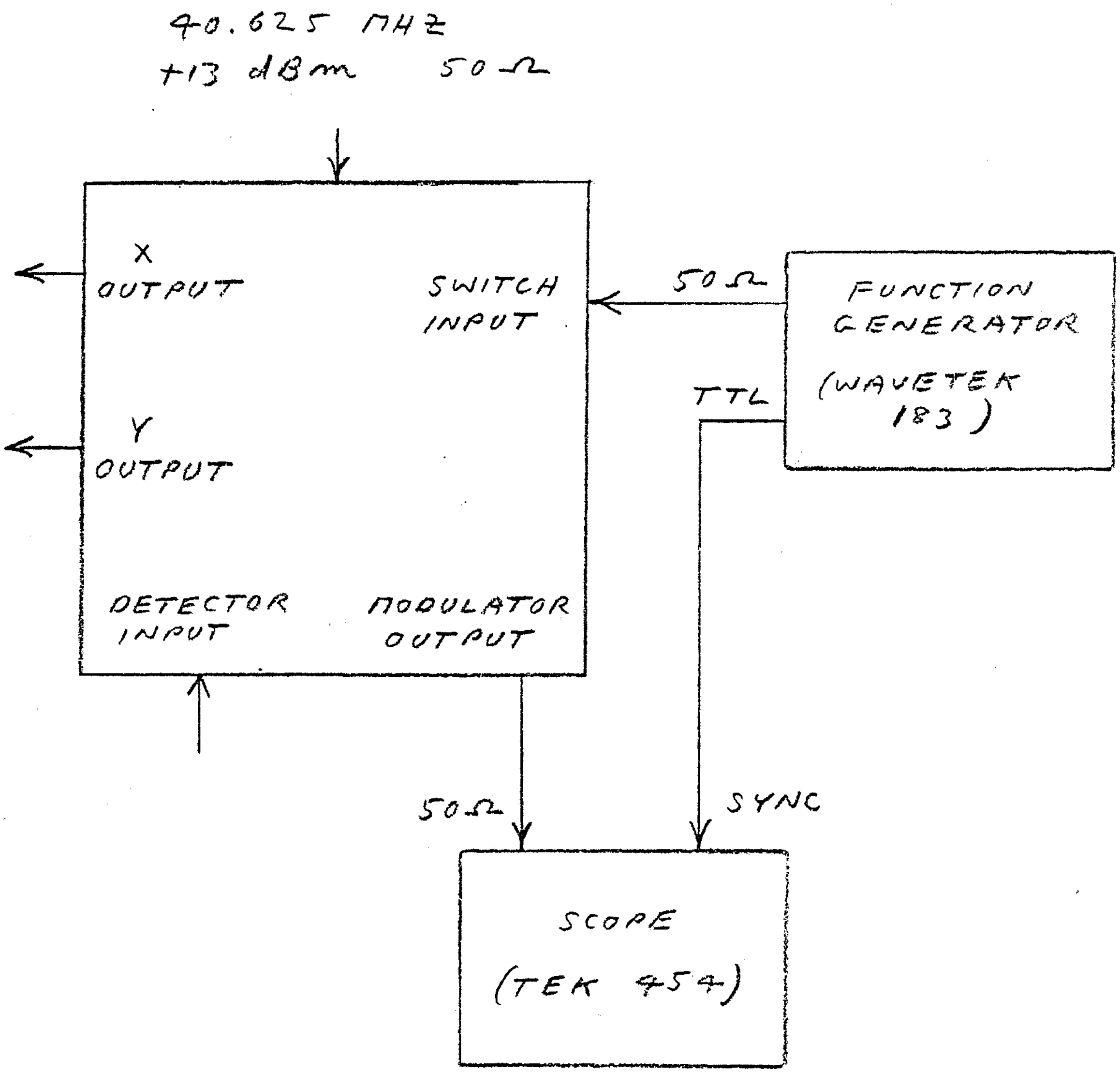


Figure 2. Test Setup For Observing Modulated Signal

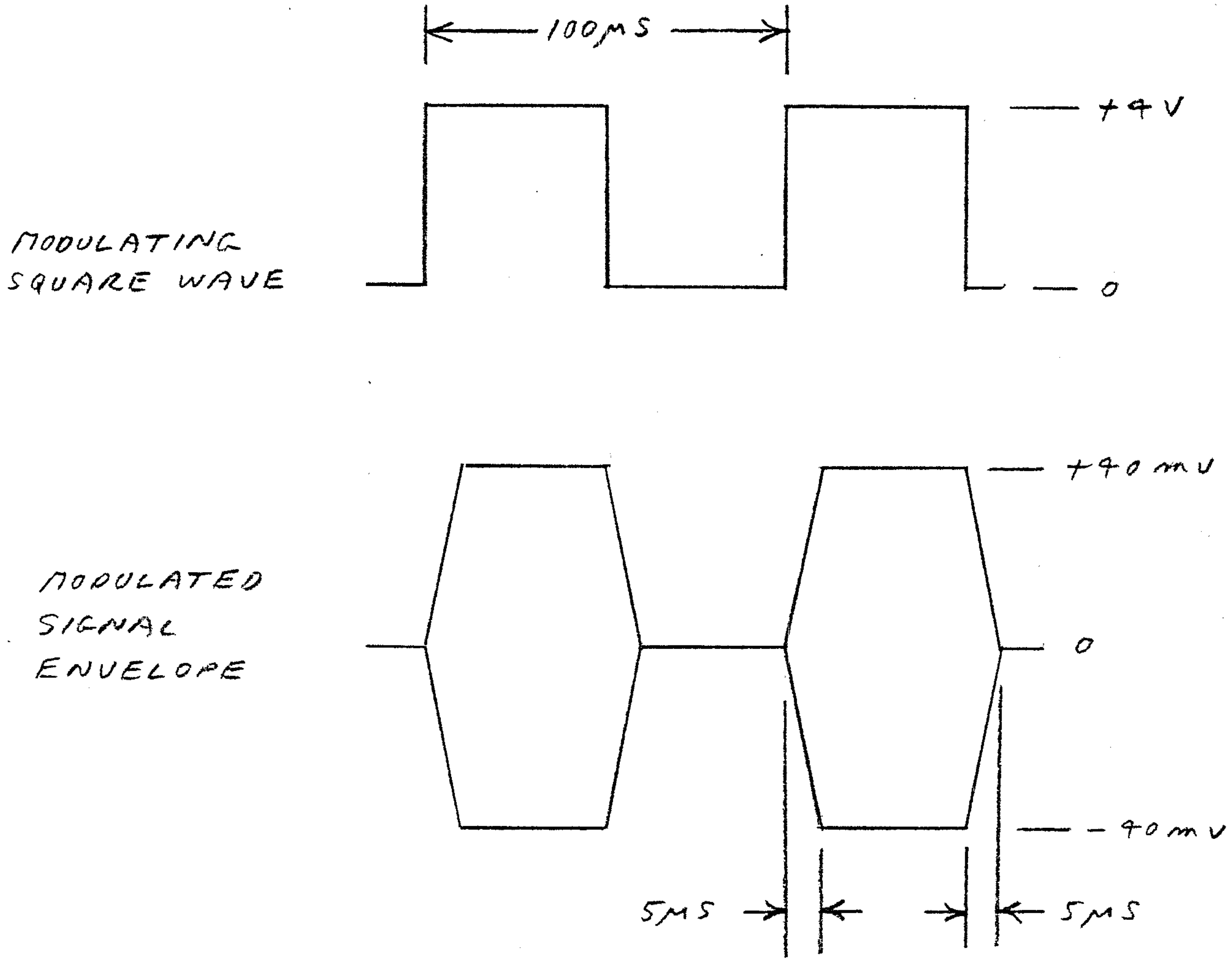


Figure 3. Modulation Waveforms

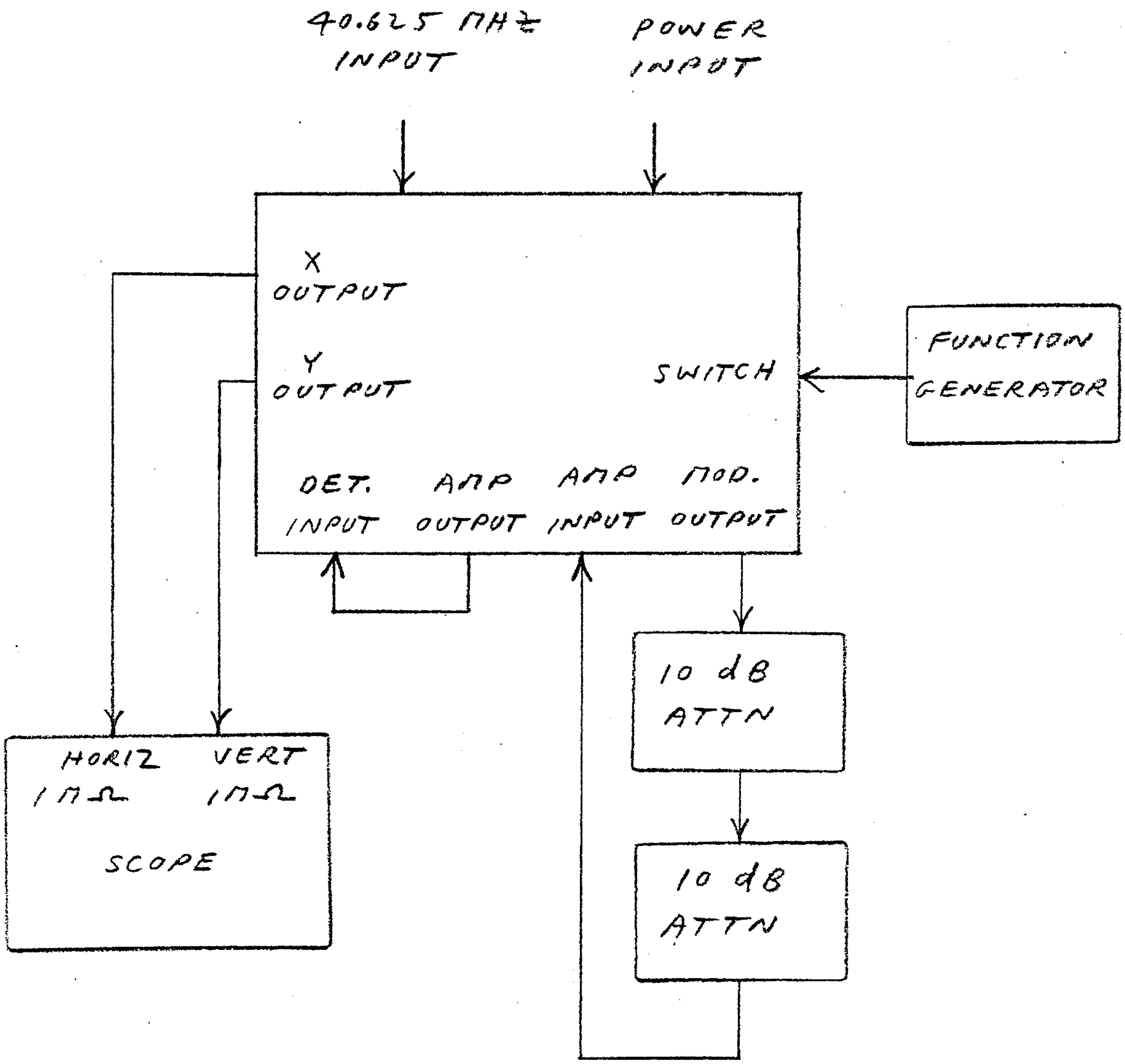


Figure 4. Test Setup for Checking Filter Test Set

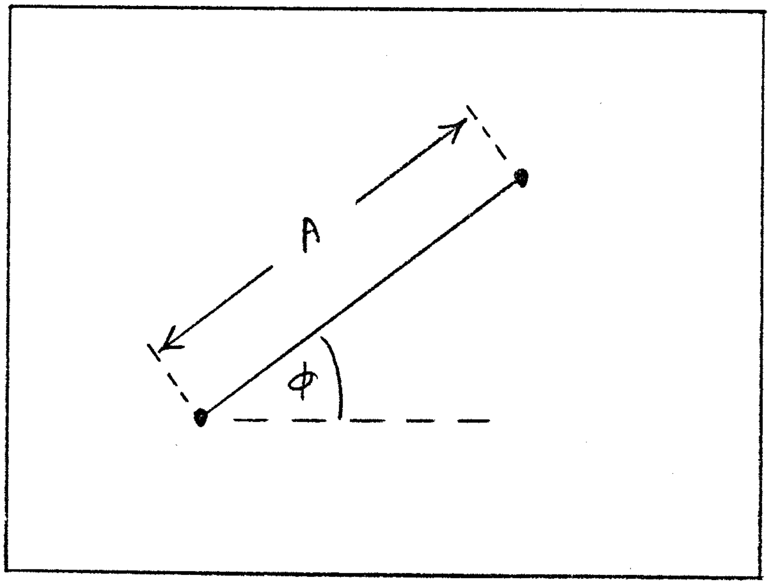


Figure 5. Amplitude and Phase of Modulated Signal Shown on X-Y Scope

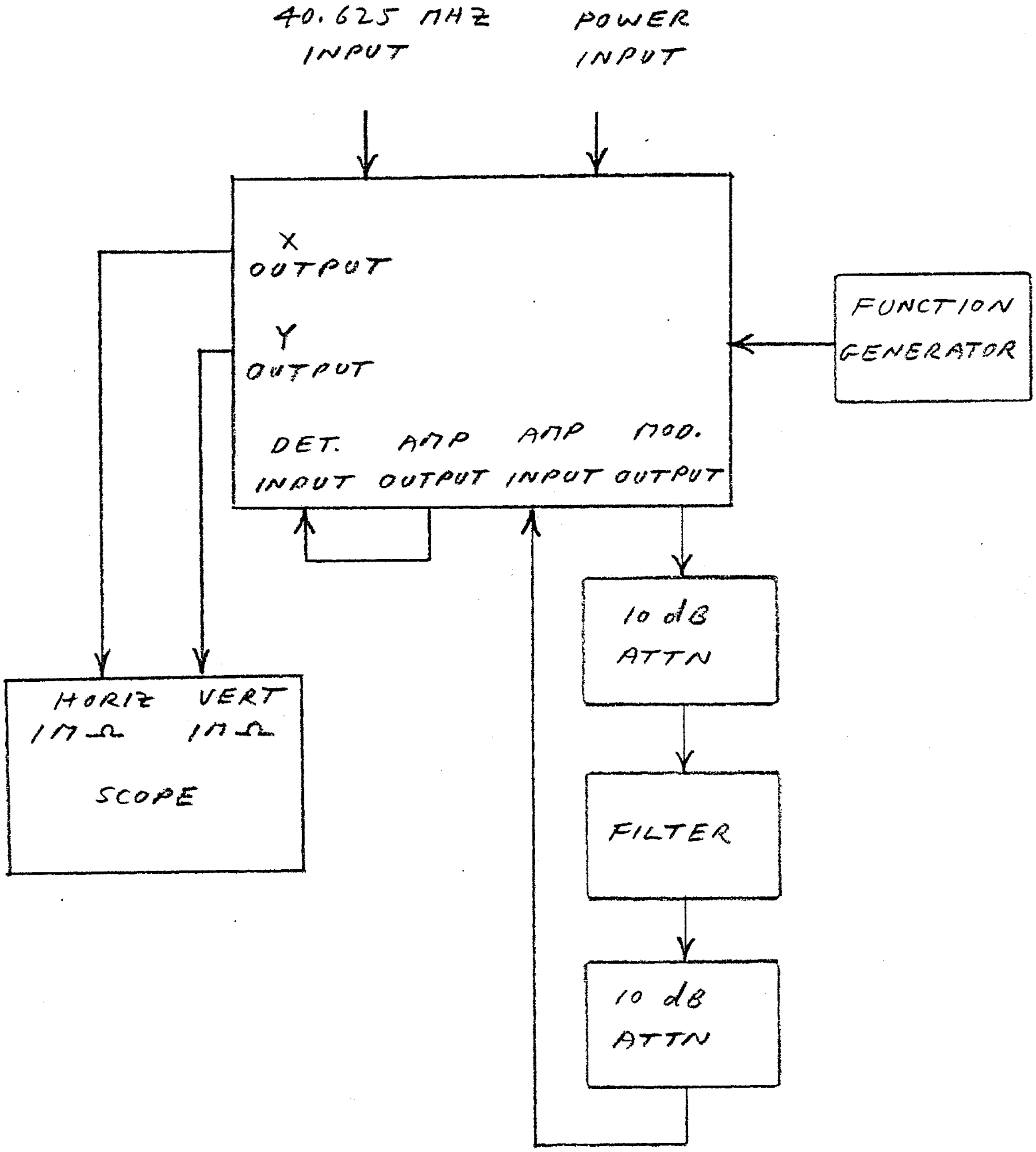


Figure 6. Test Setup for Testing Filters

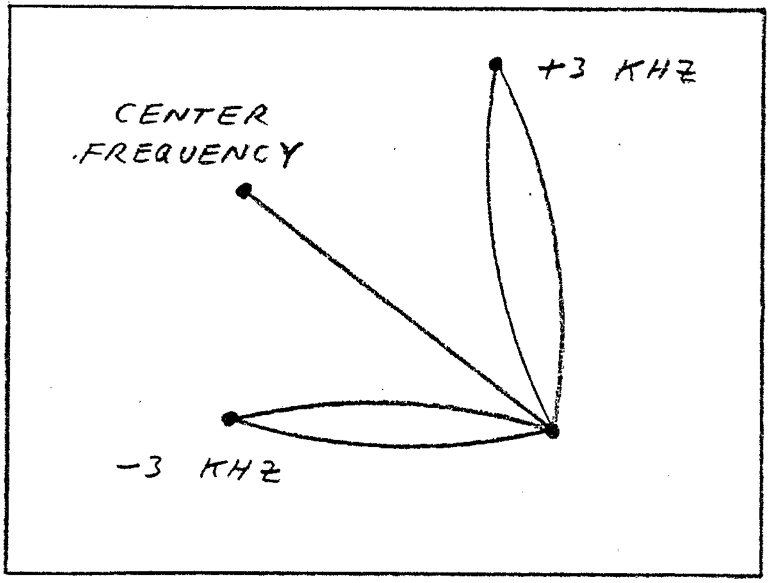
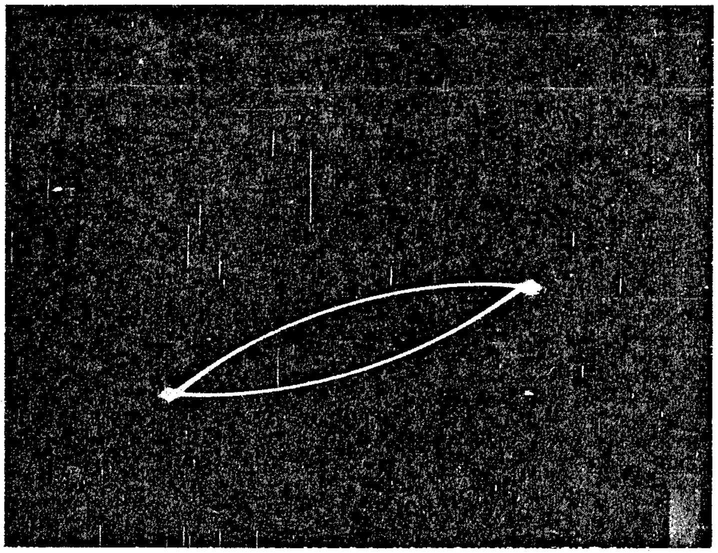
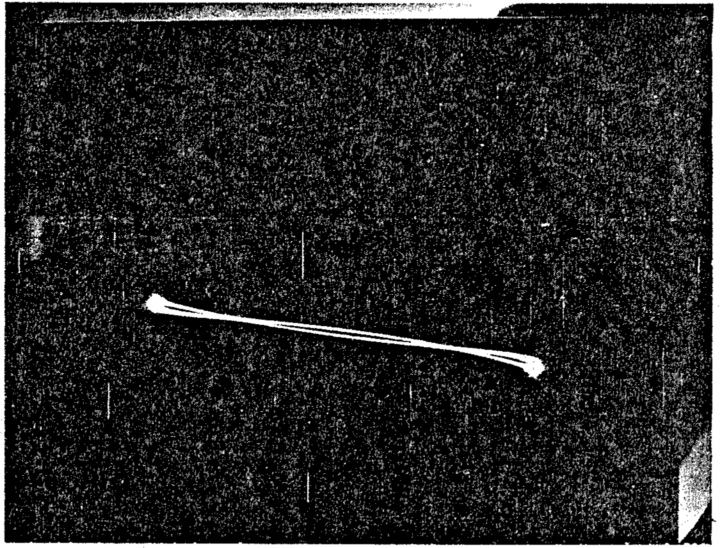


Figure 7. Transition Line Shapes for Center Frequency and ± 3 kHz, with Filter in Test Circuit

Filter 7118A-2,
40.628 MHz

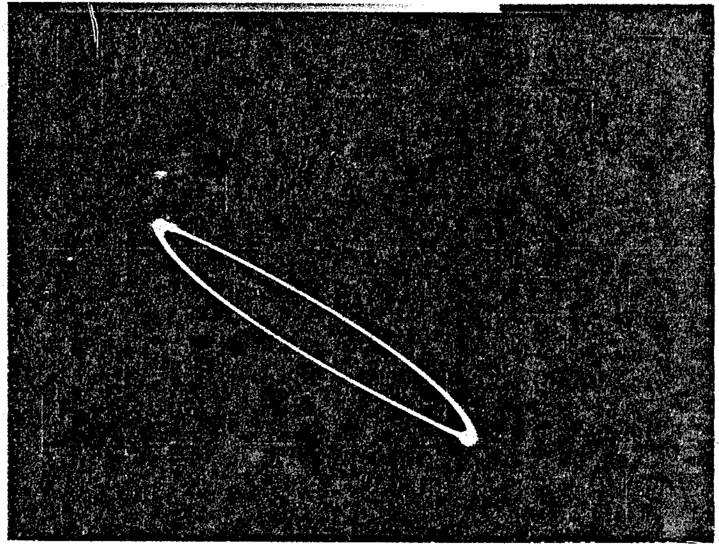


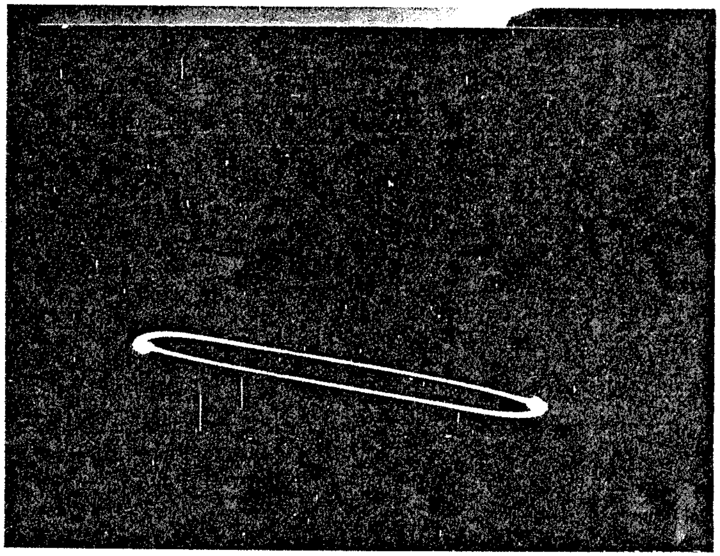
Filter 7118A-2,
40.625 MHz



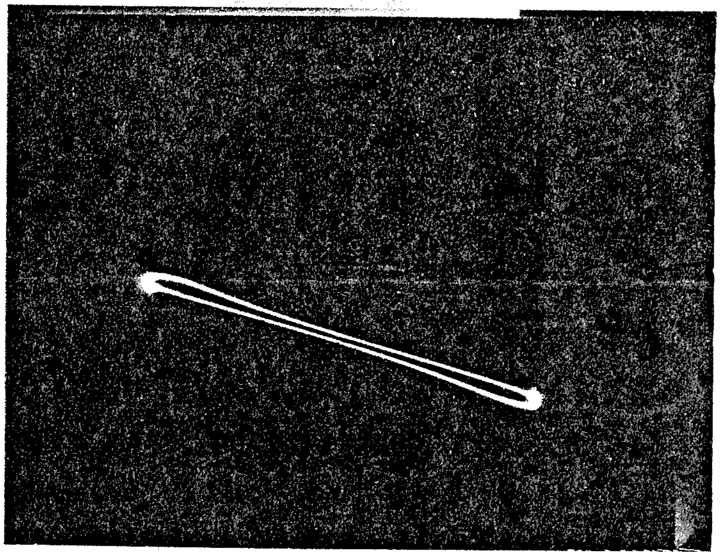
Filter 7118A-2,
40.622 MHz

This filter has the desired characteristics.



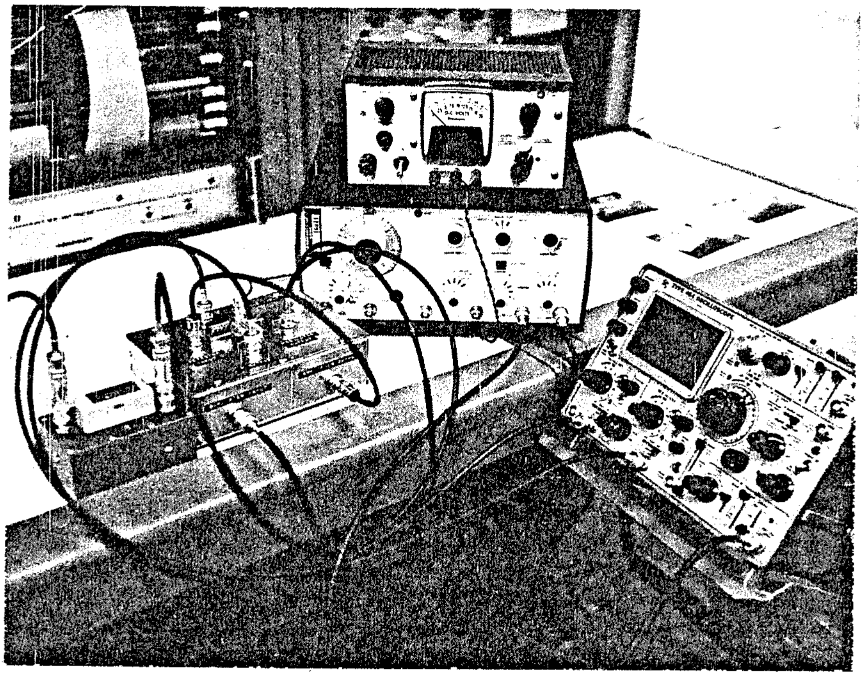


Filter 7118A-4, 40.625 MHz

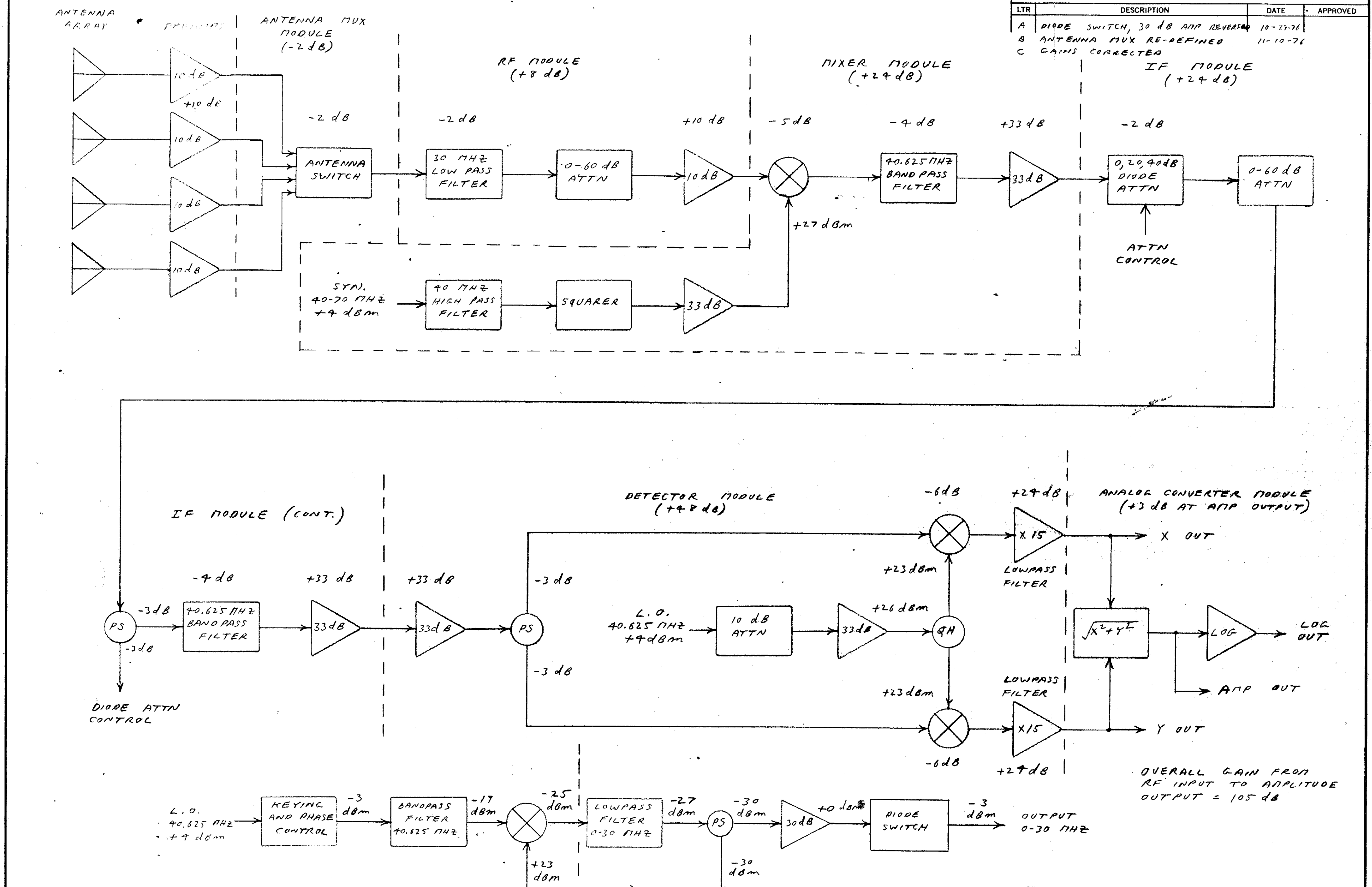


Filter 7118A, 40.624 MHz

This filter is off center and does not have a good gaussian response.



Setup for testing filters, showing filter, 10 dB coaxial attenuators, test set, power supply, Wavetek 183 function generator, and Tektronix 454 oscilloscope.



REVISIONS

LTR	DESCRIPTION	DATE	APPROVED
A	DIODE SWITCH, 30 dB AMP REVERSED	10-29-76	
B	ANTENNA MUX RE-DEFINED	11-10-76	
C	GAINS CORRECTED		

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC ± ANGLES ±

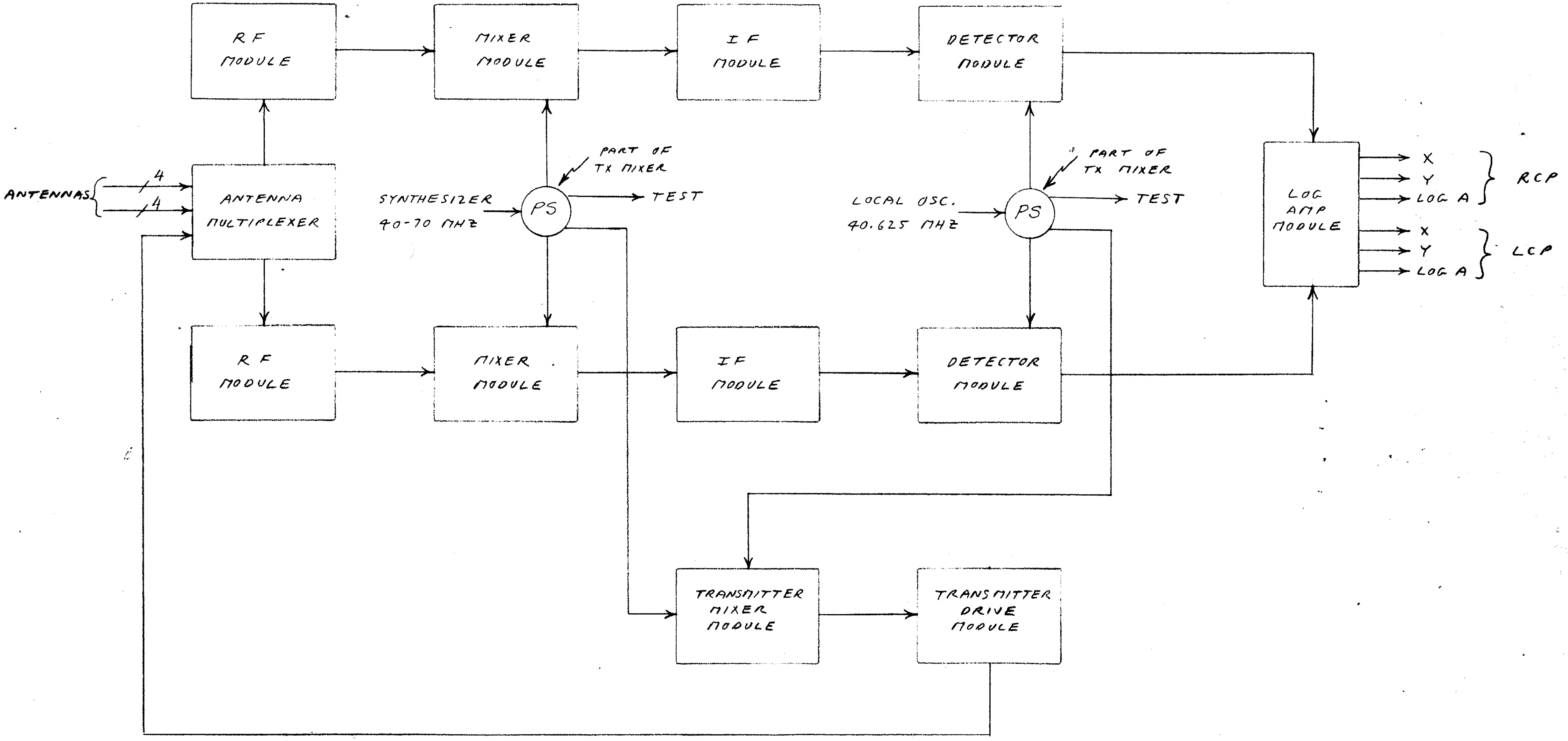
APPROVALS	DATE
DRAWN	JJ
CHECKED	

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

HFS ANALOG SYSTEM
SIMPLIFIED BLOCK DIAGRAM

SCALE 7-20-78
SIZE C
DRAWING NO. HFS-101
DO NOT SCALE DRAWING
SHEET

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS DEC ANGLES
± ± ±

APPROVALS	DATE
DRAWN	
CHECKED	

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

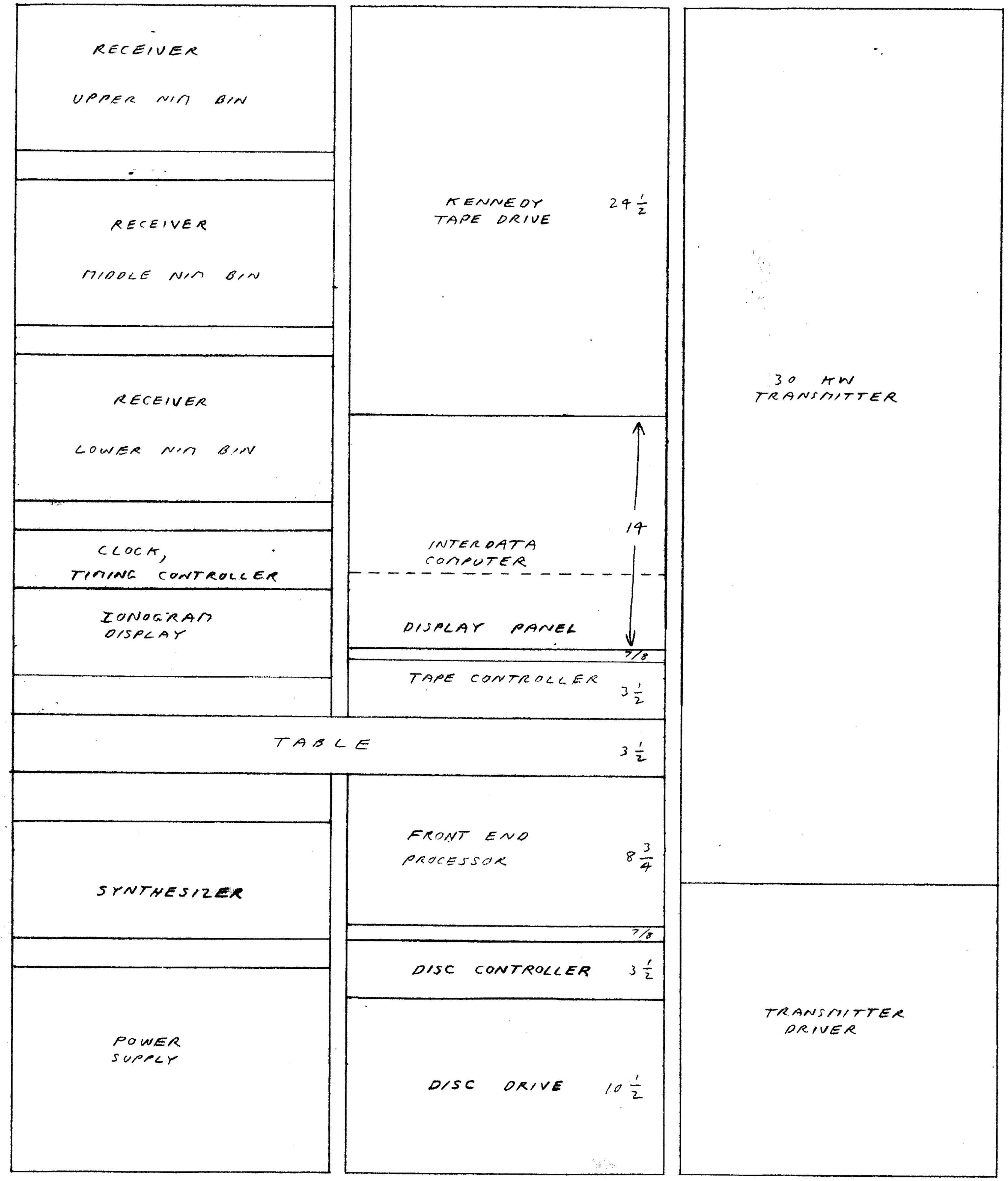
DUAL CHANNEL MODULE INTERCONNECTIONS

SCALE	SIZE	DRAWING NO.
7-20-78	C	HFS-102

DO NOT SCALE DRAWING
SHEET

REVISIONS

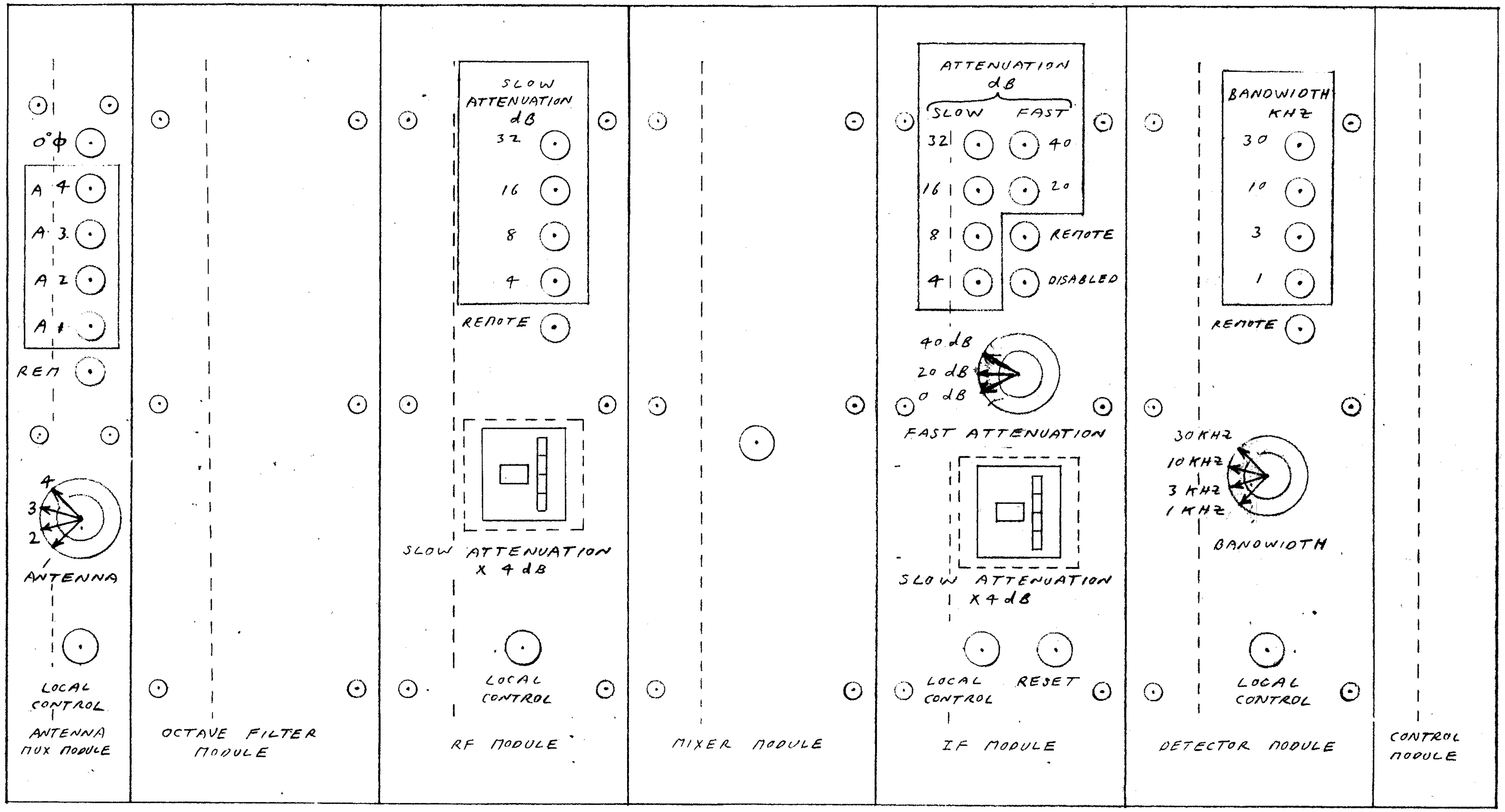
LTR	DESCRIPTION	DATE	APPROVED



TOLERANCES UNLESS OTHERWISE SPECIFIED FRACTIONS DEC ANGLES ± ± ±	SPACE ENVIRONMENT LABORATORY ERL ● NOAA ● BOULDER COLO
APPROVALS / DATE	CABINET FRONT PANEL LAYOUT
DRAWN	
CHECKED	SCALE 7-20-78 / SIZE C / DRAWING NO. HFS-103
	DO NOT SCALE DRAWING / SHEET

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS DEC ANGLES
± ± ±

APPROVALS	DATE
DRAWN	
CHECKED	

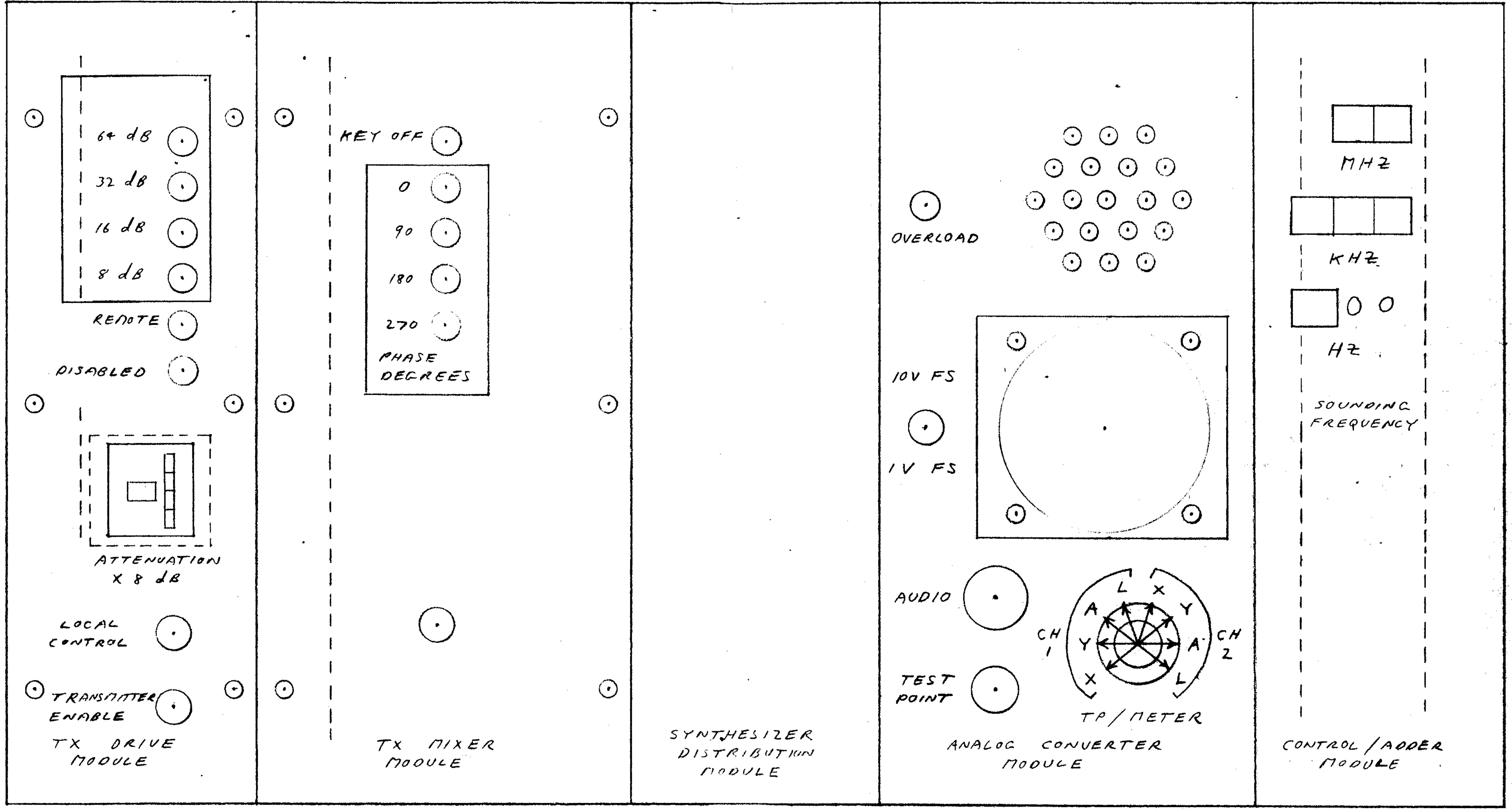
SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

UPPER, MIDDLE NIM BINS
FRONT VIEW

SCALE 1-20-78
SIZE C
DRAWING NO. HFS-104

DO NOT SCALE DRAWING
SHEET

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



TOLERANCES UNLESS
OTHERWISE SPECIFIED
FRACTIONS DEC ANGLES
± ± ±

APPROVALS	DATE
DRAWN	
CHECKED	

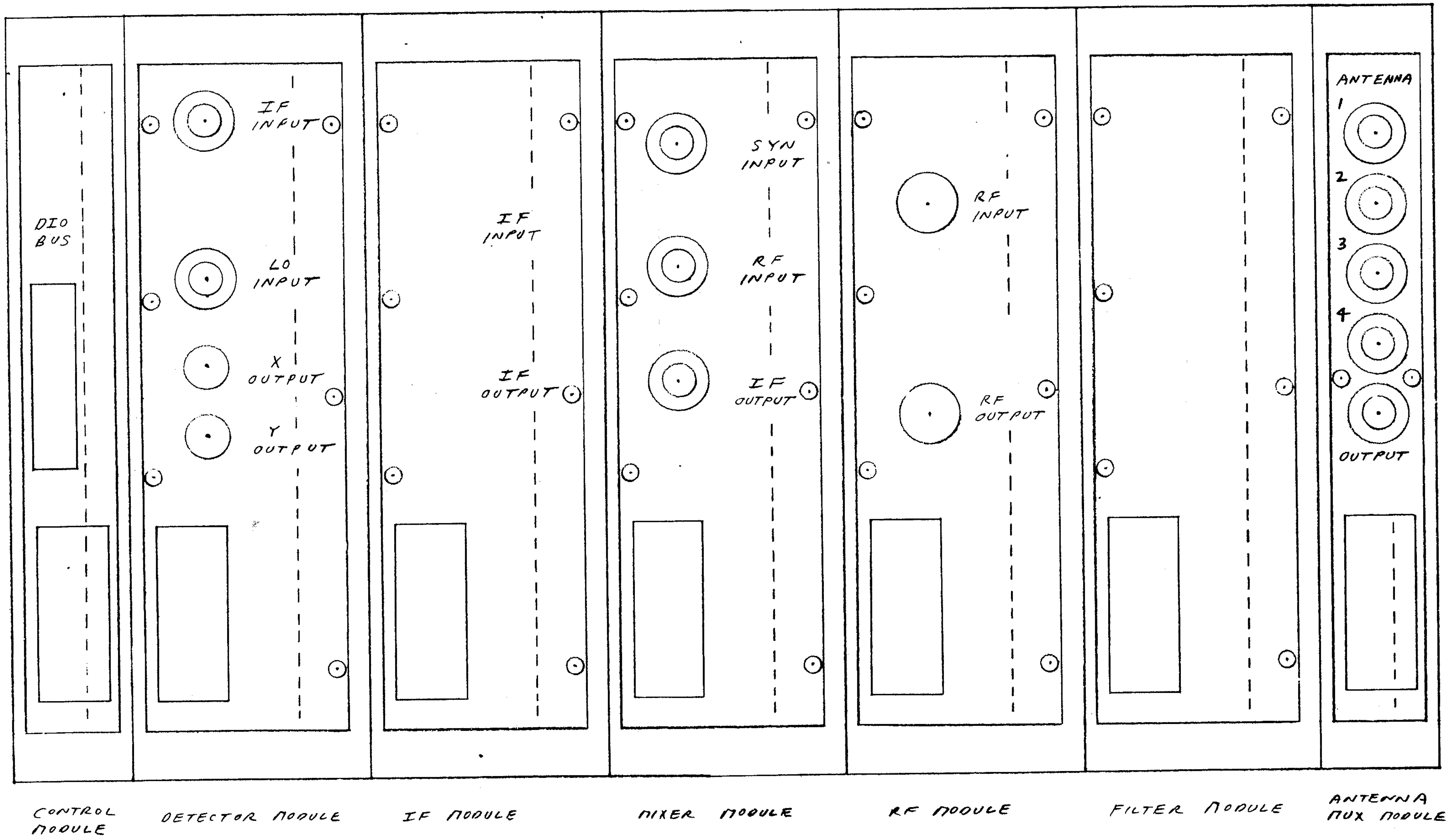
SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

LOWER NIM BIN
FRONT VIEW

SCALE	SIZE	DRAWING NO.
1-20-78	C	HFS-105

DO NOT SCALE DRAWING
SHEET

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
A	ANT MUX CONNECTORS RE-NUMBERED	7-6-81	JJ



TOLERANCES UNLESS OTHERWISE SPECIFIED FRACTIONS ± DEC ± ANGLES ±		**SPACE ENVIRONMENT LABORATORY** **ERL ● NOAA ● BOULDER COLO**	
APPROVALS	DATE	UPPER, MIDDLE NIM BINS REAR VIEW	
DRAWN			
CHECKED		SCALE 7-20-78	SIZE C · DRAWING NO. HFS-106
		DO NOT SCALE DRAWING	SHEET

REVISIONS			
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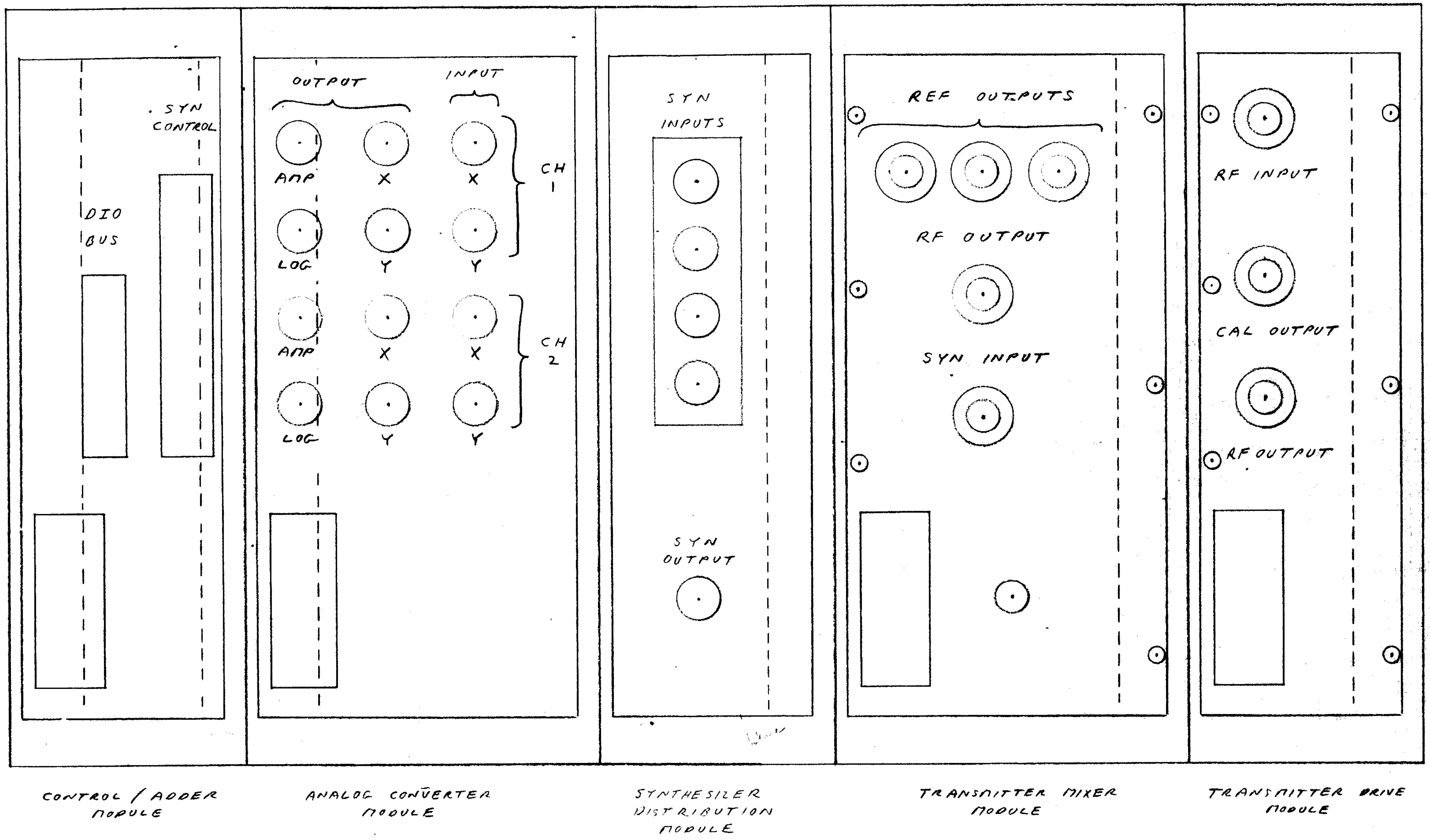


TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS DEC ANGLES
± ± ±

APPROVALS	DATE
DRAWN	
CHECKED	

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

LOWER NIM BIN
REAR VIEW

SCALE 7-20-78
SIZE C
DRAWING NO. HFS-107
DO NOT SCALE DRAWING
SHEET

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

		UPPER NIM BIN DIO FOR CHANNEL 1 MIDDLE NIM BIN DIO FOR CHANNEL 2											LOWER NIM BIN DIO				
		ANTENNA MUX		OCTAVE FILTER		RF		IF		DETECTOR		ANALOG CONV. / TX MIXER	TX DRIVE	CONTROL/ADDER			
	BIT	CH1 10	CH 2 11	CH1 12	CH2 13	CA-1 14	CH 2 15	CH 1 16	CH 2 17	CH 1 18	CH 2 19	NO ADDRESS	1A	1B	1C	1D	1E
LSB	0 LSB	0	1	0	1	0	1	0	1	0	1		0	1	0	1	0
	1	0	0	1	1	0	0	1	1	0	0		1	1	0	0	1
ADDRESS	2	0	0	0	0	1	1	1	1	0	0		0	0	1	1	1
	3	0	0	0	0	0	0	0	0	1	1		1	1	1	1	1
	4	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1
	5	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0
CONTROL FROM CONTROL MODULE	0 LSB	A	ANTENNA	A	BAND	4	ATTENUATION	4	ATTENUATION	A	BANDWIDTH		8 ATTENUATION	1	1	1	.ORF
	1	B		B		8		8		B			16	2 H	2 T	2 U	LRF
	2			C		16		16					32	4 HZ	4 K	4 M	POF
	3			D		32		32					64	8	8	8	
	4	L/R CONTROL		L/R CONTROL		L/R CONTROL		L/R CONTROL		L/R CONTROL			L/R CONTROL	1	1	1	
	5													2 U	2 H	2 T	
	6													4 K	4 K	4 M	
	7													8	8	8	
FLAG TO CONTROL MODULE	0 LSB	A	ANTENNA	A	BAND	4	ATTENUATION	4	ATTENUATION	A	BANDWIDTH		8 ATTENUATION				
	1	B		B		8		8		B			16				
	2			C		16		16					32				
	3			D		32		32					64				
	4	L/R CONTROL		L/R CONTROL		L/R CONTROL		L/R CONTROL		L/R CONTROL			L/R CONTROL				
	5																
	6																
	7																
CONTROL FROM TSG	0 LSB	RX DISABLE						RESET					TX ENABLE				
	1											TX PULSE KEYING					
	2											ϕ_1 TX PHASE CODE					
	3											ϕ_2					
	4	RX PHASE CODE ϕ_3															
	5							A FAST ATTN									
	6							B									
INTERRUPT	0 LSB							IF DISABLED									
	1											OVERLOAD					

ORF = OUT-OF-RANGE FLAG
LRF = LOCAL/REMOTE FLAG
POF = POWER ON FLAG

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS DEC ANGLES
± ± ±

APPROVALS	DATE
DRAWN	
CHECKED	

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

BIT ASSIGNMENTS
FOR HFS RECEIVER DIO'S

SCALE 7-20-78
SIZE C
DRAWING NO. HFS-108

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

CONTROL MODULE DIO CONNECTOR (P10 A, B)

1	0	LSB	ADDRESS
2	1		
3	2		
4	3		
5	4		
6	5	MSB	
7	0	LSB	DATA IN TO CONTROL MODULE
8	1		
9	2		
10	3		
11	4		
12	5		
13	6		
14	7	MSB	
15	0	LSB	DATA OUT FROM CONTROL MODULE
16	1		
17	2		
18	3		
19	4		
20	5		
21	6		
22	7	MSB	
23	ADDRESS STROBE		
24	DATA STROBE		
25	GROUND		

CONTROL MODULE NIM CONNECTOR (P1A, B)

A	A	ANT CONTROL	ANT MUX
B	B		
C	L/R		
D	A	ANT FLAG	
E	B		
F	L/R		
H	A	BAND CONTROL	OCT FIL
J	B		
K	C		
L	D		
M	L/R		
N	A	BAND FLAG	
P	B		
R	C		
S	D		
T	L/R		
U	4	ATTN CONTROL	RF
V	8		
W	16		
X	32		
Y	L/R		
Z	4	ATTN FLAG	
a	8		
b	16		
c	32		
d	L/R		
e	4	ATTN CONTROL	IF
f	8		
h	16		
j	32		
k	L/R		
m	4	ATTN FLAG	
n	8		
p	16		
r	32		
s	L/R		
t	A	BW CONTROL	DET
u	B		
v	L/R		
w	A	BW FLAG	
x	B		
y	L/R		

ANTENNA MUX (P7A, B)

A	A	ANT CONTROL
B	B	
C		
D		
E	L/R	
F	A	ANT FLAG
H	B	
J		
K		
L	L/R	
M		
N	RX DISABLE	
P	RX PHASE CODE ϕ_3	
R		
S		

FILTER (P6 A, B)

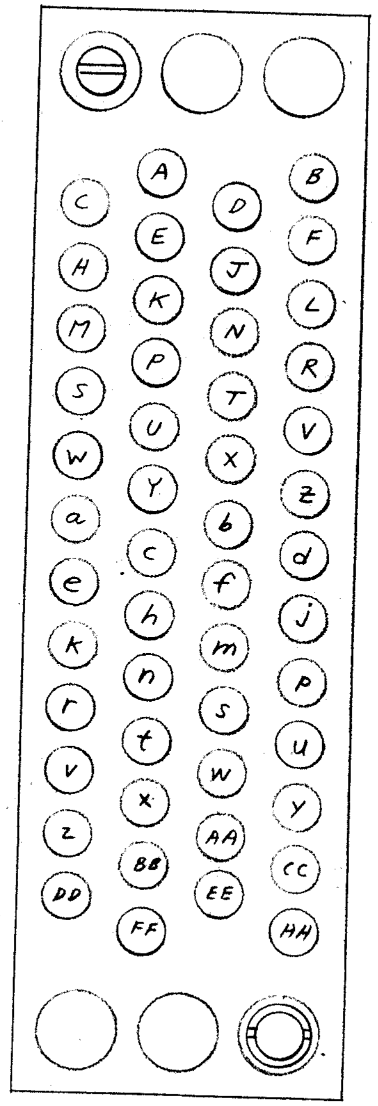
A	A	BAND CONTROL
B	B	
C	C	
D	D	
E	L/R	
F	A	BAND FLAG
H	B	
J	C	
K	D	
L	L/R	
M		
N		
P		
R		
S		

RF (P5 A, B)

A	4	ATTN CONTROL
B	8	
C	16	
D	32	
E	L/R	
F	4	ATTN FLAG
H	8	
J	16	
K	32	
L	L/R	
M		
N		
P		
R		
S		

IF (P3 A, B)

A	4	ATTN CONTROL
B	8	
C	16	
D	32	
E	L/R	
F	4	ATTN FLAG
H	8	
J	16	
K	32	
L	L/R	
M		
N	RESET	
P	A	FAST ATTN
R	B	
S		
T	IF DISABLED INTERRUPT	



MODULE CONNECTOR
REAR VIEW

ALL MODULES

AA	
BB	
CC	+28 V
DD	+15 V
EE	+5 V
FF	-15 V
HH	GROUND

DETECTOR (P2 A, B)

A	A	BW CONTROL
B	B	
C		
D		
E	L/R	
F	A	BW FLAG
H	B	
J		
K		
L	L/R	
M		
S	X OUT	DET
T	Y OUT	
W	X OUT	ACTIVE FILTER
X	Y OUT	

TOLERANCES UNLESS OTHERWISE SPECIFIED FRACTIONS ± DEC ± ANGLES ±		SPACE ENVIRONMENT LABORATORY ERL ● NOAA ● BOULDER COLO		
APPROVALS	DATE	MODULE CONNECTORS UPPER, MIDDLE NIM BINS		
DRAWN				
CHECKED		SCALE 1-20-78	SIZE C	DRAWING NO. HFS-109
		DO NOT SCALE DRAWING		SHEET

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

CONTROL / ADDER DIO CONNECTOR (P10C)

1	0	LSB
2	1	
3	2	ADDRESS
4	3	
5	4	
6	5	MSB
7	0	LSB
8	1	
9	2	
10	3	
11	4	DATA IN TO CONTROL MODULE
12	5	
13	6	
14	7	MSB
15	0	LSB
16	1	
17	2	
18	3	DATA OUT FROM CONTROL MODULE
19	4	
20	5	
21	6	
22	7	MSB
23	ADDRESS STROBE	
24	DATA STROBE	
25	GROUND	

CONTROL / ADDER NIM CONNECTOR (P1C)

A	8		
B	16		
C	32	ATTN CONTROL	
D	64		
E	L/R		TX DRIVE
F	8		
H	16		
J	32	ATTN FLAG	
K	64		
L	L/R		

CONTROL / ADDER SYN CONNECTOR (P11C)

1	OUT-RANGE FLAG	
2	2	
3	1	10 KHZ
4	4	
5	8	
6	GND	
7	GND	
8	4	100 KHZ
9	8	
10	GND	
11	GND	
12	L/R FLAG	
13		
14		
15		
16		
17		
18	GND	
19	GND	
20	2	10 MHZ
21	4	
22	4	100 HZ
23	1	
24		
25	GROUND	
26	2	
27	1	
28	4	1 KHZ
29	8	
30		
31	GND	
32	GND	
33	2	100 KHZ
34	1	
35	GND	
36	GND	
37	POWER ON FLAG	
38		
39	2	
40	1	1 MHZ
41	4	
42	8	
43	GND	
44	GND	
45	GND	
46	1	10 MHZ
47	8	
48	2	100 HZ
49	8	
50	GROUND	

ANALOG CONVERTER (P2C)

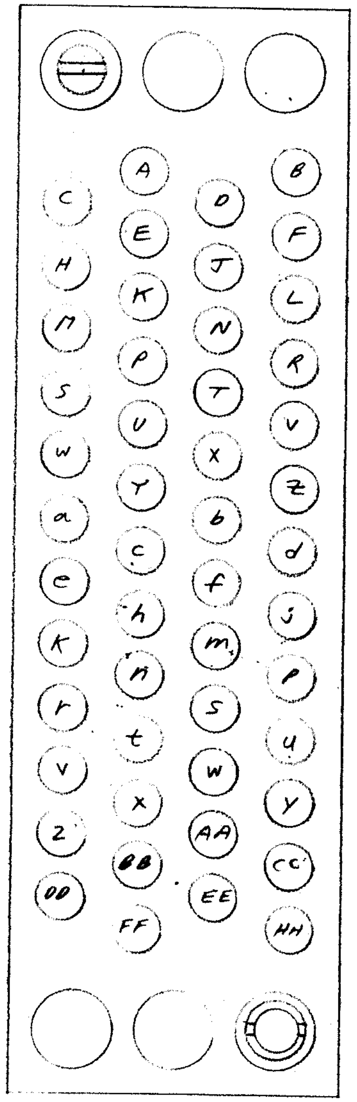
A	X IN	
B	Y IN	
C	X OUT	
D	Y OUT	CH 1
E	√ OUT	
F	LOG OUT	
H	LOWPASS √ OUT	
J		
K	X IN	
L	Y IN	
M	X OUT	
N	Y OUT	CH 2
P	√ OUT	
R	LOG OUT	
S	LOWPASS √ OUT	
T	OVERLOAD INTERRUPT	

TRANSMITTER MIXER (P3C)

A		
B		
C		
D		
E		
F		
H		
J		
K		
L		
M		
N	$\phi 1$	TX PHASE CODE
P	$\phi 2$	
R	TX KEY	

TRANSMITTER DRIVE (P4C)

A	8	
B	16	
C	32	ATTN CONTROL
D	64	
E	L/R	
F	8	
H	16	
J	32	ATTN FLAG
K	64	
L	L/R	
M		
N	TX ENABLE	



ALL MODULES

AA	
BB	
CC	+28 V
DD	+15 V
EE	+5 V
FF	-15 V
HH	GROUND

AUDIO MODULE

A	X IN	
B	Y IN	CH 1
C	√ IN	
D	LOG IN	
E	X IN	
F	Y IN	CH 2
H	√ IN	
J	LOG IN	

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC ± ANGLES ±

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

MODULE CONNECTORS
LOWER NIM BIN

APPROVALS	DATE
DRAWN	
CHECKED	

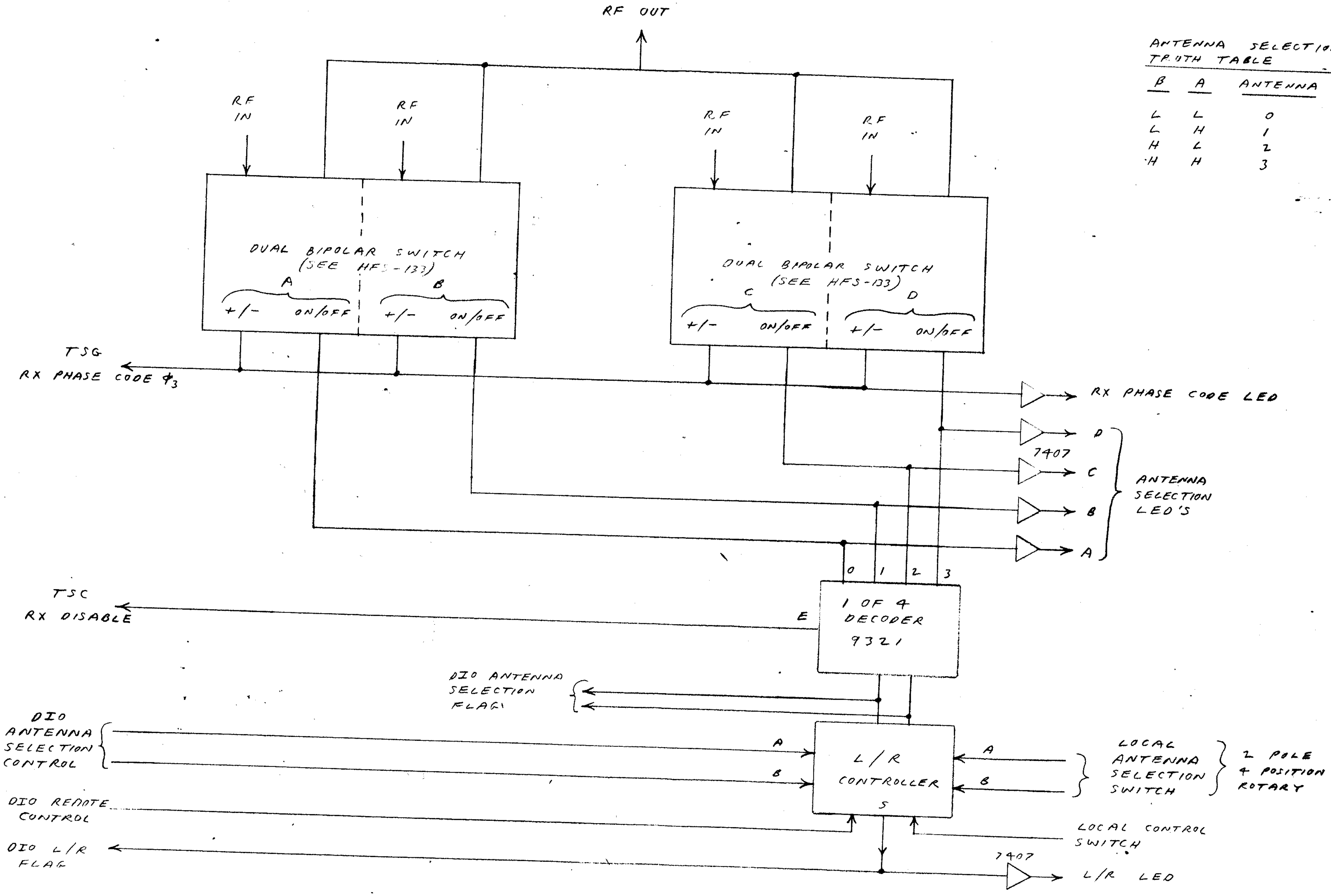
SCALE 7-20-78
SIZE C
DRAWING NO. HFS-110
DO NOT SCALE DRAWING
SHEET

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED

ANTENNA SELECTION TRUTH TABLE

B	A	ANTENNA
L	L	0
L	H	1
H	L	2
H	H	3



TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS DEC ANGLES
± ± ±

APPROVALS	DATE
DRAWN	
CHECKED	

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

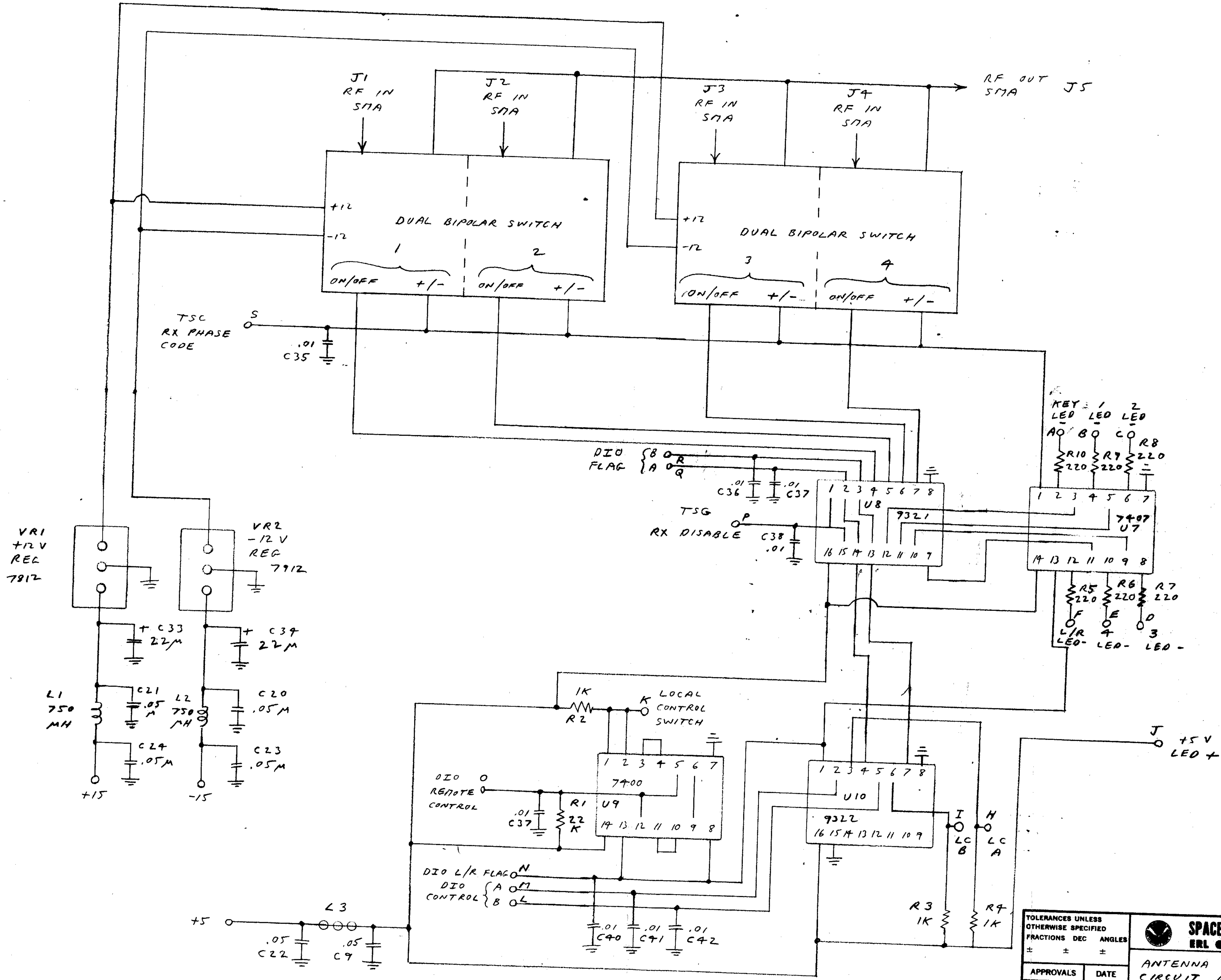
ANTENNA MULTIPLEXER MODULE BLOCK DIAGRAM

SCALE	SIZE	DRAWING NO
7-20-78	C	HFS-111

DO NOT SCALE DRAWIN

REVISIONS

LTR	DESCRIPTION	DATE	APPROVE



TOLERANCES UNLESS OTHERWISE SPECIFIED		
FRACTIONS	DEC	ANGLES
±	±	±

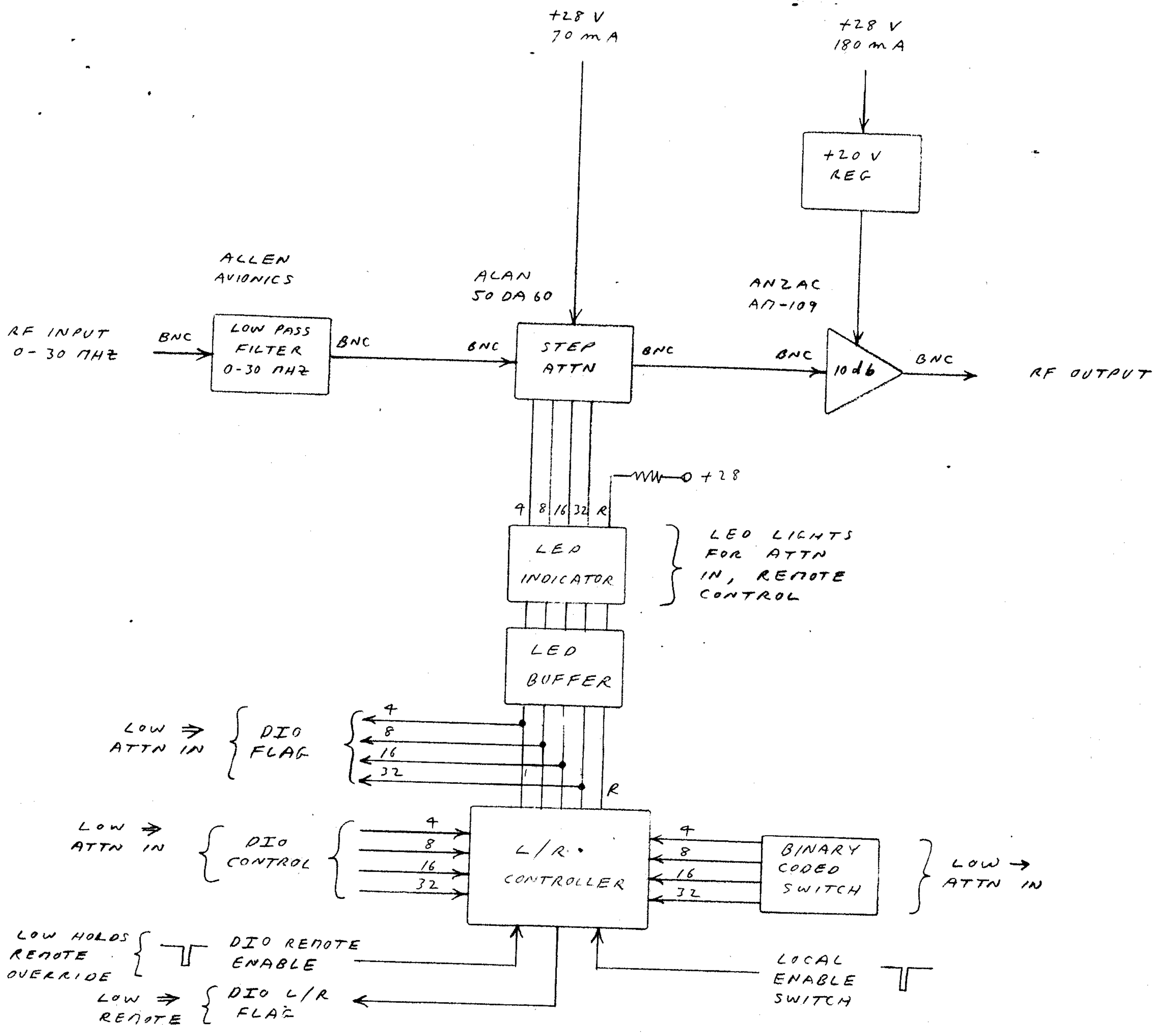
APPROVALS	DATE
DRAWN	
CHECKED	

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

ANTENNA MUX MODULE
CIRCUIT DIAGRAM
BOTTOM VIEW

SCALE	SIZE	DRAWING NO.
1-20-78	C	HFS-112

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



TOLERANCES UNLESS
OTHERWISE SPECIFIED
FRACTIONS DEC ANGLES
± ± ±

APPROVALS	DATE
DRAWN	
CHECKED	

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

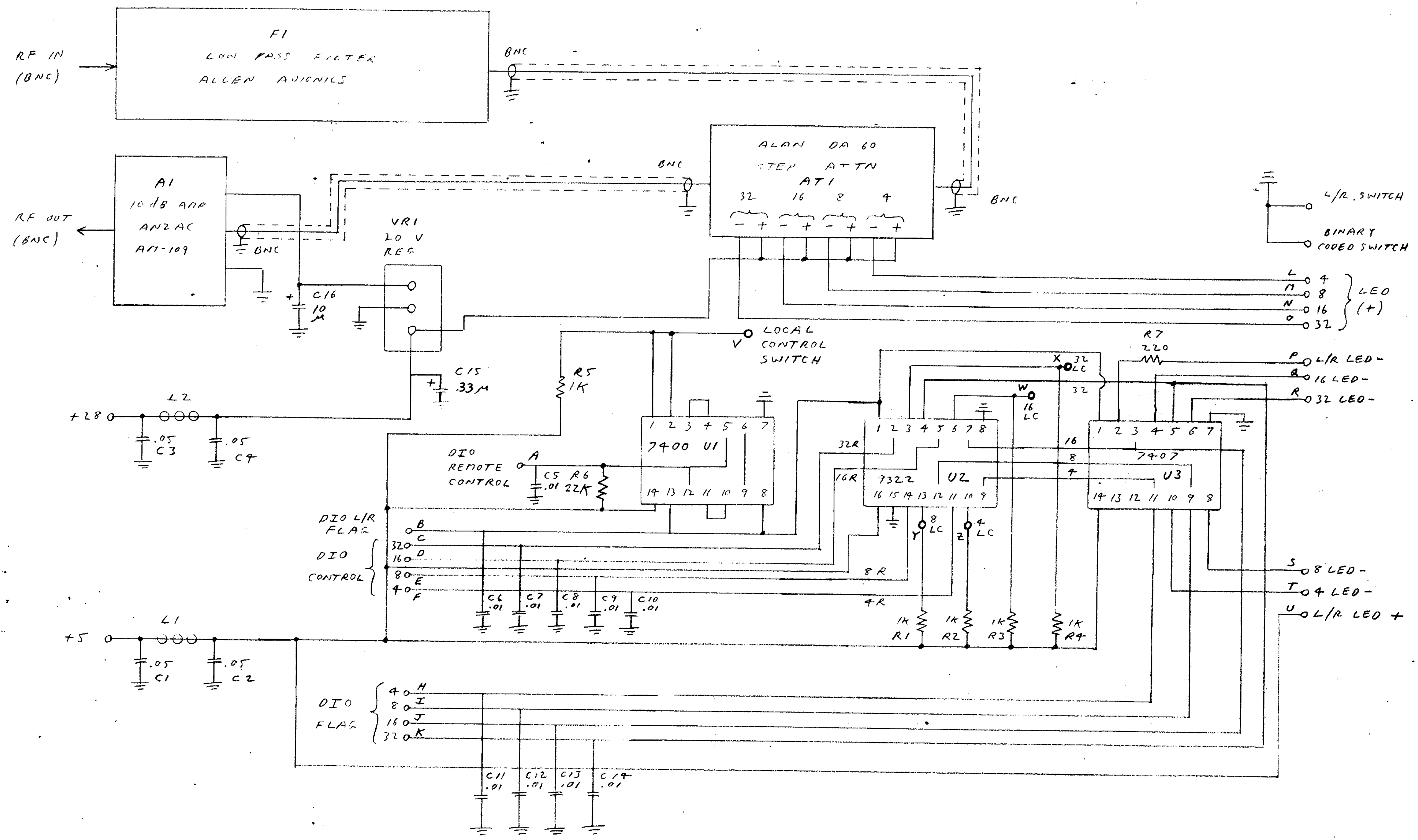
RF MODULE
BLOCK DIAGRAM

SCALE
7-20-78

SIZE
C

DRAWING NO.
HFS-113

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS DEC ANGLES
± ± ±

APPROVALS	DATE
DRAWN	
CHECKED	

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

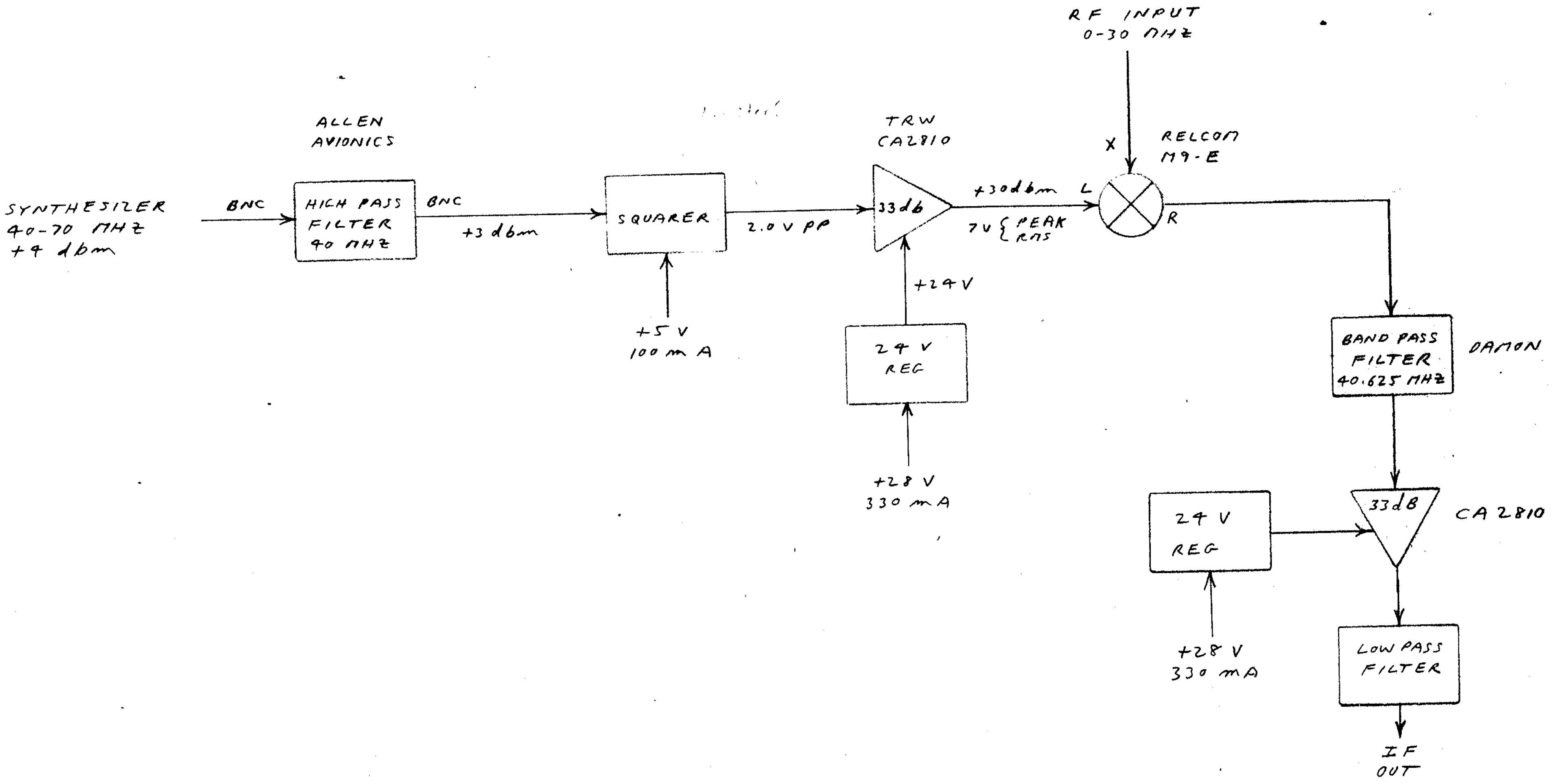
RF MODULE
CIRCUIT DIAGRAM
BOTTOM VIEW

SCALE 7-10-78
SIZE C
DRAWING NO. HFS-114

DO NOT SCALE DRAWING
SHEET

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



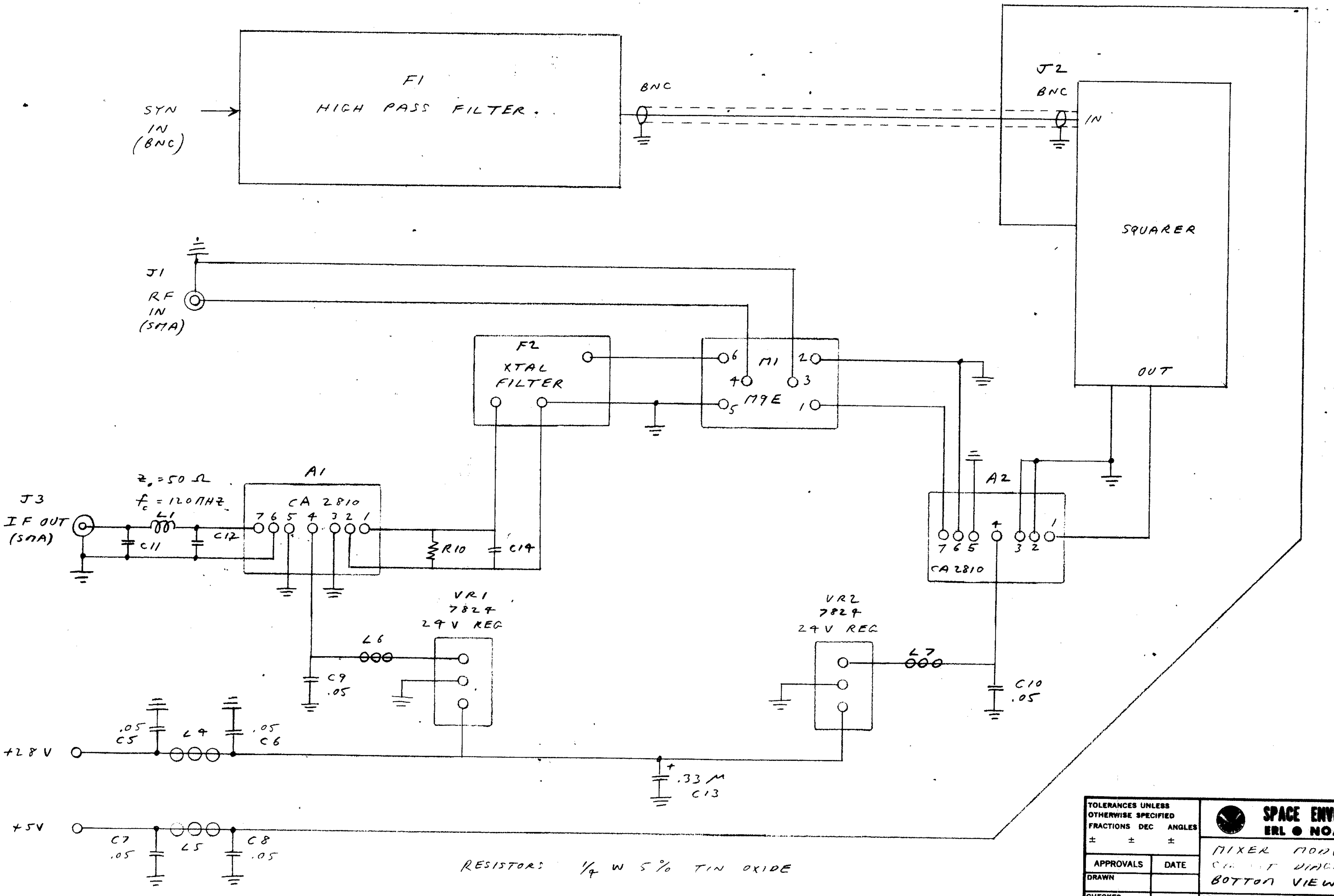
TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC ± ANGLES ±

APPROVALS	DATE
DRAWN	
CHECKED	

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

MIXER MODULE
BLOCK DIAGRAM

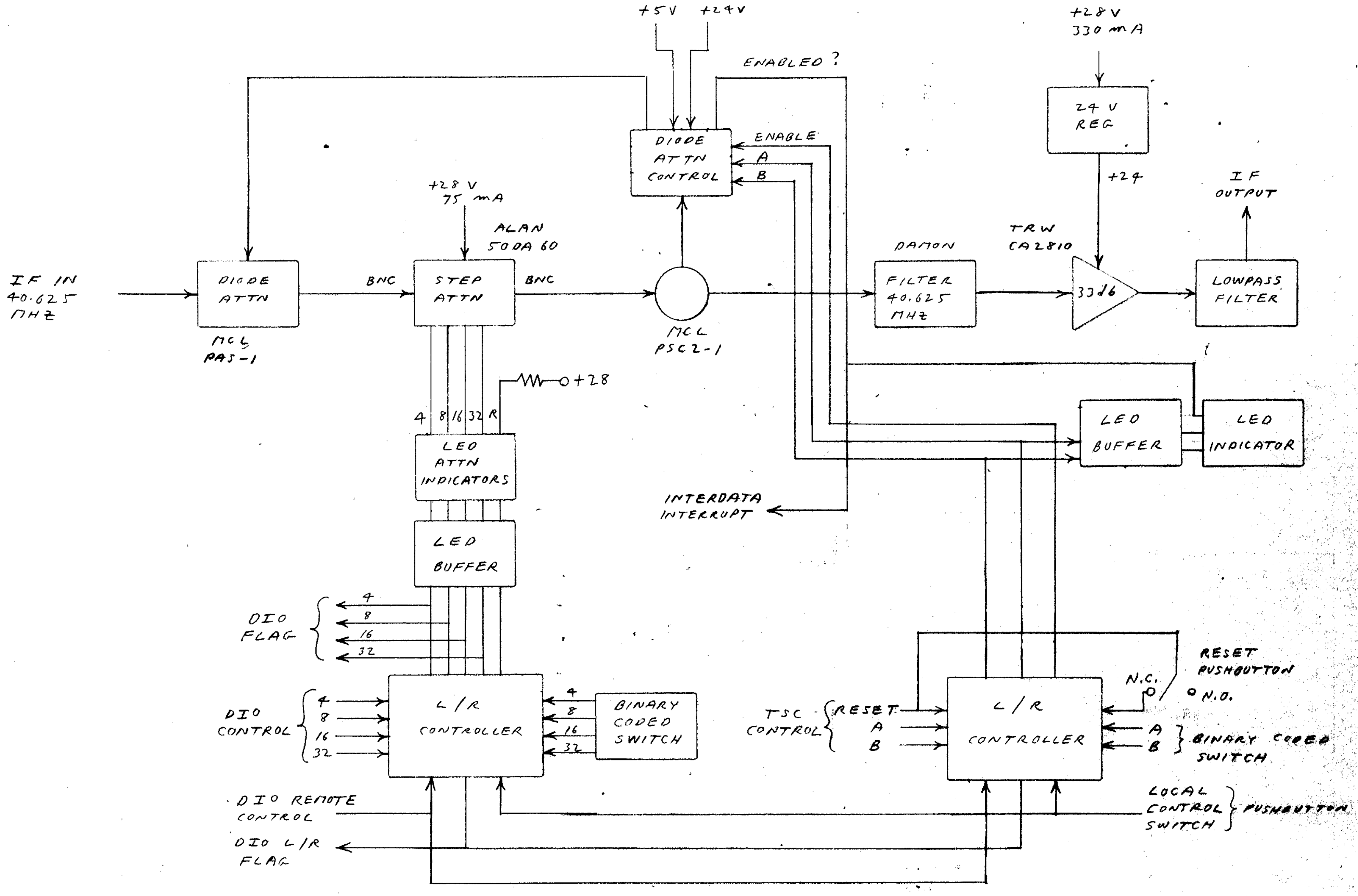
SCALE 7-20-78
SIZE C
DRAWING NO. HFS-115
DO NOT SCALE DRAWING
SHEET



RESISTORS 1/4 W 5% TIN OXIDE

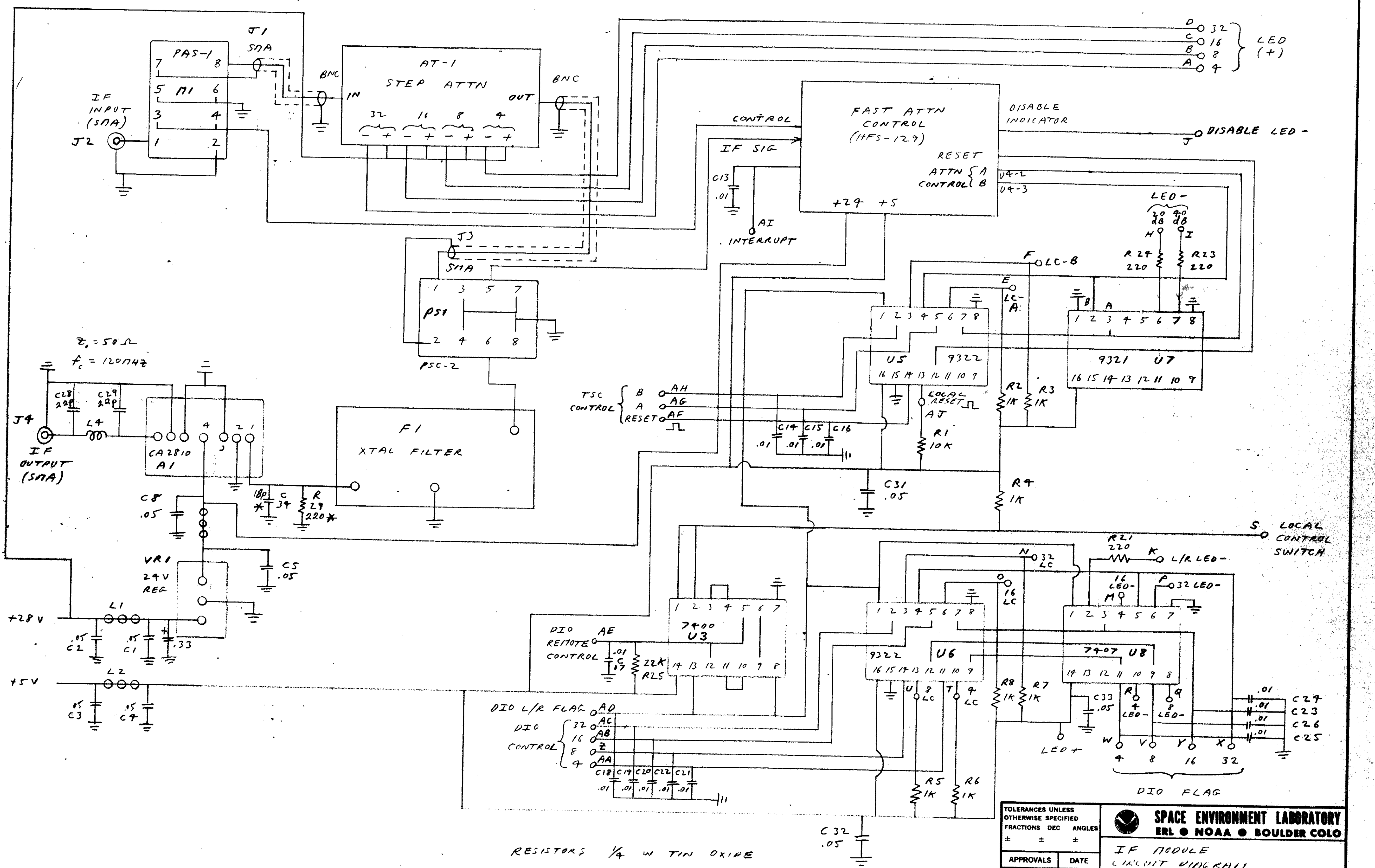
TOLERANCES UNLESS OTHERWISE SPECIFIED			SPACE ENVIRONMENT LABORATORY ERL ● NOAA ● BOULDER COLO		
FRACTIONS ±	DEC ±	ANGLES ±	MIXER MODULE CIRCUIT DIAGRAM BOTTOM VIEW		
APPROVALS	DATE				
DRAWN					
CHECKED			SCALE 1-20-78	SIZE C	DRAWING NO. HFS-116

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



TOLERANCES UNLESS OTHERWISE SPECIFIED FRACTIONS ± DEC ± ANGLES ±		**SPACE ENVIRONMENT LABORATORY** **ERL ● NOAA ● BOULDER COLO**		
APPROVALS	DATE	IF MODULE BLOCK DIAGRAM		
DRAWN				
CHECKED		SCALE 7-20-78	SIZE C	DRAWING NO. HFS-117
		DO NOT SCALE DRAWING		SHEET

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



RESISTORS 1/4 W TIN OXIDE

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC ± ANGLES ±

APPROVALS	DATE
DRAWN	
CHECKED	

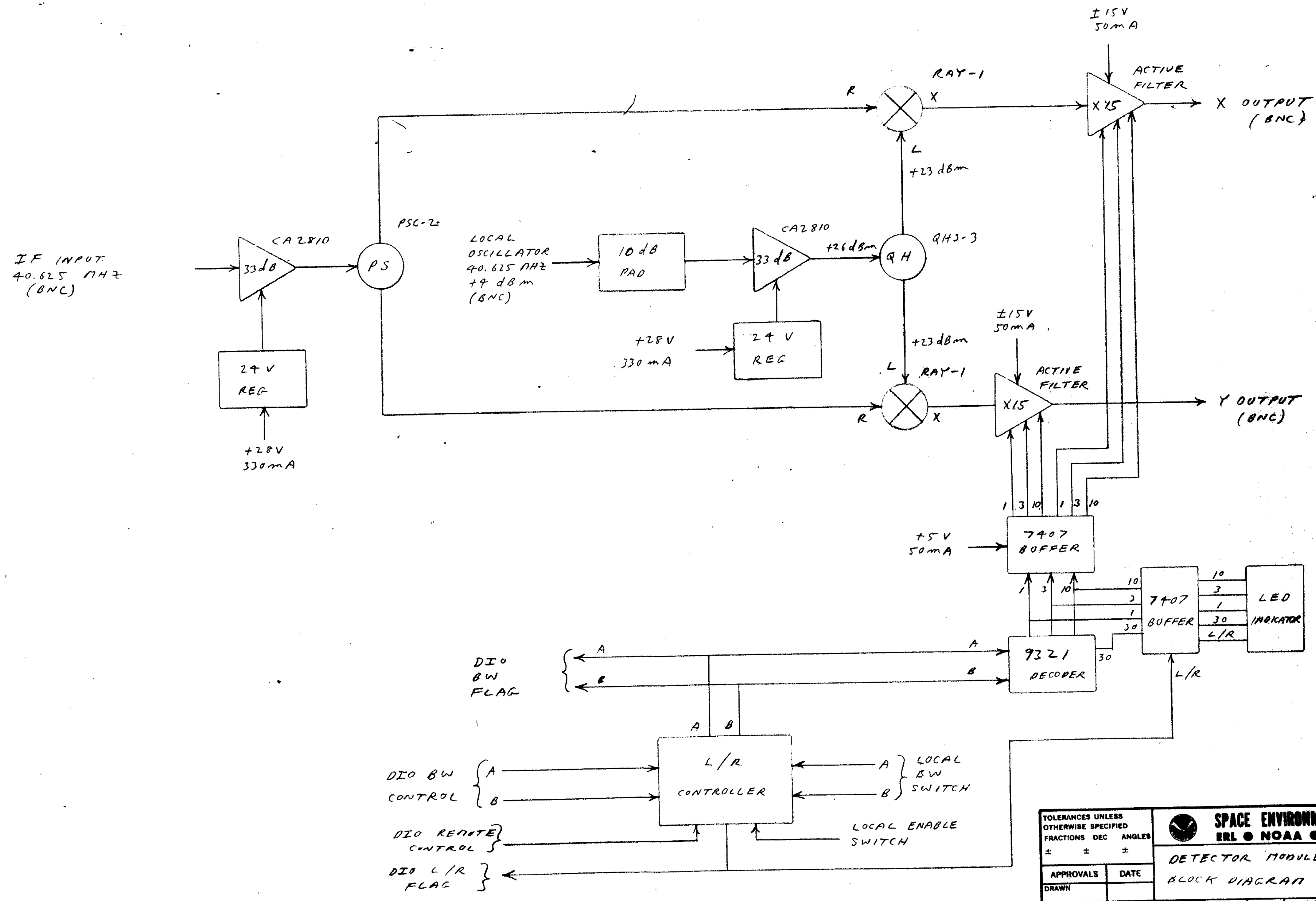
SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

IF MODULE
CIRCUIT DIAGRAM
BOTTOM VIEW

SCALE 7-20-78
SIZE C
DRAWING NO. HFS-118
DO NOT SCALE DRAWING
SHEET

BISHOP GRAPHICS/ACCUPRESS
REORDER NO. A-5766

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



TOLERANCES UNLESS OTHERWISE SPECIFIED		
FRACTIONS	DEC	ANGLES
±	±	±

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

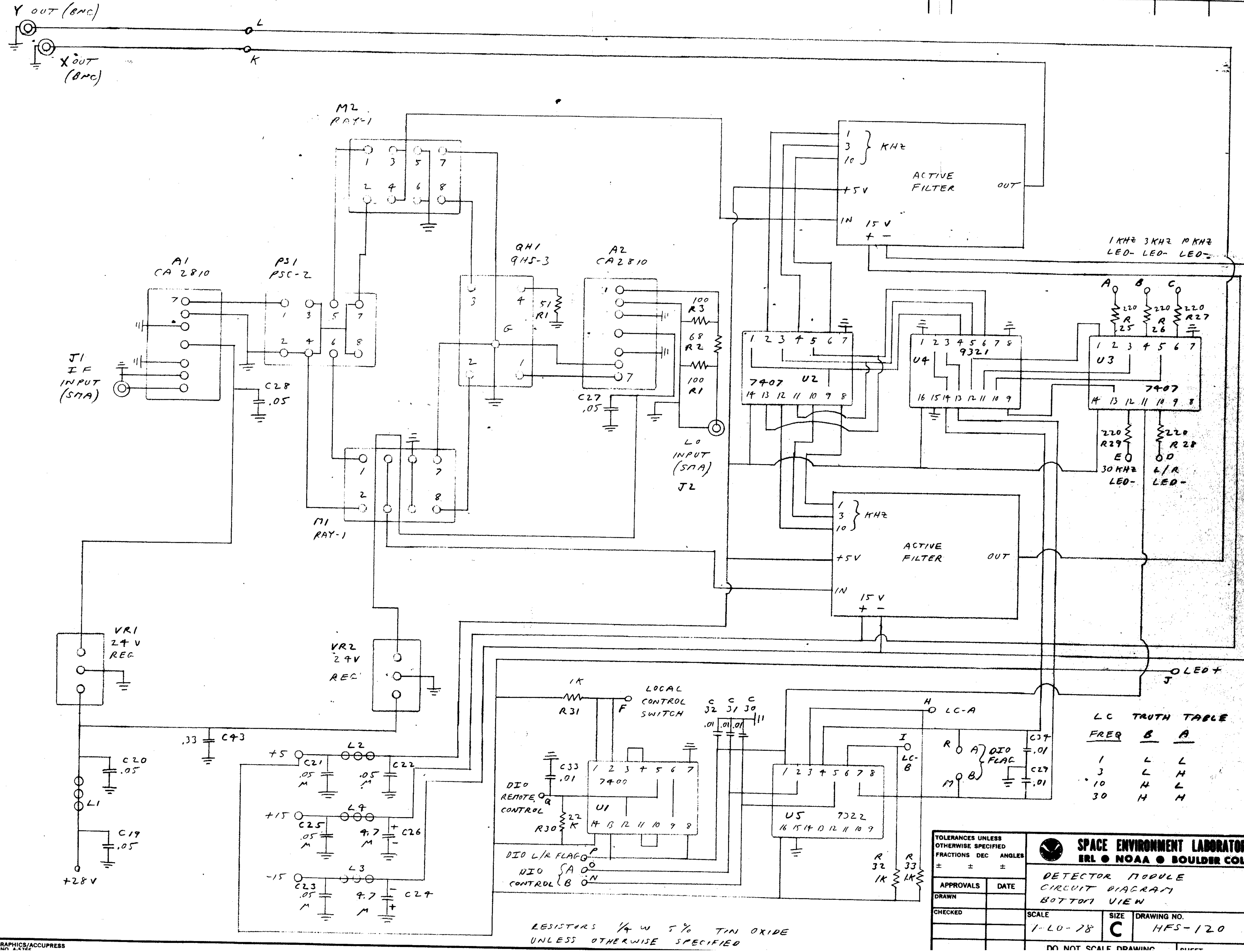
DETECTOR MODULE
BLOCK DIAGRAM

APPROVALS	DATE
DRAWN	
CHECKED	

SCALE 1-20-78
SIZE C
DRAWING NO. HFS-119

DO NOT SCALE DRAWING
SHEET

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



LC TRUTH TABLE

FREQ	B	A
1	L	L
3	L	H
10	H	L
30	H	H

RESISTORS 1/4 W 5% TIN OXIDE
UNLESS OTHERWISE SPECIFIED

TOLERANCES UNLESS
OTHERWISE SPECIFIED

FRACTIONS	DEC	ANGLES
±	±	±

APPROVALS	DATE
DRAWN	
CHECKED	

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

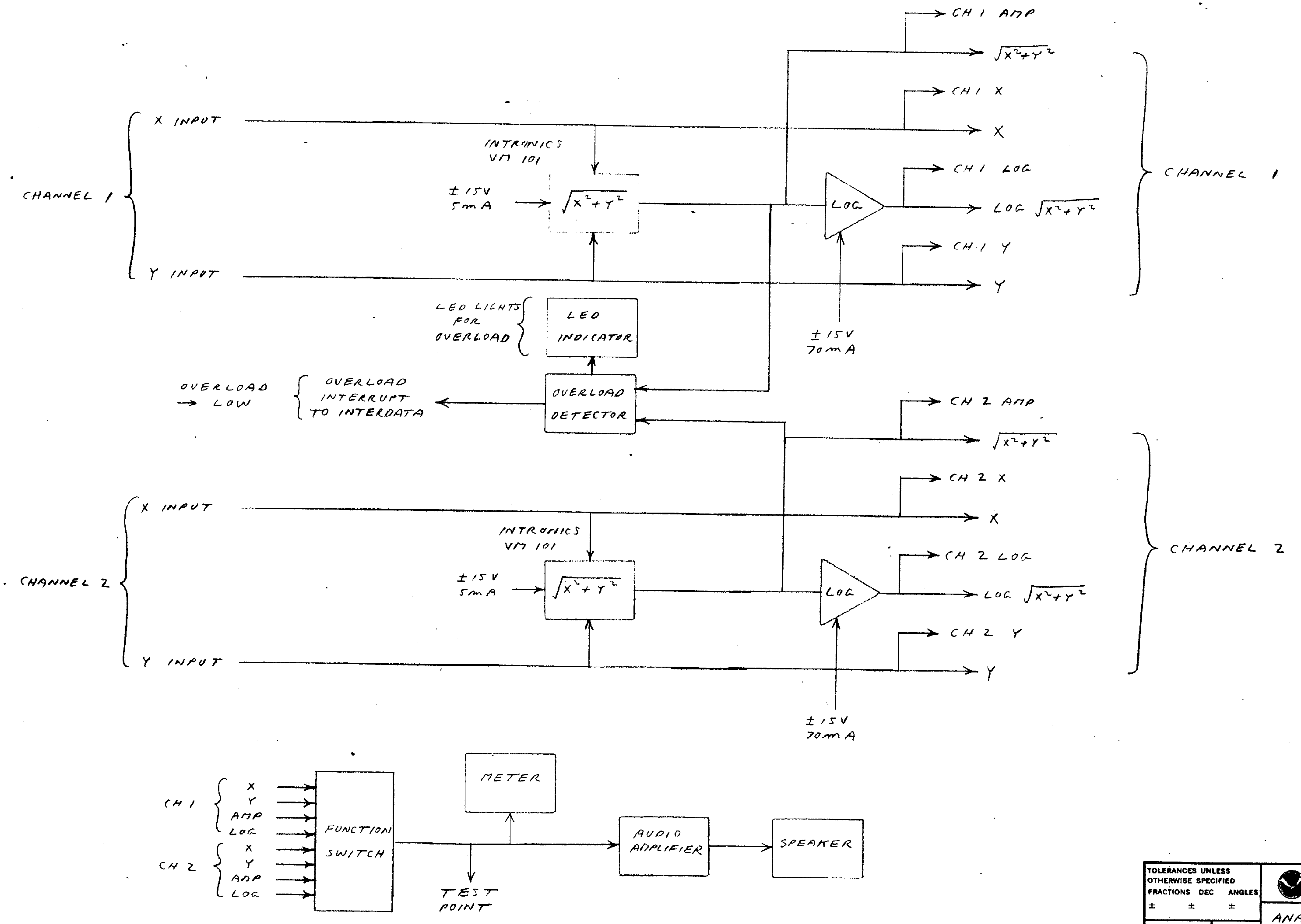
DETECTOR MODULE
CIRCUIT DIAGRAM
BOTTOM VIEW

SCALE	SIZE	DRAWING NO.
1-20-78	C	HFS-120

DO NOT SCALE DRAWING
SHEET

REVISIONS

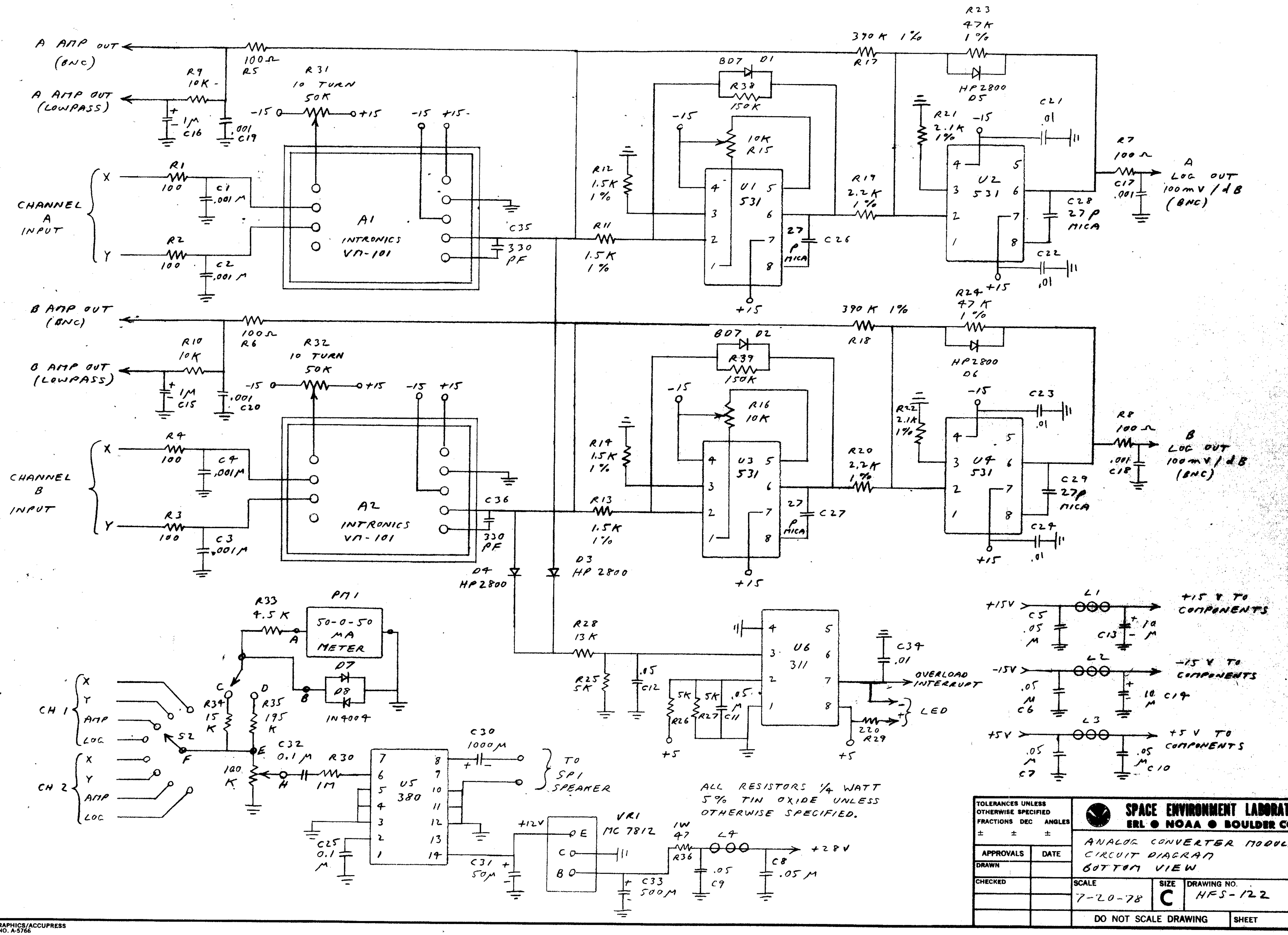
LTR	DESCRIPTION	DATE	APPROVED



TOLERANCES UNLESS OTHERWISE SPECIFIED FRACTIONS DEC ANGLES ± ± ±	**SPACE ENVIRONMENT LABORATORY** **ERL ● NOAA ● BOULDER COLO**
APPROVALS / DATE	ANALOG CONVERTER MODULE BLOCK DIAGRAM
DRAWN	
CHECKED	SCALE 7-20-78 / SIZE C / DRAWING NO. HFS-121
	DO NOT SCALE DRAWING / SHEET

BISHOP GRAPHICS/ACCUPRESS

LTR	DESCRIPTION	DATE	APPROVED



ALL RESISTORS 1/4 WATT 5% TIN OXIDE UNLESS OTHERWISE SPECIFIED.

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC ± ANGLES ±

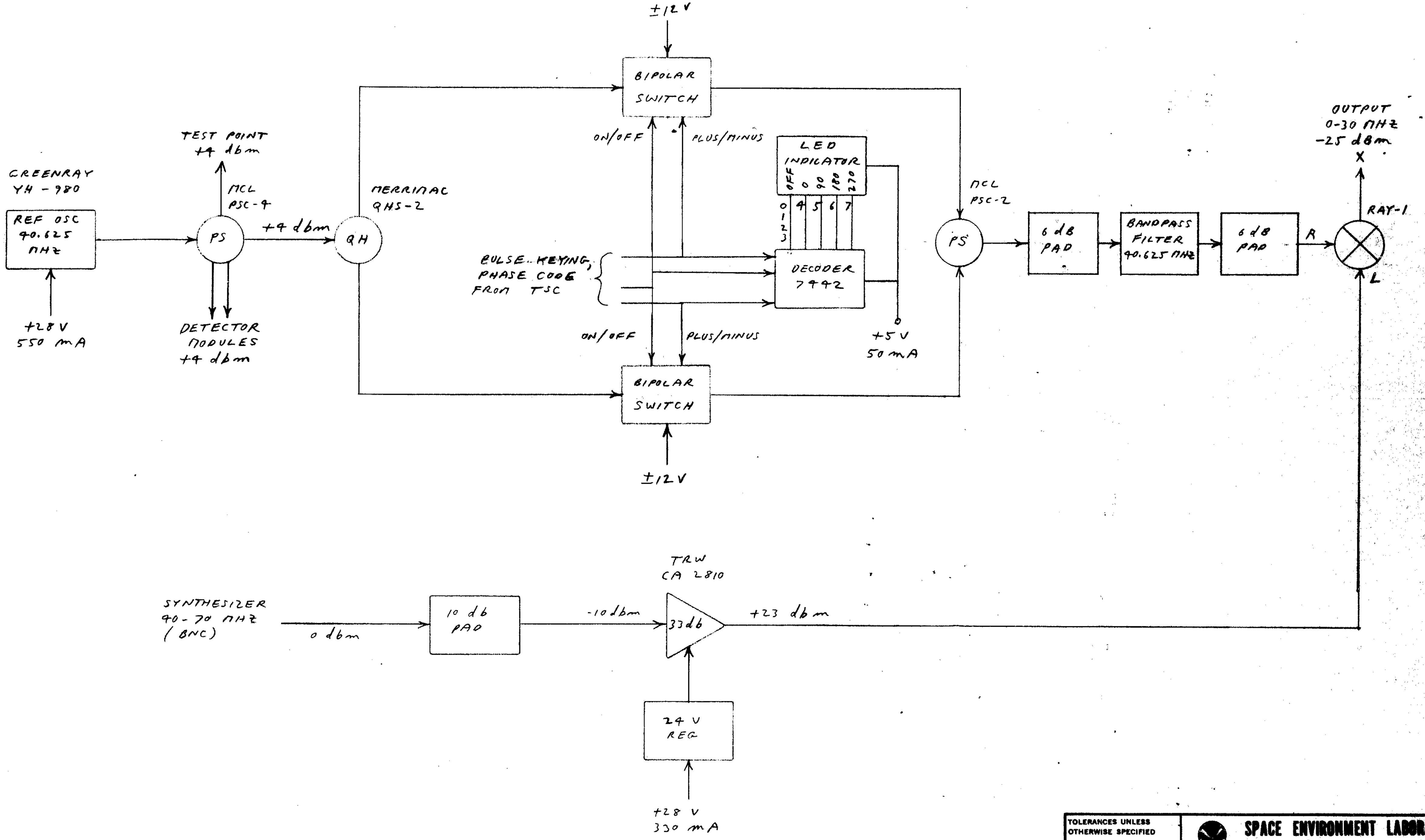
APPROVALS	DATE
DRAWN	
CHECKED	

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

ANALOG CONVERTER MODULE
CIRCUIT DIAGRAM
BOTTOM VIEW

SCALE 7-20-78
SIZE C
DRAWING NO. HFS-122
DO NOT SCALE DRAWING
SHEET

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC ± ANGLES ±

APPROVALS	DATE
DRAWN	
CHECKED	

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

TRANSMITTER MIXER MODULE
BLOCK DIAGRAM

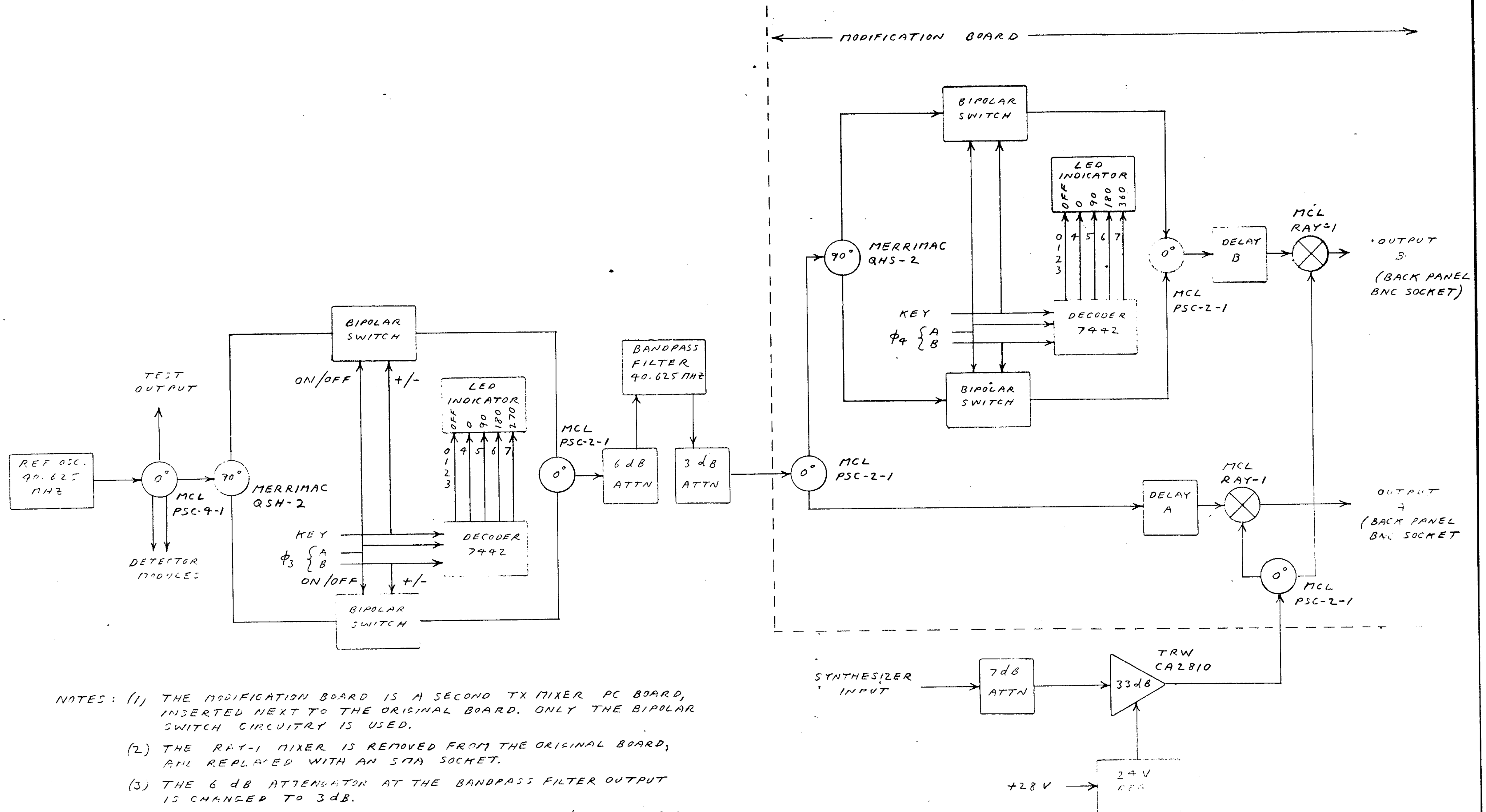
SCALE 7-20-78
SIZE C
DRAWING NO. HFS-123

DO NOT SCALE DRAWING
SHEET

BISHOP GRAPHICS/ACCUPRESS
REORDER NO. A-5766

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



NOTES:

(1) THE MODIFICATION BOARD IS A SECOND TX MIXER PC BOARD, INSERTED NEXT TO THE ORIGINAL BOARD. ONLY THE BIPOLAR SWITCH CIRCUITRY IS USED.

(2) THE RAY-1 MIXER IS REMOVED FROM THE ORIGINAL BOARD, AND REPLACED WITH AN SMA SOCKET.

(3) THE 6 dB ATTENUATOR AT THE BANDPASS FILTER OUTPUT IS CHANGED TO 3 dB.

(4) DELAYS "A" AND "B" ARE LENGTHS OF RG 174/U COAXIAL CABLE USED TO ADJUST THE PHASE OF OUTPUTS "A" AND "B".

(5) THE TWO-WAY POWER DIVIDER (PSC-2-1) AT THE MODIFICATION BOARD INPUT OCCUPIES THE SPACE OF THE FOUR-WAY DIVIDER (PSC-4) ON THE ORIGINAL BOARD. CIRCUIT-SIDE CONNECTIONS ARE ALTERED.

(6) THE ORIGINAL BOARD OUTPUT AND MODIFICATION BOARD INPUT ARE CONNECTED BY RG 174/U COAXIAL CABLE WITH SMA PLUGS.

(7) THE OUTPUT OF THE CA2810 RF AMPLIFIER CONNECTS TO THE MODIFICATION BOARD VIA COAXIAL CABLE, INSTEAD OF TO THE QUADRATURE HYBRID ON THE ORIGINAL BOARD.

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC ± ANGLES ±

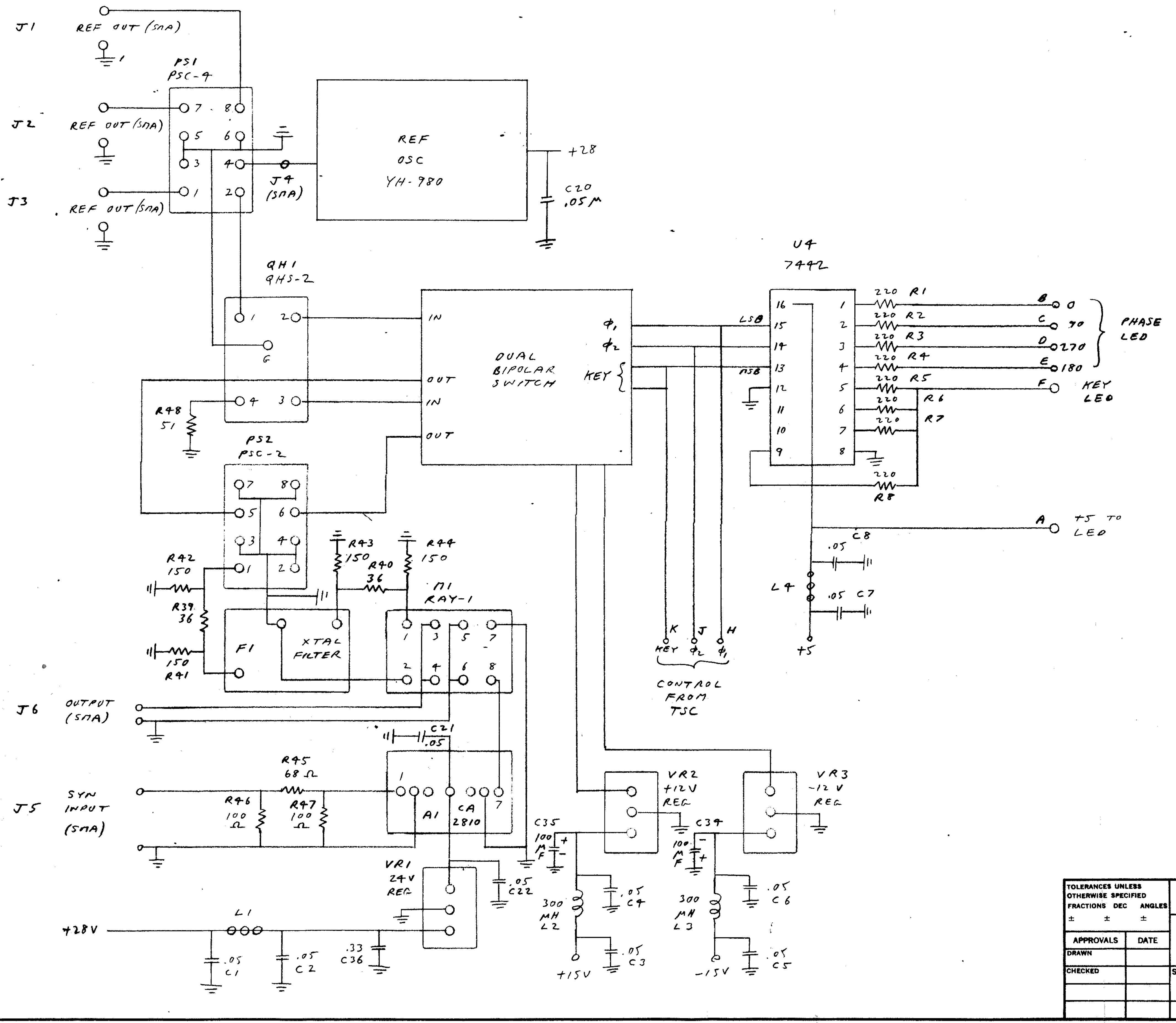
APPROVALS	DATE
DRAWN JJ	7-20
CHECKED	81

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

HF RADAR
MODIFIED TRANSMITTER
MIXER MODULE

SCALE
SIZE C
DRAWING NO. HFS 123A
DO NOT SCALE DRAWING
SHEET

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



TOLERANCES UNLESS OTHERWISE SPECIFIED		
FRACTIONS	DEC	ANGLES
±	±	±

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

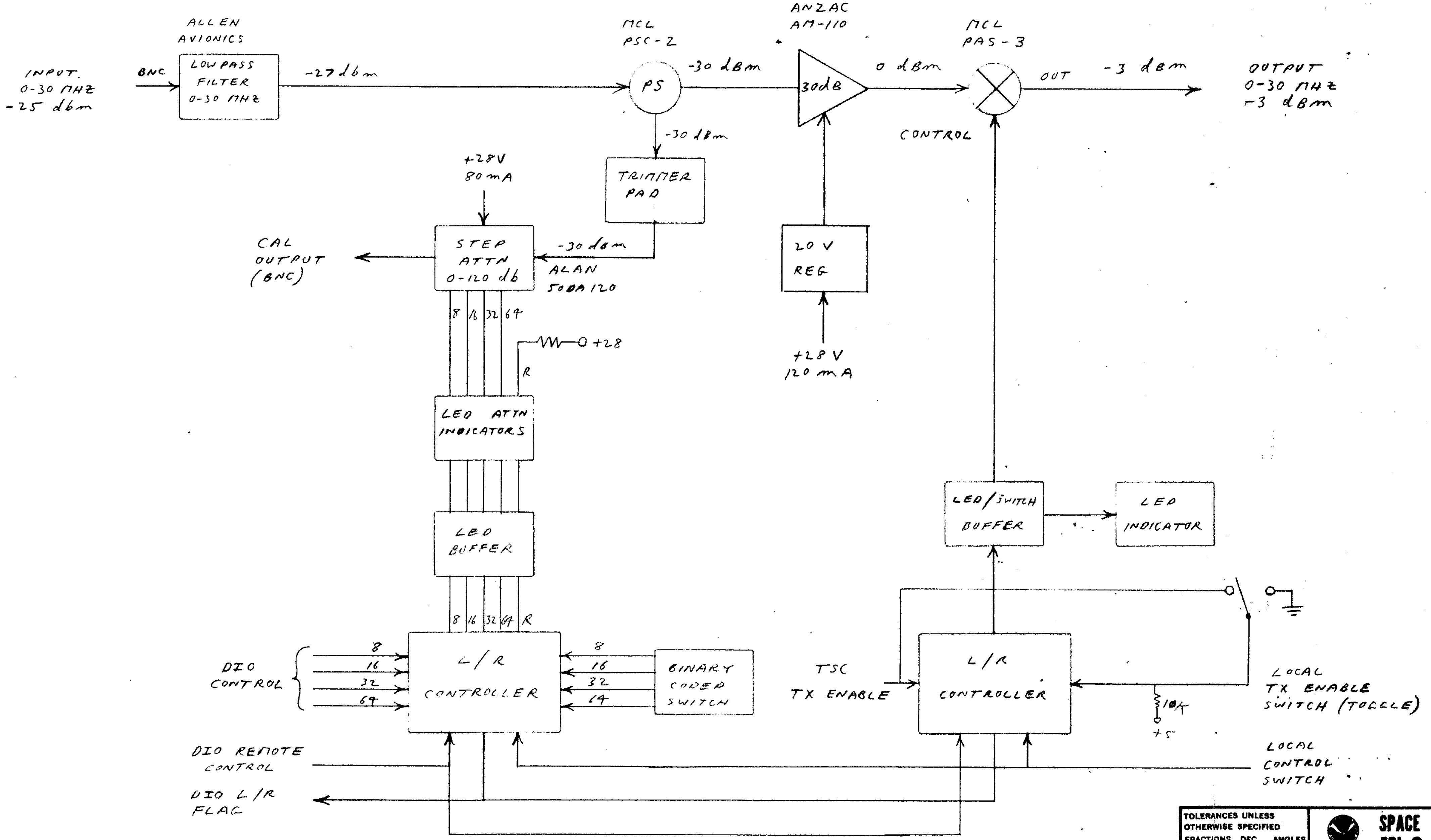
TRANSMITTER MIXER MODULE
CIRCUIT DIAGRAM
BOTTOM VIEW

APPROVALS	DATE
DRAWN	
CHECKED	

SCALE	SIZE	DRAWING NO.
7-20-78	C	HFS-124

DO NOT SCALE DRAWING
SHEET

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACTIONS	DEC	ANGLES
±	±	±

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

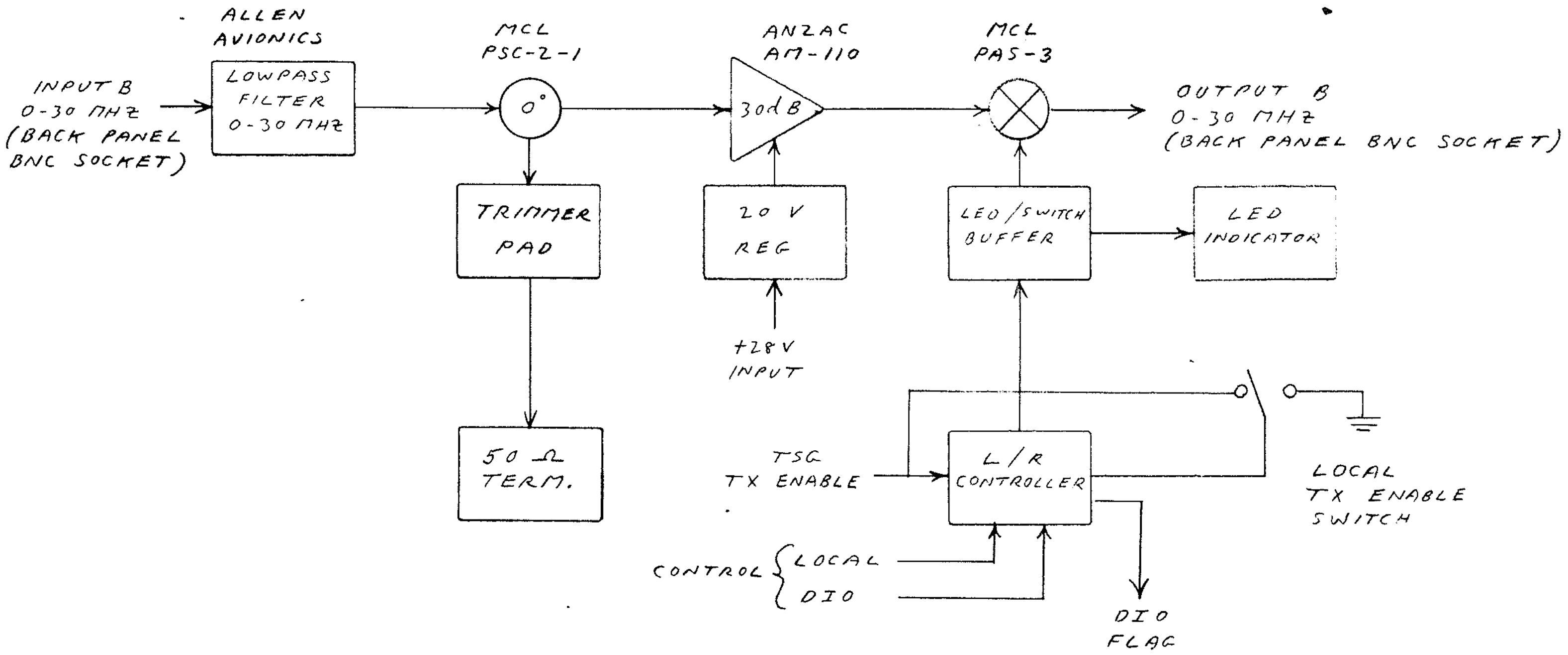
TRANSMITTER DRIVE MODULE
BLOCK DIAGRAM

APPROVALS	DATE
DRAWN	
CHECKED	

SCALE 7-20-78
SIZE C
DRAWING NO. HFS-125
DO NOT SCALE DRAWING
SHEET

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



NOTES: (1) THE MODIFIED TRANSMITTER DRIVE MODULE USES THE SAME PRINTED CIRCUT BOARD AS THE ORIGINAL MODULE.

(2) THE STEP ATTENUATOR AND ITS CONTROLLER CIRCUITS ARE NOT USED. THEY ARE REPLACED WITH AN SMA 50 Ω TERMINATION AT THE TRIMMER PAD OUTPUT. THE TRIMMER PAD IS JUMPERED FOR ZERO ATTENUATION.

(3) THE FRONT PANEL BINARY CODED SWITCH AND THE BACK PANEL DIO CONNECTIONS ARE NOT REQUIRED.

(4) INPUT "B" OF THE MODIFIED TRANSMITTER DRIVE MODULE CONNECTS TO OUTPUT "B" OF THE MODIFIED TRANSMITTER MIXER MODULE.

(5) THE MODIFIED TRANSMITTER DRIVE MODULE IS CONTAINED IN A DOUBLE WIDTH VECTOR NIM MODULE, SEPARATE FROM THE ORIGINAL TRANSMITTER DRIVE.

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC ± ANGLES ±

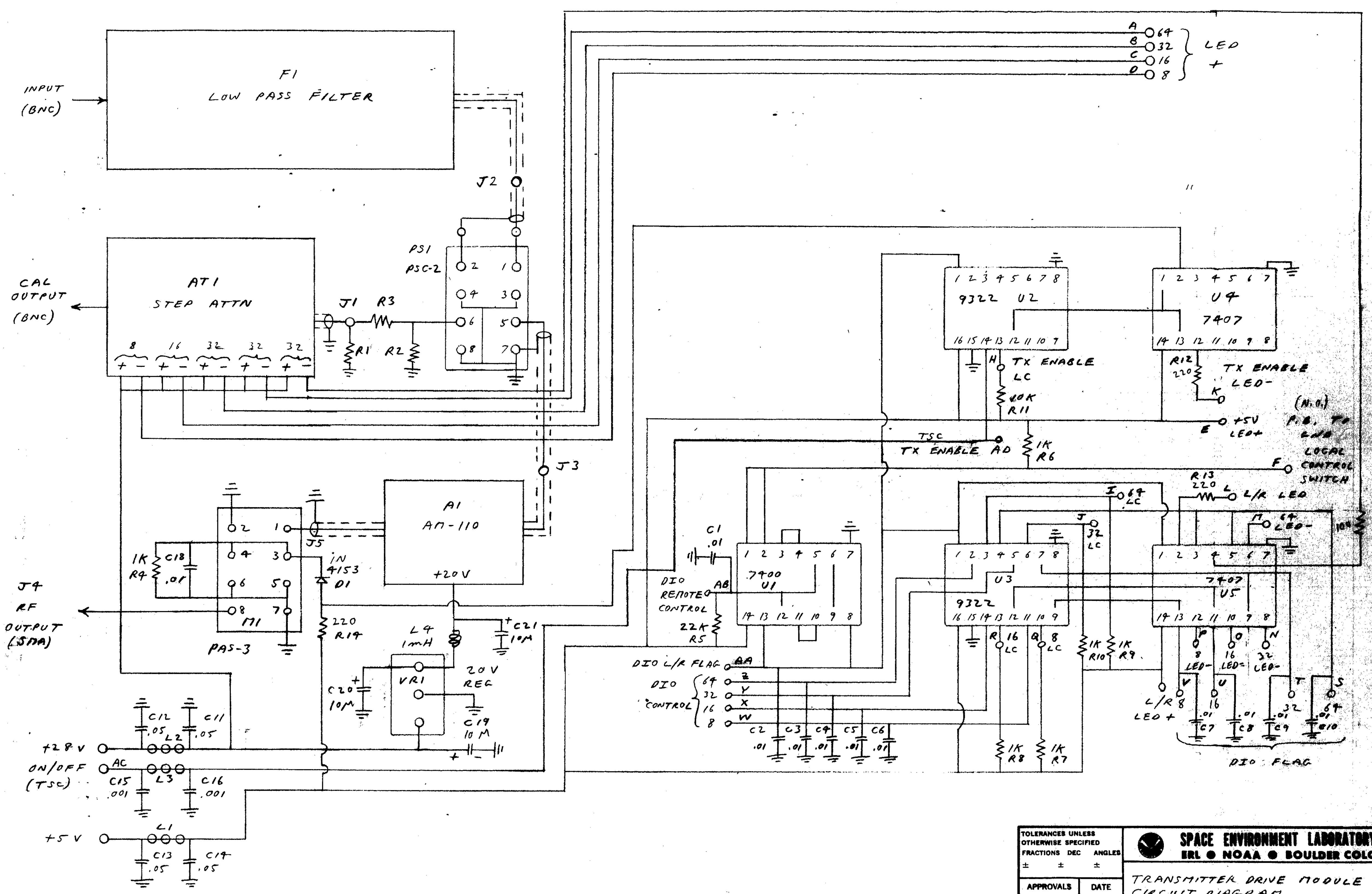
APPROVALS	DATE
DRAWN JJ	7-20
CHECKED	81

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

HF RADAR
MODIFIED TRANSMITTER
DRIVE MODULE

SCALE
SIZE C
DRAWING NO. HFS 125A
DO NOT SCALE DRAWING
SHEET

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACTIONS	DEC	ANGLES
±	±	±

APPROVALS	DATE
DRAWN	
CHECKED	

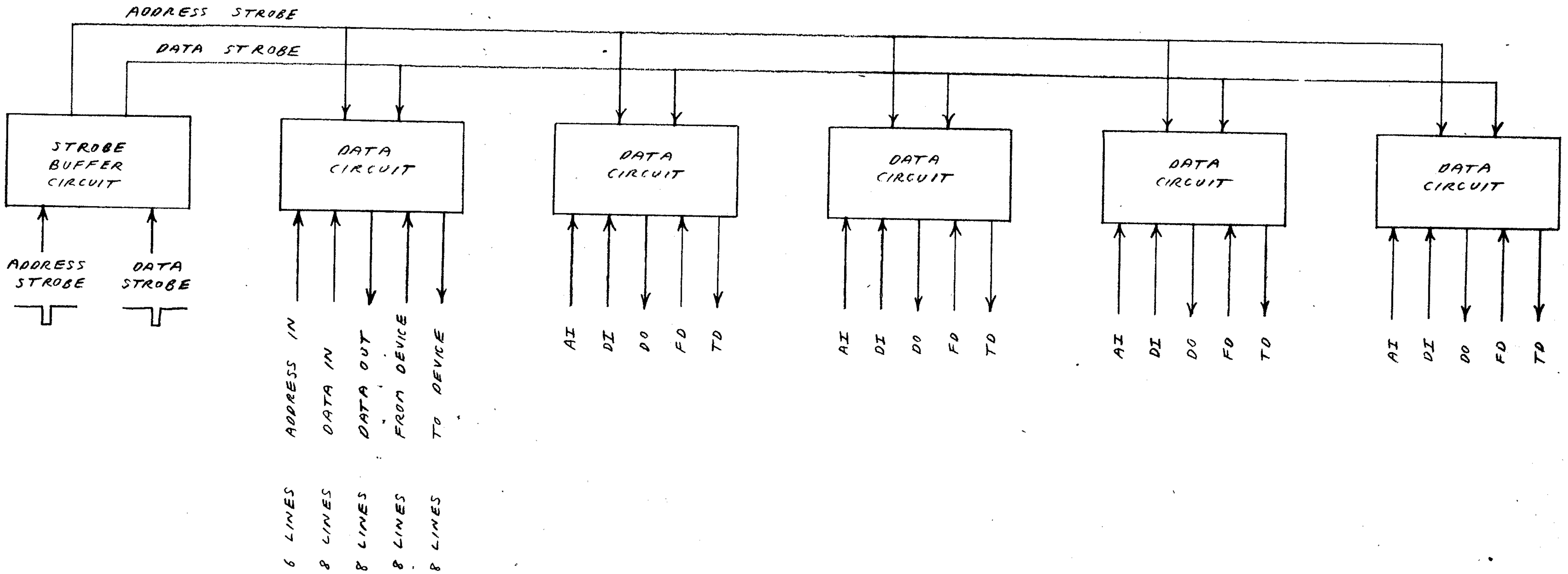
SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

TRANSMITTER DRIVE MODULE
CIRCUIT DIAGRAM
BOTTOM VIEW

SCALE	SIZE	DRAWING NO.
7-20-78	C	HFS-126

DO NOT SCALE DRAWING | SHEET

LTR	DESCRIPTION	DATE	APPROVED



TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC ± ANGLES ±

APPROVALS	DATE
DRAWN	
CHECKED	

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

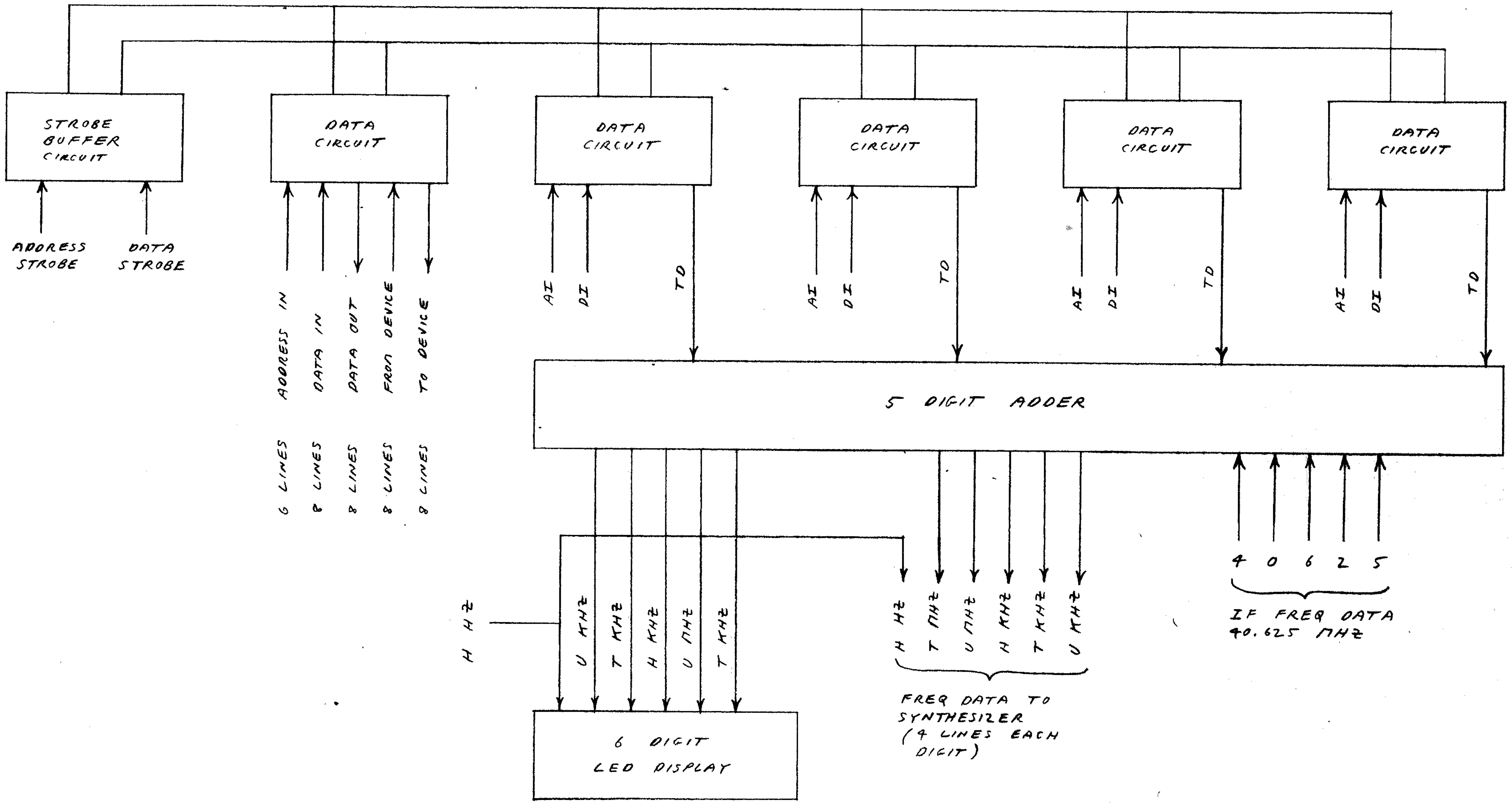
CONTROL MODULE
BLOCK DIAGRAM

SCALE 7-20-78
SIZE C
DRAWING NO. HFS-127
DO NOT SCALE DRAWING
SHEET

BISHOP GRAPHICS/ACCUPRESS
REORDER NO. A-5766

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACTIONS	DEC	ANGLES
±	±	±

APPROVALS	DATE
DRAWN	
CHECKED	

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

CONTROL /ADDER MODULE
BLOCK DIAGRAM

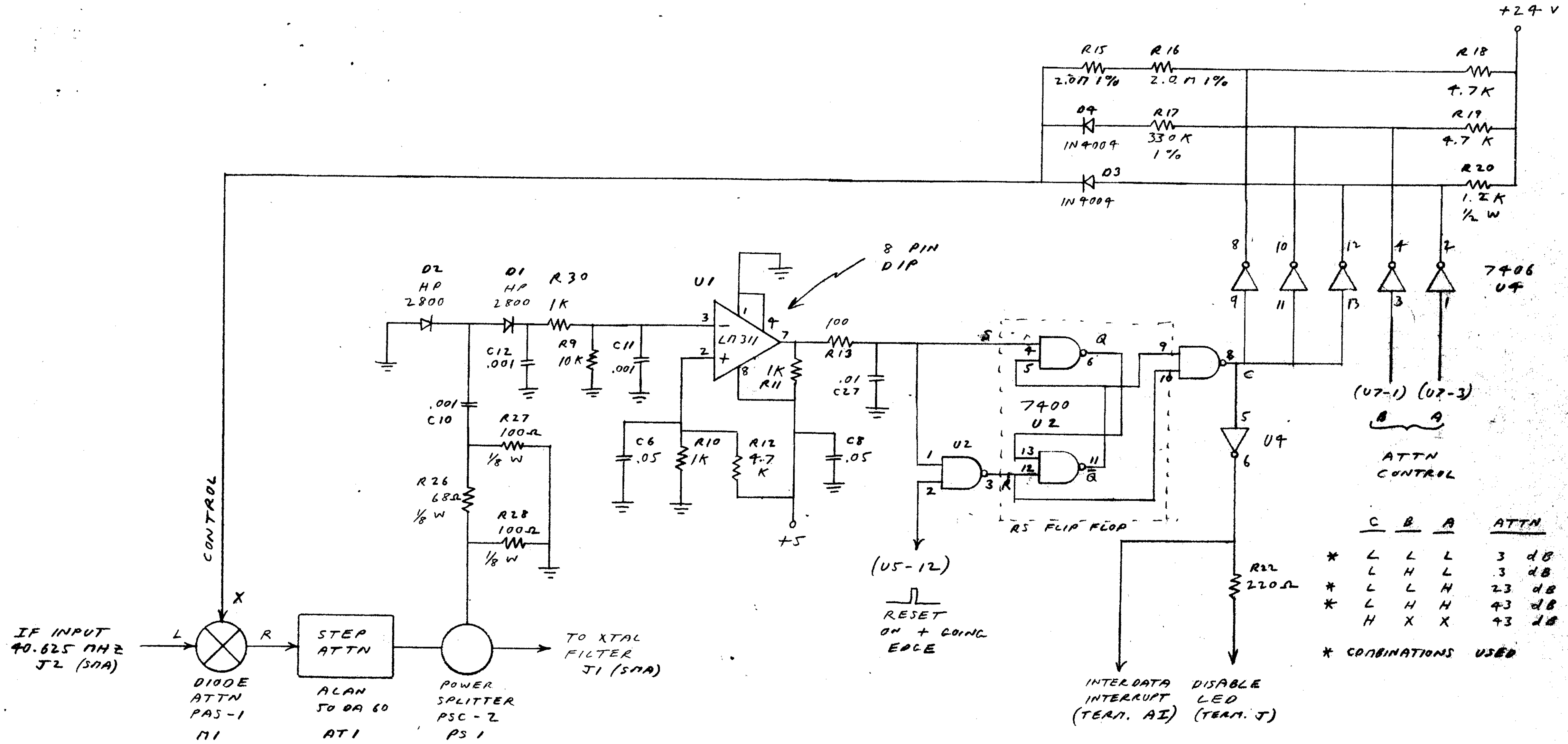
SCALE	SIZE	DRAWING NO.
7-20-78	C	HFS-128

DO NOT SCALE DRAWING

SHEET

BISHOP GRAPHICS/ACCUPRESS
REORDER NO. A-5766

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



ATTN
CONTROL

	C	B	A	ATTN
*	L	L	L	3 dB
	L	H	L	.3 dB
*	L	L	H	23 dB
*	L	H	H	43 dB
	H	X	X	43 dB

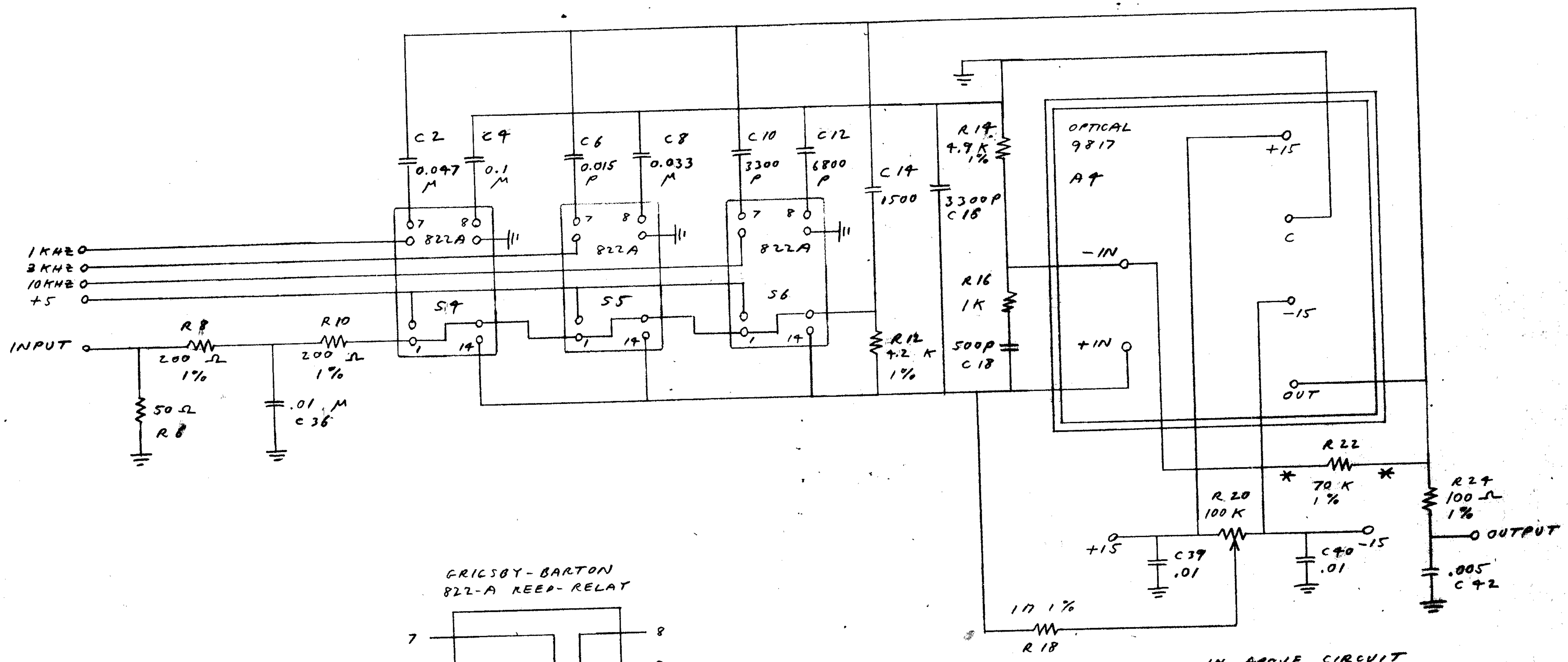
* COMBINATIONS USED

ALL RESISTORS ¼ WATT TIN OXIDE 5%
UNLESS OTHERWISE SPECIFIED.

TOLERANCES UNLESS OTHERWISE SPECIFIED			SPACE ENVIRONMENT LABORATORY ERL ● NOAA ● BOULDER COLO		
FRACTIONS ±	DEC ±	ANGLES ±	FAST ATTENUATOR SUB-MODULE CIRCUIT		
APPROVALS		DATE			
DRAWN					
CHECKED			SCALE 7-20-78	SIZE C	DRAWING NO. HFS-127
			DO NOT SCALE DRAWING		SHEET

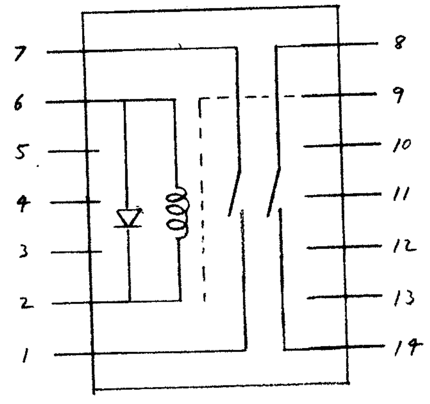
REVISIONS

LTR	DESCRIPTION	DATE	APPROVED

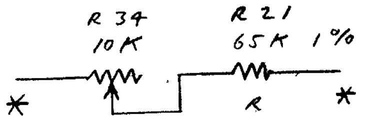


IN ABOVE CIRCUIT
COMPONENTS ARE IDENTIFIED (R1, C2, ETC.)
FOR "Y" CHANNEL.

GRIGSBY-BARTON
822-A REED-RELAY



BOTTOM VIEW



REPLACE R WITH ABOVE
CIRCUIT IN "X" CHANNEL
FOR GAIN BALANCE.

TOLERANCES UNLESS OTHERWISE SPECIFIED		
FRACTIONS	DEC	ANGLES
±	±	±

APPROVALS	DATE
DRAWN	
CHECKED	

SPACE ENVIRONMENT LABORATORY
ERL • NOAA • BOULDER COLO

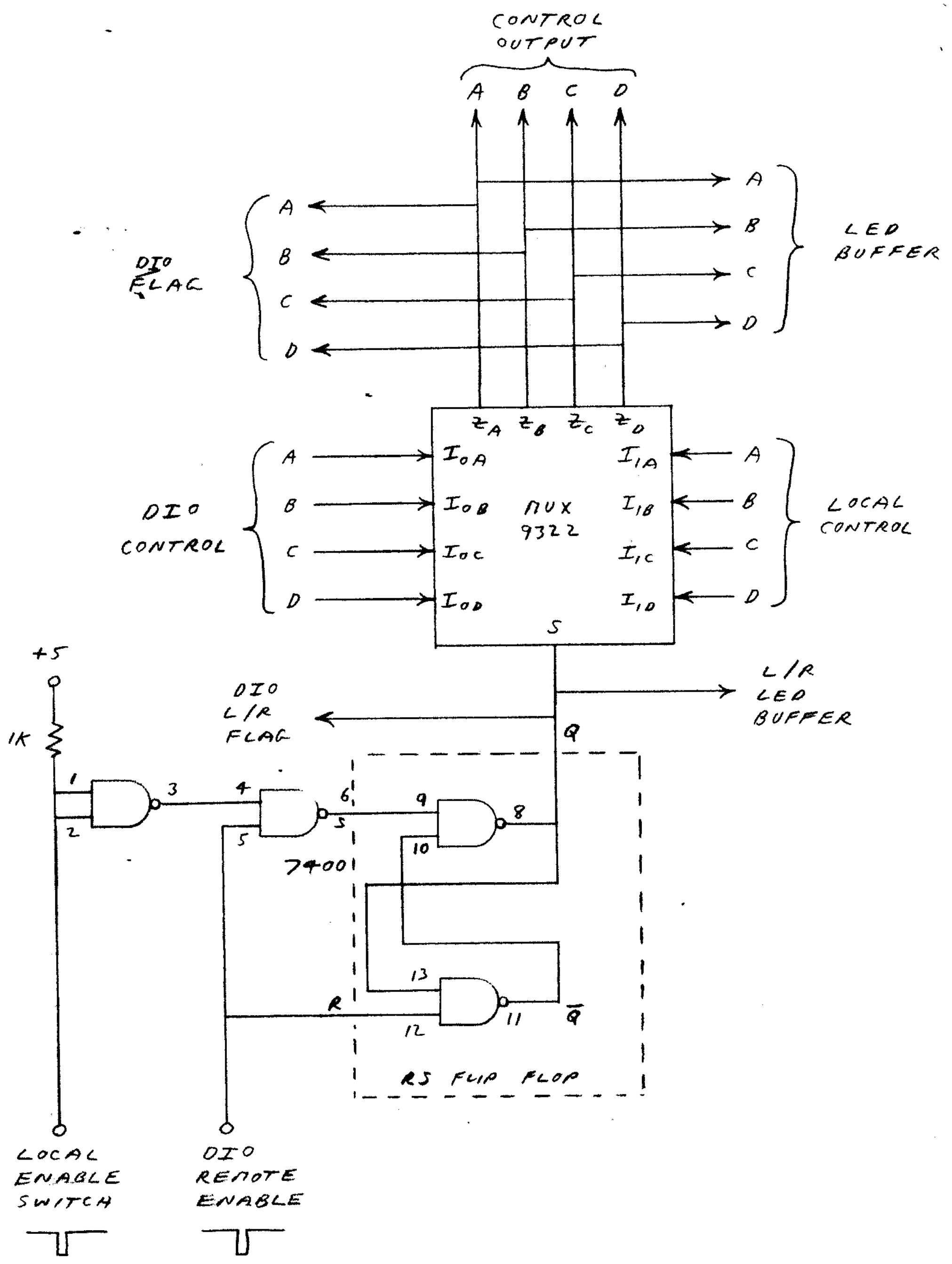
ACTIVE FILTER
CIRCUIT DIAGRAM
BOTTOM VIEW

SCALE	SIZE	DRAWING NO.
7-20-78	C	HFS-130

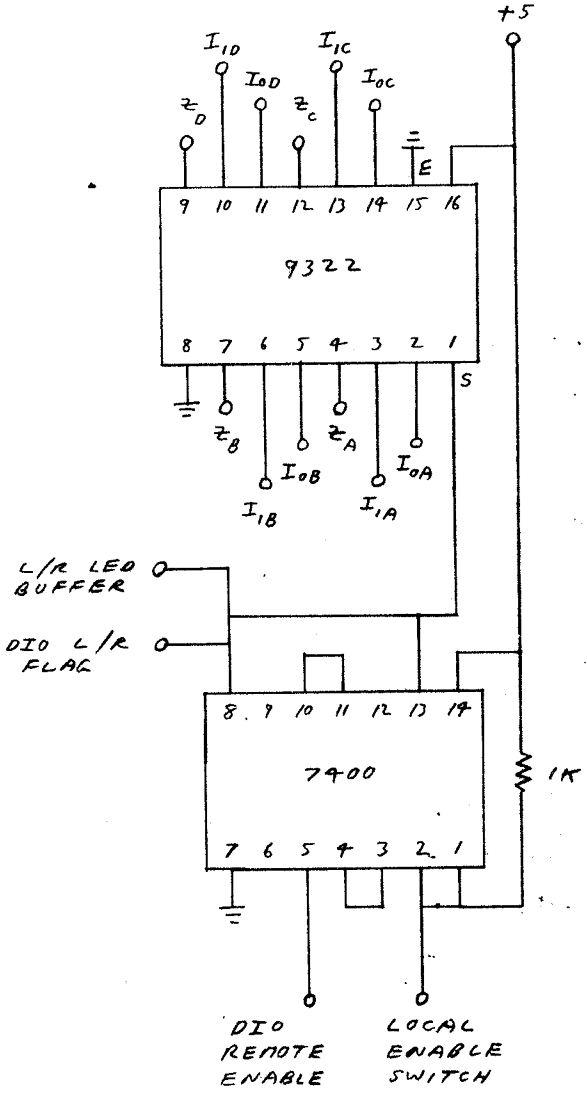
DO NOT SCALE DRAWING

SHEET

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



BLOCK DIAGRAM



BOTTOM VIEW

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC ± ANGLES ±

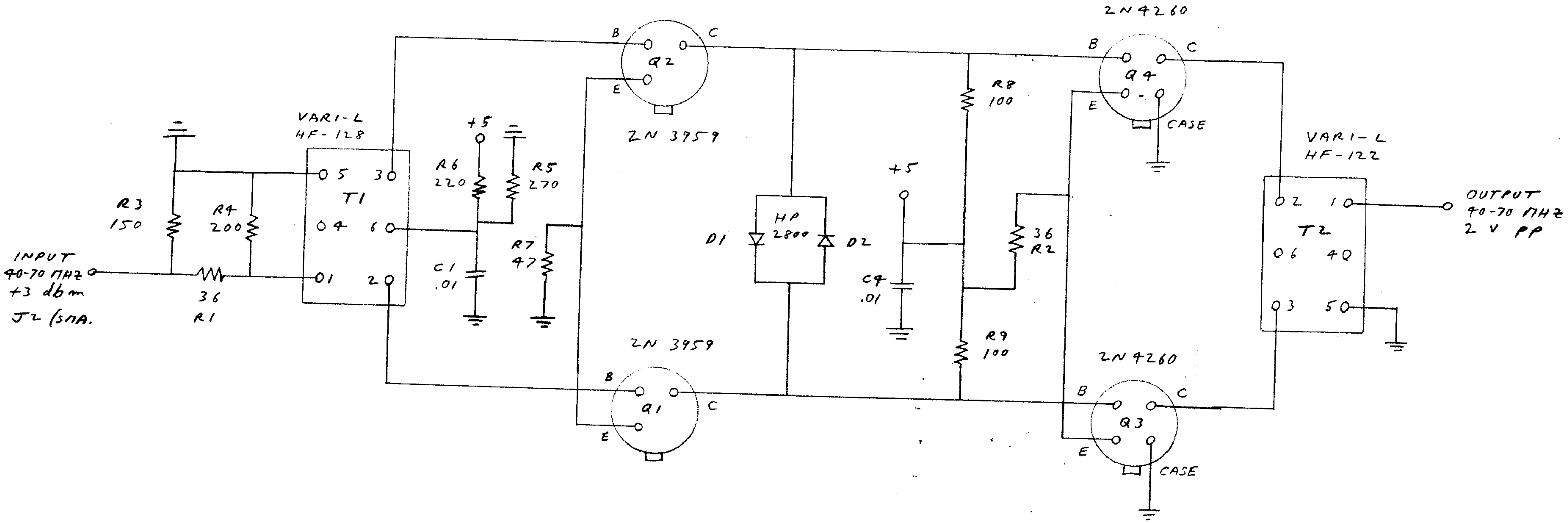
APPROVALS	DATE
DRAWN	
CHECKED	

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

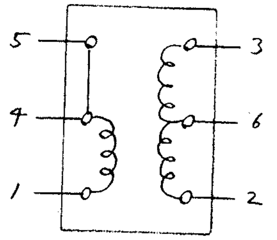
L/R CONTROLLER
BLOCK DIAGRAM

SCALE 7-20-78
SIZE C
DRAWING NO. HFS-131
DO NOT SCALE DRAWING
SHEET

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

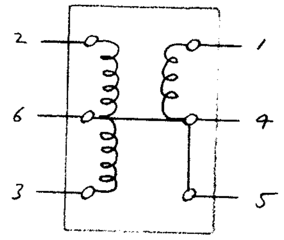


50Ω UN– 200Ω BAL



VARI-L HF-128

200Ω BAL– 50Ω UNBAL

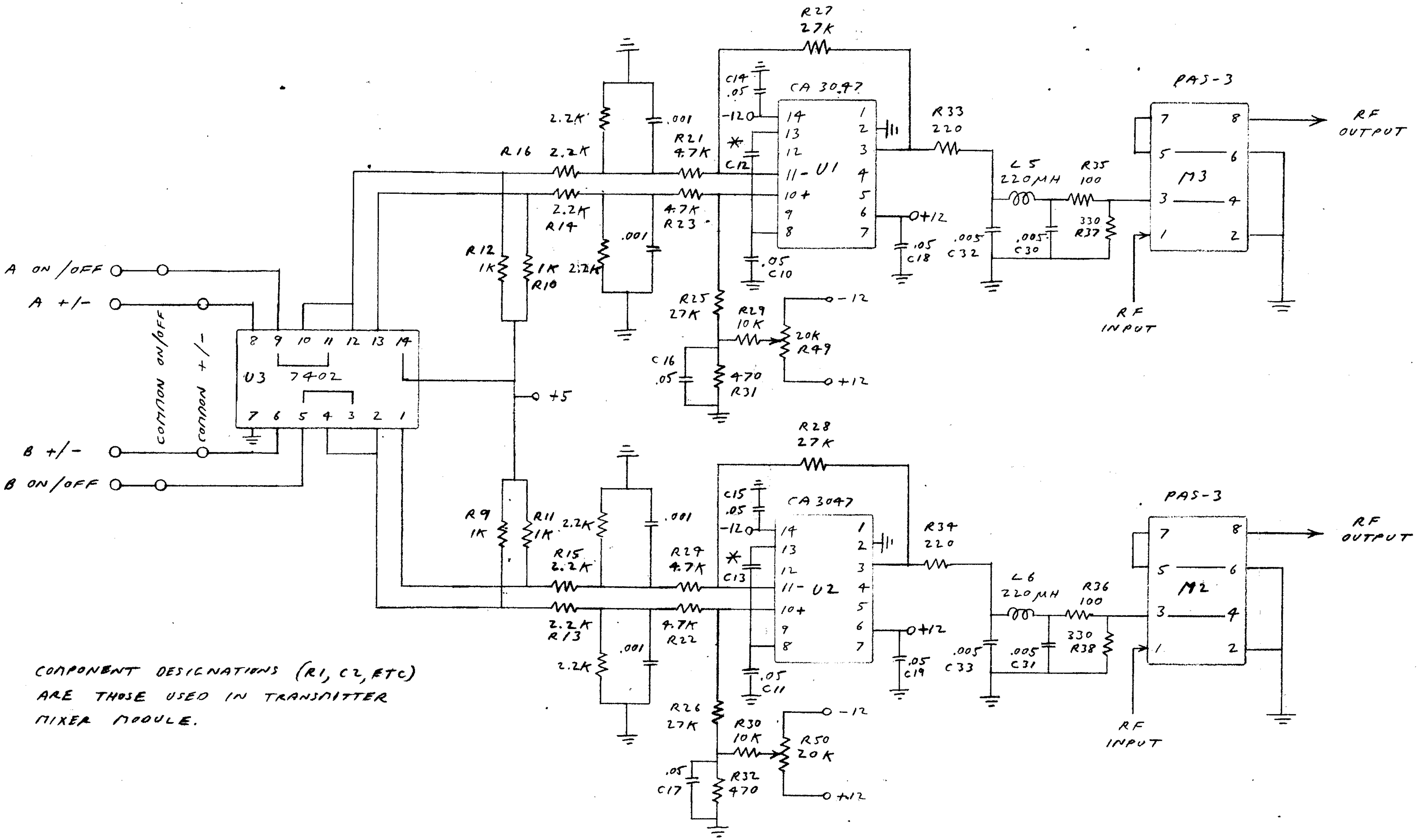


VARI-L HF-122

ALL RESISTORS 1/8 W 5% TIN OXIDE

TOLERANCES UNLESS OTHERWISE SPECIFIED FRACTIONS DEC ANGLES ± ± ±	**SPACE ENVIRONMENT LABORATORY** **ERL ● NOAA ● BOULDER COLO**
APPROVALS / DATE	SQUARER CIRCUIT DIAGRAM BOTTOM VIEW
DRAWN	
CHECKED	SCALE 7-20-78 · SIZE C · DRAWING NO. HFS-132
	DO NOT SCALE DRAWING · SHEET

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



COMPONENT DESIGNATIONS (R1, C2, ETC) ARE THOSE USED IN TRANSMITTER MIXER MODULE.

* 0.1 µF WHEN USED IN ANTENNA MUX MODULE
0.05 µF WHEN USED IN TRANSMITTER MIXER MODULE

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC ± ANGLES ±

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

DUAL BIPOLAR SWITCH
CIRCUIT DIAGRAM
BOTTOM VIEW

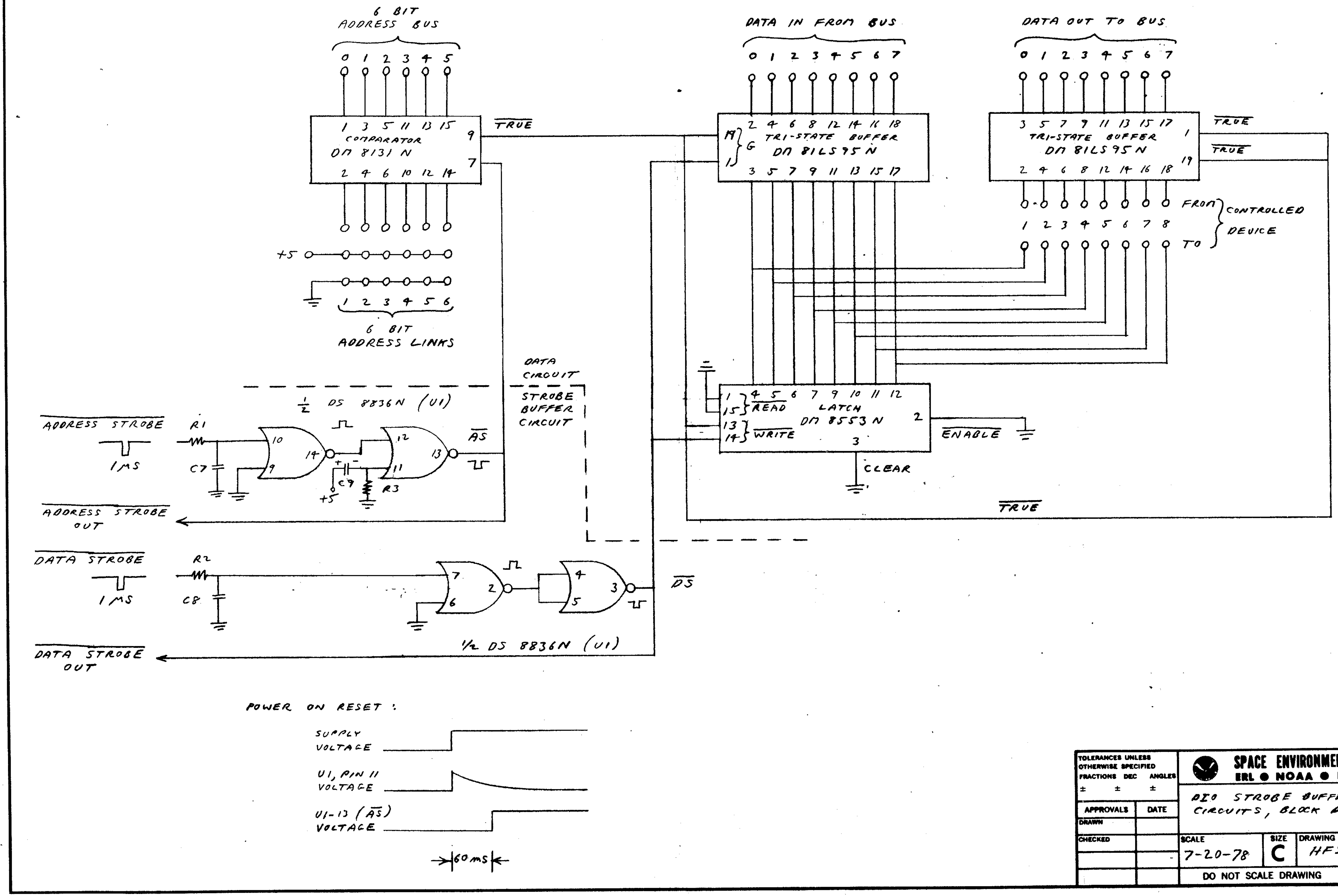
APPROVALS	DATE
DRAWN	
CHECKED	

SCALE 1-20-78
SIZE C
DRAWING NO. HFS-133

DO NOT SCALE DRAWING
SHEET

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACTIONS	DEC	ANGLES
±	±	±

APPROVALS	DATE
DRAWN	
CHECKED	

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

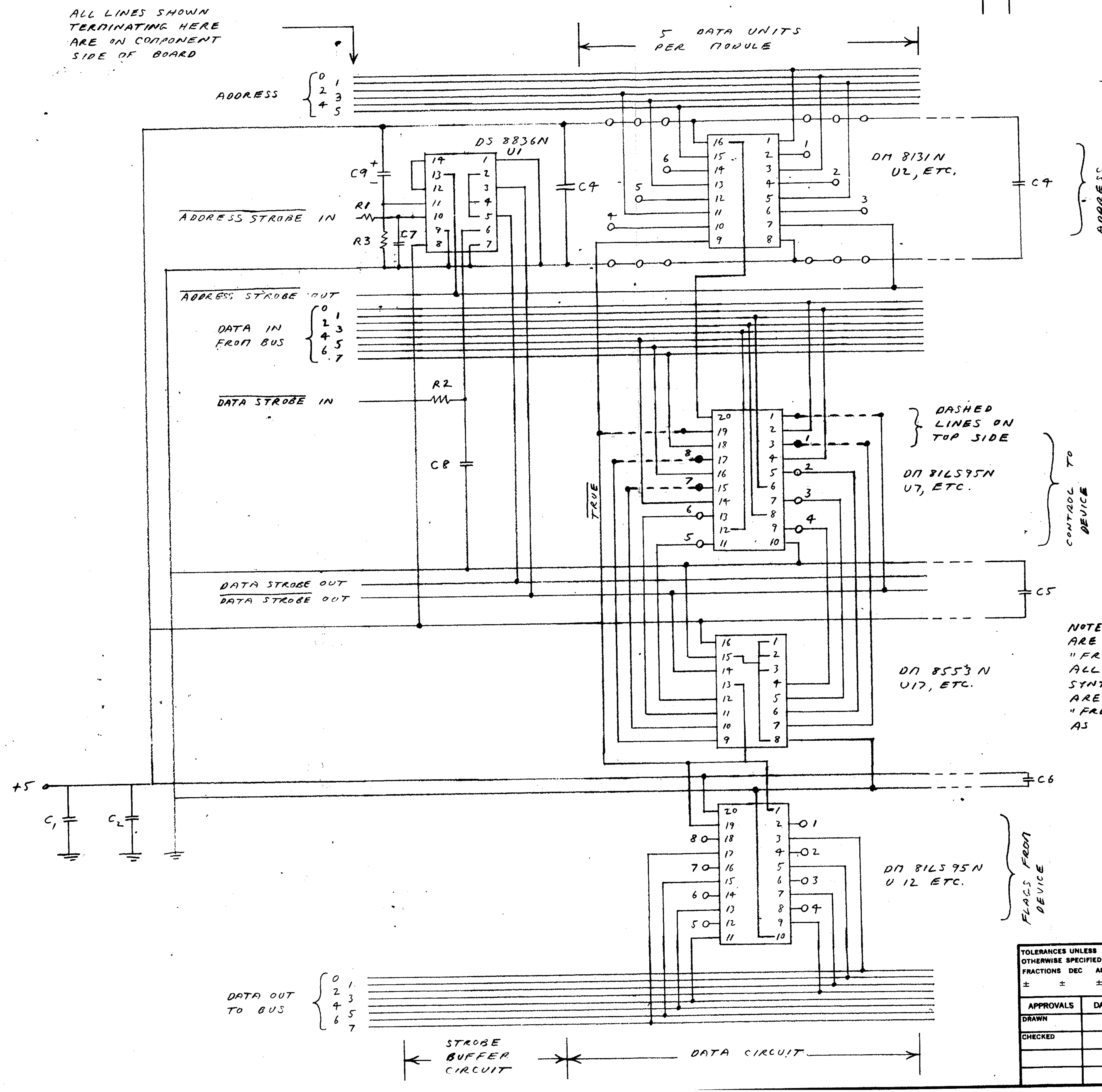
DIO STROBE BUFFER, DATA CIRCUITS, BLOCK DIAGRAM

SCALE 7-20-78
SIZE C
DRAWING NO. HFS-134

DO NOT SCALE DRAWING
SHEET

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



NOTE: UNUSED "TO DEVICE" OUTPUTS ARE CONNECTED TO CORRESPONDING "FROM DEVICE" INPUTS. IN ADDITION, ALL "TO DEVICE" OUTPUTS TO THE SYNTHESIZER FREQUENCY CONTROL ARE ALSO CONNECTED TO THE "FROM DEVICE" INPUTS, TO BE USED AS FLAGS.

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC ± ANGLES ±

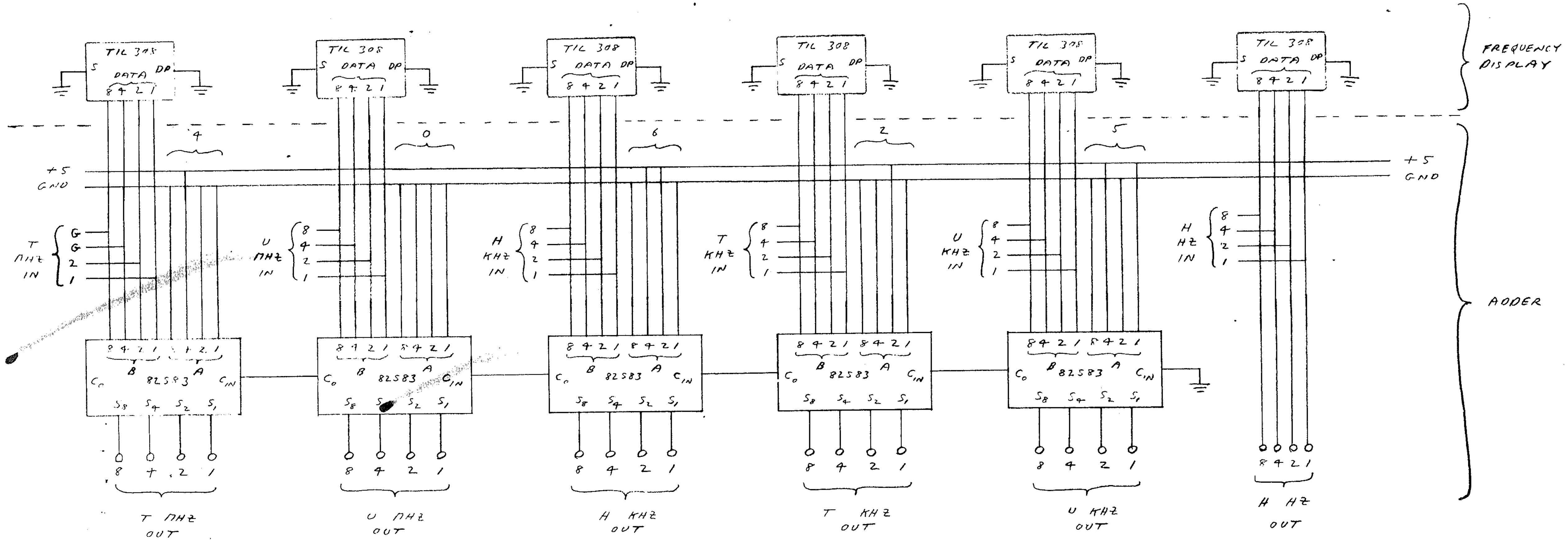
SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

DIO STROBE BUFFER, DATA CIRCUITS
CIRCUIT DIAGRAM
BOTTOM VIEW

APPROVALS	DATE
DRAWN	
CHECKED	

SCALE 7-20-78
SIZE C
DRAWING NO. HFS-135
DO NOT SCALE DRAWING
SHEET

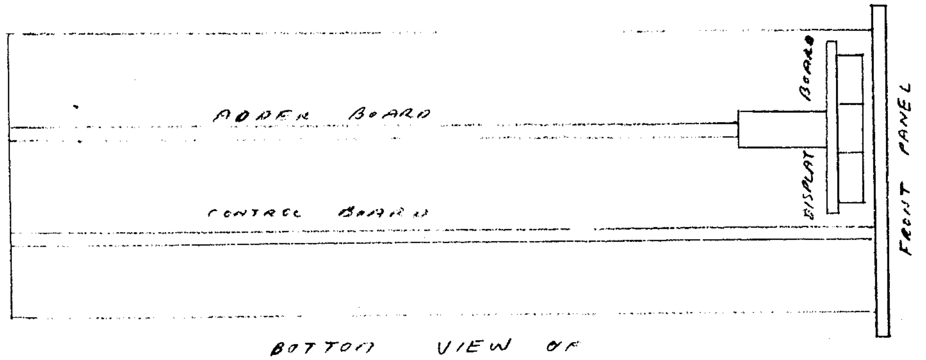
REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
A	T MHZ 8, 4 INPUTS GROUNDED	7-6-81	JJ



INPUTS CONNECT TO "TO DEVICE"
ON CONTROL MODULE

OUTPUTS CONNECT TO SYNTHESIZER CONNECTOR

FLAGS CONNECT TO "FROM DEVICE"
ON CONTROL MODULE



BOTTOM VIEW OF
CONTROL/ADDER MODULE

TOLERANCES UNLESS
OTHERWISE SPECIFIED
FRACTIONS ± DEC ±1 ANGLES ±

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

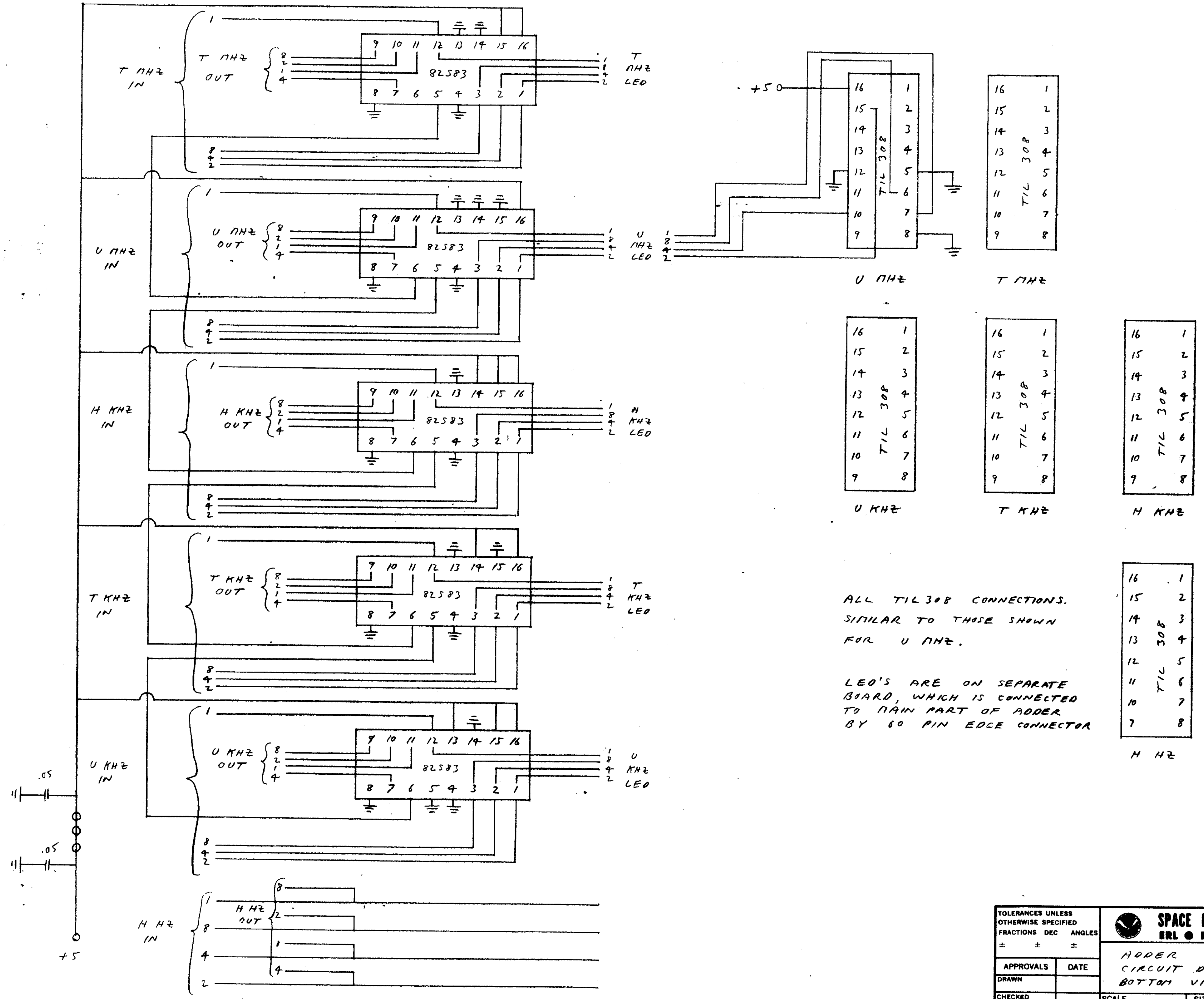
ADDER AND FREQ. DISPLAY
BLOCK DIAGRAM

APPROVALS	DATE
DRAWN	
CHECKED	

SCALE 7-20-78
SIZE C
DRAWING NO. HFS-136
DO NOT SCALE DRAWING
SHEET

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



ALL TIL308 CONNECTIONS. SIMILAR TO THOSE SHOWN FOR U MHZ.

LED'S ARE ON SEPARATE BOARD, WHICH IS CONNECTED TO MAIN PART OF ADDER BY 60 PIN EDGE CONNECTOR

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC ± ANGLES ±

APPROVALS | DATE
DRAWN
CHECKED

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

ADDER
CIRCUIT DIAGRAM
BOTTOM VIEW

SCALE 7-20-78
SIZE C
DRAWING NO. HFS-137

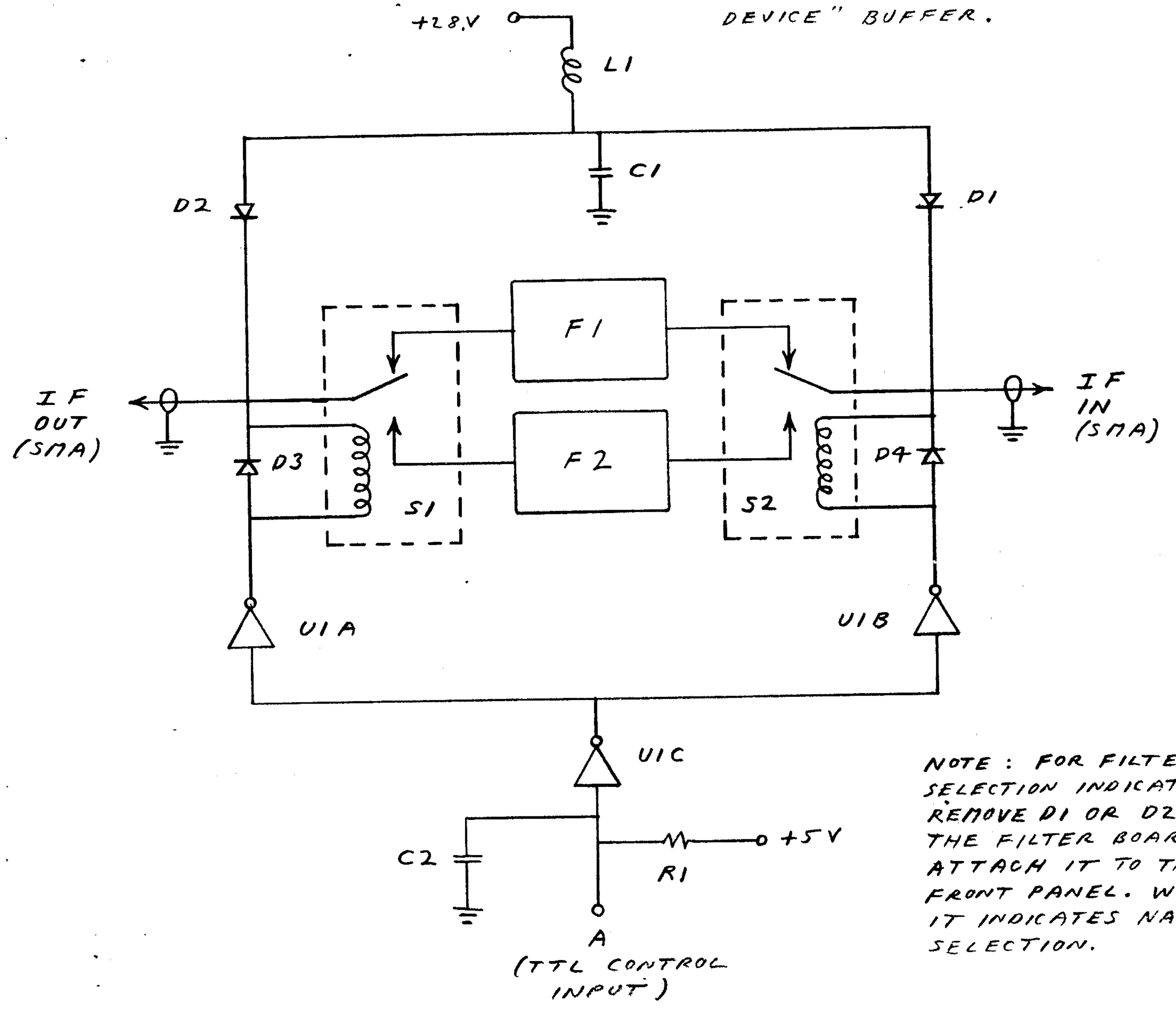
DO NOT SCALE DRAWING
SHEET

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED

DIO CONNECTIONS

IN BOTH CONTROL MODULES AND THE CONTROL/ADDER MODULE, PIN z CONNECTS TO DIO E, "TO DEVICE", BIT 7. THERE IS NO FLAG FROM THE FILTER SELECTOR, SO NO CONNECTION TO THE "FROM DEVICE" BUFFER.



NOTE : FOR FILTER SELECTION INDICATOR, REMOVE D1 OR D2 FROM THE FILTER BOARD AND ATTACH IT TO THE MODULE FRONT PANEL. WHEN ON, IT INDICATES NARROW BAND SELECTION.

PARTS LIST

R1	10 K 1/8 W 5% CARBON
C1, C2	0.1 μF 50 V MONOLITHIC
L1	FERRITE BEAD, PERMAG AR9701-1
D1, D2	LED, MONSANTO MV 5023
D3, D4	DIODE, 1N 4004
U1	HEX INVERTER, 7406
S1, S2	RELAY, TELEDYNE 712-26
F1	FILTER, DAMON 7550A (WIDE)
F2	FILTER, DAMON 7118A (NARROW)

FILTER SELECTION

DIO ADDRESSES :

CH 1 MIXER & IF	ADDR 18_H
CH 2 MIXER & IF	ADDR 19_H
TX MIXER	ADDR $1E_H$

WIDE / NARROW BAND SELECTED BY BIT 7 (MSB) AS FOLLOWS :

1XXX XXXX → WIDE
0XXX XXXX → NARROW

BACK PANEL CONNECTIONS

FILTER BOARD CONTROL TERMINAL "A" CONNECTS TO PIN "M" ON EACH MODULE 50 PIN CONNECTOR, WHICH CONNECTS TO PIN "z" (LOWER CASE) OF THE CONTROL MODULE 50 PIN CONNECTOR. THE MIXER AND IF MODULES FOR EACH CHANNEL CONNECT TO THE SAME PIN OF THE CONTROL MODULE. LINE FROM "A" TO "M" REQUIRES ONE FERRITE BEAD, SAME TYPE AS L1.

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC. ± ANGLES ±

APPROVALS	DATE
DRAWN JJ	9-8
CHECKED	80

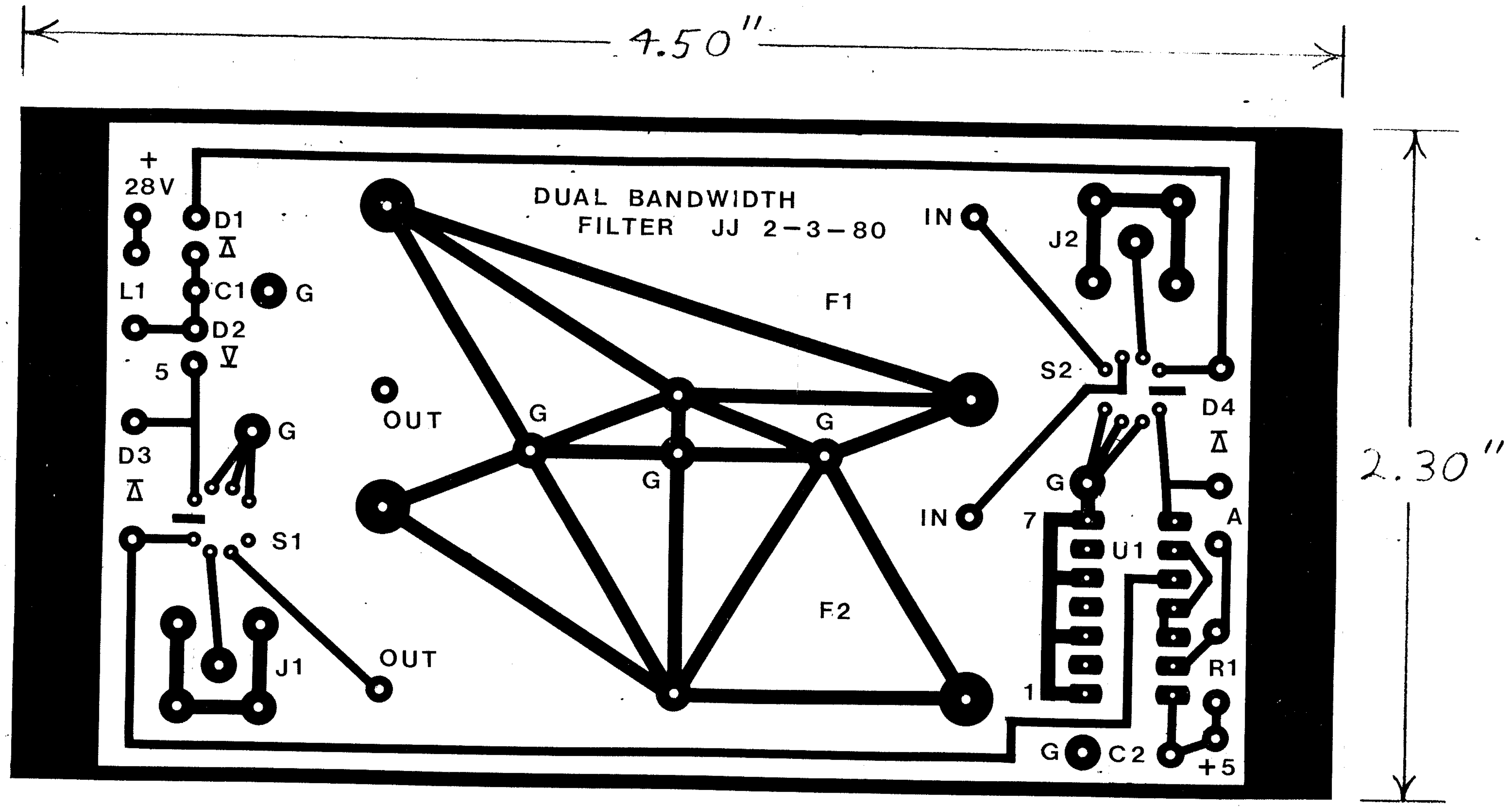
SEL - NOAA

HF RADAR RECEIVER
CRYSTAL FILTER MODIFICATION

SCALE
SIZE B
DRAWING NO. 138
DO NOT SCALE DRAWING
SHEET

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACTIONS	DEC.	ANGLES
±	±	±

DUAL BANDWIDTH FILTER

APPROVALS	DATE
DRAWN JJ	2- -
CHECKED	80

SCALE

SIZE B

DRAWING NO. 139

DO NOT SCALE DRAWING

SHEET

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

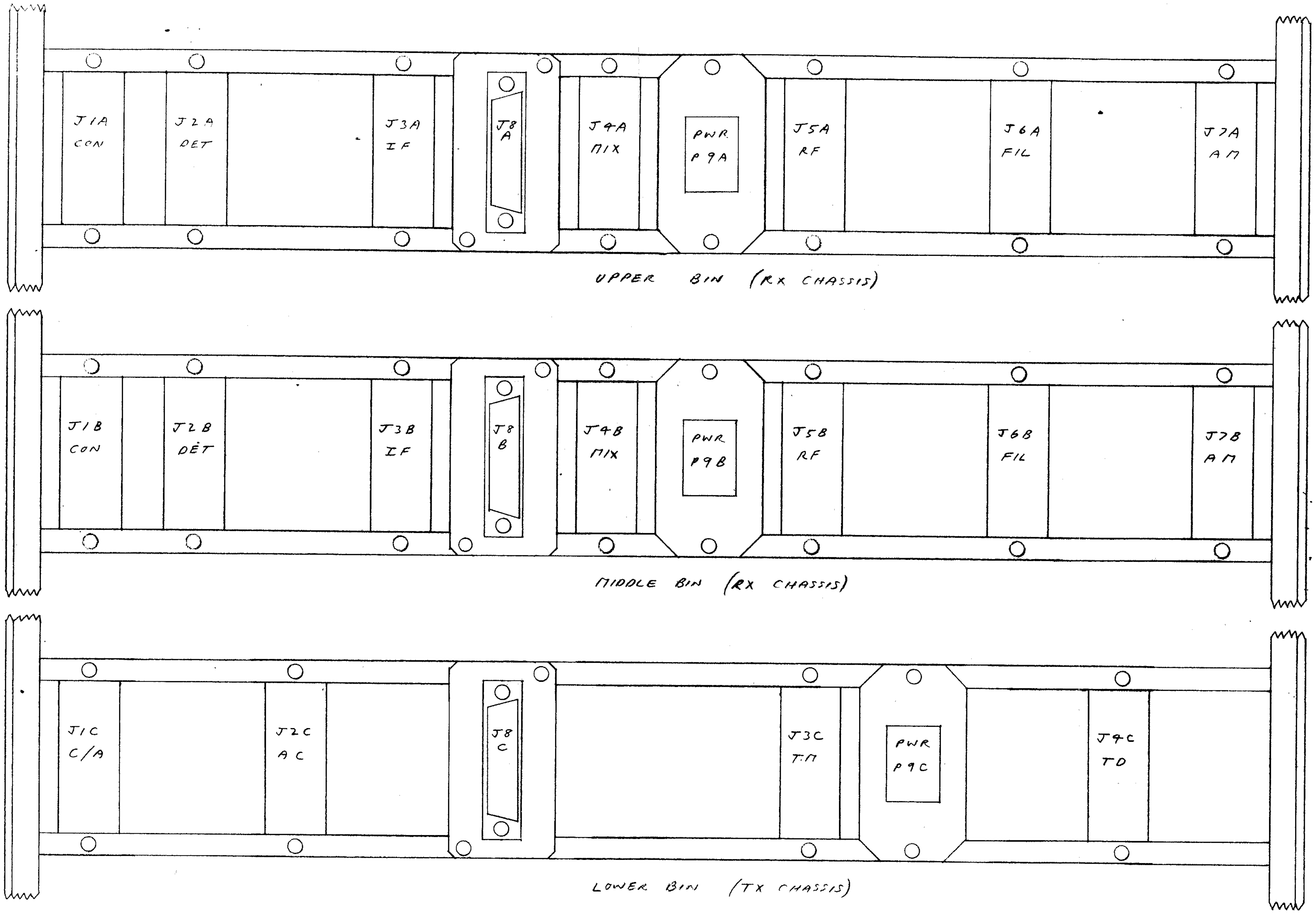
* TWO REQUIRED

LABEL	NAME	DESCRIPTION	* ANTENNA MUX MODULE	* RF MODULE	* MIXER MODULE	* IF MODULE	* DETECTOR MODULE	ANALOG CONVERTER MODULE	TRANSMITTER MIXER MODULE	TRANSMITTER DRIVE MODULE	* CONTROL MODULE	CONTROL-ADDER MODULE	SYNTHESIZER DISTRIBUTION MODULE	PREAMP MODULE	* OCTAVE FILTER MODULE	NOT IN ANY MODULE	TOTAL
A	RF AMPLIFIER	ANZAC AM-109		1										4			6
A	RF AMPLIFIER	ANZAC AM-110								1							1
A	RF AMPLIFIER	TRW CA 2810			2	1	2		1								11
A	VECTOR MODULE	INTRONICS VM-101						2									2
AT	ATTENUATOR	ALAN 50 DA 60-S		1		1											4
AT	ATTENUATOR	ALAN 50 DA 120-S								1							1
F	HIGHPASS FILTER	ALLEN F302, 40 MHZ			1												2
F	LOW PASS FILTER	ALLEN F 301, 30 MHZ		1						1							3
F	LOWPASS FILTER	ALLEN 73 MHZ											1				1
F	BANDPASS FILTER	DAMON 7118 A, 40.625 MHZ			1	1			1								5
A	OPERATIONAL AMPLIFIER	OPTICAL ELECTRONICS 9817					2										4
M	ELECTRONIC ATTENUATOR	MCL PAS-3	4						2	1							11
M	DOUBLE BALANCED MIXER	WATKINS-JOHNSON M9-E			1												2
M	ELECTRONIC ATTENUATOR	MCL PAS-1				1											2
M	DOUBLE BALANCED MIXER	MCL RAY-1					2		1								5
PS	POWER SPLITTER, 2 WAY	MCL PSC-2-1					1		1	1							4
PS	POWER SPLITTER, 4 WAY	MCL PSC-4-3							2								2
QH	QUADRATURE HYBRID	MERRIMAC QHS-3					1		1								3
S	REED RELAY	GRIGSBY-BARTON GB 822A-2					6										12
S	BINARY CODED SWITCH	EECO 177633-G		1		1				1							5
T	TRANSFORMER	VARI-L HF 128			1												2
T	TRANSFORMER	VARI-L HF 122			1												2
Q	TRANSISTOR	2N 3959			2												8
N	NIM MODULE, SINGLE WIDTH	VECTOR NIM-1387-CPA-14	1								1						4
N	NIM MODULE, DOUBLE WIDTH	VECTOR NIM-2787-CPA-14		1	1	1	1			1		1	1		1		13
N	NIM MODULE, TRIPLE WIDTH	VECTOR NIM-4087-CPA-14						1	1								2
N	NIM BIN	VECTOR CN-87A-14														3	3
OSC	CRYSTAL OSCILLATOR	GREENRAY YH-980							1								1
U	OPERATIONAL AMPLIFIER	RCA 3047	4						2								10
U	VOLTAGE COMPARATOR	NS LM 311			1			1									3
U	AUDIO AMPLIFIER	NS LM 380						1									1
U	OPERATIONAL AMPLIFIER	NS LM 531						4									4
U	DATA COMPARATOR	NS DM 8131 N									5	5					15
U	TRI-STATE BUFFER	NS DM 81LS95 N									10	10					30
U	TRI-STATE LATCH	NS DM 8553 N									5	5					15
U	QUAD NOR GATE	NS DS 8836 N									1	1					3
U	ADDER	SIGNETICS 82S83-B										5					5
U	7 SEGMENT DECODER-DISPLAY	TI TIL-308										6					6
U	QUAD NAND GATE	FAIRCHILD 7400	1	1		2	1			1							11
U	QUAD NOR GATE	FAIRCHILD 7402	2						1								5
U	HEX INVERTER BUFFER	FAIRCHILD 7406				1											2
U	HEX BUFFER	FAIRCHILD 7407	1	1		1	2			2							12
U	DECODER	FAIRCHILD 7442							1								1
U	DUAL DECODER	FAIRCHILD 9321 PC	1			1	1										6
U	QUAD MULTIPLEXER	FAIRCHILD 9322 PC	1	1		2	1			2							12
D	LIGHT EMITTING DIODE	RED	6	5		8	5	1	4	6							35
D	SILICON DIODE	1N 4004				2											2
D	SILICON DIODE	HP 2800				2											2
D	BACK DIODE	GE BD-7						2									2
VR	VOLTAGE REGULATOR	+24 V 7824			2	1	2		1								9
VR	VOLTAGE REGULATOR	+20 V MOTOROLA 7720CP		1						1							3
VR	VOLTAGE REGULATOR	+12 V 7812	1					1									3
VR	VOLTAGE REGULATOR	-12 V 7912	1					1									3
PS	POWER SPLITTER, 4 WAY	MERRIMAC PD 40-55											1				1
Q	TRANSISTOR	2N 4260			2												

TOLERANCES UNLESS OTHERWISE SPECIFIED FRACTIONS DEC ANGLES ± ± ±		**SPACE ENVIRONMENT LABORATORY** **ERL ● NOAA ● BOULDER COLO**	
APPROVALS	DATE	OVERALL RECEIVER PARTS LIST	
DRAWN			
CHECKED		SCALE 7-20-78	SIZE C
		DRAWING NO. HFS-161	
		DO NOT SCALE DRAWING	SHEET

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



TOLERANCES UNLESS OTHERWISE SPECIFIED

FRACTIONS	DEC	ANGLES
±	±	±

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

NIM BIN REAR CONNECTORS

APPROVALS	DATE
DRAWN JJ	
CHECKED	

SCALE 7-20-78

SIZE C

DRAWING NO. HFS - 162

DO NOT SCALE DRAWING

SHEET

DIO CONNECTIONS

FUNCTION			FROM	TO	TYPE	COLOR
A	ANT CON	AM	J1*A	J7* A	#24 STR.	BRN
B			B	B		RED
L/R			C	E		GRN
A	ANT FLG		D	F		BLU
B			E	H		VIO.
L/R			F	L		BLK
A	BAND CON	FIL	H	J6* A		BRN
B			J	B		RED
C			K	C		ORA
D			L	D		YEL
L/R			M	E		GRN
A	BAND FLG		N	F		BLU
B			P	H		VIO
C			R	J		GRA
D			S	K		WHI
L/R			T	L		BLK
4	ATTN CON	RF	U	J5* A		BRN
8			V	B		RED
16			W	C		ORA
32			X	D		YEL
L/R			Y	E		GRN
4	ATTN FLG		Z	F		BLU
8			a	H		VIO
16			b	J		GRA
32			c	K		WHI
L/R			d	L		BLK
4	ATTN CON	IF	e	J3* A		BRN
8			f	B		RED
16			h	C		ORA
32			j	D		YEL
L/R			k	E		GRN
4	ATTN FLG		m	F		BLU
8			n	H		VIO
16			p	J		GRA
32			r	K		WHI
L/R			s	L		BLK
A	BW CON	DET	t	J2* A		BRN
B			u	B		RED
L/R			v	E		GRN
A	BW FLG		w	F		BLU
B			x	H		VIO
L/R			y	L		BLK
8	ATTN CON	TD	J1C-A	J4C-A		BRN
16			B	B		RED
32			C	C		ORA
64			D	D		YEL
L/R			E	E		GRN
8	ATTN FLG		F	F		BLU
16			H	H		VIO
32			J	J		GRA
64			K	K		WHI
L/R			L	L		BLK

* A AND B

TSG CONNECTIONS

FUNCTION		FROM	TO	TYPE	COLOR	
					MPI	NOAA
TX ENABLE		J8* 1		#24 STR.		
RESET		2	J3* N		RED	VIO
RX DISABLE		3	J7* N		RED	GRN
TX KEY		4				
φ1	TX φ CODE	5				
φ2		6				
φ3 RX φ CODE		7	J7*P		ORA	BLU
A	FAST ATTN	8	J3*P		ORA	GRA
B		9	J3*R		YEL	WHI
OVERLOAD (ANALOG)		12				
RX DISABLE (+15 dBm)		13	J3*T		BLU	RED
GND		25	GND		BLK	BLK
GND		11	GND		BLK	BLK
TX ENABLE		J8C-1	J4C-N	#22 STR.	RED	RED
RESET		2				
RX DISABLE		3				
TX KEY		4	J3C-R	#24 STR.	YEL	YEL
φ1	TX φ CODE	5	N		RED	RED
φ2		6	P		ORA	ORA
φ3 RX φ CODE		7				
A	FAST ATTN	8				
B		9				
OVERLOAD (ANALOG)		12	J2C-T		BLU	BLU
RX DISABLE (+15 dBm)		13				
GND		25	GND	#22 STR.	BLK	BLK
GND		11	GND	"		

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED
A	DIO "TO" CONNECTIONS CORRECTED	2-3-81	JJ

POWER CONNECTIONS

FUNCTION	P9 PIN	COLOR
+28 V	5	BLUE
+15 V	4	RED
-15 V	2	WHITE
+5 V	3	ORANGE
GND	1, 6	BLACK

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS DEC ANGLES
± ± ±

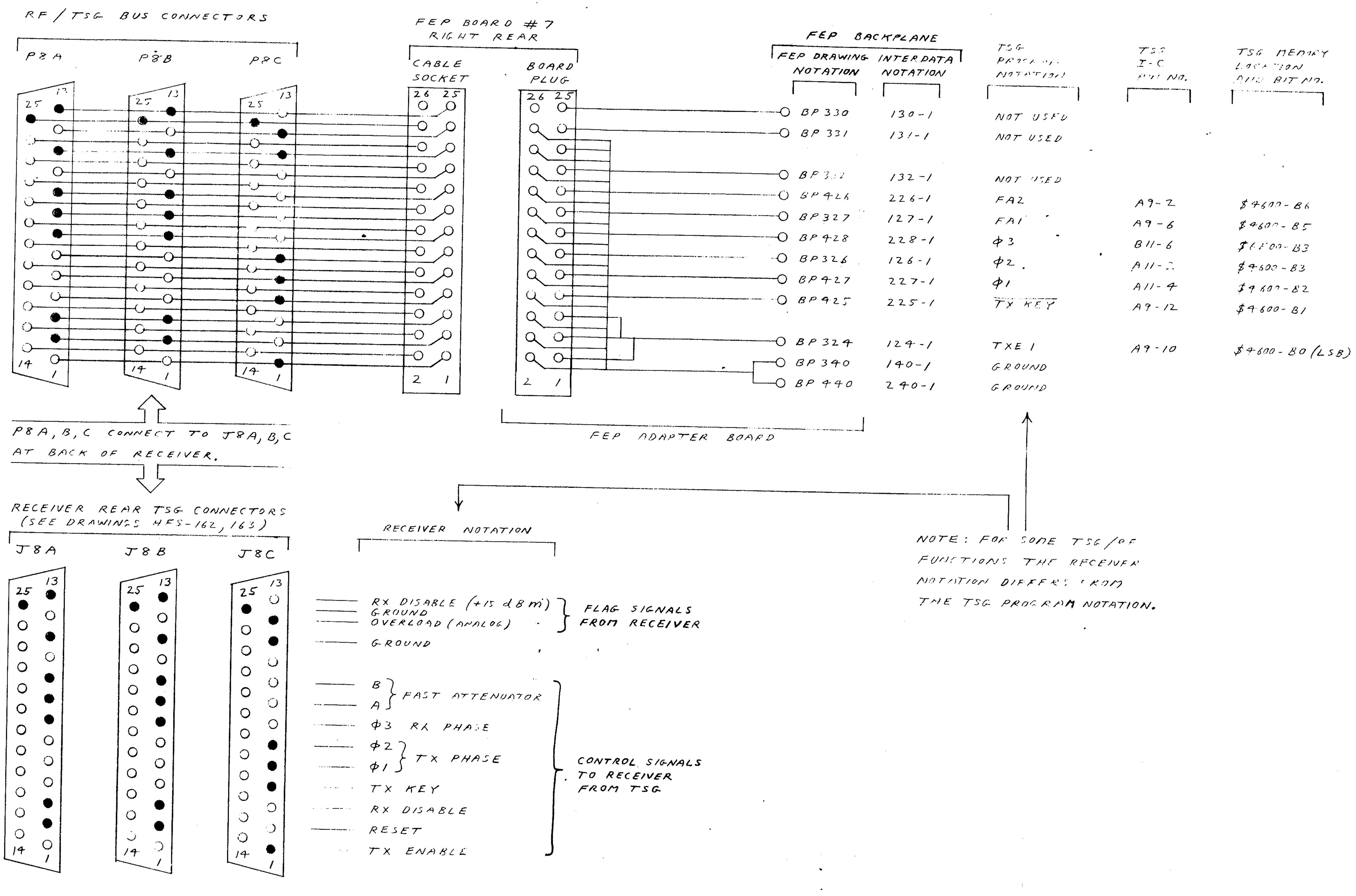
APPROVALS	DATE
DRAWN	
CHECKED	

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

NIM BIN
REAR CONNECTIONS AND
CABLES

SCALE 7-20-78
SIZE C
DRAWING NO. HFS-163
DO NOT SCALE DRAWING
SHEET

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



FEP DRAWING NOTATION	INTERDATA NOTATION	TSG PROGRAM NOTATION	TSG I-C PIN NO.	TSG MEMORY LOCATION AND BIT NO.
BP 330	130-1	NOT USED		
BP 331	131-1	NOT USED		
BP 332	132-1	NOT USED		
BP 426	226-1	FA2	A9-2	$4600-B6
BP 327	127-1	FA1	A9-6	$4600-B5
BP 428	228-1	Φ3	B11-6	$4600-B3
BP 326	126-1	Φ2	A11-2	$4600-B3
BP 427	227-1	Φ1	A11-4	$4600-B2
BP 425	225-1	TX KEY	A9-12	$4600-B1
BP 324	124-1	TXE 1	A9-10	$4600-B0 (LSB)
BP 340	140-1	GROUND		
BP 440	240-1	GROUND		

NOTE: FOR SOME TSG/RF FUNCTIONS THE RECEIVER NOTATION DIFFERS FROM THE TSG PROGRAM NOTATION.

● INDICATES CONNECTION TO RECEIVER MODULES

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS DEC ANGLES
± ± ±

APPROVALS	DATE
DRAWN JJ	7-6
CHECKED	81

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

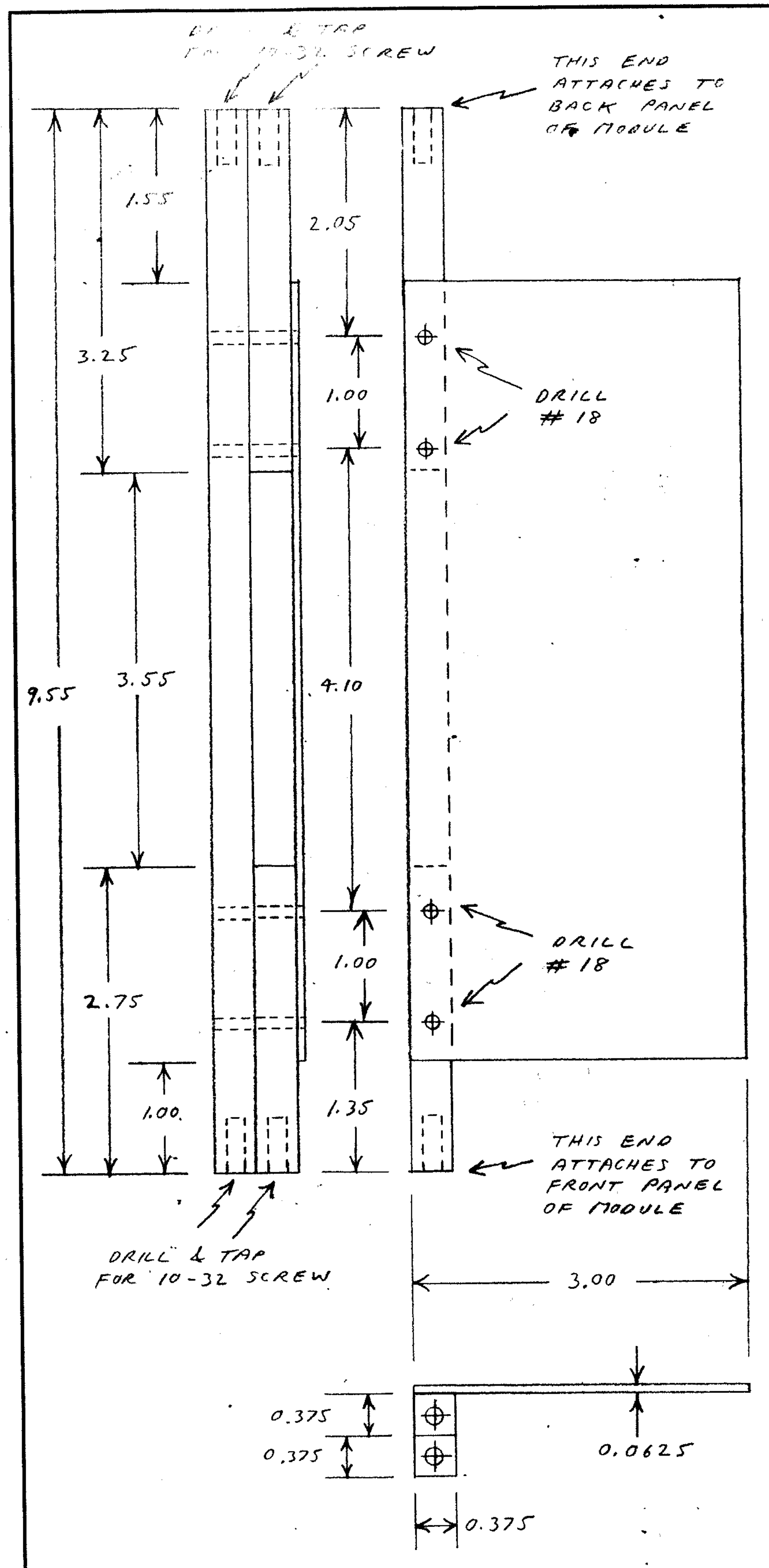
RF/TSG BUS CONNECTIONS
TO RECEIVER AND FEP

SCALE
SIZE C
DRAWING NO. 163-A
DO NOT SCALE DRAWING
SHEET

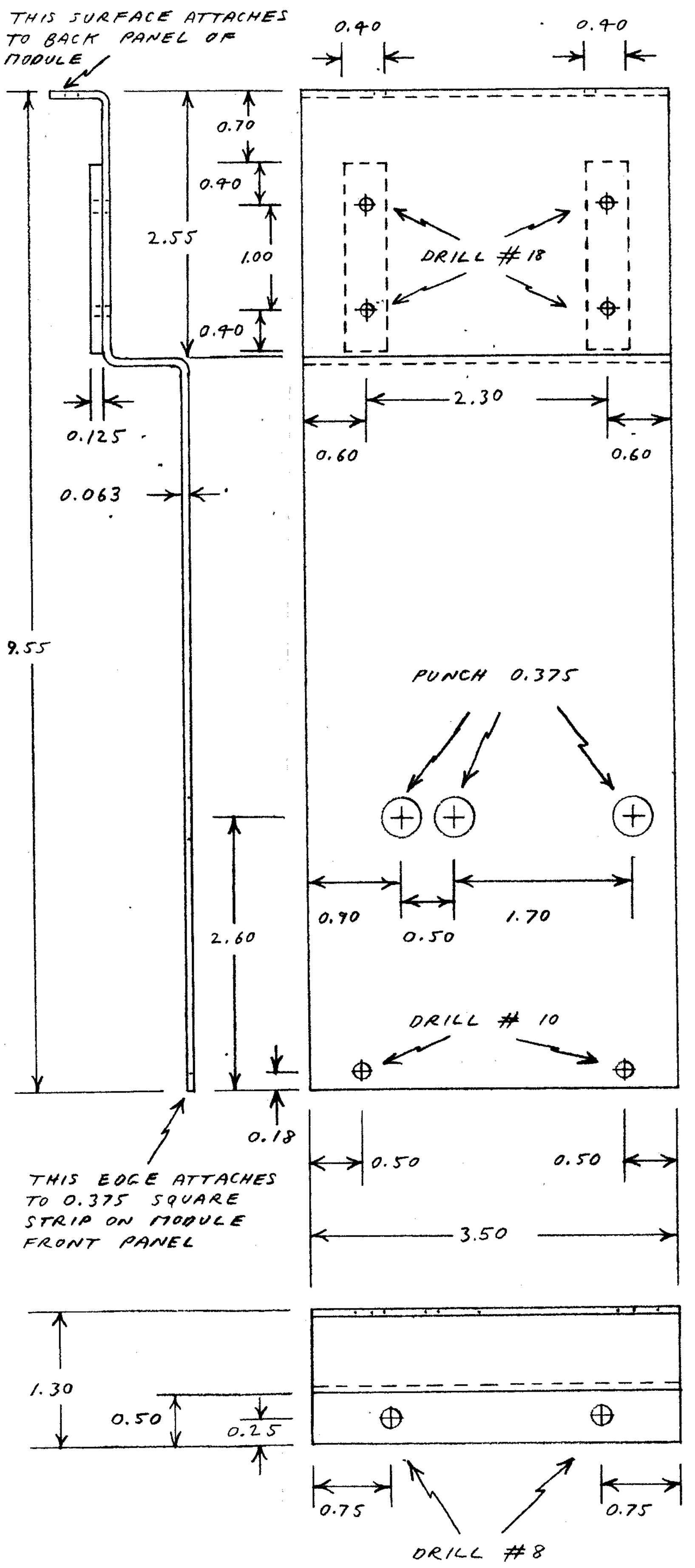
REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

NOTES:

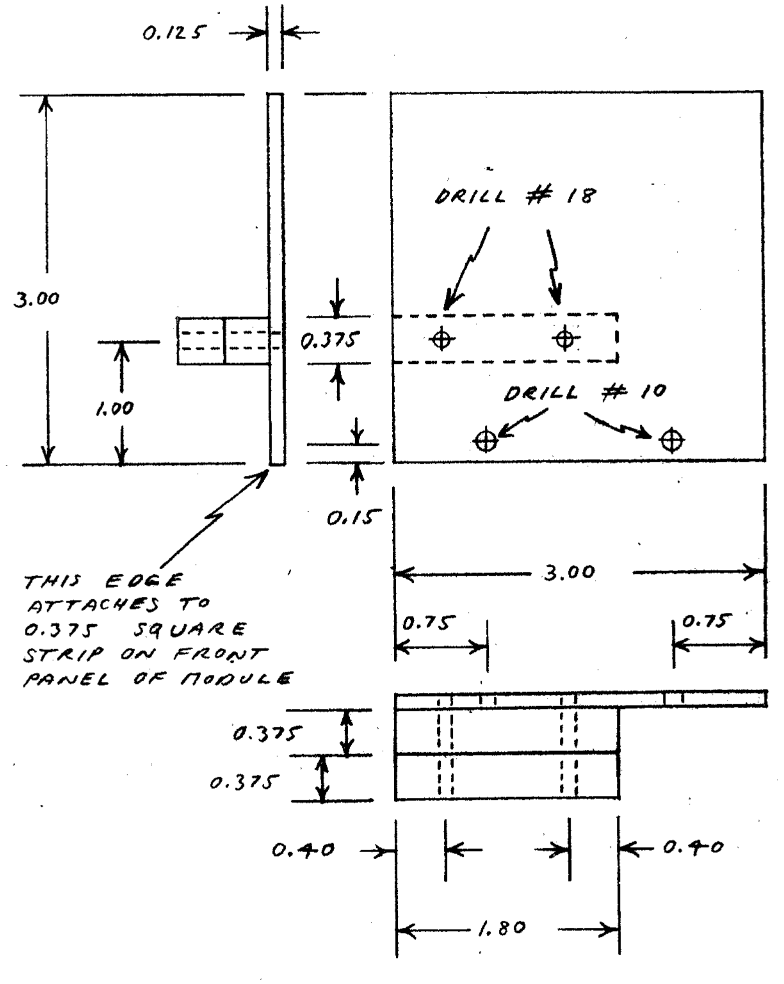
(1) ALL MATERIAL IS ALUMINUM.
(2) ALL #18 HOLES ARE FOR 6-32 SCREWS.
(3) ALL #10 HOLES ARE FOR 8-32 SCREWS.
(4) ALL #8 HOLES ARE FOR 10-32 SCREWS.
(5) DIMENSIONS IN INCHES



MIXER MODULE



DETECTOR MODULE



IF MODULE

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC ±.03" ANGLES ±

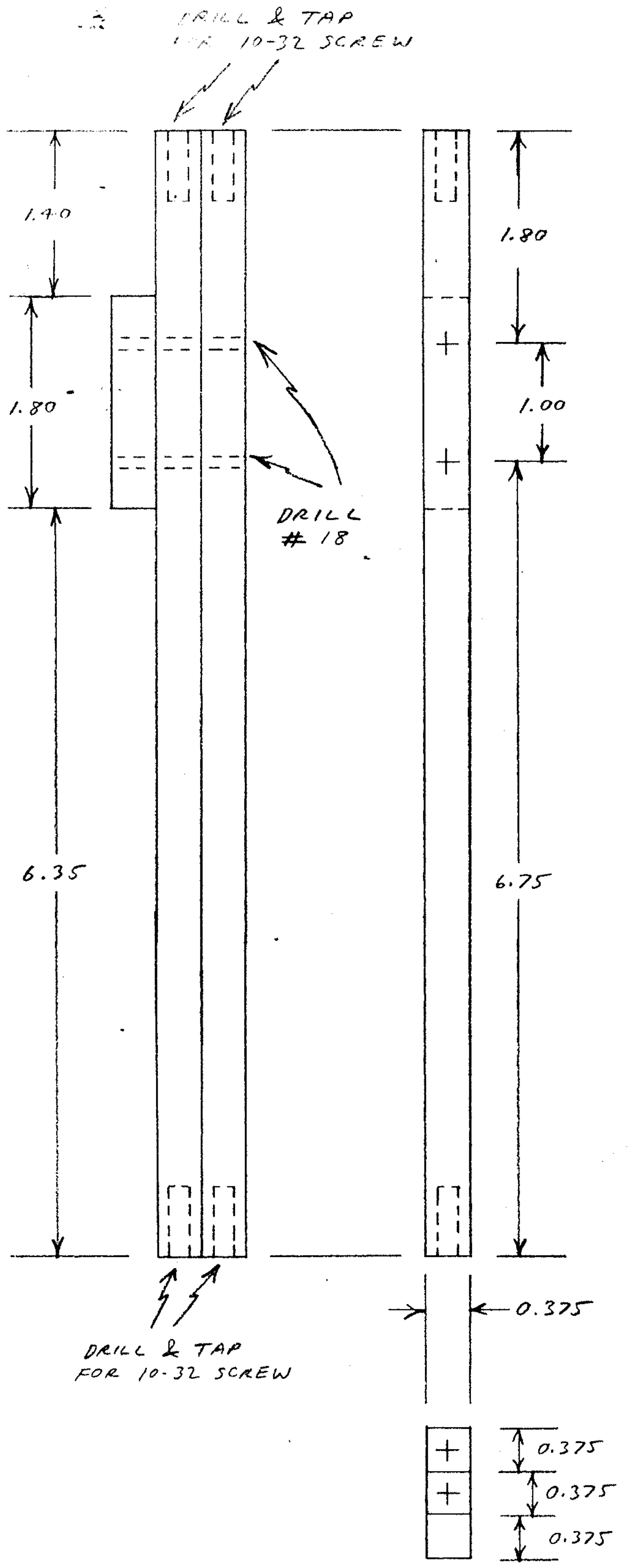
APPROVALS	DATE
DRAWN JJ	7-20-78
CHECKED	

SPACE ENVIRONMENT LABORATORY
ERL • NOAA • BOULDER COLO

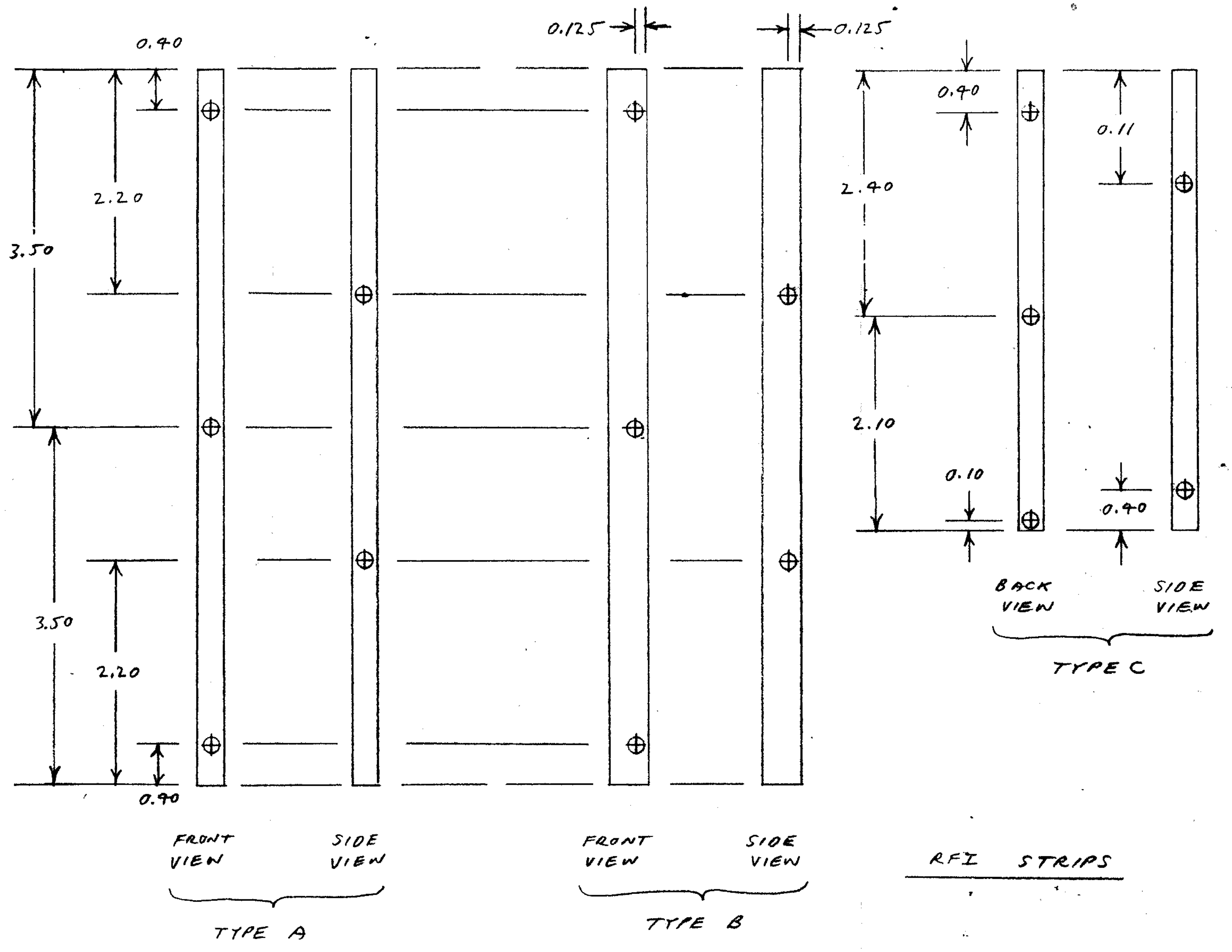
RECEIVER MODULE HEAT SINKS AND RFI STRIPS

SCALE
SIZE C
DRAWING NO. HFS-164
DO NOT SCALE DRAWING
SHEET 1/2

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



TRANSMITTER MIXER MODULE



RFI STRIPS

NOTES: (1) ALL MATERIAL IS ALUMINUM
(2) #18 HOLES ARE FOR 6-32 SCREWS
(3) ALL HOLES IN EMI STRIPS ARE DRILLED AND TAPPED FOR 4-40 SCREWS
(4) DIMENSIONS IN INCHES

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC ± .03" ANGLES ±

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

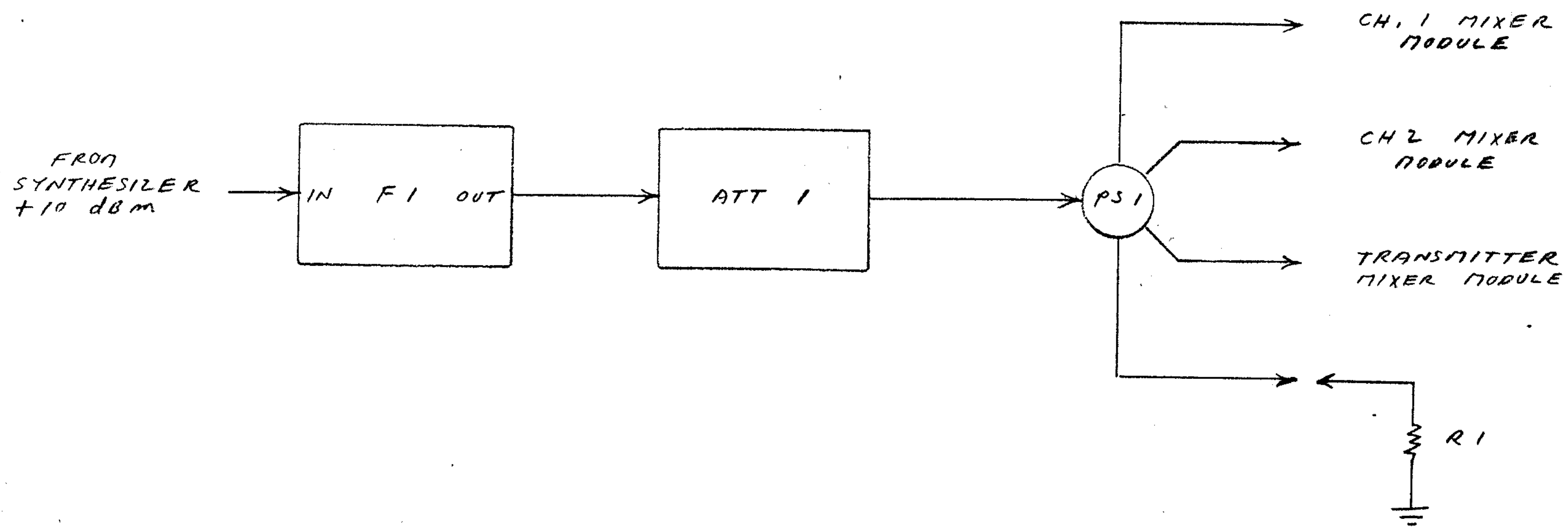
APPROVALS	DATE
DRAWN JJ	7-20
CHECKED	78

RECEIVER MODULE
HEAT SINKS AND
RFI STRIPS

SCALE
SIZE C
DRAWING NO. HFS-164
DO NOT SCALE DRAWING
SHEET 2/2

REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



F1	LOWPASS FILTER, ALLEN AVIONICS FC 73 MHZ Z 50
ATT 1	COAXIAL ATTENUATOR, 3 dB, 50 Ω
PS 1	4 WAY POWER SPLITTER, MERRIMAC PD-40-55
R 1	COAXIAL TERMINATION, 50 Ω

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC ± ANGLES ±

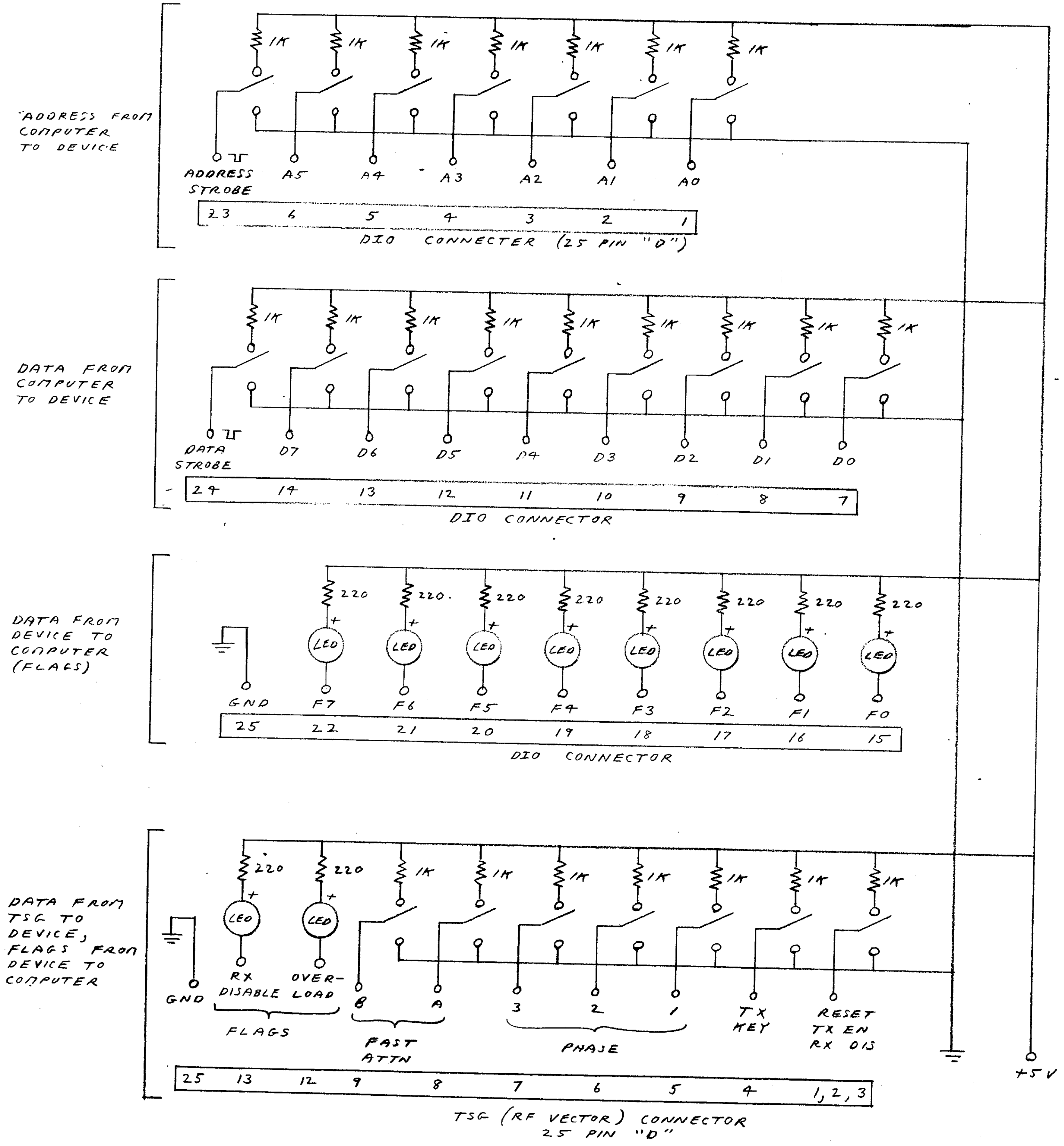
APPROVALS	DATE
DRAWN	7-20
CHECKED	78

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

SYNTHESIZER DISTRIBUTION MODULE

SCALE
SIZE C
DRAWING NO. HFS 165
DO NOT SCALE DRAWING
SHEET

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
A	CONNECTOR PIN ADDED	11-11-87	TJ



TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC ± ANGLES ±

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

APPROVALS	DATE
DRAWN	7-20
CHECKED	78

DIO - TSG SIMULATOR

SCALE

SIZE C

DRAWING NO. HFS - 166

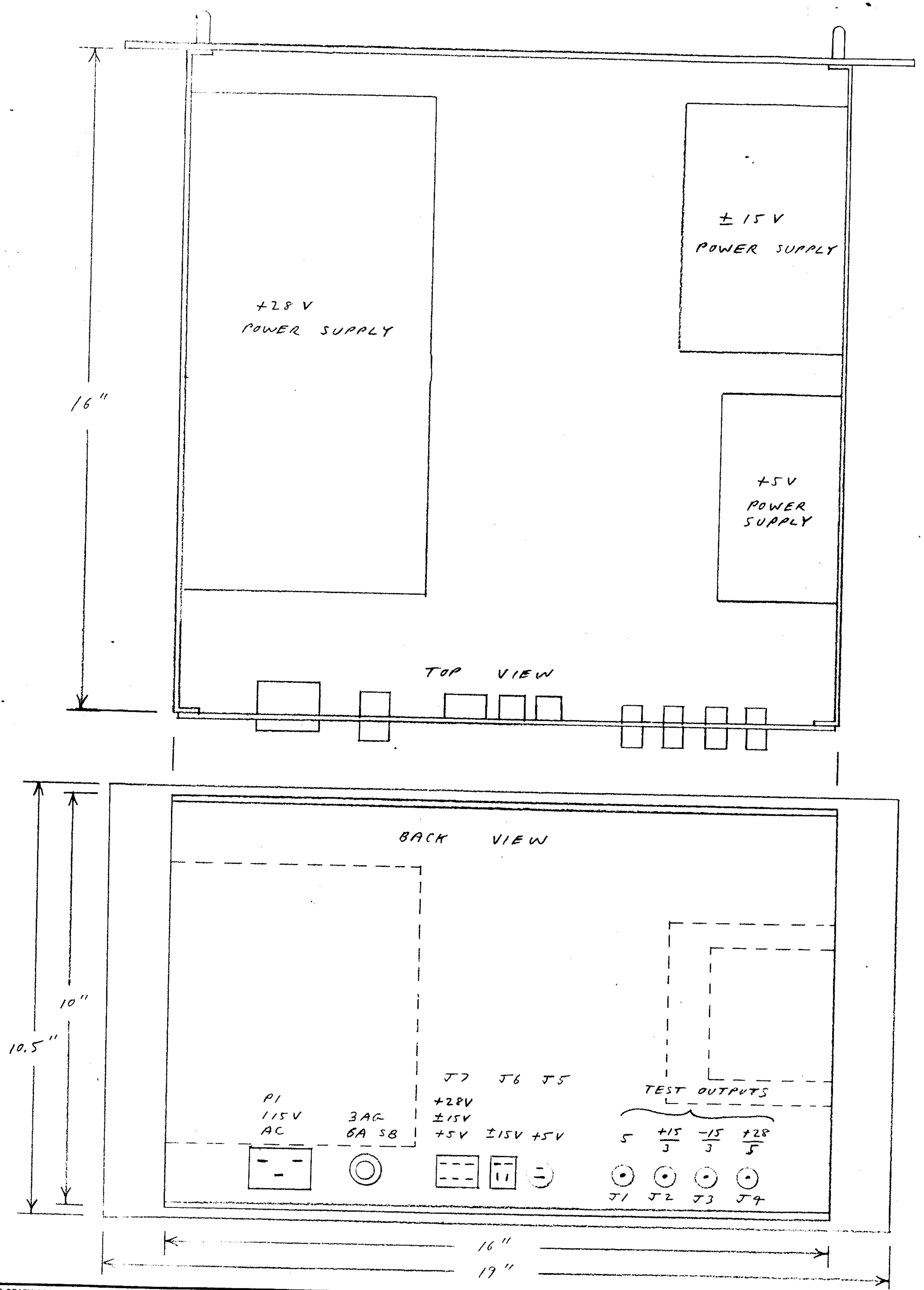
DO NOT SCALE DRAWING

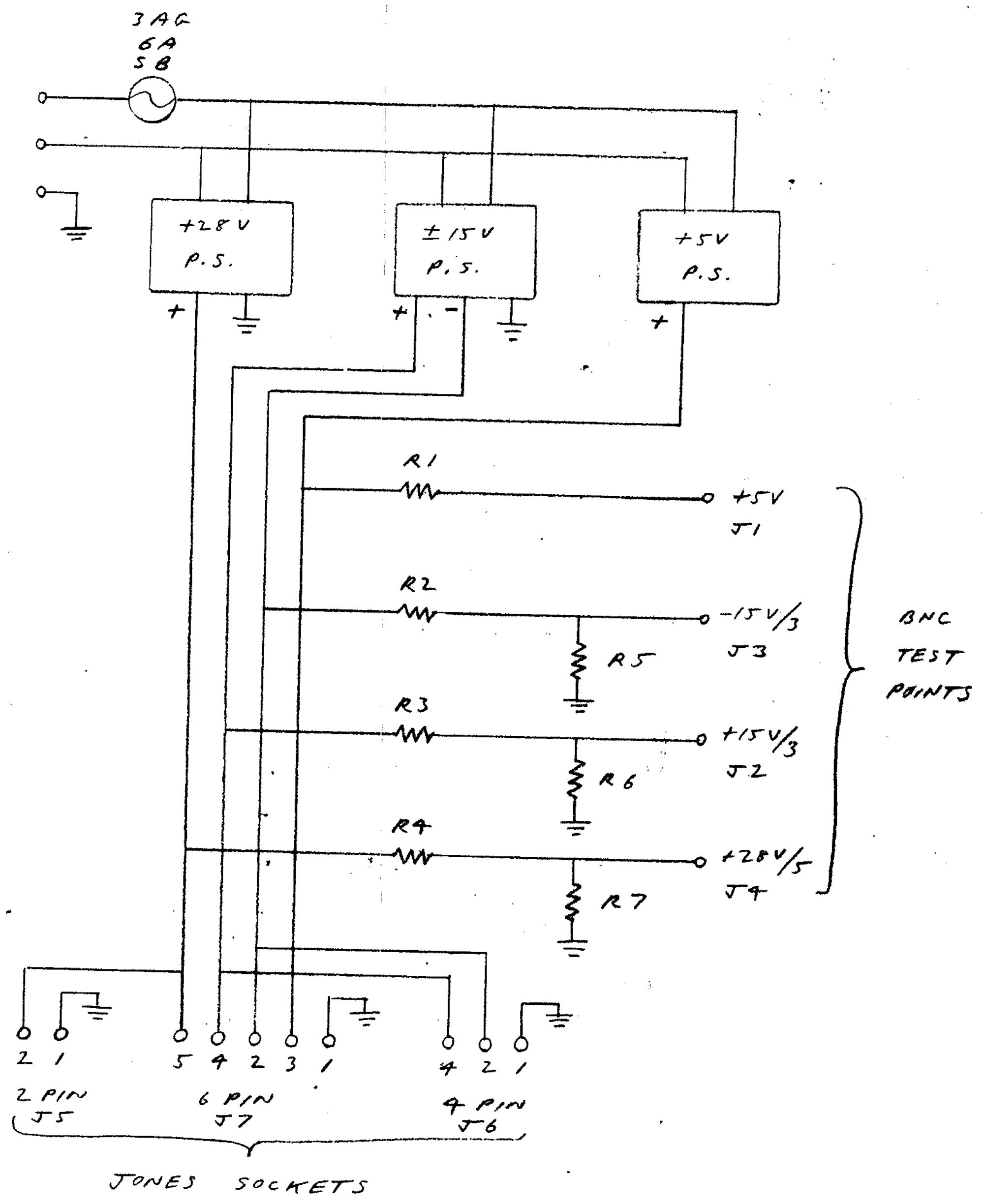
SHEET

BISHOP GRAPHICS/ACCUPRESS
REORDER NO. A-5766

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED

NOTES:
(1) TOP, BOTTOM, SIDES, AND BACK PANELS ARE 0.0625" ALUM.
(2) FRONT PANEL IS STANDARD 10.5" X 19" X 0.125" RACK PANEL.
(3) TOP AND BOTTOM PANELS ARE PUNCHED WITH 40 SQUARE INCHES OF HOLES FOR VENTILATION.
(4) 4.25" HANDLES ON FRONT PANEL.
(5) POWER SUPPLIES BOLTED TO SIDE PANELS





R1	1K	1/4 W 1 %
R2, R3	3K	
R4	5K	
R5, R6	1.5K	
R7	1.25K	

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC ± ANGLES ±

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

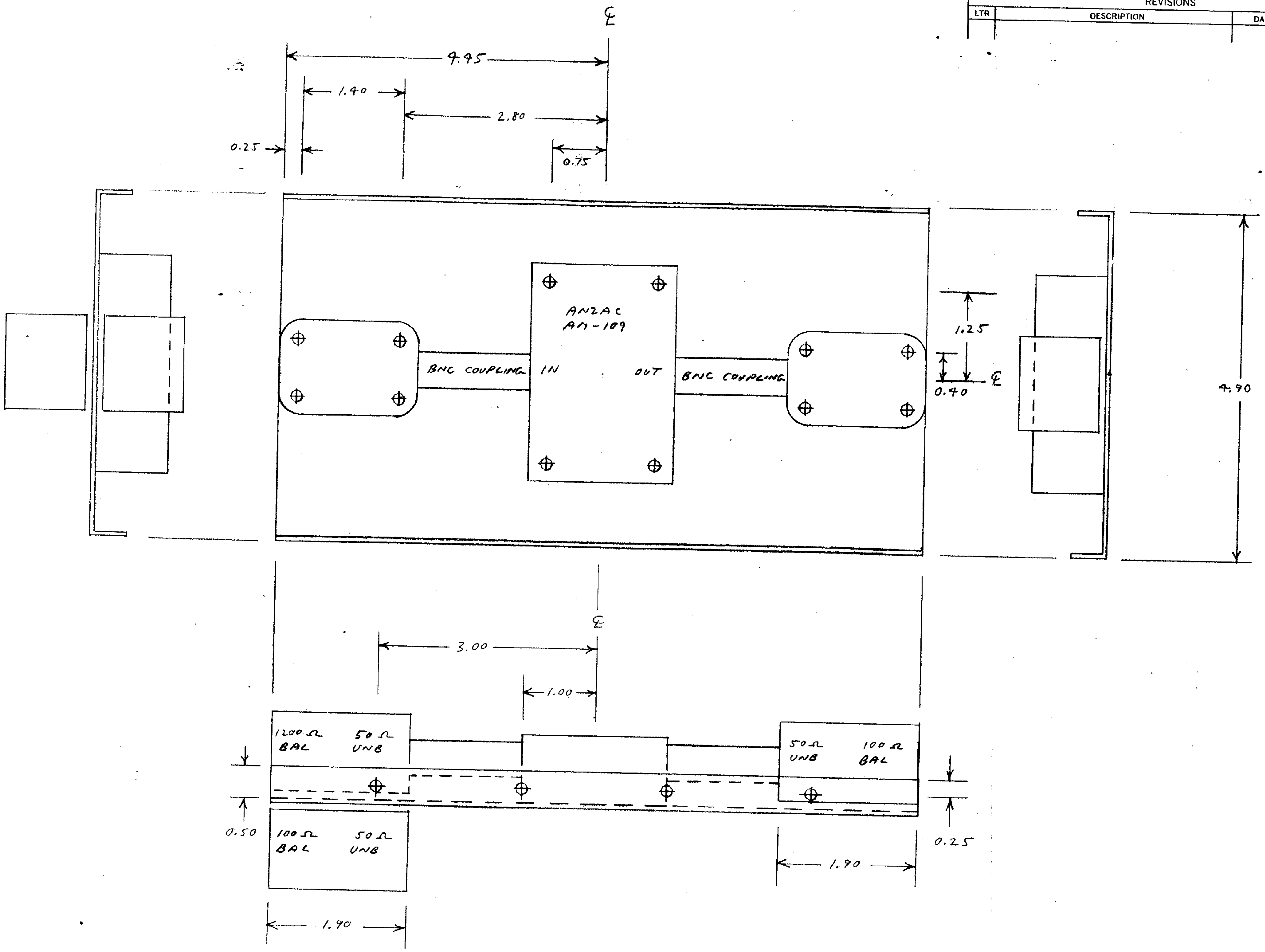
APPROVALS	DATE
DRAWN JJ	7-20
CHECKED	78

RECEIVER POWER SUPPLY

SCALE
SIZE C
DRAWING NO. HFS-167
DO NOT SCALE DRAWING
SHEET

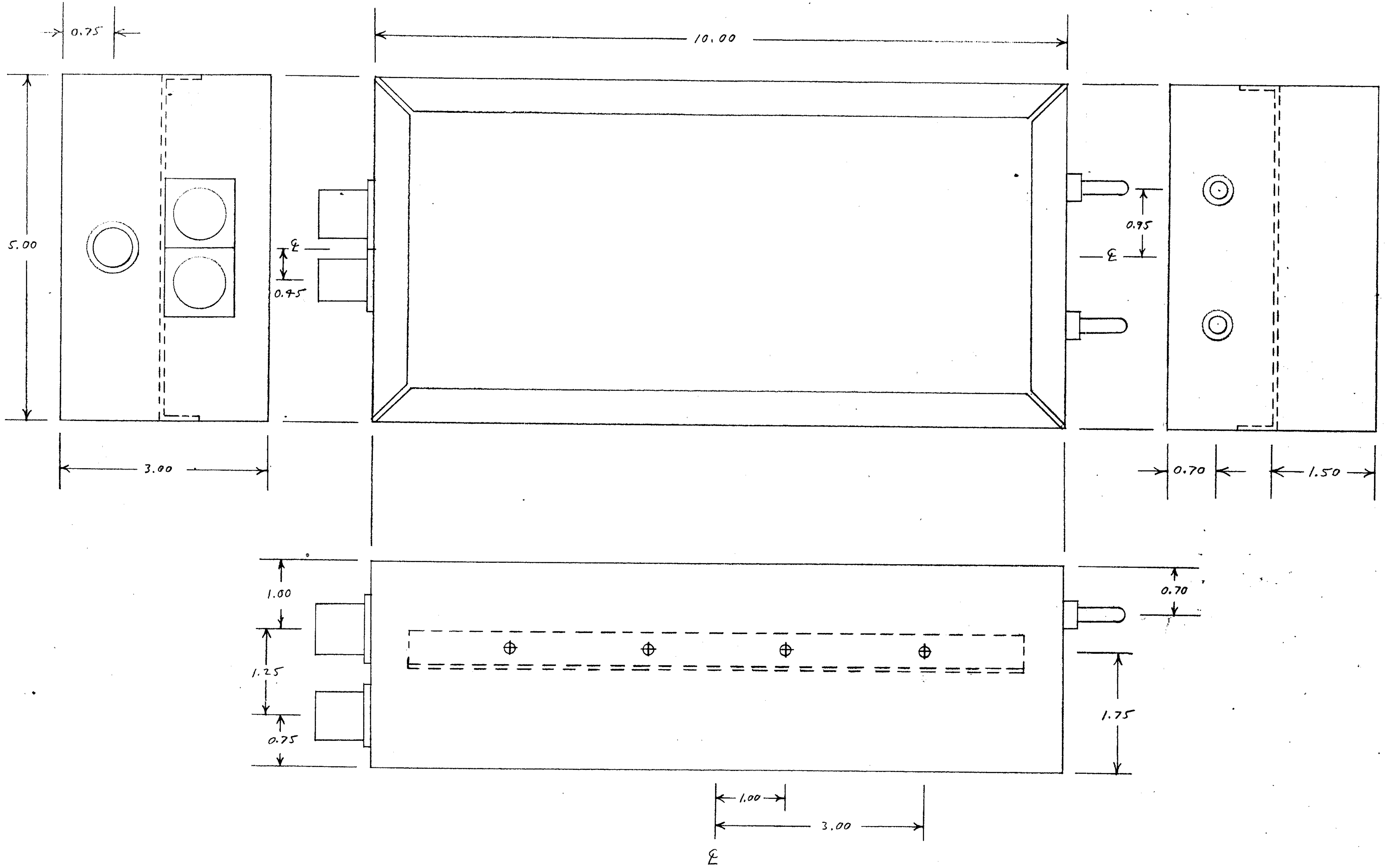
REVISIONS

LTR	DESCRIPTION	DATE	APPROVED



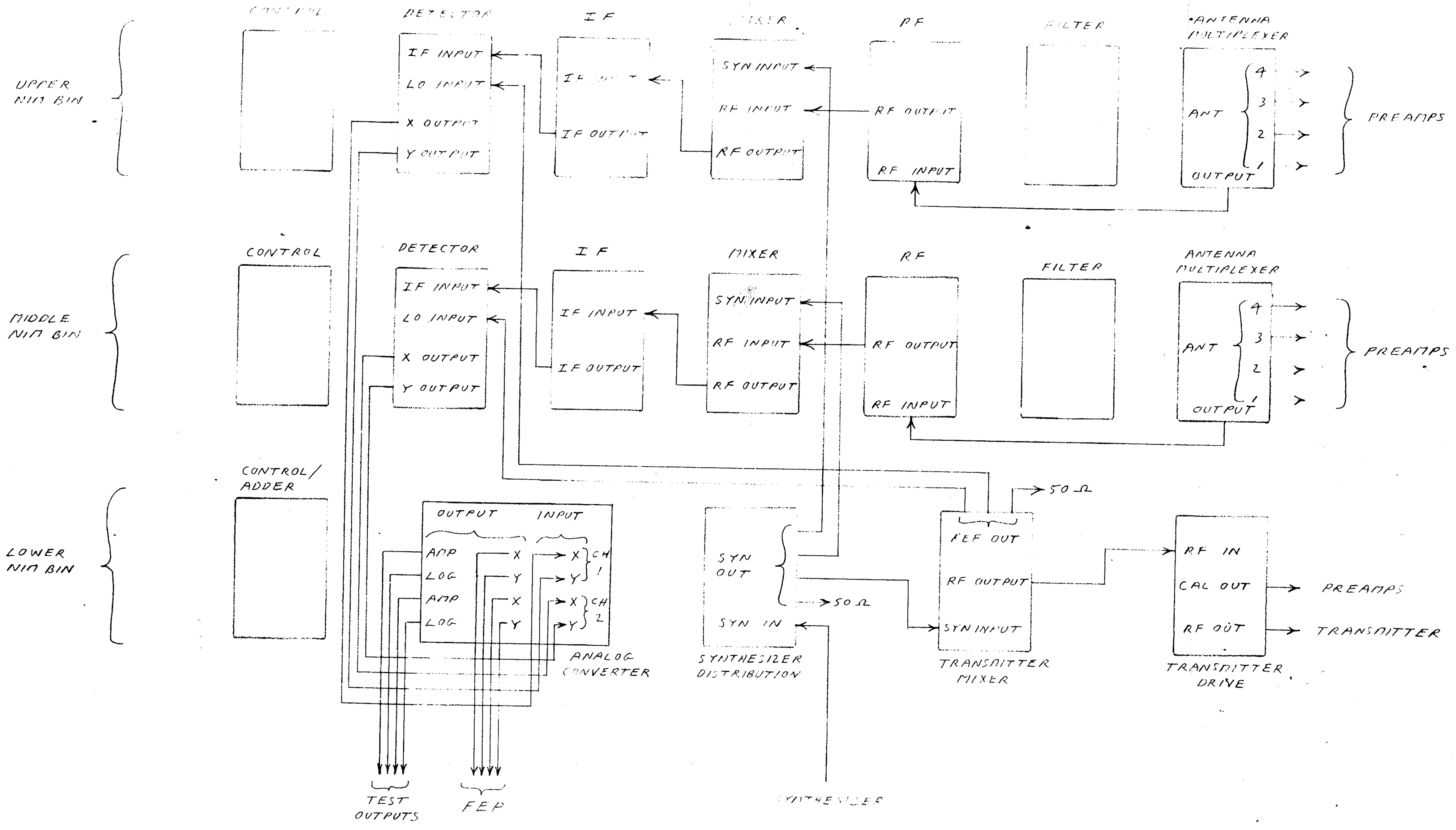
TOLERANCES UNLESS OTHERWISE SPECIFIED FRACTIONS DEC ANGLES ± ± ±	**SPACE ENVIRONMENT LABORATORY** **ERL ● NOAA ● BOULDER COLO**
APPROVALS / DATE	ANTENNA PREAMP BOX - INTERNAL PARTS
DRAWN 7-20	
CHECKED 78	SCALE / SIZE C / DRAWING NO. HFS-168
	DO NOT SCALE DRAWING / SHEET

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



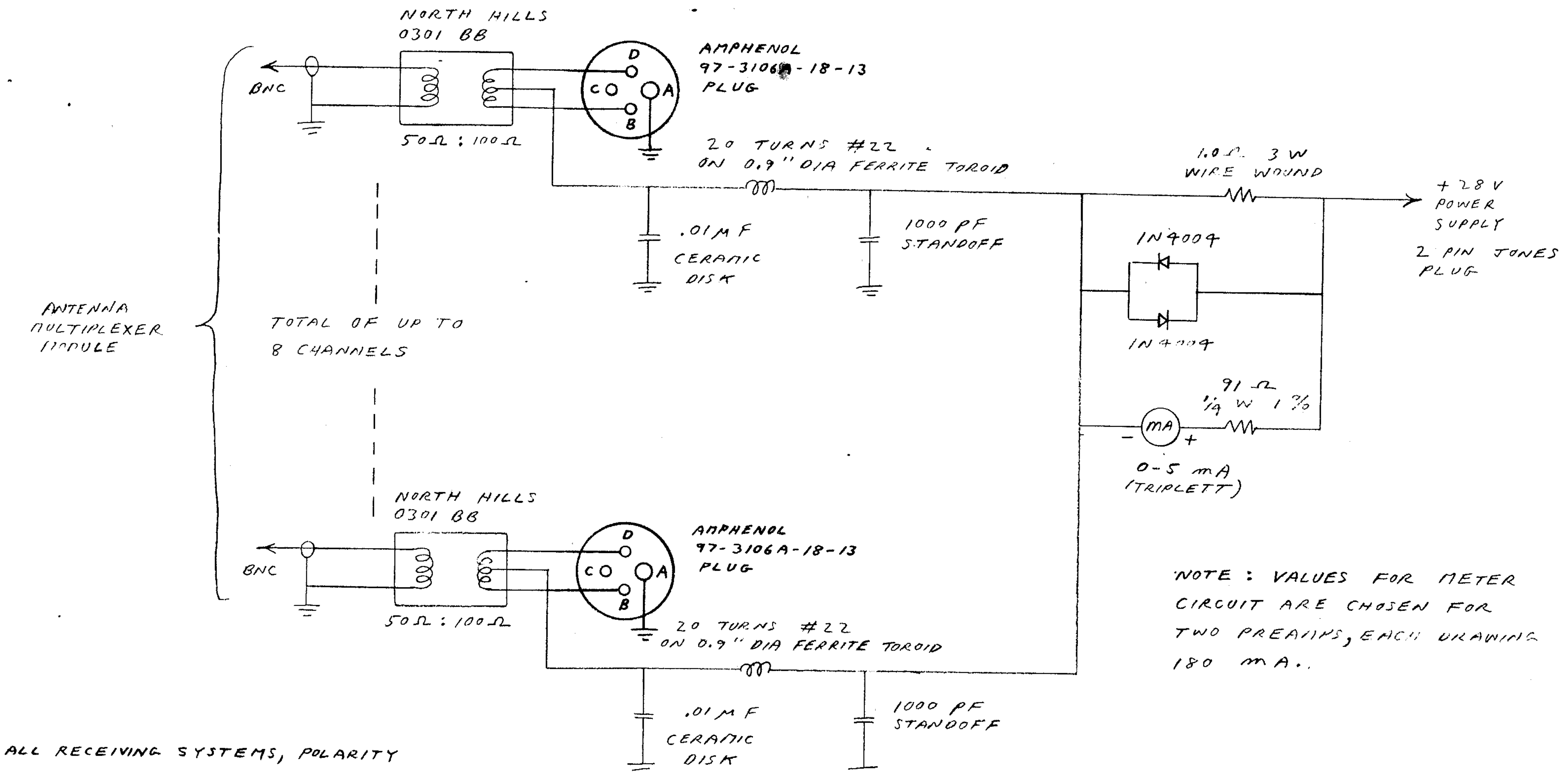
TOLERANCES UNLESS OTHERWISE SPECIFIED FRACTIONS DEC ANGLES ± ± ±	**SPACE ENVIRONMENT LABORATORY** **ERL ● NOAA ● BOULDER COLO**
APPROVALS DATE	ANTENNA PREAMP BOX - EXTERNAL PARTS
DRAWN 7-20	
CHECKED 78	SCALE SIZE C DRAWING NO. HFS-169
	DO NOT SCALE DRAWING SHEET

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED



TOLERANCES UNLESS OTHERWISE SPECIFIED		**SPACE ENVIRONMENT LABORATORY** **ERL ● NOAA ● BOULDER COLO**		
FRACTIONS ± DEC ± ANGLES ±		RECEIVER COAXIAL CABLE CONNECTIONS		
APPROVALS	DATE			
DRAWN J. T.	11-25			
CHECKED	78	SCALE	SIZE C	DRAWING NO. [illegible]
		DO NOT SCALE DRAWING		SHEET

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
A	PREAMP CONNECTOR CHANGED	7-6-81	JJ
B	NOTE ADDED	7-28-81	JJ



NOTE : VALUES FOR METER CIRCUIT ARE CHOSEN FOR TWO PREAMPS, EACH DRAWING 180 mA..

NOTE : IN ALL RECEIVING SYSTEMS, POLARITY BETWEEN THE BALANCED OUTPUT OF THE 0301 BB TRANSFORMER AT THE ANTENNA PREAMP (DRAWING 413) AND THE BALANCED INPUT OF THE 0301 BB TRANSFORMER AT THE RECEIVER PREAMP PANEL MUST BE CONSISTANT, SO THAT THE PHASES OF THE RF SIGNALS AT THE RECEIVER INPUT WILL BE CONSISTANT. CONSISTANT POLARITY MUST BE MAINTAINED IN THE WIRING BETWEEN TRANSFORMERS AND AMPHENOL CONNECTORS, AND IN THE RG-22 TWINAXIAL TRANSMISSION LINE FROM PREAMP TO RECEIVER.

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC ± ANGLES ±

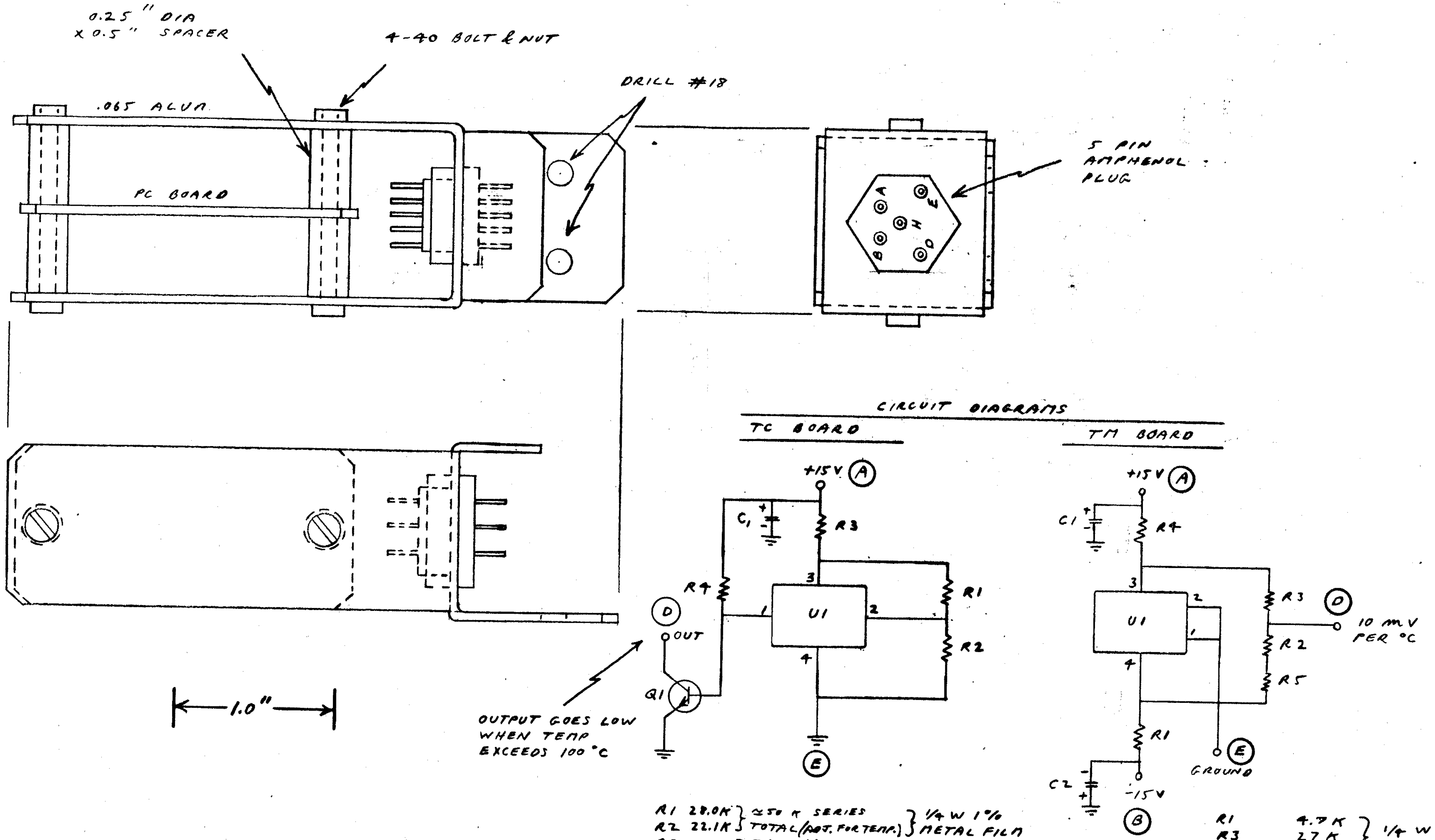
APPROVALS	DATE
DRAWN JJ	11-29
CHECKED	78

SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

RECEIVER PREAMP PANEL, CIRCUIT DIAGRAM

SCALE
SIZE C
DRAWING NO. HFS 171
DO NOT SCALE DRAWING
SHEET

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
A	CIRCUIT DIAGRAM, PARTS LIST, MECH DRAWING REVISED.	4-4-79	JJ
B	Q1 ADDED	6-27-79	JJ
C	SENSOR OUTPUT NOTES REVISED	3-11-80	JJ



OUTPUT GOES LOW WHEN TEMP EXCEEDS 100 °C

R1 28.0K } ≃50 K SERIES } 1/4 W 1%
R2 22.1K } TOTAL (ADJ. FOR TEMP.) } METAL FILM
R3 7.5K 1/4 W 5% METAL FILM
R4 1.0 M 1/4 W 5% CARBON

C1 1.0 μF SOLID TANTALUM
U1 NATIONAL SEMICONDUCTOR LX5700
Q1 2N3904

R1 4.7 K } 1/4 W 5%
R3 27 K } METAL FILM
R4 12 K }
R2, R5 ≃ 40 K SERIES TOTAL, FOR TEMP ADJUST } 1/4 5% OR 1% M.F.
C1, C2 1.0 μF SOLID TANTALUM
U1 NATIONAL SEMICONDUCTOR LX 5700

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± DEC ± ANGLES ±

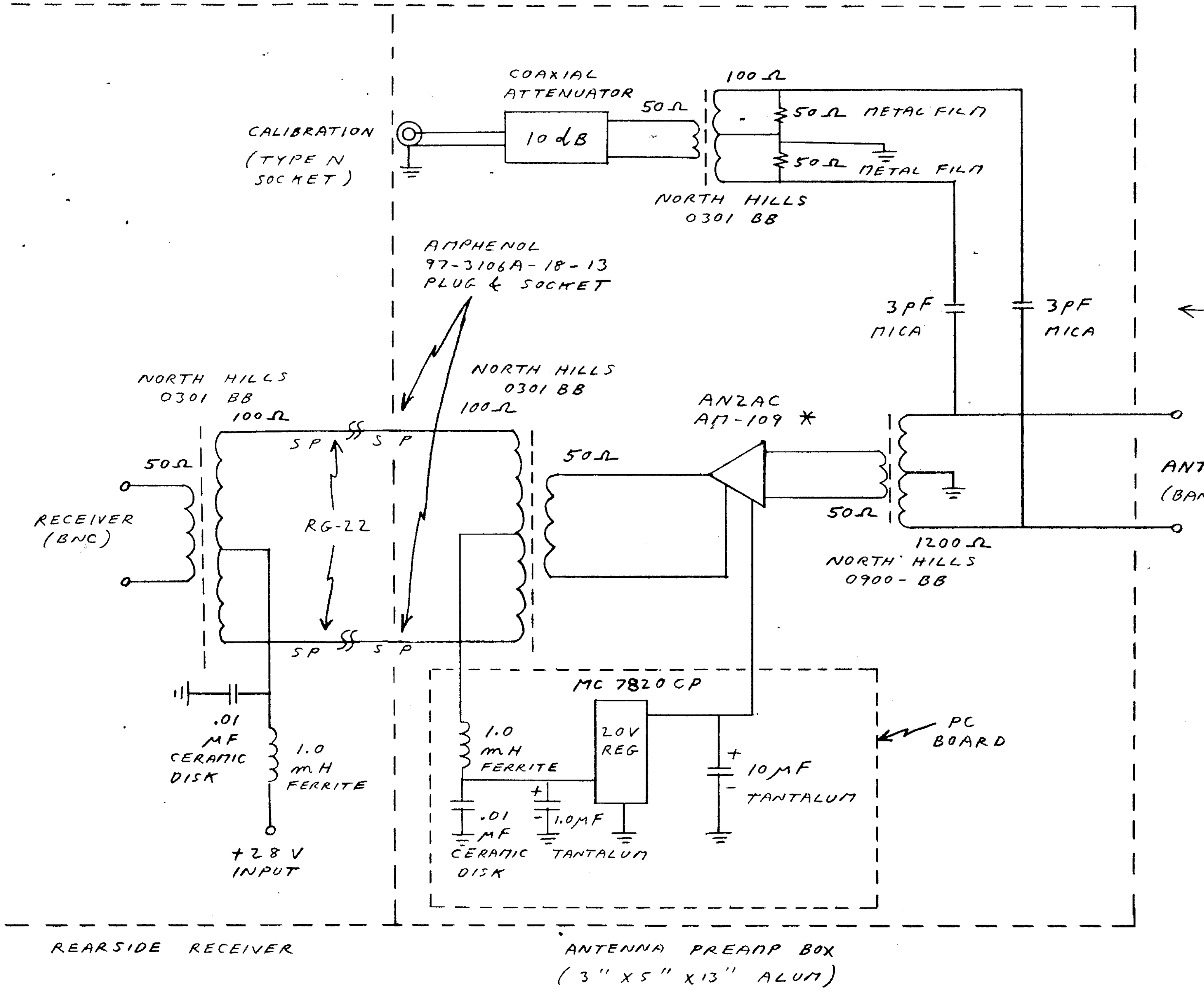
SPACE ENVIRONMENT LABORATORY
ERL ● NOAA ● BOULDER COLO

TEMPERATURE SENSOR

APPROVALS	DATE
DRAWN JJ	6-27
CHECKED	77

SCALE
SIZE C
DRAWING NO. HFS-193
DO NOT SCALE DRAWING
SHEET

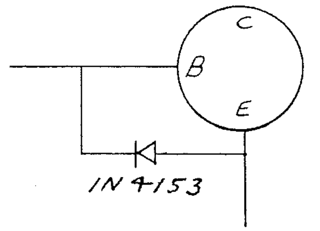
REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
A	REDRAWN, MODIFIED	11-26-79	JJ
B	ANTENNA TRANSFORMER C.T. GROUNDED, NOTE ON 3 PF CAP. MATCHING ADDED.	10-23-80	JJ
C	AMPHENOL CONNECTOR PINS ADDED	7-6-81	JJ
D	NOTE ADDED	7-28-81	JJ



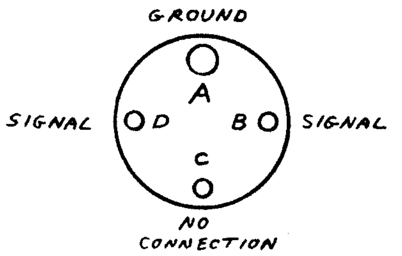
NOTE: THE TWO 3 PF CAPACITORS SHOULD BE MATCHED TO 0.1 PF, INCLUDING LEADS.

NOTE: IN ALL RECEIVING SYSTEMS, POLARITY BETWEEN THE BALANCED OUTPUT OF THE 0301 BB TRANSFORMER AT THE ANTENNA PREAMP AND THE BALANCED INPUT OF THE 0301 BB TRANSFORMER AT THE RECEIVER PREAMP PANEL (DRAWING 171) MUST BE CONSISTANT, SO THAT THE PHASES OF THE RF SIGNALS AT THE RECEIVER INPUT WILL BE CONSISTANT. CONSISTANT POLARITY MUST BE MAINTAINED IN THE WIRING BETWEEN TRANSFORMERS AND AMPHENOL CONNECTORS, AND IN THE RG-22 TWINAXIAL TRANSMISSION LINE FROM PREAMP TO RECEIVER.

* AMPLIFIER MODIFIED BY ADDITION OF DIODES BETWEEN BASE AND EMITTER OF EACH TRANSISTOR AS SHOWN:



AMPHENOL CONNECTOR PINS



TOLERANCES UNLESS OTHERWISE SPECIFIED FRACTIONS ± DEC ± ANGLES ±	**SPACE ENVIRONMENT LABORATORY** **ERL ● NOAA ● BOULDER COLO**	
APPROVALS / DATE	ANTENNA PREAMP HF RADAR	
DRAWN		
CHECKED 10-23-80 JJ	SCALE	SIZE C / DRAWING NO. 413
	DO NOT SCALE DRAWING	SHEET