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~~TECHNICAL DESCRIPTION~~

VAMPAN INTERCEPT SYSTEM

Proj "A"

(Vehicle 4413)

Prepared by: [redacted]
Payload Engineer

Approved by: [redacted]
Advanced Techniques

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BYEMAN-TALENT-KEYHOLE-COMINT
CONTROL SYSTEMS JOINTLY

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SECTION 1
INTRODUCTION

VAMPAN is a satellite-borne reconnaissance system whose mission is to search for and locate pulsed radar targets of interest in the 100- to 1000-MHz frequency range. The VAMPAN system will be installed on a spin-stabilized P-11 subsatellite (Vehicle 4413) which will be launched into a nominal 270-n.m. circular orbit by an Atlas-Agena booster. The spacecraft will spin on its axis (nominally parallel to the earth's axis) at an initial spin rate of approximately 60 rpm, decaying to approximately 40 rpm after nine months in orbit.

Target signals will be received simultaneously by two pairs of planar spiral antennas (high band and low band) oriented perpendicular to the spin axis and separated from each other by approximately one to four wavelengths (depending upon the received frequency). Direction finding of each emitter in two orthogonal planes will be accomplished by measuring the phase difference between outputs from the two antennas as the satellite spins one or more revolutions. Targets within 330-n.m. ground range from nadir and less than 50 degrees from the satellite spin axis should be located with less than [redacted] rss error on a single pass. Correlation of data from additional passes will increase the location accuracy. 50X1

The VAMPAN reconnaissance system comprises the payload receiving antennas, the payload receivers, a data storage and transmission subsystem, a command subsystem, and ancillary equipment. (See Figure 1-1.) The payload receivers consist of a high-band receiver unit (A-Box) covering the frequency range from 400 to 1000 MHz and a low-band receiver unit (B-Box) covering the frequency range from 100 to 400 MHz. Each receiver unit contains a matched pair of superheterodyne receivers and a crystal video receiver. The super-heterodyne receivers provide pulse amplitude, pulsewidth, carrier frequency, and geoposition measurements. Phase difference measurements of pulse signals are obtained using the superheterodyne receivers in pairs. The crystal video receiver provides scan rate, antenna pattern, PRF, pulsewidth, and signal power measurements. [redacted] 50X1

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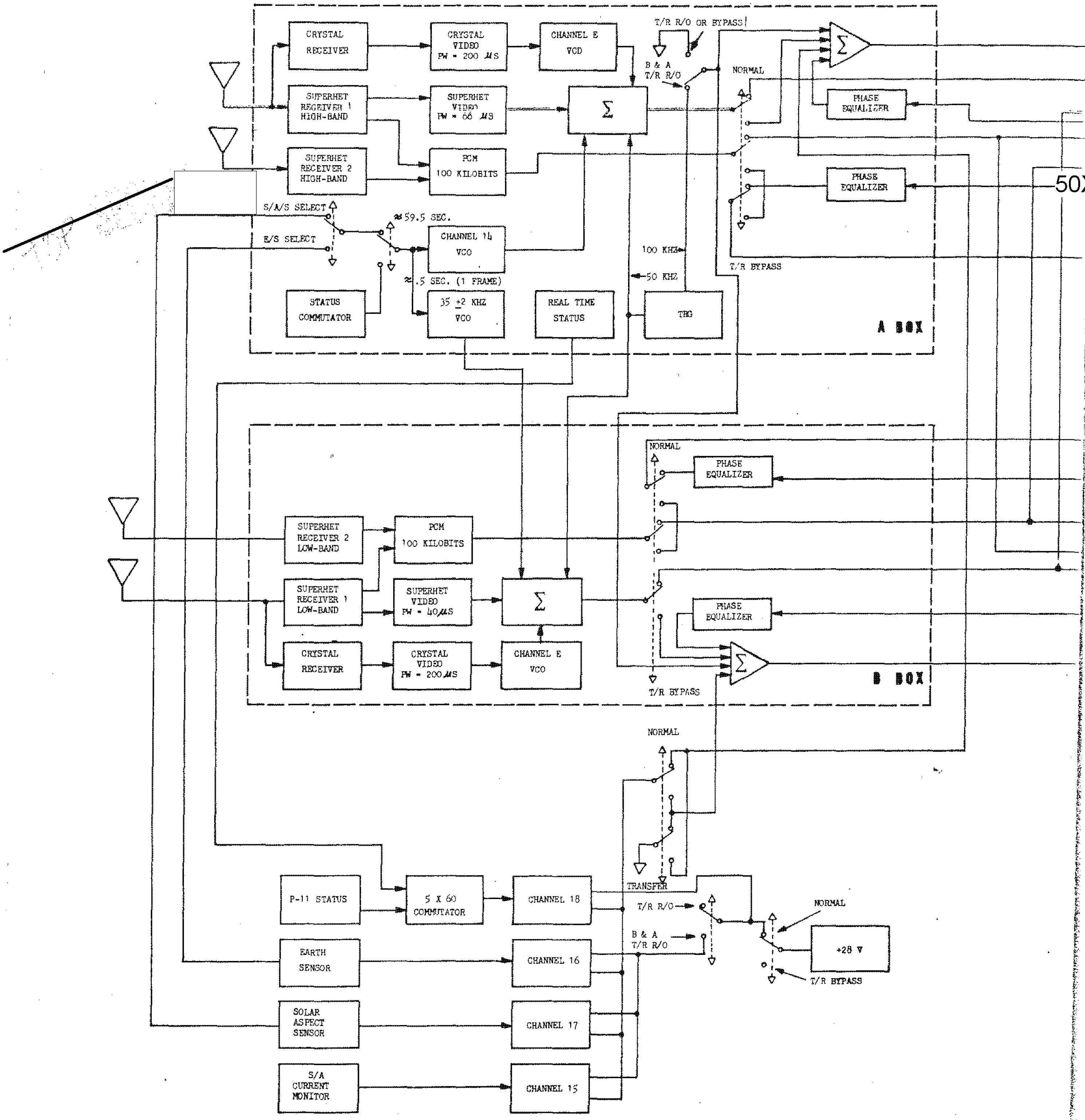

CRYSTAL RECEIVER
CRYSTAL VIDEO PW = 200 μS
CHANNEL E VCO
T/R R/O OR BYPASS
B & A T/R R/O
NORMAL
SUPERHET RECEIVER 1 HIGH-BAND
SUPERHET VIDEO PW = 66 μS
Σ
PHASE EQUALIZER
SUPERHET RECEIVER 2 HIGH-BAND
PCM 100 KILOBITS
PHASE EQUALIZER
S/A/S SELECT
≈59.5 SEC.
E/S SELECT
CHANNEL 14 VCO
100 KHZ
T/R BYPASS
50 KHZ
≈.5 SEC. (1 FRAME)
STATUS COMMUTATOR
35 ±2 KHZ VCO
REAL TIME STATUS
TRG
A BOX
NORMAL
PHASE EQUALIZER
SUPERHET RECEIVER 2 LOW-BAND
PCM 100 KILOBITS
SUPERHET RECEIVER 1 LOW-BAND
SUPERHET VIDEO PW = 40μS
Σ
PHASE EQUALIZER
CRYSTAL RECEIVER
CRYSTAL VIDEO PW = 200μS
CHANNEL E VCO
T/R BYPASS
B BOX
NORMAL
TRANSFER
P-11 STATUS
5 X 60 COMMUTATOR
CHANNEL 18
T/R R/O
NORMAL
B & A T/R R/O
+28 V
EARTH SENSOR
CHANNEL 16
T/R BYPASS
SOLAR ASPECT SENSOR
CHANNEL 17
S/A CURRENT MONITOR
CHANNEL 15

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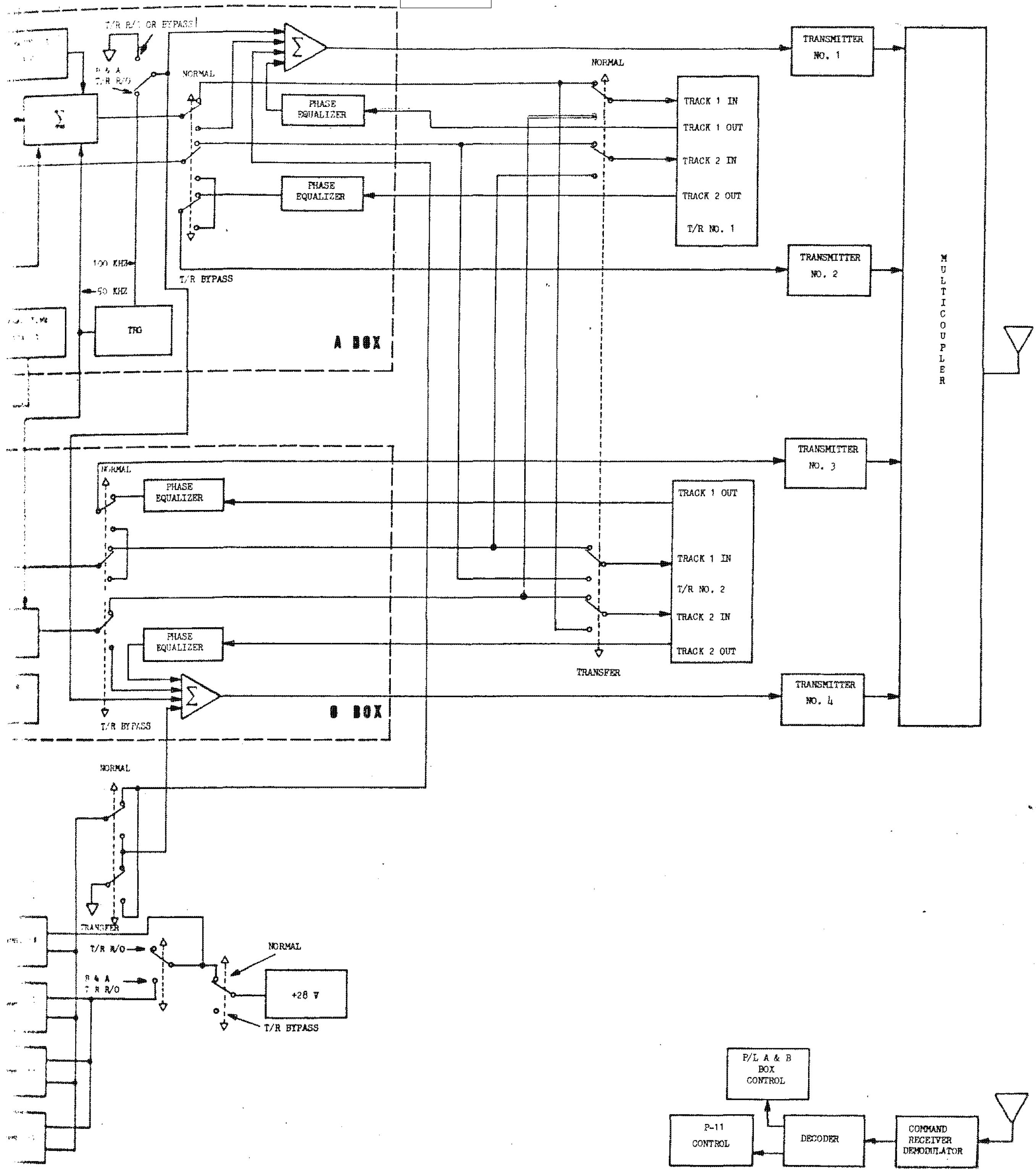

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Figure 1-1. VAMPAN Intercept System Block Diagram

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SECTION 2

SYSTEM DESCRIPTION

2.1 PAYLOAD ANTENNAS

The VAMPAN reconnaissance system uses two pairs of planar spiral antennas for reception of signals of interest: one pair for low-band (100 to 400 MHz) reception and one pair for high-band (400 to 1000 MHz) reception. The spiral elements are formed by a gold deposition process on dacron mesh sheets and are made as nearly omnidirectional as possible. Both of the high-band and one of the low-band spirals are formed on a 4-ft. x 8-ft. dacron sheet; the remaining low-band spiral is formed on a separate 4-ft. x 4-ft. dacron sheet. Figure 2-1 shows the antennas mounted on the P-11 subsatellite. During ascent, the dacron sheets are furled. After orbit has been attained, a stored program command unfurls the antennas. Pertinent antenna characteristics are as follows:

Gain:	Omnidirectional*
Polarization:	Circular
Impedance:	50 ohms
VSWR:	$\leq 2.5:1$

The antenna pairs use a phase measurement system embodying basic interferometer principles for target geopositioning. Phase measurement consists of determining the phase differential of an incident RF wavefront striking two antennas that are spatially displaced relative to the wavefront. The phase differential in the two arms of the antenna system is proportional to the difference in travel time from the emitter source to the two receiving antennas and is, therefore, proportional to the difference between the two transmission path lengths. Since the physical separation of the antennas is small compared to the path lengths, the path difference is directly proportional to the direction cosine (with respect to the antenna baseline)

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* Actual antenna patterns are shown in the VAMPAN payload calibration data report.

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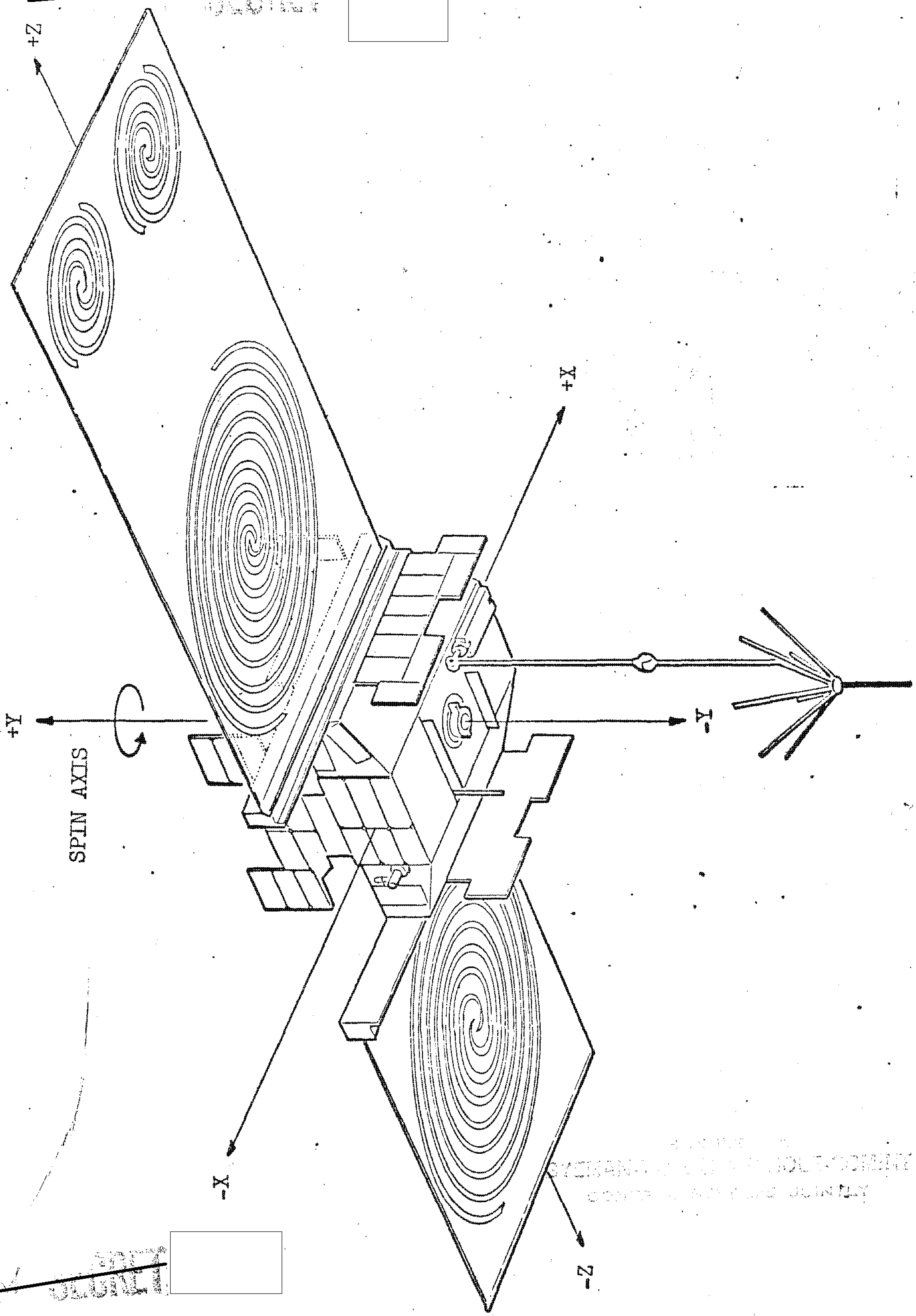

Figure 2-1. VAMPAN Receiver Antennas Mounted on P-11 Spacecraft

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of a vector pointing to the signal source. The direction cosine varies as the antennas turn, thus allowing this angle to be resolved into an elevation angle plus an azimuth angle. The vehicle coordinate system is defined with respect to ground coordinates based on vehicle ephemeris data and earth sensor signals. Figure 2-2 shows the phase measurement geometry.

2.2 PAYLOAD RECEIVERS

The payload receiver subsystem contains six receivers: a low-band (100 to 400 MHz) crystal video receiver, a pair of low-band sweeping superheterodyne receivers, a high-band (400 to 1000 MHz) crystal video receiver and a pair of high-band superheterodyne receivers. Figure 2-3 is a block diagram of the high-band receiver unit, and Table 2-1 summarizes the primary receiver characteristics. The high-band receivers, a time reference generator (TRG) and a 28-point status commutator are contained in the payload A Box. The low-band receivers are contained in the payload B Box. The A and B Boxes are independent of each other except for status monitor points and TRG interconnects. Some commands control both boxes, but except for these interconnects the boxes can be considered as separate payloads.

2.2.1 High-Band Receiver Unit (A Box)

The high-band receiver unit contains a broadband, 400-to 1000-MHz crystal video receiver, a pair of sweeping superheterodyne receivers covering the 400-to 1000-MHz band, a time reference generator (TRG), and a 28-point, 75-sample-per-second solid state status commutator.

2.2.1.1 Crystal Video Receiver. The RF input to the crystal video receiver is coupled from the same antenna used by one of the superheterodyne receivers via a calibrator coupler and calibrator isolation switch, passed through a 400- to 1000-MHz bandpass filter to a wideband RF amplifier, and applied to a crystal detector/amplifier. The video amplifier following the crystal detector has a psuedolog output. A 40-db input to the detector is compressed into a 20-db range. The compressed output pulses are then applied via a

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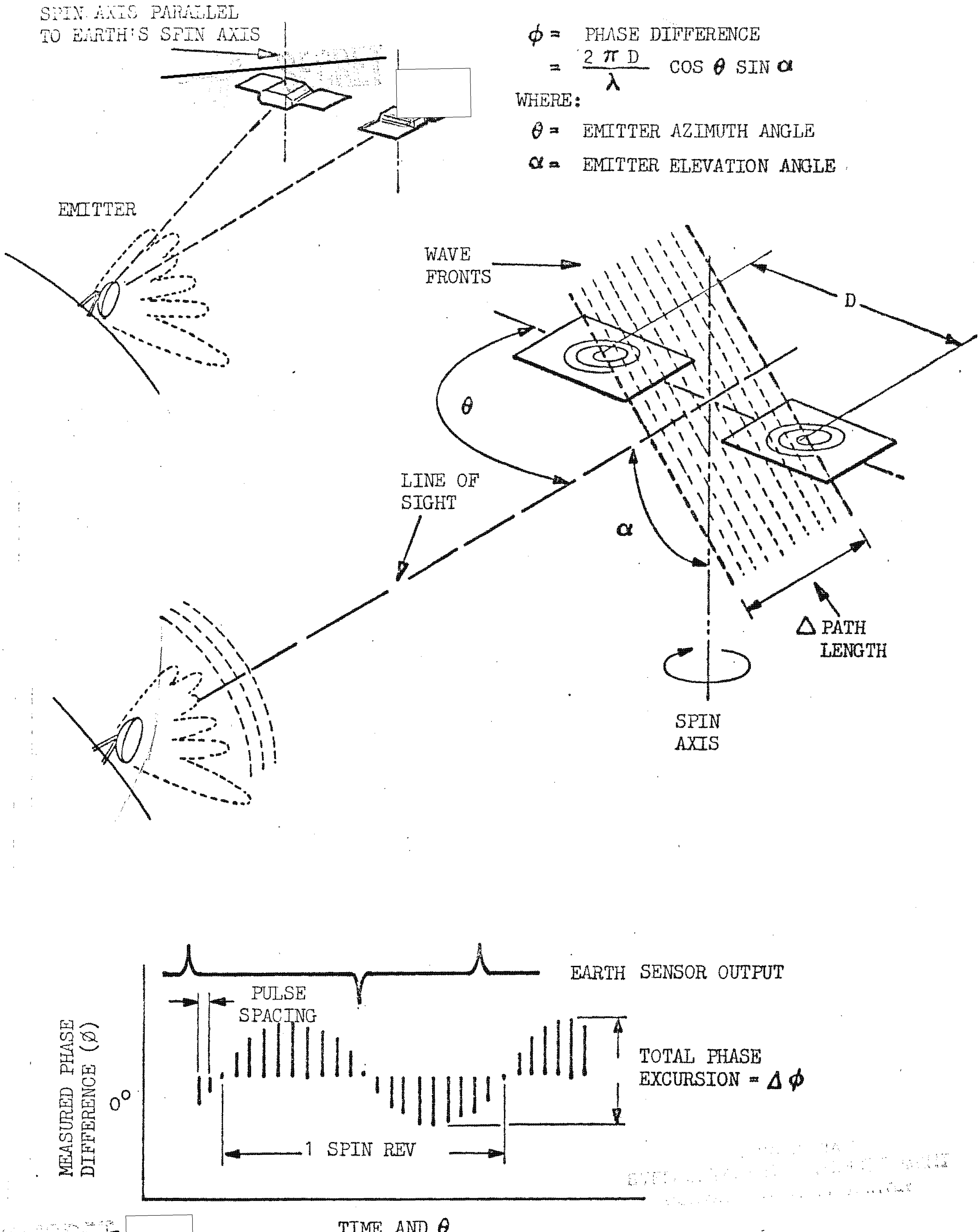

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Figure 2-2. Phase Measurement Geometry

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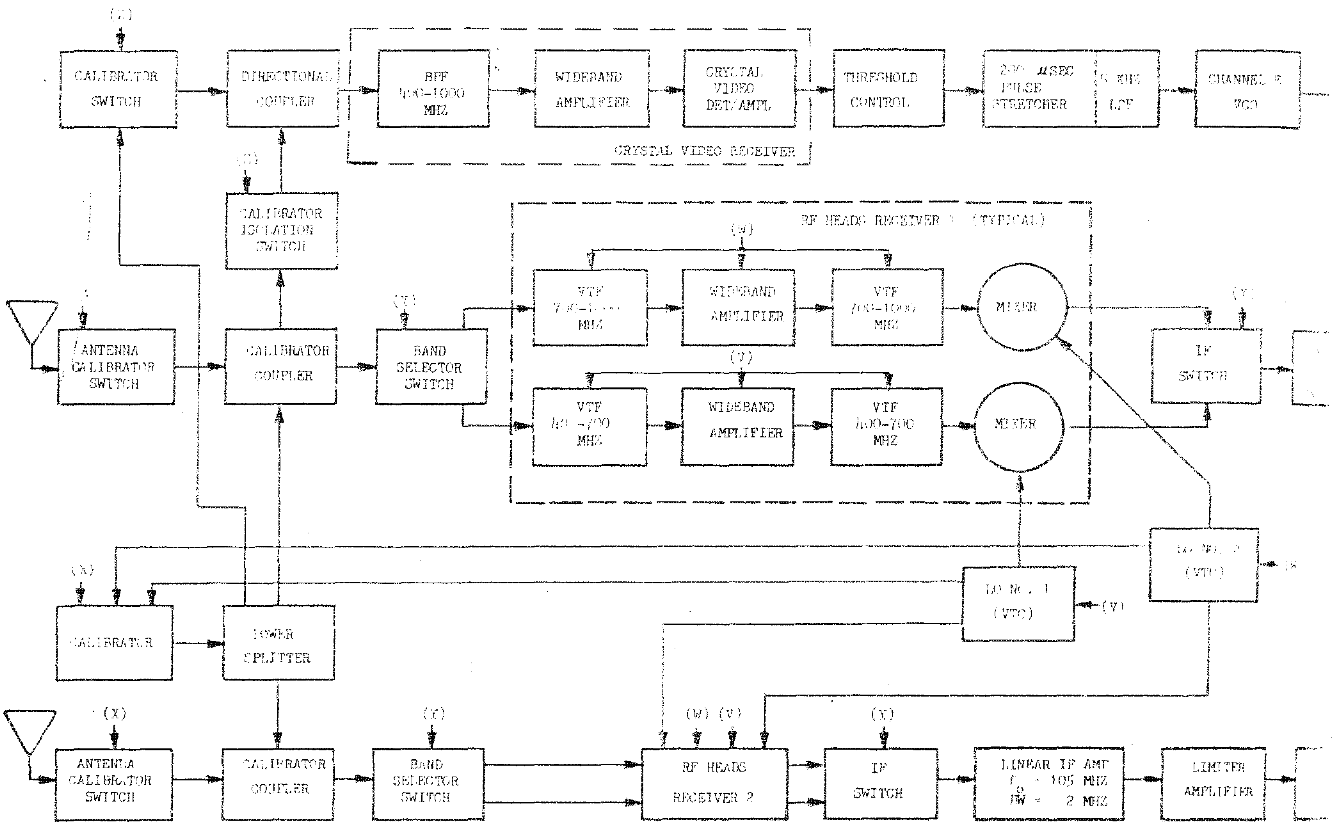

NOTE:

A BOX RECEIVER BLOCK SHOWN

B BOX RECEIVER BLOCK IS THE SAME, EXCEPT:

1. FREQUENCY BANDS (100-200 MHZ & 2[illegible]-4[illegible] MHZ)
2. IF FREQUENCIES (MAIN IF f_o = 40 MHZ BW [illegible] MHZ
   LOG IF f_o 40 MHZ BW 5[illegible] KHZ)
3. STATUS COMMUTATOR & TRG NOT REQUIRED
4. DATA OUTPUTS TO DIFFERENT T/R & XMTR (REFER TO FIGURE 1-1)
5. SUPERHET PULSE STRETCHER 40 MS LPF = 25 KHZ

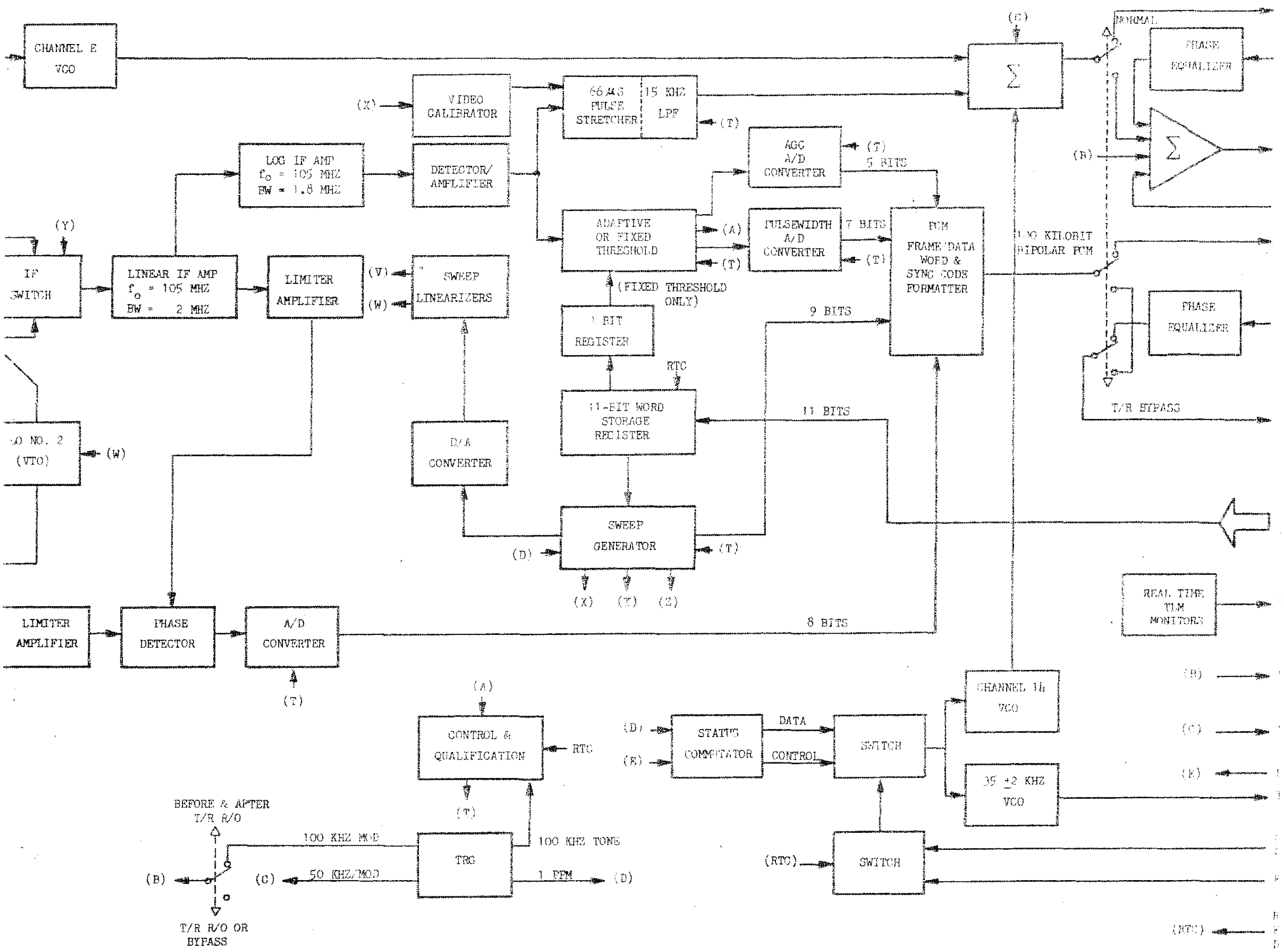

Figure 2-3. High-Band Payload Unit Block Diagra

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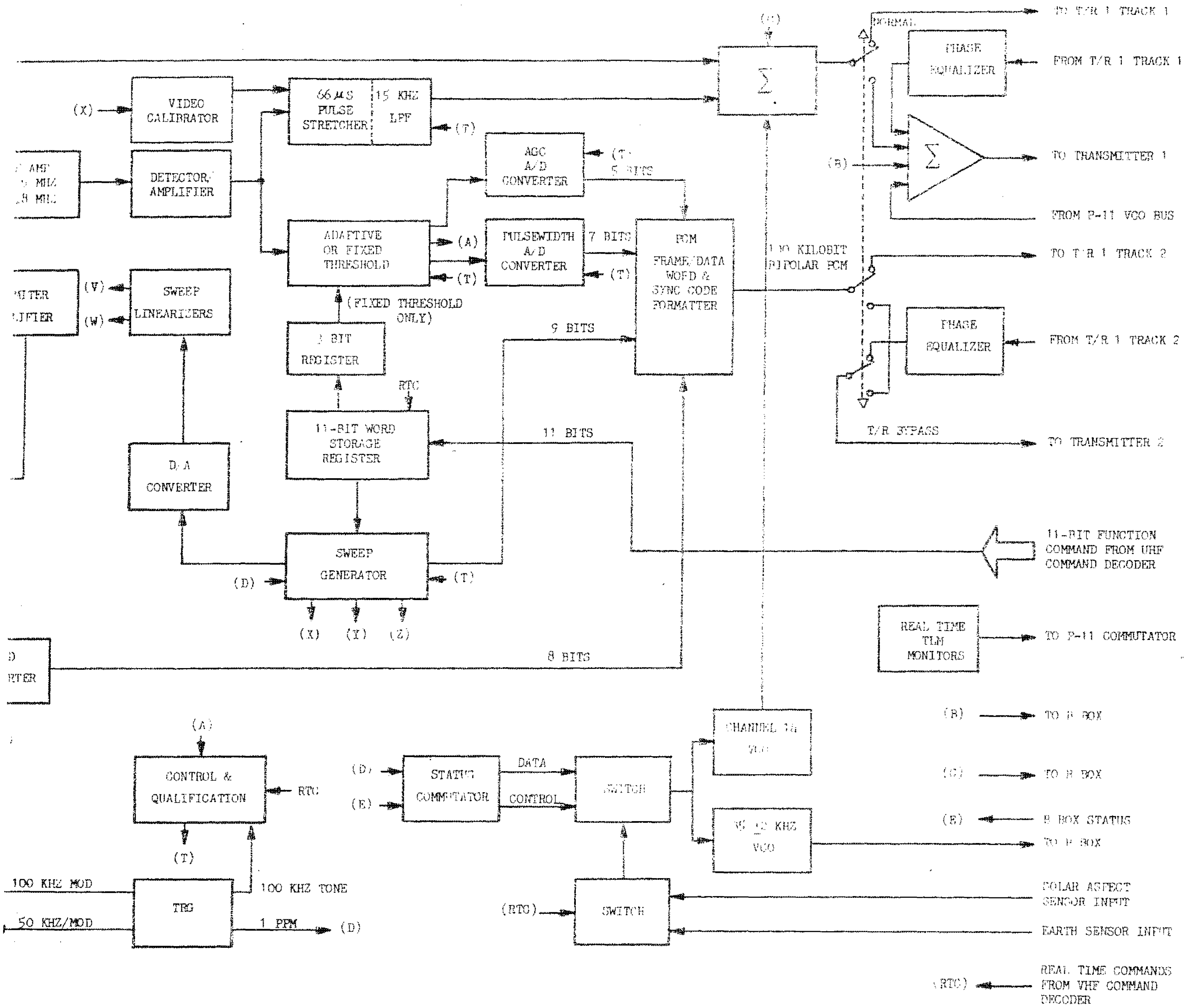

Figure 2-3. High-Band Payload Receiver Unit Block Diagram

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TABLE 2-1

SUMMARY OF RECEIVER SUBSYSTEM CHARACTERISTICS

Receiver Subsystem

Total receiver frequency coverage:	100 to 1000 MHz
Individual receiver frequency coverage:	
Low-band sweeping superhets	100 to 400 MHz in 600-kHz steps
Low-band crystal video	100 to 400 MHz
High-band sweeping superhets	400 to 1000 MHz in 1.2-MHz steps
High-band crystal video	400 to 1000 MHz
Receiver Sensitivity (S/N = 1)	
Low-band sweeping superhets:	
100 to 200 MHz	-92 dbm
200 to 400 MHz	-99 dbm
Low-band crystal video:	-54 dbm
High-band sweeping superhets:	
400 to 700 MHz	-99 dbm
700 to 1000 MHz	-98 dbm

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threshold control circuit to a 200-usec pulse stretcher that frequency modulates an IRIG channel E VCO. The crystal detector video output pulse must exceed a preset threshold for approximately 2 usec before a 200-usec pulse is generated. The amplitude of the generated pulse is proportional to the amplitude of signals received during the 10-usec period after the preset threshold has been exceeded. Successive 200-usec stretched pulses are generated as long as the amplitude of the video pulse is above the preset threshold. This condition would exist when a pulse longer than 202 usec was intercepted.

The output of the IRIG channel E VCO is applied to the tape recorder input via a summing amplifier in the normal readin mode and directly to a VHF transmitter in the tape recorder bypass mode.

2.2.1.2 Superheterodyne Receivers. The high-band superheterodyne receiver pair nominally sweeps through the 400- to 1000-MHz band in 512 1.2-MHz steps.* The two single-conversion superheterodyne receivers are tuned by common voltage-tuned oscillators (VTO's). One VTO covers the 400- to 700-MHz band and a second VTO covers the 700- to 1000-MHz band. Each receiver contains two preselectors that are tuned to the selected frequency step by the same sweep generator that controls the VTO's. The tunable preselectors consist of voltage-tuned filters (VTF's) coupled to wideband amplifiers. The 3-db bandwidth of the VTF's is approximately 10 percent of the lowest frequency over which the filters are tuned.

RF Heads

Each receiver has two RF heads that contain the RF preselectors and mixers. One RF head in each of the receiver pairs and one of the common local oscillators (VTO's) cover the 400- to 700-MHz band. The 700- to 1000-MHz band is covered by a second set of RF heads and a second VTO. The VTO that is to be used and the associated RF heads are selected by control logic in the data processor section of the receiver.

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* See VAMPAN payload calibration data report for exact frequencies.

Tuning Modes

The data processor section contains the circuits that control the receivers and condition the video outputs for data storage and/or transmission. The logic circuits can be commanded to program one of three tuning modes: The first mode (band scan) consists of 1.2-MHz frequency steps that cover the 400- to 700-MHz band, the 700- to 1000-MHz band, or the 400- to 1000 MHz band. The frequency tuning rate is 10 steps per second unless a signal is intercepted that satisfies a preset threshold requirement. If a qualifying signal is intercepted, the frequency step is held for 1.5 seconds. The second mode (fixed frequency) allows the VTO to be programmed to a discrete frequency step and held there until commanded to another step or to another mode. The third mode (incremental scan) consists of stepping the VTO across any five successive frequency steps in the 400- to 1000-MHz range. The center frequency step is selected by an 11-bit word. The stepping rate and hold logic is the same as that used in mode one.

Discrete real time commands are used to select mode one. A command address and an 11-bit command word from the UHF command decoder selects modes two and three. (Refer to Table 2-2 for functions of command addresses (C/A) and the 11-bit word.)

IF Amplifiers

Receiver number one has two parallel IF channels, each having a center frequency of 105 MHz. The first IF amplifier is a linear amplifier having a bandwidth of 2 MHz. The output of this amplifier is limited and applied to one input of a phase detector. (The second input to the phase detector is from a matched linear IF amplifier in receiver number two.) The second IF amplifier is a log amplifier having a bandwidth of 1.8 MHz. The output of this amplifier is envelope detected and applied to the data processor section.

Phase Detector

The phase detector produces an analog output proportional to the phase difference of an RF carrier intercepted by each of the high-band antennas. The two receivers are phase balanced; therefore, the phase difference voltage at the output of the phase detector is a function of the time of

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TABLE 2-2

COMMAND ADDRESS FUNCTIONS

Command	Name	Function
C/A 3*	A Box Digital Command	Command Address (C/A) 3 followed by 11-bit command function words select:** 1) 400-1000 MHz Band Fixed Thresholds (4 steps) 2) 400-1000 MHz Band sweep lock up on one frequency step, overrides RTC's 20, 21 and 22 3) 400-1000 MHz Band continuously sweeps 5 frequency steps (selected frequency step ±2 steps) overrides RTC's 20, 21 and 22
C/A 4**	B Box Digital Command	Command Address (C/A) 4 followed by 11-bit command function words select:** 1) 100-400 MHz Band Fixed Thresholds (4 steps) 2) 100-400 MHz Band sweep lock up on one frequency step, overrides RTC's 23, 24 and 25 3) 100-400 MHz Band continuously sweep 5 frequency steps (selected frequency ±2 steps) overrides RTC's 23, 24 and 25.

NOTES: * Execute RTC-16 before selecting function 1)
Execute RTC-17 before selecting functions 2) or 3)

** Execute RTC-18 before selecting function 1)
Execute RTC-19 before selecting functions 2) or 3)

If function 1) plus 2) or 3) is required, send the 11-bit word f[redacted]ction 1) first. 50X1

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TABLE 2-2 (Continued)

11-Bit Function Words (LSB is on the left)

Variable Threshold (Threshold No. 3)		
	0 0 0 0 0 0 0 0 0 1 0	Base threshold + adaptive off
	0 0 0 0 0 0 1 0 0 1 0	5 db above base threshold + adaptive off
	0 0 0 0 0 0 0 1 0 1 0	10 db above base threshold + adaptive off
	0 0 0 0 0 0 0 0 1 1 0	15 db above base threshold + adaptive off
Frequency Select (Typical)		
Step 1	1 0 0 0 0 0 0 0 0 0 1	Lock up discrete frequency (fixed freq.)
Step 2	0 1 0 0 0 0 0 0 0 0 1	Lock up discrete frequency (fixed freq.)
Step 3	1 1 0 0 0 0 0 0 0 0 1	Lock up discrete frequency (fixed freq.)
Step 511	1 1 1 1 1 1 1 1 1 0 1	Lock up discrete frequency (fixed freq.)
Step 1	1 0 0 0 0 0 0 0 0 1 1	Sweep discrete frequency ±2 steps (incremental scan)
Step 2	0 1 0 0 0 0 0 0 0 1 1	Sweep discrete frequency ±2 steps (incremental scan)
Step 3	1 1 0 0 0 0 0 0 0 1 1	Sweep discrete frequency ±2 steps (incremental scan)
Step 511	1 1 1 1 1 1 1 1 1 1 1	Sweep discrete frequency ±2 steps (incremental scan)

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arrival of the incident RF wavefront at the antennas. The phase detector analog output is converted to an 8-bit digital word if the received signal qualifies in the log IF data processor section.

Threshold Circuits

The log IF envelope detector output is applied to a threshold circuit and to a 66-usec pulse stretcher. The threshold circuit criteria must be met before any measurements of an incoming pulse can be conditioned for data storage and/or transmission. Two types of threshold control can be selected by command: adaptive threshold and fixed threshold. (See Figure 2-4.) The adaptive threshold allows threshold No. 2 to remain at a base level (15 db greater than thermal noise) in the absence of signal. In the presence of CW signals, the threshold rises above the base level by an amount equal to the resultant CW amplitude. In the presence of pulsed signals whose amplitudes exceed the base threshold at an average rate exceeding 1800 pulses per second, threshold No. 2 rises to a level that reduces the average pulse rate exceeding threshold No. 2 to 1500 ±300 pulses per second. Threshold No. 2 is always 6 db greater than threshold No. 1 and threshold No. 3 is always 6 db less than peak pulse amplitude. The fixed threshold mode is selected by C/A 3 and an 11-bit word.

The 11-bit command function word (see Table 2-2) allows threshold No. 2 to be set to 0, 5, 10, or 15 db above the base threshold level. In either the adaptive or fixed threshold mode the pulsewidth measurement starts when threshold No. 1 has been exceeded and ends when the signal drops below threshold No. 3. Threshold No. 2 must be exceeded within 1.1 usec after threshold No. 1 has been exceeded or all measurements are discarded in the data processor. If threshold No. 2 is exceeded within 1.1 usec after threshold No. 1 has been exceeded, a data word is generated and the pulse is stretched 66 usec when the signal drops below threshold No. 3. (See Figure 2-4.)

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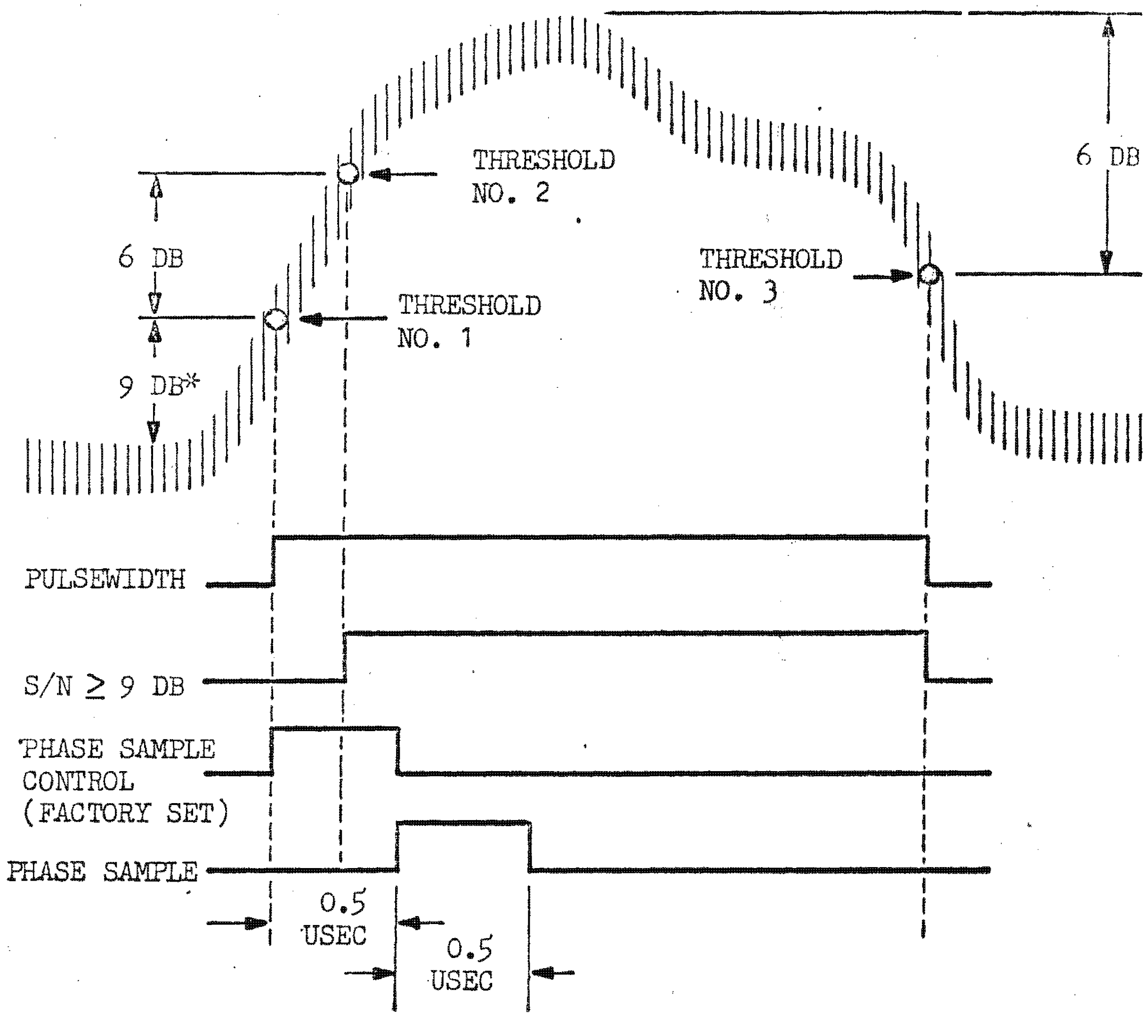

NOTES: Threshold No. 2 is by definition the base threshold when 1) in the adaptive threshold mode when signals are <u>not</u> present or 2) in the fixed threshold mode when 0 db is selected.

* Nominal value required when threshold No. 2 equals base threshold.

Figure 2-4. Superheterodyne Video Threshold Qualification

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PCM Frame Word

At the start of every target search period, a 29-bit, bipolar, binary frame word is generated at a 100-kilobit-per-second rate. The frame word consists of a 15-bit frame sync word, a 9-bit frequency step word, and a 5-bit threshold setting word. (See Figure 2-5.) The search interval normally extends for 90 msec after the 10-msec frame word interval; however, when a signal that meets the threshold requirements is intercepted, the search time is extended to 1.5 seconds. In the frequency sweeping modes, a frequency step occurs with the start of every frame word. In the fixed-frequency mode, the search logic is the same as in the frequency sweeping modes except that the same frequency step is selected. In all three tuning modes, the threshold setting word is generated 9950 usec after the start of the sync word to permit the signal environment to be sampled and the threshold to be set when in the adaptive threshold mode

PCM Data Word (See Figure 2-6)

An 18-bit, bipolar, binary data word is generated at a 100-kilobit-per-second rate for each signal pulse that meets the three threshold requirements. The data word consists of a 2-bit sync word, an 8-bit phase measurement word, a 7-bit pulsewidth measurement word, and a 1-bit end of word bit. Phase measurement resolution is 1.41 electrical degrees per bit, and pulsewidth resolution is as follows:

a. 0.2 usec per bit for pulsewidths from 1.2 to 4 usec

b. 0.4 usec per bit for pulsewidths from 4 to 8 usec

c. 0.8 usec per bit for pulsewidths from 8 to 16 usec

d. 1.6 usec per bit for pulsewidths from 16 to 120 usec.

Pulsewidth measurement starts when threshold No. 1 has been exceeded and ends when the signal drops below threshold No. 3. Phase measurement is made during the 0.5 usec period which starts 0.5 usec after threshold No. 1 has been exceeded.

2.2.1.3 Data Outputs (See Figure 2-7). Two channels of data are generated in the payload A Box during readin. One channel consists of 3-level, bipolar nonreturn-to-zero (NRZ) digital frame and data words generated at a 100-kilobit rate. The second channel is a multiplexed signal consisting of the

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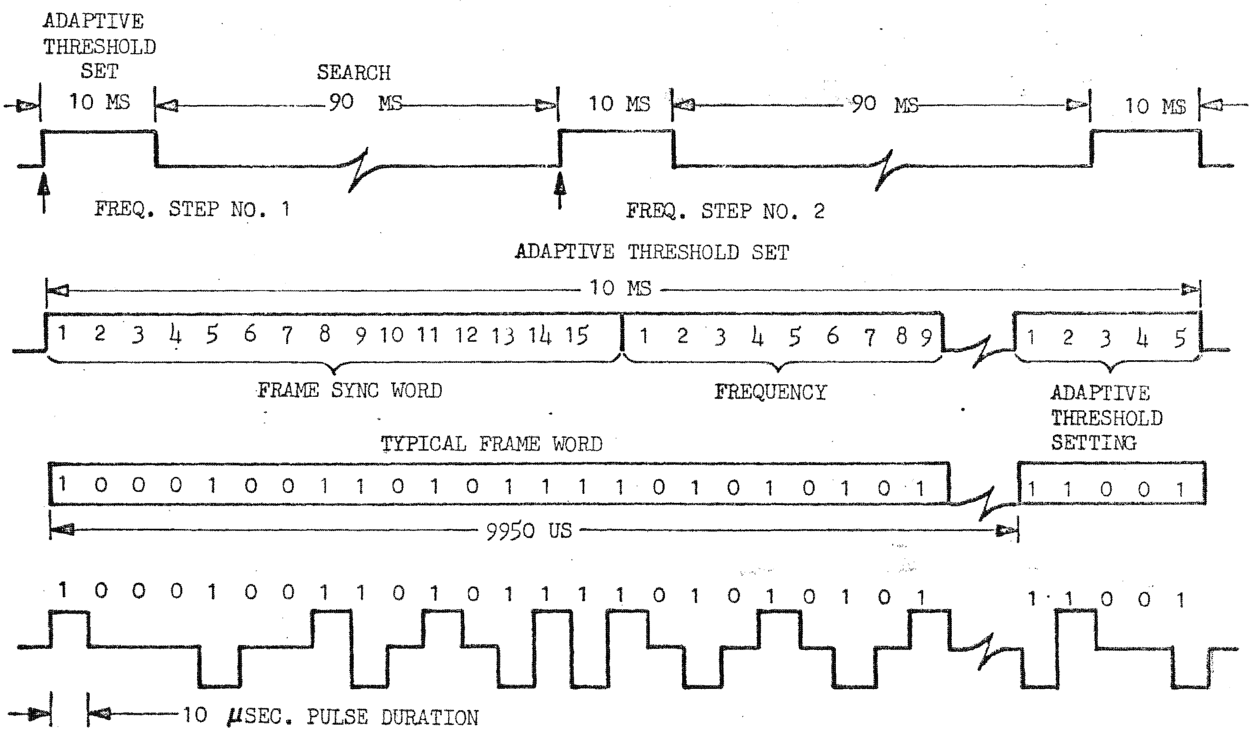

Figure 2-5 Frame Word Format

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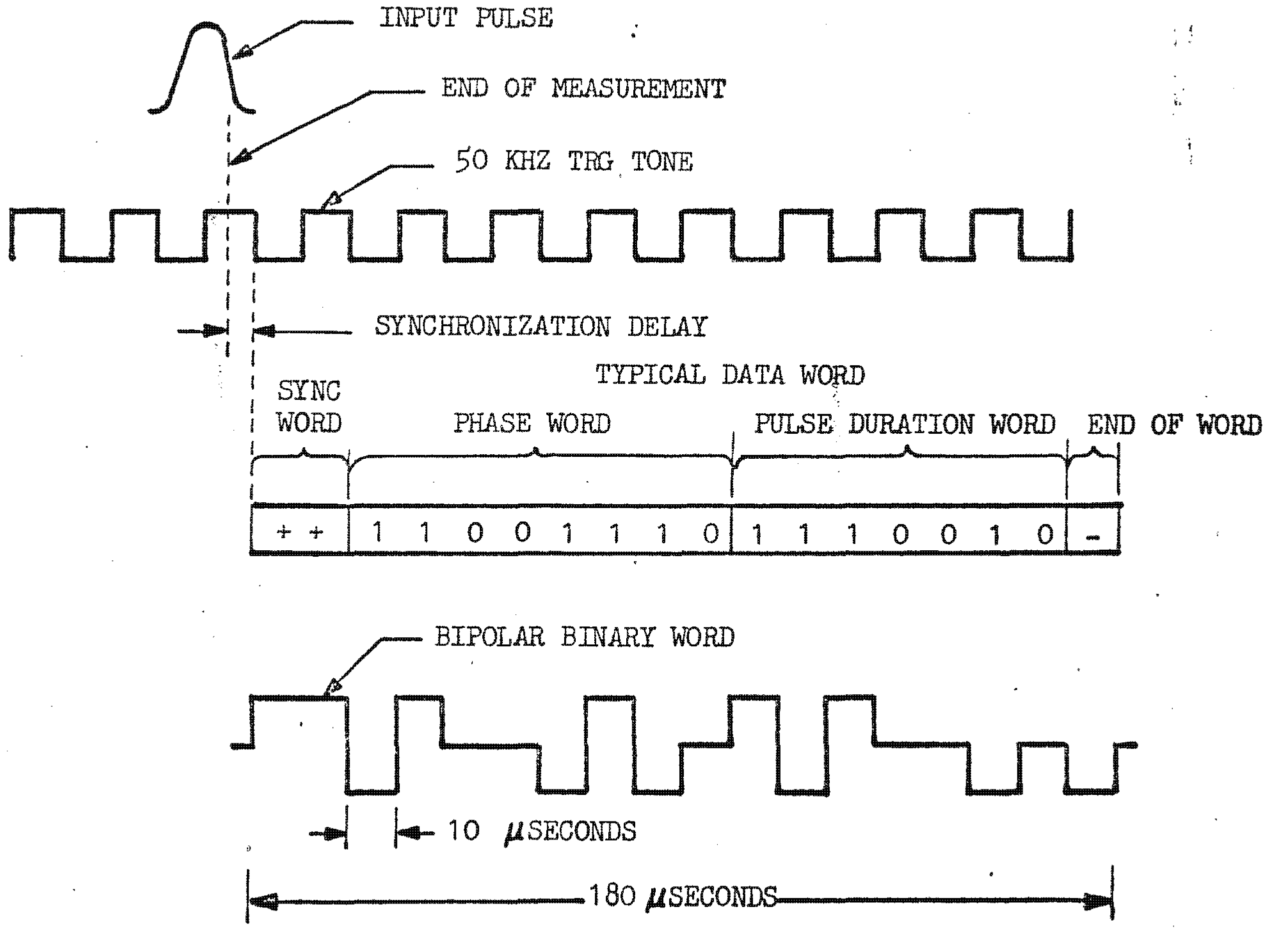

Figure 2-6. Data Word Format

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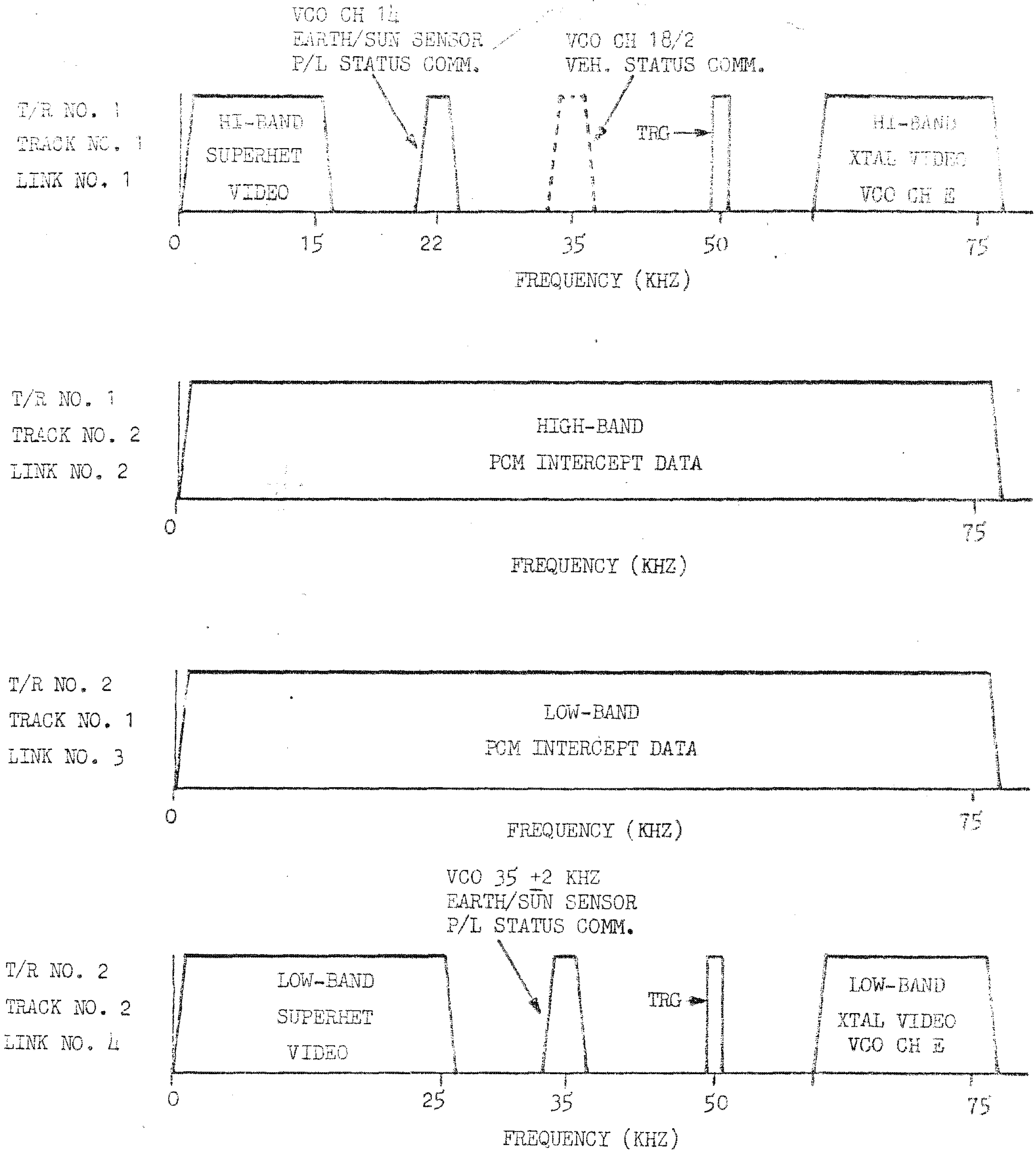

NOTES:
1. Readin format of 2:1 speed ratio tape recorders shown. Readout format is two times frequencies shown.
2. Ch 18 VCO is read out in real time. It is shown at half frequency to indicate its position in the readin spectrum of the T/R.
3. Tape recorder input transfer mode interchanges T/R 1 track 1 with T/R 2 track 2 and T/R 1 track 2 with T/R 2 track 1.

Figure 2-7. Tape Recorder Input Data Format following:

a. Superheterodyne video pulses stretched to 66 usec
b. IRIG channel 14 VCO modulated by the sun/earth sensors or the payload status commutator
c. 50-kHz reference tone modulated by the AN/GSQ-53 time word
d. IRIG channel E VCO modulated by the high-band, 200-usec stretched crystal video pulses.

During the tape recorder readin mode, the 100-kilobit PCM channel and the multiplexed signal are recorded on two tracks of one of the two 150-kHz, 2:1 (readout/readin) magnetic tape recorders. During tape recorder readout mode, the two tape recorder outputs are routed back to the payload where the signals are phase equalized to compensate for tape recorder phase distortion. The PCM phase equalizer output is applied to one of the four VHF transmitters. The multiplexed output of the other phase equalizer is summed with an IRIG channel 18 VCO (modulated by the P-11 status commutator) and then applied to the input of one of the VHF transmitters. (See Figure 2-7, noting that the frequencies are multiplied by 2 because of the tape recorder readout-to-readin ratio of 2:1.) The data format during tape recorder bypass mode is also the same as shown in Figure 2-7 except that the channel 18/2 data are omitted.

The before-and-after tape recorder readout data format is shown in Figure 2-8. The PCM channel is no longer present, and the multiplexed channel consists of the following:

a. IRIG channel 15 VCO modulated by the P-11 solar array current monitor
b. IRIG channel 16 VCO modulated by the P-11 earth sensor data
c. IRIG channel 17 VCO modulated by the P-11 solar aspect sensor data
d. IRIG channel 18 VCO modulated by the P-11 status commutator
e. 100-kHz TRG reference tone modulated by the payload AN/GSQ-53 time word.

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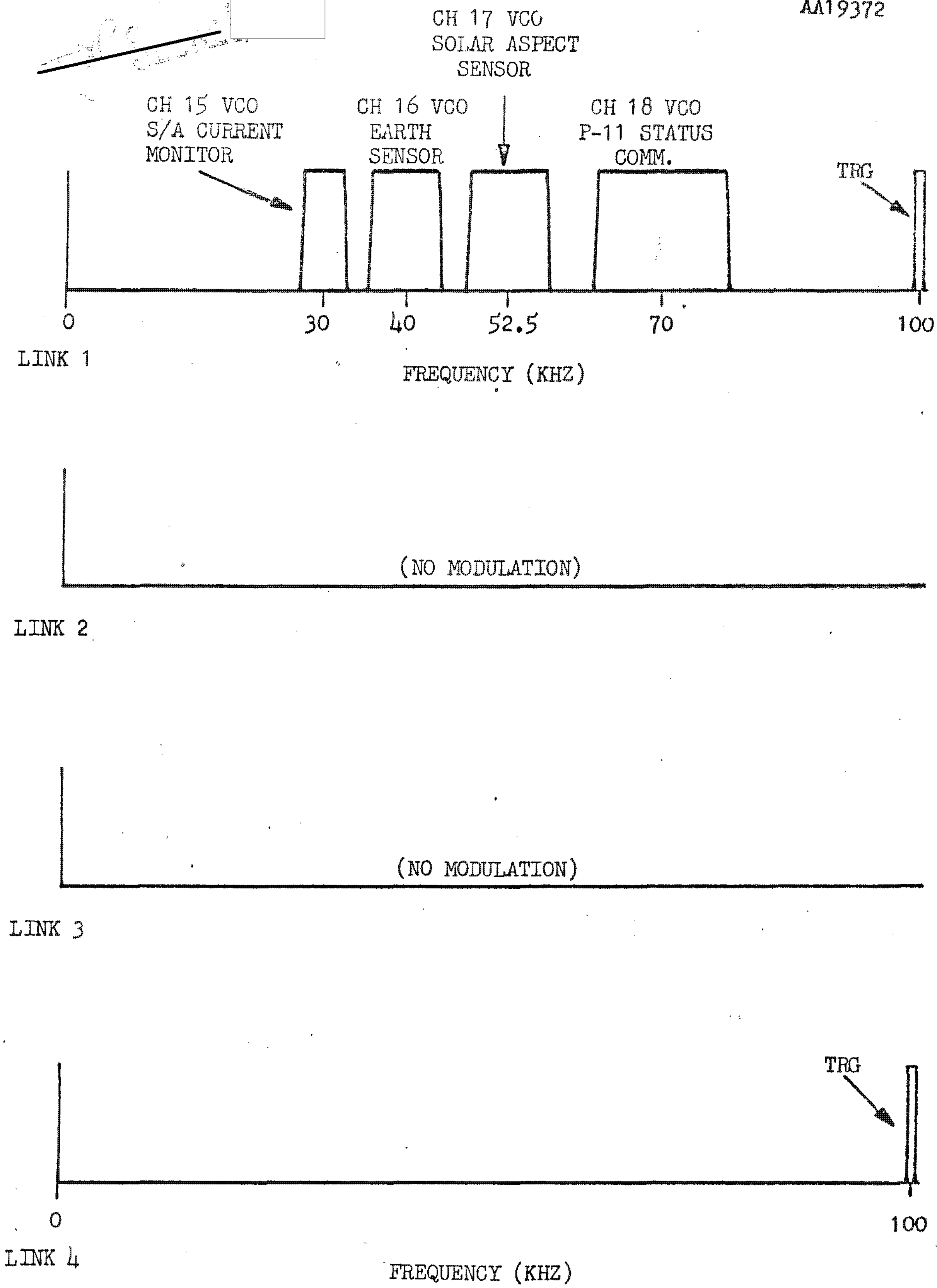

NOTE: Tape recorder input transfer mode connects the Ch 15, 16, 17 and 18 VCO's to link 3.

Figure 2-8. Before and After Tape Recorder Readout Data Format

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2.2.1.4 Earth/Sun Sensors and Payload Status Commutator. An IRIG channel 14 VCO is modulated by either earth sensor or sun sensor marker pulses, as selected by real time command. Once every minute the sensor modulation is interrupted and the two VCO's are modulated by one frame of the 28-point status commutator. The status commutator inputs are from both the A and B Boxes and are shown in Table 2-3. The channel 14 VCO is multiplexed with the A Box superheterodyne video pulse stretcher, TRG, and VCO data. The redundant channel 35 ± 2 kHz VCO is multiplexed with the B Box superheterodyne video pulse stretcher, TRG, and VCO data. (See Figure 2-7.)

2.2.1.5 Time Reference Generator. The time reference generator (TRG) is used as the basic time reference in both payload boxes. Two of the TRG outputs are multiplexed with data outputs; these are the 50-kHz and the 100-kHz reference tones which are amplitude modulated by a binary-coded-decimal time word using the AN/GSQ-53 format. (See Figures 2-7 and 2-8.) The TRG is a separate unit contained in the payload A Box and is supplied with continuous power from the P-11 spacecraft.

Frequency stability of the TRG is as follows:

Short Term: One part in 10^8 parts or better

Long Term: One part in 10^6 parts or better.

Short-term stability as used herein is defined as the frequency deviation for averaging times from 100 usec to 10 seconds; long-term stability is defined as the frequency deviation for averaging times greater than 10 seconds. Frequency accuracy is 5 parts in 10^5 parts or better.

2.2.1.6 Calibrator Signals. Three different calibration signals are generated and inserted into the receivers during a normal readin mode (see Figure 2-9.) The first signal comprises a 50-msec burst of 5-usec pulses at a PRF of 1 kHz applied to the front end of the superheterodyne and crystal video receivers once per minute. This calibration signal is inserted in the center of the passband of the frequency step to which the superheterodyne receivers are tuned to provide the following: (1) a zero-phase reference check in the phase detector channel of the

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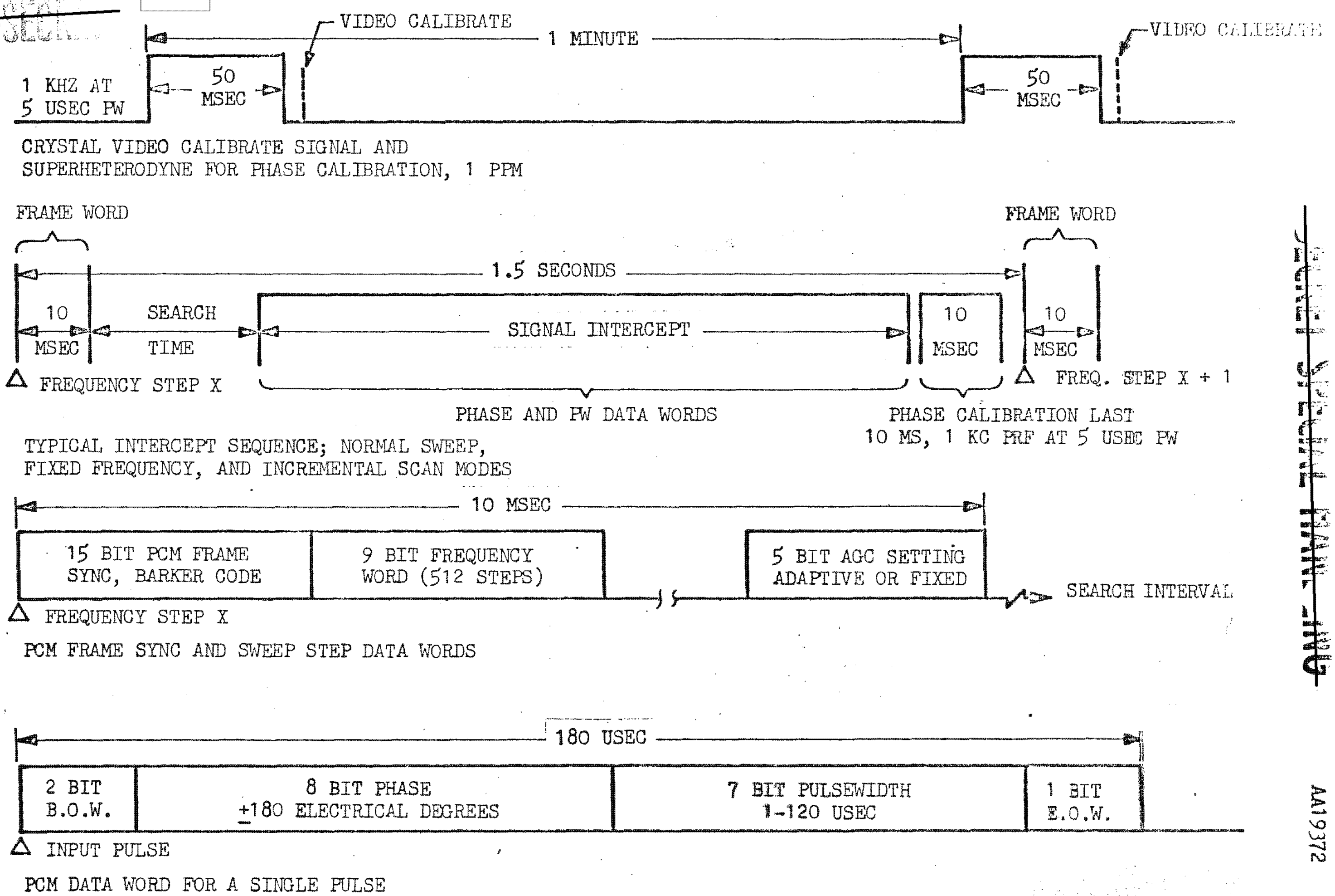

Figure 2-9. Calibrator Signals and PCM Words

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TABLE 2-3

28-POINT STATUS COMMUTATOR (NRZ)

Commutator Position	Description
1	Cal 1/2 (2.5 V)
2	100-400 MHz fixed threshold monitor (5 levels) P/L monitor No. 2
3	400-1000 MHz fixed threshold monitor (5 levels) P/L monitor No. 1
4	100-400 MHz scan mode monitor (3 levels) P/L monitor No. 3
5	400-1000 MHz scan mode monitor (3 levels) P/L monitor No. 4
6	Frequency lock-up monitor (4 levels) P/L monitor No. 5
7	Incremental scan monitor (4 levels) P/L monitor No. 6
8	T/R bypass monitor (2 levels) P/L monitor No. 7
9	S/A/S - E/S relay monitor (2 levels) P/L monitor No. 8
10	Cal 1/2 (2.5 V)
11	Temperature monitor VTO No. 1, 100-200 MHz
12	Temperature monitor VTO No. 2, 200-400 MHz
13	Temperature monitor phase detector, 100-400 MHz
14	Temperature monitor VTO No. 3, 400-700 MHz
15	Temperature monitor VTO No. 4, 700-1000 MHz
16	Temperature monitor phase detector, 400-1000 MHz
17	Cal + (5.0 V)
18	Temperature monitor power converter, 100-400 MHz
19	Temperature monitor power converter, 400-1000 MHz
20	Temperature monitor, TRG
21	Voltage monitor +10 V, 100-400 MHz
22	Voltage monitor +10 V, 400-1000 MHz
23	Cal Z (Grd)
24	Cal 1/2 (2.5 V)
25	Cal Z (Grd)
26	Sync (5.3 V)
27	Sync (5.3 V)
28	Sync (5.3 V)

superheterodyne receivers and (2) a check of all the data processor outputs of the crystal video and superheterodyne receivers. The second calibration signal, similar to the first calibration signal except that the time duration is 10 msec, is applied to the front ends of the superheterodyne receivers during the last 10 msec of the 1.5-second frequency hold after a valid signal intercept. The primary purpose of this signal is to provide a zero-phase reference check at the intercept frequency. The antenna inputs are disconnected by RF switches during the time that calibration signals one and two are present to prevent interference from target signals. The third calibration signal is a video pulse nominally 66 usec wide and one half the maximum video amplitude. This signal is inserted into the superheterodyne video output once per minute. The primary purpose of this signal is to permit evaluation of data storage and transmission quality independent of receiver sensitivity and RF calibrator levels.

2.2.2 Low-Band Receiver Unit (B Box)

The low-band receiver unit contains a broadband, 100- to 400-MHz crystal video receiver and a pair of sweeping superheterodyne receivers covering the 100- to 400-MHz band.

2.2.2.1 Crystal Video Receiver. The low-band crystal video receiver is similar to the high-band unit except for the frequency coverage.

2.2.2.2 Superheterodyne Receivers. The low-band superheterodyne receivers are basically similar to the high-band units, with the following differences:

a. Band Coverage

   100 to 400 MHz in 512 0.6-MHz steps

   RF head and VTO No. 1 cover the 100- to 200-MHz band

   RF head and VTO No. 2 cover the 200- to 400-MHz band

b. IF Channels

   Linear IF BW = 1 MHz, f_o = 40 MHz

   Log IF BW = 0.8 MHz, f_o = 40 MHz

c. Superheterodyne Pulse Stretcher

   Pulsewidth = 40 usec

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d. Threshold Circuits

Threshold No. 2 must be exceeded within 1.5 usec after threshold No. 1 has been exceeded before data are processed.

e. Data Outputs

The PCM output contains the same data word types as the payload A Box.

The multiplexed output channel to the tape recorder during readin is as follows (see Figure 2-7):

1) Superheterodyne video pulses stretched to 40 usec
2) 35 $\pm$2-kHz VCO modulated by the sun/earth sensors or the payload status commutator (redundant data)
3) 50-kHz reference tone modulated by the AN/GSQ-53 time word
4) IRIG channel E VCO modulated by the low-band 200-usec stretched crystal video pulses.

f. Calibrator

The RF calibrators are the same as those in the high-band unit, but the video calibrator pulse is 40 usec wide.

During tape recorder readout, the data format for the PCM channel is the same as that of the high-band unit. The multiplexed output to the transmitter is the same as the readin format multiplied by 2. The data format during the bypass mode is the same as shown in Figure 2-7. The before-and-after tape recorder readout data format consists of a 100-kHz reference tone modulated by the AN/GSQ-53 time word.

2.3 DATA RECORDING AND TRANSMISSION SUBSYSTEM

2.3.1 Tape Recorders

Two dual-track, magnetic tape recorders are used to store the payload and earth/sun sensor data during payload readin. Tape recorder readin time is a nominal 12 minutes with a frequency response of $\pm$3 db over the 300-Hz to 75-kHz range. The dynamic range is 25 db with a linear input/output

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response. Readout tape speed is double the readin speed; therefore, the nominal readout time is six minutes and the readin frequencies are doubled. A 50-kHz reference tone is applied to one track of each tape recorder during readin to permit tape speed compensation during ground data processing. The tape recorder track assignments for the payload data during the normal tape recorder mode are as follows (see Figure 2-7):

T/R No.	Track No.	Data
1	1	High-band multiplex signal (66-usec pulses, IRIG chan 14 VCO, 50-kHz reference tone and IRIG chan E VCO)
1	2	High-band PCM data
2	1	Low-band PCM data
2	2	Low-band multiplex signal (40-usec pulses, 35 ±2-kHz VCO, 50-kHz reference tone, and IRIG chan E VCO)

Tape recorder inputs can be transferred by real time command to interchange T/R No. 1 track No. 1 with T/R No. 2 track No. 2 and T/R No. 1 track No. 2 with T/R No. 2 track No. 1. The tape recorder can also be bypassed by real time command. In the tape recorder bypass mode, the payload outputs that normally go to the tape recorder inputs are applied directly to the telemetry transmitters. This mode permits the payload data to be transmitted to a ground station in real time.

2.3.2 Data Transmission

Four 2-watt FM, VHF telemetry transmitters operating at 228, 232, 238 and 242 MHz are used to transmit payload and vehicle data. All four transmitters are coupled to a multicoupler that feeds a VHF monopole having extended radial elements to provide a good ground plane. The location of the telemetry antenna on the spacecraft is shown in Figure 2-1. All transmitters are operated simultaneously during readout, thus permitting both tape recorders to be read out simultaneously. The data format during tape recorder readout is shown in Figure 2-7, and the data format before and after tape recorder readout is shown in Figure 2-8. Vehicle status data are normally transmitted via telemetry link No. 1, except during a tape recorder transfer mode which places these data on telemetry link No. 4.

Transmitter inputs are not interchangeable; therefore, each transmitter is connected as follows to a specific tape recorder output during tape recorder readout:

Transmitter	T/R	Track
1	1	1
2	1	2
3	2	1
4	2	2

During a tape recorder bypass mode, the transmitters are disconnected from the tape recorder channels and connected to the payload real time data outputs as follows:

Transmitter	P/L Box	Data Type
1	A	Multiplex
2	A	PCM
3	B	PCM
4	B	Multiplex

The vehicle VCO bus (IRIG channels 15 thru 18) and the 100-kHz reference tone are not present on any of the transmitters during the tape recorder bypass mode.

2.4 COMMAND SUBSYSTEM

The P-11 command system provides 32 real time commands (RTC's), 7 command addresses (CA's), 6 stored program commands (SPC's) and 2 base module events. The command subsystem consists of a UHF (375.2 MHz) phase-modulated command receiver/demodulator, a command decoder and a programmable timer.

2.4.1 Command Receiver/Demodulator and Decoder

The command receiver/demodulator and decoder combination utilizes a VHF phase-modulated carrier for the ground/space link. The carrier is modulated by tones corresponding to digital data bits. A data word contains 22 bits sent at a maximum rate of 1 kilobit per second and consists of a start bit, a 5-bit vehicle address, a 3-bit command address, an 11-bit command function, a parity bit, and a final stop bit.

Each bit represents one of four tones: an "S" tone for start and stop bits, a tone for a "1," a tone for a "0," and an "R" tone. The "R" pulse, which indicates a single repetition of the preceding bit, is used as a "1" or "0" when the data require transmission of two consecutive "1's" or "0's." Tone frequencies for the various bits are as follows:

Bit		Tone
"S"	(for start and stop bits)	6.0 kHz
"R"	(used for a single repetition of the preceding bit)	8.5 kHz
"1"		11.0 kHz
"0"		13.5 kHz

The receiver/demodulator converts the UHF carrier phase-modulated tones into four signals (S, R, 1, 0) which are processed into three data outputs (S, 1, 0). The digital decoder accepts the data outputs and, if the sequence of pulses forms a valid message (as determined by address, length, and parity checks), provides the appropriate command. The demodulator also controls its own internal power and provides a signal that can be used to control power to the digital decoder. The power control turns on all internal power and provides a POWER ON signal to the decoder upon receipt of the first "S" tone. One second (minimum) after the receipt of the last data tone, the demodulator removes the POWER ON signal and switches its internal power to standby power.

The command decoder output may be any one of 32 real time commands or any one of 7 command address outputs. The 32 RTC's are derived from the first 5 command function bits if the 3 command address bits are all zeros. RTC's related to the payload are shown in Table 2-4.

The seven C/A's are selected by the three command address bits if the command address bits are other than all zeros. A discrete command is

TABLE 2-4

PAYLOAD REAL TIME COMMANDS

Mode	Command	Name	Function
	RTC-1	TM ON	P/L A & B TM power ON*
			P/L A & B "Before and After T/R R/O" Power ON
	RTC-2	TM OFF	P/L A & B Readin Power OFF
			P/L A & B "Before and After T/R R/O" Power OFF
			P/L A & B TM Power OFF
			P/L A & B "During T/R R/O" Power OFF
	RTC-3	T/R R/O	Switch "During T/R R/O" Power to P/L A & B ON
			Switch "Before and After T/R R/O" Power to P/L A & B OFF
H	RTC-13	T/R Bypass Reset	P/L A & B Box Data Outputs connected to T/R Input
A1	RTC-16	A Box AGC ON	A Box Adaptive Threshold selected
			Clear A Box Command Memories
A2	RTC-17	A Box Frequency Select Clear	A Box 11-bit Command Memory cleared
B1	RTC-18	B Box AGC ON	B Box Adaptive Threshold selected
			Clear B Box Command Memories
B2	RTC-19	B Box Frequency Select Clear	B Box 11-Bit Command Memory cleared
C1	RTC-20	A Box 400-700 MHz Sweep Mode	A Box Superhet Receivers sweeping continuously from 400-700 MHz nominally
C2	RTC-21	A Box 700-1000 MHz Sweep Mode	A Box Superhet Receivers sweeping continuously from 700-1000 MHz
C3	RTC-22	A Box 400-1000 MHz Sweep Mode	A Box Superhet Receivers sweeping continuously 400-1000 MHz

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* Refer to LMSC/B118295, "Command List FTV 4413 (U)," for complete command listing.

TABLE 2-4 (Continued)

Mode	Command	Name	Function
D1	RTC-23	B Box 100-200 MHz Sweep Mode	B Box Superhet Receivers sweeping continuously 100-200 MHz
D2	RTC-24	B Box 200-400 MHz Sweep Mode	B Box Superhet Receivers sweeping continuously 200-400 MHz
D3	RTC-25	B Box 100-400 MHz Sweep Mode	B Box Superhet Receivers sweeping continuously 100-400 MHz
E	RTC-26	Select E/S	Select Earth Sensor output for recording during P/L readin
F	RTC-27	Select S/A/S	Select Solar Aspect Sensor output for recording during P/L readin
G	RTC-29	Select T/R Bypass	P/L A & B Box Data Outputs connected to the transmitters bypassing the tape recorders.

generated each time a command address word is accepted by the decoder. Each time a discrete C/A is generated, an 11-bit function command is read out in parallel. The 11-bit function command word consists of bits 10 thru 20 of the 22-bit command word to the command receiver. Two of the seven C/A's (C/A 3 and 4) and 11-bit function commands are utilized by the payload units. Four of the C/A's (C/A 1, 2, 6, and 7) and 11-bit function commands are used to load and start the programmable timers. C/A 5 is a spare.

C/A 3 enables the payload A-Box to accept the 11-bit function command, and C/A 4 enables the payload B-Box to accept the 11-bit function command. The 11-bit function command words are used as follows: (1) to select one of four fixed thresholds, and (2) to lock the sweep on a discrete frequency step or (3) to sweep ±2 steps (incremental scan) about a discrete frequency in the payload box that is enabled by the C/A. C/A 3 is logically related to RTC's 16, 17, 20, 21, and 22 as follows: RTC-16 selects the adaptive threshold mode (AGC) and clears the two storage registers in the A-Box which may be loaded by C/A3. RTC's 20, 21 and 22 select the sweep mode if the 11-bit frequency register is clear, and RTC 17 clears the A Box 11-bit command memory.

C/A 4 is logically related to RTC's 18, 19, 23, 24, and 25 in the same way that C/A 3 is related to RTC's 16, 17, 20, 21 and 22. A typical A Box command sequence utilizing C/A 3 and the 11-bit function command would be as follows (see Table 2-2):

Command	Function
1. Execute RTC-16	a. 3-bit threshold register and 11-bit frequency register cleared in A-Box. b. The sweep mode would now be determined by the last RTC sent of RTC's 20, 21 and 22. c. Receivers in adaptive threshold mode.
2. Execute C/A 3 plus following 11-bit word LSB MSB 0 0 0 0 0 0 1 0 0 1 0	Variable threshold 5 db above base threshold enabled
3. Execute C/A 3 plus following 11-bit word LSB MSB 0 1 0 0 0 0 0 0 0 0 1	a. Variable threshold remains at 5 db above base threshold. b. Superhet receivers lock up on tuning step 2.

Commands are verified via an acceptance pulse generated in the digital decoder during message execution. The acceptance pulse, the 3 command address bits and the 11 command function bits are transmitted to the ground via a VHF PAM/FM/FM, 5-sample-per-second commutated channel.

2.4.2 Programmable Timer

The stored program commands (SPC's) are provided by a programmable timer having three types of command outputs: (1) stored program commands, (2) primary and companion events, and (3) base module timer events.

2.4.2.1 Stored Program Commands. There are six stored program commands that are preset before launch. The SPC's are used for pyro events that initiate P-11 spin-up, ignition, and antenna and solar array deployment.

The preset timed events are started by the P-11/Agena separation switches.

2.4.2.2 Primary and Companion Events. The two primary events are used to turn on the payload readin power and the earth/sun sensor power and to start tape recorder readin. Each of the two primary events has an associated companion event that starts to clock out when the primary event has counted down. The companion event turns off the payload readin power and the earth/sun sensor power and stops the tape recorders if they are not already at the end-of-tape position. The primary events are selected by command addresses that use the 3 command address bits and the 11 command function bits. The command address output serves as a "clear," "read," and "start" pulse for the programmable timer. The "clear" function drives the timer's 11-bit loadable register to the all "0's" state, and the "read" function gates the information in the decoder's 11-bit function register into the timer's 11-bit loadable timing register. The "start" function initiates the countdown process which results in a programmable event output at some later time as determined by the "time word." Primary event time delays of up to 16,378 seconds in 8-second increments can be selected by C/A. Two companion event time delays are preset before launch. A 7-minute or a 14-minute companion event delay may be selected by real time command.

2.4.2.3 Base Module Timer Events. The third type of command output is determined by the 2 base module timers. Base module timer No. 1 is started by RTC 1 and counts down in 12 minutes. It is used to back up RTC 2, "telemetry off" (exclusive of payload A and B readin power off and tape recorder stop). Base module timer No. 2 is started by RTC 3 and is used as a backup event to stop tape recorder No. 1 and No. 2, to switch payload A and B "during T/R R/O power" off, to switch payload A and B "before and after T/R R/O power" on, to apply power to P-11 VCO's 15, 16, and 17, and to start solar array calibration. Base module timer No. 2 counts down in a time (nominally 390 seconds) which will allow a full tape recorder readout.

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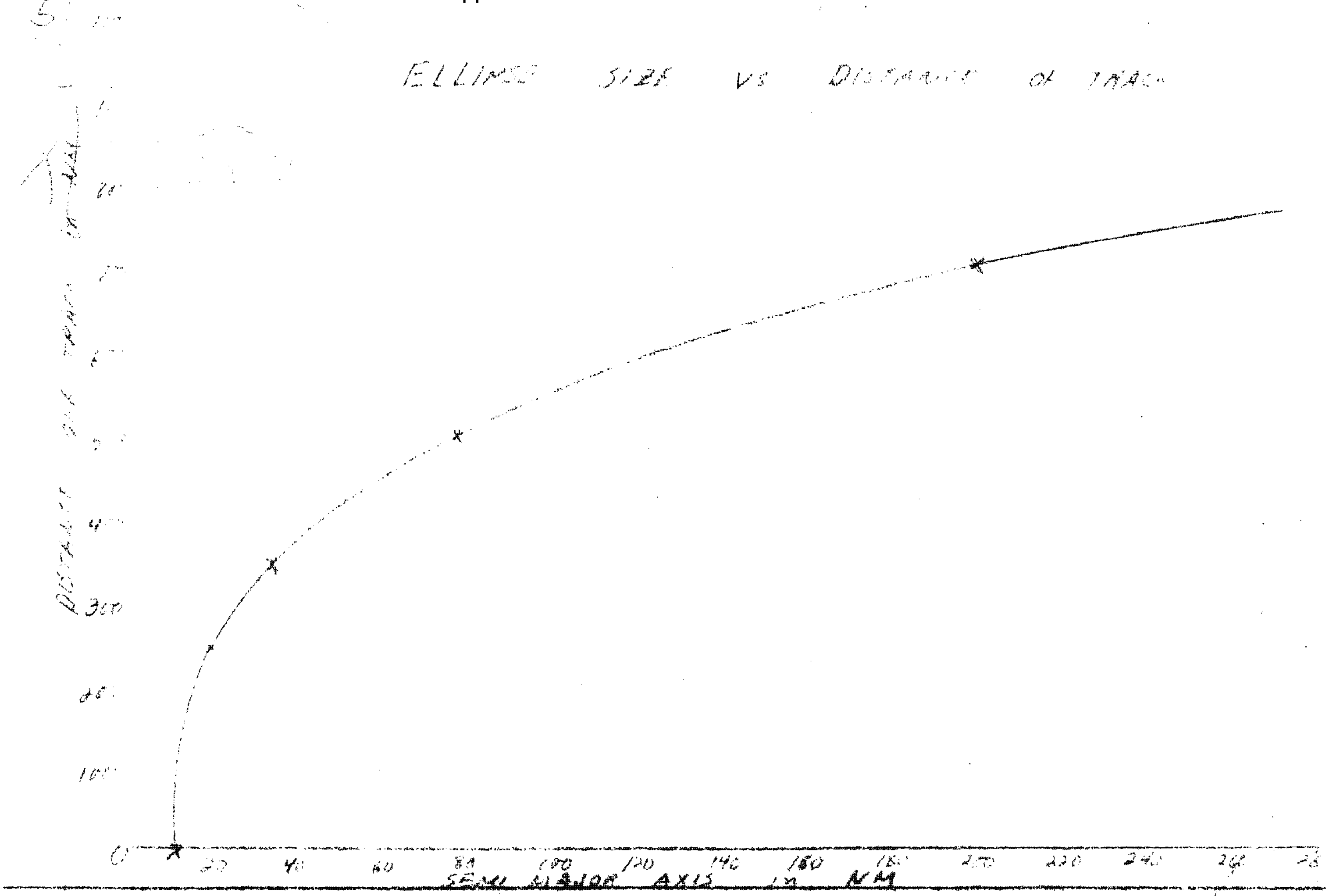
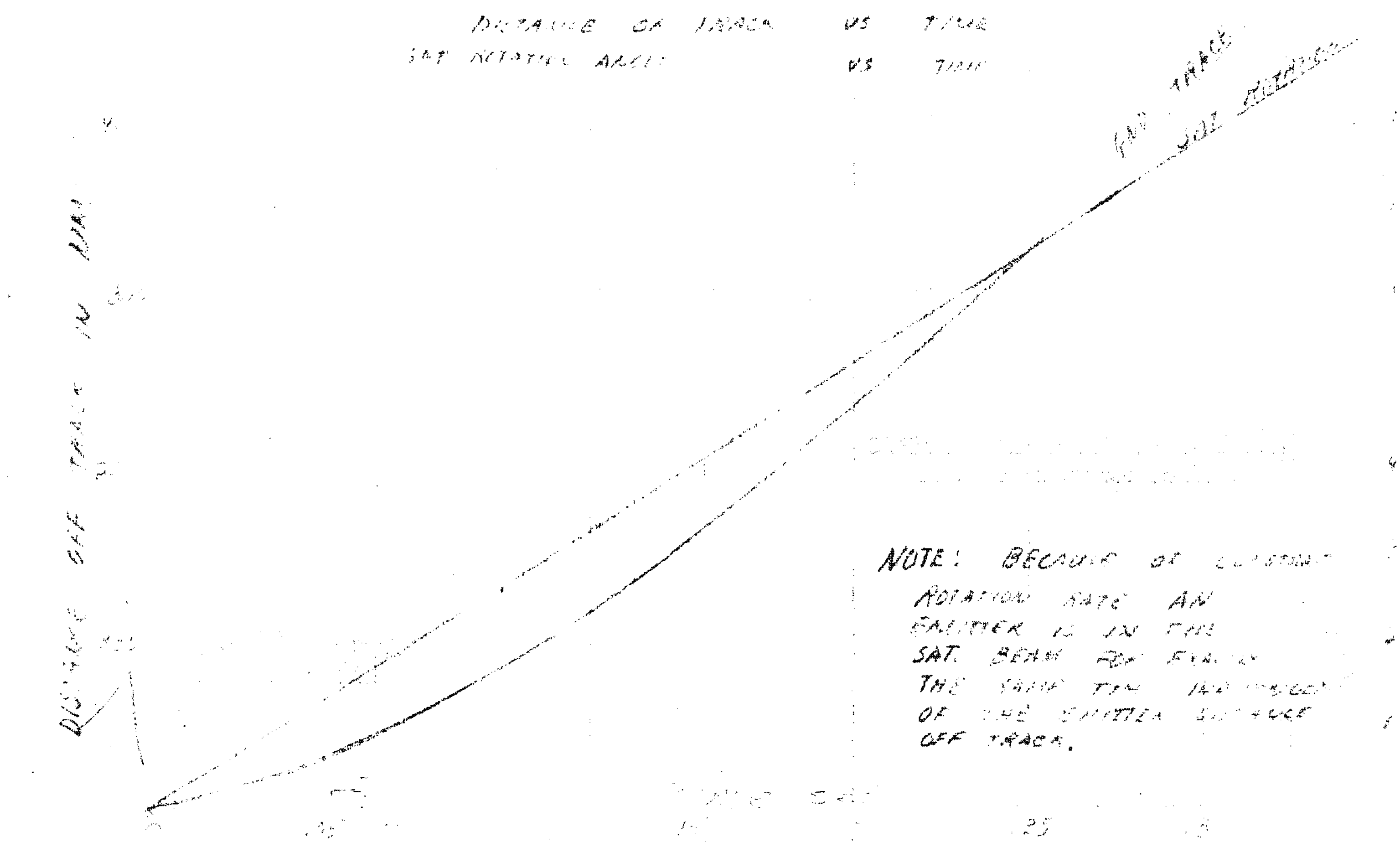
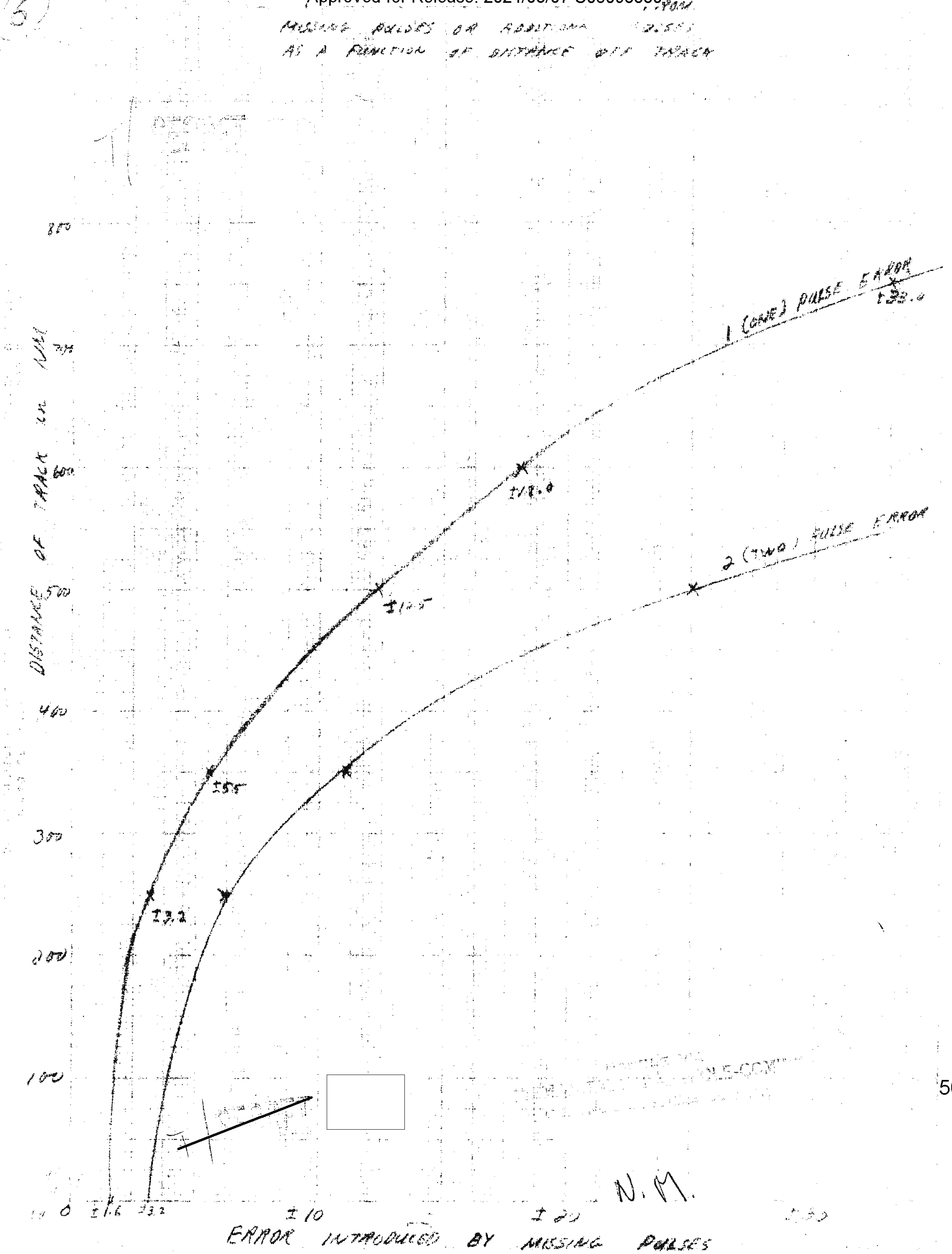

SIZE VS
300
0
20
40
60
80
100
120
140
160
200
220
240
SEMI MAJOR AXIS IN NM


DISTANCE OF TRACK VS TIME
VS
DISTANCE OFF TRACK IN NM
NOTE: BECAUSE OF
ROTATION RATE AN
EMITTER IS IN THE
SAT. BEAM FOR
THE SAME TIME
OF THE EMITTER
OFF TRACK.

(5)


MISSING PULSES OR
AS A FUNCTION OF DISTANCE OFF TRACK
DISTANCE OF TRACK IN NM
ERROR INTRODUCED BY MISSING PULSES
1 (ONE) PULSE ERROR
2 (TWO) PULSE ERROR
100
200
300
400
500
600
700
800
0
±10
±20
±5.5
±3.2
N.M.

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