HANDLE VIA BYEMAN
CONTROL CHANNELS

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BYE-1106-69
SORS 11./34
4 February 1969

# U N I T E D   S T A T E S   I N T E L L I G E N C E   B O A R D

## S I G I N T   C O M M I T T E E

## SIGINT OVERHEAD RECONNAISSANCE SUBCOMMITTEE

MEMORANDUM FOR THE MEMBERS OF THE SIGINT OVERHEAD RECONNAISSANCE SUBCOMMITTEE

SUBJECT: Mission Description of TIVOLI II - SIGINT Mission 7330

1. The attached technical/operational Mission Desription for TIVOLI II, Mission 7330, has been provided to the SORS by the NRO Staff and is forwarded herewith for your information.

2. Please note that the NRO Staff has stated in the covering memorandum that the SORS collection guidance will be most meaningful if geographical areas and target coverage are provided in priority order with indications of the times of day when coverage may be most productive.

[redacted] (b)(1) (b)(3)

EXECUTIVE SECRETARY
SIGINT OVERHEAD RECONNAISSANCE SUBCOMMITTEE

Enclosure:
a/s



GROUP 1
Excluded from automatic downgrading and declassification

~~TS~~ NATIONAL RECONNAISSANCE OFFICE
WASHINGTON, D.C.

THE NRO STAFF

BYE-1106-69
SORS 11./34
4 February 1969

MEMORANDUM FOR CHAIRMAN, SIGINT OVERHEAD RECONNAISSANCE SUBCOMMITTEE

SUBJECT: Mission Description of SIGINT Mission 7330 (TIVOLI II)

The mission description for TIVOLI II is forwarded as an attachment to this correspondence. This SIGINT reconnaissance system is designed to meet the requirements of USIB D-41.14/246, USIB S-10.9/2, USIB S-10.9/5, and USIB S-10.9/8.

Mission 7330 is a spin-stabilized P-989 satellite which is scheduled to be launched into a nominal 275-nautical mile circular orbit by a Thor/Agena booster. The TIVOLI II intercept system can perform directed search and a limited general search against signals using intra- and inter-pulse modulation within the 50 to 4020 MHz band.

TIVOLI II system design is basically the same as TIVOLI I with certain design modifications which permit extension of the RF range from 50 to 4020 MHz vice 100 to 4020 MHz, elimination of the sample and hold subsystem, and the capability to select up to three different collection configurations per rev vice only one. The attached mission description contains an outline of those aspects at variance with SORS 11.12, dated 18 January 1968.

The ~~planned~~ launch date, predicated on launch of the primary payload, is 7 May 1969. Mission lifetime is expected to be 9 months. A nominal 10 to 12 collection revs per day should be available for mission accomplishment.

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It would be meaningful to the National Reconnaissance Office if SORS collection guidance specifies geographic area/target coverage in priority order, referenced when possible to time of day.

EDWIN F. SWEENEY
Colonel, USAF
Deputy Director for
Satellite Operations

Attachment
As Stated

TIVOLI II

MISSION DESCRIPTION

## 1.1 GENERAL

The orbital payload system comprises five broad beamwidth receiving antennas, the TIVOLI intercept system, two 1 MHz tape recorders, two UHF transmitters, one VHF transmitter, a command receiver and a decoder, earth and solar sensors, and associated telemetry equipment. The chief features of the system are:

- Choice of wide or narrow IF bandwidth.
- Choice of high or low sensitivity.
- Choice of manual or automatic gain control.
- Detected and predetected outputs.
- Tunable to any one of 3,970 integer frequencies in the 50 to 4020 MHz frequency band for an indefinite period or tunable in any predetermined frequency sector ranging from 10 to 299 MHz wide throughout the entire frequency range.
- Choice of 1 or 4 MHz frequency step increments.
- Choice of wideband detected outputs (AM or FM).
- Capability of real time output (tape recorder bypass).
- Internal RF calibrator that can be disabled if desired.

## 1.2 PARAMETERS

| | |
|---|---|
| Altitude: | 275 n.m. |
| Inclination Angle: | $90^{\circ} \pm 20^{\circ}$ |

| | |
|---|---|
| Direction of Spin: | CCW when viewed from -Y axis |
| Orbital Life: | 1 year, minimum |
| Initial Spin Rate: | 71.1 rpm ± 3° |
| Minimum Spin Rate after 6 Months on Orbit: | 40 rpm |
| Receiving Antenna Depression Angle (angle between P-989 -Y spin axis and the center axis of the main antenna beam): | Planar spiral (100 to 500 MHz) -0°; Conical spiral (400 to 2020 MHz) 35°; Conical spiral array (1980 to 4020 MHz) -35° |
| Low Frequency Monopole: | 50 to 75 MHz |
| High Frequency Monopole: | 75 to 100 MHz |
| Intercept System Frequency Range: | 50 to 4020 MHz |
| Frequency Accuracy: | Maximum error, 0.01% of input frequency; nominal error, 0.005% of input frequency |
| Tuning (Digital): | Stationary at any one of 3970 integer frequencies or tunable through any one of 16 preselected frequency bands (either the entire band or pre-selectable bandwidth sectors of 10, 20, 40, 80, or 160 MHz). In the optional submode (e.g., submode E), the system can step over the frequency range from 50 to 307 MHz at a rate of 1 second per step. |
| RF Dynamic Range: | |
| Low Power Mode: | -90 to -40 dbm, nominal |
| High Power Mode: | -70 to -20 dbm, nominal |

Effective RF Bandwidths:

| | |
|---|---|
| Wide IF: | 10 MHz |
| Narrow IF: | 1 MHz |

Signal Outputs Available:

a. Folded 4.5 to 3.0 MHz bandwidths compressed into 750 KHz bandwidths (predetected) or two unfolded 750 KHz bandwidths (predetected)

b. Envelope detector: 16 or 750 KHz bandwidths

c. FM discriminator: 200, 500, or 750 KHz bandwidths

d. Status, timing, and reference

## 1.3 SYSTEM SENSITIVITY

The sensitivity of the intercept system varies as a function of the system operational mode configuration and frequency.

| | Subsystem | | |
|---|---|---|---|
| | Predetection Channel 1A | Predetection Channel 2 | Envelope Detector & FM Discriminator |
| Mode A Approximate Noise Bandwidth | 3.0 MHz | 4.5 MHz | 10 MHz |
| Mode A Sensitivity | | | |
| 50-99 MHz | -103.0 dbm | -101.0 dbm | -98.0 dbm |
| 100-500 MHz | -101.0 dbm | - 99.0 dbm | -96.0 dbm |
| 480-1020 MHz | -101.5 dbm | - 99.5 dbm | -96.5 dbm |
| 980-2020 MHz | - 99.0 dbm | - 97.0 dbm | -94.0 dbm |
| 1480-4020 MHz | - 96.5 dbm | - 94.5 dbm | -91.5 dbm |

| | Subsystem | | |
|---|---|---|---|
| | Predetection Channel 1A | Predetection Channel 2 | Envelope Detector & FM Discriminator |
| Mode C, D Approximate Noise Bandwidth | 750 KHz | 750 KHz | 1 MHz |
| Mode C, D Sensitivity | | | |
| 50-99 MHz | -109.0 dbm | -109.0 dbm | -108.0 dbm |
| 100-500 MHz | -107.0 dbm | -107.0 dbm | -106.0 dbm |
| 480-1020 MHz | -107.5 dbm | -107.5 dbm | -106.5 dbm |
| 980-2020 MHz | -105.0 dbm | -105.0 dbm | -104.0 dbm |
| 1980-4020 MHz | -102.5 dbm | -102.5 dbm | -101.5 dbm |

## 2. ANTENNAS.

Five separate intercept system antennas (two monopoles, a conical spiral, and a conical spiral array) are required to cover the frequency range from 50 to 4020 MHz. The intercept antennas are deployed as shown in Diagram 1 when the subsatellite achieves orbit.

### 2.1 ANTENNA SPECIFICATIONS

Antenna specifications are as follows:

a. Sensor C1 (Low-Frequency Monopole)

| | |
|---|---|
| Frequency Range (Min): | 50 to 72 MHz |
| -3 db Gain, High Frequency: | -5 db |
| -3 db Gain, Low Frequency: | -5 db |
| Beamwidth: | 75 degrees (approximately) |
| Polarization: | Linear |

b. Sensor C2 (High-Frequency Monopole)

| | |
|---|---|
| Frequency Range (Min): | 73 to 99 MHz |
| -3 db Gain, High Frequency: | -5 db |
| -3 db Gain, Low Frequency: | -5 db |
| Beamwidth: | 75 degrees (approximately) |
| Polarization: | Linear |

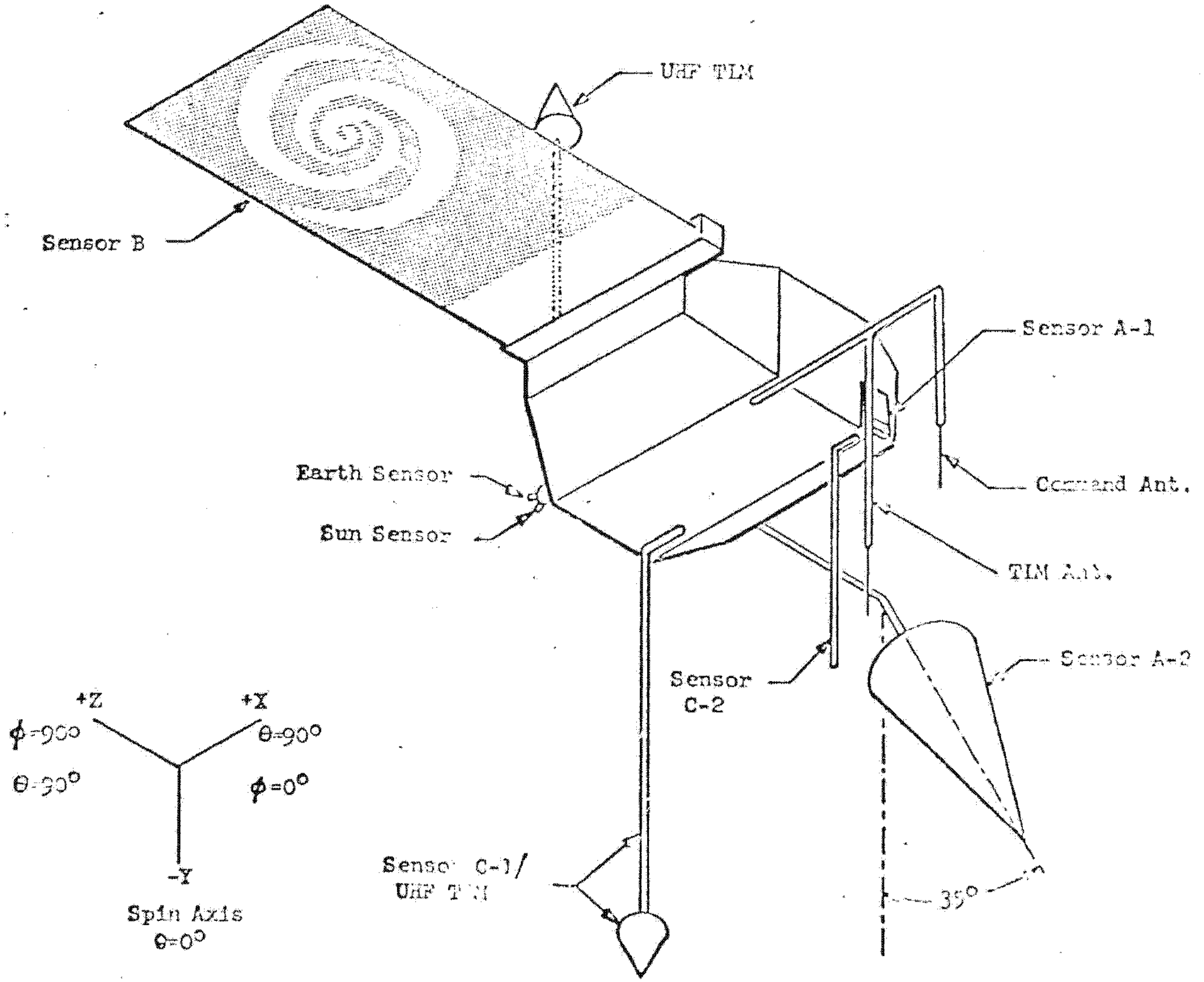


Diagram 1 Spacecraft Antenna Configuration

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c. Sensor B (VHF Planar Spiral)

| | |
|---|---|
| Frequency Range (Min): | 100 to 500 MHz |
| -3 db Gain, High Frequency: | 0 db |
| -3 db Gain, Low Frequency: | 0 to -18 db |
| Beamwidth: | 80 degrees (bidirectional) |
| Polarization: | Circular |

d. Sensor A2 (UHF Conical Spiral)

| | |
|---|---|
| Frequency Range (Min): | 400 to 2020 MHz |
| -3 db Gain, High Frequency: | + 3 db |
| -3 db Gain, Low Frequency: | + 3 db |
| Beamwidth: | 90 degrees |
| Polarization: | Circular |

e. Sensor A1 (S-Band Conical Spiral Array)

| | |
|---|---|
| Frequency Range (Min): | 1980 to 4020 MHz |
| -3 db Gain, High Frequency: | + 7.5 db |
| -3 db Gain, Low Frequency: | + 5 db |
| Beamwidth: | 40 degrees by 80 degrees |
| Polarization: | Circular |

## 3. INTERCEPT SYSTEM

### 3.1 DESCRIPTION

The TIVOLI intercept system is housed in two separate packages referred to as the A and B boxes and mounted on the -Z and + Z wings of the spacecraft. Each box weighs approximately 35 pounds, and the total system consumes about 75 watts of battery power during the readin mode. Diagram 2 is a block diagram of the intercept system.

The intercept system comprises a frequency translator, a receiver, a signal conditioner, and a programmer. The receiver and frequency translator when combined can tune to any integer frequency from 50 to 4020 MHz. The receiver subsystem alone covers the 50 to 500 MHz band. The translator downconverts incoming RF signals from

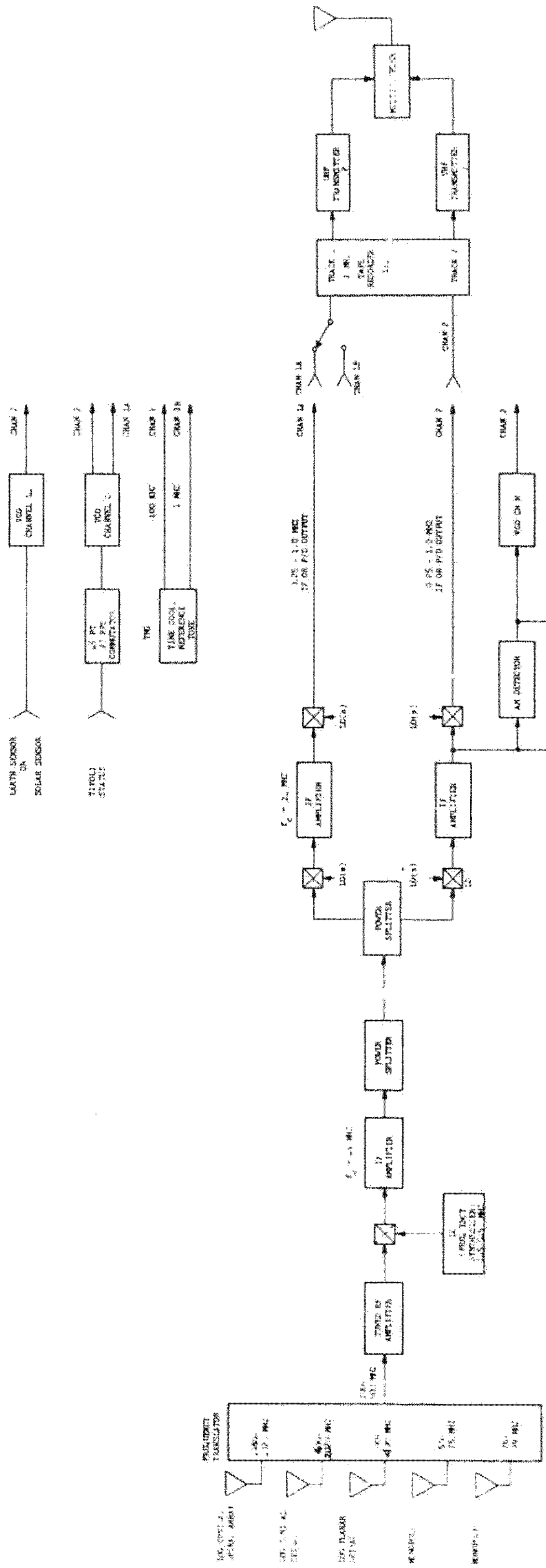

DIAGRAM 2. INTERCEPT SYSTEM

480 to 4020 MHz into the 105 to 395 MHz band for processing by the receiver. The RF signals in the 50 to 99 MHz band are upconverted to 308 to 357 MHz. Received signals are processed into a form compatible with the telemetry system by a signal conditioner. The programmer decodes, stores, and executes the commands necessary to select, initiate, and control the desired system operational mode.

## 3.2 FREQUENCY TRANSLATOR

The frequency translator filters, amplifies, and downconverts RF signals in the 480 to 2020 MHz and the 1980 to 4020 MHz frequency bands into a 290 MHz bandwidth (105 to 395 MHz) within the receiver tuning range. In the 50 to 99 MHz frequency band, the frequency translator upconverts the RF signals into the 308 to 357 MHz band. The translator has five RF input terminals: HF-1 (50 to 75 MHz), HF-2 (75 to 99 MHz), VHF (100 to 500 MHz), UHF (400 to 2020 MHz), and S-Band (1980 to 4020 MHz). These terminals are fed by the two monopoles, VHF window shade, UHF conical spiral, and S-band conical spiral array antennas, respectively.

The translator divides the 50 to 4020 MHz spectrum into 16 discrete frequency bands referenced to as translator frequency bands E, O, and 1 through 14. The translator is designed such that only one band is active during any given time, i.e., primary DC power is applied only to those amplifiers and oscillators associated with the actual frequency band; thereby, minimizing the possibility of spurious output signals.

Inputs HF-1 and HF-2 (sensor C-1 and C-2 inputs, respectively) of Band E are amplified by a transistor amplifier and upconverted to 308 to 357 MHz, which is within the receiver frequency range. Selection of the appropriate input sensor is controlled by the system programmer.

Band O is fed directly to the receiver without being downconverted. When the translator is commanded to Band O (100 to 500 MHz), the VHF antenna is connected directly to the receiver when the intercept system is in the high-sensitivity (low-input-power) mode. A 20 db attenuator is inserted between the antenna and the receiver in the low sensitivity (high input power) mode.

Bands 1 through 14 each provide downconversion of a discrete 290 MHz sector of the input frequency range from 480 to 4020 MHz. Bands 1 through 6 translate input frequencies from 480 to 2020 MHz, and Bands 7 through 14 translate input frequencies from 1480 to 4020 MHz. Each of the 14 bands overlaps its adjacent frequency band(s) by 40 MHz to allow tuning across any 40 MHz sector (or less) in the entire RF range without having to switch between two translator frequency bands.

The upper 14 bands consist of wideband preselection filters, wideband tunnel diode or transistor amplifiers, 290 MHz bandwidth filters, frequency converters, and RF diode switches. The preselection filters and amplifiers are bypassed in the high power mode; thereby increasing the intercept system average noise figure from 10 to 20 db. All RF switch positions are controlled by the "translator frequency band selection" commands.

## 3.3 RECEIVER

The receiver is a superheterodyne type that includes a tunable RF preselector, a mixer and a frequency synthesizer, an IF power splitter, and a dual-channel predetection output subsystem (see Diagram 3). The RF preselector and mixer are housed in the A box with the frequency translator, while the remainder of the receiver, the power supply, the programmer, and the signal conditioner are all housed in the B box.

### 3.3.1 FREQUENCY BAND TUNING

The intercept system pass band (50 to 4020 MHz) is divided into 3,970 linear 1 MHz frequency increments or steps, which are grouped into the 16 translator frequency bands in the order previously mentioned. It is possible to tune to any integer frequency or through any predetermined sector within any one of the 16 translator bands by externally executing a command to downconvert the selected active band into the receiver frequency range. To complete the process, the receiver tunable selector and frequency synthesizer are externally programmed to tune to the desired integer frequency or to tune through the desired sector within the translated frequency band. All the actual digital or step tuning performed by the intercept system is accomplished by the receiver.

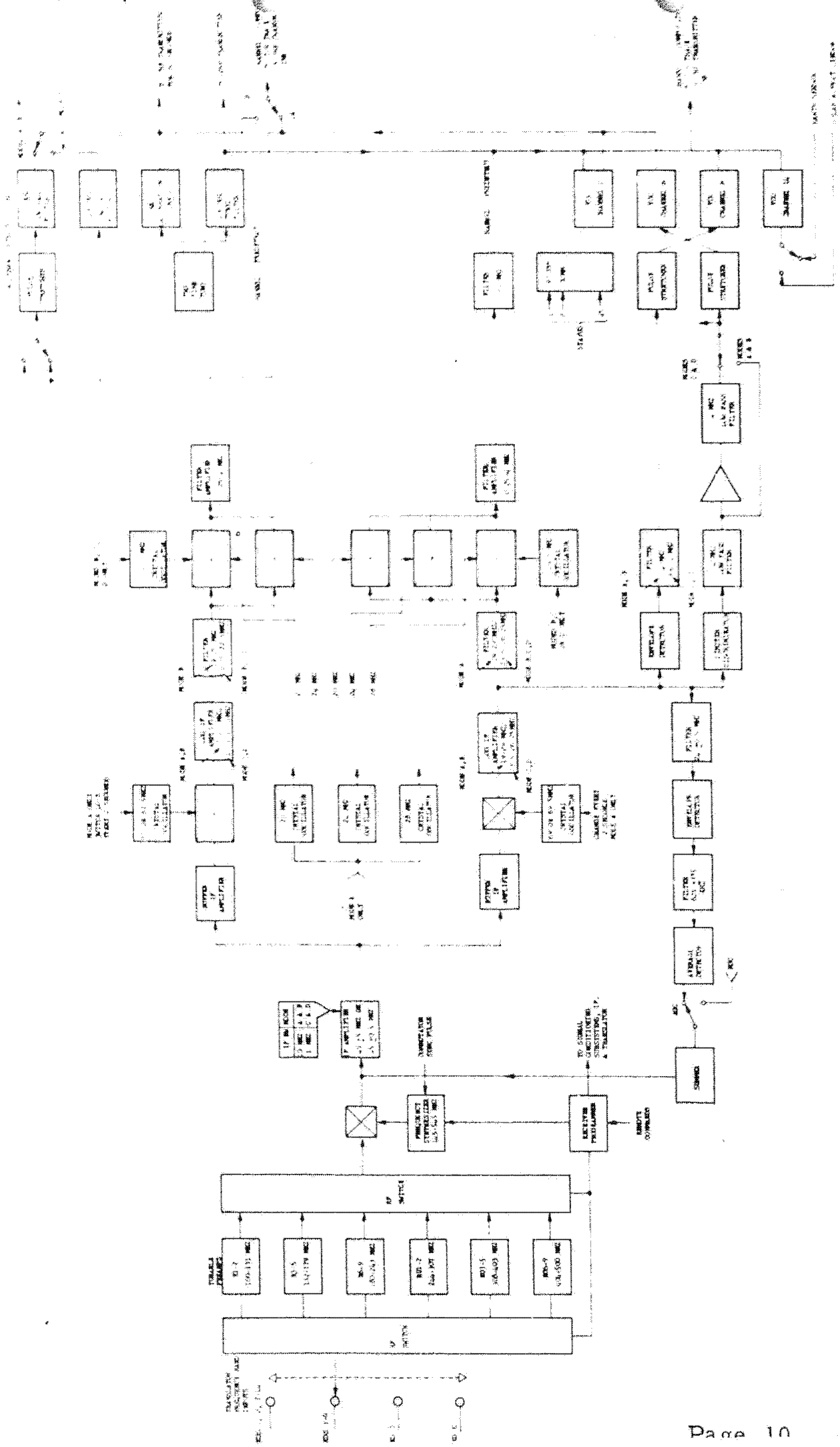

DIAGRAM 3. RECEIVER

## 4.1 DATA OUTPUT FORMAT

The composite output signals of the intercept system, referred to as the Channel 1A, Channel 1B, and Channel 2 composite signals, can be applied to the tape recorder for storage (tape recorder normal mode) or connected directly to the UHF transmitters (tape recorder bypass mode). The composite signals are frequency multiplexed as shown in Diagram 4. The Channel 2 composite signal is always present at the system Channel 2 output terminals. Either Channel 1A or 1B composite signals are present at the system Channel 1 output terminals. When Mode D is commanded, composite signals 1B and 2 are present, except that the wideband detected video bandwidth on Channel 1B is reduced to 400 KHz.

The Channel 1 and 2 composite signals are telemetered via the UHF links. The VHF link is used to relay real time spacecraft status and attitude data.

## 5.1 MODE E OPERATION

The Mode E option extends the lower frequency range of the intercept system to 50 MHz and increases the rate of certain time functions in the 50 to 307 MHz band as follows:

| | Mode E Enable | Mode E Disable |
|---|---|---|
| Frequency Step Rate | One step/sec | One step/four sec |
| Mode A Picket Shift | Two shifts/sec | One shift/two sec |
| 1B Alternate (FM, AM) | Two shifts/sec | One shift/two sec |

When scanning from 50 to 307 MHz, the intercept system uses three sensors: Sensor C-1 (50 to 73 MHz), C-2 (74 to 99 MHz), and Sensor B (100 to 307 MHz). The payload programmer automatically switches the system to the appropriate sensor.

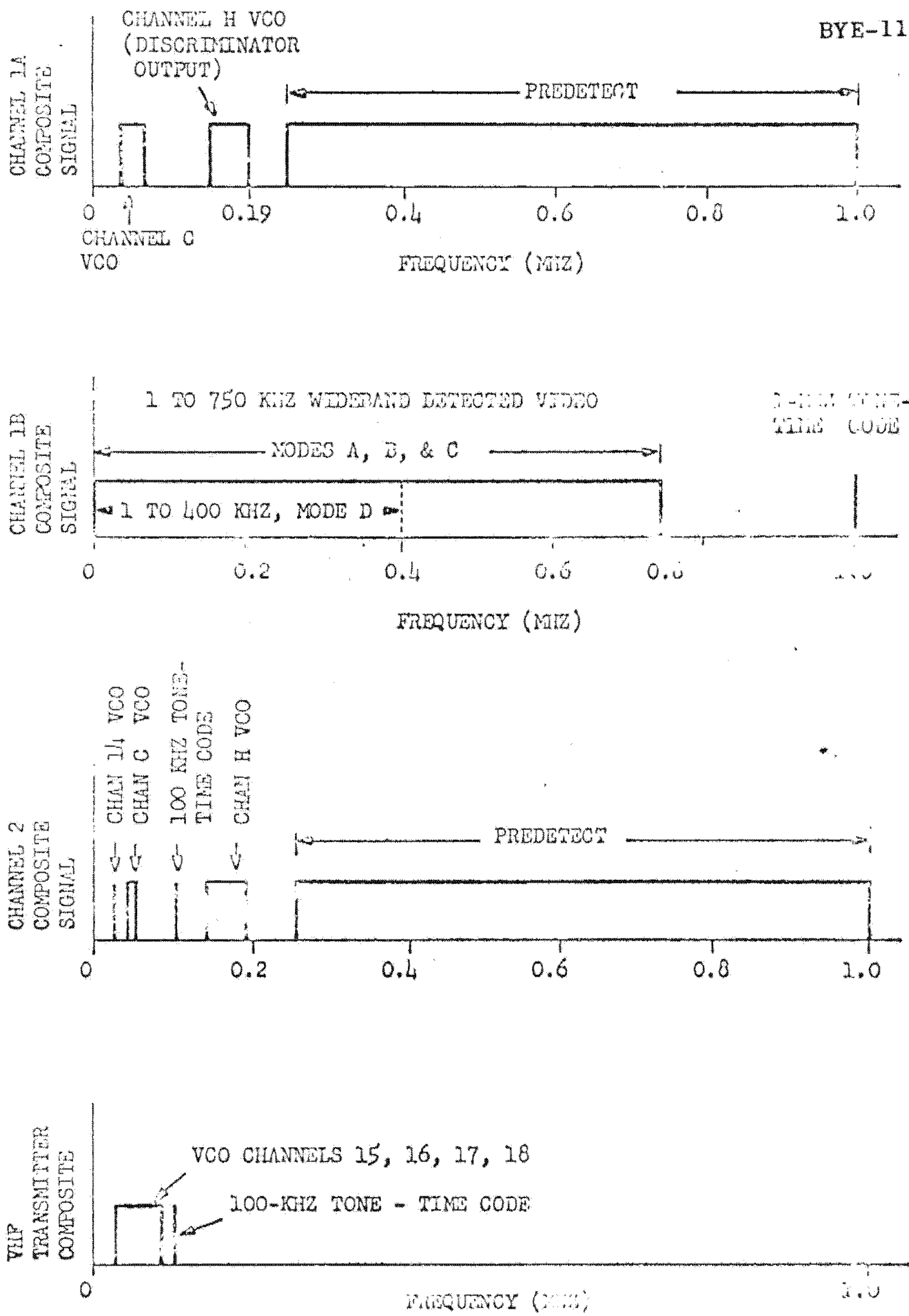


DIAGRAM 4. Frequency M... ...mat

## 6.1 COMMAND OPTION

A command option exists that permits selection of one, two, or three collection configuration per rev, subject to the constraint that total readin time is restricted to 335 seconds, the recorder capacity. A recorder bypass option exists (transpond) which will be utilized for CONUS calibration operations only.