FINAL REPORT

FOR

A RETARDING ION MASS SPECTROMETER FOR THE DYNAMICS EXPLORER-1

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RETARDING ION MASS SPECTROMETER FOR DYNAMICS EXPLORER-1

FINAL REPORT

This report covers the development of the Retarding Ion Mass Spectrometer (RIMS) for the Dynamics Explorer-1 (DE-1) spacecraft. The RIMS instrument was one of six instruments aboard the DE-1 spacecraft launched from the Western Test Range on August 3, 1981. At this time (almost 4 years after launch) the RIMS is actively supplying data of interest to the scientific investigators.

Following the launch in August of 1981 the UTD/CSS has participated in the data analysis phase of the Dynamics Explorer investigation.

The RIMS instrument has been documented by the preparation of a Technical Memorandum NASA TM-82484 issued by the Space Science Laboratory of NASA/MSFC. The TM-82484 has been incorporated in this report as Section I.

The data analysis activities have emphasized the cross calibration of the DE-1 RIMS with the DE-2 RPA instrument. These activities are expected to yield published results in the near future. A series of mini-reports and data plots are provided in Section II of this report.

SECTION I

INSTRUMENT DESCRIPTION-NASA/MSFC TM-82484

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1.0 INTRODUCTION

The Retarding Ion Mass Spectrometer (RIMS) Instrument is one of six instruments on the Dynamics Explorer A (DE-1) spacecraft launched from the Western Test Range on August 3, 1981.

The RIMS is an instrument designed to measure the details of the thermal plasma distribution. It combines the ion temperature determining capability of the retarding potential analyzer (RPA) with the compositional capabilities of the mass spectrometer and adds multiple sensor heads to sample all directions relative to the spacecraft direction.

The purpose of this document is to describe the RIMS instrument, to provide an instrument functional description, document the test and calibration activities, and to describe the commands which can be stored in the instrument logic to control its operation.

2.0 SCIENCE OBJECTIVES

The RIMS instrument on the high-altitude DE spacecraft utilizes a RPA for energy analysis in series with a magnetic ion mass spectrometer (IMS) for mass analysis. The instrument is designed to operate in two basic commandable modes (1) a high-altitude mode in which the density, temperature, and bulk flow characteristics of H^+, He^+, O^+, He^{++}, and O^{++} ions are measured, and (2) a low-altitude mode which concentrates on the composition in the 1 to 32 amu range. Table 1 lists the parameters to be measured with their ranges, accuracies, and temporal resolution.

TABLE 1 PARAMETERS MEASURED BY THE RIMS INSTRUMENT

	Range	Accuracy	Resolution
Principal Apogee Mode* (1500 km):			
Density H^+, He^+, O^+, He^{++}, O^{++}	0.1 – 10^6 ions/cm^3	±10%	Nominally 0.5 sec (1/64 sec maximum) Complete – 1 spacecraft spin (6 sec)
Temperature H^+, He^+, O^+, He^{++}, O^{++}	0 – 45 eV	±5%	0.5 sec Complete (6 sec)
Bulk Flow H^+, He^+, O^+, He^{++}, O^{++}	0.5 km/sec and up	Highly Temperature Dependent	(6 sec)
Spacecraft Potential	Few Volts Positive – 45 V Negative	0.1 V	(6 sec)
Principal Perigee Mode* (< 1500 km):			
Ion Composition	1 to 32 amu 0.1 – 10^6 ions/cm^3	10 pts/mass peak	6 sec

*These modes of operation are commandable. Either mode can be operated throughout the orbit.

The instrument will furnish fundamental information in the following specified areas:

a) The densities of H^+, He^+, O^+, He^{++}, and O^{++} in the ionosphere, plasmasphere, plasma trough, and polar cap. This includes the density distribution along B in the vicinity of the satellite apogee.

b) The temperature of H^+ He^+, O^+, He^{++}, and O^{++} ions in the ionosphere, plasmasphere, plasma trough, and polar cap (energy range 0 to 50 eV).

c) The bulk flow velocities of H^+, He^+, O^+, He^{++}, and O^{++} in the plasmasphere, plasma trough, and polar cap.

d) The changing character of the cold plasma density, temperature, and bulk flow in regions of interaction with hot plasma such as at the boundary between the plasmasphere and the ring current.

e) The detailed composition of ionospheric plasma in the 1 to 32 amu range.

3.0 INSTRUMENT DESCRIPTION

The DE-1 RIMS consists of four instrument assemblies interconnected to form one experiment. Three of the assemblies are sensor heads and one is the central electronics shown in Figure 1. The three heads are labeled according to their mounting axis on the DE-1 spacecraft; radial, +Z, and -Z. The central electronics assembly (CEA) provides the spacecraft interface, all data processing, command decoding, and complete timing control of the entire RIMS experiment. Each sensor head contains a RPA with a two-channel IMS mounted directly behind it. Surrounding and attached to the entrance to the sensor head is a 20-cm circular aperture plane. The plane is connected to a relay which can, by spacecraft major mode relay command, connect it to either spacecraft chassis ground or to the aperture potential power supply output. The aperture potential power supply can be set, by spacecraft minor mode A command, to 0, -2, -4, or -8 V.

The retarding grid of the RPA is connected to the retarding potential power supply through a shielded conductor. The retarding potential may be set to any one of 1024 steps from 0 to +51.15 V. The RPA collector plate is connected through a co-axial cable to a 5-decade logarithmic amplifier. The reference voltage for the front end of the log amp is the output of the aperture potential power supply. The output of the log amp is converted, by command from the CEA, to a 10-bit digital word using an analog/digital (A/D) converter. The digital word is held in a holding register until the CEA is ready to read and process this data.

The two-channel IMS uses channel electron multipliers (CEMs) as detectors. The two CEMs in each sensor head are powered by a single multiplier high-voltage power supply which can be set, by spacecraft minor mode 'A' command, to any one of four voltages, -1200, -2100, -2400, and -2800 V. The IMS accelerating voltage comes from a sweep high-voltage power supply that can be addressed to any one of 4096 steps between 0 and -2250 V.

The output of each detector is connected to a pulse amplifier whose output is sent to a level detector. The discrimination level can be set to a high or low value by spacecraft minor mode 'A' command. Pulses from the discriminator are coupled

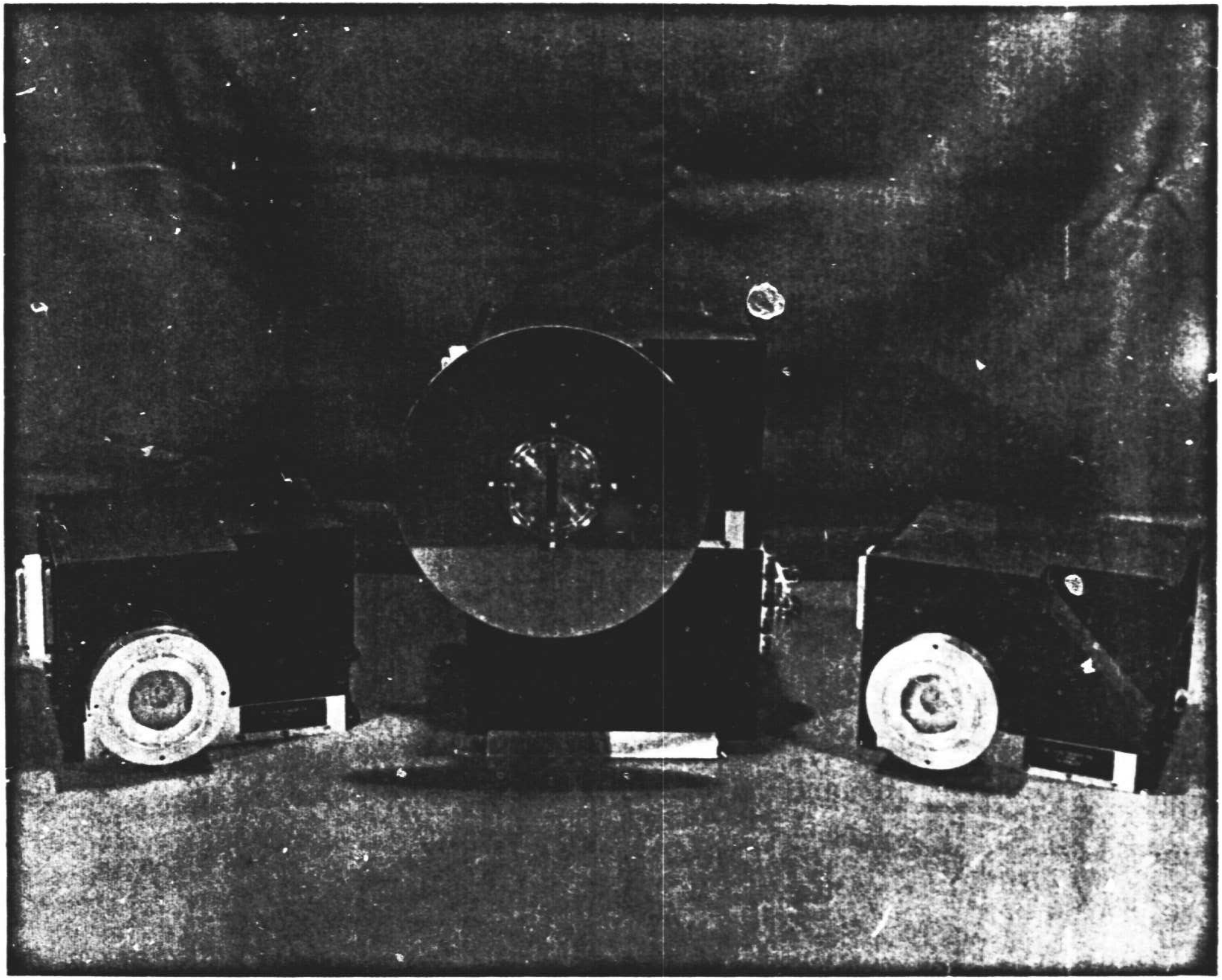


Figure 1. The three RIMS sensor heads and the central electronics assembly showing the narrow field of view for the radial head and its aperture plane.

to an 18-stage binary counter. Four bits of the counter are located in each head, and the other 14 bits of each accumulator are located in the CEA.

3.1 Configuration

The RIMS instrument consists of four packages, three sensor heads and a CEA. One head is mounted to look radially out of the spacecraft perpendicular to the spacecraft spin axis while the other two look along the ±Z (spin) axis as shown in Figure 2.

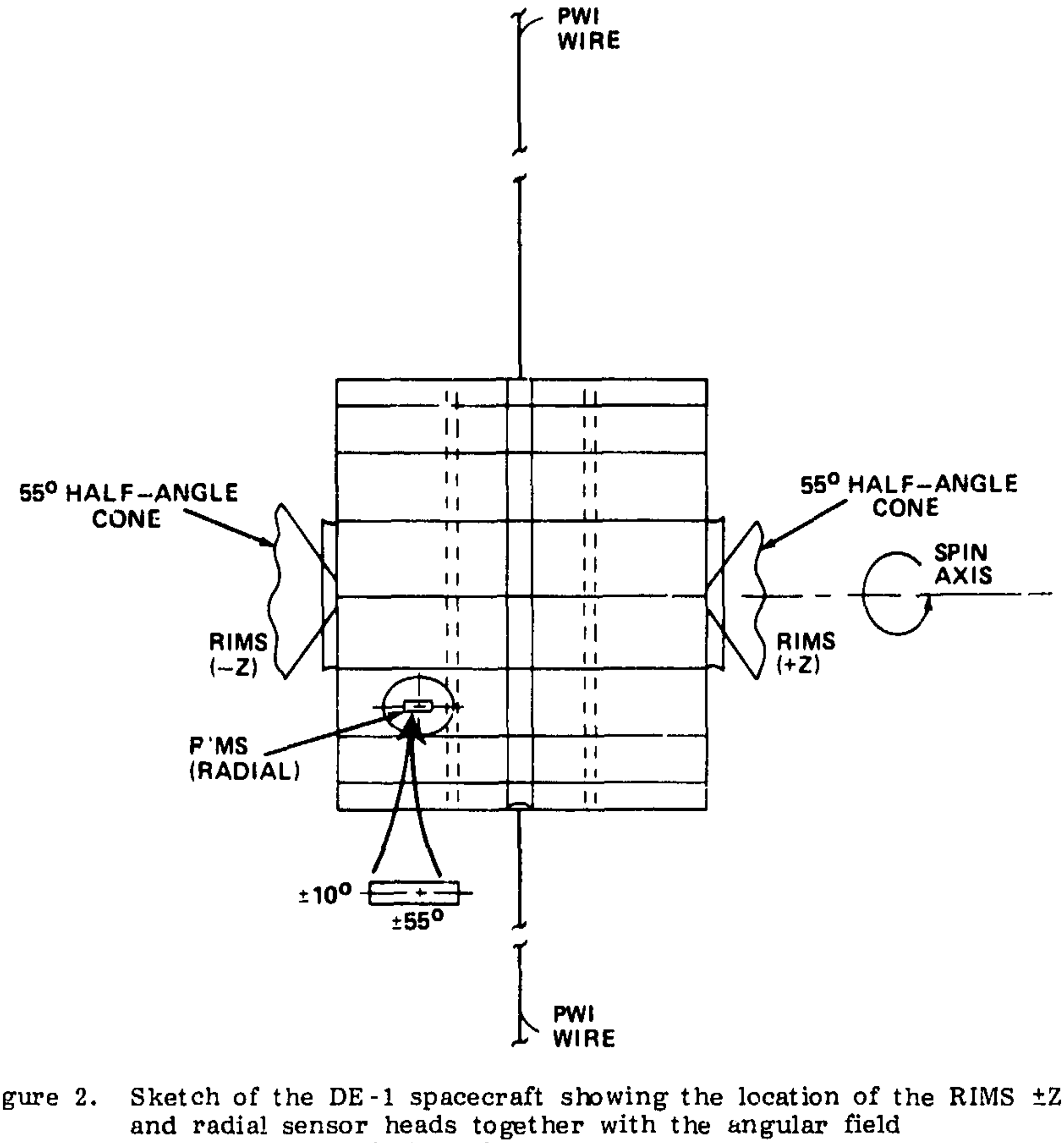


Figure 2. Sketch of the DE-1 spacecraft showing the location of the RIMS ±Z and radial sensor heads together with the angular field of view of each sensor.

Each sensor head consists of a RPA followed by a magnetic mass analyzer with two separate exit slits corresponding to two mass ranges in the ratio 1:4. Figure 3 is a cutaway view of the RIMS sensor head showing the path of thermal ions through the analyzer. The total mass range covered is 1 to 32 amu. Figure 4 is a schematic drawing of a sensor head (the three are identical except that the radial aperture is reduced to ±10 deg in the plane perpendicular to the spin axis) showing the entrance aperture, which is mounted flush with a ground plane on the outer surface of the spacecraft, and the RPA grids and ion collector plate, followed by the mass analyzer. The latter consists of an entrance (collimating) slit set, magnetic analyzer, collector slits, and electron multiplier detectors.

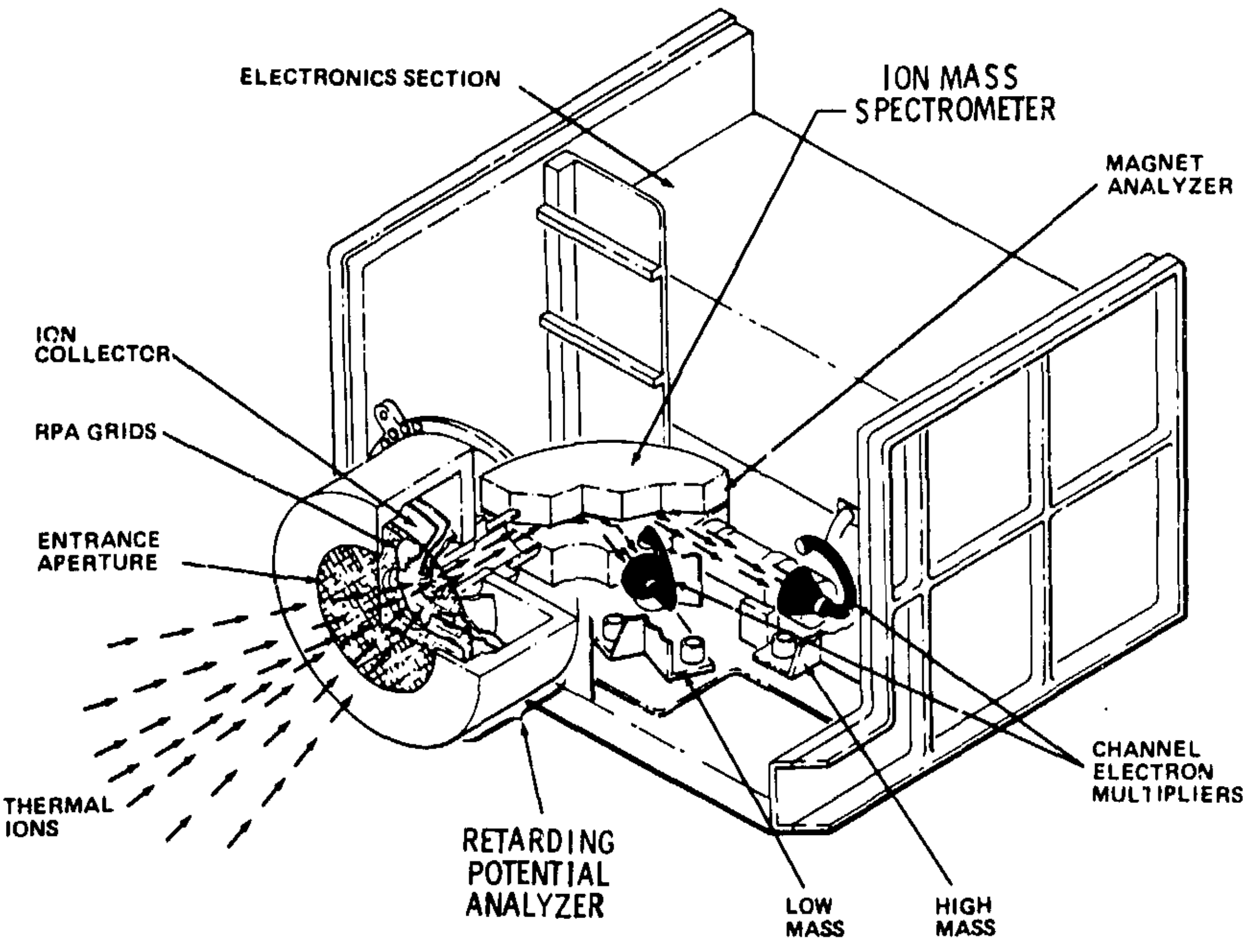


Figure 3. Cutaway view of a RIMS sensor head showing the path of thermal ions through the analyzer. The arrows show the ions' entry through the retarding potential analyzer and ion mass spectrometer sections with detection by the channel electron multipliers.

Ambient ions enter through the aperture. The aperture potential may be selected by command to any of four values including zero to bias out a non-zero spacecraft potential. Ions having sufficient energy to pass the retarding grid may either be collected on the RPA collector or pass into the mass analyzer. The RPA retarding grid voltage is programmable over a 0 to 51.2 V range, referenced to the aperture potential, by a minor mode command (paragraph 4.6.2.3). Any 32 of 1024 voltage steps may be selected. The collector output consists of a retarding potential analysis of the ambient ions.

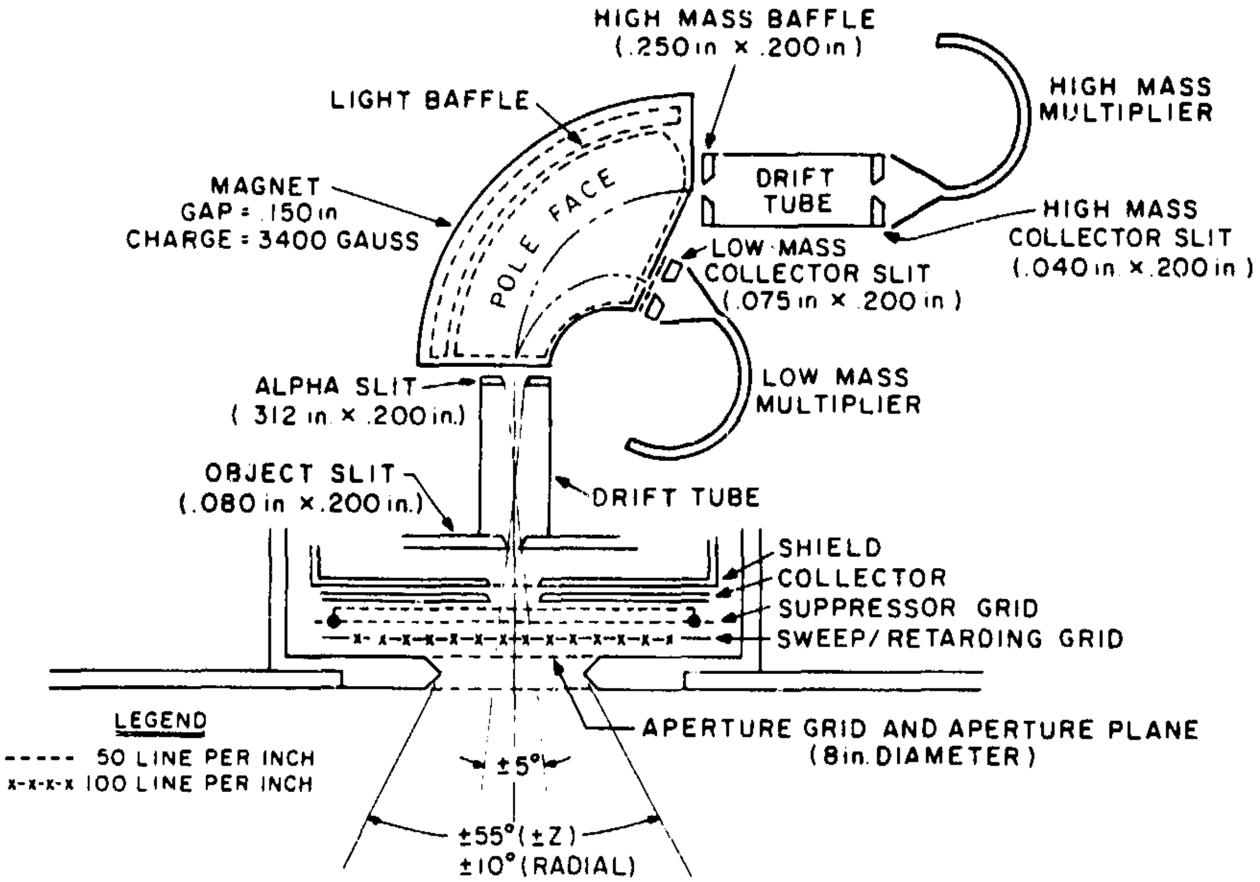


Figure 4. Schematic diagram of the RIMS sensor head showing the entrance aperture, RPA grids, ion collector plate, the mass analyzer, and the slits which define the ion path.

Those ions passing into the mass analyzer are sorted according to their charge to mass ratio. The proper combination of ion accelerating voltage, magnetic field strength, and ion beam radius in the magnetic field determines the mass of the ion focused on each collector slit. Varying the ion accelerating voltage varies the ion mass detected. Ions of mass 1 to 8 amu and 4 to 32 amu can be focused on the low and high mass slits, respectively. Ions exiting the collector slits are counted by the CEM detectors. The ion mass range is also programmable by a minor mode command (paragraph 4.6.2.5). Any 32 of 4096 voltage steps may be selected. All 32 steps may be the same, in which case the mass analyzer will be locked onto a given set of mass peaks having the ratio 1:4. For example, the most likely combination will be 1 and 4 amu (H^+ and He^+), 2 and 8 amu, or 4 and 16 amu. The fixed mass analyzer mode will generally be used when the RPA analysis is being done.

3.2 Mechanical

Figures 5 and 6 are outline drawings of the central electronics and sensor packages, respectively. Figure 7 shows the location of the packages in the spacecraft. The total weight of the RIMS instrument is 13.06 kg as follows: R sensor 3.38 kg, +Z sensor 3.49 kg, -Z sensor 3.48 kg, and the CEA 2.71 kg. The sensor and CEA housing are aluminum coated with alodine 1200S. All outer surfaces of the

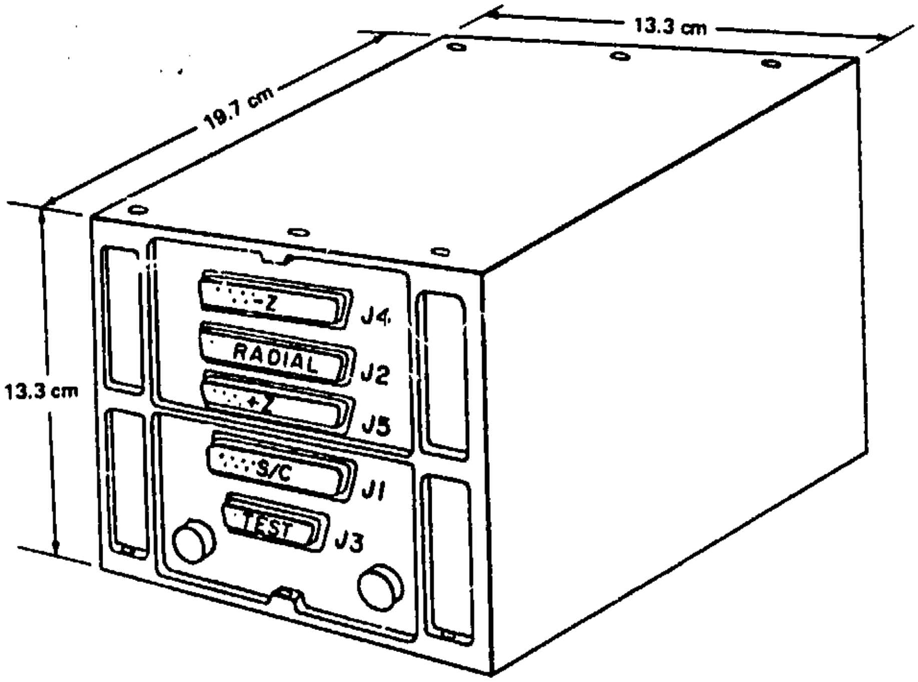


Figure 5. RIMS CEA envelope drawing.

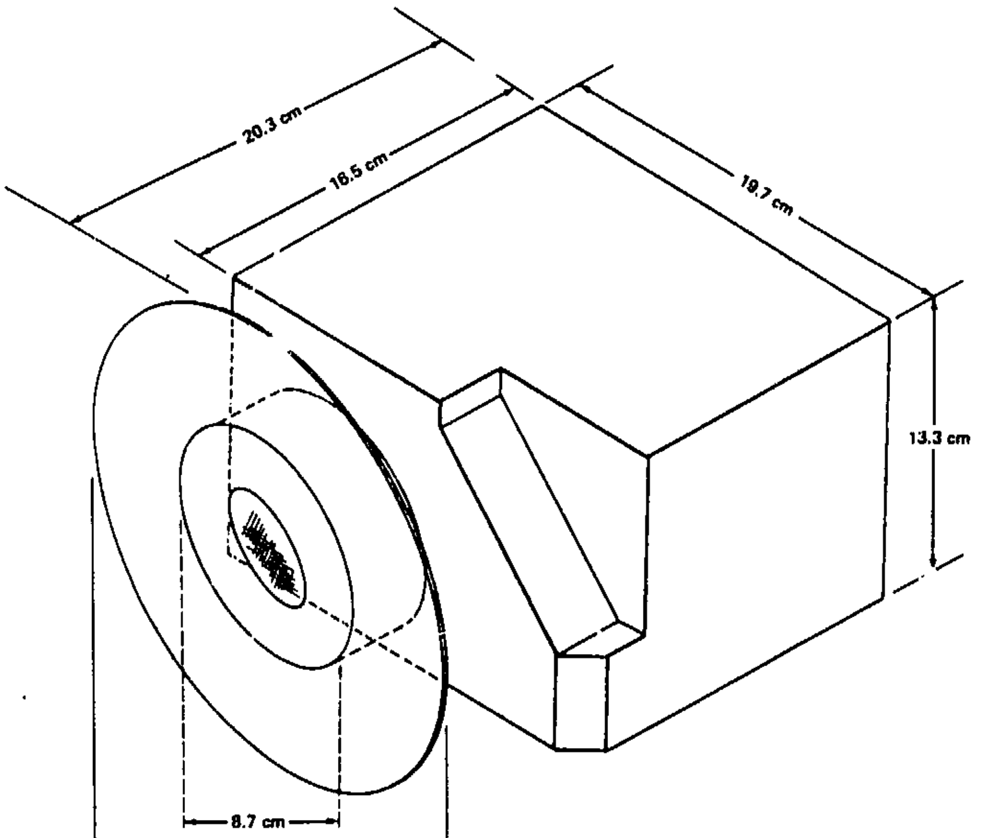


Figure 6. RIMS sensor head envelope drawing.

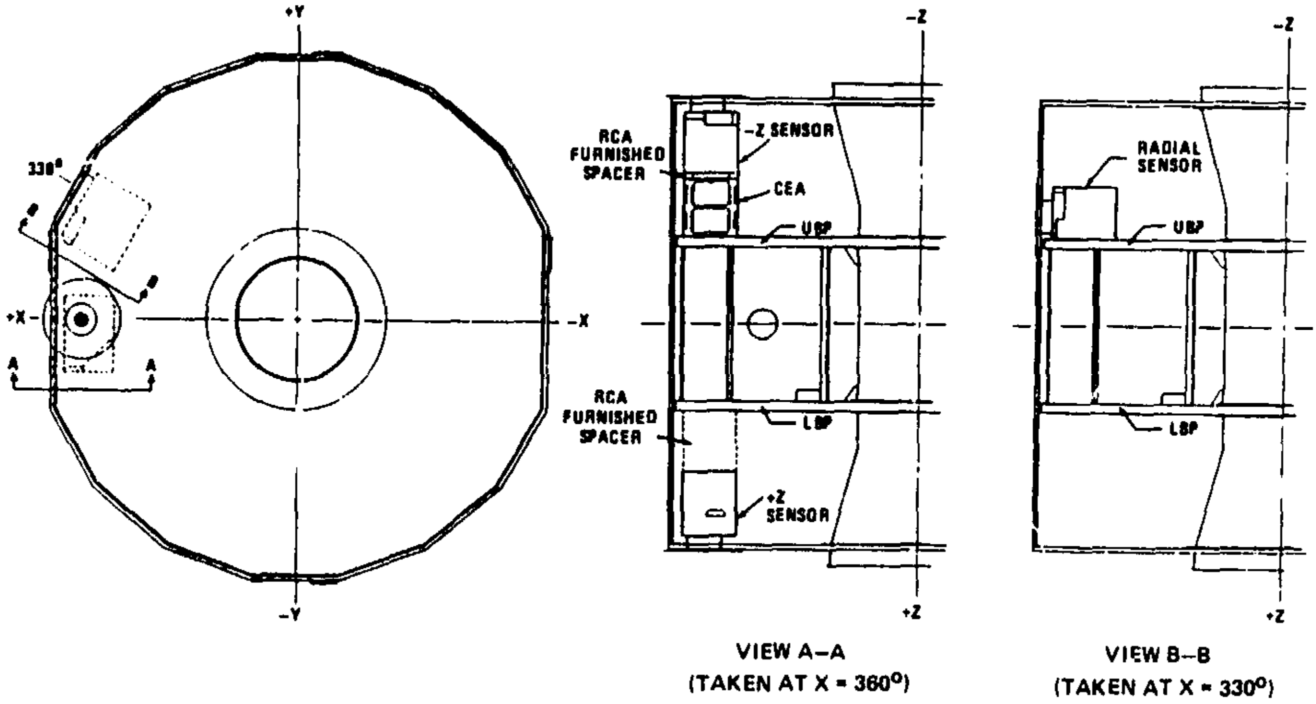


Figure 7. Location of the RIMS packages in the DE-1 spacecraft.

three sensor heads except the bottom and back were black anodized for thermal control. The CEA was black anodized except for the top and bottom surfaces. All RIMS surfaces exposed to space are gold plated. The back of the aperture plane is black anodized.

3.3 Electrical

The electronics of the RIMS sensor heads are identical and interface with the CEA.

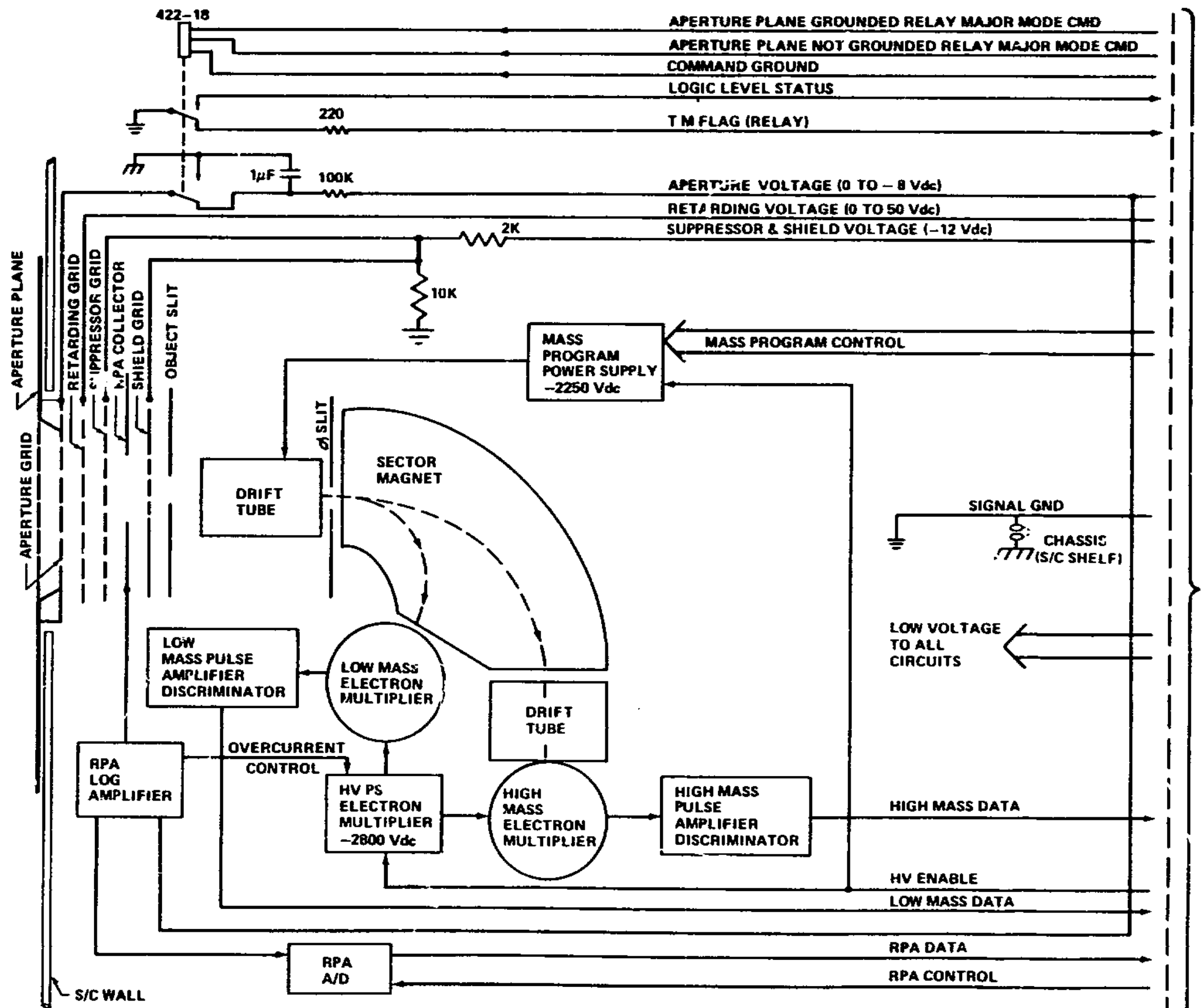
3.3.1 Sensor Electronics

Figure 8 is a schematic block diagram of the RIMS sensor head electronics showing the flow of control signals, sensor voltages, and signal paths. Each circuit unit is described in the following paragraphs.

3.3.1.1 Mass Program Power Supply

The mass sweep potential is generated by this circuit in the range of 0 to -2250 Vdc. Primary power is the spacecraft -24.5 Vdc. Twelve bits coming serially from the central electronics control this power supply output.

An oscillator operating at approximately 34 kHz has its output coupled through a step up transformer and voltage quadrupler to produce the required high voltage.



DE–A RIMS SENSOR ASSEMBLY FUNCTIONAL BLOCK SCHEMATIC

Figure 8. Schematic block diagram of the RIMS sensor head electronics showing the control of the ion analyzer and interfaces to the CEA.

Variation of the drive to the oscillator push pull transistors control the high-voltage amplitude. Isolation between spacecraft power and signal ground in the control loop is provided by an optical coupler.

The sweep supply is capable of changing voltage more rapidly in the increasing voltage direction because the inverter is actively driven in this direction but relies on passive discharge of the output filter capacitors through the feedback resistor when decreasing output voltage. The time required for sweep voltage changes places some limitations in the mass sampling scheme that can be programmed into the instrument. Sweep voltage changes greater than 5 percent will result in loss of data accumulation time.

3.3.1.2 Channel Electron Multiplier High Voltage Power Supply

Both CEMs in each sensor head are powered from a single high-voltage power supply contained in each sensor head. CEM voltages are controlled by 2 bits resulting in four selectable outputs for each sensor head (-1200, -2100, -2400, and -2800 Vdc). The high voltage and control loop portions are very similar to the mass sweep high-voltage power supply circuits.

In the sensor heads, a signal from the log-amp overcurrent can override the voltage selection signals and send the output voltage to -1200 V to protect the CEMs from the high count rates that are expected at ionospheric altitudes.

3.3.1.3 Ion Current Logarithmic Amplifier

This circuit produces a logarithmic output voltage, V, in the range 0 to +10 Vdc for an input current, i, of 10^{-11} to 5×10^{-7} A. A constant internal bias of 10^{-11} A is provided. V is related to i by:

$$V = 2.128\ [\log_{10}\ (i + 10^{-11}) + 11] \quad .$$

The logarithmic relationship results from utilizing the highly predictable relationship between collector current and base-emitter voltage of a bipolar transistor.

The input stages are referenced to the aperture grid potential, and the output is referenced to signal ground. A 10 bit A/D converter is used to digitize the output; this information being transmitted serially to the central electronics. The output from this logarithmic amplifier is used to reduce the high voltage on the electron multipliers when the current exceeds the preset values.

3.3.1.4 Pulse Amplifier/Counter

Charge pulses from each CEM are converted to voltage pulses, amplified, and coupled to an 18-stage binary counter. The first four stages are in the Pulse Amplifier/Counter circuits and the remainder in the central electronics.

The input charge pulses pass through a 100 ohm resistor to ground, thus generating voltage pulses. These are amplified and coupled to a level detector which discriminates between ion generated pulses and circuit noise. The discriminator has two levels to accommodate changes in noise level. One stage of gain follows the discriminator and feeds a Schmitt trigger which decreases the transition time of the resulting pulses. The pulses are then fed to the binary counter.

3.3.2 Central Electronics

Figure 9 is a functional schematic block diagram of the central electronics box. This diagram shows the interface signals with the DE-1 spacecraft. The data outputs are synchronized to the telemetry minor frame rate. Each circuit function is described in the following paragraphs.

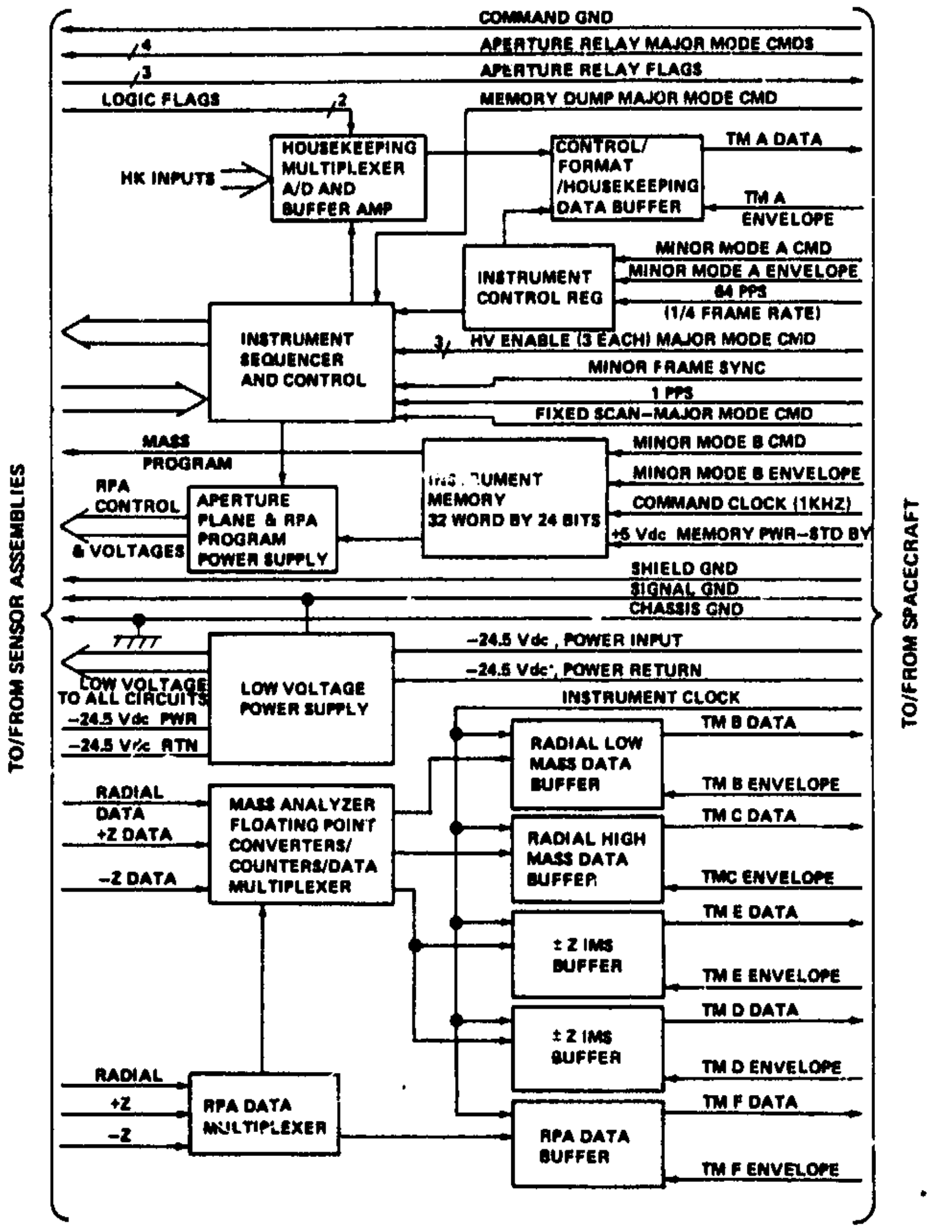


Figure 9. Schematic block diagram of the RIMS CEA showing the control elements which drive the three sensor heads and the interface to the DE-1 spacecraft.

3.3.2.1 Low Voltage Power Supply

Three basic functions are performed by the low-voltage power supply (1) conditioning the incoming power, (2) isolating it from the instrument low voltages, and (3) regulating those low voltages.

Incoming -24.5 Vdc power passes through a turn-on-transient limiting circuit before being chopped in a 20-kHz driven inverter. This chopper frequency is derived from 80 kHz discrete flip-flop whose output is divided by 4. Outputs of the inverter are (1) ±12 Vdc (unregulated and referenced to aperture plane voltage), (2) two +25 Vdc lines, (3) ±15 Vdc to ±12 Vdc regulators, and (4) ±55 Vdc (unregulated). One of the +25 V outputs goes to the 5-V switching regulator. The ±12-V regulators are linear I.C. types utilizing external boost transistors for additional current carrying capability.

3.3.2.2 Retarding Potential Power Supply

Output range of this supply is 0 to +51.15 V in 50-mV steps when in the program mode. This voltage range is covered in 75-mV steps when in the fixed scan mode and is non-programmable. This range is referenced to the aperture grid potential in both modes. Input control is a 10-bit signal for either mode from the CEA.

The digital control is fed to a D/A converter whose reference is either 5.12 V for 50 mV steps in the programmable mode or 7.68 V for 75 mV steps in the fixed scan mode. The D/A output goes to a differential amplifier and is summed with an aperture grid reference signal to produce a retarding potential referenced to aperture potential. Following the differential amplifier is a two-stage transistor amplifier.

3.3.2.3 Aperture Grid Power Supply

A 2-bit command is used in controlling this power supply which has the following output voltages: 0, -2, -4, and -8 Vdc. Output voltage is compared to a reference through selectable resistors to achieve control. A high-current output stage provides a low impedance for other circuits referenced to this power supply.

3.3.2.4 Memory Control

The memory control assembly does all read/write operations and monitors the health of the memory. All minor mode 'B' commands are received by this assembly and it keeps the master sequencer updated as to its status and health. This assembly also generates the fixed scan address for the retarding potential power supply.

3.3.2.5 Data Accumulators

This assembly contains the six accumulators and holding registers associated with each IMS channel. Each accumulator data is multiplexed into the data compressor to be output.

3.3.2.6 Data Compression

This assembly contains the circuitry for compressing each accumulator output into a 10-bit base 2-floating point number (6-bit mantissa and 4-bit exponent) for output into the telemetry buffers. This assembly also contains the major mode command circuits and status bits.

3.3.2.7 Housekeeping and Telemetry Buffers

Instrument health and monitor outputs are received by this assembly and multiplexed into an A/D for conversion to an 8-bit telemetry word. This assembly contains all telemetry data buffers for the instrument.

3.3.2.8 Data Selector and Instrument Control Register

This assembly receives the minor mode 'A' command and stores it in the Instrument Control Register (ICR). This register contains all information needed to reconfigure the instrument and to select various combinations of data outputs to be loaded into the telemetry buffers.

3.3.2.9 Master Sequencer

The master sequencer is the controlling assembly for the RIMS instrument. It sequentially determines when all circuits are to perform their various duties and keeps a status check on all commands and timing required to maintain instrument health and operation. All data collection and processing by the RIMS instrument is under the control of this assembly.

3.4 Definition of Terms

The following terms are defined in accordance with their usage in describing the RIMS.

3.4.1 Instrument Cycle

The instrument cycle is 32 data samples from each data source. The RIMS completes one instrument cycle each 0.5 sec (32 quarter minor frames or 8 minor frames).

3.4.2 Measurement Interval

Each data sample represents a period of 1/4 minor frame (15.625 msec). This interval consists of an integration interval and a data processing interval.

3.4.3 Integration Interval

During the measurement interval, the IMS accumulators are active for a period of 12 msec.

3.4.4 Data Processing Interval

This period of 3.625 msec is used to process the data accumulated during the integration interval and to establish the mass voltage and retarding voltage for the next integration period.

4.0 INSTRUMENT FUNCTIONAL DESCRIPTION

The RIMS operating sequence is controlled by an internal memory in the CEA which is programmed by ground command. This feature is mandated by the versatility of the instrument and the intrinsic variability of the plasma it is designed to analyze.

4.1 Instrument Mode Commands

There are nine major mode commands furnished by the spacecraft to the RIMS instrument. The commands are listed below along with their function.

4.1.1 Major Mode Relay Commands

The RIMS experiment receives four major mode relay commands.

4.1.1.1 Radial Aperture Plane-Grounded

The radial aperture plane-grounded (RAPG) command sets the relay in the radial head to the grounded plane position (chassis ground). This relay has two sets of contacts. One set is used to control the aperture plane, and the other set is used as flags for the spacecraft and the CEA. The spacecraft flag is sent directly through the CEA to the telemetry. The CEA flag is used in a status word of telemetry word 7. This command is sent automatically by the spacecraft at RIMS Power ON and RIMS Power OFF.

4.1.1.2 Radial Aperture Plane Programmed

The radial aperture plane programmed (RAPP) command sets the radial aperture plane relay to the programmed position connecting the plane and the entire sensor head to the aperture potential power supply.

4.1.1.3 Z Aperture Planes-Grounded

The Z aperture planes grounded (ZAPG) command sets the +Z and -Z aperture plane relays to the grounded plane position (chassis ground). Each head has a separate relay but this command is routed to both heads. Separate +Z and -Z flags are the same as the radial head relay flag and this command is also automatically sent by the spacecraft at RIMS Power ON and RIMS Power OFF. Only the +Z CEA flag is used in the status word of telemetry word 7.

4.1.1.4 Z Aperture Planes-Programmed

The Z aperture planes programmed (ZAPP) command sets the +Z and -Z relays to the programmed position, connecting the aperture plane and the entire sensor head to the aperture potential power supply.

4.1.2 Major Mode Logic Commands

The RIMS experiment receives five major mode logic commands.

4.1.2.1 Radial High Voltage Enable

The radial high voltage enable (RHVE) command sets a control bit in the CEA which waits for the next 1 sec synchronization pulse (1 pps) before sending the 'HIGH VOLTAGE ON' logic level command to the radial head. This bit is also used in the status word.

4.1.2.2 +Z High Voltage Enable

The +Z high voltage enable (PZHVE) command is used the same as the RHVE command.

4.1.2.3 -Z High Voltage Enable

The -Z high voltage enable (NZHVE) command is used the same as the RHVE command.

4.1.2.4 Fixed Scan Enable

The fixed scan enable (FSCAN) command sets a control bit in the CEA. When the next 1 pps pulse occurs, the fixed scan generator is activated. This bit is also used as a flag bit in the status word.

4.1.2.5 Memory Dump

The memory dump (MDUMP) command sets a control bit in the CEA. When the next 1 pps pulse occurs, a dump of the RIMS memory begins. This bit is also used as a flag bit in the status word. The duration of a memory dump is 2 sec.

4.1.3 Minor Mode Commands

Two minor mode commands are received by the RIMS instrument.

4.1.3.1 Minor Mode 'A'

The RIMS minor mode 'A' command is a 32-bit serial word that is received and stored in a command register. The trailing edge of the command envelope sets a control bit indicating a new command is ready to be loaded into the instrument control register at the next 1 pps pulse.

4.1.3.2 Minor Mode 'B'

The RIMS minor mode 'B' command is a 32-bit serial word that is received and stored in a command register. This command is used exclusively for loading the 32-word instrument memory. The sequence of 32 words sets up the mass spectrometer and RPA steps that will be executed during the instrument cycle. The leading edge of the command envelope sets a memory load control bit which disengages all access to the memory by the instrument master sequencer and places the instrument in the calibration mode during this time. The trailing edge of the command envelope sets another bit that starts the memory write sequence. The memory load control bit can be reset by a bit in the command word or it will automatically reset 2 sec after the first command is received.

4.2 Telemetry Word Assignments

The RIMS instrument is assigned 26 8-bit telemetry words. These words and their positions within the minor frame are shown in Figure 10. Five groups of 5 each telemetry words (8 bit) are used, and each group is considered a telemetry channel by the RIMS processor. Each telemetry channel contains 4 each 10-bit instrument words.

4.3 Master Sequencer

The master sequencer is the controlling circuit for all functions within the RIMS instrument. It generates the necessary timing instructions to configure the instrument operation modes, accumulate and process all data, and decode and execute the spacecraft commands. It consists of a closed loop sequencer which has a possible

1	2	3	4	5	6	7 A	8	9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24	25	26	27 B	28	29	30	31	32
33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
49	50	51	52	53	54	55	56	57	58	59 C	60	61	62	63	64
65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	F 91	92	93	94	95	96
97	98	99	100	101	102	103	104	105	106	107 D	108	109	110	111	112
113	114	115	116	117	118	119	120	121	122	E 123	124	125	126	127	128

TM A – INSTR/MODE/DATA FORMAT – WORD 7
TM B – RADIAL LM IMS – WORDS 25-29
TM C – RADIAL HM IMS – WORDS 57-61
TM D – Z IMS MULTIPLEXED – WORDS 105-109
TM E – Z IMS MULTIPLEXED – WORDS 121-125
TM F – RPA MULTIPLEXED – WORDS 89-93

Figure 10. DE-1 telemetry word with the RIMS telemetry assignments.

12 branches, making up to 19 decisions and executing from 40 to 60 timing commands each time around the loop. The sequencer starts the loop at the 64 pps mark. Figure 11 is a flow diagram of the master sequencer.

4.4 Data Accumulators

RIMS has three sensor heads with two IMS channels per head totaling six channels of IMS data as shown in Figure 12. The output of each channel pre-scalar (located in a head) is sent via shielded cable to their respective data accumulator. Each CEA accumulator is a 14-bit binary counter with an 18-bit holding register attached in parallel. The four pre-scalor bits are input in parallel directly from each sensor head channel. When the integration time has expired at the 64 pps pulse, the master sequencer stops the accumulator, transfers and latches all six channels of IMS data into their respective holding registers. When data processing is completed, the accumulators are reset and are free to begin a new accumulation.

4.5 Data Compression

The data compression circuitry consists of a 4-bit counter, an 18-bit shift register, a sequencer, and a 10-bit output buffer. The master sequencer serially shifts the contents of an accumulator holding register into the compression register. The compression sequencer is now commanded, by the master sequencer, to begin the data compression. The contents of the compression register are shifted to the right until the most significant bit (MSB) contains a '1' or until 11 shift pulses are counted.

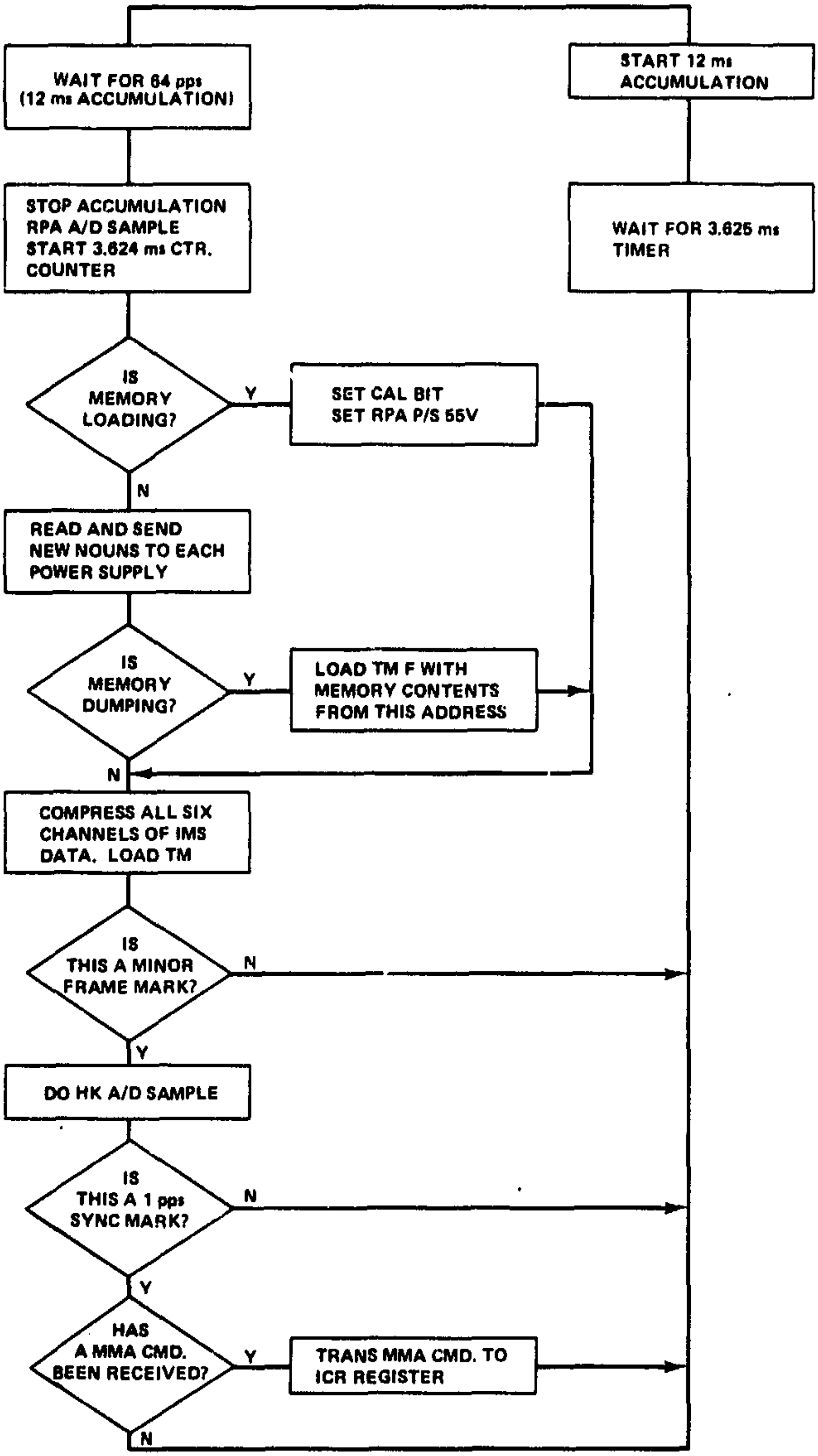


Figure 11. RIMS master sequencer simplified flow diagram.

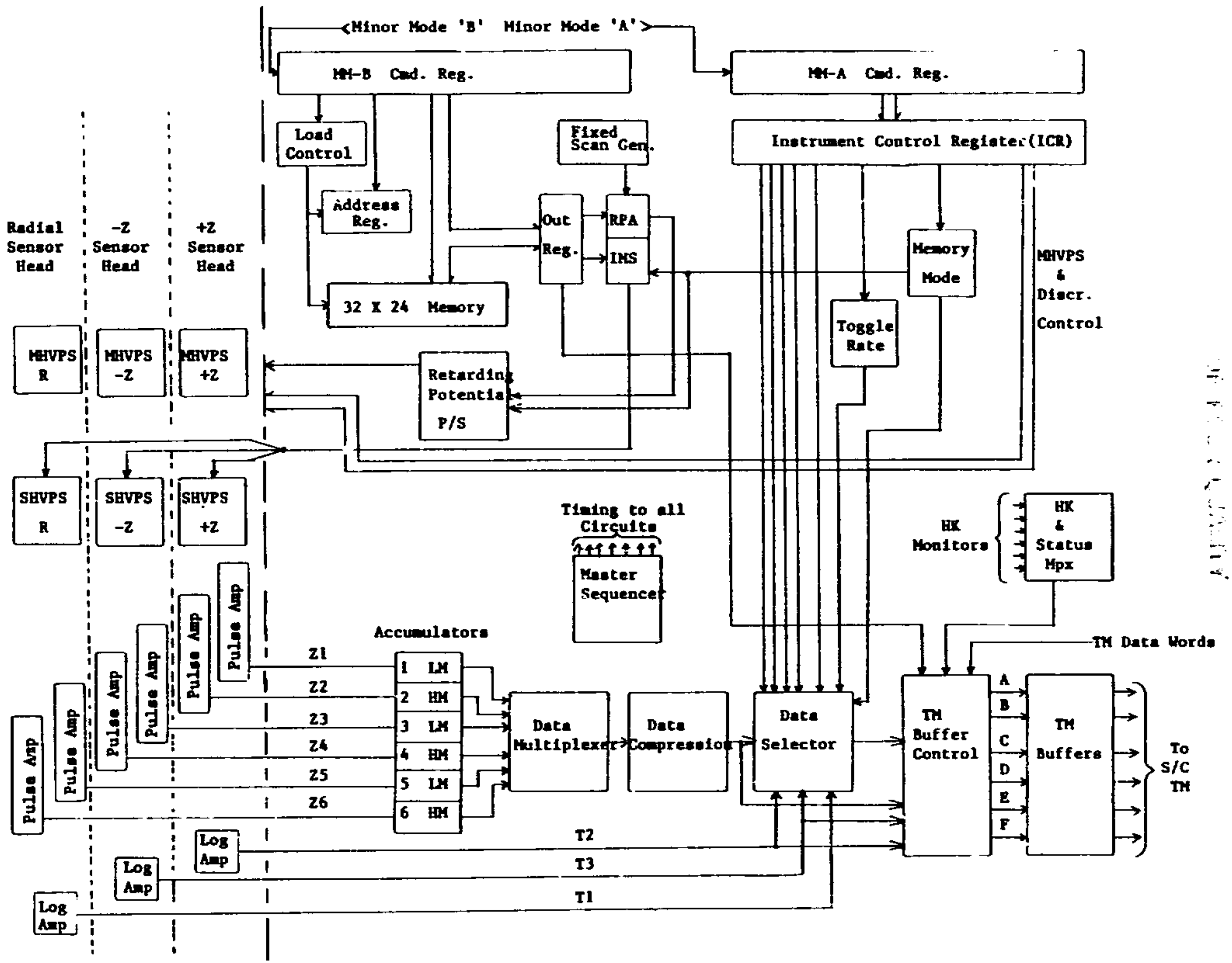


Figure 12. RIMS functional diagram.

a) IF the shift count is less than 11, the 6 bits after the MSB are parallel loaded into the 6 MSBs of the output buffer. The 4-bit shift count is then parallel loaded into the remaining 4 bits, with the MSB first.

b) IF the shift count is 11 and the MSB is a '1', the output buffer is loaded the same as (a).

c) IF the shift count is 11 and the MSB is a '0', then the shift counter is advanced by one making the shift count now 12. The output buffer is then loaded the same as (a).

The MSB of the compression register is never used in the output word. The decompression formula is therefore:

$$\text{If } S < 12, \text{ then num} = (D + 64) \times 2^{(11 - S)}$$

$$\text{If } S = 12, \text{ then num} = D$$

where

D is the 6 bits of data

S is the 4 bits shift count.

After the 10-bit compressed word is assembled in the output buffer the master sequencer is signaled that compression of this accumulator is finished. The master sequencer then serially shifts the contents of the output buffer through the data selector circuit into the appropriate telemetry buffer or into the bit bucket.

4.6 Data Selector

Each RIMS sensor head has three data outputs, the RPA and high and low mass IMS channels as shown in Figure 12. The RIMS sensors therefore output 9 measurements each 1/4 frame or 36 instrument words (10-bit words) per telemetry minor frame.

Since a telemetry channel (40 bits) can only contain 4 instrument words (10 bits), only 20 of the 36 (4 instrument words × 5 telemetry channels) instrument words may be loaded into the telemetry channels each telemetry frame. Table 2 provides a listing of telemetry word assignments.

4.6.1 Telemetry Channel Assignments

The RIMS instrument has 6 telemetry channels, A through F as shown in Figure 10. Channels A, B, and C are fixed and cannot be changed and are:

Channel A (telemetry word 7) Housekeeping and status

Channel B (telemetry words 25 through 29) Radial IMS low-mass channel

Channel C (telemetry words 57 through 61) Radial IMS high-mass channel

TABLE 2. TELEMETRY WORD ASSIGNMENTS

Sensor	Designation	Output Bits per 1/4 main frame	Output Bits per main frame	Telemetry Cnannel	Telemetry Words per main frame
Housekeeping/status	HS	–	8	A	1
Radial Low Mass	RL	10	40	B	5
Radial High Mass	RH	10	40	C	5
+Z Low Mass*	Z1	10	40	D	5
+Z High Mass*	Z2	10	40		
-Z Low Mass*	Z3	10	40	E	5
-Z High Mass*	Z4	10	40		
Radial RPA**	T1	10	40		
+Z RPA**	T2	10	40	F	5
-Z RPA**	T3	10	40		
					26

*Any two of these outputs are input into TM channels D and E.

**Any one of these outputs is input into TM channel F.

The Z sensor heads IMS outputs have been assigned Z numbers for convenience and clarity:

Z1 = +Z LM channel

Z2 = +Z HM channel

Z3 = -Z LM channel

Z4 = -Z HM channel

The three RPA outputs, radial, +Z, and -Z, have been assigned T numbers as follows:

T1 = Radial RPA

T2 = +Z RPA

T3 = -Z RPA

Telemetry channel D (telemetry words 105 through 109) and channel E (telemetry words 121 through 125) in Figure 10 are read by telemetry as separate channels, but they are loaded by the master sequencer as one 80-bit telemetry register when the instrument is in the IMS mode. Since the four Z IMS channels output data each 1/4 frame, 16 instrument words are available each minor frame. Since channels D and E can only hold 8 instrument words, only two of the four Z channels may be loaded each 1/4 frame. Selection of the two channels is made by minor mode 'A' command. Also within this command, an alternate pair of Z channels must be selected. The initial pair of Z channels is loaded into the telemetry register for a selected number of minor frames and then the alternate pair is loaded for the same number of minor frames. The possible output channels and their associated telemetry words are shown in Table 2.

The number of minor frames that each pair of Z heads output is controlled by the Toggle rate bits of the minor mode 'A' command. The toggle rate choices are 8, 4, 2, and 1 minor frames. Since 16 minor frames equal 1 sec, the settings are synchronized with the 1-pps pulse.

For example, if the initial pairs were Z1Z3 and the alternate pairs were Z2Z4 and the toggle rate was 8, then, starting with the first accumulation after the 1-pps pulse, Z1Z3 would be loaded into telemetry channels D and E for 8 minor frames then Z2Z4 would be loaded for 8 minor frames.

An RPA output is loaded into telemetry channel F. Three RPA data words are generated each 1/4 frame but telemetry channel F can hold only one of these words. Therefore the initial T output is selected by minor mode 'A' along with the alternate T selection. The toggle rate is also controlling the number of minor frames of initial T before switching to the alternate T output. Remember, minor mode 'A' commands are only loaded into the instrument control register at the 1-pps pulse.

The initial and alternate pair selection of the IMS data words is accomplished in the data selector circuitry. The six IMS data accumulators are stacked in the same order as the Z channel assignments, i.e., Z1 data is fed to accumulator 1, Z2 to accumulator 2, etc. Accumulator 5 contains the radial low-mass data and accumulator 6 contains the radial high-mass data. The data selector contains four gates assigned 1 through 4. Two of these gates are allowed to open by either the initial setting or the alternate setting. The output of these four gates is combined to form one of the input lines into the telemetry channel D and telemetry channel E buffers.

The master sequencer compression routine transfers each accumulator, in order, into the data compression register and upon completion of the compression, tries to open the appropriate gate to transfer the output buffer contents into the telemetry buffer. When a selected Z value matches the accumulator number the gate will open and the data word is loaded into the telemetry buffer. Accumulator 5 is always loaded into telemetry channel B and accumulator 6 is always loaded into telemetry channel C.

The RPA data initial and alternate selection is done by opening one of three gates, one for each sensor head. The master sequencer serially shifts all three RPA data words simultaneously to these gates. One of these words will pass through the open gate into the telemetry channel F buffer.

4.6.2 Instrument Modes

The five major hardware modes into which the RIMS can be commanded and their hierarchy are given in Table 3. The following paragraphs define the contents of each telemetry channel for the instrument modes.

TABLE 3. RIMS HARDWARE MODE HIERARCHY

Mode	Channel B	Channel C	Channel D	Channel E	Channel F
1. Memory Load	CAL	CAL	CAL	CAL	BKG
2. Memory Dump					
(IMS Mode)	RLM	RHM	Z PAIRS[a]	Z PAIRS[a]	MEMORY
(RPA Mode)	RLM	RHM	T2[b]	T3[b]	MEMORY
3. RPA	RLM	RHM	T2[b]	T3[b]	T1[b]
4. Cyclic	RLM	RHM	Z PAIRS[b]	Z PAIRS[b]	T[b]
5. IMS	RLM	RHM	Z PAIRS[a]	Z PAIRS[a]	T[a]

CAL – Calibration

BKG – Background

a – Programmable by minor mode

b – Fixed

4.6.2.1 Memory Load Mode

The RIMS internal memory can only be loaded by minor mode 'B' commands. When the first minor mode 'B' command is received, the control bit "ML" is set. The master sequencer then sets the internal 'calibrate bit' which sends the retarding potential power supply to 55 V and switches the internal timing clock into the pre-amps as calibrate pulses. These pulses are counted and processed as data pulses thereby checking the data processing circuitry from end-to-end on all IMS channels. The RPA output should read only background counts while the 55 V retarding potential is applied to the retarding grid.

4.6.2.2 Memory Dump Mode

When the memory dump command is received, starting at the next 1-pps pulse, telemetry channel F will contain the contents of memory address 0 as shown in Figure 13. This will occur regardless of which mode, IMS, RPA, or Fixed Scan, the instrument is in. During a memory dump, memory is read each 1/4 frame but the address is incremented by the master sequencer only at the minor frame mark. Memory contains 32 nouns, therefore it will take exactly 2 sec (32 × 0.0625) for memory to dump. The 1-pps memory address reset does not occur during a memory dump. An automatic memory dump occurs every 256 sec.

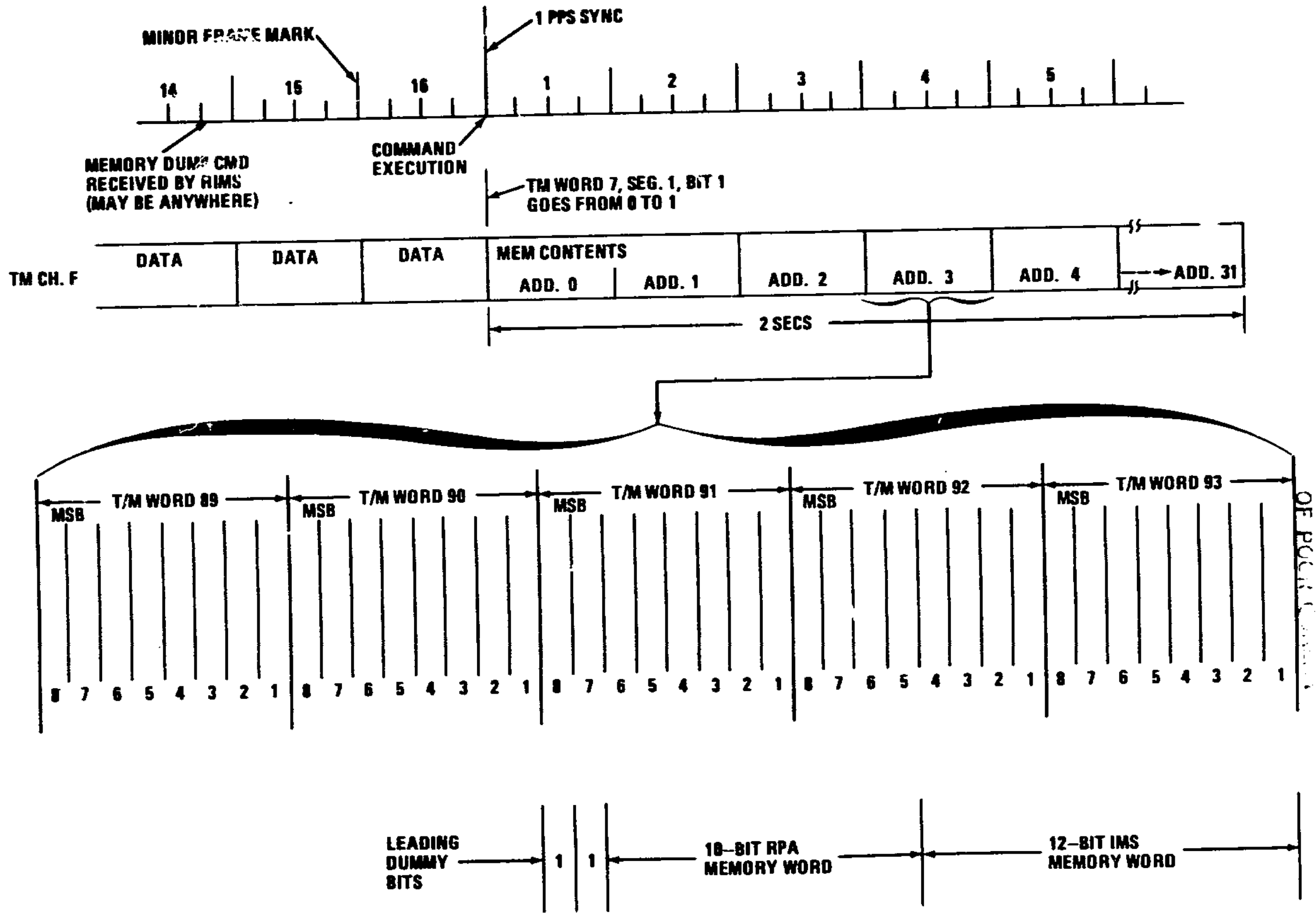


Figure 13. RIMS memory dump format and memory addresses versus data accumulation.

4.6.2.3 RPA Mode

This mode is set by a bit in the minor mode 'A' command word. The data from the +Z and -Z IMS channels are not loaded into the telemetry buffer. Telemetry channel D is loaded with the +Z RPA data, telemetry channel E is loaded with the -Z RPA data, and telemetry channel F is loaded with the radial RPA data. The initial and alternate setting and the toggle rate have no effect.

4.6.2.4 Cyclic Mode

The cyclic mode is set by the initial T bits of the minor mode 'A' command. This mode commands the instrument to cycle through the three heads and load fixed sets of data into the telemetry buffers. Starting with the first integration period after the 1-pps pulse, T1 data is loaded into telemetry channel F and Z1 and Z3 data is loaded into telemetry channels D and E; then T2 is loaded into telemetry channel F and Z1 and Z2 into telemetry channels D and E; then T3 is loaded into telemetry channel F and Z3 and Z4 into telemetry channels D and E. This cycle repeats as long as this mode is in effect. The cycle speed is controlled by the toggle rate. If the toggle rate is 4, then T1-Z1Z3 are loaded for four minor frames than T2-Z1Z2 are loaded for four minor frames, etc. When this mode is in effect, minor frame 1 and T1 data only synchronize together every 3 sec, regardless of the toggle rate. Note: You must be able to determine by status flags (telemetry word 7) when this mode begins due to the 3 sec synchronization with minor frame 1.

4.6.2.5 IMS Mode

This is the normal operating mode for the RIMS. Telemetry channels B and C contain the radial IMS data channels. Telemetry channels D and E contain the selected pairs of +Z and -Z data channels and telemetry channel F contains one of the RPA outputs from either of the three heads. This is the turn-on mode for the RIMS. Figure 14 shows the complete turn-on default configuration.

4.7 Housekeeping and Status Multiplexer

The housekeeping and status multiplexer consists of a 16-channel multiplexer, a 4-bit counter, a 2X amplifier, an A/D converter, and associated circuitry to parallel input the status information from the instrument as shown in Figure 15. The counter is synchronized to the 1-pps pulse and is incremented by the minor frame mark (16 pps). The first four positions of the multiplexer contain 32 bits of status information which are parallel loaded 8 bits per word into the telemetry channel A output buffer. Positions 5 through 15 contain the monitors for the instrument. As the multiplexer counter is advanced by 1, a 0 to +5 V analog monitor is input into the 2X amplifier. The output of this amplifier is a 0 to 10 V monitor signal that is then converted by the 12-bit A/D converter. The 8 MSBs are serially loaded into the telemetry channel A output buffer. Position 16 is a spare and will always read 0.

4.8 Memory

The RIMS instrument contains an in-flight memory which can be programmed. The random access memory (RAM) is configured as 32 words of 24 bits each. A word consists of a 10-bit retarding potential power supply address (RPA noun), a 2-bit separator, and a 12-bit IMS sweep power supply address (IMS noun).

32 31 30	29 28 27	26 25	24 23	22 21	20 19	18	17 16	15 14 13 12	11	10	9	8	7	6 5	4 3	2 1
INITIAL PAIR	ALTERNATE PAIR	INIT. HEAD	ALT. HEAD	TOGGLE RATE	APERT. POTENT.	RPA	MEMORY MODE	SPARES	LEV.	INH	R	+Z	−Z	R	+Z	−Z
Z OUTPUT CHANNEL SELECT		T OUTPUT CHANNEL SELECT							RADIAL OVER-CURRENT		DISC. THRESHOLD CONTROL			MULTIPLIER HV CONTROL		

TM D & E SELECT CODE

INITIAL	(32,31,30)	ALTERNATE	(29,28,27)
*Z1Z3	000	*Z2Z4	000
Z1Z2	001	Z1Z2	001
Z1Z4	010	Z1Z4	010
Z2Z3	011	Z2Z3	011
Z2Z4	100	Z1Z3	100
Z3Z4	101	Z3Z4	101
Z1Z3	110	Z2Z4	110
Z1Z3	111	Z2Z4	111

Z1=+ZLM Z2=+ZHM Z3=−ZLM Z4=−ZHM

TM F SELECT CODE

INITIAL	(26,25)	ALTERNATE	(24,23)
*T1 (R)	00	*T1	00
T2 (+Z)	01	T2	01
T3 (-Z)	10	T3	10
CYCLIC	11	T1	11

MULTIPLIER HV CONTROL

	R (6,5)	+Z (4,3)	−Z (2,1)
*−2100V	00	00	00
−2400V	01	01	01
−2800V	10	10	10
−1200V	11	11	11

TOGGLE RATE (MINOR FRAMES)

	(22,21)
*8	00
4	01
2	10
1	11

APERTURE POTENTIAL

	(20,19)
*0	00
-2	01
-4	10
-8	11

MEMORY MODE

(17,16)	
00	*FULL MEMORY
10	RPA(MEM) IMS(1975V)
01	IMS(MEM) RPA(0V)
11	ALTERNATE(8sec 00, 8 sec 10)

RADIAL OVER CURRENT

(10,11)	
00	*ROC ON – LO LEVEL
01	ROC ON – HI LEVEL
10	ROC OFF – LO LEVEL
11	ROC OFF – HI LEVEL

DISCRIMINATOR CONTROL

	R (9)	+Z (8)	−Z (7)
*DISC LO	0	0	0
DISC HI	1	1	1

DATA MODE

(18)	
0	*IMS MODE (TOGGLING, TM D & E = Z IMS DATA)
1	RPA MODE (NO TOGGLING, TM F=T1, TM D=T2, TM E=T3)

*INDICATES TURN ON DEFAULT SELECTION

Figure 14. Minor mode 'A' command word.

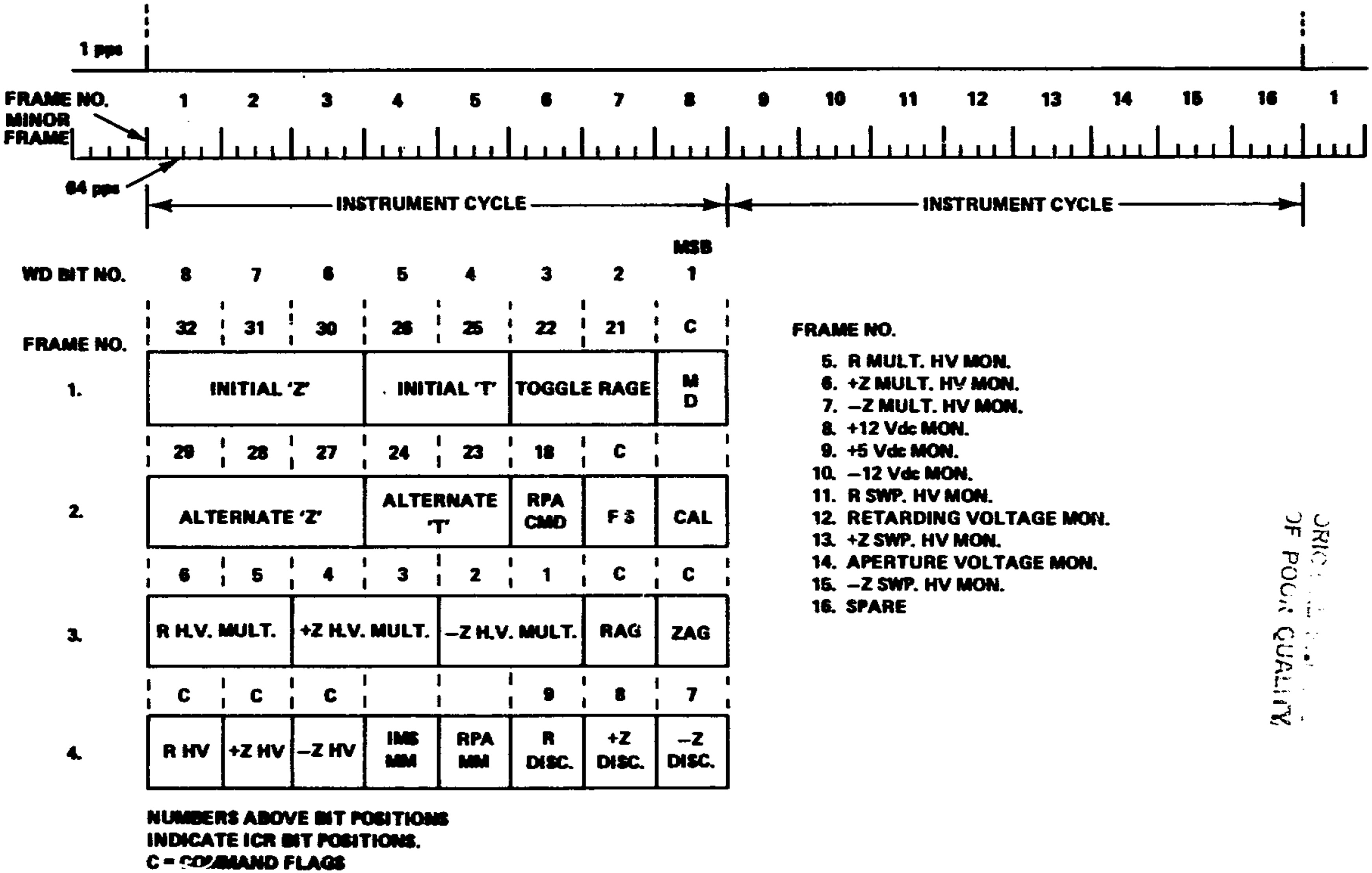


Figure 15. Telemetry word 7 multiplier position assignments.

The RIMS memory can only be loaded by the minor mode 'B' command from the spacecraft. The minor mode 'B' command is a 32-bit serial word that contains four basic pieces of command data (1) the memory dump bit, (2) the memory load clear bit, (3) the memory address (5 bits), and (4) the nouns to be loaded into memory (24 bits) as shown in Figure 16.

The leading edge of the minor mode 'B' command envelope sets a memory load bit indicating to the master sequencer that loading of memory has begun and addressing or reading of memory is not to be executed by the master sequencer until this bit is cleared.

The trailing edge of the envelope sets the start bit of the memory write sequencer. This sequencer transfers the address portion of the command into the address register, closes the tri-state switches presenting the nouns to memory input, and then the proper write pulses to write into memory.

If bit No. 31, the 'memory load clear' bit, shown in Figure 16 is set to a '1' the 'ML' bit is then cleared after the write cycle and memory is again available to the master sequencer. If bit 31 is a '0' then the 'memory write sequencer' waits for the next command word. Thirty-two minor mode 'B' command words are required to completely load memory.

If bit 32, 'memory dump request,' is also a '1' when bit 31 is a '1', then memory loading stops and a memory dump begins at the next 1-pps pulse (Fig. 16).

When the master sequencer detects that the memory load bit is a '1', it also sets the 'CAL' bit which commands the retarding potential power supply to 55 V preventing ions from entering the IMS, and allows the calibrate pulses to enter the front end of the pulse amplifiers on all three sensor heads. The calibrate output should read 1850 to 1950 counts per integration.

An auto reset counter is started when the memory load bit is first set. This counter counts minor frame mark pulses and if the count reaches 32 before the memory load bit is cleared, the memory load bit is automatically cleared. If memory is still being loaded by command, the next command envelope will set the memory load bit back to a '1' and the counter will restart from '0'. This counter prevents instrument hangup in CAL mode (memory loading) if the last command word does not contain a '1' in bit 31 (memory load clear). Any number of minor mode 'B' commands may be sent. However, the last command should contain a '1' in bit 31 to clear the memory load bit allowing the master sequencer to again access the memory.

The minor mode command clock is asynchronous to all other clocks. This simply means that a command word may be received anytime. However, the master sequencer is controlling when memory is accessed and when the calibrate pulses are input, therefore, memory access will begin at the next 64-pps pulse (1/4 frame mark) after memory load clears. Memory address will not be synchronized until the next 1-pps pulse.

4.9 Memory Mode

The memory mode is controlled by the 2 bits in the minor mode 'A' command as shown in Figure 14. The RIMS memory contains an IMS noun (sweep address) and a RPA noun (retarding potential address) at any one of 32 addresses within the memory. In all memory modes, both nouns are read from the memory address of the

32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
MDR	MLC	SPARE	MEM ADDRESS					RPA NOUN										SPARE	SPARE	IMS NOUN											

MDR – MEMORY DUMP REQUESTED. SETS 'MEMORY DUMP' CONTROL BIT IF MLC = 1.
MLC – MEMORY LOAD CLEAR. CLEARS 'MEMORY LOADING' CONTROL BIT.

NOTE: A MAJOR MODE 'MEMORY DUMP' WILL BE TERMINATED UPON RECEIPT OF A MINOR MODE 'B' COMMAND. IF THE CMD 'B' CONTAINS AN MDR AND MLC, THEN A MEMORY DUMP WILL RESTART FROM THE BEGINNING.

MDR	MLC	RESULT	MD	ML
1	1	LAST CMD. BEGIN MEM DUMP	1	0
0	1	LAST CMD. NO MEM DUMP	0	0
X	0	MEMORY LOADING	0	1
* X	0	MEM DUMP (MAJOR MODE)	1	1

X = DON'T CARE

* MEMORY DUMP WILL NOT START UNTIL MEMORY LOADING HAS STOPPED.

Figure 16. Minor mode 'B' command word.

address register into their respective buffers. If the memory mode is NORMAL, both nouns are simultaneously sent to their respective power supplies. If the mode is IMS, the IMS noun is sent to the sweep power supplies in the sensor heads but the RPA noun is not sent to the retarding potential power supply. Instead, an all zeros noun is sent ('0' V retarding potential). If the memory mode is RPA, the RPA noun is sent normally but the IMS sweep power supplies are commanded to go to the fixed scan position of mass 1 and 4 (1975 V) on the low and high mass multipliers of all three heads. If the memory mode is ALTERNATE, the RPA noun is always sent normally. The IMS noun is sent for 8 sec then the sweep supplies are commanded to the mass 1 and 4 position (1975 V) for 8 sec. This cycle continues while in this mode. The 8 sec memory mode time is not synchronized to the spacecraft 8 sec major frame. The 8 sec cycle time within the CEA starts at power ON and runs continuously and is not reset to '1' upon receipt of the mode command. The first half cycle will be short as shown in Figure 17.

Status bits and HK monitors indicate which 8 sec cycle is in effect for any 1 sec data block. Toggle rates are in effect in all memory modes.

4.10 Fixed Scan Generator

The fixed scan generator is included in case the instrument memory is lost. This circuit consists of a 10-bit counter with associated gating to generate a 32-step 4 piece linear, exponential ramp. The output of each bit is parallel loaded into the RPA scan output register to be sent serially to the retarding potential power supply instead of the memory noun. The ramp is generated by switching the counter input to different stages at certain counts, and consists of 1 step at 0 V, 13 steps of 0.15 V, 6 steps of 0.6 V, 5 steps of 2.4 V, and 7 steps of 4.8 V.

The IMS sweep power supplies are commanded to the masses 4 and 1 (1975 V) position during fixed scan mode. The fixed scan mode will stay in effect until a minor mode 'B' is received by the instrument or until the instrument power is turned off.

4.11 Standby Memory Power

The spacecraft provides +5 Vdc standby memory power. This 5 Vdc is diode (ed) with the +5 Vdc from the instrument low voltage power supply to form a power line to the RIMS memory. The standby memory power is independent of the RIMS instrument power and is turned ON/OFF by a separate power ON command. The purpose of this memory power is to provide a low power mode of operation to conserve spacecraft power and to minimize the up linking of memory loads.

When the RIMS instrument power ON command is received the instrument begins operating using the contents of memory. The memory contents have been saved by keeping the memory alive through the standby memory power. Orbit operations have shown that this mode of operation is unreliable because the memory has been observed to change following an instrument power ON/OFF/ON sequence. Therefore, the most acceptable mode of continuous memory is to keep the instrument power on. Otherwise, it is necessary to uplink a new memory load sequence.

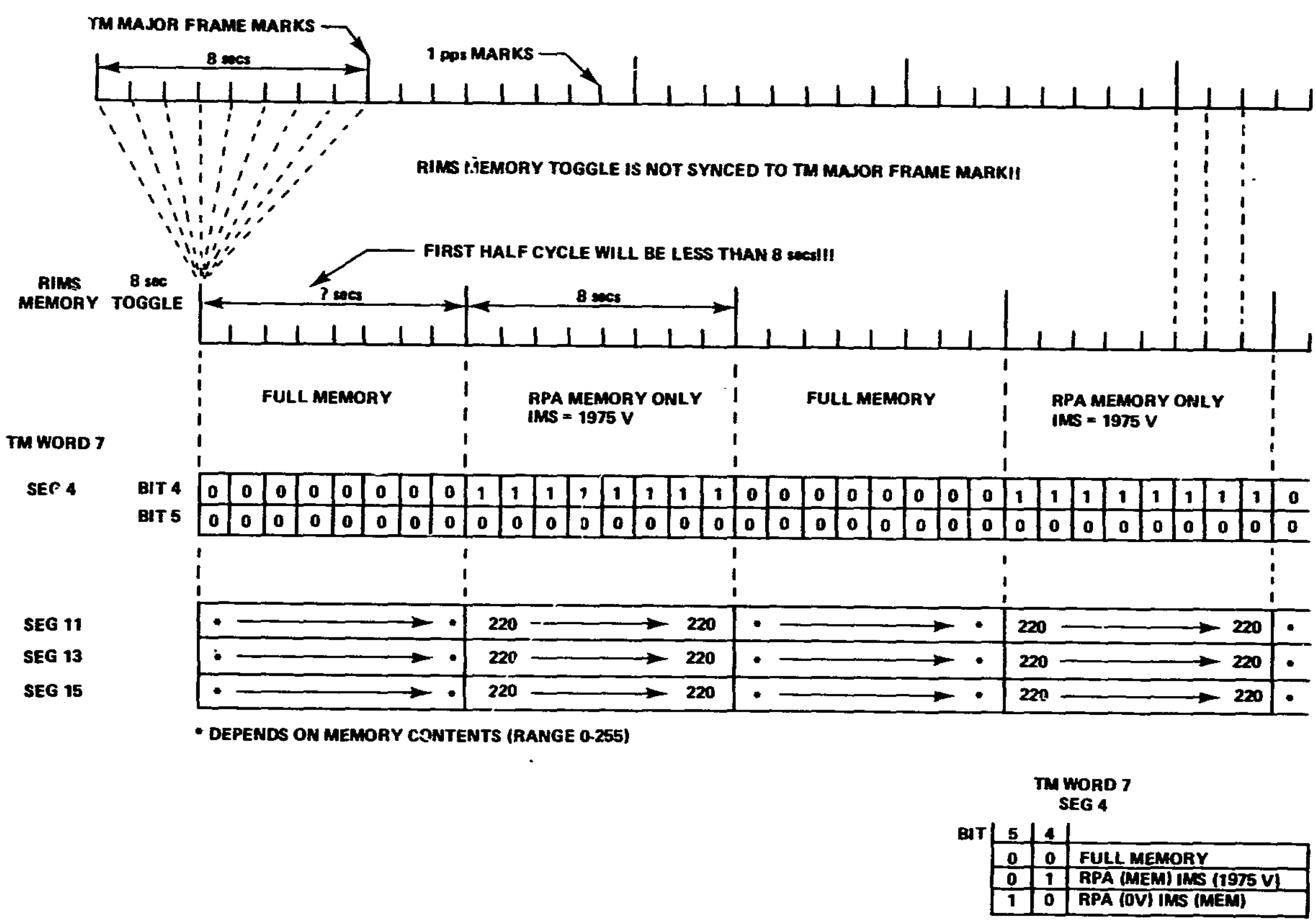


Figure 17. RIMS memory toggle format.

4.12 Memory Dump

When the memory dump command is received, beginning at the next 1-pps pulse, telemetry channel F will contain the contents of memory address 0 (Fig. 13). This will occur regardless of which mode, IMS, RPA, or fixed scan, the instrument is in. During a memory dump, memory is read each 1/4 frame but the address is incremented by the master sequencer only at the minor frame mark. Memory contains 32 nouns, therefore, it will take exactly 2 sec (32×0.0625) for memory dump. The 1 pps memory address reset does not occur during a memory dump. An automatic memory dump occurs every 256 sec.

4.13 Instrument Control Register

The ICR is a 32-bit register which controls the configuration of the instrument circuits and operating modes. This register is loaded from the minor mode 'A' command register by the master sequencer.

At the 1-pps pulse, the master sequencer checks the minor mode 'A' control bit to see if a new ICR word has been received. If the control bit is a '1', the master sequencer parallel transfers the contents of the command register into the ICR. The bit assignments and function of each bit are shown in Figure 14. Since the ICR is only updated at the 1-pps pulse, the status words in telemetry word 7 are always current with the ICR contents. The ICR is initially loaded with all zeros at power ON.

4.14 Over Current Protection

The log amp current in each of the three heads is used to reduce the voltage to the CEMs when certain limits are exceeded. Once the protection is activated, the current is tested every 9 sec to determine if the CEM voltage can be returned to normal.

4.14.1 Radial Over Current

Bit 10 of the minor mode 'A' command is used to turn the radial over current protection on or off. Bit 11 is used to command the protection circuit into one of two sensing levels. If bit 11 is '0' and the radial log amp senses a collector current greater than 10^{-10} A, the radial multiplier high-voltage power supply is commanded to the -1200 V step. This step is held until 9 sec after the log amp current drops below 10^{-10} A. The multiplier high voltage is then released to return to its original setting (-1200, -2100, -2400, or -2800 V). If bit 11 is a '1' then the log amp current must be greater than 10^{-9} A before the radial multiplier high-voltage power supply is reduced to -1200 V.

During on-orbit operations there is an unidentified spacecraft noise source which activates the over current protect circuit when operating in the most sensitive mode. The instrument is operated so that the log amp current must be greater than 10^{-9} A to activate the protect circuit.

4.14.2 ±Z Over Current

The ±Z over current protection is always in the protect mode and is pre-set to 5×10^{-9} A. The CEM high voltage is the same as for the radial sensor.

5.0 TEST AND CALIBRATION

The RIMS protoflight instrument underwent all environmental test specified by the DE project.

The RIMS calibration activities were conducted in three increments: an initial calibration in the Marshall Space Flight Center (MSFC) facility, a comparative calibration in the University of Bern plasma facility [1], and a final calibration using the flight multipliers in the MSFC facility. The goal of these three tests was the determination of the instrument mass resolution, the angular response, and the absolute sensitivity. Only the final calibration results will be given in this report.

5.1 Environmental Test Program

The DE-RIMS protoflight instrument underwent test at The University of Texas at Dallas (UTD), MSFC, Goddard Space Flight Center (GSFC), and RCA-Astro-Electronics during the process of becoming Flight Qualified for the DE-1 spacecraft. The test program fulfilled the requirements of the Dynamics Explorer Environmental Testing Specification GSFC-DE-400-001-A.

5.1.1 Test Sequence

The DE-RIMS Protoflight instrument successfully completed the sequence of tests given in Table 4. Test reports and data have been filed with the DE Project Office and the results will not be discussed in this report.

TABLE 4. RIMS TEST SEQUENCE

Test Name	Date
A) Electrical Interface Tests	11-28-79
B) Weight, Center of Gravity, and Mechanical Interface Checks	1-15-80 12-14-79
C) Electromagnetic Compatibility	12-11-79 6-16-80
D) Vibration	12-14-79 1-15-80
E) Pyroshock	1-15-80
F) Acceleration	1-15-80
G) Magnetics	12-15-79
H) Thermal Vacuum	1-25-80

5.2 Calibration

The calibration of the RIMS/DE instrument was divided into three areas. These were the angular calibration to determine the angular sensitivity and the solid angle response, absolute calibration to determine the effective areas of the instrument, and mass sweeps to determine the location and width of the mass peaks.

The calibration apparatus is sketched in Figure 18. The ion gun furnished a stable beam of low-energy ions with a beam diameter sufficiently large to illuminate the entire entrance aperture of RIMS. A manifold external to the chamber allowed controlled leak rates for the gases hydrogen, helium, and nitrogen (air). Ion beam currents were measured by a Faraday cup mounted on a swing arm which could position the cup directly over the RIMS entrance aperture for a measurement. The RIMS instrument was mounted on a tilting fixture which allowed the axis of rotation to be fixed at any azimuth. In this way the RIMS was essentially moved in a polar coordinate system (θ, ϕ) with a scan around the axis of rotation equivalent to a scan in θ and a rotation of the fixture equivalent to a scan in ϕ.

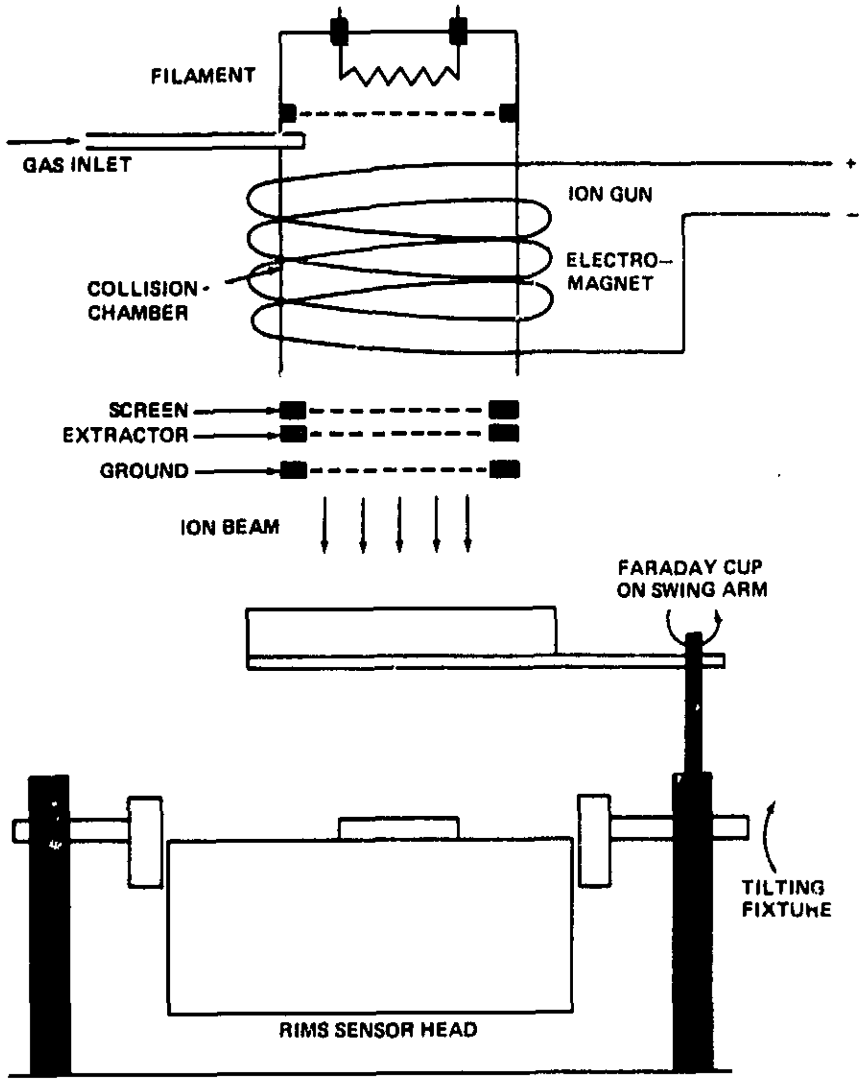


Figure 18. A sketch of the apparatus used in the calibration showing the ion source, Faraday cup, and RIMS mounted in the tilting fixture.

5.2.1 Angular Calibration

Angular calibrations were done at fixed beam energies of 5, 10, and 30 eV for the masses 1, 2, and 4 in the low-mass channel and masses 4, 16, and 32 in the high-mass channel. Values of ϕ were set in 30-deg increments ranging from ϕ = 0 to ϕ = 150 deg. For each value of ϕ, θ was stepped in 5-deg increments between θ = -60 deg to θ = +60 deg. The entire data set was therefore equivalent to ϕ = 0 to 330 deg in 30-deg increments and θ = 0 to ±60 deg in 5-deg increments, for a total of 150 points in space for each of 3 energies and 6 masses.

The angular scan data were transferred to punched cards and were plotted using a contour plotting routine. Plots were made both of the raw data with $\Delta\phi$ = 30 deg and smoothed data with $\Delta\phi$ = 5 deg. Figures 19 and 20 show examples of these plots for the radial sensor head at m = 2 and E = 10 eV. To compute the solid angle Ω, a numerical evaluation was made of the integral:

$$\Omega = \int R_1(\theta,\phi) \sin\theta \, d\theta \, d\phi$$

where $R_1(\theta,\phi)$ is the response function normalized to unity.

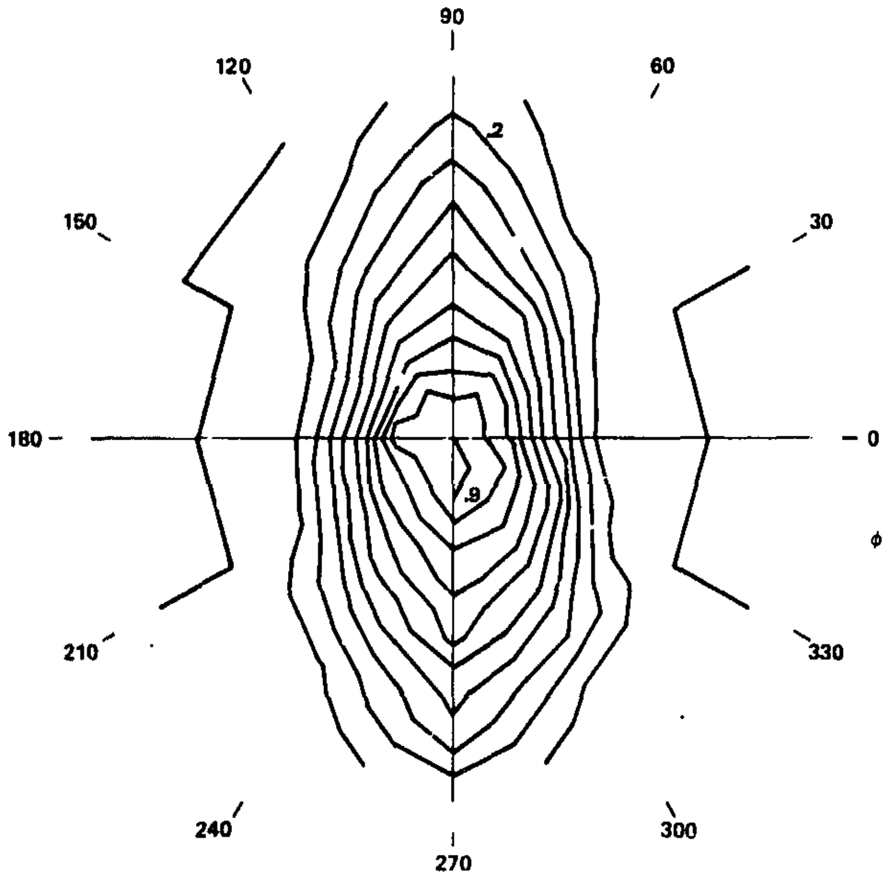


Figure 19. Contour plot of raw data showing the angular response of the RIMS radial heat at 10 eV for mass 2. Values of ϕ were incremented in 30 deg steps from 0 deg to 150 deg. For each value of ϕ, θ was stepped in 5 deg increments from -60 deg to +60 deg. The geometric factor was computed to be 0.70454.

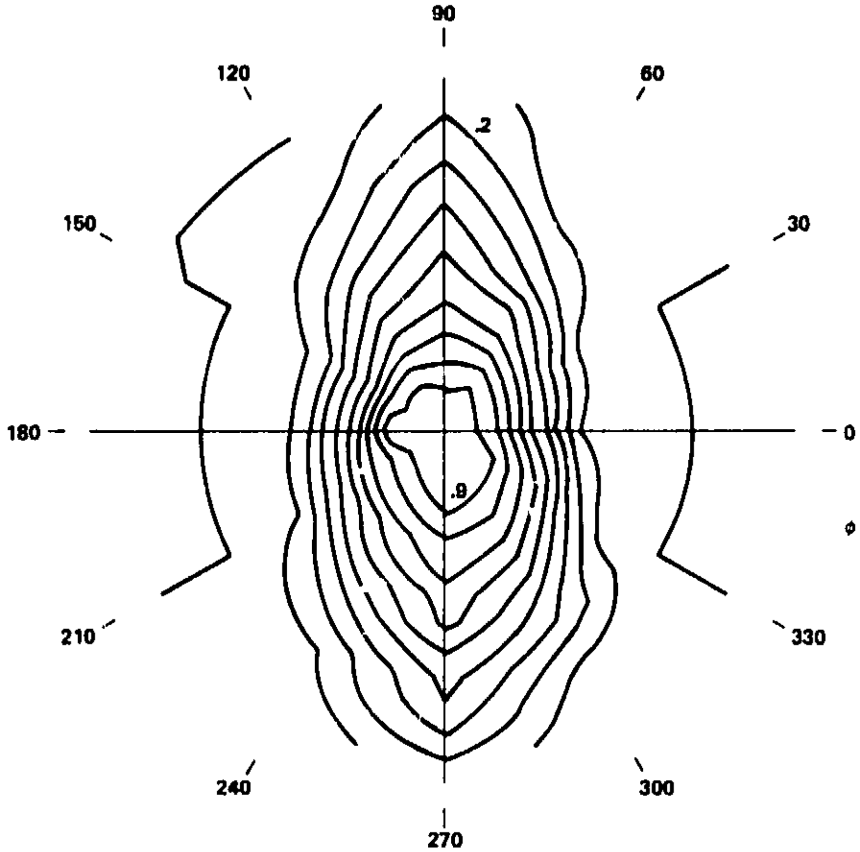


Figure 20. Contour plot of smoothed data showing the angular response of the RIMS radial head at 10 eV for mass 2. Values of ϕ were incremented in 5 deg steps in the computer program from 0 deg to 150 deg. For each value of ϕ, θ was stepped in 5 deg increments from -60 deg to +60 deg.

Figures 21, 22, and 23 show plots of Ω as a function of mass and energy for the three sensor heads. It is seen that the +Z and -Z heads have similar responses, while Ω for the R head is less due to the external collimator added to that sensor head. The value of Ω at E = 0 for the +Z and -Z heads was computed based on the input grid geometry according to:

$$\Omega = \int_0^{2\pi} \int_0^{\theta_0 = 55^\circ} \cos\theta \sin\theta \, d\theta \, d\phi = 2.1 \text{ STER}$$

The value of Ω at E = 0 for the R head was obtained by extrapolation to be

$$\Omega_R = 0.85 \text{ STER}$$

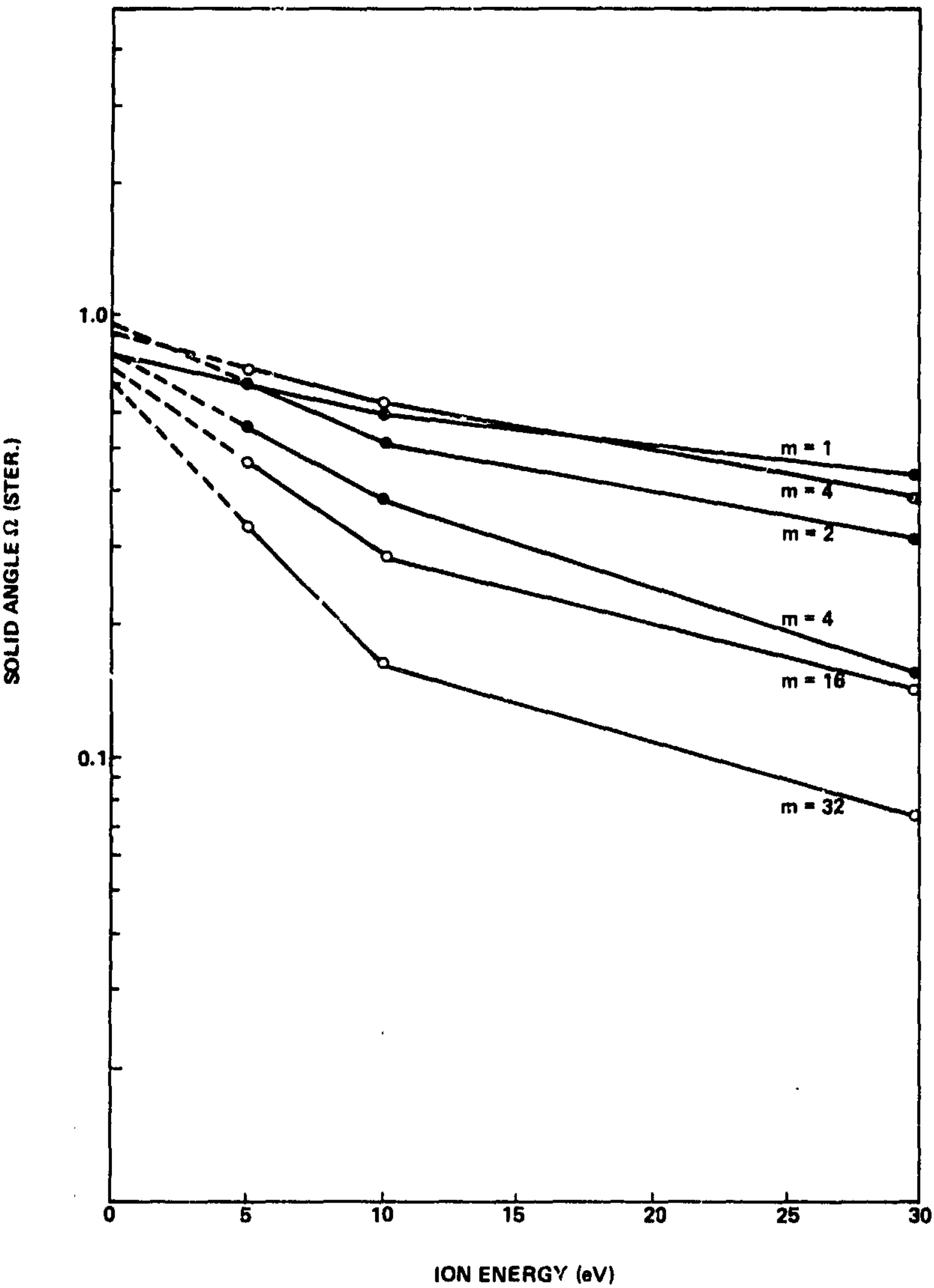


Figure 21. Calculated solid angle of the RIMS radial sensor head as a function of energy.

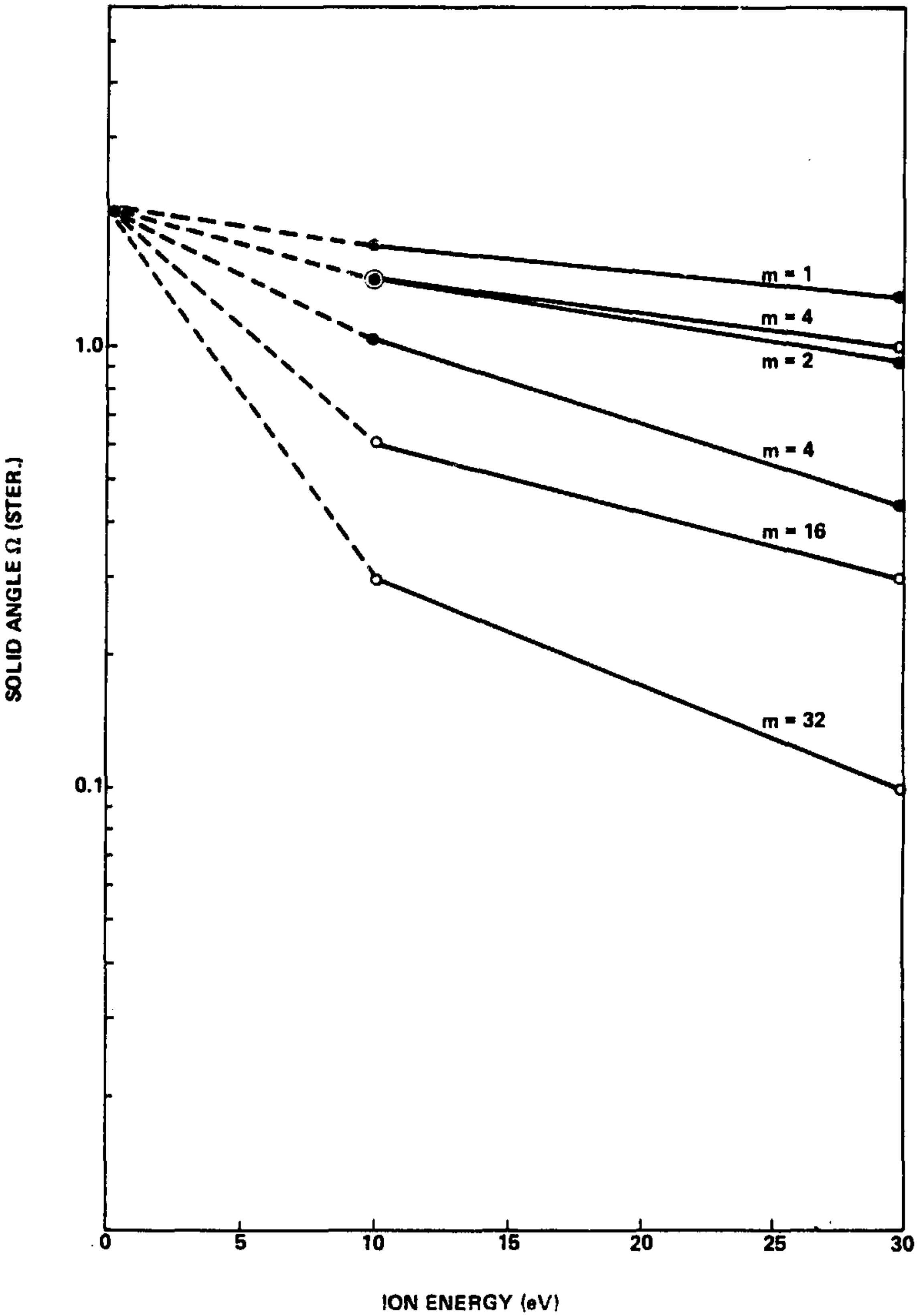


Figure 22. Calculated solid angle of the RIMS +Z sensor head as a function of energy.

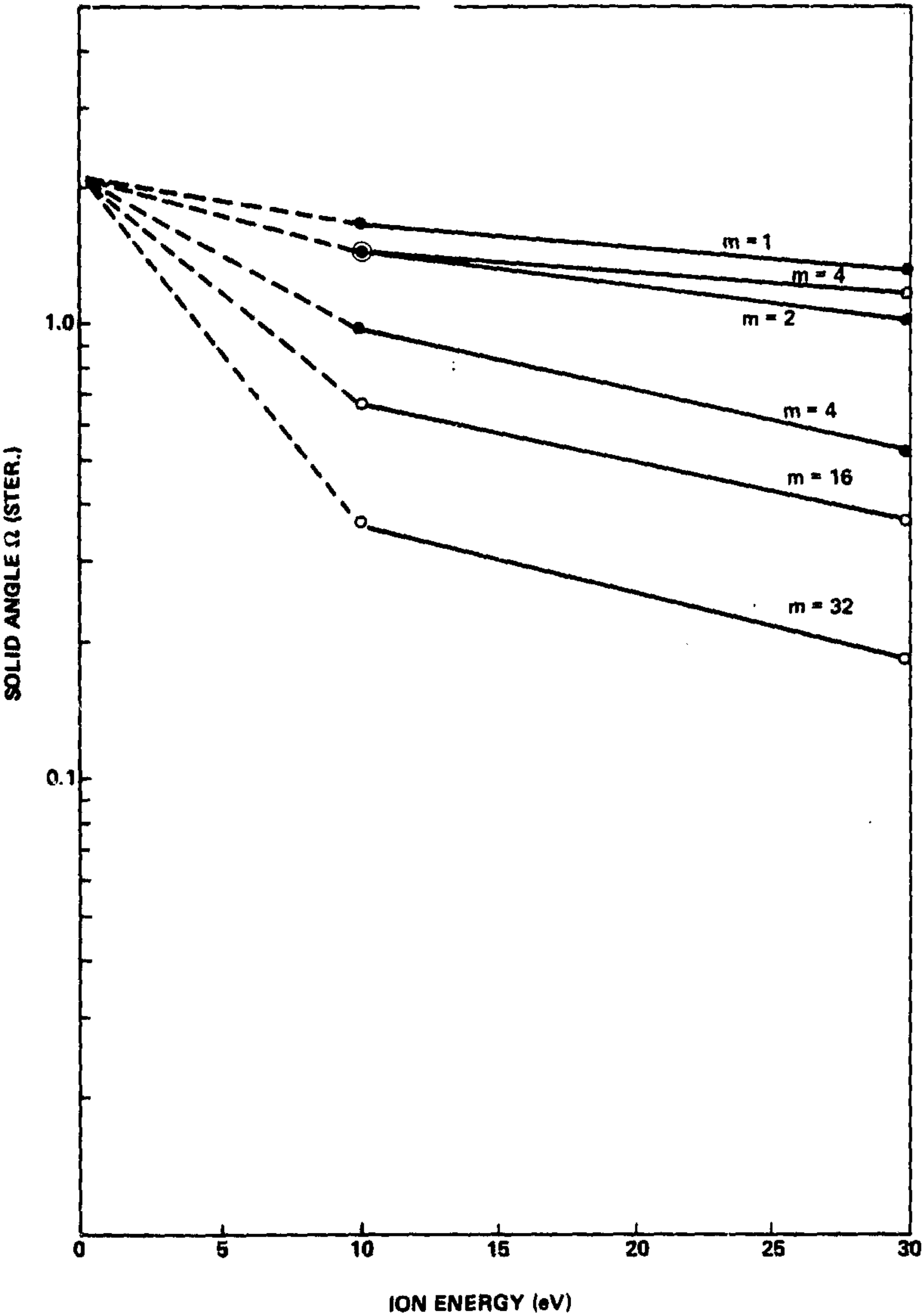


Figure 23. Calculated solid angle of the RIMS -Z sensor head as a function of energy.

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5.2.2 Absolute Calibration

The total ion current was measured by the Faraday cup immediately before and after a mass sweep. An example of a mass sweep is plotted in Figure 24. The top panels are data from the high-mass channel and the bottom panels the low-mass channel. The mass numbers for the peaks are indicated. Under the assumption that the RIMS mass sweep detects all ion species present in the beam, the effective area A_e of the RIMS is related to the input flux by the equation:

$$\Sigma_i \, CR_i = A_e \, F$$

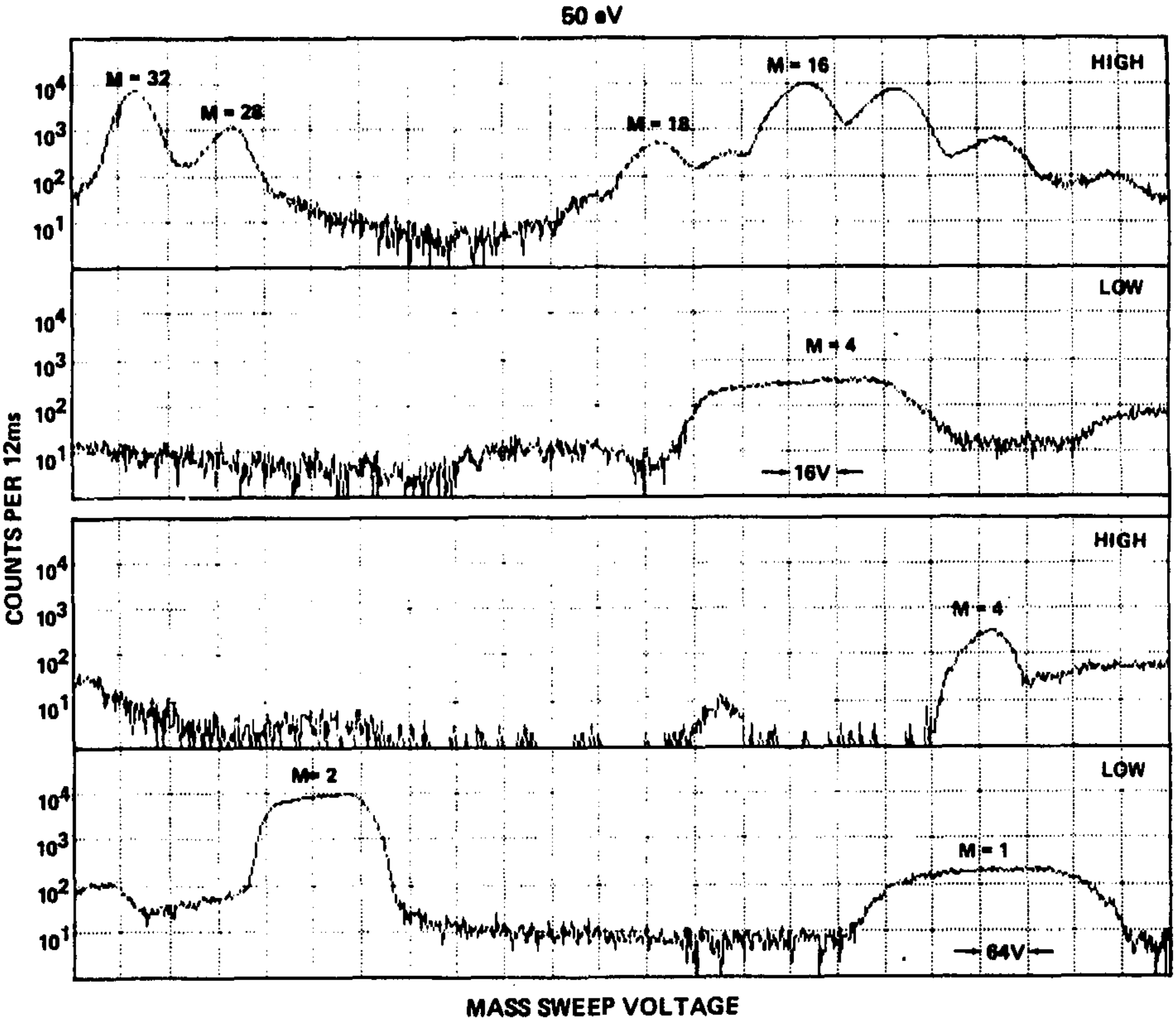

Figure 24. A complete mass spectrum measured in the MSFC calibration facility showing a sweep of the low mass (1 to 8 amu) and high mass (4 to 32 amu) channels.

where CR_i is the counting rate due to the ith ion species, and F is the input ion flux in units of ions/cm^2. The input flux F is computed from the Faraday cup current I_c according to:

$$F = \frac{I_c}{q \times A_c \times T}$$

where $q = 1.602 \times 10^{-19}$, A_c is the area of the Faraday cup ($A_c = \pi$ cm^2), and T is the combined transmission of two grids ($T = 0.81$). The mass sweeps at E = 30 eV and E = 10 eV for each head were used to compute effective areas. Calculated effective areas were in the range of 1.39×10^{-2} cm^2 to 3.29×10^{-2} cm^2. Figure 25 shows a plot of the calculated effective areas as a function of the Faraday cup current, showing a clear trend to larger values as the current decreases. This trend could possibly be caused by an offset in the measured cup current from high-energy electrons generated in the ion pumps. This would decrease the apparent ion current for the smaller values of ion current, thus making the calculated effective areas larger.

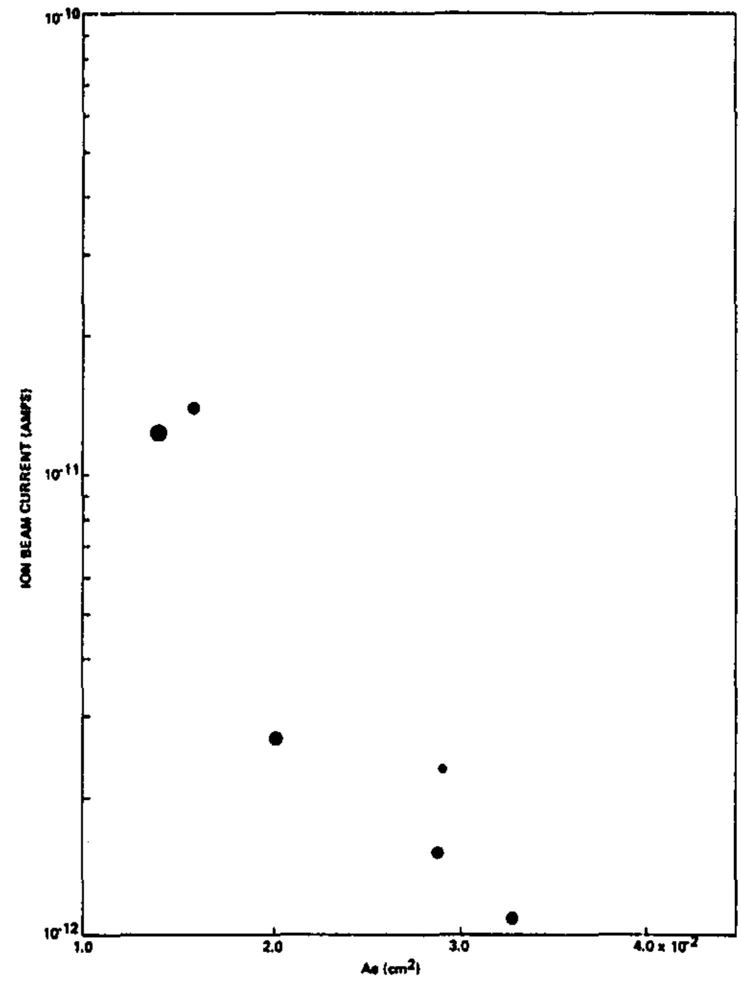

Figure 25. Calculated effective areas of the RIMS sensor heads as a function of the Faraday cup current.

The theoretical value of the effective area can be calculated by consideration of of the instrument geometry. The entrance slit has an area of 0.1 cm^2. The grid assembly contains a total of 6 grids with a combined transmission of $T = 0.478$. If we assume a channeltron efficiency of 0.7 (based on the measurements of Fields, Burch, and Oran [2]), then the value of the effective area computes to be $A_e = 3.3 \times 10^{-2}\ cm^2$, which is near the upper range of the effective areas calculated from the calibration data. It should be remarked that a similar spread in the calculated effective area was observed in the calibration of the LIMS/SCATHA instrument [3], as well as a similar discrepancy in the theoretical and measured effective areas. Apparently there are particle losses in the instrument which are not accounted for, or the channeltron efficiency is less than supposed. However, two facts are clear, that there is no statistically significant difference in the effective areas of the high-mass and low-mass channels, and that there are no significant differences among the three sensor heads. This is confirmed by a preliminary examination of flight data when the instrument was in a warm, isotropic plasma. The recommendation is, then, that initially we adopt a value of the effective area as:

$$A_e = 2.0 \times 10^{-2}\ cm^2$$

and adjust this value as we are able to compare data with other measurements of plasma density on the spacecraft.

5.2.3 Calibration of the Radial Electrometer/RPA

The following lists the transmission characteristics of the various grids and the areas of the RPA collector plate and entrance slit.

a) Aperture grid pair: $T = 0.81$

b) RPA grid: $T = 0.81$

c) Suppressor grid pair: $T = 0.81$

d) Shield grid: T - 0.90

e) RPA collector area: $A_c = 1.813\ cm^2$

f) Entrance slit area: $A = 0.1\ cm^2$.

The combined effect of the grids in front of the RPA collector is then $T = (0.81)^3 = 0.531$. The equation relating electrometer current to ion flux is:

$$\text{Flux (ions/cm}^2\text{-sec)} = \frac{i}{T \times A_c \times q} = i \times 6.496 \times 10^{18}$$

This equation is only valid in high mach number flow at a ram angle of 0 deg. The conversion from telemetry reading to current is given in paragraph 3.3.1.3.

5.2.4 Location of Mass Peaks

The plots of mass sweeps, such as that shown in Figure 24, serve as well to calibrate the mass peak location of the RIMS. The mass sweep voltage is generated by a power supply whose input reference is a 12-bit word with decimal value ranging from 0 to 4095. The output voltage ranges from 0 to 2250 V. Therefore, the conversion from mass step to voltage is 0.54945 V/mass step. Each mass sweep consists of 46 separate data files, with each file consisting of data from a 32-step memory load. Each mass sweep plot therefore consists of 1472 mass steps. The mass step memory loads were generated according to the following algorithm:

$$\text{Mass Step} = 394 + I + KE \qquad I = 1,736$$

$$\text{Mass Step} = 1130 + 4\ (I - 736) + KE \qquad I = 737,\ 1472$$

The factor KE corrects for the ion beam energy and is computed by:

$$KE = 18 - E\ (4095/2250)$$

so that at E = 10 eV, KE = 0, and for E = 0 eV, KE = 18.

The top panels in the mass sweeps therefore have data points for each mass step while the bottom panels have data points for every fourth mass step. The mass range extends from m = 32 to m = 1. The procedure then for computing the mass step and voltage for 0 eV beam of a given mass specie is as follows:

a) Get value of I from the mass sweep plot.

b) Determine mass step assuming KE = 0.

c) Add 18 to the mass step determined in (b) to get mass step for E = 0 eV.

d) Multiply mass step by 0.54945 to get the voltage.

This procedure resulted in the following values for mass 16(0^+) for the three heads:

Radial	Mass Step = 910 ;	V_{ma} = 500.0 V
+Z	Mass Step = 910 ;	V_{ma} = 500.0 V
-Z	Mass Step = 914 ;	V_{ma} = 502.2 V

where V_{ma} is the mass acceleration voltage.

Since $\Delta m/m = \Delta E/E = 0.03 = 15$ V at 0^+, this 2 V difference among the heads is not significant. Therefore, we adopt for the mass calibration:

$$V_{ma} = \frac{7998.0\ V}{m}$$

Solving this equation for selected ion mass results in Table 5 for the RIMS.

TABLE 5. MASS PEAK LOCATION

Mass/Q	V_{ma}	Mass Step
4(He^+/H^+)	1999.51	3640
8(O^{++}/He^{++})	999.76	1820
16(O^+/He^+)	499.88	910
32(O_2^+/O^{++})	249.94	455

6.0 INSTRUMENT FLIGHT OPERATIONS

The RIMS in-flight control can be subdivided into four major groups of operations. These are:

a) Power Supply Control and Settings

b) Channeltron Management

c) Downlink Data Selection

d) IMS/RPA Operating Sequences.

In each of these areas there is a group of commands, or more properly "instructions" or "settings," which can be stored in the instrument's logic to control its operation or data return. The purpose of this section is to list and describe each of these commands, to structure their place in the overall instrument configuration and control scheme, and to describe the procedure involved in developing and implementing a complete "command sequence."

Unfortunately, the task is not straight forward. Because of the variety of spacecraft interface specifications, instrument safety considerations, EMI requirements, etc., the actual instrument control organization bears only a slight resemblance to the above operational organization. In addition, it will be necessary to thread into the operations description, a description of the computerized command catalog system. This system is one of a hierarchy of mnemonics which begins by naming each individual command and ends with a unique name for each command sequence. The system is complex but must be considered in the overall operating philosophy as it subtly imposes certain requirements on the instrument operating approach.

Figure 26 shows a conceptual overview of the system organization and the first level of detail within the software/command/hardware linkage. The hardware control includes the four groups of RIMS operations plus the two commandable spacecraft

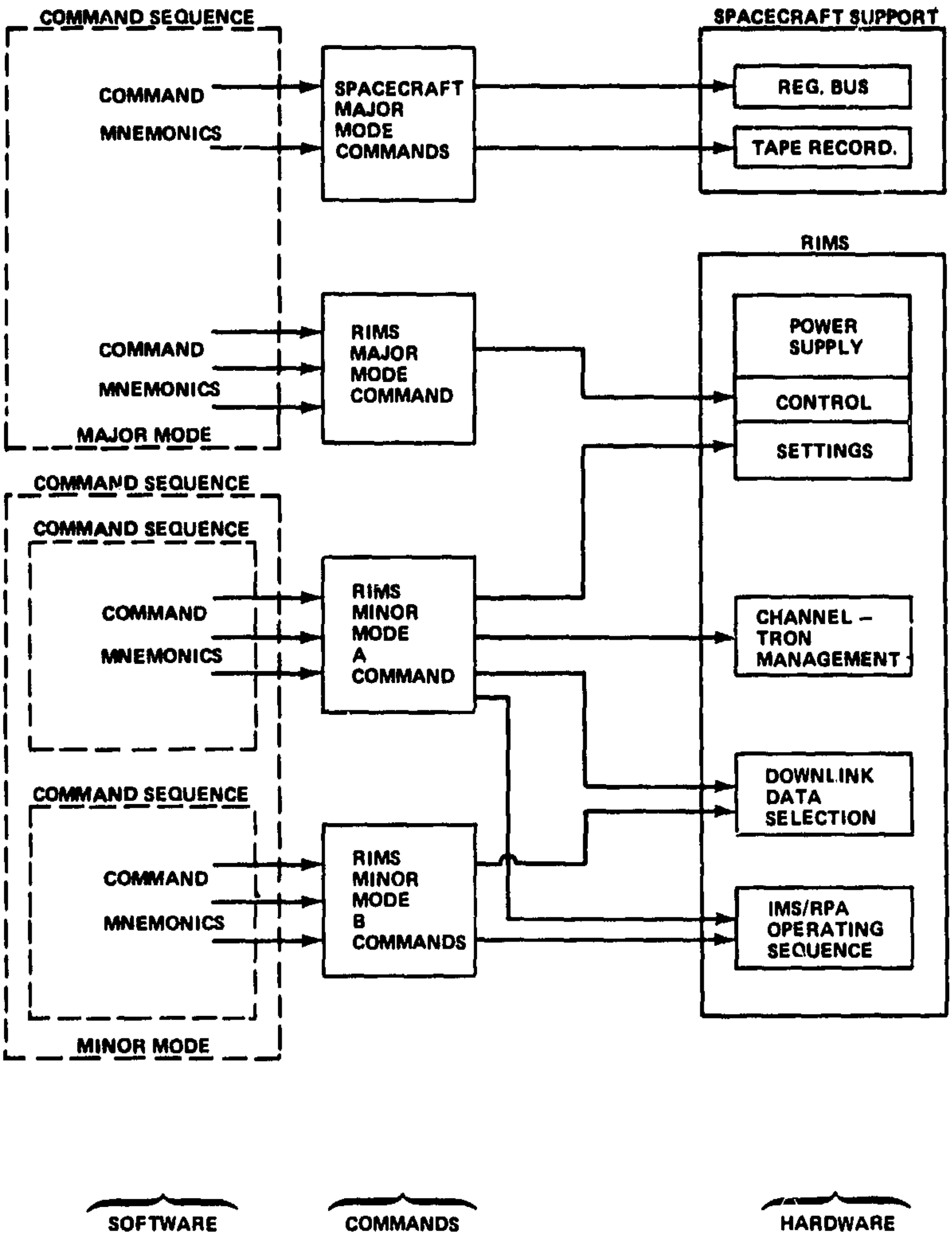

Figure 26. RIMS hardware/software control interface.

subsystems which must be managed in conjunction with experiment operations (the tape recorder and the regulated power bus). The details of the command control within the RIMS groups are described in the next section. The two spacecraft systems will need no further description other than to note that RIMS turn-on sequences must include "Reg. On" and "Tape On" commands even though they may be redundant.

The controlling commands which link the hardware to the control software are subdivided into three classifications: Major Mode, Minor Mode 'A', and Minor Mode 'B'. The assignment of a command function into a classification is somewhat arbitrary from the instrument's point of view but, in general, the major mode commands are at the top of the control organization and are reserved for the turn-on or enabling of major subsystems.

Minor Mode 'A' commands occupy the mid-level in the classification organization and are reserved for instrument-only (in this case RIMS) operations. These commands are generally intended for instrument settings which would be expected to be changed only occasionally. An example would be the channeltron operating voltage. A significant operational inconvenience will be encountered when measurements are specified which require a repeated changing of commands in this category. Such operations will require a special command to the instrument for each setting change. An example would be the cycling of the aperture bias voltage.

The bottom of the organization is occupied by the Minor Mode 'B' commands. These commands are actually a binary load of the instrument's IMS/RPA sequence memory; although it is possible to command a dump of the memory contents into the down link data channels via a Minor Mode 'B' command. Each address in the 32 address memory requires a separate command to effect the load of that address.

The dotted boxes on the left of Figure 26 show an outline of the software implemented command cataloging system. Each individual command is assigned a unique mnemonic. Subsequently, the series of commands necessary to effect a desired instrument operating configuration are grouped according to their command classification and this group of commands is assigned its own unique command sequence mnemonic. It is possible to nest the command sequence so the separate Minor Mode 'A' and Minor Mode 'B' command sequence mnemonics can be grouped under a third mnemonic which then allows the entire load, exclusive of the enabling Major Mode Commands, to be referenced by invoking a single name.

6.1 Operational Control Groups

6.1.1 Power Supply Control and Settings

Exclusive of the power supplies which control the mass settings of the IMS and provide voltage for the operation of the RPA, there are 6 separate supplies which must be managed via 11 Major Mode and 16 Minor Mode 'A' commands to effect complete instrument operation. These six supplies and their functions are listed in Table 6.

The overall relation between the supplies and their 27 controlling commands is shown in Figure 27. In this figure the six supplies and their functional settings are shown in the dotted boxes. Also included within the boxes are the Minor Mode 'A' mnemonics which provide the authority to command these respective settings. As noted in the figure, only those supplies which can be varied require Minor Mode 'A' commands and those commands are directly associated with the settings.

The enabling authority for the supplies is controlled via Major Mode commands only. The controlling logic is diagrammed in the center of Figure 27 along with the associated Major Mode mnemonics. The Low Voltage and Memory power supplies are straight forward with "PWRON" and "MEMON" commanding the supplies on and "PWROF" and "MEMOF" commanding the supplies off.

TABLE 6. RIMS POWER SUPPLIES AND POWER SUPPLY FUNCTIONS

Supply	Function
Low Voltage Power Supply	From the spacecraft regulated bus (-24.5 V). Supplies all instrument systems except the Channeltron operating voltage.
Memory Power Supply	Provides a "keep-alive" supply (5 V) for the IMS/RPA memory for periods when the low voltage supply is off.
Aperture Plane Potential	Provides the negative bias potential for the conducting plane around the detector apertures. EMI specifications require grounding these planes when not in use.
Radial Channeltron High Voltage	Supplies the operating high voltage to the Channeltron pair in the radial head.
+Z Channeltron High Voltage	Supplies the operating high voltage to the Channeltron pairs in the +Z heads.
-Z Channeltron High Voltage	Supplies the operating high voltage to the Channeltron pair in the -Z head.

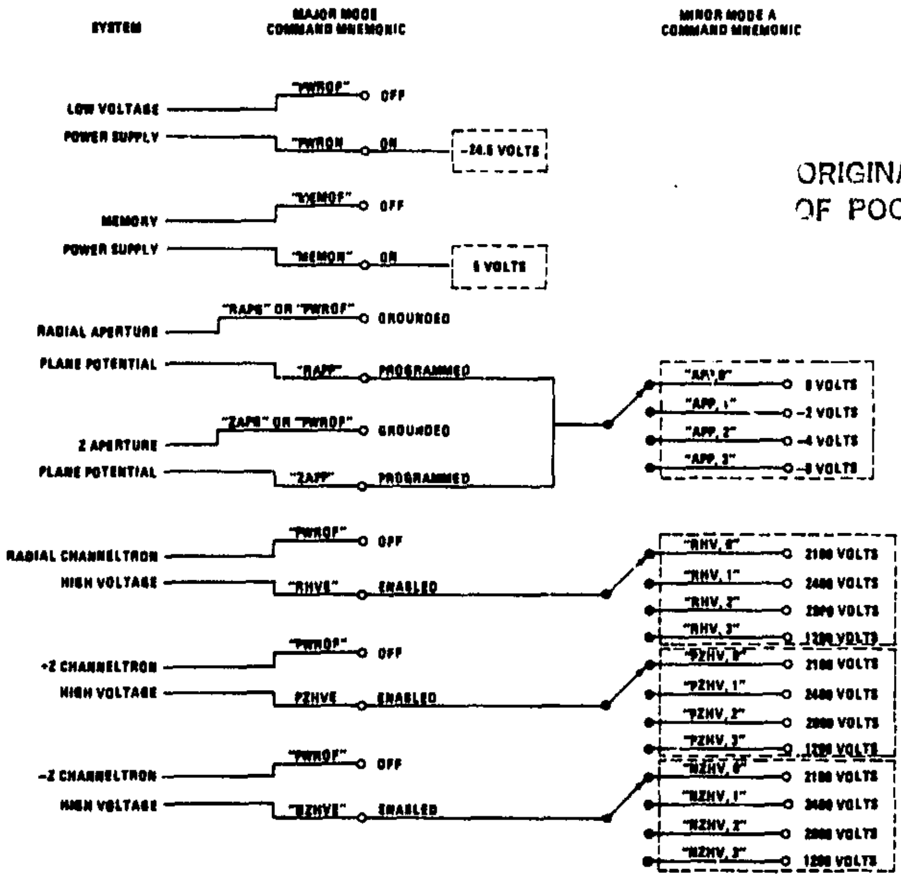

Figure 27. RIMS power supply command control.

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The switching of the aperture plane potentials is somewhat more complicated because of the ability within the instrument to enable the Z-pair and the radial independently. The command "RAPP" switches the radial aperture plane from spacecraft ground to the programmed setting while "ZAPP" similarly switches both Z aperture planes to the setting. The return of the planes to ground can also be controlled independently via "RAPG" and "ZAPG"; or together, via a "PWROF" command.

The three high-voltage supplies to the three channeltron pairs are commanded on independently via "RHVE", "PZHVE", and "NZHVE" but can only be turned off together with the instrument's low voltage via a "PWROF" command. It is to be noted that when the "PWROF" command is invoked, it not only switches off all supplies except the memory supply, but it also imposes an aperture potential setting of 0 V and a high voltage setting of 2100 V on the three high-voltage supplies. When the instrument is next turned on by the Major Mode command string "PWRON, RAPP, ZAPP, RHVE, PZHVE, NZHVE" it will be in the Minor Mode 'A' configuration shown by the pointers in Figure 27.

6.1.2 Channeltron Management

The channeltron detectors on the RIMS instrument pose certain specialized problems which have been addressed in the instrument design and command structure. A portion of their command control capability is actually located in the power supply design through its ability to vary the high voltage on the units. It is anticipated that these voltages will be adjusted through the course of the instrument lifetime to compensate for aging. Otherwise, the command control of the channeltrons allows for a selection of the noise threshold at which the channeltron detection circuits begin counting and a selection of the flux level at which the high voltage to the radial unit is reduced to inhibit counting.

The inclusion of the threshold select capability on the instrument is more for the sake of completeness of control than for an actual preconceived operational requirement. The control is a set of three single-pole, single-throw switches which allow for the selection of one of two threshold levels on each channeltron. The mnemonics for the switch control are given in Table 7. It will be noted that the "PWROF" defaults the settings to the lower threshold as it is anticipated that this setting will be utilized for all science operations.

The command control on the radial over flux protection allows for a selection of one of two preset count rate levels at which the high voltage to the radial channeltrons is automatically reduced below the operating level to 1200 V. The protection feature can also be inhibited. The controlling signal for the automatic switch-down is derived from the current to the radial head collector. Commands, mnemonics, and current levels are listed in Table 8.

It should be noted that the Z-channeltrons are designed with a fixed protection level at 5×10^{-9} A sensed from their respective current collectors. This protection cannot be inhibited.

TABLE 7. CHANNELTRON THRESHOLD SETTING

THRESHOLD SELECT	MNEMONIC	
	MINOR MODE A	MAJOR MODE
RADIAL		
LO	RTLO	PWROF
HI	RTHI	
+Z		
LO	PZTLO	PWROF
HI	PZTHI	
−Z		
LO	NZTLO	PWROF
HI	NZTHI	

TABLE 8. RADIAL CHANNELTRON PROTECTION

PROTECTION SETTING	MNEMONIC (MINOR MODE A)	COLLECTED CURRENT
LO CURRENT	ROCLO	10^{-10} AMPS
HI CURRENT	ROCHI	10^{-9} AMPS
INHIBITED	ROCIN OR ROCIN3	---

6.1.3 Downlink Data Selection

The science information provided by the RIMS instrument at each measurement point (16 msec) consists of output from nine separate sensors. These are:

a) Radial High Mass Channeltron

b) Radial Low Mass Channeltron

c) Radial Collector Current

d) +Z High Mass Channeltron

e) +Z Low Mass Channeltron

f) +Z Collector Current

g) -Z High Mass Channeltron

h) -Z Low Mass Channeltron

i) -Z Collector Current.

However, because of the limited amount of telemetry resources available on the spacecraft and the slowly varying nature of the data from the Z-heads, not all of the data are downlinked at any given time. Instead, the data system provides instantaneous space for only a subset. This subset consists of data from the Radial High and Radial Low channeltrons plus data from three of the remaining seven sensors, as selected by the user. To provide a more comprehensive coverage of the set of sensors the selection of the assignable channels can be multiplexed to an alternate set of three sensors at one of four rates (each 4, 8, 16, or 32 data points). This provides access to a maximum of eight of the nine sensors.

Figure 28 shows further details of the arrangement. Of the three assignable data channels, one is reserved for use by the current collectors. The other two handle the channeltron data from the two Z-heads. When coupled with the multiplexing, this arrangement allows all channeltron data to be transmitted (four Z-sensors switched into two channels plus the two dedicated radial channels), but only two of the three current collectors.

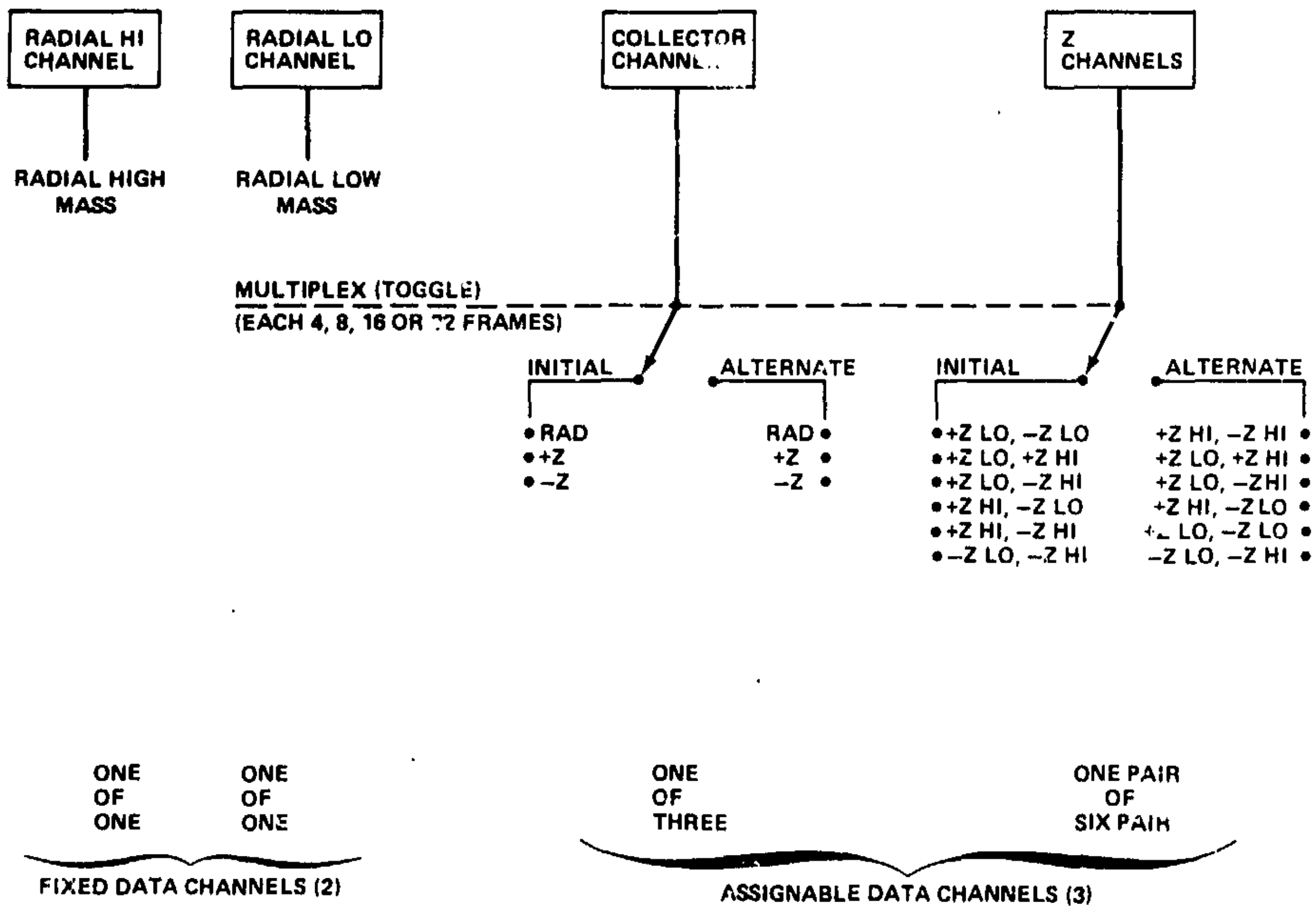


Figure 28. Downlink data selection - IMS mode.

It is possible to configure the data selection such that data from all three of the current collectors are provided, but this can only be done at the expense of eliminating data from the Z-channeltrons. In this mode, the data channel dedicated to the current collectors is fixed to the radial collector and the Z-assignable channels become dedicated to the two Z-collectors. No multiplexing of data information is possible. This secondary configuration is called the "RPA Mode" to distinguish it from the "IMS Mode" of Figure 28. The mnemonic structure for the commanding of the data selection configuration is shown in Table 9.

TABLE 9. MNEMONICS - DATA CHANNEL CONFIGURATION

MODE	DATA SELECTION	MULTIPLEX PERIOD	MNEMONIC (MINOR MODE A)
RPA	N. A.	N. A.	RPAT3
IMS			RPAT1*
	COLLECTOR CHANNEL		
	INITIAL		
	RADIAL		TSELI, 0*
	+Z		TSELI, 1
	−Z		TSELI, 2
	ALTERNATE		
	RADIAL		TSELA, 0*
	+Z		TSELA, 1
	−Z		TSELA, 3
	Z−CHANNELS		
	INITIAL		
	+Z LO, −Z LO		ZSELI, 0*; ZSELI, 6; ZSELI, 7
	+Z LO, +Z HI		ZSELI, 1
	+Z LO, −Z HI		ZSELI, 2
	+Z HI, −Z LO		ZSELI, 3
	+Z HI, −Z HI		ZSELI, 4
	−Z LO, −Z HI		ZSELI, 5
	ALTERNATE		
	+Z HI, −Z HI		ZSELA,0*; ZSELA, 6; ZSELA, 7
	+Z LO, +Z HI		ZSELA, 1
	+Z LO, −Z HI		ZSELA, 2
	+Z HI, −Z LO		ZSELA, 3
	+Z LO, −Z LO		ZSELA, 4
	−Z LO, −Z HI		ZSELA, 5
		32 FRAMES	MFT, 0*
		16 FRAMES	MFT, 1
		8 FRAMES	MFT, 2
		4 FRAMES	MFT, 3

*SELECTION CONFIGURATION AT INSTRUMENT POWER−ON.

6.1.4 IMS/RPA Operating Sequences

The basic scientific operation of the RIMS instrument centers around the reprogrammable memory which controls the voltage of the instrument's RPA and IMS. This memory is organized as a 2 × 32 array with one column containing RPA settings and one containing IMS settings. Figure 29 shows a pictoral representation of the array. Access to the memory is by row, with each row considered to be an individual address. In operation, the instrument sequentially executes the pair of settings at each address at the rate of one each 16 msec and then repeats from the top after finishing the set.

ADDRESS	RPA	IMS
0	10 BITS	12 BITS
1	10 BITS	12 BITS
2	10 BITS	12 BITS
3	10 BITS	12 BITS
4	10 BITS	12 BITS
5	10 BITS	12 BITS
6	10 BITS	12 BITS
7	10 BITS	12 BITS
8	10 BITS	12 BITS
9	10 BITS	12 BITS
10	10 BITS	12 BITS
11	10 BITS	12 BITS
12	10 BITS	12 BITS
13	10 BITS	12 BITS
14	10 BITS	12 BITS
15	10 BITS	12 BITS
16	10 BITS	12 BITS
17	10 BITS	12 BITS
18	10 BITS	12 BITS
19	10 BITS	12 BITS
20	10 BITS	12 BITS
21	10 BITS	12 BITS
22	10 BITS	12 BITS
23	10 BITS	12 BITS
24	10 BITS	12 BITS
25	10 BITS	12 BITS
26	10 BITS	12 BITS
27	10 BITS	12 BITS
28	10 BITS	12 BITS
29	10 BITS	12 BITS
30	10 BITS	12 BITS
31	10 BITS	12 BITS

Figure 29. IMS/RPA reprogrammable memory array.

The actual contents of the memory are digital words; 10 bits in the case of the RPA side and 12 bits in the IMS portion. As a result, the actual voltages which can be achieved are quantized. The parameters of the control are given in Table 10. In the case of the mass spectrometers the actual mass setting is of more interest than the voltage setting so an approximate and empirical relation between voltage and mass number for the high mass channel is given in the table.

Load access to the memory itself is via Minor Mode 'B' commands and is accomplished one address at a time The instruction contains the digital IMS setting, the

TABLE 10. IMS/RPA DIGITAL SETTING CONTROL

	RPA		IMS*	
	VOLTS	10–BIT SETTING	VOLTS	12–BIT SETTING
MIN	0	0	0	0
MAX	51.15	1023	2250	4095
INCREMENT	0.050	1	0.5495	1

***IMS MASS NUMBER = 7998/(IMS VOLTS)**

digital RPA setting, the designated address for the command, and a "clear-to-load" instruction. The command mnemonic format is as follows:

IMS = XXXX, RPA = XXXX, MA = XX, MLC*

- MLC: Load Clearance
- MA = XX: Memory Address, 0 through 31
- RPA = XXXX: RPA Digital Setting, 0 through 1023
- IMS = XXXX: IMS Digital Setting, 0 through 4095

* An instruction to dump the entire memory contents through the data channels after the command is loaded can be substituted for the clear-to-load. The alternate mnemonic is "MDR".

To increase the flexibility of the control of the mass/energy cycling, there are four minor mode commands and one major mode command available which impose settings which supercede those settings specified in the memory array. These five control options are listed in Table 11 with their appropriate mnemonic. Invoking these commands does not alter the contents of the memory itself; hence, switching among them can be accomplished without reloading the array.

A summary organization, tabular listing, and text reference for all RIMS commands is given in Appendix A.

TABLE 11. MEMORY ACCESS COMMANDS

IMS/RPA CONTROL	MNEMONIC
1. DEFAULT RPA TO ZERO VOLTS ACCESS IMS MEMORY INSTRUCTIONS ONLY	MEMMI (MINOR MODE A)
2. DEFAULT IMS TO H^+/He^+ ION PAIR ACCESS RPA MEMORY INSTRUCTIONS ONLY	MEMMR (MINOR MODE A)
3. ALTERNATE FULL MEMORY CONTROL WITH "MEMMR" EACH EIGHT SECONDS	MEMMF3 (MINOR MODE A)
4. OPERATE WITH NORMAL MEMORY CONTROL	MEMMF (MINOR MODE A)
5. DEFAULT IMS SETTING TO H^+/He^+ AND RPA SETTINGS TO BUILT–IN CIRCUIT CONTROL (MEMORY FAILURE OPTION)	FSCAN (MAJOR MODE)

6.2 General Programming Approach

The first step in creating a RIMS operating program is, of course, selecting a scientific objective. Preferably, this is done after a review of existing data. Subsequently, the capabilities of the instrument and the DE-1 satellite characteristics must be analyzed to determine how best to utilize and combine them in achieving the desired measurements. Unfortunately, in this step it is sometimes necessary to accept compromises between the "desirable" and the "achievable." The final step should be the review of existing operating programs to determine if one already exists which substantially achieves the desired objectives.

To demonstrate the overall procedure an example will be worked through in detail. This example will be the standard RIMS survey mode. That particular case is chosen because it flexes almost all of the RIMS scientific control capability and, since a substantial amount of data is taken in this mode, a thorough understanding of it and the resulting data serves as a useful starting point in understanding the RIMS measurements.

The scientific motivation behind the survey mode was to provide an operating sequence which would effectively sample the ambient low-energy plasma for the relative abundance of the major known species and provide an adequate energy analysis of each of these species. It was intended that the mode would be used initially to develop a baseline picture of the composition and energy variations of the ionic species in the plasmasphere and low-altitude magnetosphere and subsequently to provide a long term data base on their morphology.

The portions of the instrument which are available to be configured to accomplish the desired measurement are the memory array of Figure 29, the memory access commands of Table 11, and the data selection configuration of Figure 28.

The ISEE low-energy ion data from the Plasma Composition Experiment established that the major probable constituents to expect in the DE-1 vicinity were H^+, He^+, O^+, He^{++}, and O^{++}. Although the ISEE observations were not sufficient to establish the absence of other species, they were sufficient to establish that the occurrence of other species was a rare event. Therefore, instrument time spent searching for species other than those mentioned could largely be instrument time spent measuring nothing. The major instrument constraint to be considered in the selection of the number of species to include in the survey is the limitation of the instruments' memory capability. With only 32 memory registers to store mass and energy step settings, the expansion of the mass survey can, at some point, limit the number of steps available for the energy analysis.

Again, from the ISEE data it had been learned that the energy of the low-energy plasma could be anywhere in the 0 to 50 V range measured by RIMS. In addition, it was evident that a major contribution of RIMS would be information on the time/location signature of the details of the energization of the ions. Hence, it was apparent that a general purpose survey mode should cover the mass range only as far as could be accomplished with adequate energy resolution maintained.

The next factor to consider in the design of the operating program is the angular coverage. The DE-1 spacecraft is spinning at a rate of approximately 10 rpm. This translates to about 1 deg of spin for each measurement point or memory step. Hence, during a complete memory execution the radial head will sweep about 32 deg. A review of the ISEE data indicates that angular widths of the order of 30 deg per energy scan are adequate for isotropic pitch angle distributions, but in the case of rapidly flowing or sharply peaked field aligned distributions it is too broad. In these cases the angular width of the sweep should be less than the angular width of the radial aperture acceptance angle. This suggests that the memory be utilized such that at least two complete RPA scans be accomplished over the 32 steps.

One of the more critical and difficult questions to answer is that of the selection of the precise voltage steps of the RPA scan. The physics of the problem of determining the bulk plasma parameters from the RPA data utilizing a single ion requires a few retarding points around the peak of the velocity distribution for a temperature solution, but a very fine sampling around the break point in the RPA curve for accurate flow velocity determinations. The latter constraint is the more difficult to meet with a limited number of steps available. The problem develops because each species has its individual RPA break point at the potential corresponding to its flow velocity and, in addition, the voltage location of the break point is translated linearly by a spacecraft potential. Therefore, in the general application, the portion of the voltage range requiring the fine sampling can be anywhere. The safest approach in selecting RPA values is to do so according to an exponential scheme. This provides the best blind chance that the proper sampling at points appropriate to a temperature determination will be collected. Its main disadvantage lies in the concentration of steps near low voltages at the expense of steps at intermediate and high voltages. Flow energies or attractive spacecraft potentials of a few volts will tend to move the cold plasma break point in the RPA curve into a region of widely spaced samples and subsequently degrade the accuracy of flow determinations in data analysis.

In summary, the points to be considered are:

a) Sampling of as many species as possible without imposing any constraints on the steps available for energy analysis. Priority in the measurements should be given to H^+, He^{++}, He^+, O^{++}, and O^+.

b) Angular width of the energy scan between 10 and 20 deg.

c) A RPA scheme containing as many points as possible with some compromise matching of the selection to the plasma phenomena considered to be of the highest importance.

The scheme chosen to implement the desired measurement is shown in Table 12. It is seen in this table that a double RPA scan has been chosen. (The reason for the lead-in 51.15 settings will be covered later). Each RPA scan consists of 14 steps in an exponential sequence but with the alternate sequence containing different values. The concentration of points at the low voltages is evident in the scan but is considered to be appropriate for measurements of flow velocities in the outer plasmasphere where the main constituent is H^+ and the spacecraft potential should be near plasma potential.

TABLE 12. RIMS SURVEY MODE

			IMS (IONS)	
ADDRESS	RPA (VOLTS)		FIRST 8 SEC	ALTERNATE 8 SEC
0	51.15		H+/He+	He+/O+
1	51.15		H+/He+	He+/O+
2	0.00		H+/He+	He+/O+
3	0.10		H+/He+	He+/O+
4	0.15		H+/He+	He+/O+
5	0.25		H+/He+	He+/O+
6	0.45		H+/He+	He+/O+
7	0.75		H+/He+	He+/O+
8	1.20		H+/He+	He+/O+
9	1.95		H+/He+	He+/O+
10	3.25		H+/He+	He+/O+
11	5.35		H+/He+	He+/O+
12	8.80		H+/He+	He+/O+
13	14.40		H+/He+	He+/O+
14	23.70	½ SEC	H+/He+	He+/O+
15	39.00		H+/He+	He+/O+
16	51.15		H+/He+	He++/O++
17	51.15		H+/He+	He++/O++
18	0.00		H+/He+	He++/O++
19	0.15		H+/He+	He++/O++
20	0.20		H+/He+	He++/O++
21	0.35		H+/He+	He++/O++
22	0.65		H+/He+	He++/O++
23	0.95		H+/He+	He++/O++
24	1.55		H+/He+	He++/O++
25	2.55		H+/He+	He++/O++
26	4.15		H+/He+	He++/O++
27	6.85		H+/He+	He++/O++
28	11.25		H+/He+	He++/O++
29	18.50		H+/He+	He++/O++
30	30.40		H+/He+	He++/O++
31	50.00		H+/He+	He++/O++

The Alternate Memory Mode of the instrument has been chosen to provide coverage of the five major species. The instrument will cycle through the programmed RPA sequence each 0.5 sec with the IMS set to the H^+/He^+ pair for 8 sec and then operate for 8 sec with the IMS switching each 0.25 sec between the He^+/O^+ pair and the He^{++}/O^{++} pair.

The final step in specifying the operating program is that of selecting the down-linked data pattern from Figure 28. These selections are straight forward. The toggle rate is chosen to be 32 frames so that the switching will be synchronous with a memory execution. The collector channel is set to the radial collector for both the initial and alternate cycle on the basis that the major contribution from this detector will be in the ionosphere where the radial detector will be ramming the plasma. The Z-channels are configured to +Z Lo, -Z Lo on the initial cycle and +Z Hi, -Z Hi on the alternate cycle for the simple reason that in the absence of a specific requirement, these detectors should be set to switch according to their power-on configuration.

The Minor Mode 'A' configuration then becomes

TSELI, 0

TSELA, 0

ZSELI, 0 (From Table 9 and Figure 28)

ZSELA, 0

MFT, 0

MEMMR (From Table 11)

Note that it is not necessary (nor allowable) to include within a science specification the channeltron high-voltage setting of Figure 27, the channeltron threshold setting of Table 7, or the protection setting of Table 8.

The final step in deriving the complete science load is that of specifying the exact operating voltages for the IMS. The fundamental relation between mass number and IMS voltages was given in Table 9 as

IMS VOLTS = 7998/(MASS NUMBER) .

However, this relation holds only if the incident ions are at zero energy. For ions whose energy is greater than zero the optimum deflection voltage given by the equation must be decreased by an amount equal to the ions energy. (The direction of this change in IMS potential can be remembered from energy considerations; that is, to compensate for increasing translation energy, the IMS voltage must be changed in the same direction as necessary to compensate for increasing mass.) The importance of this shift in IMS setting with external energy is mass dependent since the width of the mass channels in the instrument is given approximately by the empirical relation

WIDTHS IN VOLTS = 64/(MASS NUMBER) .

For H^+ the effect is negligible relative to the 50 V energy range of the instrument but for O^+ it is significant.

To deal with the characteristic during energy scans of the RPA the equation for relating IMS volts to mass number can be modified to

IMS VOLTS = 7998/(MASS NUMBER) - RPA VOLTS , This modification assures that if these are unretarded ions at the higher RPA settings, the IMS will have been "tuned" to measure them.

With this last expression it is possible to derive the IMS settings necessary to fully specify the sequence of Table 12.

The results of this and the other portions of the command sequence are listed on the form in Figure 30. This form was devised to serve as a check list and record for the science-related instrument settings and contains all appropriate Minor Mode 'A' and Minor Mode 'B' commands. Note that only the IMS values for the heavier ion species are listed in the IMS column, and that there is no need to list the IMS setting for the default pair in effect during the alternate cycle. Also note that the IMS values are not in agreement with those generated by the relations in this section. Those values in the figure were derived prior to a rigorous evaluation of calibration data. Later operational versions of this command sequence reflect the refined values.

D.E./RIMS COMMAND SEQUENCE

INVESTIGATOR: C. BAUGHER

DATE: 3-21-80

SEQUENCE NAME = T 8 1 6 E 0 0
7 CHAR.

MODE = T 8 1 6 E
5 CHAR.

REGION: ALL

INVESTIGATION:

OBJECTIVE: GENERAL SURVEY FOR MAIN CONSTITUENTS.

MINOR MODE A

INITIAL Z: ZSELI = 0

ALTERNATE Z: ZSELA = 0

INITIAL RPA HEAD: TSELI = 0

ALTERNATE RPA HEAD: TSELA = 0

TOGGLE RATE: MFT = 0

APERTURE POTENTIAL: APP = 0

RPA MODE ☐
IMS MODE ☑
CHECK ONE

ALTERNATE MEMORY MODE ☑
RPA DEFAULT ☐
IMS DEFAULT ☐
NORMAL MEMORY CONTROL ☐
CHECK ONE

MINOR MODE B

ADDRESS	RPA VOLTS	IMS VOLTS
1	51.15	496.75
2	51.15	496.75
3	.00	496.75
4	.10	496.65
5	.15	496.60
6	.25	496.50
7	.45	496.30
8	.75	496.00
9	1.20	495.55
10	1.95	494.80
11	3.25	493.50
12	5.35	491.40
13	8.80	487.95
14	14.40	482.35
15	23.70	473.05
16	39.00	457.75
17	51.15	982.85
18	51.15	982.85
19	.00	982.85
20	.15	982.70
21	.20	982.65
22	.35	982.50
23	.55	982.30
24	.95	982.90
25	1.55	981.30
26	2.55	980.30
27	4.15	978.20
28	6.85	976.00
29	11.25	971.60
30	18.50	964.35
31	30.40	952.45
32	50.00	932.85

Figure 30. Command sequence form - survey mode.

The final point to cover with regard to the IMS/RPA is the necessity for the lead-in 51.15 V settings of the RPA. This requirement derives from the finite time required for the IMS power supply to make large changes in voltage. In the example command sequence this supply must make two of these changes; one from 457.75 V to 982.85 V and one from 932.85 V to 496.75 V. Both of these changes require more time than is available between measurement points, and during the voltage recovery interval the data from the instrument is invalid. Hence, it is necessary to insure the RPA scan commences only after the power supply has settled. The actual RPA setting during the settling period is not critical but has been chosen to be 51.15 V for the dual purpose of flagging the points in software and restricting counts on the channeltrons by shutting out the maximum amount of plasma.

As an approximate guide the following relations can be used to determine the number of invalid data points after a large change in the IMS setting:

Mass Setting Increasing

INVALID POINTS = RND [0.2 (Δ MASS NUMBER)]

Mass Setting Decreasing

INVALID POINTS = RND [0.1 (Δ MASS NUMBER)]

with the higher mass channel used for the determination.

Note that the change from 457.75 to 982.85 V is one of decreasing mass and the dead time could be restricted to one data point. The expansion to two points is both for symmetry purposes and an artifact of the systemization of RPA sequences covered in Appendix D.

6.3 Instrument Modes, Command Sequences, and Naming Conventions

In order to catalog and track the operation of the DE instruments the project has imposed a naming convention on the multitude of possible operations of each experiment. The intention is to file each instrument configuration as an abbreviated mnemonic and subsequently catalog the scientific operations time-line utilizing these mnemonics.

For this purpose, two separate classifications are required. The first is a Mode name. A Mode is defined as a general category of operations such as cusp measurements, if a geophysical perspective is used, or a mass sweep, if an instrument perspective is used. The Mode name is restricted to five characters. For RIMS, the instrument perspective was chosen as the classifying agent and a preliminary list of possible modes was derived prior to launch. This preliminary set is given in Table 13.

A comparison of the several modes in this table will reveal that the survey mode of the previous section is a "T816E" mode where the letter E refers to the RPA sequence of Table 12 and Appendix D. Note that this mode name has been entered in the appropriate location of the form in Figure 30.

The second classification is the Command Sequence name. This is the mnemonic assigned to the actual sequence of commands which specify the instrument configuration. Eight characters have been allowed for the word. With the structuring of the mode name from the instrument perspective it is possible to simply expand the mode

TABLE 13. RIMS NOMINAL OPERATING MODES

Mode Mnemonic	Brief Description
HIXXZ	A family of modes in which the instrument is measuring only one mass pair and concentrating on either high mass or angular resolution. The two unspecified locations in the mnemonic denoted by X will specify the heavier of the pair while the location denoted by Z refers to an RPA program.
SVXXZ	A family at survey modes in which the instrument splits its observing pattern between the H^+/He^+ mass pair and one other mass pair. The definition of the unspecified locations is the same as in the previous case. The total cycle time is 16 sec.
SXYYZ	A survey mode in which the RPA analysis is performed on the H^+/He^+ pair plus two other ion pairs. The total cycle time in this mode is 0.5 sec.
TXYYZ	A survey mode which is similar to the previous survey mode with the exception of the sequencing pattern. In this case, the H^+/He^+ setting is maintained for 8 sec with an RPA cycle each 0.25 sec. In the subsequent 8-sec half of the cycle time, the instrument toggles between the alternate pairs each 0.25 sec. The total cycle time is 16 sec.
MXXYY	A mass sweep mode starting at mass XX and ending at mass YY. The specified mass numbers are those of the heavy mass channel. The lower mass channel will be operating and measuring mass species of one-fourth of these mass values. Note: The sweep may not be continuous within the specified range, if prior instrument experience has indicated that certain mass numbers are unpopulated. The cycle time is 0.5 sec.
CXXYY	A mass sweep mode with interspersed RPA analysis of the H^+/He^+ pair. The cycle time is 16 sec.
SSZZZ	A special science mode to be determined after launch. Contact the RIMS Investigator.
PLPHN	Plasma mode used to investigate spacecraft/plasma interactions. Geophysical data may be available, but will require special interpretation. N is the program number.
INSTR	Instrument check out, test, and calibration modes.

name by appending characters to indicate the various specific configurations of the instrument. In the case of the example command sequence developed in the previous section the name assigned is "T816E00". Note that only seven of the eight possible characters have been used. The eighth character is reserved for internal sub-classifications of the parts of the command sequence which will be described in the next section.

6.4 Creating a RIMS Command Sequence File

Subsequent to finalizing a desired RIMS operating program and filling out a Command Sequence Form, it is necessary to create a file on the Sigma-9 which contains the command sequence in the format specified by the DE Experiment Operations Coordinator. The format requirements are largely undocumented and what is presented here was developed by trial and error. The actual translation of the contents of the form into the appropriate structure is accomplished through a tutorial and interactive program in the RIMS account on the Sigma 9. Hence, it is not necessary to accomplish the translation by hand but it is desirable to understand the format.

As was mentioned in the introduction, the structure is basically one of a heirarchy of mnemonics. Figure 26 shows their basic structuring relative to the instrument. The dotted blocks on the left of the figure indicate two major groups. The lower group contains the RIMS Minor Mode 'A' and Minor Mode 'B' commands and will be the first described. To take advantage of the information which can be conveyed by an example, we will continue working through the survey mode.

The overall group is referenced by a single mnemonic, and specifying that mnemonic is intended to uniquely specify a Minor Mode 'A' and 'B' load for the instrument. This mnemonic is selected to be the seven letter sequence name which was established when the Command Sequence Form was completed. In this case "T816E00".

The T816E00 command sequence is formed from two other command sequences, one for the Minor Mode 'B' commands and one for the the Minor Mode 'A' commands. The problem is to uniquely convey the details of the entire instrument load in these two eight letter words.

Consider the Minor Mode 'A' command first. Since there are eight letters to work with, it is desirable to break the function of the Minor Mode 'A' commands down into eight groups. One logical arrangement is as follows:

1) Alternate T and Z Selection
   3 possible T selections (Table 9)
   8 possible Z selections (Table 9)
   24 combinations

2) Initial T and Z Selection
   3 possible T selections (Table 9)
   8 possible Z selections (Table 9)
   24 combinations

3) Memory Access Configuration
   4 possible Toggle Rates (Table 9)
   4 possible Memory Access Commands (Table 9)
   2 possible modes (RPA or IMS)
   32 combinations

4) High Voltage Select
   3 power supplies (Table 6)
   3 operational settings each (Fig. 27)
   27 combinations

5) Threshold Select
   3 heads
   2 levels (Table 8)
   8 combinations

6) Aperture Potential
   1 power supply (Table 6)
   4 levels (Fig. 27)
   4 combinations

7) Overcurrent Level
   1 head
   2 levels (Table 8)
   2 combinations

8) Overcurrent Protection
   1 head
   2 possibilities (ON/OFF)
   2 combinations

Each of the groups contains fewer than the 36 symbols provided by the alphabet and the digits and each combination can therefore be specified by a single character. Items 1 through 5 are large groups and require reference to look-up tables for the relation between the setting and the cataloging character. These tables are located in Appendix B. The number of combinations in items 6, 7, and 8 are purposely kept small so that the mnemonic could be readily interpreted to determine the status of these more critical settings.

This can be seen in the structure of the eight letter word:

```
P L _ O A _ _ _
8 7 6 5 4 3 2 1
```

Location eight will contain either a "P" for "Protection On" or a "U" for "Unprotected". Location seven will contain either a "H" for "High Level" or a "L" for "Low Level". Location six will contain the actual negative bias voltage on the aperture planes (0, 2, 4, or 8).

Four of the eight Minor Mode 'A' groups are for items which change only rarely or could effect instrument health, if they are mis-set. These are items 8, 7, 5, and 4. As a result they are not included in the Command Sequence Form and require a special editing of the command sequence file to effect a change. This provides a safe guard in that it is impossible to effect a change of these parameters unintentionally. A summary of these character assignments is given in Figure 31.

Referring to the above, the tables of Appendix B and the Survey Mode Command Sequence Form gives "PL00AAAA" for the mnemonic which uniquely describes the Major Mode 'A' load for the survey mode. For a reason which will become evident at the end of this section, this Minor Mode 'A' mnemonic will now be reassigned the name "T816E00X", where the first seven characters are derived from the Command Sequence mnemonic.

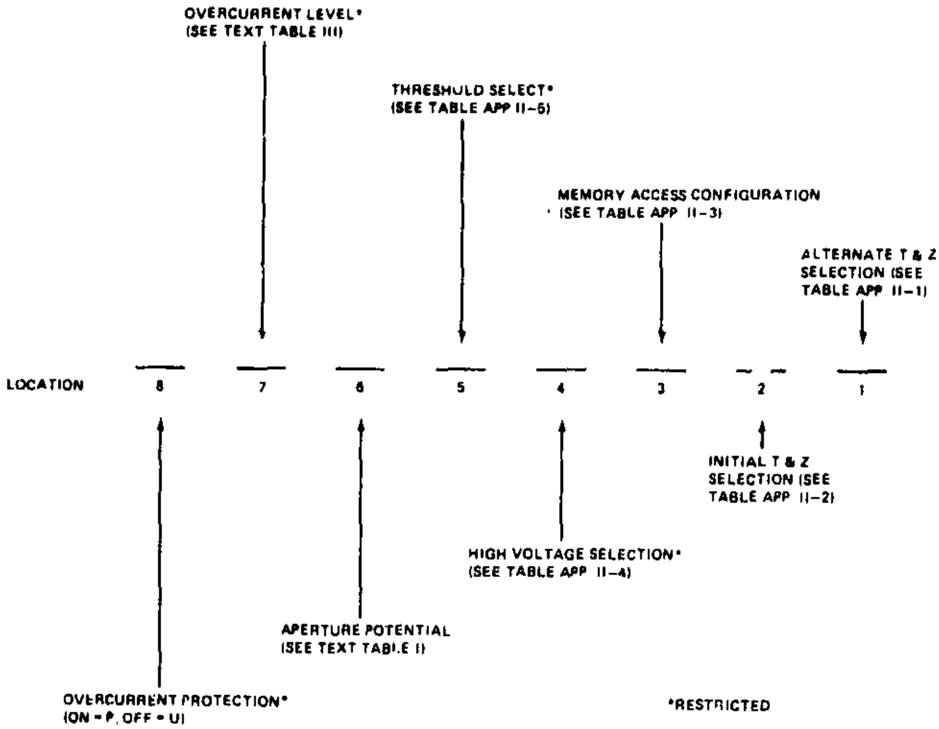


Figure 31. Minor mode "A" mnemonic structure.

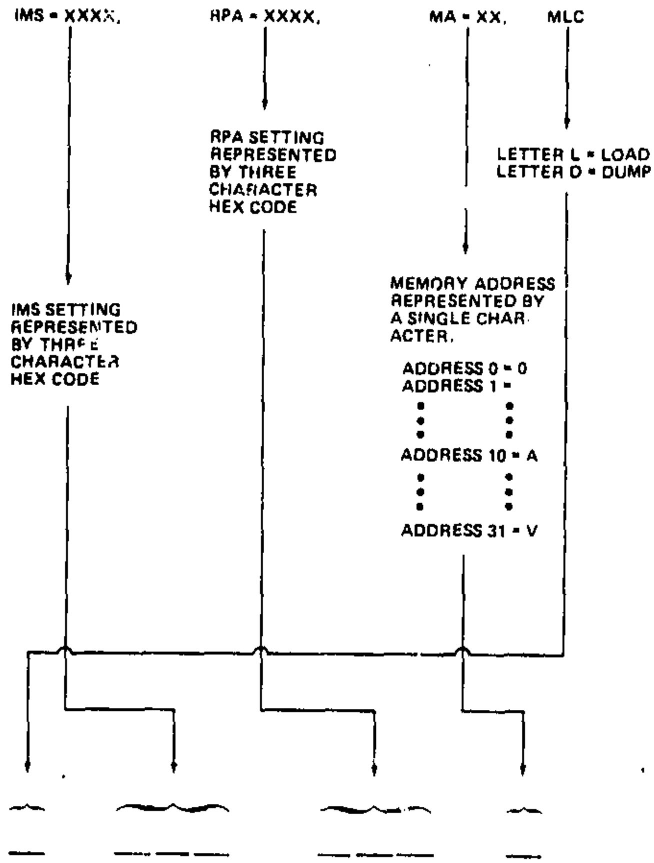


Figure 32. Minor mode "B" mnemonic structure.

The Minor Mode 'B' command structure is substantially different but the approach to representing a Minor Mode 'B' load by a single eight character mnemonic can be made more logical. For the Minor Mode 'B' load there are 32 addresses, each of which can contain any of 1024 RPA settings, 4096 IMS settings, and either a "clear to load" or a memory dump instruction. The diagram of Figure 32 demonstrates the approach selected to represent these 2.7×10^8 combinations.

The basic Minor Mode 'B' load is subdivided into its four specific functions; the IMS setting, the RPA setting, the memory address, and the status of the load-bit. Each of these groups is then assigned a logical scheme to convert their setting into a character or a group of characters. The two possible configurations of the load bit are assigned a letter; "L" for clear to load and "D" for memory dump. Since the final mnemonic must begin with a character, this item is assigned to the first location.

The four digit IMS setting is reduced to three digits by converting the number to hexadecimal. These three characters are then assigned to the three indicated locations. Likewise, the four digit RPA setting is converted, reduced, and assigned to the next three locations. Finally, the memory address is represented by a single character and assigned to the last location. The results are an eight character mnemonic which uniquely describes a single line of RIMS memory. Referring back to the survey mode, the first entry of the Minor Mode 'B' command would become "L3883FF0".

At this point it is possible to take advantage of the grouping of individual mnemonics under a separate mnemonic. Logically it would seem appropriate to group all 32 entries under a single name but a program limitation on the Sigma 9 prevents it from accepting the very large number of characters in this operation. It is necessary first to subdivide the 32 into four groups of eight each. These four subgroups can then be assigned an intermediate mnemonic. In our example the first eight Minor Mode 'B' commands are grouped under the label T816E00A, the second eight the mnemonic T816E00B, the third eight the mnemonic T816E00C, and the last eight T816E00D. The final level of identification can now take place with the assignment

Command Sequence T816E00

= Command Sequence T816E00X

+ Command Sequence T816E00A

+ Command Sequence T816E00B

+ Command Sequence T816E00C

+ Command Sequence T816E00D.

A complete example of a RIMS memory load development through the interactive Sigma 9 program is given in Appendix C.

At this point, it is appropriate to refer back to the step of relabling the Minor Mode A mnemonic in terms of the Command Sequence name; i.e., equivalencing PL00AAAA to T816E00X prior to the nesting of the five components into a single command sequence. A major motivation for this is the simplification which occurs in the "mental bookkeeping" for this whole rather esoteric procedure. It is possible to quickly cross-associate Minor Mode 'A' configurations with their appropriate Command Sequence or Mode without having to maintain a cross reference list. Prior to flight, this step was considered an operational requirement in order to handle the situation in which power to the RIMS instrument was inadvertently interrupted. When such an interrupt occurs the programmed Minor Mode 'A' settings are lost but the memory power supply was intended to maintain continuity in the RPA/IMS memory. In this case, the remedial action through ground control to reestablish the RIMS operating configuration without outside communication back to the command data base was to have been to quickly determine the mode the instrument was in at the time of the power loss and then issue the "X" version of the mode.

However, during the initial post flight operations it was discovered that the memory maintenance circuit was unreliable. Hence, to assure complete recovery from any break in power to RIMS, it is necessary to load the entire sequence anyway. Although this essentially alleviated the requirement for maintaining the extra name for the Minor Mode 'A' settings, the approach remains convenient.

7.0 INSTRUMENT PERFORMANCE ANALYSIS

The ISIS-II and AE-C and D IMS, both successfully flown on their respective spacecrafts, exhibited a response to an ambient ion concentration of 10^2 ions/cm^3 of 2×10^{-11} A output current from the electron multiplier. This is equivalent to a sensitivity of 1×10^4 counts/sec for an ion density of 1/cm^3. The RIMS instrument has a factor of five increased sensitivity caused by its wider slits and shorter path length for the ion beam through the mass analyzer.

At a particle density of 10^{-2} ion/cm^3, the minimum ion density to be measured by RIMS, the counting rate will be 100 counts/sec. The integration period is 0.012 sec which yields a minimum counting rate of about 1 count/period.

The maximum counting rate of the detectors is 10 MHz. This corresponds to 1.2×10^5 counts/12 msec counting period. The maximum ion density that can be measured before counter saturation occurs is 1×10^3 ions/cm^3. At this density, the RPA collector current will be approximately 1×10^{-10} A. The log amp detector which measures the RPA collector current has a range of 1×10^{-11} to 5×10^{-7} A. Therefore, there is about a decade overlap with the IMS output on each channel and a maximum ion concentration measurement capability of 10^6 ions/cm^3. This is sufficiently over the expected F2 maximum density to give a reasonable safety margin without saturating the collector. The overlap between RPA collector current and IMS counts permit in-flight calibration of the instrument to augment the pre-flight laboratory calibrations.

APPENDIX A

RIMS COMMAND MNEMONICS

The following is a complete list of RIMS command mnemonics together with the reference list to explanatory figures and tables in this document.

MAJOR MODE

Mnemonic	Function and Reference
RIMS, PWRON	Applies - 24.5 V to RIMS - Figure 27
RIMS, PWROF	Removes - 24.5 V from RIMS - Figure 27
RIMS, MEMON	Applies - 5 V to Instrument Memory - Figure 27
RIMS, MEMOF	Removes - 5 V from Instrument Memory - Figure 27
RIMS, RAPG	Grounds Radial Aperture Plane - Figure 27
RIMS, RAPP	Enables Program Radial Aperture Plane - Figure 27
RIMS, ZAPG	Grounds Z Aperture Planes - Figure 27
RIMS, ZAPP	Enables Program Z Aperture Planes - Figure 27
RIMS, RHVE	Enables Radial Channeltron High Voltage - Figure 27
RIMS, PZHVE	Enables +Z Channeltron High Voltage - Figure 27
RIMS, NZHVE	Enables -Z Channeltron High Voltage - Figure 27
RIMS, FSCAN	Imposes RPA/IMS hardware default (for memory failure) - Table 11
RIMS, MDUMP	Commands RIMS Memory Dump N.A.

MINOR MODE A

Mnemonic	Function and Reference
RHV,0	Sets Radial High Voltage to 2100 V - Figure 27
RHV,1	Sets Radial High Voltage to 2400 V - Figure 27
RHV,2	Sets Radial High Voltage to 2800 V - Figure 27
RHV,3	Sets Radial High Voltage to 1200 V - Figure 27
PZHV,0	Sets +Z High Voltage to 2100 V - Figure 27
PZHV,1	Sets +Z High Voltage to 2400 V - Figure 27
PZHV,2	Sets +Z High Voltage to 2800 V - Figure 27
PZHV,3	Sets +Z High Voltage to 1200 V - Figure 27
NZHV,0	Sets -Z High Voltage to 2100 V - Figure 27
NZHV,1	Sets -Z High Voltage to 2400 V - Figure 27
NZHV,2	Sets -Z High Voltage to 2800 V - Figure 27
NZHV,3	Sets -Z High Voltage to 1200 V - Figure 27
APP,0	Programs Aperture Potential to 0 V - Figure 27
APP,1	Programs Aperture Potential to -2 V - Figure 27
APP,2	Programs Aperture Potential to -4 V - Figure 27
APP,3	Programs Aperture Potential to -8 V - Figure 27
RTLO	Sets Radial Channeltron Threshold Low - Table 7
RTHI	Sets Radial Channeltron Threshold High - Table 7

Mnemonic	Function and Reference
PZLO	Sets +Z Channeltron Threshold Low - Table 7
PZHI	Sets +Z Channeltron Threshold High - Table 7
NZLO	Sets -Z Channeltron Threshold Low - Table 7
NZHI	Sets -Z Channeltron Threshold High - Table 7
ROCLO	Radial Overcurrent Protection 10^{-10} A - Table 8
ROCHI	Radial Overcurrent Protection 10^{-9} A - Table 8
ROCIN	Radial Overcurrent Protection Inhibited - Table 8
ROCIN3	Radial Overcurrent Protection Inhibited - Table 8
RPAT1	IMS Mode - Figure 28 and Table 9
RPAT3	RPA Mode - Table 9
MEMMI	Read IMS Memory, Default RPA to zero - Table 11
MEMMR	Read RPA Memory, Default IMS to H^+/He^+ - Table 11
MEMMF3	Alternate Memory Mode - Table 11
MEMMF	Normal and Full Memory Control - Table 11 and Figure 29
TSELI,0	Sets Collector Channel to Radial on Initial Cycle
TSELI,1	Sets Collector Channel to +Z on Initial Cycle
TSELI,2	Sets Collector Channel to -Z on Initial Cycle
TSELA,0	Sets Collector Channel to Radial on Alternate Cycle - Figure 28 and Table 9
TSELA,1	Sets Collector Channel to +Z on Alternate Cycle - Figure 28 and Table 9
TSELA,2	Sets Collector Channel to -Z on Alternate Cycle - Figure 28 and Table 9
ZSELI,0	Sets Initial Z Selection to +ZLO, -ZLO - Figure 28 and Table 9
ZSELI,1	Sets Initial Z Selection to +ZLO, +ZHI - Figure 28 and Table 9
ZSELI,2	Sets Initial Z Selection to +ZLO, -ZHI - Figure 28 and Table 9
ZSELI,3	Sets Initial Z Selection to +ZHI, -ZLO - Figure 28 and Table 9
ZSELI,4	Sets Initial Z Selection to +ZHI, -ZHI - Figure 28 and Table 9
ZSELI,5	Sets Initial Z Selection to -ZLO, -ZHI - Figure 28 and Table 9
ZSELI,6	Sets Initial Z Selection to +ZLO, -ZLO - Figure 28 and Table 9
ZSELI,7	Sets Initial Z Selection to +ZLO, -ZLO - Figure 28 and Table 9
ZSELA,0	Sets Alternate Z Selection to +ZHI, -ZHI - Figure 28 and Table 9
ZSELA,1	Sets Alternate Z Selection to +ZLO, +ZHI - Figure 28 and Table 9
ZSELA,2	Sets Alternate Z Selection to +ZLO, -ZHI - Figure 28 and Table 9
ZSELA,3	Sets Alternate Z Selection to +ZHI, -ZLO - Figure 28 and Table 9
ZSELA,4	Sets Alternate Z Selection to +ZLO, -ZLO - Figure 28 and Table 9
ZSELA,5	Sets Alternate Z Selection to -ZLO, -ZHI - Figure 28 and Table 9
ZSELA,6	Sets Alternate Z Selection to +ZHI, -ZHI - Figure 28 and Table 9
ZSELA,7	Sets Alternate Z Selection to +ZHI, -ZHI - Figure 28 and Table 9
MFT,0	Sets Toggle Period to 32 - Figure 28 and Table 9
MFT,1	Sets Toggle Period to 16 - Figure 28 and Table 9
MFT,2	Sets Toggle Period to 8 - Figure 28 and Table 9
MFT,3	Sets Toggle Period to 4 - Figure 28 and Table 9

MINOR MODE A (Concluded)

Mnemonic	Function and Reference
INIT	Initializes Minor Mode A Configuration to: RHV,0 PZHV,0 NZHV,0 APP,0 ROCLO RPAT1 MEMMF TSELI,0 TSELA,0 ZSELI,0 ZSELA,0 MFT,0

MINOR MODE B

Mnemonic	Function and Reference
IMS,XXXX	Sets IMS to Digital Value - Text, IMS/RPA Operating Systems Specified by XXXX
RPA,XXXX	Sets RPA to Digital Value - Ibid. Specified by XXXX
MA,XX	Specifies Memory Address XX - Ibid.
MLC MLC1	Clear to Load Memory Address - Ibid.
MDR	Dump Memory After Load - Ibid.

APPENDIX B

MINOR MODE A MNEMONIC REFERENCE TABLES

These tables list the look-up code which is used in the RIMS Command Sequence Program to provide a unique name for each Minor Mode A configuration. Only the first five of the eight character locations are included. The assignments into the remaining three locations are described in the text in the section on naming conventions and in Figure 31.

LOCATION NO. 1 ALTERNATE Z & T SETTING

ALTERNATE Z \ ALTERNATE T	0	1	2
0	A	B	C
1	D	E	F
2	G	H	J
3	K	L	M
4	N	P	Q
5	R	S	T
6	U	V	W
7	X	Y	Z

LOCATION NO. 2 INITIAL Z & T SETTING

INITIAL Z \ INITIAL T	0	1	2
0	A	B	C
1	D	E	F
2	G	H	J
3	K	L	M
4	N	P	Q
5	R	S	T
6	U	V	W
7	X	Y	Z

LOCATION NO. 3 – MEMORY ACCESS CONFIGURATION

	IMS				RPA			
FRAMES / TOGGLE	ALTER NATE	RPA ONLY	IMS ONLY	FULL MEM ORY	ALTER NATE	RPA ONLY	IMS ONLY	FULL MEM ORY
8	A	B	C	D	R	S	T	U
4	E	F	G	H	V	W	X	Y
2	I	J	K	L	Z	2	3	4
1	M	N	P	Q	5	6	7	8

LOCATION NO. 4 – HIGH VOLTAGE SELECT
– RESTRICTED –

RADIAL H.V. = 0

+Z / –Z	0	1	2
0	A	B	C
1	D	E	F
2	G	H	J

RADIAL H.V. = 1

+Z / –Z	0	1	2
0	K	L	M
1	N	P	Q
2	R	S	T

RADIAL H.V. = 2

+Z / –Z	0	1	2
0	U	V	W
1	X	Y	Z
2	2	3	4

LOCATION NO. 5 THRESHOLD SELECT
– RESTRICTED –

RAD. SELECT LO

+Z / –Z	LO	HI
LO	0	2
HI	3	4

RAD. SELECT HI

+Z / –Z	LO	HI
LO	5	6
HI	7	8

APPENDIX C

INTERACTIVE COMMAND SEQUENCE PROGRAM

Subsequent to completing a DE/RIMS Command Sequence form (blank copy included at the end of this appendix) it is necessary to execute the SIGMA 9 routine which formats the load for the D.E. EOCOPS catalog. A complete execution of this program is included in, and forms the balance of this section. With the exception of the first page of the operation, the program is self-explanatory. Understanding the first page requires some familiarity with the SIGMA 9 editor.

The program consists of four subsections. These are:

1) Minor Mode 'A' Commands

2) Minor Mode 'B' Commands

3) Error Checking and Correction

4) Listing of the catalog entries.

The answer of any questions within these sections is prompted by a question mark.

The only operation which is not covered by the program is a modification of the restricted settings in the Minor Mode 'A' command. To effect a change in these settings again requires a knowledge of the SIGMA 9 editor; but, with this knowledge and this document, the appropriate steps will be obvious.

```
EDIT CMD:RIMSCS
EDIT HERE
•TY 1-5
   1.000 IR F:1
   2.000 ISET F:1/RIMSCMDSEQ:INOUT:SAVE
   3.000 ILMN:RIMSCS.
   4.000 IR F:1
--EOF HIT AFTER 4.
•/RIMSCMDSEQ/S/T816E00/
--EOF HIT AFTER 4.
•TY 1-5
   1.000 IR F:1
   2.000 ISET F:1/T816E00:INOUT:SAVE
   3.000 ILMN:RIMSCS.
   4.000 IR F:1
--EOF HIT AFTER 4.
•E

!
```

```
THIS ROUTINE FORMATS A D.E. RIMS COMMAND SEQUENCE
FOR THE D.E. EOCOPS CATALOG. ANSWER THE FOLLOWING:

 ENTER MODE MNEMONIC (FIVE CHARACTERS).
?T816E
 ENTER COMMAND SEQUENCE MNEMONIC (SEVEN CHARACTERS).
?T816E00
 ENTER MINOR MODE "A" COMMANDS.

 ENTER INITIAL Z (INTEGER).
?0
 ENTER ALTERNATE Z (INTEGER).
?0
 ENTER INITIAL RPA (INTEGER).
?0
 ENTER ALTERNATE RPA (INTEGER).
?0
 ENTER TOGGLE RATE (INTEGER).
?0
 ENTER APERTURE POTENTIAL (0,1,2, OR 3).
?0
 ENTER IMS OR RPA MODE (IMS OR RPA).
?IMS

 ENTER ONE OF THE FOLLOWING CONDITIONS:
        1       ALTERNATE MEMORY MODE
        2       RPA ACCESS ONLY
        3       IMS ACCESS ONLY
        4       FULL MEMORY ACCESS

 ENTER NUMBER (1,2,3, OR 4).
?1
 IF YOU WANT TO STOP HERE, ENTER 'STOP'.
 TO CONTINUE TO THE RIMS MEMORY LOAD, HIT RETURN.
?
```

OF POOR QUALITY

ENTER MINOR MODE "B" COMMANDS.

```
MEMORY ADDRESS NUMBER: 1
ENTER RPA POTENTIAL.
?51.15
ENTER IMS SETTING.
?496.75
MEMORY ADDRESS NUMBER: 2
ENTER RPA POTENTIAL.
?51.15
ENTER IMS SETTING.
?496.75
MEMORY ADDRESS NUMBER: 3
ENTER RPA POTENTIAL.
?0.
ENTER IMS SETTING.
?496.75
MEMORY ADDRESS NUMBER: 4
ENTER RPA POTENTIAL.
?.1
ENTER IMS SETTING.
?488.55
MEMORY ADDRESS NUMBER: 5
ENTER RPA POTENTIAL.
?.15
ENTER IMS SETTING.
?496.6
MEMORY ADDRESS NUMBER: 6
ENTER RPA POTENTIAL.
?.25
ENTER IMS SETTING.
?496.5
MEMORY ADDRESS NUMBER: 7
ENTER RPA POTENTIAL.
?.45
ENTER IMS SETTING.
?493.3
MEMORY ADDRESS NUMBER: 8
ENTER RPA POTENTIAL.
?.75
ENTER IMS SETTING.
?496.
MEMORY ADDRESS NUMBER: 9
ENTER RPA POTENTIAL.
?1.2
ENTER IMS SETTING.
?495.55
MEMORY ADDRESS NUMBER:10
ENTER RPA POTENTIAL.
?1.95
ENTER IMS SETTING.
?494.8
MEMORY ADDRESS NUMBER:11
ENTER RPA POTENTIAL.
?3.25
ENTER IMS SETTING.
?493.5
MEMORY ADDRESS NUMBER:12
ENTER RPA POTENTIAL.
?5.35
ENTER IMS SETTING.
?491.4
MEMORY ADDRESS NUMBER:13
ENTER RPA POTENTIAL.
?8.8
ENTER IMS SETTING.
?487.95
MEMORY ADDRESS NUMBER:14
ENTER RPA POTENTIAL.
?14.4
ENTER IMS SETTING.
?482.35
```

```
MEMORY ADDRESS NUMBER:15
ENTER RPA POTENTIAL.
?23.7
ENTER IMS SETTING.
?473.05
MEMORY ADDRESS NUMBER:16
ENTER RPA POTENTIAL.
?39.
ENTER IMS SETTING.
?457.75
MEMORY ADDRESS NUMBER:17
ENTER RPA POTENTIAL.
?51.15
ENTER IMS SETTING.
?982.65
MEMORY ADDRESS NUMBER:18
ENTER RPA POTENTIAL.
?51.15
ENTER IMS SETTING.
?982.65
MEMORY ADDRESS NUMBER:19
ENTER RPA POTENTIAL.
?0.
ENTER IMS SETTING.
?982.65
MEMORY ADDRESS NUMBER:20
ENTER RPA POTENTIAL.
?.15
ENTER IMS SETTING.
?982.7
MEMORY ADDRESS NUMBER:21
ENTER RPA POTENTIAL.
?.2
ENTER IMS SETTING.
?982.65
MEMORY ADDRESS NUMBER:22
ENTER RPA POTENTIAL.
?.35
ENTER IMS SETTING.
?982.5
MEMORY ADDRESS NUMBER:23
ENTER RPA POTENTIAL.
?.55
ENTER IMS SETTING.
?982.3
MEMORY ADDRESS NUMBER:24
ENTER RPA POTENTIAL.
?.95
ENTER IMS SETTING.
?982.9
MEMORY ADDRESS NUMBER:25
ENTER RPA POTENTIAL.
?1.55
ENTER IMS SETTING.
?981.3
MEMORY ADDRESS NUMBER:26
ENTER RPA POTENTIAL.
?2.55
ENTER IMS SETTING.
?980.3
MEMORY ADDRESS NUMBER:27
ENTER RPA POTENTIAL.
?4.15
ENTER IMS SETTING.
?978.7
MEMORY ADDRESS NUMBER:28
ENTER RPA POTENTIAL.
?6.85
ENTER IMS SETTING.
?976.
```

```
 MEMORY ADDRESS NUMBER:29
 ENTER RPA POTENTIAL.
?11.25
 ENTER IMS SETTING.
?971.5
 MEMORY ADDRESS NUMBER:30
 ENTER RPA POTENTIAL.
?18.5
 ENTER IMS SETTING.
?964.35
 MEMORY ADDRESS NUMBER:31
 ENTER RPA POTENTIAL.
?30.4
 ENTER IMS SETTING.
?952.45
 MEMORY ADDRESS NUMBER:32
 ENTER RPA POTENTIAL.
?50.
 ENTER IMS SETTING.
?932.65
 HIT RETURN TO CONTINUE.
?
```

```
YOUR Z NUMBER IS    5629
YOUR M NUMBER IS   42637

ARE THESE ENTRIES ALL CORRECT ?

1        MODE MNEMONIC        :T816E
2        COMMAND SEQUENCE     :T816E00
3        INITIAL Z            : 0
4        ALTERNATE Z          : 0
5        INITIAL RPA          : 0
6        ALTERNATE RPA        : 0
7        TOGGLE RATE          : 0
8        APERTURE POTENTIAL: 0
9        IMS OR RPA MODE      :IMS

       1 ---- ATERNATE MEMORY MODE
       2 ---- RPA ACCESS ONLY
       3 ---- IMS ACCESS ONLY
       4 ---- FULL MEMORY ACCESS
10       CONDITION CHOSEN   : 1

HIT RETURN TO CONTINUE
?
```

ADRESS	RPA VOLTS	IMS VOLTS
1	51.15	496.75
2	51.15	496.75
3	.00	496.75
4	.10	486.65
5	.15	496.60
6	.25	496.50
7	.45	496.30
8	.75	496.00
9	1.20	495.55
10	1.95	494.80
11	3.25	493.50
12	5.35	491.40
13	8.80	487.95
14	14.40	482.35
15	23.70	473.05
16	39.00	457.75
17	51.15	982.85
18	51.15	982.85
19	.00	982.85
20	.15	982.70
21	.20	982.65
22	.35	982.50
23	.55	982.30
24	.95	982.90
25	1.55	981.30
26	2.55	980.30
27	4.15	978.70
28	6.85	976.00
29	11.25	971.60
30	18.50	964.35
31	30.40	952.45
32	50.00	932.85

11 CHANGES ANY RPA VOLTS
12 CHANGES ANY IMS VOLTS
13 REVIEWS ALL ENTRIES

```
 ENTER A NUMBER (1-13)
 ENTER 0 IF ALL ENTRIES ARE CORRECT
?0
 DO YOU WANT YOUR CARD IMAGES PRINTED ?
 ENTER Y FOR YES, OR N FOR NO.
?Y
```

```
DEF: SATID=A.
DEF: EXPT=RIMS;
     CATAL(  :OMML
CAT: MMPRE=...MSMA;
     MNAME=PLOOAAAA;
     MINOR=' NZHV:0, PZHV:0, RHV:0, NZTLO, PZTLO, RTLO, ROCLO,
            MEMMF3, APP:0, MFT:0, TSELA:0, TSELI:0, ZSELA:0,
            ZSELI:0, RPATI'.
CAT: CMDSEQ=T816E00X:0/PLOOAAAA.
CAT: MMPRE=RIMSMB;
     MNAME=L3883FF0;
     MINOR=' IMS:904, RPA:1023, MA:0, MLC'.
CAT: MNAME=L3883FF1;
     MINOR=' IMS:904, RPA:1023, MA:1, MLC'.
CAT: MNAME=L3880002;
     MINOR=' IMS:904, RPA:0, MA:2, MLC'.
CAT: MNAME=L3750023;
     MINOR=' IMS:885, RPA:2, MA:3, MLC'.
CAT: MNAME=L3870034;
     MINOR=' IMS:903, RPA:3, MA:4, MLC'.
CAT: MNAME=L3870055;
     MINOR=' IMS:903, RPA:5, MA:5, MLC'.
CAT: MNAME=L3870096;
     MINOR=' IMS:903, RPA:9, MA:6, MLC'.
CAT: MNAME=L38600F7;
     MINOR=' IMS:902, RPA:15, MA:7, MLC'.
CAT: MNAME=L3850188;
     MINOR=' IMS:901, RPA:24, MA:8, MLC'.
CAT: MNAME=L3840279;
     MINOR=' IMS:900, RPA:39, MA:9, MLC'.
CAT: MNAME=L382041A;
     MINOR=' IMS:898, RPA:65, MA:10, MLC'.
CAT: MNAME=L37E068B;
     MINOR=' IMS:894, RPA:107, MA:11, MLC'.
CAT: MNAME=L37780C;
     MINOR=' IMS:887, RPA:176, MA:12, MLC'.
CAT: MNAME=L36D1200;
```

```
        MINOR=' IMS:877, RPA:288, MA:13, MLC'.
CAT:    MNAME=L35C1DAE;
        MINOR=' IMS:860, RPA:474, MA:14, MLC'.
CAT:    MNAME=L34130CF;
        MINOR=' IMS:833, RPA:780, MA:15, MLC'.
CAT:    MNAME=L6FC3FFG;
        MINOR=' IMS:1788, RPA:1023, MA:16, MLC'.
CAT:    MNAME=L6FC3FFH;
        MINOR=' IMS:1788, RPA:1023, MA:17, MLC'.
CAT:    MNAME=L6FCL001;
        MINOR=' IMS:1788, RPA:0, MA:18, MLC'.
CAT:    MNAME=L6FC003J;
        MINOR=' IMS:1788, RPA:3, MA:19, MLC'.
CAT:    MNAME=L6FC004K;
        MINOR=' IMS:1788, RPA:4, MA:20, MLC'.
CAT:    MNAME=L6FB007L;
        MINOR=' IMS:1787, RPA:7, MA:21, MLC'.
CAT:    MNAME=L6FE00BM;
        MINOR=' IMS:1787, RPA:11, MA:22, MLC'.
CAT:    MNAME=L6FC013N;
        MINOR=' IMS:1788, RPA:19, MA:23, MLC'.
CAT:    MNAME=L6F901FO;
        MINOR=' IMS:1785, RPA:31, MA:24, MLC'.
CAT:    MNAME=L6F7033P;
        MINOR=' IMS:1783, RPA:51, MA:25, MLC'.
CAT:    MNAME=L6F5053Q;
        MINOR=' IMS:1781, RPA:83, MA:26, MLC'.
CAT:    MNAME=L6F0089R;
        MINOR=' IMS:1776, RPA:137, MA:27, MLC'.
CAT:    MNAME=L6E80E1S;
        MINOR=' IMS:1768, RPA:225, MA:28, MLC'.
CAT:    MNAME=L6DA172T;
        MINOR=' IMS:1754, RPA:370, MA:29, MLC'.
CAT:    MNAME=L6C5260U;
        MINOR=' IMS:1733, RPA:608, MA:30, MLC'.
CAT:    MNAME=D6A13E8V;
        MINOR=' IMS:1697, RPA:1000, MA:31, MDR'.
CAT:    CMDSEQ=T816E00A:0/L3883FF0, 0/L3883FF1, 0/L3880002,
```

```
          0/L3750023, 0/L3870034, 0/L3870055, 0/L3870096,
          0/L38600F7.
CAT: CMDSEQ=TB16E00B:0/L3850188, 0/L3840279, 0/L382041A,
          0/L37E06B3, 0/L377080C, 0/L36D120D, 0/L35C1DAE,
          0/L34130CF.
CAT: CMDSEQ=TB16E00C:0/L6FC3FFG, 0/L6FC3FFH, 0/L6FC0001,
          0/L6FC003J, 0/L6FC004K, 0/L6FB007L, 0/L6FB008M,
          0/L6FC013N.
CAT: CMDSEQ=TB16E00D:0/L6F901FO, 0/L6F7033P, 0/L6F5053Q,
          0/L6F0089R, 0/L6EB0E1S, 0/L6DA172T, 0/L6C5260U,
          0/D6A13E8V.
CAT: CMDSEQ=TB16E00:4/TB16E00X, 8/TB16E00A, 12/TB16E00B,
          16/TB16E00C, 20/TB16E00D.

RIMS COMMAND SEQUENCE COMPLETED.
*STOP* 0
***XEQ TERMINATED***
```

D. E./RIMS COMMAND SEQUENCE

INVESTIGATOR: ____________________

DATE: ____________________

SEQUENCE NAME = _ _ _ _ _ _ _
7 char.

MODE = _ _ _ _ _
5 char.

REGION

INVESTIGATION:

OBJECTIVE:

MINOR MODE B

ADDRESS	RPA VOLTS	IMS VOLTS
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
31		
32		

MINOR MODE A

INITIAL Z: ZSELI =

ALTERNATE Z: ZSELA =

INITIAL RPA HEAD: TSELI =

ALTERNATE RPA HEAD: TSELA =

TOGGLE RATE: MFT =

APERTURE POTENTIAL: APP =

RPA MODE ☐
IMS MODE ☐ CHECK ONE

ALTERNATE MEMORY MODE ☐
RPA DEFAULT ☐
IMS DEFAULT ☐ CHECK ONE
NORMAL MEMORY CONTROL ☐

APPENDIX D

RETARDING POTENTIAL ANALYZER SEQUENCE NAMING CONVENTION AND PROGRAMMING RULES

The RIMS RPA voltage generator has 1024 (0 to 1023) possible steps with a resolution of 0.05 V. The voltage ranges from 0 to 51.15 V. A Memory Load can program 32 sequential RPA steps. There are no restrictions on the RPA step order, as the settling time is very small.

Most RPA sequences will be either linear sequences where the adjacent step spacing is constant; or equi-log sequences where the ratio of adjacent steps is constant, that is

$$V_i + \frac{1}{V_i} = (1 + d)$$

DEFINE: S = RPA sequence index, with S ranging from 1 to N

N = number of RPA steps in the sequence

(1 + d) = Ratio of adjacent steps

Then an equi-log RPA sequence is computed by:

$$V_{RPA} = K\ (1 + d)^{S-2}$$

Such that:

For S = 1 $\quad V_{RPA} = 0$ (by definition)

For S = 2 $\quad V_{RPA} = V1$ (first non-zero step)

For S = N $\quad V_{RPA} = V_{max}$ (maximum RPA voltage)

Where N, V_1, and V_{max} are selected for a particular application.

An example is given in Table D-1:

Let

$$N = 10,\ V_1 = 0.1,\ V_{max} = 10$$

$$V_1 = K\ (1 + d)^0 => K = V_1 = 0.1$$

$$V_{max} = 10.0 = 0.1\ (1 + d)8 => (1 + d) = 1.778$$

The above equations for defining an equi-log RPA sequence can be modified slightly so that a single equation can be written for the entire sequence. The modified sequence is:

$$V_{RPA} = -K + K\ (1 + d)^{S-1} \quad .$$

Unfortunately, this form does not allow K and d to be computed analytically given V_1, V_{max}, and N. However, an approximate method is the following:

1) Select V_1, V_{max}, N.

2) Use the equation $V_{RPA} = K\ (1 + d)^{S-1}$ to compute K and d such that $V_{RPA} = V_1$ for s = 1 and $V_{RPA} = V_{max}$ for s = N. Compute all steps.

3) Modify the values by subtracting K from each value computed in (2) above.

An example is given in Table D-2:

$N = 10,\ V_1 = 0.1,\ V_{max} = 10.0$

$=> K = 0.1,\ (1 + d) = 1.668.$

RPA STEP SEQUENCES DEFINITION

General Guidelines

1) If a RPA sequence is to be used with a mass scan which requires a settling time for the IMS voltage, then that settling time should be flagged with 51.15-V settings of the RPA.

2) For RPA sequences, the first step is always 0 V, the first non-zero step is 0.1 V.

3) RPA sequences are to be identified with a single letter, excluding "I" and "O".

4) To properly supply data to the RIMS Summary Plots there must be n = 2, 3, 4, 8, or 16 zero settings of the RPA within the 32 steps. The distribution need not be exactly uniform but must, at a minimum, locate a zero setting within each 32/n bin. Greater than 16 zero settings will "turn-off" the summary plots.

RPA Sequence A — Full Equi-Log Scan

2 steps 51.15 V
30 steps 0 to 50 V Equi-Log Spacing
s = 1 $V_{RPA} = 0$
s = 2 - 30 $V_{RPA} = 0.1\ (1 + 0.2485)^{s-2}$
s = 14 $V_{RPA} = 0$

RPA Sequence B – Full Linear Scan

2 steps 51.15 V
30 steps 0 to 50 V linear spacing
$V_{RPA} = 1.724 \times (s-1)$: $s = 1 - 30$
$V_{RPA} = 0$ $s = 14$

RPA Sequence C – Low-E Equi-Log Scan

2 steps 51.15 V
30 steps 0 to 20 V Equi-Log spacing
$s = 1$ $V_{RPA} = 0$
$s = 2 - 30$ $V_{RPA} = 0.1\ (1 + 0.2083)^{s-2}$
$s = 14$ $V_{RPA} = 0$

RPA Sequence D – Equi-Log – Linear Combination

2 steps 51.15 V
10 steps 0 to 10 V Equi-Log
20 steps 10 to 50 V Linear at 2 V/step
$s = 1$ $V_{RPA} = 0$
$s = 2 - 10$ $V_{RPA} = 0.1\ (1 + 0.7783)^{s-2}$
$s = 11 - 30$ $V_{RPA} = 2\,s - 10$
$s = 14$ $V_{RPA} = 0$

RPA Sequence E – Interleaved Equi-Log Scans with 2 scans per Memory Cycle.

See Table D-3 for definition of RPA Sequence E.

RPA Sequence F – 2 Low-Energy Equi-Log Scans per Memory Cycle.

2 steps 51.15 V
14 steps 0 to 20 V Equi-Log
$s = 1$ $V_{RPA} = 0$
$s = 2 - 14$ $V_{RPA} = 0.1\ (1 + 0.5551)^{s-2}$
Repeat 1 time

RPA Sequence G – 3 Full Equi-Log Scans per Memory Cycle.

2 steps 51.15 V
8 steps 0 to 50 V Equi-Log
$s = 1$ $V_{RPA} = 0$
$s = 2 - 8$ $V_{RPA} = 0.1\ (1 + 1.817)^{s-2}$
Repeat 2 times

RPA Sequence H – 3 Low-Energy Equi-Log Scans per Memory Cycle.

2 steps 51.15 V
8 steps 0 to 20 V Equi-Log
$s = 1$ $V_{RPA} = 0$
$s = 2 - 8$ $V_{RPA} = 0.1\ (1 + 1.4183)^{s-2}$
Repeat 2 times

RPA Sequence J – 4 Full Equi-Log Scans per Memory Cycle.

2 steps 51.15 V
6 steps 0 to 50 V Equi-Log
s = 1 $V_{RPA} = 0$
s = 2 - 6 $V_{RPA} = 0.5\ (1 + 2.162)^{s-2}$
Repeat 3 times

RPA Sequence K – 4 Low-Energy Equi-Log Scans per Memory Cycle.

2 steps 51.15 V
6 steps 0 to 20 V Equi-Log
s = 1 $V_{RPA} = 0$
s = 2 - 6 $V_{RPA} = 0.5\ (1 + 1.5148)^{s-2}$
Repeat 3 times

RPA Sequence L – Full Range Equi-Log Scan with Alternating Zeroes.

s = 1, 3, 5 ---- S odd: $V_{RPA} = 0$
s = 2, 4 ------ S even: $V_{RPA} = 0.1\ (1 + 2.302)^{s-2}$

RPA Sequence M – 2 Full Equi-Log Scans per Memory Cycle.

2 steps 51.15 V
14 steps 0 to 50 V Equi-Log
s = 1 $V_{RPA} = 0$
s = 2 - 14 $V_{RPA} = 0.1\ (1 + 0.6785)^{s-2}$
Repeat 1 time

RPA Sequence N – Modified Equi-Log Scan.

See Table D-4 for definition of RPA sequencer N.

RPA Sequence P – Linear RPA Scan to study polar wind flows.

Linear Scan 0 to 10 V.
2 steps 51.15 V
30 steps 0 to 10.15 V
s = 1 $V_{RPA} = 0$
s = 2 - 20 $V_{RPA} = 0.35(s-1)$
s = 14 $V_{RPA} = 0$

RPA Sequence Q – Modified version of RPA Sequence E. Combination of linear steps up to 5 V and equi-log steps thereafter. See Table D-5 for definition of RPA Sequence Q.

TABLE D-1. EQUI-LOG RPA SEQUENCE

s	VRPA
1	0.00
2	0.100
3	0.178
4	0.316
5	0.562
6	1.00
7	1.78
8	3.16
9	5.62
10	10.00

TABLE D-2. EQUI-LOG RPA SEQUENCE FROM ONE EQUATION

s	V1RPA	VRPA
1	0.1	0.0
2	0.1668	0.067
3	0.278	0.178
4	0.464	0.364
5	0.774	0.674
6	1.29	1.19
7	2.15	2.05
8	3.59	3.49
9	5.99	5.89
10	10.00	9.90

TABLE D-3. INTERLEAVED RPA SEQUENCE E, 0 TO 50 V EQUI-LOG

Step No.	VRPA	Step No.	VRPA
1	51.15	17	51.15
2	51.15	18	51.15
3	0.00	19	0.00
4	0.10	20	0.15
5	0.15	21	0.20
6	0.25	22	0.35
7	0.45	23	0.55
8	0.75	24	0.95
9	1.20	25	1.55
10	1.95	26	2.55
11	3.25	27	4.15
12	5.35	28	6.85
13	8.80	29	11.25
14	14.40	30	18.50
15	23.70	31	30.40
16	39.00	32	50.00

TABLE D-4. RPA SEQUENCE N, MODIFIED EQUI-LOG SCAN

Step No.	VRPA	Step No.	VRPA
1	51.15	17	3.25
2	51.15	18	3.80
3	0.00	19	4.35
4	0.10	20	5.45
5	0.20	21	6.80
6	0.30	22	8.45
7	0.40	23	10.55
8	0.60	24	13.20
9	0.75	25	16.50
10	0.90	26	20.55
11	1.15	27	25.70
12	1.55	28	30.00
13	1.85	29	35.00
14	2.25	30	40.00
15	2.75	31	45.00
16	0.00	32	50.00

TABLE D-5. RPA SEQUENCE Q, LINEAR-LOG INTERLEAVED SCAN

Step No.	VRPA	Step No.	VRPA
1	51.15	17	51.15
2	51.15	18	51.15
3	0.00	19	0.00
4	0.25	20	0.50
5	0.75	21	1.00
6	1.25	22	1.50
7	1.75	23	2.00
8	2.25	24	2.50
9	2.75	25	3.00
10	3.50	26	4.00
11	4.50	27	5.35
12	6.85	28	8.80
13	11.25	29	14.40
14	18.50	30	23.70
15	30.40	31	39.00
16	50.00	32	46.00

REFERENCES

1. Balsiger, H., Eberhardt, P., Geiss, J., and Young, D. T.: Spa. Sci. Instr., vol. 2, 1976, p. 499.

2. Fields, S. A., Burch, J. L., and Oran, W. A.: Rev. Sci. Instr., vol. 48 (8), 1977, p. 1076.

3. Reasoner, D. L., Chappell, C. R., Fields, S. A., and Lewter, W. J.: Rev. Sci. Instr., vol. 53 (4), 1982, p. 0058.

APPROVAL

INSTRUMENT MANUAL FOR THE RETARDING ION MASS SPECTROMETER ON DYNAMICS EXPLORER-1

By S. A. Fields, C. R. Baugher, C. R. Chappell, D. L. Reasoner,
H. D. Hammack, W. W. Wright, and J. H. Hoffman

The information in this report has been reviewed for technical content. Review of any information concerning Department of Defense or nuclear energy activities or programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

A. J. DESSLER
Director
Space Sciences Laboratory

SECTION II

DATA ANALYSIS-REPORT EXCERPTS

REPORT No. 67 July 23, 1985

During this funding period we have brought together simultaneous measurements of the plasma environment made at high and low altitudes by DE-1 and DE-2. These measurements have been described separately in previous reports. RIMS observes a so called 'upwelling ion event' showing a mass dispersion signature such that heavier ions are observed at greater distances toward the nightside of the cusp. We have previously used this data to calculate the antisunward flow velocity to produce such a signature from a point acceleration source in the cusp region. Almost simultaneous observations from DE-2 allowed us to derive the high latitude convection signature during the event and to confirm that the required antisunward velocities of about 1 km/sec did indeed exist. The additional information that can now be added to the picture involves the existence of a confined outflow region in the cusp. The data from DE-2 show that an enhanced upward flux of thermal ions is observed in the cusp region. The thermal ion flux is in excess of $10^9 cm^{-2} sec^{-1}$. The ions observed by DE-2 do not have the energy nor do we observe the mechanism that will provide the energy with which they are observed at DE-1. Thus, while the restricted source location can be confirmed by the low altitude measurements, we can only state that the energization mechanism must exist above the DE-2 observation altitude of about 900 km. Figure 1 illustrates the available observations and their interpretation in terms of a restricted energization process in the cusp.

There appears to exist occasions when the energization process that produces the ionospheric ions seen by DE-1 does in fact occur at DE-2 altitudes. We have now identified the occasions when transversely accelerated ions are observed on DE-2 that would provide the appropriate energy ions observed by DE-1. While there are not as yet any magnetic conjunctions of this type we plan to examine the plasma conditions prevailing at the time and the flux of accelerated ions that is produced. It may be that we can reconcile these findings with the numerous observation of upflowing ions seen by DE-1.

2.0 NEXT PERIOD ACTIVITIES

a) Provide engineering support to RIMS instrument.

b) Submit final report.

c) Close contract July 31, 1985

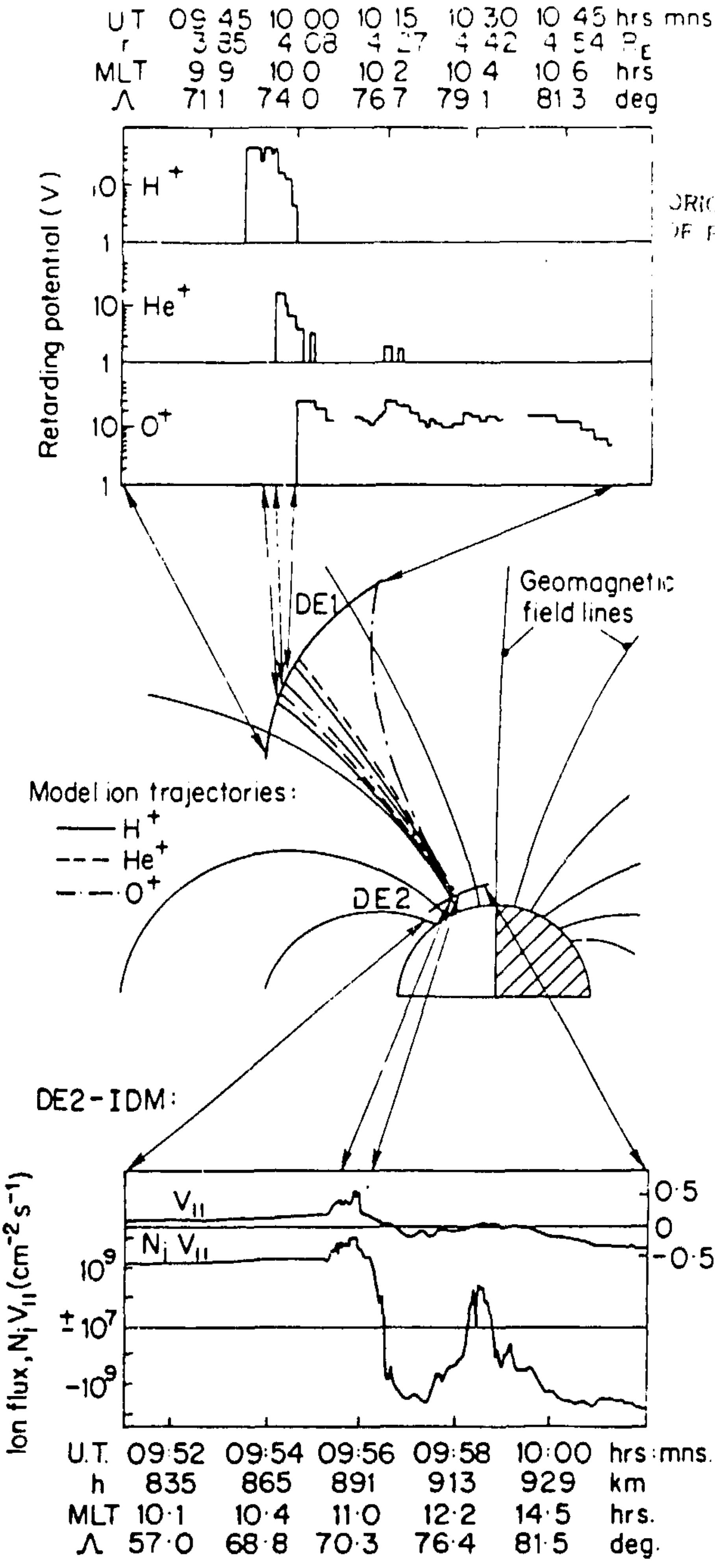


Figure 1. RIMS DATA ANALYSIS

REPORT NO. 65 DECEMBER 1984

Our work during this funding period has continued in a search for the location of ionospheric sources for thermal ions seen in the inner magnetosphere. In such a study the time required for ions energized near the altitude of DE-2 to reach the DE-1 spacecraft is an important consideration. This factor, coupled with the fact that the timing of DE-1/DE-2 coincidences is not always ideal, means that account must be taken of the E x B drift motion of the plasma. This information can be deduced from the DE-2 measurements of ion drift perpendicular to B. Figure 1 shows the ion drift velocities observed during an upward flowing ion event seen in the cusp region by both DE-1 and DE-2. By integrating this data along the satellite track it is possible to produce a candidate global convection signature that is shown by the heavy dashed curve. It shows that ions accelerated at low altitude will E x B drift almost anti-sunward along the satellite track as they move up the field lines. The DE-1 RIMS data should therefore see an energy dispersion signature that can be explained in terms of this drift motion that approaches 1 km/sec. If the source of ionospheric ions is confined in latitude and local time, then one would expect perhaps to observe a fountain effect in which close to the source one observes upgoing ions and further away in the E x B direction one sees downgoing ions. A picture of this nature is beginning to emerge.

It thus still remains to investigate the nature of the localized low altitude acceleration mechanism. Some insight into this problem can be gained by examining the local properties of the plasma at DE-2 altitudes. Figure 2 shows the fluxes of energetic electrons and ions seen at two fixed pitch angles on DE-2. The upflowing ion event reported previously was located at 23:29:20 UT at which time enhanced fluxes of relatively low energy electrons and ions are observed. Previous studies of these ion events by Heelis et.al. (1984) show them to have relative maxima in the ion flux near 90 degrees pitch angle. Both field aligned and parallel acceleration appear to be contributing to the observed acceleration in such an event. The degree to which this substorm related phenomenon observed at DE-2 correlates with the upflowing ion events observed at DE-1 has not yet been determined. There is, however, a unique opportunity to compare the details of pitch angle and energy distributions of both electrons and ions for the two good DE-1/DE-2 coincidences we have identified. This work will be pursued in the coming months.

Reference

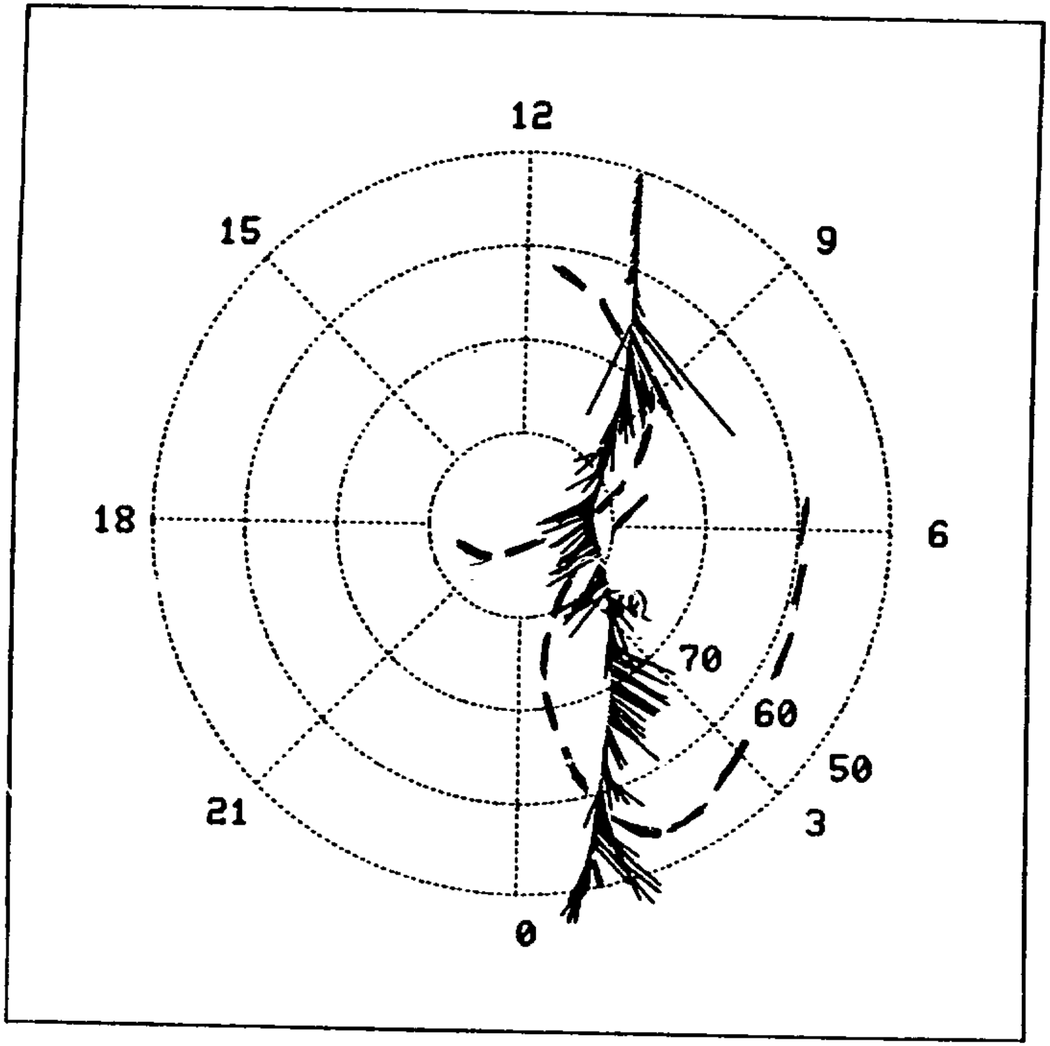
Heelis, R. A., J. D. Winningham, M. Sugiura, and N. M. Maynard, Particle acceleration parallel and perpendicular to the magnetic field observed by DE-2, J. Geophys. Res., 89, 3893-3902, 1984

RESOLUTION IS NOW EVERY 4 POI
ENTER DESIRED RESOLUTION OR RE

DE-B ION DRIFT VELOCITIES

MLT V ILAT NORTHERN HEMISPHERE

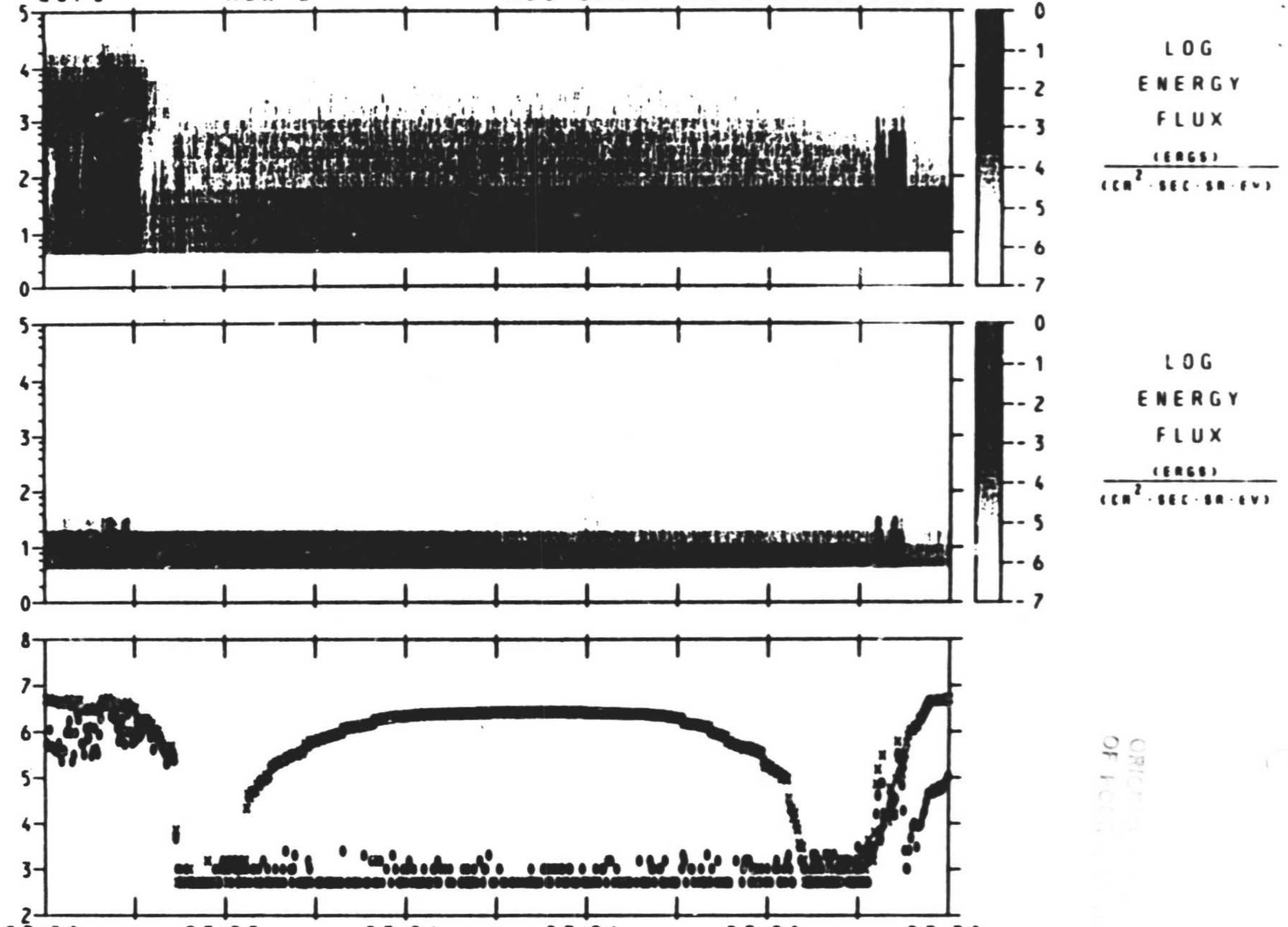
DAY 82 60 UT 23:23 ORBIT 3130



DATE: 3/ 1/82 DAY : 82060

DYNAMICS EXP)RER-2 — CRBIT # 317

GSFC — ROW B — • ALL DATA ARE UNVERIFIED.



UT (HH:MM)	23:20	23:22	23:24	23:26	23:28	23:30
IL (DEG)	73.85	79.95	82.00	77.35	70.11	62.07
MLT(HH:MM)	02:35	04:20	06:52	08:46	09:46	10:20
ALT. (KM)	533	499	466	434	404	376
LST(HH:MM)	23:51	23:51	11:46	11:50	11:50	11:50
LAT (DEG)	75.97	83.56	88.78	81.05	73.24	65.36
LONG(DEG)	10.90	10.52	-171.4	-170.9	-171.3	-171.8
SAT. DARK						

REPORT NO. 64 AUGUST 1984

During the last funding period we have devoted the majority of our time to the study of ionospheric sources for magnetospheric plasma. This study has been stimulated by the visit of a graduate student to Marshall Space Flight Center for the purpose of utilizing both DE-1 and DE-2 data.

The results of this study come from two good magnetic conjunctions of DE-1 and DE-2, from which RIMS and IDM/RPA data can be used. Both conjunctions occur in the high latitude cusp region - one when DE-1 is at high altitudes and another when it is lower in altitude. The data sets from DE-1 and DE-2 allow us to examine the prevailing conditions and the time history of particular upflowing ion events.

Figure 1 shows the signature of these events seen by DE-2. Here the drift velocity parallel to the magnetic field lines and the field-aligned ion flux are shown, along with two components of the horizontal ion drift velocity. At cusp latitudes near 10:00 hrs MLT the upward ion flux observed by DE-2 exceeds 2×10^9 cm^{-2} s^{-1} and approaches 10^{10} cm^{-2} s^{-1}. DE-1 passes through the same region about 3 minutes earlier, and the data in Figure 2 show the gradual change in pitch angle distribution and the abrupt cutoff seen on the equator edge of an upflowing ion event. Using two events of this kind, we plan to compare the O^+ fluxes observed at DE-1 and DE-2 and to use the known convective paths of the plasma to project the extent of the upflowing events in the ionosphere. A draft manuscript describing this phenomenon is in preparation.

When account is taken of the time delay between DE-1 and DE-2 passes and the ionospheric convection speed, it is possible to deduce that the initial acceleration of the ionospheric ions takes place in a confined local time and latitude region. By assuming some stationarity in the event we plan to examine the pitch angle and energy distribution of the ions and electrons on DE-1 and DE-2 to discover the possible acceleration mechanisms.

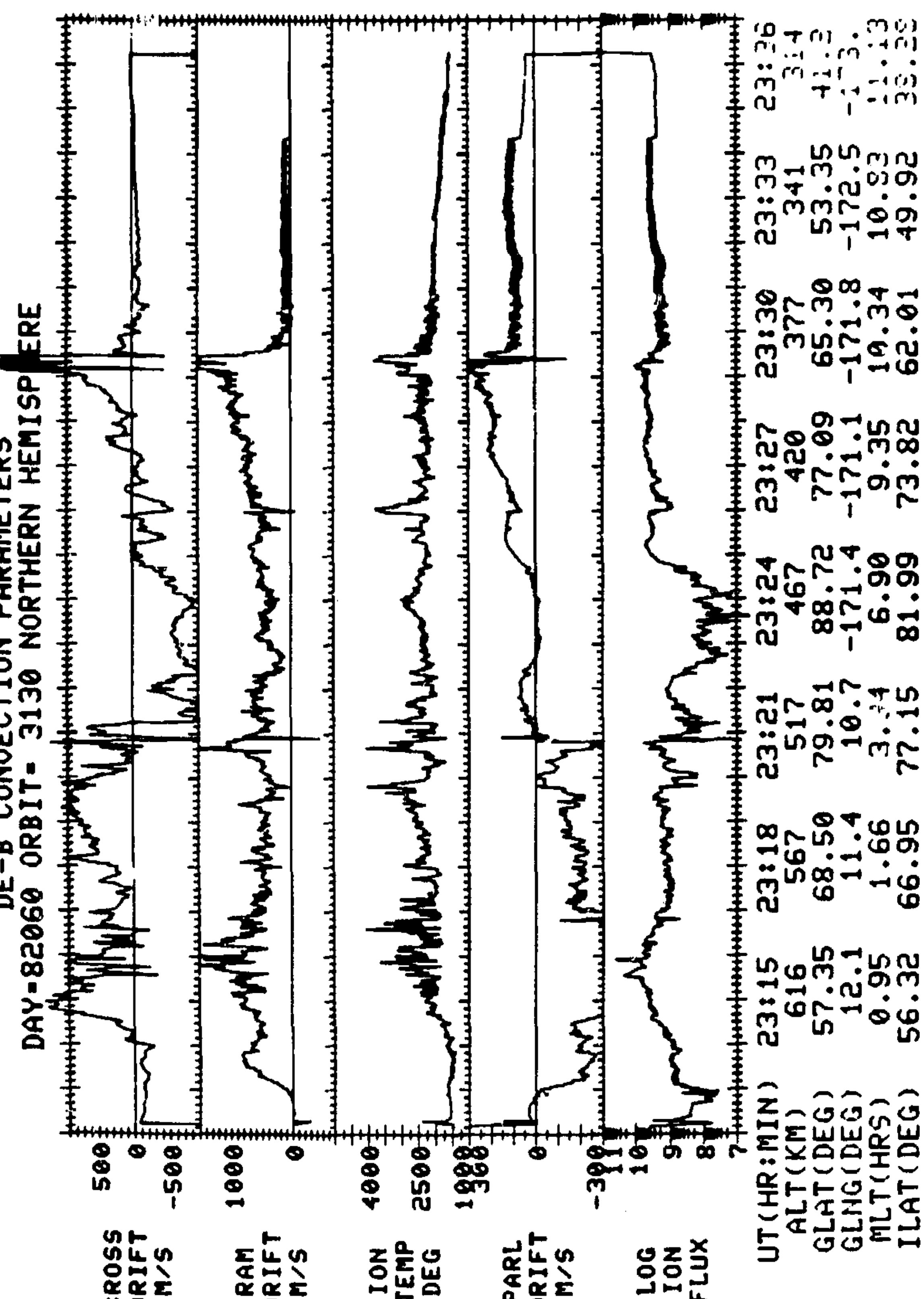

DE-B CONVECTION PARAMETERS
DAY=82060 ORBIT= 3130 NORTHERN HEMISPHERE
CROSS DRIFT M/S
500
0
-500
RAM DRIFT M/S
1000
0
ION TEMP DEG
4000
2500
1000
PARL DRIFT M/S
300
0
-300
LOG ION FLUX
11
10
9
8
7
UT(HR:MIN) 23:15 23:18 23:21 23:24 23:27 23:30 23:33
ALT(KM) 616 567 517 467 420 377 341
GLAT(DEG) 57.35 68.50 79.81 88.72 77.09 65.30 53.35
GLNG(DEG) 12.1 11.4 10.7 -171.4 -171.1 -171.8 -172.5
MLT(HRS) 0.95 1.66 6.90 9.35 10.34 10.93
ILAT(DEG) 56.32 66.95 77.15 81.99 73.82 62.01 49.92
UTD SPACE SCIENCES

FIGURE 1

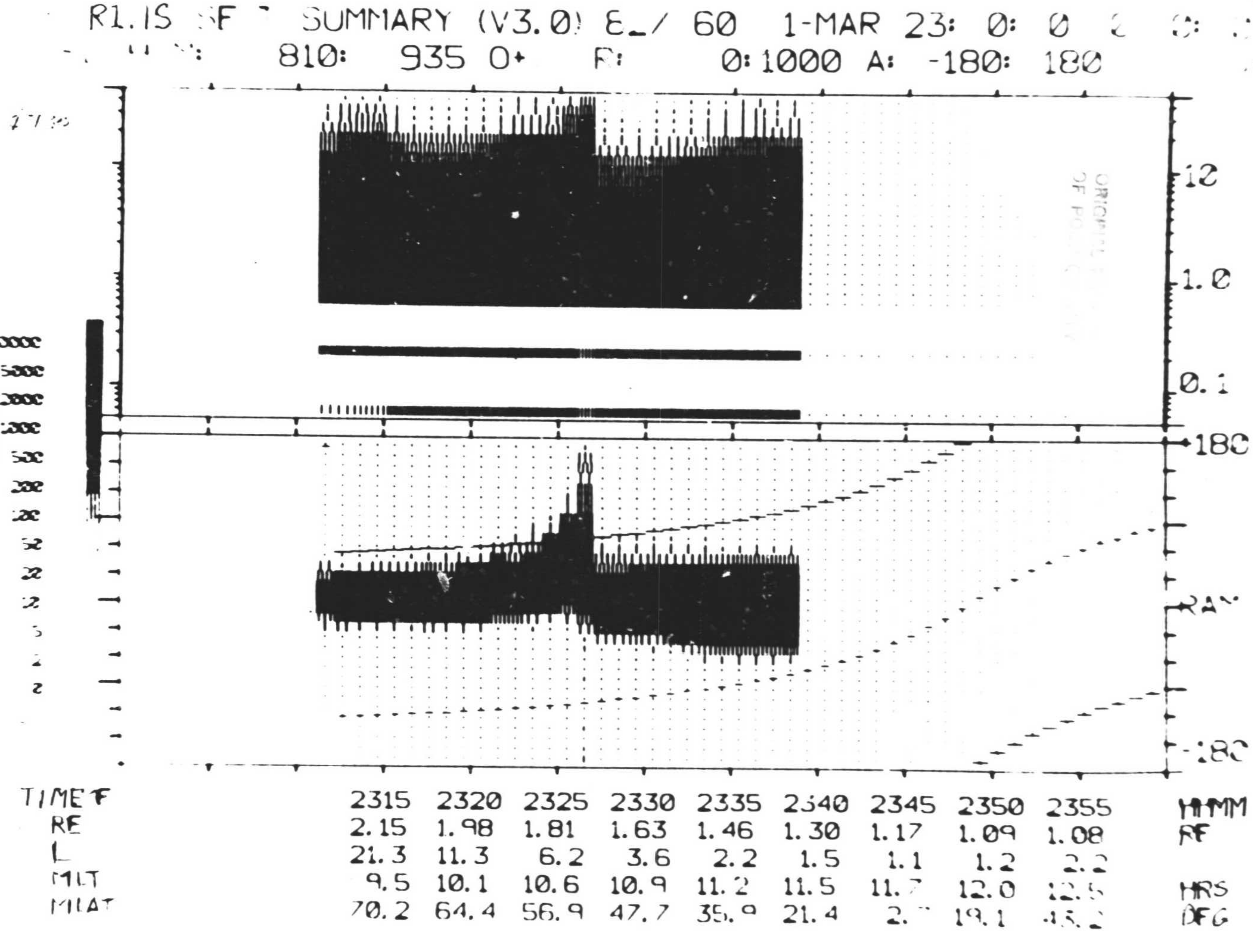

R1.IS SF SUMMARY (V3.0) E_/ 60 1-MAR 23: 0: 0
810: 935 0+ F: 0:1000 A: -180: 180
12
1.0
0.1
180
-180
TIME F 2315 2320 2325 2330 2335 2340 2345 2350 2355 HHMM
RE 2.15 1.98 1.81 1.63 1.46 1.30 1.17 1.09 1.08 RE
L 21.3 11.3 6.2 3.6 2.2 1.5 1.1 1.2
MLT 9.5 10.1 10.6 10.9 11.2 11.5 12.0 HRS
MLAT 70.2 64.4 56.9 47.7 21.4 19.1 DEG

FIGURE 2

REPORT NO. 63 MAY 1984

Work is continuing in two areas described in the last report. Despite the difficulties associated with the interpretation of the retarding potential characteristics from the RIMS instrument, we have been able to start on an intercalibration of the DE-1 and DE-2 instrumentation. In the area of magnetospheric plasma sources using DE-1 and DE-2 conjunctions, we have prepared the DE-2 ion drift data for upflowing ion events seen on DE-1 and expect one of our graduate students to visit MSFC this summer for the purpose of finalizing this study.

1. F-region space/time variations

In this area it has been our intent to intercalibrate the electrometers on DE-1 RIMS and the DE-2 RPA. The instrument function of RIMS requires that data from perigee be obtained in order that the electrometer output from this instrument can be used. Our intent has been to perform the intercalibration in both an O^+ and H^+ rich gas, but to date we have not found DE-1 and DE-2 coincidences where H^+ was the dominant ion species. There are, however, many cases when O^+ is the dominant species and DE-1 and DE-2 were sufficiently close that a useful calibration can be performed. In the last report we mentioned the rather uncharacteristic behavior of the retarding potential curve from the RIMS electrometer. Nevertheless, we feel reasonably confident that the saturation current can be usefully employed to determine the total ion concentration. Figure 1 shows a typical I-V curve obtained from the RIMS at low altitude. Applying an expression for the ion flux, F, of the form

$$F = 6.496 \times 10^{18} I$$

where I is the ion current, we can deduce a total ion concentration N_i of

$$N_i = 4.73 \times 10^5 \text{ cm}^{-3}$$

at this time. Simultaneous data taken by the RPA on DE-2 provide a total ion concentration of

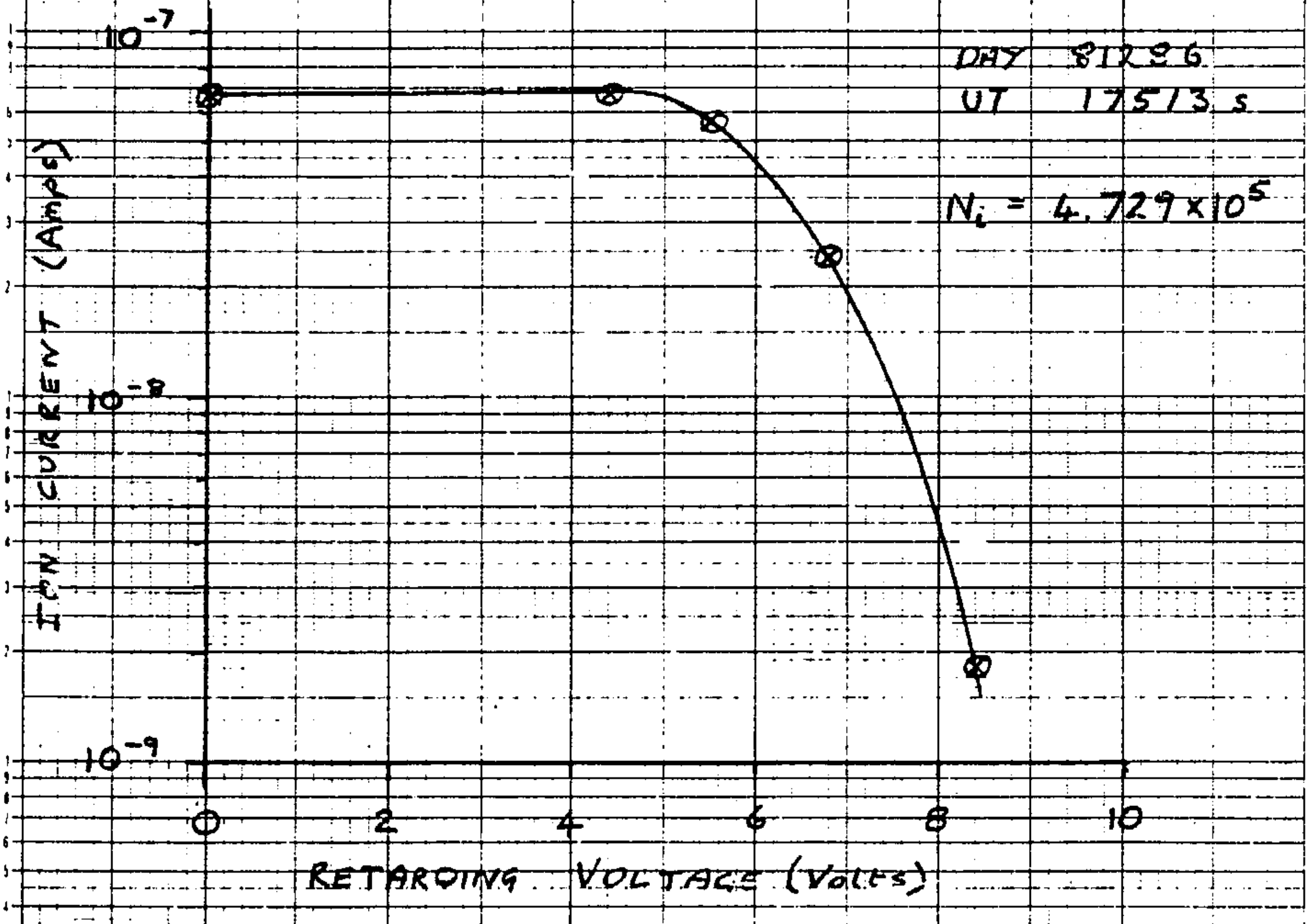
$$N_i = 4.23 \times 10^5 \text{ cm}^{-3}$$

where our best fit to the available data indicates a composition that is 98.6% O^+ and 1.4% light ions.

Both these numbers are obtained using laboratory derived constants for grid transmission and effective area. While they differ by a little more than 10% we cannot with confidence prefer one to the other without an examination or some consistent behavior. This goal is presently being pursued.

2. Ionospheric Plasma Sources

Eye examination of upflowing ion events from DE-2 has provided a very small data set of DE-1 and DE-2 conjunctions to study. The problem lies in our ability to distinguish fluxes of less than about 10^9 cm^{-2} s^{-1} except in special circumstances from DE-2. From the perspective of DE-1, however, O^+ fluxes of 2-5 x 10^8 cm^{-2} s^{-1} can represent significant contributions to the magnetospheric ion population. In order to maximize the available data set, MFSC scientists have provided us with a list of upflowing ion events seen by DE-1. We are currently reducing and examining the DE-2 data for these periods with a view to establishing the low altitude boundary conditions that must apply. This study is expected to be most productive this summer when a UTD graduate student will visit MSFC to conduct the DE-1/DE-2 data comparisons.



DAY 81226
UT 17513 s
$N_i = 4.729 \times 10^5$
10^{-7}
10^{-8}
10^{-9}
ION CURRENT (Amps)
0
2
4
6
8
10
RETARDING VOLTAGE (Volts)

FIGURE 1

REPORT NO. 62 FEBRUARY 1984

We are examining simultaneous data taken on DE-1 and DE-2 by the RIMS instrument and the IDM and RPA, respectively. Our objective is twofold: first, to compare data taken near perigee on DE-1 with that taken near the same altitude on DE-2; second, to examine plasma conditions on the same magnetic flux tube at points separated by several thousand kilometers. The scientific insight we expect to obtain pertains to the spatial and temporal evolution of F-region plasma in the first case and to the means by which F-region plasma is accelerated into the magnetosphere in the second case. These scientific goals have been necessarily preceded by a detailed data selection criteria and an analysis of the data quality which will be described here.

1. F-region space/time variations

It has been our intent to first assess the capabilities of the RIMS instrument as a retarding potential device. In previous reports we have described our efforts to use the IMS data to measure the ion temperatures and drift velocities, and the spacecraft potential. Lately we have been attempting to obtain low altitude RIMS data in conjunction with data from DE-B, with the intent of inter-calibrating the electrometer of RIMS against the DE-B RPA. The next step would be to use the calibrated electrometer to calibrate the IMS. This exercise has proved very frustrating. First there were computer tape interface problems (with a long turn-around time) that prevented us from seeing any data at all. Now we do have some data to examine, but the electrometer data themselves are difficult to interpret.

For instance, and this is where we are today, the retarding sweeps on the three attached printouts were acquired on consecutive spins near 580 km on pass #248 on day 81-286. The electrometer counts are quite consistent between sweeps, and the curves appear to saturate nicely near 800 counts ($\sim 10^{-7}$) amps), and this information is promising and could be useful. It is the cutoff characteristics that are troublesome, even though they are repetitive. There simply isn't any way that a reasonable retarding ion current could reduce by 4 decades between 8.45 and 10.55 volts. Does this mean that the retarding potential steps are different from the printout values above 8.45 volts? If so, has this always been the case? Why is there no noise level signal on the electrometer? It was built with one, as I understand it. As we find answers to these questions we should progress toward our objectives, but this may well require seeing much larger volumes of data than have so far been examined.

2. Ionospheric plasma sources

Recently a list of magnetic conjunctions between DE-1 and DE-2 has been prepared, and those occurring in the northern auroral zone when DE-1 and DE-2 are separated by several thousand kilometers have been examined. Figure 1 shows an example of the ion drift signature on DE-2 that we have used to detect field-aligned ion flow. A small list of these events has been created, and we are presently examining the DE-2 data quality and interpretation in terms of possible ion acceleration mechanisms. These include intense field-aligned currents for spatially confined events and plasma expansion due to Joule heating for events over larger spatial scales such as are shown here. Identification of the appropriate DE-1 data segments and an interpretation of the RIMS data will now be sought. We expect that the available data sets with identifiable and reproducible characteristics on DE-1 and DE-2 may be quite small and that only case study analysis will be possible. Such an analysis should, however, provide useful insights to the problem and we expect to have made significant progress in the next few months.

TABLE I

					R.V.	Counts
BLOCK, #=	1					
0,00	1	0	4	0	16.35	846
0,05	1	0	4	0	15.42	844
0,10	1	0	4	0	14.49	844
0,15	1	0	4	0	13.56	843
0,20	1	0	4	0	12.54	841
0,25	1	0	4	0	11.71	839
0,30	1	0	4	0	10.78	836
0,40	1	0	4	0	9.85	834
0,45	1	0	4	0	8.92	831
0,60	1	0	4	0	7.99	328
0,75	1	0	4	0	7.07	828
0,90	1	0	4	0	6.14	827
1,15	1	0	4	0	5.21	826
0,00	1	0	4	0	4.28	841
1,00	1	0	4	0	3.35	827
2,25	1	0	4	0	2.42	827
2,80	1	0	4	0	1.50	827
3,50	1	0	4	0	0.57	827
4,35	1	0	4	0	-0.35	828
5,45	1	0	4	0	-1.28	830
6,80	1	0	4	0	-2.21	823
8,45	1	0	4	0	-3.14	764
10,55	1	0	4	0	-4.27	0
13,20	1	0	4	0	-4.99	0
16,50	1	0	4	0	-5.92	0
20,55	1	0	4	0	-6.85	0
25,70	1	0	4	0	-7.78	0
32,05	1	0	4	0	-8.71	0
40,05	1	0	4	0	-9.64	0
50,00	1	0	4	0	-10.56	0
51,15	1	0	4	0	-11.49	0
51,15	1	0	4	0	-12.42	0

ORIGINAL PAGE IS
OF POOR QUALITY

TABLE II

BLOCK,#= 2

					R.V.	Counts
0,00	1	0	4	0	19.79	849
0,05	1	0	4	0	18.86	847
0,10	1	0	4	0	17.93	847
0,15	1	0	4	0	17.00	845
0,20	1	0	4	0	16.08	844
0,25	1	0	4	0	15.15	843
0,30	1	0	4	0	14.22	841
0,40	1	0	4	0	13.29	839
0,45	1	0	4	0	12.36	835
0,60	1	0	4	0	11.43	831
0,75	1	0	4	0	10.51	830
0,90	1	0	4	0	9.58	830
1,15	1	0	4	0	8.65	827
0,00	1	0	4	0	7.72	844
1,80	1	0	4	0	6.79	828
2,25	1	0	4	0	5.86	828
2,80	1	0	4	0	4.93	829
3,50	1	0	4	0	4.01	829
4,35	1	0	4	0	3.08	829
5,45	1	0	4	0	2.15	832
6,80	1	0	4	0	1.22	823
8,45	1	0	4	0	0.29	767
10,55	1	0	4	0	-0.63	0
13,20	1	0	4	0	-1.55	0
16,50	1	0	4	0	-2.48	0
20,55	1	0	4	0	-3.41	0
25,70	1	0	4	0	-4.34	0
32,05	1	0	4	0	-5.27	0
40,05	1	0	4	0	-6.20	0
50,00	1	0	4	0	-7.12	0
51,15	1	0	4	0	-8.05	0
51 15	1	0	4	0	-8.98	0

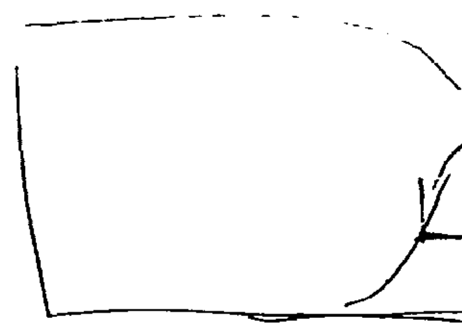


TABLE III

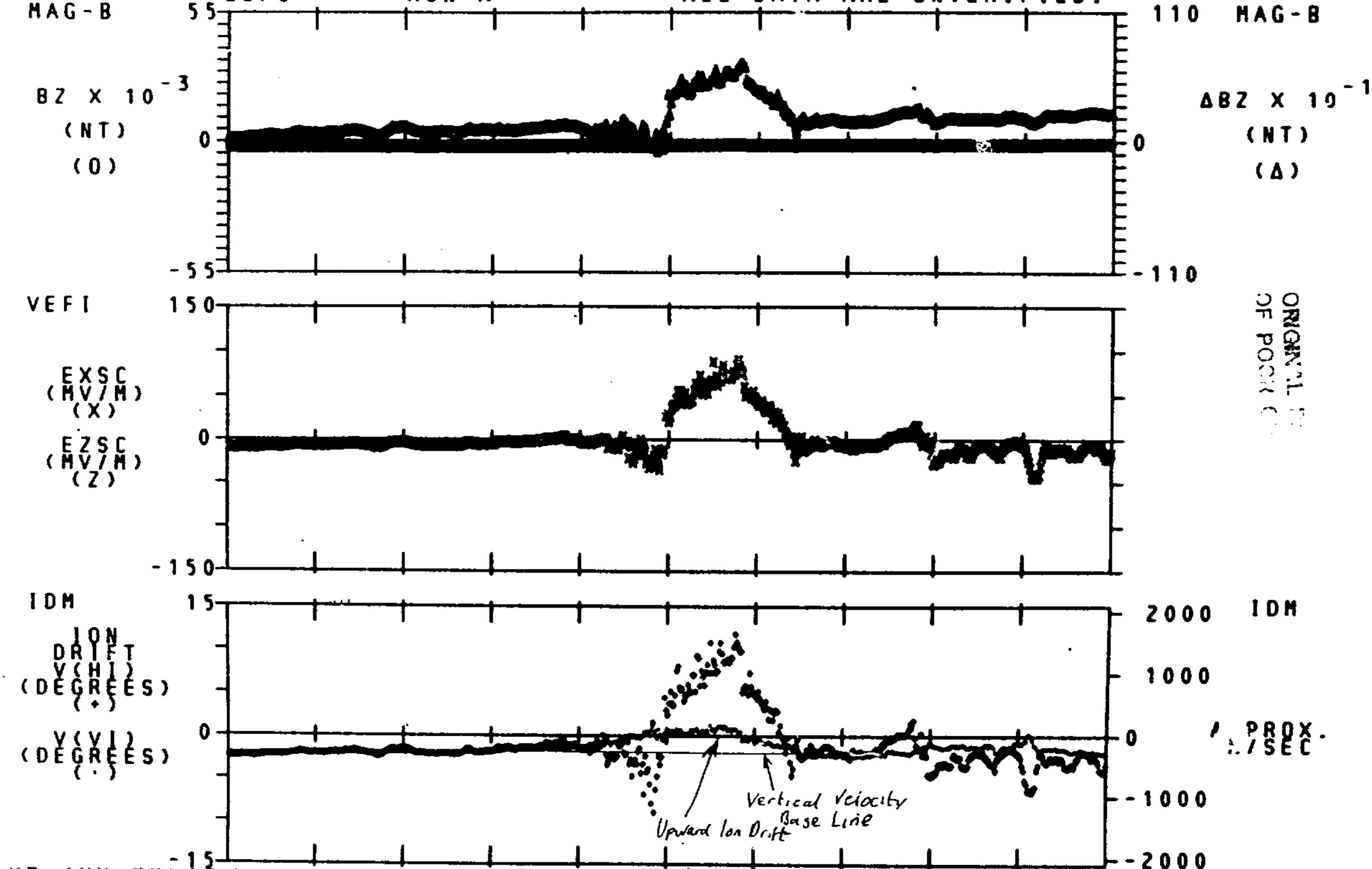
BLOCK,#= 2

					K.V.	Counts
0,00	1	0	4	0	23.27	852
0,05	1	0	4	0	22.34	851
0,10	1	0	4	0	21.41	849
0,15	1	0	4	0	20.48	848
0,20	1	0	4	0	19.56	846
0,25	1	0	4	0	18.63	846
0,30	1	0	4	0	17.71	843
0,40	1	0	4	0	16.77	841
0,45	1	0	4	0	15.84	835
0,60	1	0	4	0	14.91	831
0,75	1	0	4	0	13.99	832
0,90	1	0	4	0	13.06	831
1,15	1	0	4	0	12.13	828
0,00	1	0	4	0	11.20	842
1,80	1	0	4	0	10.27	827
2,25	1	0	4	0	9.34	828
2,80	1	0	4	0	8.42	829
3,50	1	0	4	0	7.49	827
4,35	1	0	4	0	6.56	828
5,45	1	0	4	0	5.63	831
6,80	1	0	4	0	4.70	823
8,45	1	0	4	0	3.77	768
10,55	1	0	4	0	2.84	0
13,20	1	0	4	0	1.92	0
16,50	1	0	4	0	0.99	0
20,55	1	0	4	0	0.06	0
25,70	1	0	4	0	-0.86	0
32,05	1	0	4	0	-1.79	0
40,05	1	0	4	0	-2.72	0
50,00	1	0	4	0	-3.64	0
51,15	1	0	4	0	-4.57	0
51,15	1	0	4	0	-5.50	0

DATE : 10/19/81
DAY : 81292

DYNAMICS. EXPLORER-2 * ORBIT # 1139

GSFC ROW A * ALL DATA ARE UNVERIFIED.



UT (HH:MM)	13:50	13:52	13:54	13:56	13:58	14:00
IL (DEG)	59.86	66.22	72.45	78.55	999.00	999.00
MLT(HH:MM)	09:01	08:58	08:52	08:39	07:49	23:21
ALT. (KM)	750	788	823	854	882	906
LST(HH:MM)	09:06	09:06	09:06	09:06	09:06	09:06
LAT (DEG)	46.27	53.39	60.43	67.39	74.29	81.14
LONG (DEG)	-74.75	-75.25	-75.74	-76.23	-76.71	-77.15
SAT. DARK						

REPORT NO. 59 MAY 1983

We are working on calibrating the RIMS radial electrometer with coincidence observation from the RPA on board the DE-B satellite. One such orbit was found for DE-A on day 81290 between 17:29 to 18:29 UT on orbit A264. The corresponding orbit for DE-B was found to be on day 81290 between 18:13 to 18:28 UT on orbit B1112. Figure 1 shows a portion of this coincident pass. Ion temperature obtained from a least squares fit to the RIMS data, as discussed in the last report (and as shown in Figure 2), with respect to the distance from the earth's center in earth radii is plotted. We are still in the process of calibration and hope to report the final result in the next report.

Next we plan to finish calibration of the RIMS electrometer so that we can get the absolute value of the ion concentration. We plan to analyze several DE-A passes from perigee height to apogee height and see the effect on ion temperature, ion concentration, drift velocity, and vehicle potential of different ionospheric and magnetospheric regions.

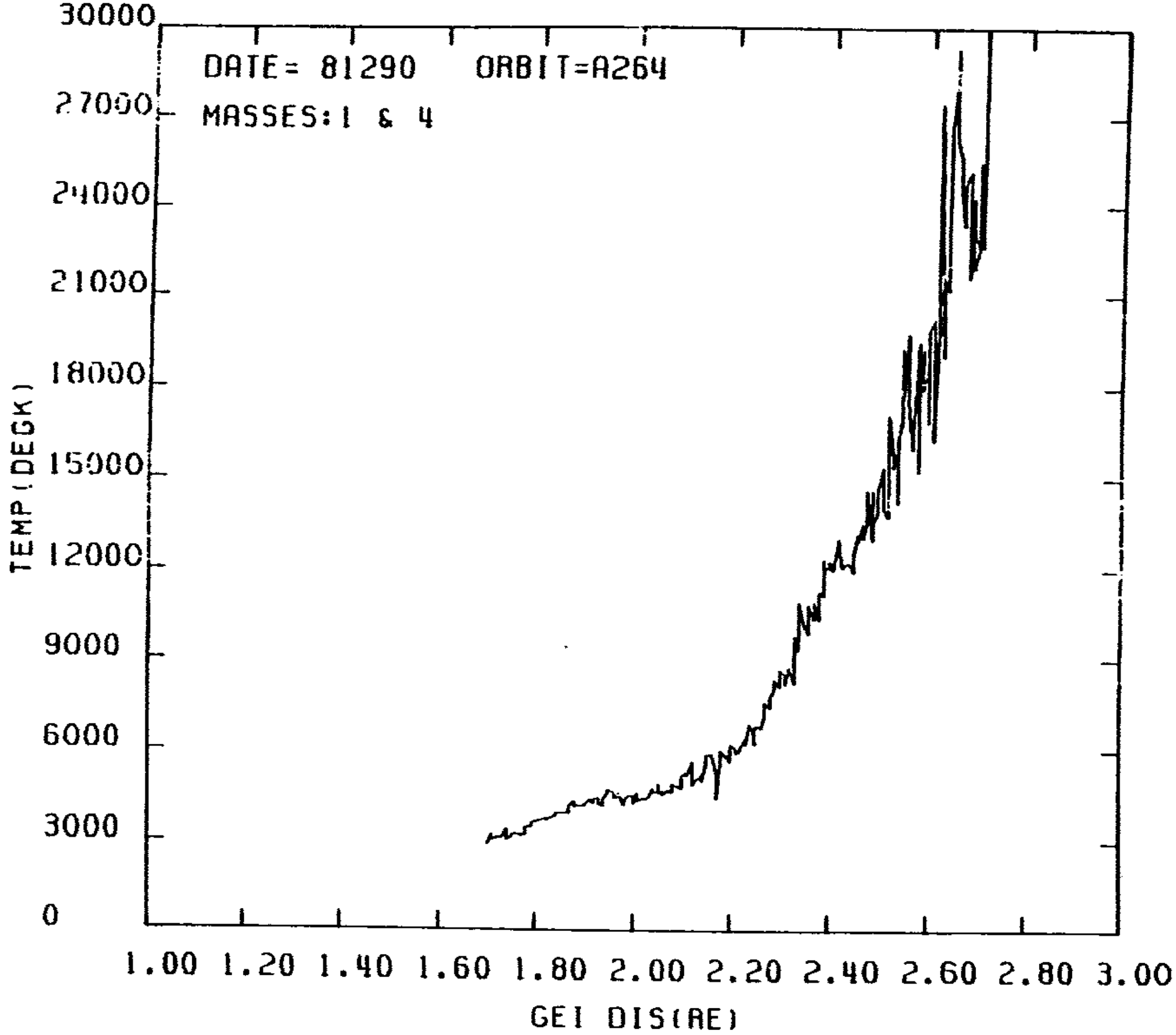

DATE= 81290 ORBIT=A264
MASSES:1 & 4
30000
27000
24000
21000
18000
15000
12000
9000
6000
3000
0
TEMP(DEGK)
1.00 1.20 1.40 1.60 1.80 2.00 2.20 2.40 2.60 2.80 3.00
GEI DIS(RE)

FIGURE 1

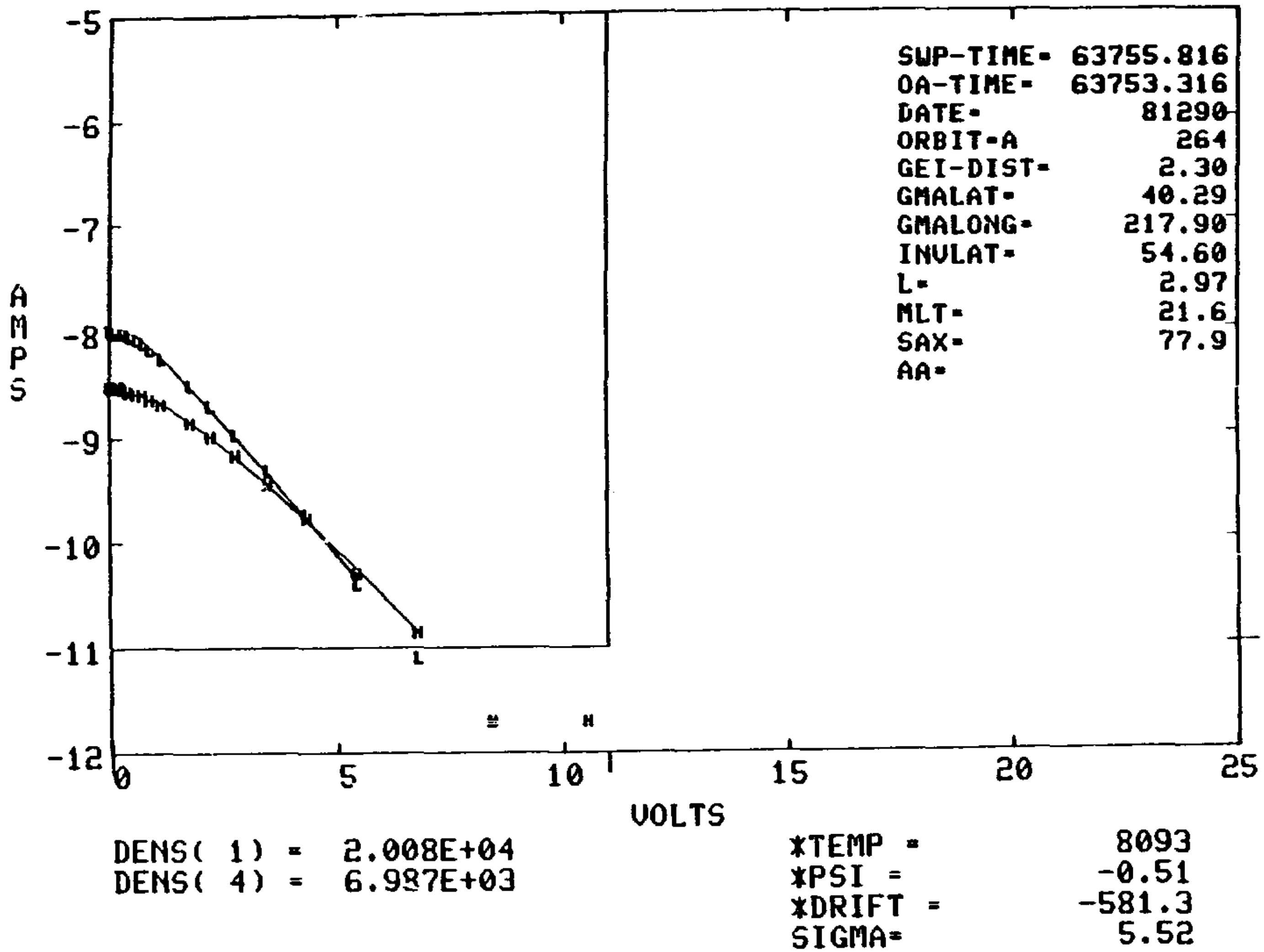

AMPS
VOLTS
-5
-6
-7
-8
-9
-10
-11
-12
0
5
10
15
20
25
SWP-TIME= 63755.816
OA-TIME= 63753.316
DATE= 81290
ORBIT-A 264
GEI-DIST= 2.30
GMALAT= 40.29
GMALONG= 217.90
INVLAT= 54.60
L= 2.97
MLT= 21.6
SAX= 77.9
AA=
DENS(1) = 2.008E+04
DENS(4) = 6.987E+03
*TEMP = 8093
*PSI = -0.51
*DRIFT = -581.3
SIGMA= 5.52

FIGURE 2

REPORT NO. 58 DECEMBER 1982

A number of computer programs have been written and tested to process and analyze RIMS data at UTD. A program to least squares analyze simultaneously more than one ion curve (with more than one retarding potential curve) from RIMS has been written and tested. By assuming the same ion temperature, vehicle potential and drift velocity along the x-axis of the spacecraft, a high mass and low mass curve are solved simultaneously utilizing a least squares approach. A program to plot this result was written and an example is presented in Figure 1. It shows RIMS current versus retarding voltage for a high mass and a low mass curve. A number of these curves have been analyzed by the above approach. The result of these analyses is shown in Figure 2 where the plot program presents the parameters obtained against geophysical quantities. Ion temperature for masses 1 and 4 are plotted versus invariant latitude for orbit A360. Also the average values of the saturation portion of the individual curves have been plotted (Figure 3) as RAW-RIMS (counts) with respect to time. The average angle of attack (AA) is shown on the same plot. A comparison of the two plots indicates any off-set in angle of attack due to drift velocity.

Next we plan to calibrate the ion concentration scale for the RIMS data by utilizing the DE-B RPA data for the same region and time. We should start routine least squares analysis of RIMS data during the next quarter. Over a period of time we also plan to compare the different ion temperatures obtained from different low mass and high mass combinations, e.g. 1 and 4, 2 and 8, 4 and 16. More data and time are needed to perform this analysis.

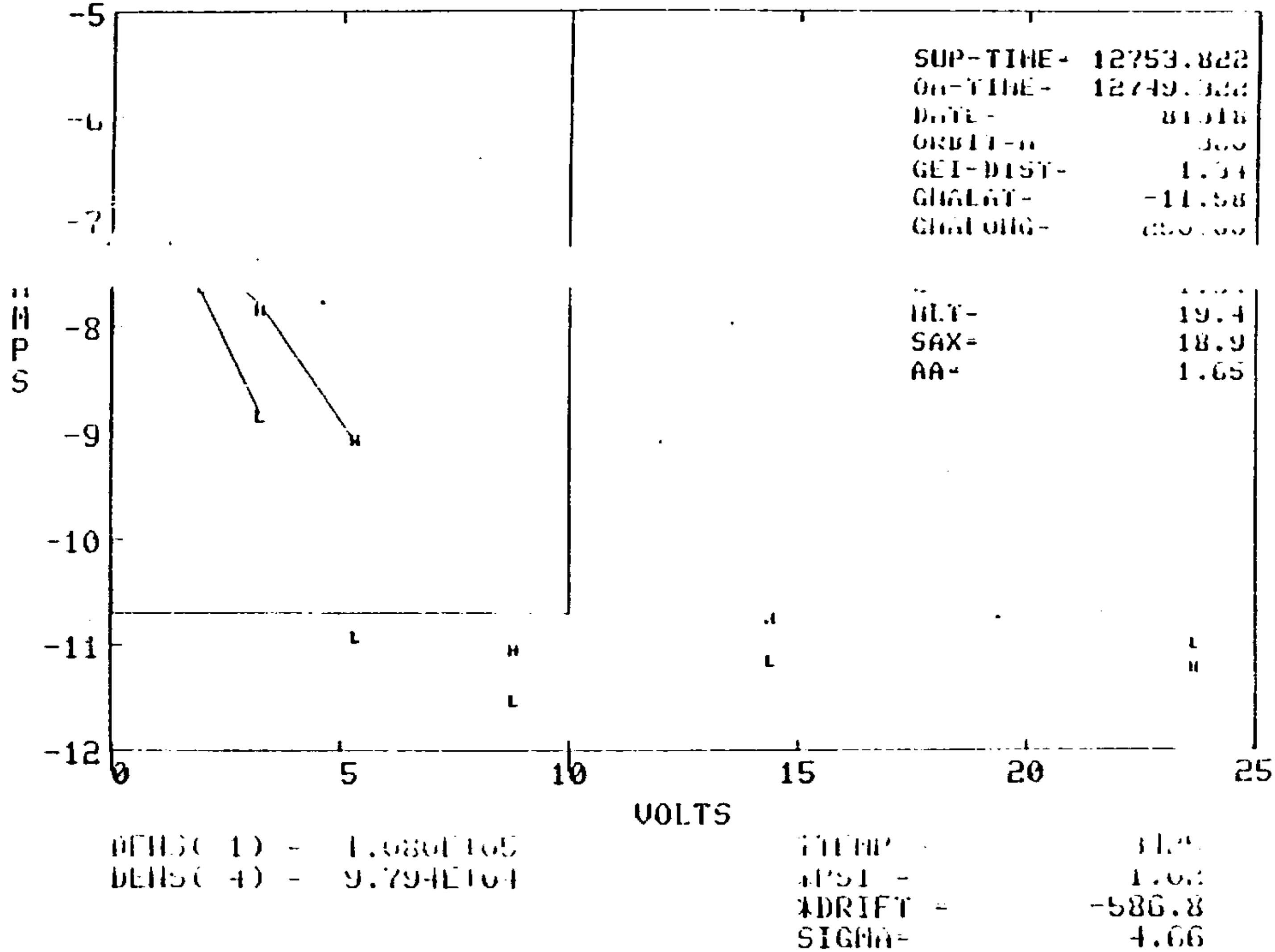
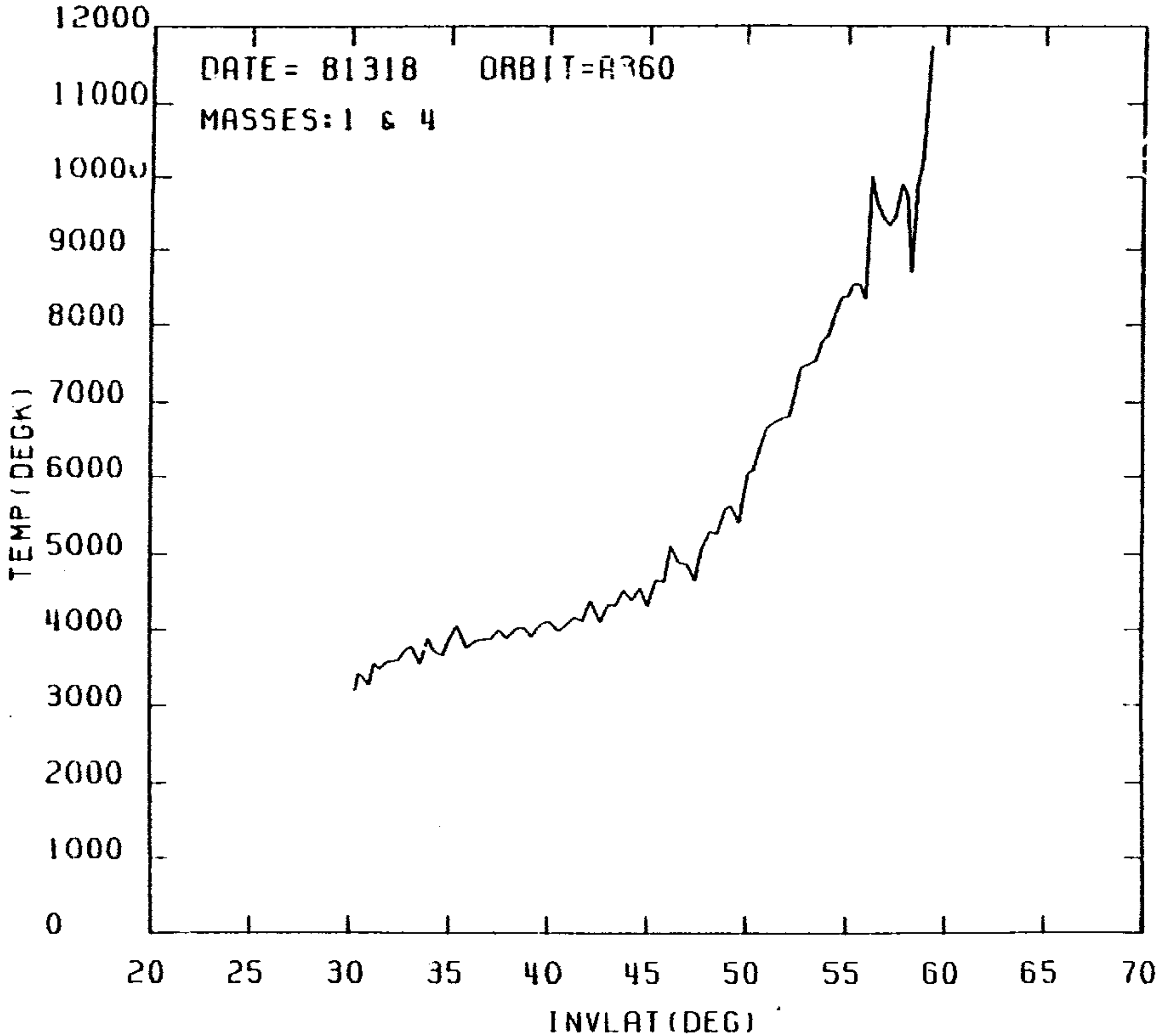

SUP-TIME- 12753.822
GEI-DIST- 1.34
GHALAT- -11.58
ALT- 19.4
SAX= 18.9
AA= 1.65
VOLTS
AMPS
DENS(4) - 9.794E+04
4DRIFT = -586.8
SIGMA- 4.66

FIGURE 1



DATE= 81318 ORBIT=A360
MASSES:1 & 4
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
TEMP(DEGK)
20
25
30
35
40
45
50
55
60
65
70
INVLAT(DEG)

FIGURE 2

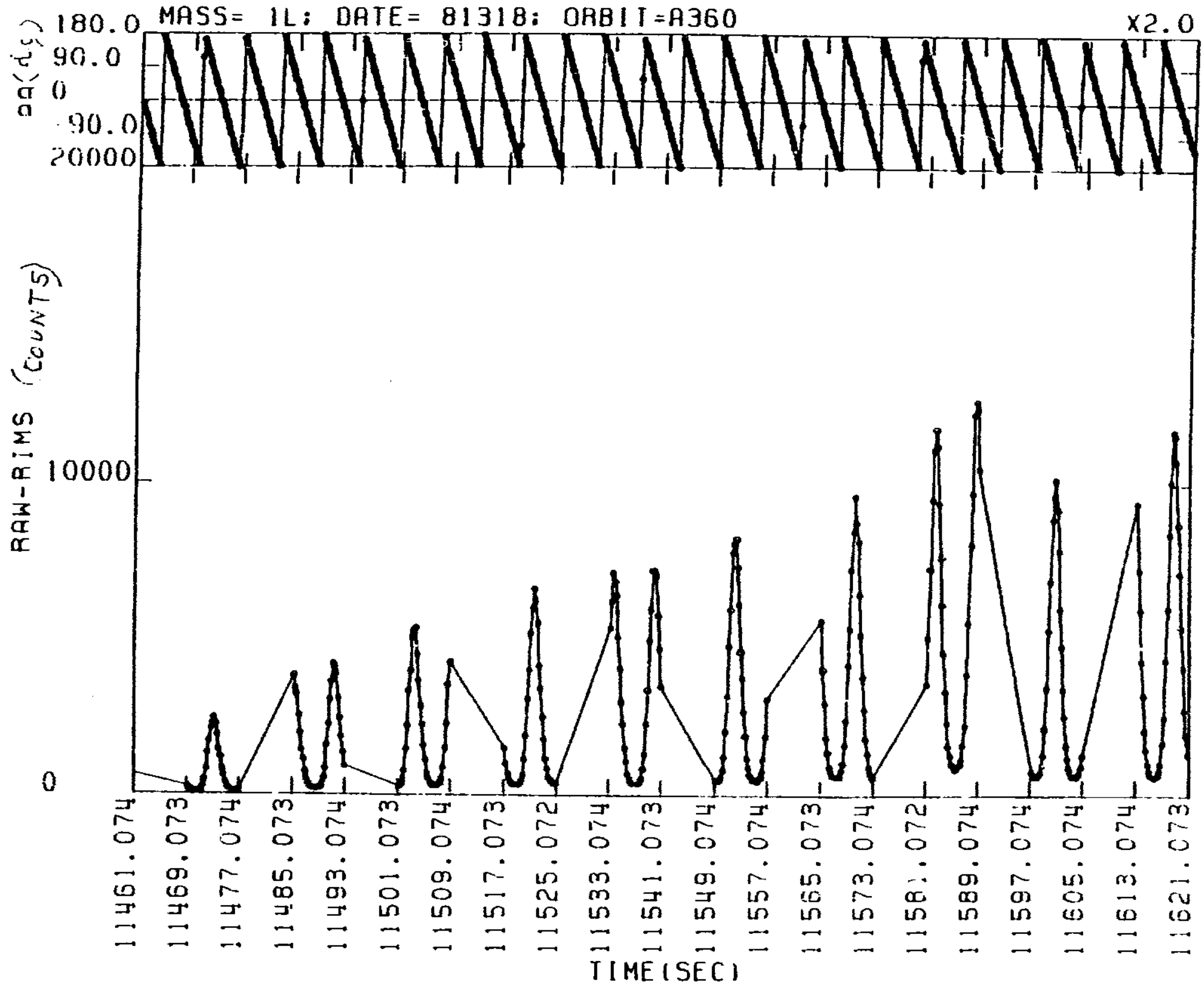

MASS= 1L; DATE= 81318; ORBIT=A360
X2.0
αα(deg)
180.0
90.0
0
-90.0
20000
10000
0
RAW-RIMS (COUNTS)
11461.074
11469.073
11477.074
11485.073
11493.074
11501.073
11509.074
11517.073
11525.072
11533.074
11541.073
11549.074
11557.074
11565.073
11573.074
11581.072
11589.074
11597.074
11605.074
11613.074
11621.073
TIME(SEC)

FIGURE 3

N82-30527

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16. ABSTRACT

The Retarding Ion Mass Spectrometer (RIMS) for Dynamics Explorer-1 is an instrument designed to measure the details of the thermal plasma distribution. It combines the ion temperature determining capability of the retarding potential analyzer with the compositional capabilities of the mass spectrometer and adds multiple sensor heads to sample all directions relative to the spacecraft ram direction. This manual provides a functional description of the RIMS, the instrument calibration, and a description of the commands which can be stored in the instrument logic to control its operation.

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