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30 September 1967

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SS-17

Prog "A"

TRIPOS III/SOUSEA II INTERCEPT SYSTEM

TECHNICAL DESCRIPTION

Prepared by [redacted]
Payload Engineer

Approved by [redacted]
Advanced Techniques

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TABLE OF CONTENTS

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LIST OF ILLUSTRATIONS

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CONTROL SYSTEMS JOINTLY

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SECTION 1

INTRODUCTION

1.1 MISSION OBJECTIVE

Vehicle 4420 is a spin-stabilized P-11 subsatellite that will be launched into a nominal 325-n.m. circular orbit by an ~~Atlas~~ Thor-Agena booster. The on-board TRIPOS III and SOUSEA II intercept system payloads will perform a general search and EOB mission for pulsed radars operating in the frequency ranges of 4 to 8 GHz (TRIPOS III) and 8 to 12 GHz (SOUSEA II). These systems intercept and record signals of interest with sufficient bandwidth to permit the derivation of technical intelligence. Radar parameters to be measured are frequency, pulse-width, power, PRF, and geoposition.

1.2 PAYLOAD DESCRIPTION

The orbital payload comprises two separate antenna and receiver subsystems, two dual-channel tape recorders, four VHF telemetry transmitters, a command and control subsystem and ancillary equipment. (See Figure 1-1). Each 3-channel receiver subsystem is connected to a pencil beam signal antenna and two broadbeam inhibit antennas.

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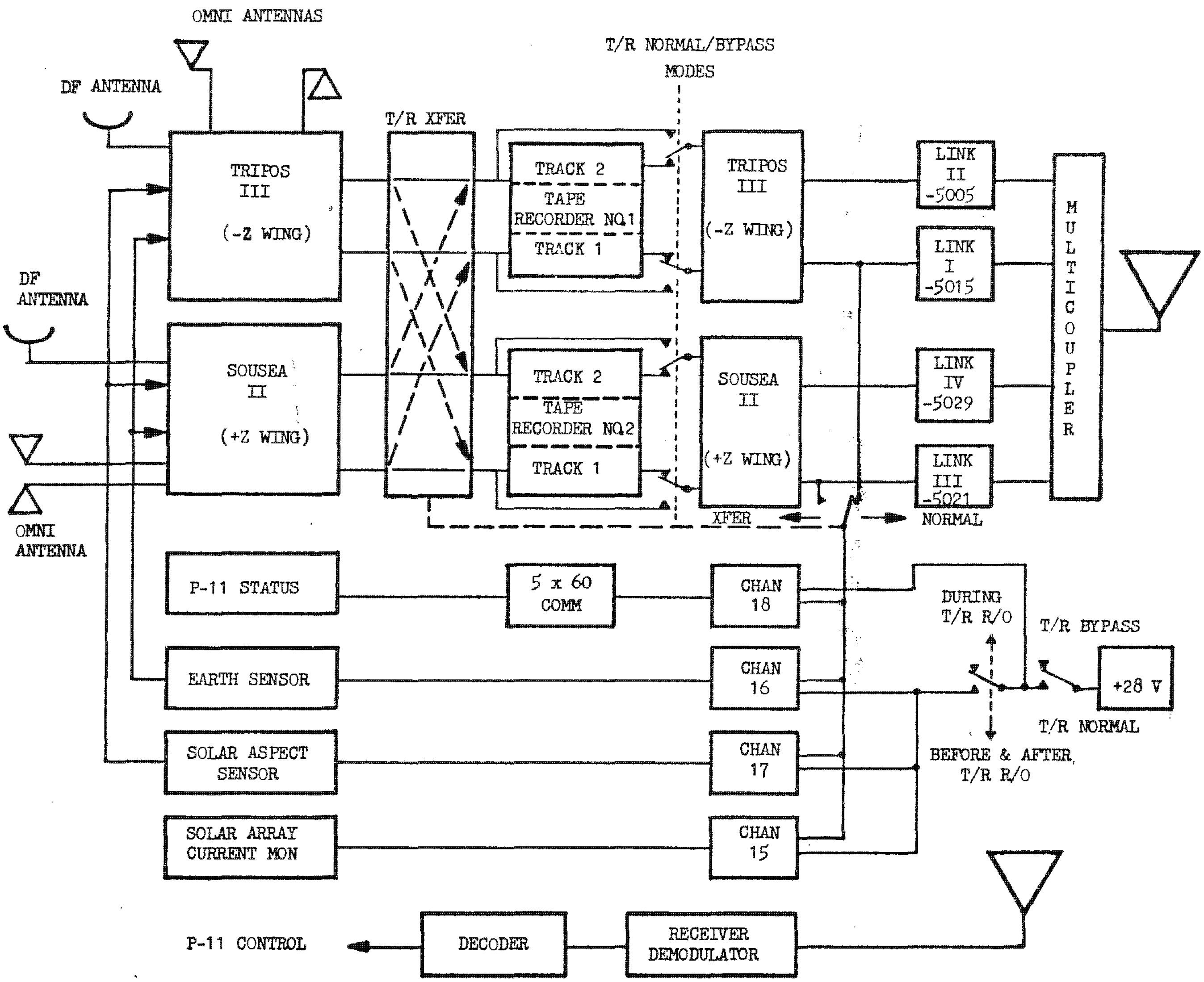

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Figure 1-1 Payload Block Diagram

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SECTION 2

SYSTEM DESCRIPTION

The TRIPOS III/SOUSEA II intercept system comprises the following:

a. TRIPOS III antenna subsystem
b. SOUSEA II antenna subsystem
c. TRIPOS III receiver subsystem
d. SOUSEA II receiver subsystem
e. Frequency measurement subsystem
f. Data storage and transmission subsystem
g. Command subsystem
h. Ancillary equipment.

Each of these subsystems is described in detail in the following sections. Figure 2-1 is a block diagram of the TRIPOS III system. Since both receiver subsystems are identical except for frequency coverage, only the TRIPOS III subsystem will be described. Differences between the two receiver subsystems will be noted.

2.1 ANTENNA SUBSYSTEMS

The receiving antennas for each receiver subsystem consist of a pencil-beam direction-finding (DF) antenna and two broadbeam, omnidirectional inhibit antennas. The signals from the inhibit antennas inhibit the side-lobe responses of the pencil-beam antenna in the DF receiver channel.

2.1.1 <u>TRIPOS III Antenna Subsystem</u> (Figure 2-2)

The pencil-beam DF antenna is a 3-foot unfurlable paraboloid having flex ribs. Characteristics of this antenna are as follows:

a. Frequency Range — 4 to 8 GHz

b. Gain (Matched Polarization)

4 GHz	26.0 db
6 GHz	29.0 db
8 GHz	32.0 db

c. Beamwidth — 3° to 6°

d. [redacted]e of Feed — Conical spiral (CP) 50X1

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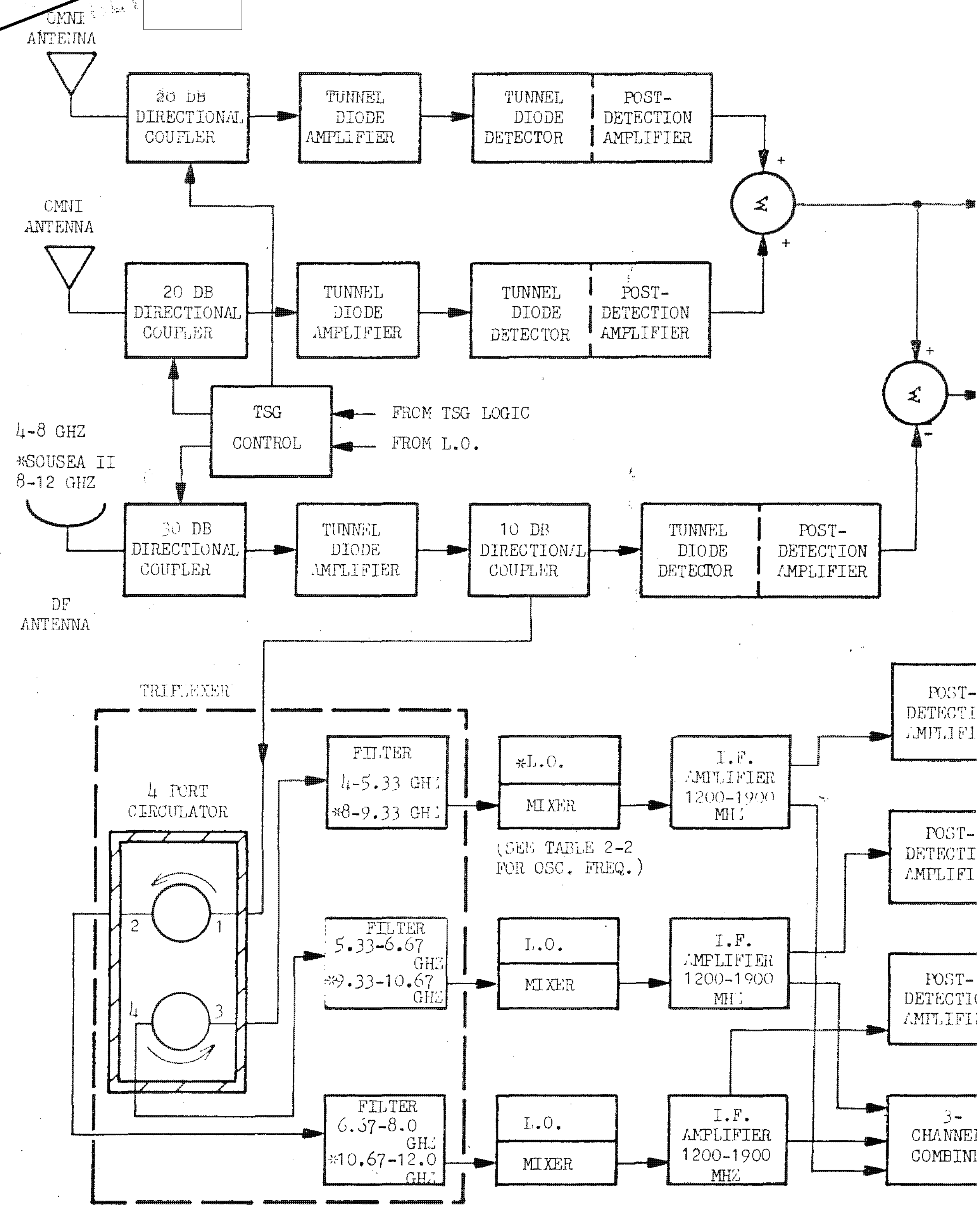
OMNI ANTENNA
20 DB DIRECTIONAL COUPLER
TUNNEL DIODE AMPLIFIER
TUNNEL DIODE DETECTOR
POST-DETECTION AMPLIFIER
OMNI ANTENNA
20 DB DIRECTIONAL COUPLER
TUNNEL DIODE AMPLIFIER
TUNNEL DIODE DETECTOR
POST-DETECTION AMPLIFIER
TSG CONTROL
FROM TSG LOGIC
FROM L.O.
4-8 GHZ
*SOUSEA II 8-12 GHZ
30 DB DIRECTIONAL COUPLER
TUNNEL DIODE AMPLIFIER
10 DB DIRECTIONAL COUPLER
TUNNEL DIODE DETECTOR
POST-DETECTION AMPLIFIER
DF ANTENNA
TRIPLEXER
4 PORT CIRCULATOR
FILTER 4-5.33 GHZ *8-9.33 GHZ
*L.O.
MIXER
(SEE TABLE 2-2 FOR OSC. FREQ.)
I.F. AMPLIFIER 1200-1900 MHZ
FILTER 5.33-6.67 GHZ *9.33-10.67 GHZ
L.O.
MIXER
I.F. AMPLIFIER 1200-1900 MHZ
FILTER 6.67-8.0 GHZ *10.67-12.0 GHZ
L.O.
MIXER
I.F. AMPLIFIER 1200-1900 MHZ
POST-DETECTI AMPLIFI
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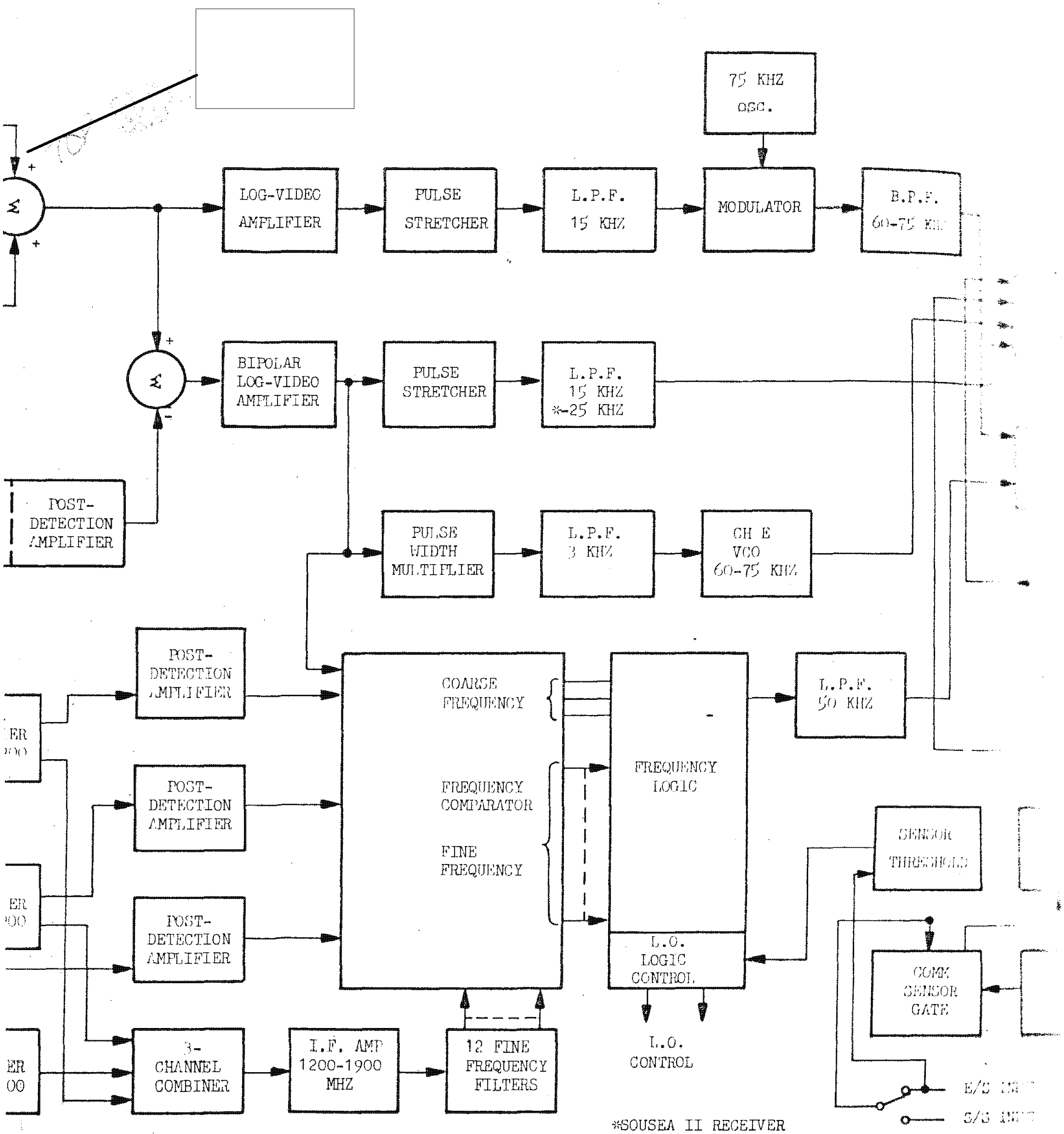

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Figure 2-1 TRIPOS III Block D

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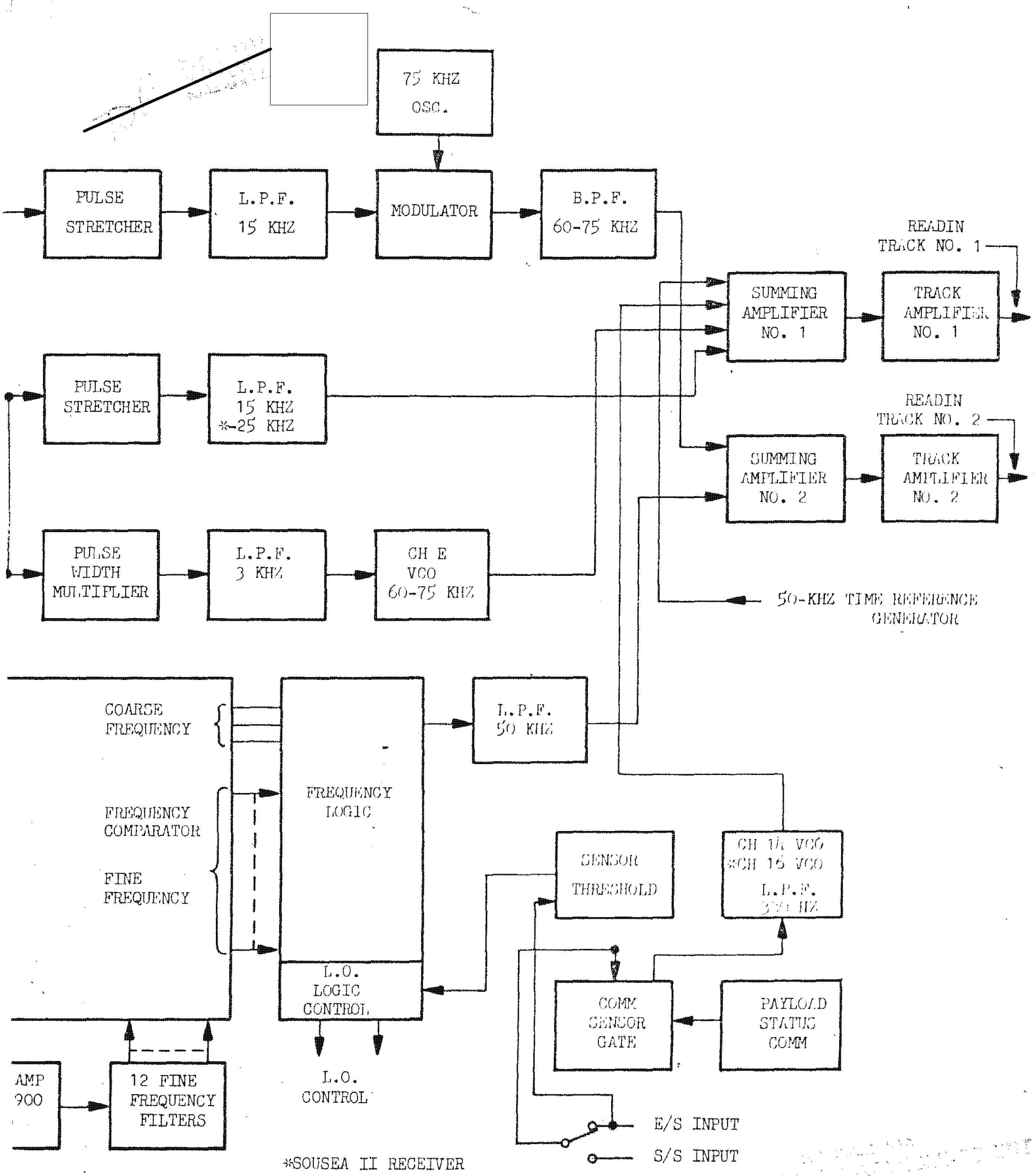

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Figure 2-1 TRIPOS III Block Diagram

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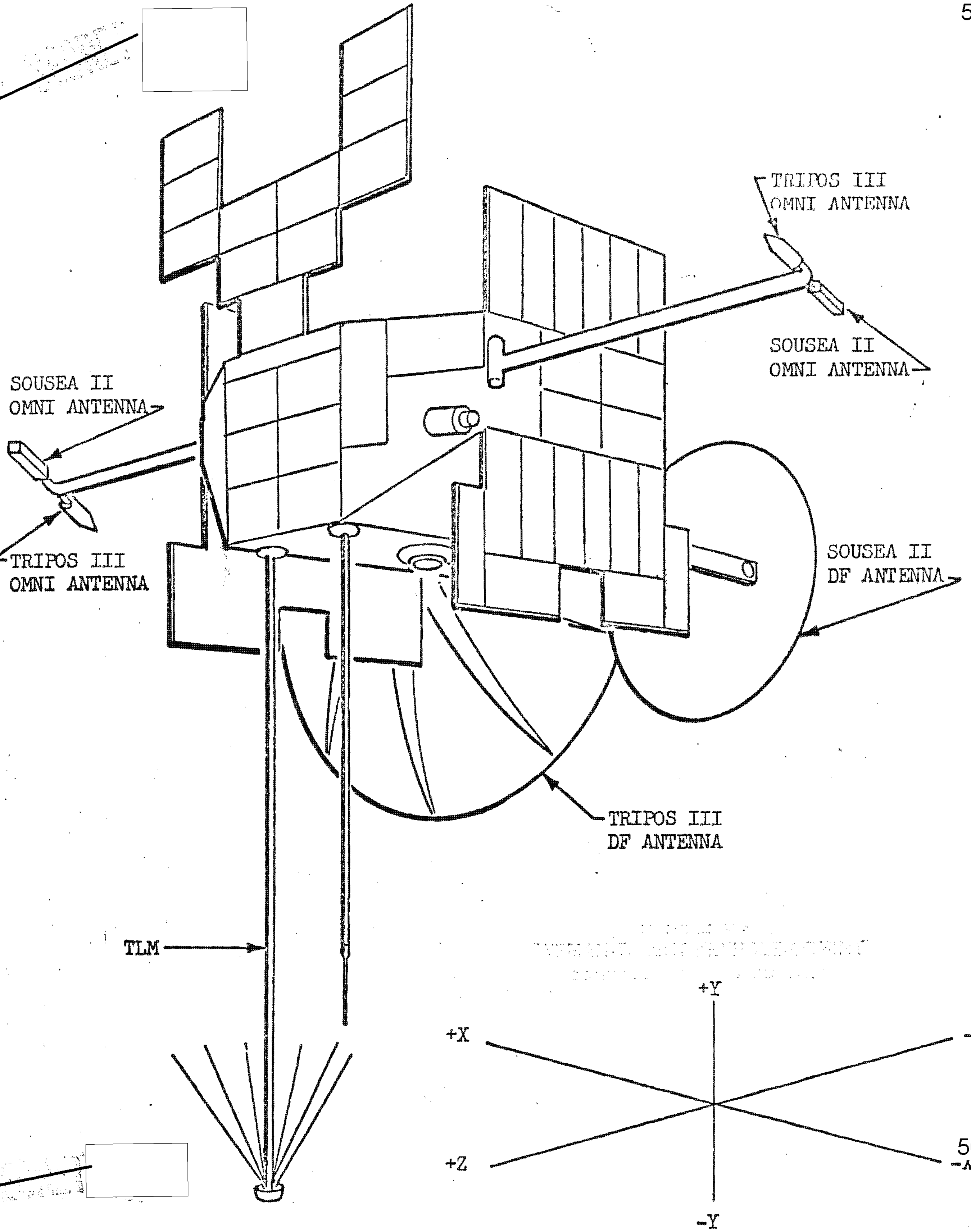

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Figure 2-2. Spacecraft Antenna Configuration (This configuration is for illustrative purposes only and does not reflect the actual antenna mounting.)

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e.	Transmission Line	Air line
f.	Boresight Axis Location	115° CW from Y-Z plane measured around +Y -Y axis looking from +Y direction. Depression angle is 54°. (See Figure 2-2)

The two inhibit antennas are boom-mounted conical spirals located 180 degrees apart on the spacecraft. Antenna characteristics are as follows:

a.	Beam Pattern	Each antenna provides hemispheric coverage; combined antennas provide omnidirectional coverage.
b.	Polarization:	Circular
c.	Transmission Line:	Air Line

2.1.2 <u>SOUSEA II Antenna Subsystem</u>

The SOUSEA II DF antenna is an 18-inch, solid magnesium paraboloid. Characteristics of this antenna are as follows:

a.	Frequency Range	8 to 12 GHz
b.	Nominal Gain (Matched Polarization)	
	8 GHz	29.0 db
	10 GHz	31.0 db
	12 GHz	32.0 db
c.	Beamwidth	4° to 6°
d.	Type of Feed	Waveguide with circular polarizing section
e.	Transmission Line	Rigid waveguide
f.	Boresight Axis Location	Along +Z axis with depression angle of 54°. (See Figure 2-2).

The two inhibit antennas are boom-mounted, rigid waveguides located 180 degrees apart on the spacecraft. Antenna characteristics are as follows:

a.	Beam Pattern	Each antenna provides hemispheric coverage; combined antennas provide omnidirectional coverage.
b.	Polarization	Circular
c.	Transmission Line	Rigid waveguide

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2.2 RECEIVER SUBSYSTEMS

2.2.1 Introduction

Each receiver subsystem consists of three crystal video receivers having RF amplifiers and crystal detectors, sum and difference circuits, log-video amplifiers, pulse stretchers, and a pulsewidth multiplier. Table 2-1 provides a summary of receiver parameters:

TABLE 2-1

RECEIVER SUBSYSTEM PARAMETERS

Parameter	TRIPOS III	SOUSEA II
Frequency Range	4-8 GHz	8-12 GHz
Sensitivity		
DF channel (S/N = 15 db)		
High-gain mode	-73 dbm ±3 db	-73 dbm ±3 db
Low-gain mode	-67 dbm ±3 db	-67 dbm ±3 db
Omni channels (S/N - 15 db)		
DF inhibit function	-75 dbm ±3 db	-75 dbm ±3 db
Omni video output	-65 dbm (or greater) ±3 db	-65 dbm (or greater) ±3 db
Dynamic Range	30 db	30 db
DF Frequency measurement		
With temperature calibration	±30 MHz	±30 MHz
Without temperature calibration	±35 MHz	±41 MHz
PW Measurement		
Range	0.25 to 10 μsec	0.25 to 10 μsec
Accuracy	±0.25 μsec or ±1% whichever is greater	±0.25 μsec or ±1% whichever is greater
Geopositioning Accuracy	[redacted]	

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2.2.2 TRIPOS III Receiver Subsystem

The signal received by the pencil-beam DF antenna is applied via a 30-db coupler (forward loss less than 1.0 db) to a tunnel-diode amplifier (TDA) consisting of four cascaded tunnel diode and circulator combinations that provide a nominal gain of 32 db. The TDA output is coupled into a 10-db directional coupler (forward loss of approximately 0.5 db) to a tunnel-diode detector and a postdetection amplifier having a bandwidth of 2.3 ±0.2 MHz. The output of the postdetection amplifier is summed with the outputs of the omnidirectional inhibit receivers. The summed signal is applied to a bipolar log-video amplifier. A portion of the RF energy from the DF channel is coupled through the 10-db directional coupler to the frequency measurement circuitry.

Signals received by the two conical spiral inhibit antennas are coupled into a 20-db directional coupler (forward loss less than 1.0 db) to their respective crystal video receivers. With the exception of the 20-db couplers, the two omni channel receivers are identical to the DF channel receiver. The outputs from the two omni channels are summed and coupled to a log-video amplifier and then to a summing network for the DF channel and omni channel outputs. The combined output is used to inhibit sidelobe responses from the pencil-beam antenna in the DF channel and to provide an output that is effectively omnidirectional in coverage.

The DF channel has two sensitivity modes: a high-gain (-73 dbm) mode and a low-gain (-65 dbm) mode. The 8-db insertion loss required for the low-gain mode is achieved by changing the bias on the TDA's in the DF channel by a relay closure initiated by external commands. The 8-db insertion loss provides for an inhibit margin between the response of the DF and omni antennas required for keeping "poke-through" to a minimum. The summed outputs from the omni channels are amplified in a log-video amplifier and applied to a pulse stretcher having a time constant of approximately 54 μsec. The amplitude of the flat-top pulse stretcher is dependent upon the amplitude of the leading edge of the incoming pulse. If a second pulse having less amplitude is received while the pulse stretcher is processing the first pulse, the second pulse will be rejected. If the amplitude of the second pulse is greater than that of the first pulse, the flat top of the pulse stretcher will assume the amplitude of the second pulse for 54 μsec. Both receiver systems use the same time constant for the omni pulse stretcher.

The DF video output is amplified in a bipolar log-video amplifier and applied to the DF channel pulse stretcher, to the pulsewidth multiplier, and to the frequency measurement threshold circuit.

The DF pulse stretchers of both receiver systems operate in the same manner as the omni pulse stretcher except that the SOUSEA II DF pulse stretcher has a time constant of 35 μsec.

The pulsewidth multiplier converts the received video bandwidth to a form compatible with tape recorder requirements. The transfer characteristics of the pulsewidth multiplier are shown in Figure 2-3.

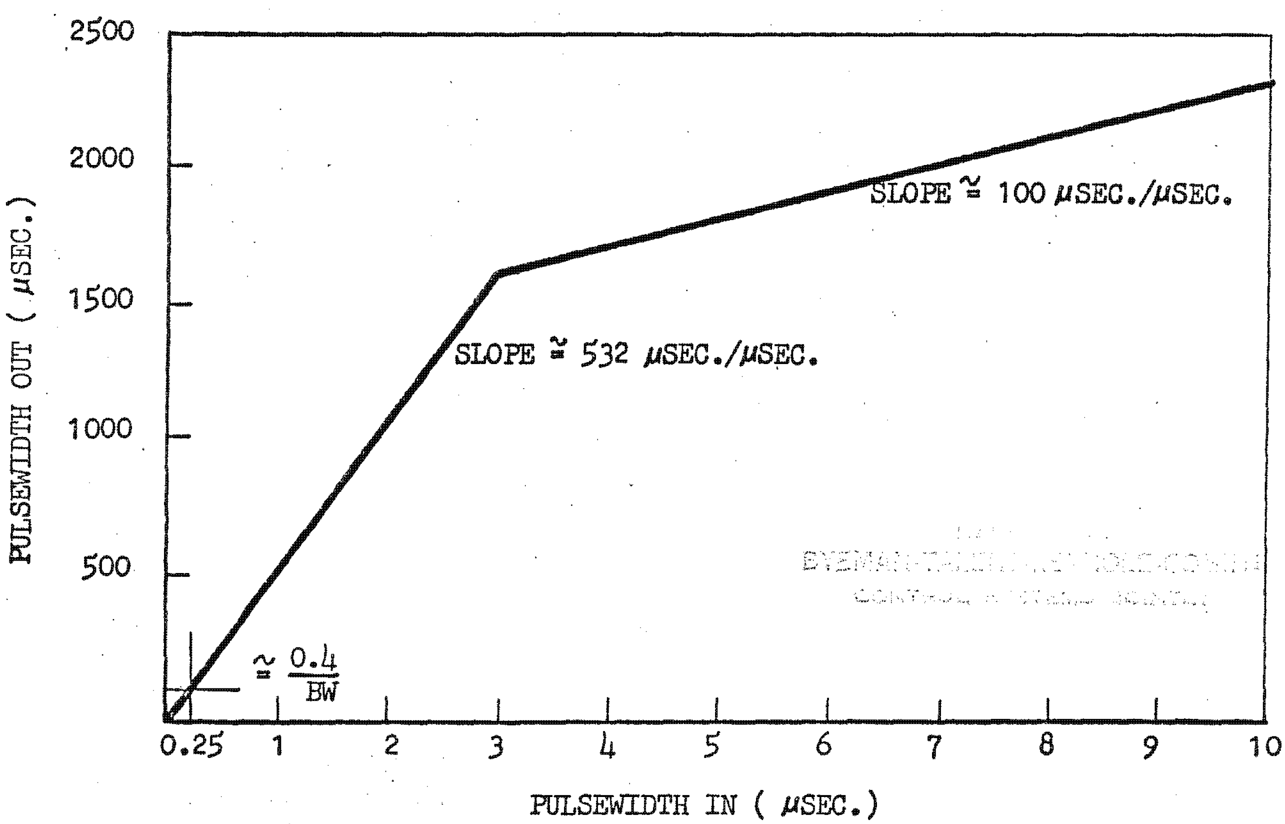

Figure 2-3. Pulsewidth multiplier transfer characteristics.

A test signal derived from a 1000-pps, 2-μusec pulsewidth generator is coupled into each receiver channel to determine the proper functioning of all receiver channels and data measuring systems. The 1000-pps signal is coupled directly into the DF channel and is counted down by four before being coupled into one of the omni channels. A complimentary signal (signal No. 3 in Figure 2-4) is coupled to the other omni channel. Signal 4 is the output of the channel summing network, and signal No. 5 from the DF channel summing network indicates that all channels are functioning properly. The test signal is applied to the receiver subsystem for 600 msec of every minute during T/R readin. Test signal frequencies are as follows:

a. TRIPOS III 5.449 and 6.116 GHz
b. SOUSEA II 9.449 and 10.119 GHz

2.2.3 Frequency Measurement Subsystem (See Figure 2-5)

The frequency measurement subsystem for each receiver is the same with the exception of the frequency range covered. Each subsystem can measure the frequency of a received pulse in half its RF band during each spin of the vehicle with an accuracy up to ±30 MHz (temperature compensated). A DF video signal having an S/N ratio of 15 db or greater is required to activate the frequency measurement subsystem encoder. The measurement subsystem consists of 3 superheterodyne receivers, 3 coarse- and 12 fine-frequency filters, fine-frequency shift register, frequency encoder and associated control logic, and local oscillator controls.

Figure 2-6 shows how the frequency band of each receiver is sampled for frequency measurement. At the beginning of each sample period, the local oscillator of each of three superheterodyne receivers is switched by an output from a multivibrator. This multivibrator is in sync with the horizon sensor or sun sensor output. In the absence of sync the multivibrator switches at a rate less than the lowest expected spin rate, approximately 41 spins per minute after nine months.

RF energy from the DF channel is coupled through a 10-db directional coupler to a triplexer consisting of a four-port circulator and three interdigital

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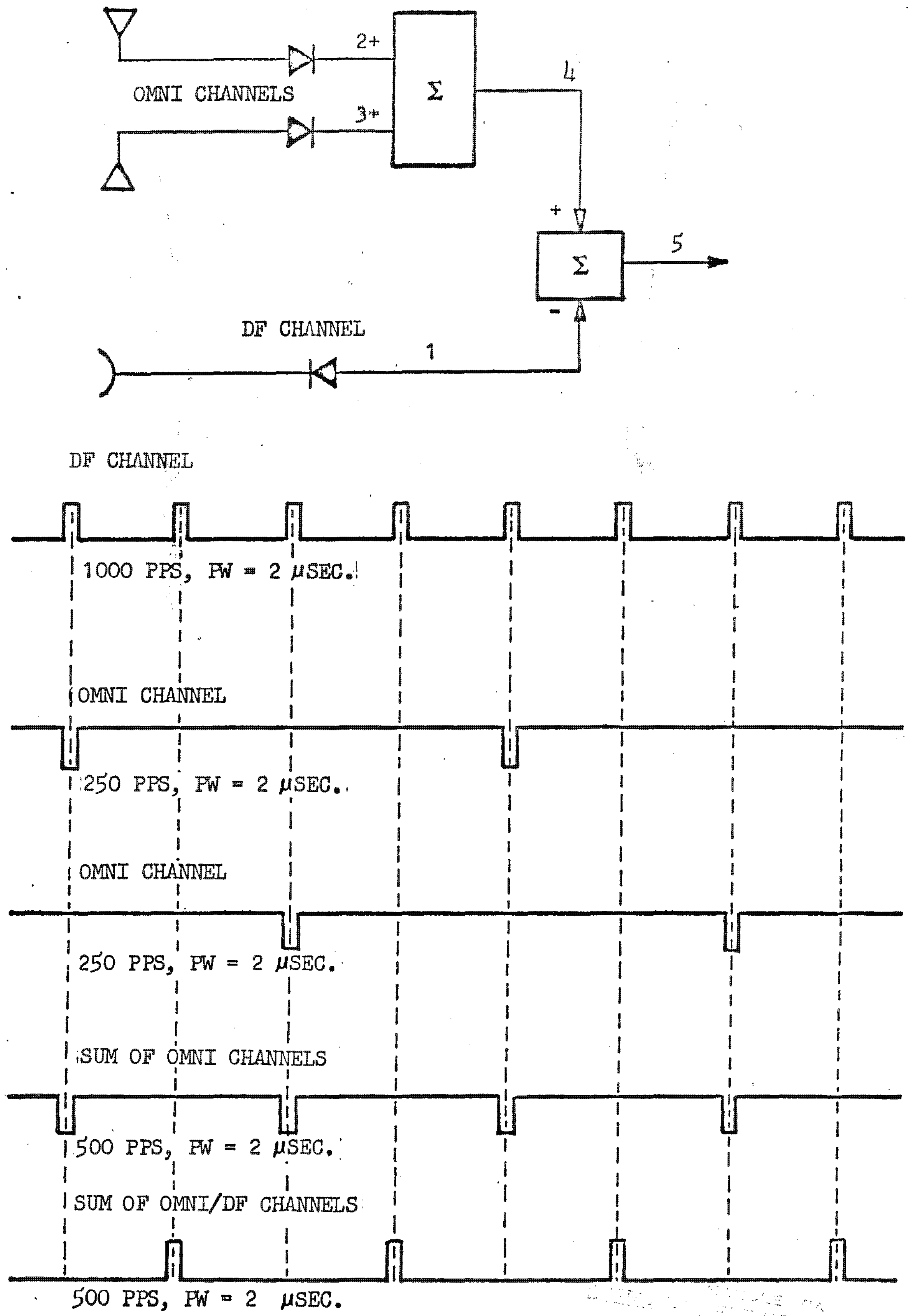

[redacted]igure 2-4 Test Signal Waveforms 50X1

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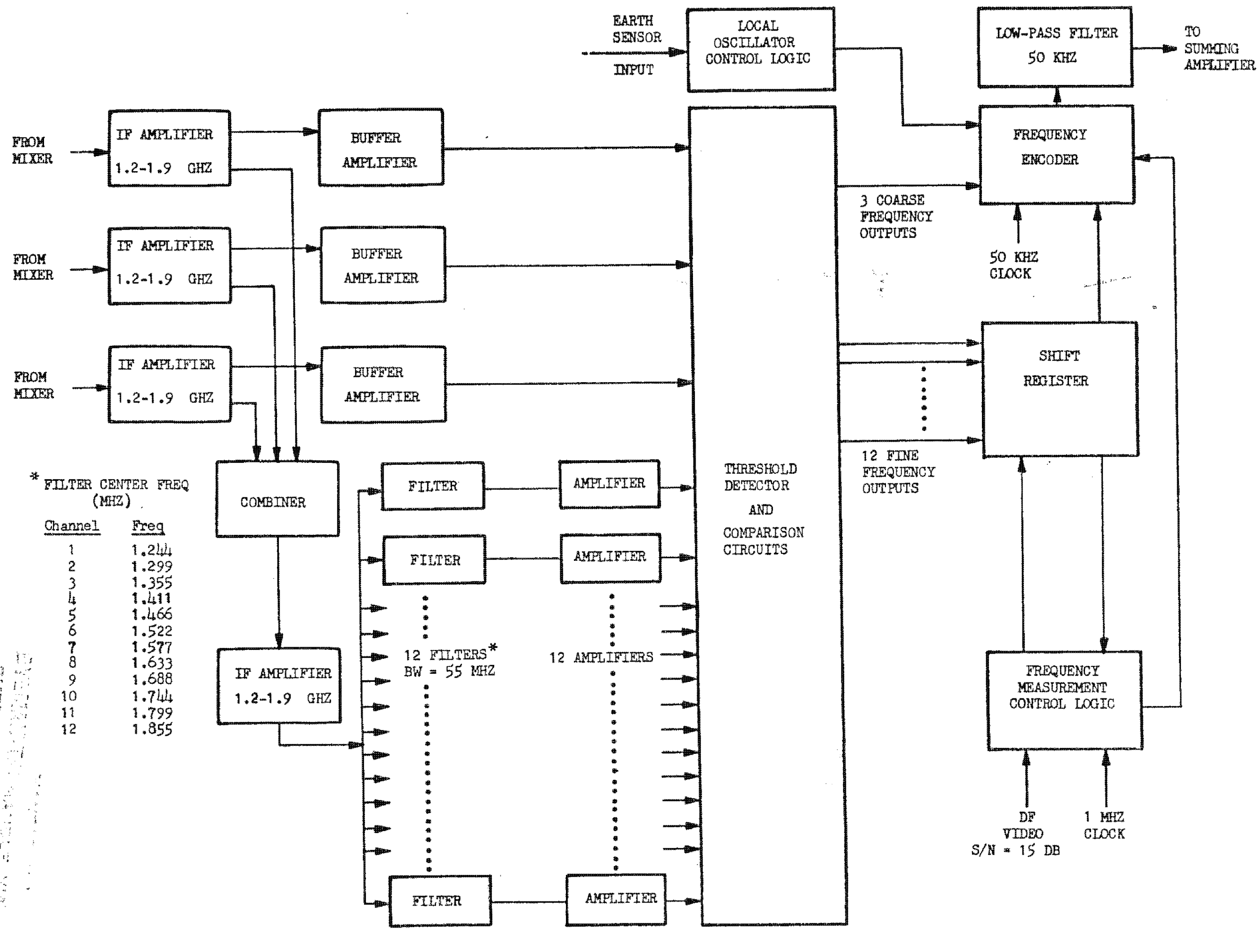

* FILTER CENTER FREQ (MHZ)

Channel	Freq
1	1.244
2	1.299
3	1.355
4	1.411
5	1.466
6	1.522
7	1.577
8	1.633
9	1.688
10	1.744
11	1.799
12	1.855

Figure 2-5 Frequency Measurement Subsystem Block Diagram

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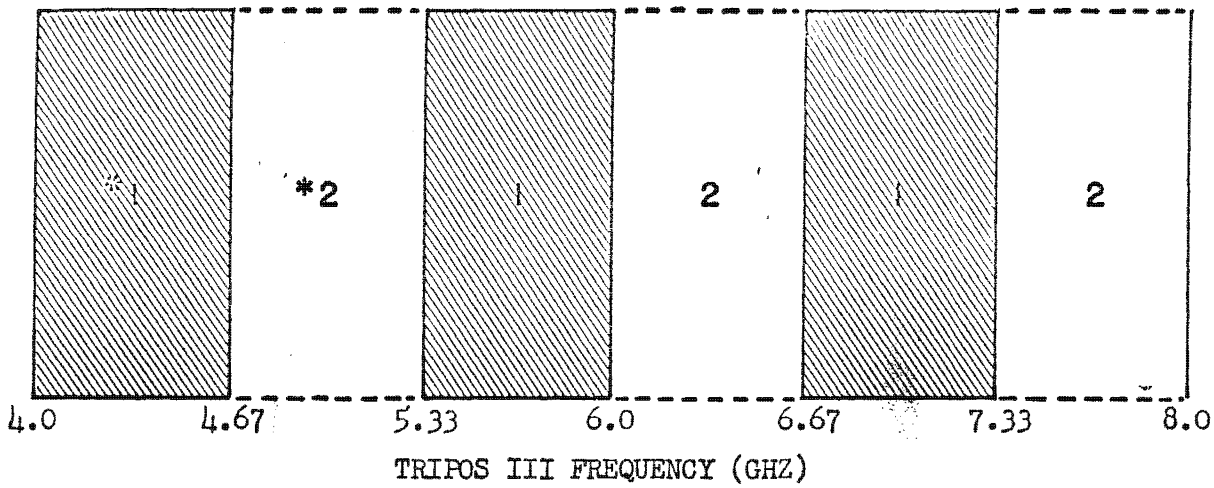

* Sample periods change every revolution of vehicle.

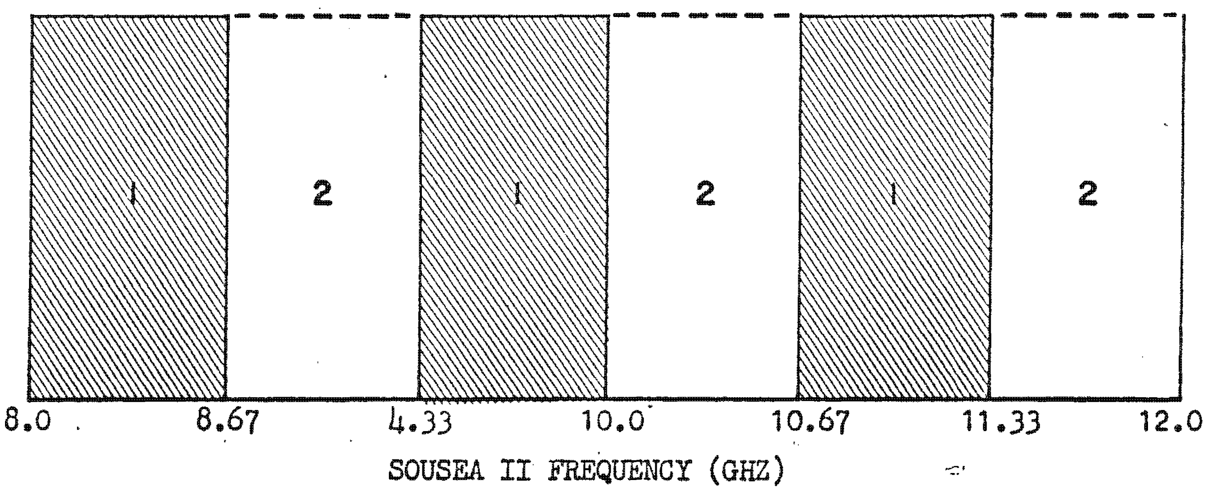

Figure 2-6. Frequency Band Sample Period Sequence.

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filters, each having a bandwidth of 1.33 GHz. The outputs of the three filters are separately applied to single-ended mixers and converted to an IF of 1.2 to 1.9 GHz.

The bandwidth requirements of each of three IF amplifiers is one-half that of the interdigital filter since only one-half of the band is sampled at one time. Each IF amplifier has two outputs: one to a postdetection amplifier and the other to a 3-channel combiner. The postdetection amplifier outputs are the coarse-frequency measurements. The output of the 3-channel combiner is amplified in a 1.2- to 1.9-GHz IF amplifier having a bandwidth of 700 MHz and applied to a double bank of 6 fine-frequency filters, each having a bandwidth of 55.55 ±0.2 MHz. The center frequency of each filter is as follows:

Filter Bank No.	Channel No.	Frequency (GHz)
1	1	1.244
	3	1.355
	5	1.466
	7	1.577
	9	1.688
	11	1.799
2	2	1.299
	4	1.411
	6	1.522
	8	1.633
	10	1.744
	12	1.855

Table 2-2 lists the local oscillator frequency assignments of the frequency measurement system.

The outputs of the 12 fine-frequency filters are amplified and applied to threshold and comparison circuits in the frequency comparator. A processed signal in the frequency channel is recorded as a binary "1" in a 12-position shift register. To reduce the possibility of a strong signal recording a binary "1" through two adjacent filters, the output of a given filter is compared separately with its adjacent filters. If the output amplitude of the center filter exceeds that of the adjacent filters, a binary "1" is recorded in the proper shift register position.

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TABLE 2-2

FREQUENCY ASSIGNMENTS OF FREQUENCY MEASUREMENT SYSTEM

Frequency Band No. and Range (GHz)	Sample Period No.	Local Oscillator Frequency (GHz)	IF Frequency Range (GHz)
(T-1) 4.000 - 4.666	1	5.883	*1.883 - 1.217
(T-2) 4.666 - 5.333	2	6.550	*1.884 - 1.217
(T-3) 5.333 - 6.000	1	7.212	*1.879 - 1.212
(T-4) 6.000 - 6.666	2	4.783	1.217 - 1.883
(T-5) 6.666 - 7.333	1	**5.450	1.216 - 1.883
(T-6) 7.333 - 8.000	2	**6.117	1.216 - 1.883
(S-1) 8.000 - 8.666	1	6.783	1.217 - 1.883
(S-2) 8.666 - 9.333	2	7.450	1.216 - 1.883
(S-3) 9.333 -10.000	1	8.117	1.216 - 1.883
(S-4) 10.000 -10.666	2	8.783	1.217 - 1.883
(S-5) 10.666 -11.333	1	9.450	1.216 - 1.883
(S-6) 11.333 -12.000	2	10.120	1.213 - 1.880

* IF frequency range for bands T-1, T-2, and T-3 are reversed due to L.O. frequency above the received signal.

** TRIPOS III receiver test signal generator frequencies.

*** SOUSEA II receiver test signal generator frequencies.

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The data stored in the coarse- and fine-frequency registers are converted into a PCM bipolar code by the frequency encoder. The encoder is actuated by an "AND" circuit when the following three conditions are met:

a. An input signal (S/N 15 db or greater) from the DF channel bipolar log-video amplifier is present
b. A signal is present in one of the fine-frequency filter shift registers
c. No signal is presently being processed.

The clock frequency of the fine-frequency shift register is 1 MHz. Figure 2-7 shows the PCM data format for the frequency measurement system. The data rate is 50 kilobits per second, bit length is 20 μsec, and the total word length is 12 bits (240 μsec). The first two bits are word sync, the next seven bits are frequency information, and the remaining three bits are end-of-word sync. The seven bits for frequency information are as follows:

a. Bits 3, 4, 5, 6 - fine frequency
b. Bits 7, 8 - coarse frequency
c. Bit 9 - local oscillator position

At times, several of the fine-frequency filter outputs will record more than one binary bit in the shift register, denoting that several frequencies have been received. The fine-frequency shift register, when interrogated, shifts to the right until a binary "1" appears at the output and is processed by the frequency encoder. All 12 shift register positions are then sampled for all binary "0's." If this is the case, the shift register is ready to accept the next input. If the shift register contains one or several "1's," it will shift right until all 12 register positions are "0." The last "1" is then processed by the frequency encoder. For example, if "1's" are registered by signals from fine-frequency filters 4, 6, and 8, only the frequency indicated by "1's" out of filters 4 and 8 would be processed. The cycle for sampling of the shift register is to sample for a "1" and then for all "0's.". If all positions are not "0" all remaining "1's" are shifted out until all "0's" are present. Only the first and last "1" readouts are processed.

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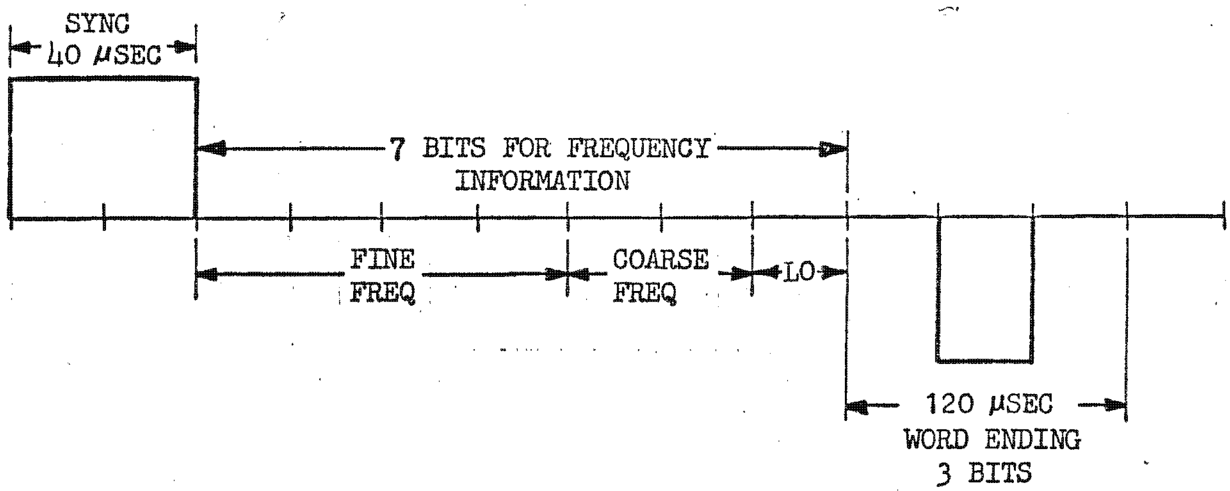
FREQUENCY READOUT IN PCM BIPOLAR CODE

	Information Bits	PCM Bits
Coarse Frequency	3	2
Fine Frequency	12	4
L.O. No.	2	1
Sync		2
Word Ending		3
Total		12 Bits

Bit Stream Format



The output of the frequency encoder is applied through a 50-kHz, low-pass filter to a summing amplifier for recording.

2.3 DATA SOTRAGE AND TRANSMISSION SUBSYSTEM

Two dual-channel tape recorders provide a total of four channels for data storage during a readin mode; thus, both the TRIPOS III and SOUSEA II readin data can be stored simultaneously. Four VHF telemetry links are used for data readout at the tracking stations.

2.3.1 TRIPOS III Data Readin

Tape recorder track No. 1 records the following data from summing amplifier No. 1 (see Figure 2-1): Maximum readin time is 12.5 minutes.

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a. DF video (up to 15 kHz)
b. Earth sensor, sun sensor, and payload status commutator data via channel 14 VCO
c. AN/GSQ-53A digital time word at 50 kHz
d. DF channel pulsewidth measurement via channel E VCO.

Tape recorder track No. 2 records the DF channel frequency measurement PCM word at a 50-kilobit-per-second rate and the omni channel video (up to 15 kHz) translated to the 60- to 75-kHz frequency band. The data format for both receiving subsystems is shown in Figure 2-8.

2.3.2 <u>SOUSEA II Data Readin</u>

Tape recorder track No. 1 contains the DF frequency measurement and the omni channel video. (Same as TRIPOS III tape recorder track No. 2.) Track No. 2 records the following:

a. DF video (up to 25 kHz)
b. Earth sensor, sun sensor, and payload status commutator data via channel 16 VCO
c. AN/GSQ-53A digital time word at 50 kHz
d. DF channel pulsewidth measurement via channel E VCO.

Tape speed compensation for both recorders is accomplished using the 50-kHz tone associated with the digital time word.

2.3.3 <u>Tape Recorder Readout</u>

Data from both receiver subsystems are read out at twice readin speed through phase-compensating networks. During the readout period of the TRIPOS III tape recorder data, the vehicle 60-point status commutator is summed to the track No. 1 output. The data format for before and after tape recorder readout is shown in Figure 2-8. Maximum readout time is 6.25 minutes.

2.4 COMMAND SUBSYSTEM

2.4.1 <u>Real Time Commands (RTC's)</u>

A UHF command receiver/demodulator and a digital command decoder provide for 28 discrete commands for vehicle and payload commanding. The function of each

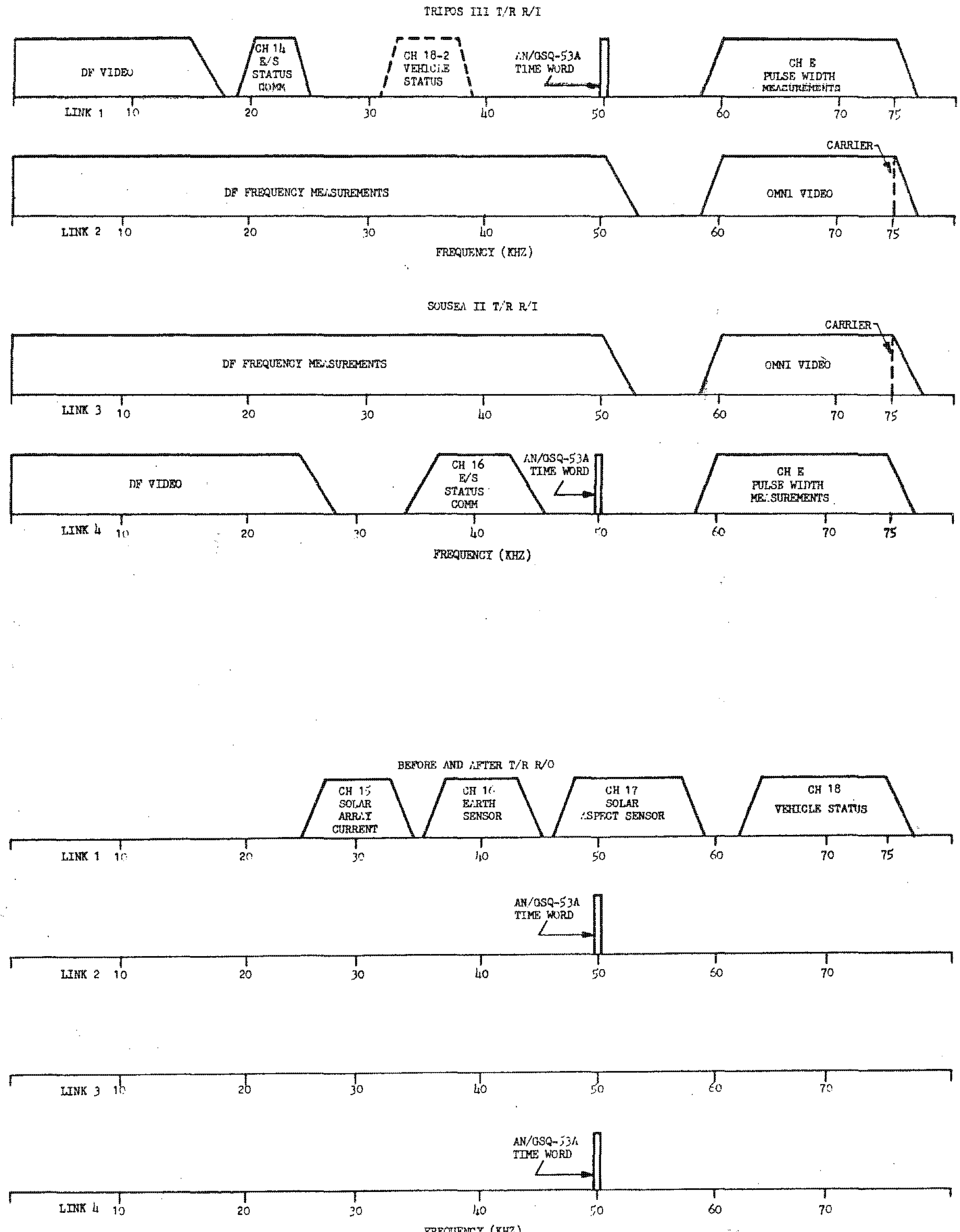

Figure 2-8 Intercept System Data Format

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command is called out in vehicle 4420 command list, "LMSC B118265." Commands affecting the operation of the payload are listed below:

Command No.	Payload Receiver	Function
RTC-17 (P/L Mode A)	SOUSEA II	High-gain mode DF channel
RTC-18 (P/L Mode B)	SOUSEA II	Low-gain mode DF channel
RTC-19 (P/L Mode C)	SOUSEA II TRIPOS III	Select earth sensor for reoording
RTC-20 (P/L Mode D)	SOUSEA II TRIPOS III	Select sun sensor for recording
RTC-21 (P/L Mode E)	SOUSEA II TRIPOS III	Tape recorder bypass
RTC-22 (P/L Mode F)	SOUSEA II TRIPOS III	Tape recorder normal
RTC-23 (P/L Mode G)	TRIPOS III	High-gain mode DF channel
RTC-24 (P/L Mode H)	TRIPOS III	Low-gain mode DF channel

2.4.2 Stored Commands

Readin power for the payload receivers and tape recorders is applied by the selection of programmable event No. 1 or No. 2 of the orbit programmable module. Readin power is turned off by companion events No. 1 or No. 2. Programmable event No. 1 and/or No. 2 can be programmed up to a duration of 16,378 seconds in 8-second increments. Each programmable event is started by separate real time commands. The companion events are programmable up to 2040 seconds in 8-second increments. Each companion event starts to clock out when its associated programmable event (i.e., programmable event No. 1 and companion event No. 1 and programmable event No. 2 and companion event No. 2) has counted down. Each companion event is programmed by real time command.

2.5 ANCILLARY EQUIPMENT

2.5.1 Payload Status Commutator

Each receiver contains a 15-point RZ format status commutator that operates at a rate of two frames per 600 msec. Point No. 1 occupies a double width of 5.2 volts and point No. 8 occupies a single width of 2.6 volts. The status commutator and earth/sun sensor channel provides either earth or sun sensor data (as selected by ground command) to a channel 14 VCO for TRIPOS III and a channel 16 VCO for SOUSEA II. Once every minute the earth/sun sensor data are interrupted for 600 μsec, and the status commutator output is switched to a VCO. Two complete commutator frames are recorded before switching back to the earth/sun sensor data.

2.5.2 Time Reference Generator

The time reference generator (TRG) for both receivers is installed in the SOUSEA II receiver subsystem. It is a 24-hour clock that provides a time word at the rate of 1-pulse-per-second. A 1-MHz and a 100-kHz signal from the TRG are applied to the frequency measurement subsystem for processing frequency data. The TRG output is bandpassed by a filter having a bandwidth of 50-kHz ±2.5 percent. The AN/GSQ-53A time code word format is used.