3. Imager

The GOES N-P Imager instrument, GFE manufactured by ITT Industries, Inc., is a five-channel (one visible, four infrared) imaging radiometer designed to sense radiant and solar reflected energy from sampled areas of the earth. By means of a servo-driven, two-axis gimbaled mirror scan system in conjunction with a Cassegrain telescope, the Imager's multispectral channels can simultaneously sweep an 8 km north-to-south swath along an east-to-west/west-to-east path at a rate of 20° (optical) per second.

A view of the Imager instrument sensor module is shown in Figure 3-1 and key Imager instrument parameters are given in Table 3-1 and Table 3-2. The wavelength allocation to the Imager's channels is given in Table 3-3. A summary of Imager performance is given in Table 3-4.

NOTE: Throughout this section, the channels are numbered according to ITT's convention. In GVAR, the channels are numbered differently, specifically channel 3 is 6.5 μm, channel 5 is non-existent, and channel 6 is 13.3 μm. Reference Figures 3-5a and 3-5b for the GVAR channel numbers.

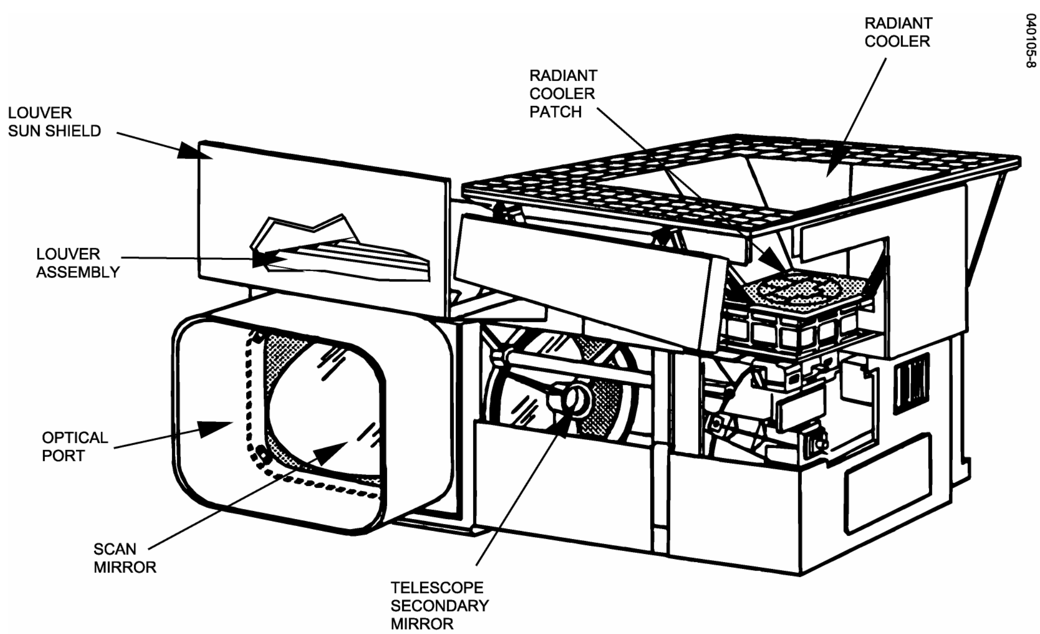


Figure 3-1. GOES N-P Imager Sensor Module

Table 3-1. Imager Instrument Characteristics

(Reference channel numbering convention note on page 3-1)

Channel	Detector Type	Nominal Square IGFOV at Nadir, km	
		GOES N	GOES O-P
1 (Visible)	Silicon	1	1
2 (Shortwave)	InSb	4	4
3 (Longwave 2)	HgCdTe	8	4
4 (Longwave 1)	HgCdTe	4	4
5 (Moisture)	HgCdTe	4	4

Table 3-2. Imager Instrument Performance Parameters

Parameter	Performance
FOV defining element	Detector
Channel-to-channel alignment Vis to IR IR to IR	 50 μrad 28 μrad
Radiometric calibration	Internal black body and space view
Signal quantizing	10 bits, all channels
Scan capability	Full earth, sector, and area
Output data rate	2,620,800 bps
Imaging areas	20.8° E-W by 21° N-S

Table 3-3. Imaging Channels Allocation

(Reference channel numbering convention note on page 3-1)

Channel No.	Wavelength Range, μm	Range of Measurement	Meteorological Objective
1	0.52 to 0.71	0 to 100% albedo	Cloud cover
2	3.73 to 4.07	4 to 335 K	Nighttime clouds
3	13.00 to 13.70	4 to 320 K	Cloud cover and height
4	10.20 to 11.20	4 to 320 K	Sea surface temperature and water vapor
5	5.80 to 7.30	4 to 320 K	Water vapor

The Imager instrument consists of electronics, power supply, and sensor modules (Figure 3-2). The electronics module provides redundant circuitry and performs command, control, and signal processing functions; it also serves as a structure for mounting and interconnecting the electronic boards for proper heat dissipation. The electronics module is mounted on the subnadir panel external to the spacecraft and is enclosed by a Faraday cage (The Faraday cage is fabricated from thermal blankets.) The power supply module contains the converters, fuses, and power control for converting and distributing spacecraft 42 volt bus power to the Imager circuits. The power supply module is mounted inside the spacecraft on the subnadir panel.

Table 3-4. Imager Performance Summary

Parameter	Performance	
System absolute accuracy	Infrared channel ≤1 K Visible channel ±5% of maximum scene radiance	
System relative accuracy	Line to line	≤0.1 K
	Detector to detector	≤0.2 K
	Channel to channel	≤0.2 K
	Blackbody calibration to calibration	≤0.35 K
Star sense area	21° N-S by 23° E-W	
Imaging rate	Full earth ≤26 min	
Time delay	≤3 min	
Fixed Earth projection and grid duration	24 hours	
Data timeliness		
Spacecraft processing	≤30 sec	
Data coincidence	≤5 sec	
Imaging periods		
Image navigation accuracy at nadir (excluding diurnally repeatable distortion)		25 μrad EW, 20 μrad NS
Registration within an image*	25 min	33 μrad EW, 28 μrad NS
Registration between repeated images*	48 hr	28 μrad

*For spec orbit

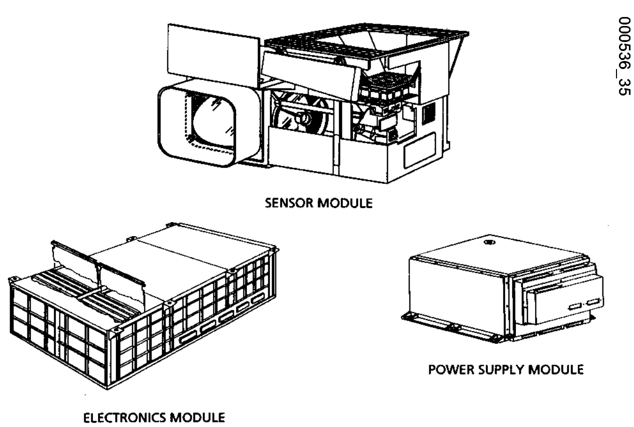


Figure 3-2. Imager Instrument Modules

The sensor module contains the telescope, scan assembly, detectors, and baseplate, along with the shields and louvers for thermal control. The sensor module is located on an optical bench which is located on the nadir face of the spacecraft.

The Imager optimizes the maximum signal flow of the optical, detection, and electronic subsystems in order to preserve the quality and accuracy of the sensed information. The scene radiance, collected by the Imager's optical system, is separated into appropriate spectral channels by beam splitters that also route the spectral energy to various visible and infrared (IR) detector sets where it is imaged onto the respective detectors for each channel. Each detector converts the scene radiance into an electrical signal that is amplified, filtered, and digitized; the resulting digital signal is routed to a sensor data transmitter for downlinking to a ground station.

A user may request one or a set of images that start at a selected latitude and longitude (or lines and pixels) and end at another latitude and longitude (or lines and pixels). The Imager scans locations in accordance with its command inputs. The image frame may include the entire earth's disk or any portion of it and the frame may begin at any time. Scan control is not limited in scan size or time; an entire viewing angle of 21° north-south (N-S) by 23° east-west (E-W) is available for star sensing. Imaging limits are 21° N-S by 20.8° E-W. Ground command can request up to 63 repeats of a given image. A frame sequence can be interrupted for "priority" scans; the system will scan a priority frame set or star sense, then automatically return to the original set.

Infrared radiometric quality is maintained by frequent views of space for reference. The space view interval is ground command selectable for space clamp mode for specific intervals of 9.2 or 36.6 seconds. In scan clamp mode, a space view will be taken at least every 2.2 seconds. Less frequent views of the full-aperture internal blackbody establishes a high-temperature baseline for calibration in orbit (via ground command or automatically). Repeat of this calibration every 10 minutes is more than adequate to maintain accuracy of the output data under the worst conditions of time and temperature. In addition to radiometric calibration, the amplifiers and data stream are checked regularly by an internal electronic staircase signal to verify stability and linearity of the output data.

Operation

The Imager is controlled via a defined set of command inputs. Position and size of an area scan are controlled by command, so the instrument is capable of full-earth imagery (21° N-S by 20.8° E-W), sector imagery that contains the edges of the earth's disk, and various area scan sizes totally enclosed within the earth scene. However, the maximum scan width processed by the operations ground equipment is 19.2°. Area scan selection permits continuous, rapid viewing of local areas for accurate wind determination and monitoring mesoscale phenomena. Area scan size and location are definable to less than one visible pixel, yielding complete flexibility.

To assist in inertial navigation, the Imager also offers a star sensing capability that can detect stars as dim as B0-class fourth magnitude. Once the time and location of a star is predicted, the Imager is pointed to that location within its 21° N-S by 23° E-W field of view (FOV), and the scan is stopped. As the star image passes through the 1×8 km visible array, it is sampled at a rate of 21,817 samples per second. The star sense sensitivity is enhanced by increasing the electronic gain and reducing the noise bandwidth of the visible preamplifiers, permitting sensing of a sufficient number of stars for image navigation and registration (INR) purposes.

By virtue of its digitally controlled scanner, the Imager provides operational imaging from full earth scan to mesoscale area scans. Accuracy of location is ensured by the absolute position control system, in which position error is noncumulative. Within the instrument, each position is defined precisely, and any chosen location can be reached and held to a high accuracy. This registration accuracy is maintained along a scan line, throughout an image, and over time. Total system accuracies relating to spacecraft motion and attitude determination also include this allocated error.

Motion of the Imager and Sounder scan mirrors causes disturbances to the spacecraft attitude, which is partially reduced by spacecraft control. Further reduction of these disturbances is accomplished by using HIRU and star tracker (ST) sensed motion along with the commanded bus attitude to form a dynamic motion compensation (DMC) signal, which is applied in the scan servo-control loop to offset the residual attitude disturbance. With this technique, the Imager and Sounder are totally independent, maintaining image location accuracy regardless of the other unit's operational status. If needed, this dynamic motion compensation scheme can be disabled by command.

The ACS also generates compensation signals that counteract predictable spacecraft attitude, orbital, and structural-thermal effects within the spacecraft-instrument combination. Observations of residual compensation errors are used to generate new fit parameters for the next 24 hour period, during which they are used to generate compensation signals for updated disturbance predictions. Ground-developed corrective algorithms are fed to the instruments via the ACS as a total image motion compensation (IMC) signal that includes the dynamic motion compensation described above.

Yaw Flip Operation

There is an alternative spacecraft orientation option for the GOES N-P satellites known as the yaw flip configuration. In this mode, the satellite is rotated 180 degrees from its normal orientation, which results in the normally north facing side of the instruments facing toward the south during summer in the northern hemisphere. Yaw flip maintains the spacecraft in a configuration that prevents the sun from entering the radiant coolers.

This mode allows operation of the instruments with the patch temperature set to LOW year round as the radiant coolers are always pointing in a direction that permits operating under winter conditions. Without yaw flip, the patch temperature settings should be LOW for winter and MID for summer. MID can be used year round without yaw flip if there is no cooler degradation as the cooler should start life with a 3°C margin at the

MID setting for summer solstice. HIGH allows for operation in the summer should some cooler degradation occur.

It should be noted that all references to the scan coordinate system will be reversed when operating in the yaw flipped mode.

Sensor Module

The sensor module consists of a radiant cooler assembly, telescope, aft optics, preamplifiers, scan aperture sunshield, scan assembly, baseplate, scan electronics, and louver assembly. The scan assembly and telescope are mounted to a common baseplate. The aft optics separates the scene radiance into five spectral bands of interest. A passive louver assembly on north panel and electrical heaters on the baseplate aid thermal stability of the telescope and major components. A passive radiant cooler with a proportionally controlled heater maintains the IR detectors at 81 K during the 6 months of winter solstice season and then at 84 K for the remainder of the year for efficient operation. A backup temperature of 87 K is also provided. The visible detectors are at instrument temperature of 13 to 30 C. The preamplifiers convert the low-level signals to higher-level, low-impedance outputs for transmission by cable to the electronics module. An expanded view of the sensor module is given in Figure 3-3.

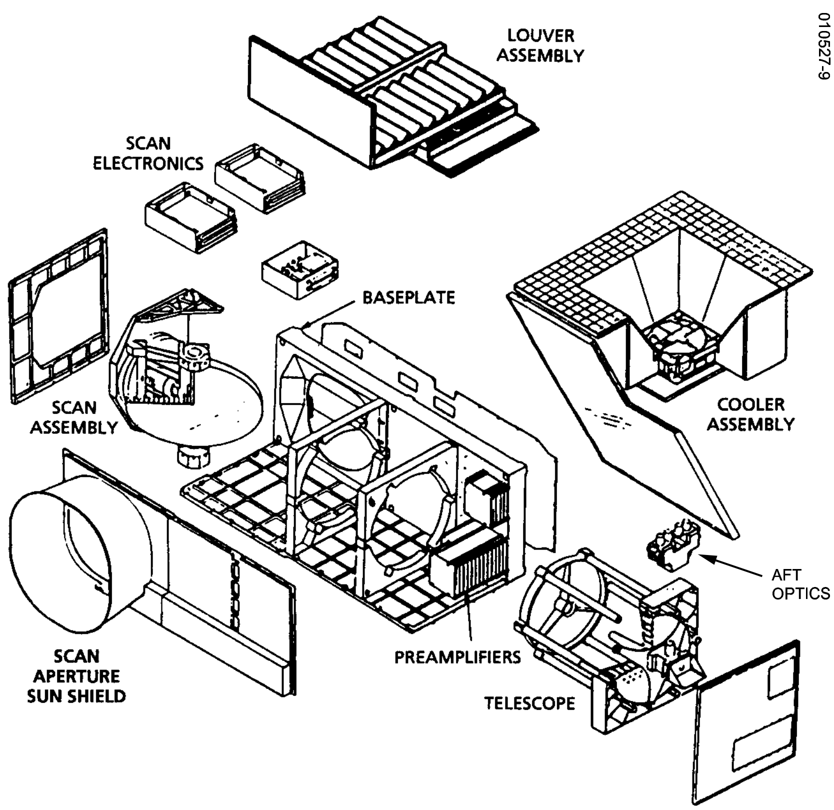


Figure 3-3. Sensor Module—Expanded View

Imager Optics

To gather emitted or reflected energy, the scanner moves a flat mirror to produce a bidirectional raster scan. Thermal emissions and reflected sunlight from the scene pass through a scan aperture protected by a sun shield, then the precision flat mirror deflects them into a reflective telescope. The telescope, a Cassegrain type with a 31.1 cm (12.2 inch) diameter primary mirror, concentrates the energy onto a 5.3 cm (2.1 inch) diameter secondary mirror. The surface shape of this mirror forms a F/6.8 focal length beam that passes the energy to the detectors via relay optics.

Dichroic beamsplitters (B/S) separate the scene radiance into the spectral bands of interest. The IR energy is deflected to the detectors within the radiative cooler, while the visible energy passes through a dichroic beamsplitter and is focused on the visible detector elements. The IR energy is separated into the 3.9, 6.55, 10.7, and 13.35 µm channels. These four beams are directed into the radiant cooler, where the spectral channels are defined by cold filters. Each of the four IR channels has a set of detectors defining the field size and shape. A schematic view of the Imager's optical elements is given in Figure 3-4.

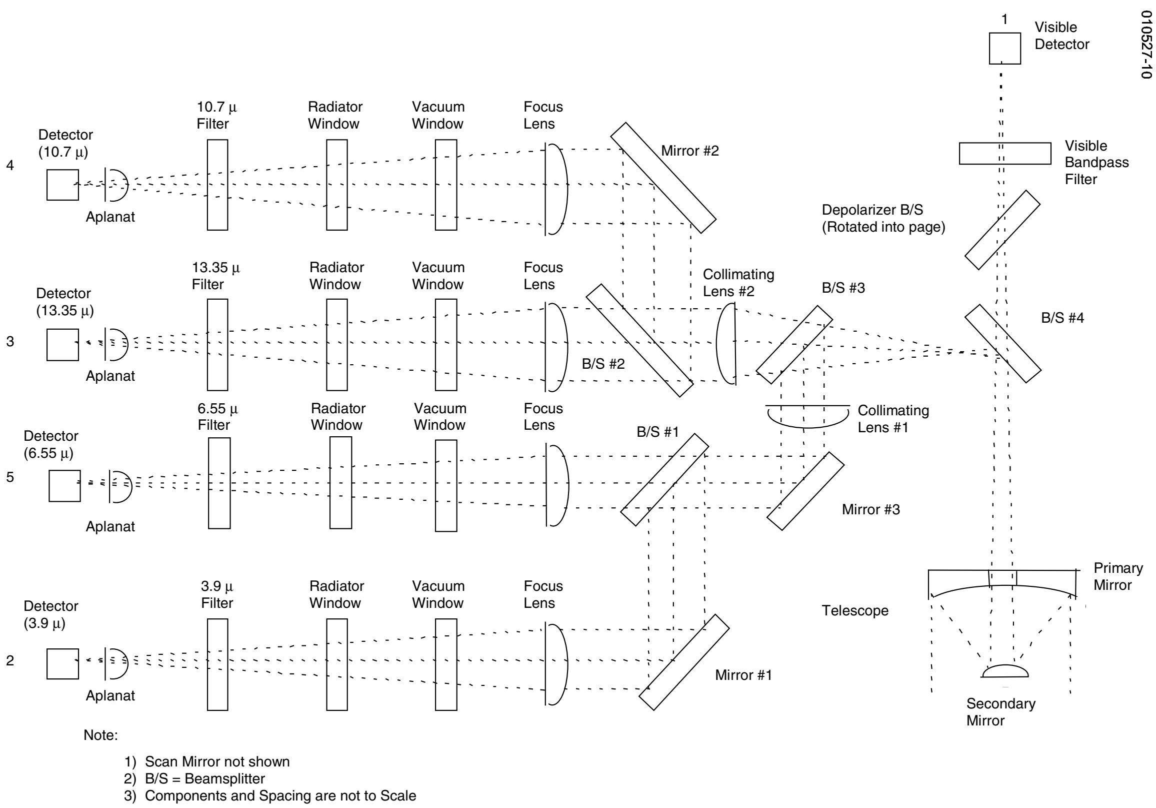


Figure 3-4. Imager Optical Elements

(Reference channel numbering convention note on page 3-1)

Optical performance is maintained by restricting the sensor module total temperature range, and radiometric performance is maintained by limiting the temperature change between views of cold space (rate of change of temperature). Thermal control also contributes to channel registration and focus stability. Thermal control design includes:

- Maintaining the Imager sensor module as adiabatically (thermally isolated) as possible from the spacecraft structure.
- Controlling the temperature during the hot part of the synchronous orbit diurnal cycle (when direct solar heating enters the scanner aperture) with a north-facing radiator whose net energy rejection capability is controlled by a louver system.
- Providing makeup heaters within the sensor module to replace the thermal energy lost to space through the scan aperture during the cold portion of the diurnal cycle.
- Providing a sun shield around the scan aperture (outside the instrument FOV) to block incident solar radiation into the instrument, thus limiting the time the aperture can receive direct solar energy.

Detectors

(Reference channel numbering convention note on page 3-1)

The Imager instrument simultaneously acquires radiometric data in five distinct wavelengths or channels, each of which is characterized by a wavelength band denoting primary spectral sensitivity. The five channels are broadly split into two classes: visible (channel 1) and infrared (channels 2-5). For these five channels, the GOES N Imager contains a total of 22 detectors, and the GOES O–P Imager contains 24 detector elements.

Visible Channel

The visible silicon detector array (channel 1) contains eight detectors (v1 to v8). Each detector produces an instantaneous geometric field of view (IGFOV) that is nominally 28 μrad on a side. At the spacecraft's subsatellite point, on the surface of the earth, 28 μrad corresponds to a square pixel that is 1 km on a side.

Infrared Channels

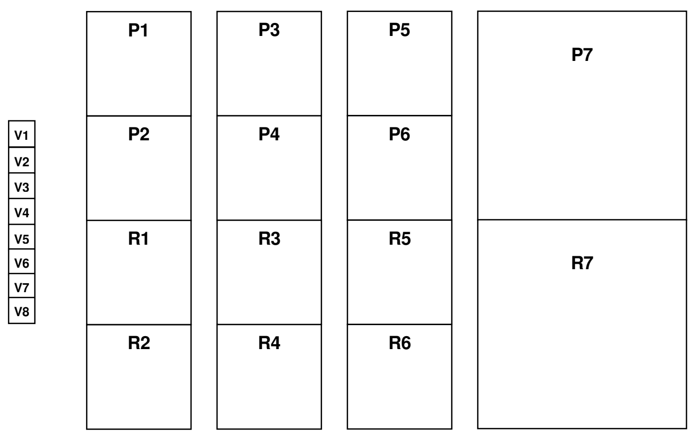
(Reference channel numbering convention note on page 3-1)

The IR channels employ four-element InSb (Indium Antinomide) detectors for channel 2 (3.9 μm), and four element HgCdTe (Mercury Cadmium Telluride) detectors for channels 4 (10.7 μm) and 5 (6.55 μm). A four-element set consists of two-line pairs providing redundancy along a line. Each detector in channels 2, 4, and 5 is square, with an IGFOV of 112 μrad, corresponding to a square pixel 4 km per side at the subsatellite point. For GOES N, channel 3 (13.25 μm) contains two square HgCdTe detectors, each with an IGFOV of 224 μrad, resulting in a subsatellite pixel 8 km on a side. For GOES O-P, channel 3 will have a four-element detector set with a 4 km pixel identical to the other IR channels.

Element Configuration

The four IR detector arrays are configured in either a side 1 or a side 2 mode, either of which can be the redundant set by choosing side 1 or side 2 electronics. The entire visible channel array (v1 to v8) is always enabled. In side 1 mode, the IR channels have only their upper detectors (1-1 to 1-7) enabled and in side 2, only their lower detectors (2-1 to 2-7). Figures 3-5 through 3-7 illustrate the detector configuration. The GVAR numbering of the pixels is shown in Figure 3-5a and 3-5b.

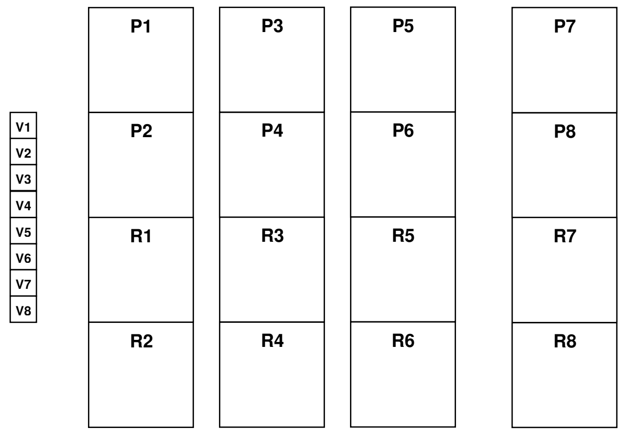
Though physically separated in the instrument, the detector arrays are optically registered. Small deviations in this optical registration are due to physical misalignments during construction and assembly of the instruments and to the size of the detector elements. These deviations consist of fixed offsets that are corrected at two levels: 1) within the instrument sampling electronics and 2) on the ground by the operations ground equipment. No corrections are applied during star sensing. Because the combination of scan rate (20 deg/sec) and detector sample rate (5460 samples per second for IR and 21840 samples per second for visible) exceeds the pixel E-W IGFOV, the Imager oversamples the viewed scene. Each visible sample is 16 µrad E-W, and each IR sample is 64 µrad E-W.



CHANNEL	1	2	3	4	6
CENTRAL WAVELENGTH (µm)	0.65	3.9	6.5	10.7	13.3
DETECTOR IGFOV (µradians)	28	112	112	112	224

Notes:
µm - micrometers (microns)
µradians - micro radians
IGFOV - Instantaneous Geometric Field-of-View

Figure 3-5a. Imager Detectors (GOES N)



CHANNEL	**1**	**2**	**3**	**4**	**6**
CENTRAL WAVELENGTH (µm)	**0.65**	**3.9**	**6.5**	**10.7**	**13.3**
DETECTOR IGFOV (µradians)	**28**	**112**	**112**	**112**	**112**

Notes:
µm - micrometers (microns)
µradians - micro radians
IGFOV - Instantaneous Geometric Field-of-View

Figure 3-5b. Imager Detectors (GOES O-P)

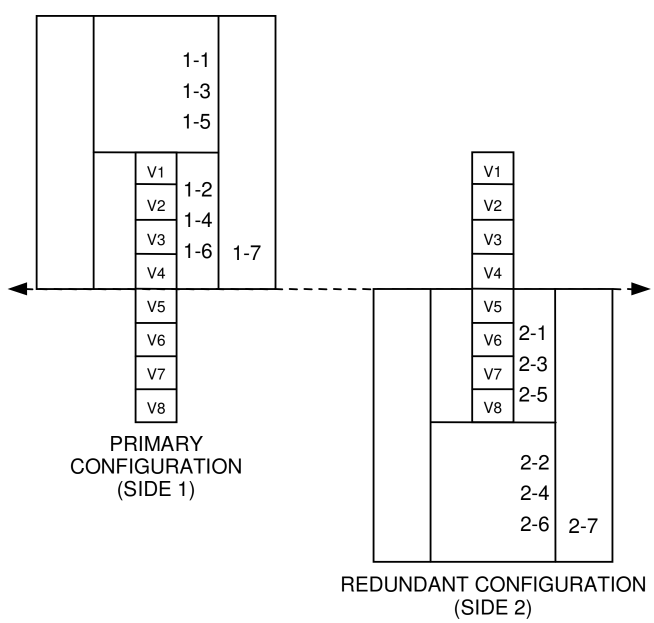


Figure 3-6a. Operational Configurations (GOES N)

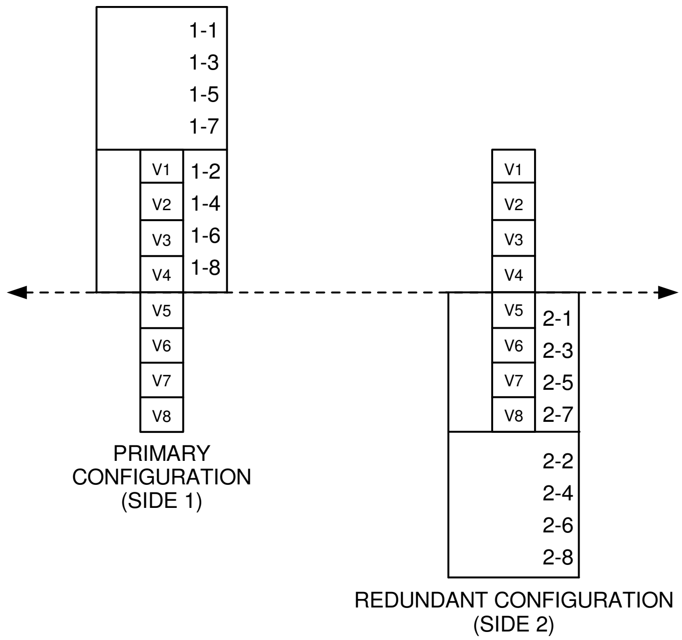


Figure 3-6b. Operational Configurations (GOES O-P)

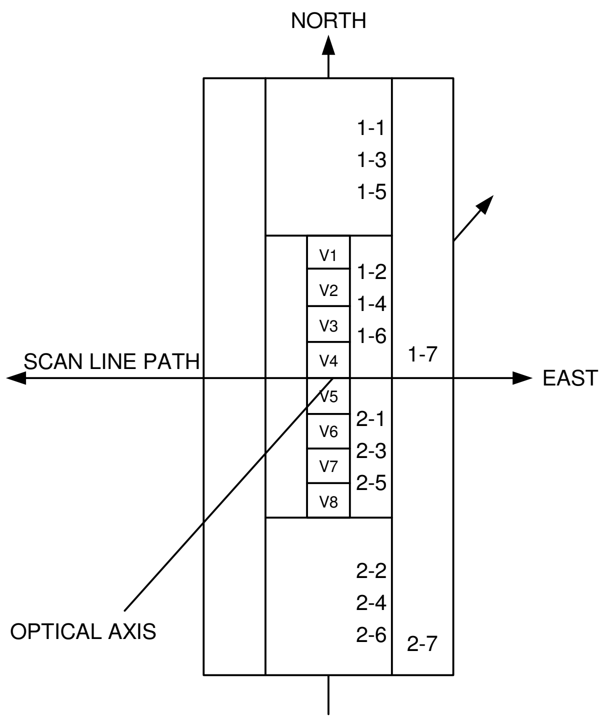


Figure 3-7a. Operational Configurations (GOES N)

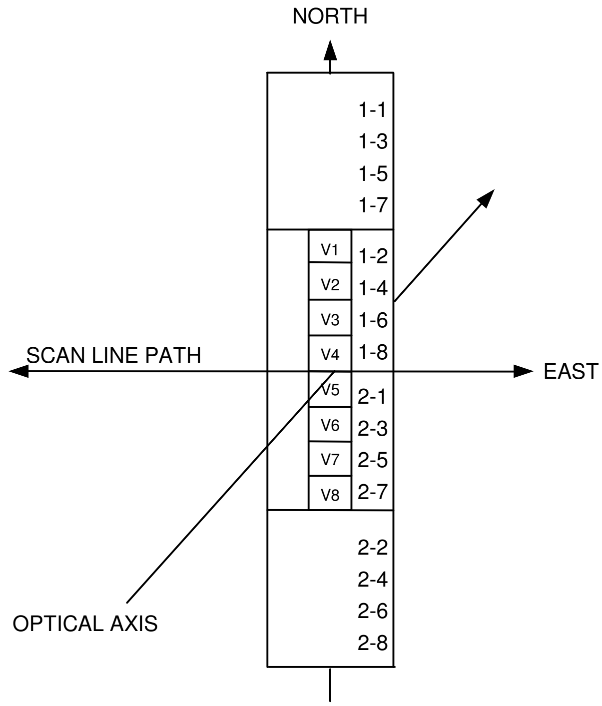


Figure 3-7b. Operational Configurations (GOES O-P)

Scan Control

The scanning mirror position is controlled by two servo motors, one for the N-S gimbal angle and one for the E-W scanning gimbal angle. Each servo motor has an associated Inductosyn that measures the mechanical shaft rotation angle. The scanning mirror position and, hence, the coordinate system used for the Imager are measured in terms of Inductosyn outputs. Scan control for both axes is generated by establishing a desired angular position for the mirror. The desired angle is input to an angular position sensor (one Inductosyn for each axis), which produces a displacement error signal. This signal is fed to a direct drive torque motor (one for each axis) that moves the mirror and sensor to the null location.

For E-W deflection, the direct-drive torque motor is mounted to one side of the scan mirror, and the position-sensing device (Inductosyn position encoder) is mounted on the opposite side. All rotating parts are on a single shaft with a common set of bearings. Using components of intrinsically high resolution and reliability, coupling of the drive, motion, and sensing is therefore very tight and precise. North-south motion is provided by rotating the gimbal (holding the above components) about the optical axis of the telescope. This rotating shaft has the rotary parts of another torque motor and Inductosyn mounted to it, again providing the tight control necessary.

Servo control is not absolutely accurate due to noise, drag, bearing imperfections, misalignment, and imperfections in the Inductosyns. The principal servo pointing and registration errors are fixed pattern errors caused by the Inductosyn position sensor and its electronic drive unit. Variations in individual Inductosyn pole patterns, imbalance between the sine and cosine drives, cross-talk and feedthrough in these circuits, and digital-to-analog (D/A) conversion errors contribute to the fixed-pattern errors. These errors are measured at ambient conditions and the correction values stored in programmable read-only memory. Corrections are applied in the scanner as a function of scan address. The measured values of fixed pattern errors vary between ±15 µrad (mechanical) with a frequency of up to four times the Inductosyn cycle; after correction, the error is reduced to within ±4 µrad. Variations of the fixed pattern error over temperature, life, and radiation conditions are minimized by design, and residual errors are accounted for in the pointing budget.

Drive and error sensing components used for the two drive axes are essentially identical. The E-W drive system has a coherent error integrator (CEI) circuit that automatically corrects for slight changes in friction or other effects. Control components are optimized for their frequency and control characteristics, and logic is developed for the precise control of position in response to a system-level control processor.

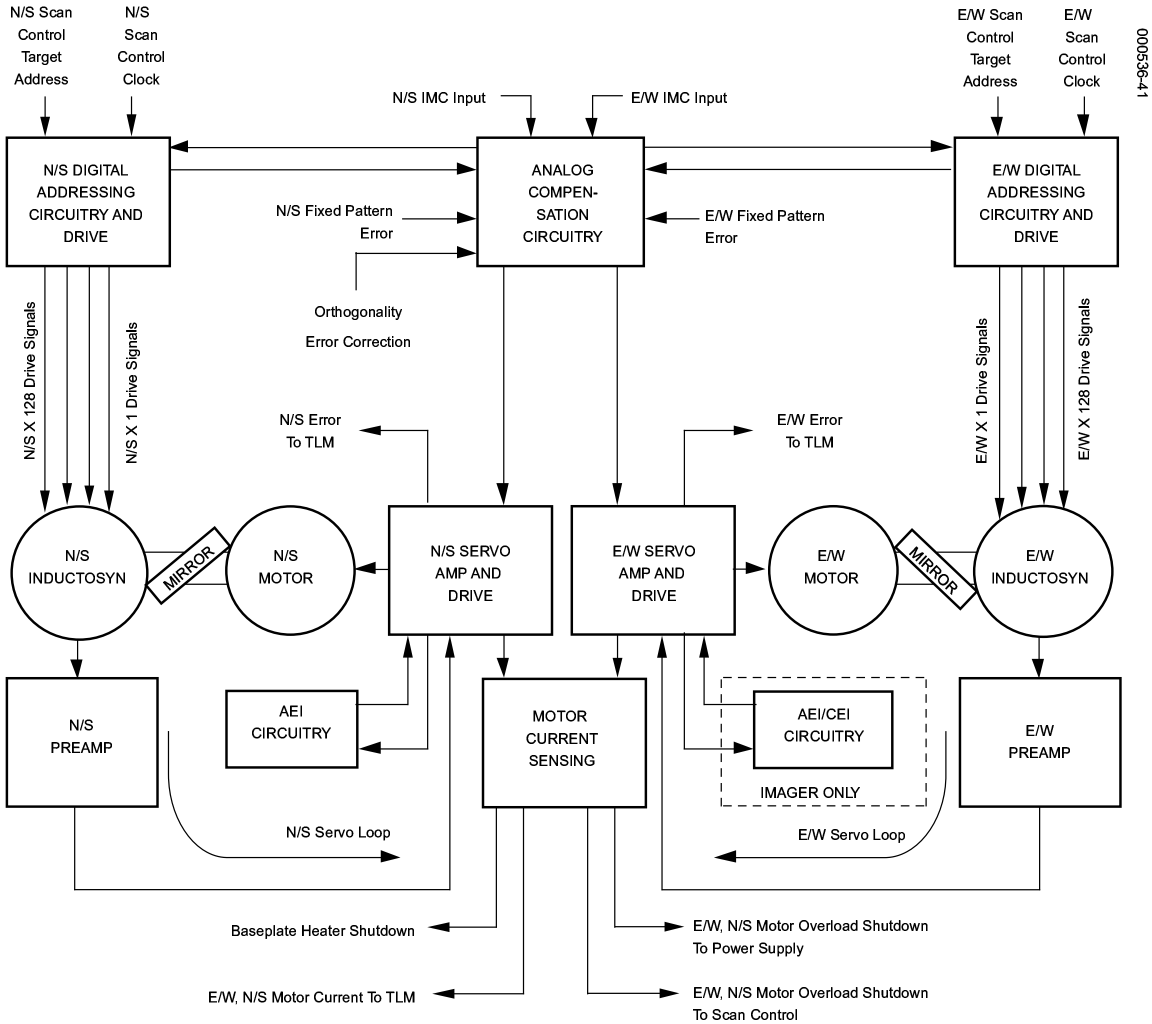
A schematic of the scan control circuitry is given in Figure 3-8.

Scan Operation

Scan control is initiated by an input command that sets start and end locations of an image frame. A location is defined by an Inductosyn cycle and increment number within the cycle, the increment number determining the value of sine and cosine for that location. Each E-W increment corresponds to 8 µrad of E-W mechanical rotation and 16 µrad of E-W optical rotation. Each N-S increment corresponds to 8 µrad of N-S mechanical and optical rotation. The distance between a present and start location is recognized, causing incremental steps (8 µrad) to be taken at a high rate (10 deg/sec) to reach that location. After the E-W slew is completed, the N-S slew begins. From the scan start position, the same pulse rate and increments are used to generate the linear scan. The scan mirror inertia smoothes the small incremental steps to much less than the error budget.

During an image scan at the scan line end location (where the commanded position is recognized), the control system enters a preset deceleration/acceleration. During this 0.2 second interval, the scan mirror velocity is changed in 32 steps by using a 32 increment cosine function of velocity control. This slows and reverses the mirror so that it is precisely located and moving at the exact rate to begin a linear scan in the opposite direction. During this interval, the N-S scan control moves the gimbal assembly 224 µrad (28 increments of 8 µrad) in the south direction. Linear scanning and N-S stepping continue until the southern limit is reached.

Scan to space for space clamp, or to star sensing, or to the IR blackbody uses the same position control and slew functions as for scan and retrace. Command inputs (for star sensing or priority frames) or internal subprograms (for space clamp and IR calibration) take place depending on the type of command, time factors, and location.



Legend

AEI	Average Error Integrator	IMC	Image Motion Compensation
CEI	Coherent Error Integrator	N/S	North/South
E/W	East/West	TLM	Telemetry

Figure 3-8. Scan Control Schematic

Image Generation

During imaging operations, a scan line is generated by rotating the scan mirror in the east-to-west direction (20 deg/sec optically) while concurrently sampling each active imaging detector (5460 per second for IR and 21840 per second for visible). At the end of the line, the scan mirror elevation is changed by a stepped rotation in the north-to-south direction. The next scan line is then acquired by rotating the scan mirror in the (opposite) west-to-east direction, again with concurrent detector sampling. Detector sampling occurs within the context of a repeating data block format. In general, all visible channel detectors are sampled four times for each data block while each active IR detector is sampled once per data block.

The mapping between cycles and increments and the instrument FOV are referenced to a coordinate frame whose origin is zero cycles and zero increments (northwest corner of the frame). In geostationary orbit, the earth will be centered within the frame, at instrument nadir, which corresponds closely to the spacecraft subsatellite point, also centered in the frame. The GVAR coordinate system is in line/pixel space and has its origin in the NW corner.

Three components making up the total misalignment in the sampled data are corrected by the instrument electronics and operations ground equipment:

- A fixed E-W offset caused by channel-to-channel variations in the signal processing filter delays.
- A fixed E-W and/or N-S offset caused by optical axis misalignments in the instrument assembly.
- A variable E-W and/or N-S offset caused by image rotation.

The Imager's coordinate system frame is shown in Figure 3-9, showing the earth disc centered in the instrument's coordinate frame, the $21° \times 23°$ operational FOV limit frame, and the $25° \times 202°$ mechanical limit frame. The earth disc subtends a 17.4° viewing angle from the geostationary altitude.

Electronics

The Imager electronics consist of a preamplifier and thermal control in the sensor assembly; command and control, telemetry, and sensor data processing contained in the electronics module; and the power supplies. The scan control electronics are contained in the electronics module. The servo preamplifiers are located at the scanner in the sensor module. A block diagram of the Imager's electronics is given in Figure 3-10.

Signal Processing

Preamplification of the low-level visible and IR channel signals occurs within the sensor module. These analog signals are routed to the electronics module, which amplifies, filters, and converts the signals to digital code. All channels in the visible and IR bands are digitized to one part in 1024 (10 bits), the visible for high-quality visible imagery and to aid star sensing capability, and the IR for radiometric measurement. Data from all channels move in continuous streams throughout the system, thus each channel's output must enter a short-term memory for proper placement in the data stream. Each channel is composed of a detector, preamplifier, analog-to-digital (A/D) converter, and signal buffer. All signal chains are totally independent and isolated. Redundant chains of signal processing circuitry are provided with each circuit ending in a line driver designed to interface with the spacecraft transmitter. (The video and formatter are redundant for the IR channels only.)

Electronic Calibration

Electronic calibration signals are injected into the preamplifiers of channels 3, 4, and 5 while the Imager is looking at space. Electronic calibration is inserted after the preamplifiers of channels 1 and 2. Sixteen precise signal levels derived from a stepped D/A converter are inserted during the 0.2-second spacelook. The calibration signal, derived from a 10-bit converter of 0.5-bit accuracy, provides the accuracy and linearity for precise calibration.

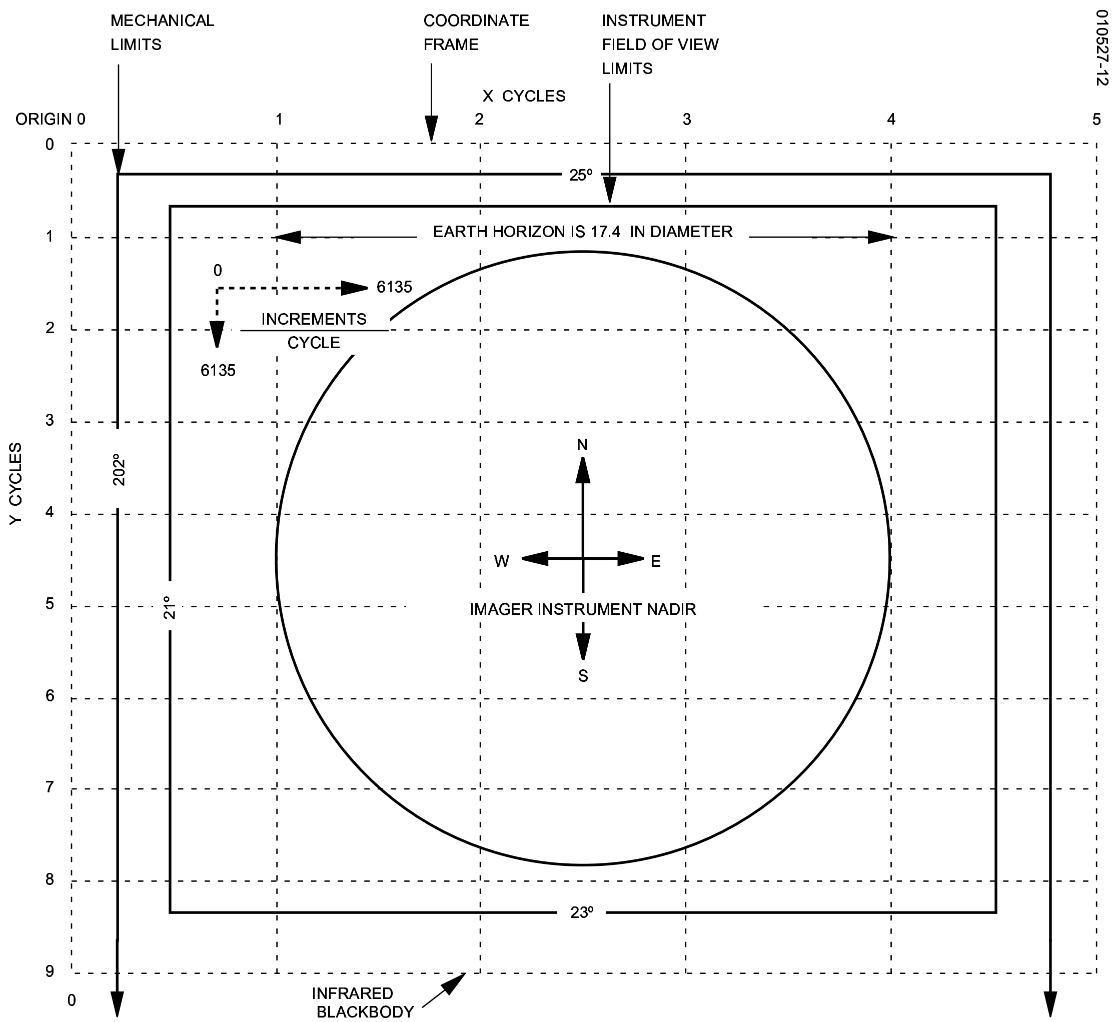


Figure 3-9. Imager Coordinate Frame

Visible Channel

Each detector element of the visible channel has a separate amplifier/processor. These current-sensing preamplifiers convert the photon-generated current in the high-impedance silicon detector into an output voltage, with a gain of about 10^8 V/A. These preamplifiers are followed by postamplifiers that contain electrical filtering and space clamping circuits. The digitization of the data signals is also part of the space clamp circuitry. The visible information is converted to 10-bit digital form, providing a range from near 0.1% to over 100% albedo. Differences of approximately 0.1% are discernible, and the linear digitization provides for system linearity errors of 0.5 bit in the conversion process. The star sense channel uses the same visible channel detectors but boosts the gain by approximately four times and reduces the bandwidth.

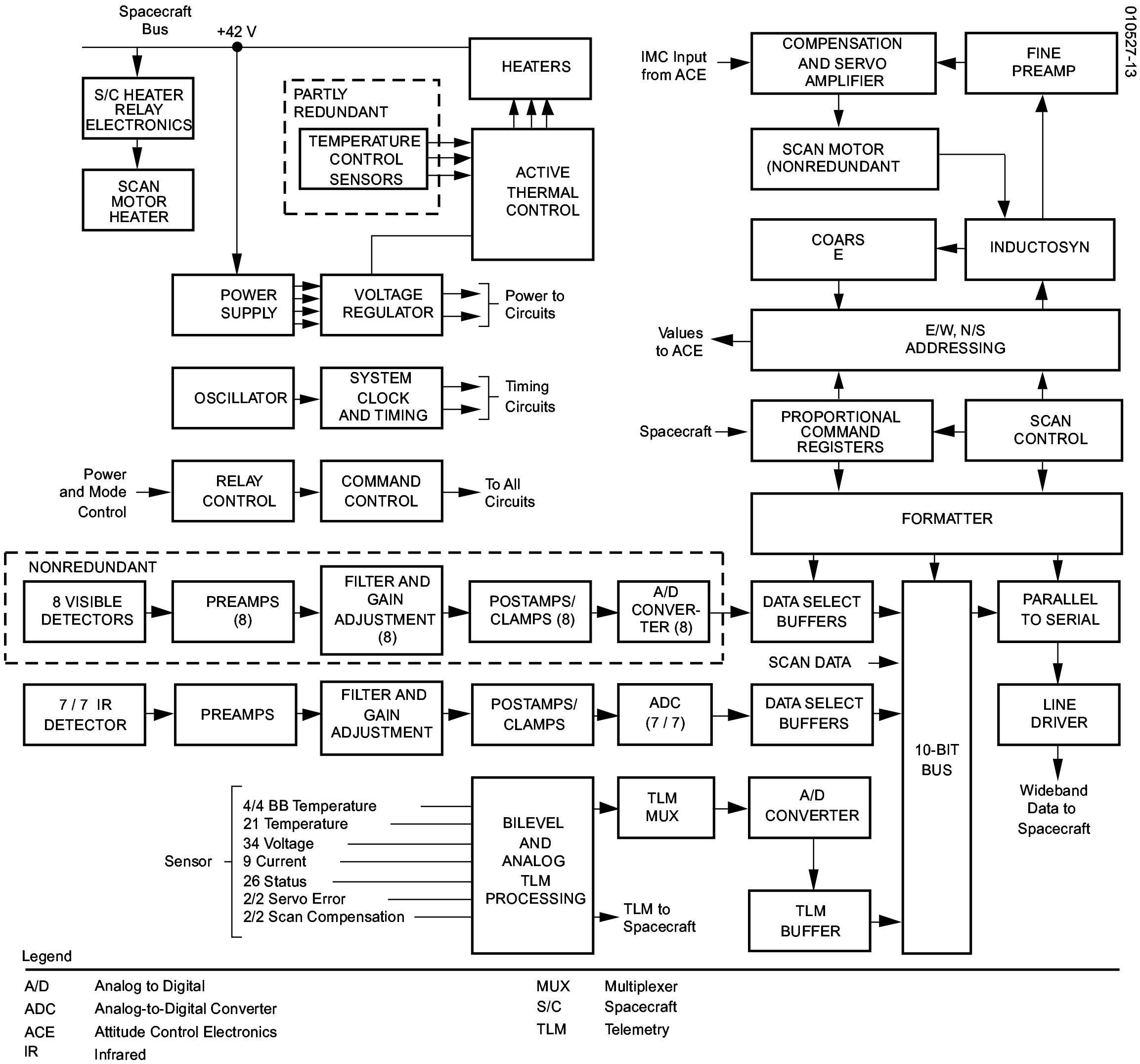


Figure 3-10. Imager Block Diagram

Infrared Channels

(Reference channel numbering convention note on page 3-1)

The IR channels have a separate amplifier/processor for each detector element. The 3.9 µm channel has a hybrid current sensing preamplifier for the high-impedance InSb detector. Individual preamplifiers for HgCdTe detector channels are mounted near the detectors in the sensor module.

The IR information is converted to 10-bit digital form, providing a range from near 0.1% to over 100% of the response range. Channels 3, 4, and 5 have a gain established for a space-to-scene temperature of 320 K, while channel 2 has a dynamic range from space to 335 K. The 10-bit digital form allows the lowest calculated noise level to be differentiated. The digital system is inherently linear with A/D converter linearity and accuracy to 0.5 bit. The binary-coded video is strobed onto the common data bus for data formatting by the system timing and control circuitry.

Formatting

The data format of Imager information is made up of blocks of data generated in a given sample time period. The Imager scans an 8 km swath using combinations of 1 km visible detectors, and 4 and 8 km IR detectors. GOES O–P has 4 km IFOV detectors for all IR channels. Oversampling causes the IR data to be collected each 64 μrad (2.28 km at nadir) using a data block format where the location of each bit within the data stream is completely identified, and all information can be separated and reformatted on the ground. The visible detectors are sampled four times during this 64 μrad period, yielding a collection rate of 16 μrad (0.57 km at nadir) per sample. The four sets of visible data combine with one set from each IR detector in each data block.

The formats consist of data blocks, 480 bits in a block, each block being broken into 48 10-bit words. The format sequence during an active scan begins with a start-of-line command from the scan control system that synchronizes the data formatter with scan control and occurs when the Imager mirror is at the start of a scan line. The header format follows, containing block synchronization and data block identifiers, spacecraft and instrument identification, status flags, attitude control electronics data, coordinates of the current scan mirror position, and fill bits to complete the data block. After the header block, active scan data blocks follow; these contain synchronization and data block identifiers, image motion compensation (IMC) data, servo error, and radiometric data.

When the mirror reaches the end of the scan line, a scan reversal sequence begins with three active scan data blocks that permit full collection of radiometric data to the end of the scan line. A trailer format, similar to the header format, identifies the 39 blocks of telemetry format data to follow.

Digital signal processing starts where data from the IR and visible detectors and telemetry merge via multiplexing and processing; a parallel-to-serial conversion and data multiplexing take place to bring sensor data together. Other information, such as synchronization pulses, scan location, and telemetry data, is assembled in the data select circuitry. These data are then passed through a line driver where pulse amplitude and impedance levels are set for the transmitter interface. These data are transmitted to the spacecraft at a rate of 2.6208 Mbits per second or 5460 blocks per second.

Power Supply

A block diagram of the Imager's power supply system is given in Figure 3-11. The power supply converts spacecraft main bus voltage (42 volts nominal) to the required instrument voltages. There are two sides (1 and 2) to the unit, each totally independent and selected by command, although only one side operates at a time.

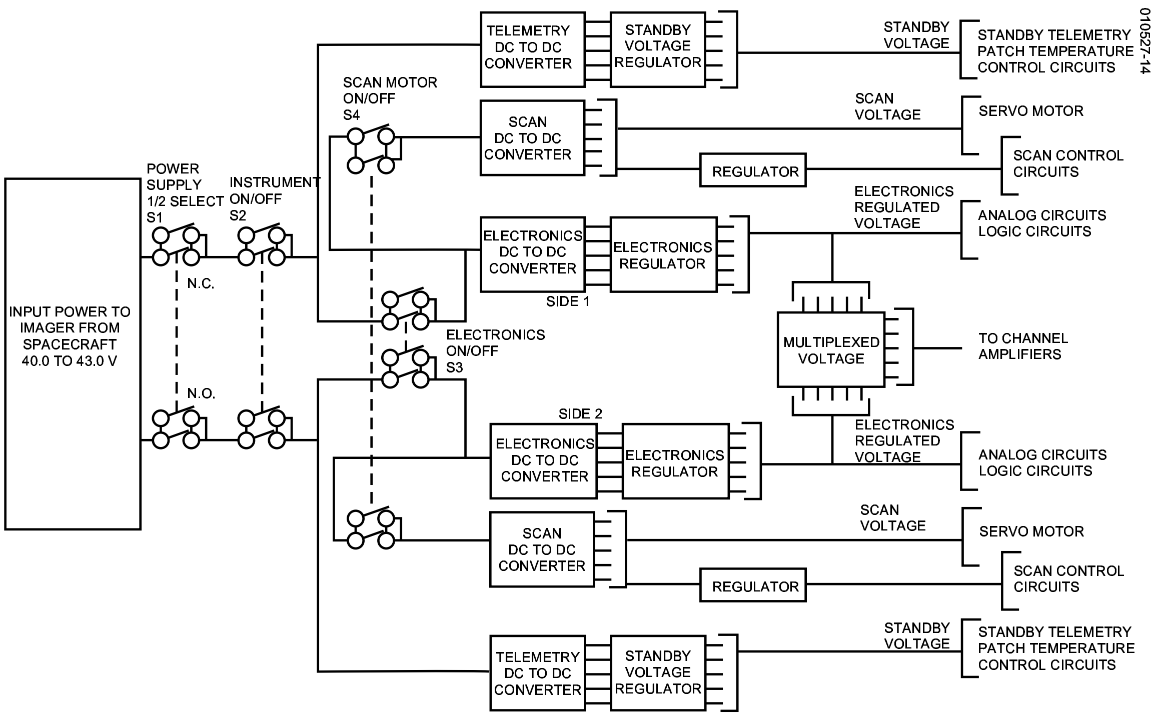


Figure 3-11. Power Supply Block Diagram

The power supply provides secondary power for the instrument by means of six DC/DC switching mode converters. Each redundant side of the instrument has three separate converters that supply power to 1) the telemetry circuits, 2) the scanner drive circuits, and 3) the remainder of the instrument electronics. The converters consist of synchronized switching circuits, transformers, rectifiers, and filters. The telemetry and electronics converters feed regulators to provide regulated voltage levels to the appropriate analog and logic circuits. The scan converter supplies power to the scan motor drive circuits and feeds a regulator to provide regulated voltage levels to scan control circuits. The converters are synchronized to 218 kHz, and the electronics and scan converters use a push-pull topology, while the telemetry converter uses a flyback configuration. A diode OR'ing circuit permits operation of all nonredundant circuits (command input circuitry, patch temperature control, visible detector circuits, etc) by either side. Control of the power supplies is achieved using relays for turn on, turn off, and side select. Ultimate protection for the spacecraft power bus is provided by having fuses on the input lines of the power supply.

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