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**An Instrument for Observing
Transient Cosmic Gamma-Ray Sources for the
ISEE-C Heliocentric Spacecraft**

W. D. Evans
W. P. Aiello
R. W. Klebesadel

MASTER

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AN INSTRUMENT FOR OBSERVING TRANSIENT COSMIC GAMMA-RAY SOURCES
FOR THE ISEE-C HELIOCENTRIC SPACECRAFT

by

NOTICE

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ABSTRACT

This report describes satellite instrumentation that would serve as one element of a three-satellite network to provide precise directional information for the recently discovered cosmic gamma-ray bursts. The proposed network would be capable of determining source locations with uncertainties of less than one arc minute, sufficient for a meaningful optical and radio search. The association of the gamma bursts with a known type of astrophysical object provides the most direct method for establishing source distances and thus defining the overall energetics of the emission process.

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I. INTRODUCTION

In 1973 Klebesadel et al.¹ announced the discovery of intense, short-duration bursts of gamma-ray photons, apparently of cosmic origin. This discovery was based on several years of data from the gamma-ray monitoring detectors on the network of Vela satellites and consisted of the detection of nearly simultaneous increases in the > 0.1 -MeV photon flux by several satellites at locations up to 240 000 km apart. This discovery ultimately might have been made by the extensive comparison of data from a variety of detectors on other satellites, but no single counting-rate increase observed with one instrument alone, and occurring only several times per year, would have been sufficient to establish the effect as genuine. In addition, the intersatellite timing provided by

the Vela system gave a means of determining the direction of propagation of the photon wavefront through space. It is this result that guaranteed that the bursts originated well outside the Earth's environment. The publication of this discovery was followed by a number of confirmatory observations and by measurements of some of the spectral, temporal, and directional characteristics of a number of burst events. Cline et al.² showed that the incident flux was unambiguously composed of hard photons, mostly in the 100 to several hundred-keV energy range, and Wheaton et al.³ independently found the direction of one event to agree with the source direction determined by the timing measurements from the Vela network. The examination of data from existing experiments during the following year and a half yielded additional time histories, spectral measurements, and directional locations, all of which generally agreed in scope with these initial observations. At the present time a total of 34 events have been identified, the initial detection of 27 having been made by the Vela satellites.

The striking nature of the cosmic gamma bursts resulted in immediate attention from the astrophysical community. The fluxes are extremely high, completely dominating all celestial and local background. The directionally isotropic distribution of the sources indicates either a stellar origin in the galactic neighborhood of the sun or an extragalactic origin. Even at stellar distances, the source luminosities exceed that of solar flares in the same energy range by about 12 orders of magnitude. Rapid fluctuations in intensity with time scales of tens of milliseconds are characteristic of the sources, indicating a maximum source size of about 5000 km. If the source area is compared with that of a Class 3 solar flare, the hard photon density in the source volume is at least a factor of 10^{15} greater.

The stimulation to theorists from this unexpected phenomenon where the parameters are so extreme - intense flux, brief duration, fine time structure, and hard spectra - has led to the publication of a large number of hypothetical source models. More than a year after these publications first began to appear, there is still no consensus as to the correct model. The reason is very simple; the existing data, although good enough to be exciting and stimulating for the production of models, are insufficient to provide any critical tests.

Suggested sources of gamma-ray bursts included supernovae, stellar superflares on magnetic white dwarf stars, "directed" flares on dwarf stars, nuclear flashes on novae, impacting comets on neutron stars, the accretion of material onto a neutron star from a giant binary companion, radiation from relativistic grains of matter entering the radiation field of the sun, decay of nuclear "goblins" (a kind of super-massive nucleus), the collapse of a dwarf star to a neutron star or black hole due to the accumulation of material from a binary companion or from interstellar material, matter-antimatter collisions, enhanced radiations from accretion disks due to supercritical mass flow, radiation accompanying "glitches" on old neutron stars, and several others. It is an imaginative list but, as stated above, the current observational data are inadequate to distinguish between competing theories.

While the instruments on existing satellites will undoubtedly continue to provide the identification of additional gamma bursts, such additional information is unlikely to produce significant observational evidence to further our understanding of the nature of the sources. New and more sophisticated experiments are needed to provide detailed spectral and temporal measurements and more precise directional information.

II. RESEARCH APPROACH

A primary objective of future observations of the transient gamma sources is the very precise determination of source directions. The required accuracies of minutes-of-arc cannot be achieved with any presently developed techniques of gamma-ray "telescopes." However, precise intersatellite timing from a network of widely separated detectors can provide the necessary results in a straightforward way. For any two satellites A and B separated by a distance d , the angle α between the direction to a distant source and the line joining A and B is:

$$\cos \alpha = \frac{c\tau}{d} ,$$

where: c = velocity of light

T = difference in the time of arrival of the signal at A and B.

The angle α defines a cone which projected onto the celestial sphere gives a circle of possible source locations. Observation from a third satellite provides an independent circle of possible source locations, and the intersections of the two circles define two possible source locations. The uncertainty in α is:

$$\Delta\alpha = \frac{c\Delta\tau}{d\sin\alpha} = \frac{1}{\sin\alpha} \left(\frac{c\Delta\tau}{d} \right), \text{ and let } T = \frac{d}{c}.$$

Thus, the greater the baseline separation between satellites, the more accurately can the source positions be determined.

This is the same method used with the Vela satellite data to make the original determinations of source directions with accuracies of a few degrees. ($T \approx 0.8$ for the Vela satellites.) With the proper implementation of planned NASA satellites it will be possible in the time period 1978-1979 to apply this technique with accuracies improved by almost three orders of magnitude. The three satellites that are most desirable as observing platforms are:

(1) ISEE-A (Mother) - Scheduled for launch in 1977 this satellite will be placed in a highly elliptical earth orbit.

(2) Pioneer Venus Orbiter - To be launched in 1978 this satellite will be placed in an orbit about Venus and will provide an intersatellite baseline of 1 A.U. ($T = 500$).

(3) ISEE-C (Heliocentric) - Also scheduled for a 1978 launch, the Heliocentric is to be placed on the sun-earth line, 0.01 A.U. from the earth. ($T = 5$)

Work is currently in progress at the Max Planck Institute for Extraterrestrial Physics to modify an instrument for the ISEE-A satellite to provide the capability for observing the gamma bursts. A LASL proposal for a gamma burst detector for the Venus Orbiter has been accepted by NASA and is currently being implemented.

Since the planning for the Helio-centric Mission (ISEE-C) had progressed beyond the initial payload selection, the possibility of modifying an already planned experiment to provide the capability for gamma-ray observations was an attractive alternative to including a new experiment. The Solar X-Ray Spectrometer Experiment, proposed by the University of California, Berkeley Space Sciences Laboratory (UCBSSL) and included as a part of the Helio-centric payload, was ideally suited for such a modification. The scintillation detector portion of the spectrometer provides the basic detector for the gamma-ray observations. The mounting position above the satellite body yields a field of view of approximately 2π steradians without serious absorption effects in the gamma-ray energy range. The orientation of the scintillation detector (symmetry axis parallel to the spacecraft spin axis) also minimizes the problem of varying sensitivity produced by spacecraft rotation.

There were, however, three areas of the Solar X-Ray Spectrometer sensor that required some changes: the scintillator crystal geometry, the collimator system, and the photon energy range covered by the experiment. The original configuration of the NaI scintillation crystal (a cylindrical section 7.6-cm o.d., 6.6-cm i.d., 2.5 cm long and mounted with the cylindrical axis parallel to the photomultiplier tube axis) was chosen to provide azimuthal symmetry with maximum area when viewed perpendicular to the symmetry axis, while minimizing the effective volume for charged particle interactions. This configuration provided an unacceptably small effective area for energetic photons and an undesirable variation in effective area with polar angle. Both difficulties were removed to a large extent by simply decreasing the inside diameter of the cylindrical section. However, unless other changes were made, the increased mass of the scintillation crystal would result in an increase in the background count rate from charged particle interactions. To counteract this, in large part, the entire crystal was surrounded by a thin plastic scintillator in a phoswich geometry to reject charged particle counts.

Collimator plates are used to restrict the field of view of the x-ray spectrometer to $\pm 5^\circ$ polar angle about the plane perpendicular to the detector symmetry axis. Since a full 4π field of view is desirable for gamma-ray observations, it is necessary that the collimator plates be transparent to photons of energy greater than 150 keV.

The original experiment covered (with the scintillation detector) the energy range 12-228 keV with eight differential energy channels and also provided two integral energy channels for photon energies > 228 keV and > 500 keV. To provide improved energy spectra at higher photon energies, three additional level discriminators were included at energies of 356, 740, and 1250 keV. The modified system provides twelve differential energy channels (SC-1 through SC-12) over the range 12-1250 keV, with the six highest energy channels (132-1250 keV) of primary interest for the gamma-ray observations. One channel (PG) containing the count rate in the plastic guard scintillator is also provided. Three additional wide channels SC-13, SC-14, and SC-15 have been formed corresponding to the energy intervals 12-36, 36-68, and 68-132 keV. In case of a large solar x-ray burst, high time resolution data from these three channels is automatically stored in the memory residing in the LASL cosmic γ -ray package and is read out in the telemetry after the x-ray burst is over. The resulting energy channels and their corresponding time resolution for the x-ray data are listed in Table I.

It should be emphasized that the basic solar x-ray data will be available in real time even when the memory is being read out. Thus, the experiment will monitor continuously the solar x-ray emission over the entire spectral range of 6-1250 keV.

III. LASL COSMIC GAMMA-RAY EXPERIMENT

The required additions to the Solar X-Ray Experiment consist entirely of electronics and include the necessary logics and solid state memory for controlling and storing the large amounts of data accumulated during the observation of a transient gamma-ray source. The several functions of the LASL memory package can be defined as follows: (1) to provide a semiconductor memory with a capacity of 32 768 bits configured as 2048 x 16 bit words, sufficient to store the time history and pulse height spectrum for the largest anticipated gamma burst; (2) to detect a rapid increase in gamma-ray count rate and to initiate a high data-rate mode during which the data are stored in the memory for subsequent read out via telemetry; (3) to provide a priority system which will automatically allocate the memory to solar x-ray events or to cosmic γ -ray events in accordance with a predetermined set of conditions. The memory is, thus,

TABLE I
ISEE-C (HELIOCENTRIC) SOLAR X-RAY SPECTROMETER
ENERGY CHANNELS AND TIME RESOLUTION

Detector	X-ray Energy Range (keV)	Symbol	Time Resolution (sec) †					
			Normal Mode (Real Time Data)	Flare-1 Mode		Flare-2 Mode		Memory Read Out Mode (Real Time Data)
				Real Time Data	Stored Data	Real Time Data	Stored Data	
Proportional Counter	6.0-7.5	PC1	0.5	0.5	---	0.5	1.0	1.0
	7.5-8.5	PC2	0.5	0.5	---	0.5	4.0	4.0
	8.5-10	PC3	0.5	0.5	---	0.5	4.0	4.0
	10-12	PC4	0.5	0.5	---	0.5	4.0	4.0
	12-16	PC5	4.0	4.0		4.0		
	16-20	PC6	4.0	4.0		4.0		
	6-8.5	PC7	---	---	0.25*	---	---	---
	8.5-12	PC8	---	---	---	---	---	---
	12-20	PC9	---	---	0.5	---	16.0	16.0
NaI (TI) Scintillator	12-20	SC1	0.5	0.5	---	0.5	4.0	4.0
	20-36	SC2	0.5	0.5	---	0.5	4.0	4.0
	36-52	SC3	0.5	0.5	---	0.5	4.0	4.0
	52-68	SC4	0.5	0.5	---	0.5	4.0	4.0
	68-100	SC5	0.5	0.5	---	0.5	4.0	4.0
	100-132	SC6	0.5	0.5	---	0.5	4.0	4.0
	132-164	SC7	0.5	0.5	---	0.5	2.0	4.0
	164-228	SC8	1.0	1.0	---	1.0	2.0	4.0
	228-356	SC9	1.0	1.0	---	1.0	4.0	16.0
	356-484	SC10	2.0	2.0	---	2.0	16.0	16.0
	484-740	SC11	2.0	2.0	---	2.0	16.0	---
	740-1250	SC12	4.0	4.0	---	4.0	---	---
	12-36	SC13	---	---	6.125*	---	1.0*	0.5*
	36-68	SC14	---	---	0.125	---	1.0	0.5
	68-132	SC15	---	---	0.125	---	1.0	0.5
Plastic Guard Scintillator		PG	4.0	4.0	1.0	4.0	16.0	16.0
Frame Counter		---	---	---	1.0	---	4.0	
Total Bits/sec			206.0	206.0	256.0	206.0	84.0	80.0

*Could be assigned to another channel by command.

†Telemetry rate 2048 bits/sec.

available to the solar x-ray portion of the experiment for storing strong solar flare data. In fact, since gamma events are expected to occur only a few times a year, the memory will be available for use by the solar x-ray portion of the experiment most of the time.

Figure 1 shows a simplified block diagram of the electronics for the LASL cosmic γ -ray experiment. Data from the six highest differential energy channels of the scintillation detector, SC-7 through SC-12, are furnished, in parallel, to this portion of the memory logics. A seventh channel, called the ST channel, is generated from the sum of the six energy channels. This sum is used to provide the high resolution time-history of the gamma-ray event. Each of the energy channels, SC-7 through SC-12, is also separately accumulated to provide six channels of Pulse Height Analysis (PHA) data. Figure A-1 of Appendix A shows that portion of the logics which accumulates the six scintillation counter energy channels in parallel, and generates the sum or ST channel. Note that Appendix A contains the complete set of schematic diagrams for the LASL cosmic γ -ray experiment.

IV. DATA HANDLING LOGIC

Table II gives the accumulation times for the various channels for cosmic gamma-ray data. As indicated in the table, data may be accumulated in two modes, fixed-time and time-to-spill. For the fixed-time mode of operation, twelve successive 11.71875-ms samples of the ST channel counts are accumulated in a 6-bit scalar while, simultaneously, 140.625-ms accumulations of the six pulse height channels, SC-7 through SC-12, are recorded. Note that the accumulation time for the pulse height channels is equal to the sum of twelve ST channel accumulations. The time required for one ST channel accumulation in the fixed time mode is equal to the time required to record 48 counts at a 4096-Hz clock rate. The twelve successive 6-bit time history samples (72 bits) are packed electronically into nine 8-bit words so that the data can be organized into blocks consisting of nine 8-bit (packed) time history words covering 140.625-ms and one 8-bit word for each of the six pulse height channels accumulated over the same 140.625-ms interval as the twelve time history samples. The block of data generated thus contains a total of 120 bits. Figure 2 illustrates the configuration of a typical block of gamma data.

Fig. 1.
Simplified block diagram of the electronics for the LASL gamma-ray experiment.

TABLE II
COSMIC GAMMA-RAY ENERGY CHANNELS AND TIME RESOLUTION

Energy Level (keV)	Channel	Bits Per Accumulation	Fixed Time Mode Accum. Time	Time to Spill Mode Accum. Time
132-164	SC-7	8	140.625 ms	>2.928 ms, <140.625 ms
164-228	SC-8	8	140.625 ms	>2.928 ms, <140.625 ms
228-356	SC-9	8	140.625 ms	>2.928 ms, <140.625 ms
356-484	SC-10	8	140.625 ms	>2.928 ms, <140.625 ms
484-740	SC-11	8	140.625 ms	>2.928 ms, <140.625 ms
740-1250	SC-12	8	140.625 ms	>2.928 ms, <140.625 ms
132-1250	ST	6	11.71875 ms	>0.244 ms, <11.71875 ms

Fig. 2.

GAMMA DATA BLOCK

Configuration of a typical gamma data block consisting of 12 6-bit time history words packed into nine 8-bit words plus six 8-bit PHA words for a total of 15 8-bit words (120 bits).

To allow for the possibility of very high count rates, the gamma logics are designed to switch automatically to a time-to-spill mode when needed. This is accomplished by requiring that no ST channel accumulation exceeds 16 counts. If 16 counts are recorded before the end of an 11.71875-ms sample period, that sample period is immediately terminated and the time required to accumulate the 16 counts is recorded in the ST data latch. In this mode of operation, the ST accumulation times will be variable as indicated in Table II, but the data are organized in the same way as for the fixed time mode, that is, twelve successive TH (Time History) samples and one sample each from the six pulse height channel form one block of gamma data. Figure A-2 in Appendix A is a schematic diagram of the time history and

Fig. 3.

Configuration of two gamma data blocks side by side in memory.

TABLE III

T-REGISTER WORD LIST
(HEADER)

WORD	DESCRIPTION
1	Sync. Word 1
2	Sync. Word 2
3	Command Register Status
4	Memory Data Ident.
5	Time (High Order 16 Bits)
6	Time (Low Order 16 Bits)
7	Flags Status
8	Flags Status
9	Y-Mem. File Counter/PG Accum. (High Order 4 Bits)
10	PG Accum. (Low Order 16 Bits)
11	Command Register Status
12	Memory Data Ident.
13	Time (High Order 16 Bits)
14	Time (Low Order 16 Bits)
15	Sync. Word 1
16	Sync. Word 2

NOTE: The word numbers indicate the order in which the corresponding words appear in the main memory header.

PHA data handling and timing logic and Fig. A-3 is a schematic of logic used to temporarily store and pack the twelve 6-bit time history samples into nine 8-bit words.

V. ORGANIZATION OF GAMMA DATA IN MEMORY

The gamma data is further organized into Data Groups consisting of 16 Gamma Data Blocks (240 words x 8 bits). A prememory consisting of 256 x 8-bit words is used to store 17 data blocks plus 1 word, of which 16 data blocks or 2.25 s of data before a gamma event trigger are transferred into the main memory in parallel with 16 data blocks (2.25 s) of real time data following a gamma event trigger. Figure 3 shows the configuration of two gamma data blocks side by side in memory. In addition, thirty-two 8-bit words are allotted to sync words, command register status, memory data identification, time, status of event flags, and plastic guard (PG) accumulations. The thirty-two 8-bit words are formatted as sixteen 16-bit words held in a "T-Register" for transfer into the main memory at the proper time. The contents of the T-register, defined as a "Header," are listed in Table III and a description of the bits in each word is contained in Table B-I through Table

Fig. 4.

GAMMA MEMORY FILE

A typical gamma memory file consists of a 16-word header followed by 32 gamma data blocks arranged in pairs as shown. A file is 256 words long by 16 bits wide (4096 bits).

B-XI in Appendix B. Figure 4 shows the configuration of a Gamma Memory File, which consists of the 16-x16-bit word header followed by 240-x 16-bit words of gamma burst event data (5.50 seconds of data). In Appendix C, Fig. C-1 indicates the configuration of the pre-memory and main memory after a gamma event trigger and just prior to entering data into the main memory while Fig. C-2 indicates the memory configuration just after the transfer of the first gamma memory file into the main memory. Figures C-3 and C-4 indicate the memory configuration prior to and after transfer of the 2nd gamma file into the main memory. Shown in Fig. C-5 is the configuration of the main memory when it is full. The total capacity of the memory (2048 x 16 bits) is sufficient to store eight memory files of gamma data. Appendix A contains the detailed schematic diagrams

for the main memory, Fig. A-4, the pre-memory, Fig. A-5, the T-register, Fig. A-6 and the management and control logic for properly entering gamma data into the main memory during an event, Fig. A-7.

VI. GAMMA EVENT TRIGGER LOGIC

Gamma-ray burst events occur infrequently and are of very brief durations. During their brief duration, however, they exhibit complex structure which can be resolved only by sampling at a rapid rate. Telemetry limitations prevent continuous rapid sampling, requiring that a storage capability be employed. The gamma event trigger logics provide a means of sensing statistically significant

rapid increases in detector event rate in order to automatically initiate a data storage sequence.

The trigger circuit maximizes sensitivity to rapidly rising transients to a degree consistent with immunity from statistical fluctuations and long-term variations in the natural backgrounds. Figure 5 is a block diagram of the logics required to detect a gamma burst. The circuit incorporates a background accumulator (M counter) reset on a 16-s time base, which generates a reference (M count) upon which the trigger levels are based. Three trigger channels are provided, with periods of 1/4, 1, and 2 s, in order to optimize sensitivity over a wider range of signal rise-time.

The anticipated accumulations of background counts in each of the trigger intervals is obtained by appropriately shifting the contents of the "M counter," because the trigger periods are binary submultiples of the 16-s M-counter period. Also, a statistical increment of approximately 5.6 standard deviations is derived from the M counter. The statistical increment may be, upon command, multiplied by a factor of 1 or 2.

The sums of the anticipated accumulations and their respective statistical increments are loaded into comparators. In order to remain within the range of the 8-bit scalars, the numbers loaded into the 1- and 2-s trigger comparators are shifted by 2 and 3 bits respectively, and inputs to those trigger accumulators are prescaled by factors of 4 and 8. When the level of the trigger accumulator attains that of the comparator, the comparator produces an output that initiates a storage sequence. Trigger accumulators are preset (to -1) to accommodate the resolution lost in the references by bit shifting.

The detailed schematic diagrams of the Gamma Event trigger logic are contained in Appendix A, Figs. A-8 through A-10.

VII. PRIORITIES AND OPTIONS

Because, under certain conditions, it is possible that confusion or conflicts can occur between "X-events" and "gamma events," it is necessary that priorities be established, and this is done in the automatic priority logic circuitry shown

Fig. 5.
Block diagram of the gamma burst trigger logic.

in the detailed schematic diagram of Fig. A-11 in Appendix A. To provide flexibility in the operation of the experiment a preferred or optional scheme can be selected by ground command. The various possibilities are illustrated in Table IV, where the effect of a gamma event and an X-event is shown for each initial state of the system. The preferred final states and the optional final states are listed in the last two columns.

Although it is unlikely, it is possible for either a solar flare or a cosmic gamma burst to cause both the x-ray count rate and the gamma-ray count rate to exceed the respective "event" thresholds. In this case, the decision between using the memory to store data in the x-ray format or the gamma-ray format will be made on the basis of the spectral distribution of the observed flux. Because solar flare x-ray spectra are usually much "softer" than cosmic gamma burst spectra, the ratio of high-energy photons to low energy photons will be used to determine if simultaneous events should be treated as solar flares or cosmic gamma events. Thus, when the ratio exceeds a preset level, a "Ratio Flag" is sent to the priority logic within the memory system where a decision is made in accordance with the priorities specified in Table IV.

VIII. EXPERIMENTAL MODES OF OPERATION

Depending on the level of the detected x-ray emission, the experiment is operated in one of five different modes: (1) Normal; (2) Flare I; (3) Flare II; (4) Special Event; (5) Memory Read-Out (MRO). These modes are designed so that optimum time resolution can be obtained for a part of the x-ray spectrum during an x-ray burst. The time resolution of the data varies with the mode of operation. During the Flare I, Flare II and Special Event modes, the data are stored in the memory and the memory is read out later during the MRO mode.

For most of the time, the experiment will be operating in the Normal Mode where solar x-ray data are accumulated and transmitted in real time. At the onset of a solar flare, as detected by a rise in count rate above a selected level of certain PHA channels in the solar x-ray portion of the experiment, Flare Mode logic is activated. The Flare I mode is intended to supplement the normal telemetry data with a high time resolution (0.125-s) history of a

TABLE IV
PRIORITIES AND OPTIONS FOR DATA STORAGE AND TELEMETRY FORMATS

Initial States			Final States			
Telemetry Format	Memory Status		Preferred		Optional	
			Telemetry Format	Memory Status	Telemetry Format	Memory Status
Normal	Empty	A Cosmic Gamma Event Produces:	Normal	Y Store	---	---
Normal	Contains an X Event	A Cosmic Gamma Event Produces:	Normal	Y Store	No Change in the Initial States	
Normal	Contains a Gamma Event	A Cosmic Gamma Event Produces:	No Change from the Initial States		---	---
Normal	Gamma Store in Progress	An X Event with "Ratio Flag" Occurring within 2 Sec ($0 \leq t \leq 2$) Produces:	Normal	X Store (Y overwritten)	---	---
Normal	Gamma Store in Progress	An X Event with "Ratio Flag" Occurring after 2 Sec Produces:	Normal	Y Store Continues	---	---
Gamma MRO in Progress	---	A Cosmic Gamma Event Produces:	No Change from the Initial States		---	---
X MRO in Progress	---	A Cosmic Gamma Event Produces:	Normal	Y Store (X Event overwritten)	No Change in the Initial States	
Normal	Empty	A Flare 1 X-Event Produces:	Normal	X-Store (Fl. 1)	---	---
Normal	Empty	A Flare 2 X-Event Produces:	Normal	X-Store (Fl. 2)	---	---
Normal	Contains a Flare 1 X-Event	A Flare 2 X-Event Produces:	Normal	X-Store (Fl. 1 overwritten)	---	---
Normal	Contains a Flare 1 Event	A Flare 1 Event Produces:	No Change in the Initial States		---	---
Normal	Contains a Flare 2 Event	A Flare 2 Event Produces:	No Change in the Initial States		---	---
Normal	Contains a Gamma Event	An X-Event Produces:	No Change in the Initial States		Normal	X-Store (Y Data overwritten)
X-MRO (Flare 2)	---	An X-Event Produces:	No Change in the Initial States		---	---
X-MRO (Flare 1)	---	A Flare 1 Event Produces:	No Change in the Initial States		---	---
X-MRO (Flare 1)	---	A Flare 2 Event Produces:	Normal	X-Store (Fl. 1 overwritten)	---	---
Y-MRO	---	An X-Event Produces:	No Change in the Initial States		---	---

HEADER	16 × 16-Bit Words	Time, Status, etc.
BLOCK No. 1	16 × 16-Bit Words	Flare Data
BLOCK No. 2	16 × 16-Bit Words	
⋮		
⋮		
⋮		
⋮		
⋮		
⋮		
BLOCK No. 125	16 × 16-Bit Words	
BLOCK No. 126	16 × 16-Bit Words	
HEADER	16 × 16-Bit Words	Time, Status, etc.

Fig. 6.

Organization of the memory for flare data.

the end of the flare. The organization of the memory for Flare I and Flare II data are shown in Fig. 6 and the header contents are shown in Tables III and B-I. Notice that Word 4 of the header record contains the information about the type of data being read out. Thus the fourth 16-bit word identifies the data as either Flare I (F1), Flare II (F2), Gamma Data (GA), or calibration data.

As previously indicated, the PHA pulse outputs from the scintillation detector channels SC-7 through SC-12 are routed to the memory for processing of "Special Events" having a "hard" or flat x-ray spectrum in contrast to the "soft" or steep spectra of normal solar flares. The "Special Events" are rare and take priority over Flare I and Flare II data. The priority logic in the memory box determines when a transfer to the "Special Event" mode is to be made.

During the memory read-out mode (MRO), real time spectral information is transmitted at a reduced rate to allow telemetry space for the MRO data. The memory contents are read out as 16-bit bytes under the direction of the MRO control logic. The data are shifted into a 16-bit register from which the real time multiplexer shifts 8 bits at a time into the telemetry bit stream in accordance with a predetermined format until the memory is empty.

portion of the x-ray spectrum. These time history data are stored in the semiconductor memory via an x-ray serial data-input interface between the SSL solar x-ray experiment and the LASL Memory Box. The data are read out into telemetry after the cessation of solar flare activity. The Flare II mode is intended to save solar flare spectral information for those solar flares intense enough to interfere with telemetry reception by storing in the memory most of the x-ray spectral information at a reduced time resolution. These data are also read out via telemetry at

TABLE V

LASL/SSL INTERFACE

<u>DEM-258</u> <u>Pin No.</u>	<u>Line</u>	<u>Description</u>
1	Flare 1 Flag	Flare 1 Alert
2	Flare 2 Flag	Flare 2 Alert
3	Ratio Flag	Flare/Gamma Priority Flag
4	MRI Available	Memory Available for Flare Data
5	MRO Available	Memory is Full
6	PDEF	(Priority Defect) Test Flag
7	SC-7	Data In (Scint. Det.)
8	SC-8	Data In (Scint. Det.)
9	SC-9	Data In (Scint. Det.)
10	SC-10	Data In (Scint. Det.)
11	SC-11	Data In (Scint. Det.)
12	SC-12	Data In (Scint. Det.)
13	PG	Data In (Plastic Guard)
14	Flare Data	Flare Serial Interface (Da)
15	Flare Shift	Flare Serial Interface (Shift)
16	Flare Gate	Flare Serial Interface (Env.)
17	MRO Data	Memory Serial Interface (Data)
18	MRO Shift	Memory Serial Interface (Shift)
19	MRO G.L.C.	Memory Serial Interface (Env.)
20	HK Request	Housekeeping Data Request Gate
21	+ V Line	Power In
22	+ V Line	Power In (Redundant)
23	Chassis/Shield Gnd.	Harness Shield & Case Gnd.
24	Common	Signal Common
25	Common	Signal Common

TABLE VI

LASL/SPACECRAFT INTERFACE

<u>DEM-259</u> <u>Pin No.</u>	<u>Line</u>	<u>Description</u>
1	Empty	
2	T1 Thermistor Mon.	Analog Temp. Mon. (1)
3	T2 Thermistor Mon.	Analog Temp. Mon. (2)
4	8192 Hz, (C5)	Redundant with Pin 5
5	8192 Hz, (C5)	Spacecraft Clock
6	Clock Slave Data	Redundant with Pin 7
7	Clock Slave Data	Serial Slave Data Interface
8	Clock Slave Transfer	Serial Slave Transfer Interface
9	Clock Slave Transfer	Redundant with Pin 8
10	Empty	
11	Empty	
12	Empty	
13	Empty	
14	+ V Monitor	Analog Power Supply Mon.
15	Command Data (A)	Serial Command Interface Data
16	Command Data (B)	Ser. Com. Inter. Data (Redundant)
17	Empty	
18	Command Shift (A)	Serial Command Interface Shift
19	Command Shift (B)	Ser. Com. Inter. Shift (Redundant)
20	Empty	
21	Command Envelope (A)	Serial Command Interface Envelope
22	Command Envelope (B)	Ser. Com. Inter. Env. (Redundant)
23	Chassis/Shield Gnd.	Harness Shield & Case Ground
24	Spurs #26 g Wire	Sig. Com. (Not Connected in Box)
25	Chassis/Shield Gnd.	Harness Shield & Case Ground

IX. SSL/LASL INTERFACE

The interface between the SSL Solar X-Ray Experiment and the LASL Memory Unit consists primarily of the Flare serial data-input interface lines, the memory serial data-output interface lines, the SC-7 through SC-12 data input lines to the memory, and the various flag lines and power lines between the two units. Table V lists these interface lines. Figure A-12 in Appendix A is a schematic diagram that contains the Flare serial interface and data merge logic while Fig. A-13 contains the MRO serial interface logic.

X. THE SPACECRAFT/LASL INTERFACE

Table VI lists the interface lines between the spacecraft and the LASL Memory Unit. These consist primarily of the serial command interface lines, the slave clock interface lines, the 8192-Hz timing pulse line and two thermistor monitor lines. Upon experiment power turn-on, the x-ray experiment is internally initialized to a quiescent mode of operation. Before configuring the experiment to a more active mode, the memory must be initialized. This is done by way of the 37-bit serial command to the memory portion of the experiment. The memory utilizes the

TABLE VII
HOUSEKEEPING DATA WORD

2 ⁰	HK*00	K*SELECT*1	0,K=1;1,K=2															
2 ¹	HK*01	K*SELECT*2	0,K=1;1,K=2															
2 ²	HK*02	K*SELECT*3	0,K=1;1,K=2															
2 ³	HK*03	Y*TRIG. 1 ENA./DIS., ENA.=1																
2 ⁴	HK*04	Y*TRIG. 2 ENA./DIS., ENA.=1																
2 ⁵	HK*05	Y*TRIG. 3 ENA./DIS., ENA.=1																
2 ⁶	HK*06	CAL. SELECT	<table><tr><td>2⁷</td><td>2⁶</td><td></td></tr><tr><td>0</td><td>0</td><td>CAL. 1</td></tr><tr><td>0</td><td>1</td><td>CAL. 2</td></tr><tr><td>1</td><td>0</td><td>CAL. 3</td></tr><tr><td>1</td><td>1</td><td>CAL. 4</td></tr></table>	2 ⁷	2 ⁶		0	0	CAL. 1	0	1	CAL. 2	1	0	CAL. 3	1	1	CAL. 4
2 ⁷	2 ⁶																	
0	0	CAL. 1																
0	1	CAL. 2																
1	0	CAL. 3																
1	1	CAL. 4																
2 ⁷	HK*07	CAL. SELECT																

2 ⁸	HK*08	PRIORITY MODE SELECT																					
2 ⁹	HK*09	MRO SELECT	<table border="1"> <tr> <td>2¹⁰</td><td>2⁹</td><td></td><td>MODE</td></tr> <tr> <td>0</td><td>0</td><td>MRO=1</td><td>AUTO</td></tr> <tr> <td>0</td><td>1</td><td>MRO=2</td><td>AUTO</td></tr> <tr> <td>1</td><td>0</td><td>MRO=3</td><td>AUTO</td></tr> <tr> <td>1</td><td>1</td><td>MRO=1</td><td>MANUAL</td></tr> </table>	2 ¹⁰	2 ⁹		MODE	0	0	MRO=1	AUTO	0	1	MRO=2	AUTO	1	0	MRO=3	AUTO	1	1	MRO=1	MANUAL
2 ¹⁰	2 ⁹		MODE																				
0	0	MRO=1	AUTO																				
0	1	MRO=2	AUTO																				
1	0	MRO=3	AUTO																				
1	1	MRO=1	MANUAL																				
2 ¹⁰	HK*10	MRO SELECT																					

2 ¹¹	HK*11	FLARE EVENT FLAG
2 ¹²	HK*12	IFC ENA./DIS., ENA.=1
2 ¹³	HK*13	SC-7 ENA./DIS., ENA.=1
2 ¹⁴	HK*14	GAMMA EVENT FLAG
2 ¹⁵	HK*15	MEMORY FULL FLAG

last 16 bits of the serial command, and these bits are loaded into a holding register at the trailing edge of the command envelope pulse. The command bits are then executed and distributed to the various parts of the experiment. The schematic diagram of the serial command interface logic is shown in Fig. A-14 of Appendix A.

The command status of the memory is read out by way of the 16-bit memory housekeeping (HK) data word.

Tables VII and VIII describe each bit in the housekeeping data word and Fig. 7 shows the proper bit pattern for normal memory operation. Figure 8 lists the 16 bits of the serial command. Except for bits 11, 14, and

15, there is correspondence between the housekeeping bits and the command bits. The corresponding command bits are "toggle command," that is, a "1" command bit causes the corresponding configuration control bit to toggle to its complement state.

To initialize the memory, it is necessary to compare the housekeeping bit pattern with the pattern in Fig. 7 to determine which command bits are to be sent.

The serial-slave clock interface between the spacecraft and the memory is used to synchronize the spacecraft clock with the internal clock in the memory. The complete spacecraft clock data are transferred at 0.5-s intervals. Consequently, synchronization can be accomplished within 0.5 s at any bit rate. As indicated in Table III, data from the internal clock in the memory appears on words 5 and 6 in the header record and is repeated in words 13 and 14.

TABLE VIII
HOUSEKEEPING DATA WORD

Bit Description																	
Octal 8-Bit Word								Octal 8-Bit Word									
2 ¹⁵	2 ¹⁴	2 ¹³	2 ¹²	2 ¹¹	2 ¹⁰	2 ⁹	2 ⁸	2 ⁷	2 ⁶	2 ⁵	2 ⁴	2 ³	2 ²	2 ¹	2 ⁰		
L				M				N				P		R		S	
								2 ¹⁴				2 ¹⁵					
L								Gamma Event Flag				Memory Full Flag					
0								No				No					
1								Yes				No					
2								No				Yes					
3								Yes				Yes					
				2 ¹¹				2 ¹²				2 ¹³					
M				Flare Event				IFC Ena./Dis.				SC-7 Ena./Dis.					
. 0				No				Disabled				Disabled					
. 1				Yes				Disabled				Disabled					
. 2				No				Enabled				Disabled					
. 3				Yes				Enabled				Disabled					
. 4				No				Disabled				Enabled					
. 5				Yes				Disabled				Enabled					
. 6				No				Enabled				Enabled					
. 7				Yes				Enabled				Enabled					
								2 ⁸				2 ⁹ , 2 ¹⁰					
M								Priority Mode				MRO Select/Mode					
. 0								Preferred				MRO = 1, Auto					
. 1								Optional				MRO = 1, Auto					
. 2								Preferred				MRO = 2, Auto					
. 3								Optional				MRO = 2, Auto					
. 4								Preferred				MRO = 3, Auto					
. 5								Optional				MRO = 3, Auto					
. 6								Preferred				MRO = 4, Manual					
. 7								Optional				MRO = 4, Manual					
								2 ⁶ , 2 ⁷									
P								Cal. Select									
. . . 0 . .								Cal. 1									
. . . 1 . .								Cal. 2									
. . . 2 . .								Cal. 3									
. . . 3 . .								Cal. 4									
				2 ³				2 ⁴				2 ⁵					
R				Y-Trig. 1				Y-Trig. 2				Y-Trig. 3					
. . . . 0 .				Disabled				Disabled				Disabled					
. . . . 1 .				Enabled				Disabled				Disabled					
. . . . 2 .				Disabled				Enabled				Disabled					
. . . . 3 .				Enabled				Enabled				Disabled					
. . . . 4 .				Disabled				Disabled				Enabled					
. . . . 5 .				Enabled				Disabled				Enabled					
. . . . 6 .				Disabled				Enabled				Enabled					
. . . . 7 .				Enabled				Enabled				Enabled					
				2 ⁰				2 ¹				2 ²					
S				K-Select 1				K-Select 2				K-Select 3					
. 0				K ₁ = 1				K ₂ = 1				K ₃ = 1					
. 1				K ₁ = 2				K ₂ = 1				K ₃ = 1					
. 2				K ₁ = 1				K ₂ = 2				K ₃ = 1					
. 3				K ₁ = 2				K ₂ = 2				K ₃ = 1					
. 4				K ₁ = 1				K ₂ = 1				K ₃ = 2					
. 5				K ₁ = 2				K ₂ = 1				K ₃ = 2					
. 6				K ₁ = 1				K ₂ = 2				K ₃ = 2					
. 7				K ₁ = 2				K ₂ = 2				K ₃ = 2					

BIT	SHOULD BE	MEANING
2 ⁰	0	K-SELECT 1 = 1
2 ¹	0	K-SELECT 2 = 1
2 ²	0	K-SELECT 3 = 1
2 ³	1	Y-TRIG. 1 ENABLED
2 ⁴	1	Y-TRIG. 2 ENABLED
2 ⁵	1	Y-TRIG. 3 ENABLED
2 ⁶	0	CAL. 1 MODE SELECTED
2 ⁷	0	(MEMORY IN-FLIGHT-CAL. MODE)
2 ⁸	0	PREFERRED PRIORITY MODE
2 ⁹	0	} MNO = 1 SELECTED
2 ¹⁰	0	
2 ¹¹	0	NO FLARE EVENT FLAG
2 ¹²	0	MEMORY IPC DISABLED
2 ¹³	1	SC-7 ENABLED
2 ¹⁴	0	NO GAMMA EVENT FLAG
2 ¹⁵	0	MEMORY IS EMPTY

Fig. 7.
HOUSEKEEPING (HK) DATA WORD
Bit pattern for initial configuration.

BIT	NAME	
2 ⁰	K-SELECT 1	TOGGLE COMMAND
2 ¹	K-SELECT 2	TOGGLE COMMAND
2 ²	K-SELECT 3	TOGGLE COMMAND
2 ³	Y-TRIG. 1	TOGGLE COMMAND
2 ⁴	Y-TRIG. 2	TOGGLE COMMAND
2 ⁵	Y-TRIG. 3	TOGGLE COMMAND
2 ⁶	CAL. MODE SEL.	TOGGLE COMMAND
2 ⁷	CAL. MODE SEL.	TOGGLE COMMAND
2 ⁸	PRIORITY MODE SEL.	TOGGLE COMMAND
2 ⁹	MNO SELECT	TOGGLE COMMAND
2 ¹⁰	MNO SELECT	TOGGLE COMMAND
2 ¹¹	RESET FLAGS	
2 ¹²	IPC ENA./DIS.	TOGGLE COMMAND
2 ¹³	SC-7 ENA./DIS.	TOGGLE COMMAND
2 ¹⁴	COMMAND IPC	
2 ¹⁵	COMMAND MNO	

Fig. 8.
COMMAND DATA WORD.

XI. LASL INSTRUMENT REQUIREMENTS

An incremental allocation of 1 W for power, 1.4 kg for weight and 1600 cm³ for volume was initially obtained from the Project Office to accommodate the LASL memory electronics package. Final figures for the flight unit are 70 mW for power, 1.271 kg for weight and 1655 cm³ for volume. The low figure of 70 mW for power resulted from the use of Complementary Symmetry Metal Oxide Semiconductor (COSMOS) integrated circuits exclusively throughout the package. A total of 389 integrated circuits were used in the unit. Figure 9 is a photograph of the LASL instrument package showing the box and three of the ten multilayer electronics boards. A fourth board is shown partially inserted into the box to illustrate the manner in which the boards are inserted and removed.

The SSL solar x-ray experiment, in addition to two other instruments, will be mounted on a tower above the body of the spacecraft. The additional weight of the LASL memory package, if mounted on the tower would have exceeded the maximum allowable tower weight determined by the requirement for spin stability. A series of discussions and meetings with SSL, Project Office designers

Fig. 9.
LASL flight instrument package.

and other tower experimenters resulted in an acceptable arrangement by interchanging the location of two experiments and mounting the LASL memory box at the base of the tower. Because this location is a very cold region being shaded from the sun by the solar cell skirt and almost completely decoupled thermally from the main equipment compartment, a modification of the tower base structure was made to allow the LASL package to view the main equipment compartment.

XII. PROJECT MANAGEMENT AND DATA ANALYSIS

For purposes of project control (interface drawings, testing procedures, scheduling, design reviews, and so on), the LASL memory package is viewed by the Project Office as a component of the SSL Solar X-Ray Experiment instrument. The analysis of solar x-ray data will remain the responsibility of SSL while analysis of cosmic gamma ray data will be the responsibility of LASL. For simplicity and convenience, it has been proposed that a separate data tape containing specifically the gamma-ray data be furnished by the Project Office to LASL.

Since the cosmic gamma-ray experiment for the ISEE-C Heliocentric spacecraft is primarily intended to serve as one element in a network of several such detector systems, it has been proposed that a system be devised for rapid comparison of results. However the method for accomplishing this is, at present, undefined. It is the intent that the results from this experiment be immediately available for mutual comparison with results from other detector systems in the network. The ISEE-C Heliocentric spacecraft is currently scheduled for launch from the Eastern Test Range at Cape Canaveral, Florida in June or July of 1978.

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supervising the final layout and construction of the ten multilayer electronics boards used in flight unit. Our thanks also to G. Peterson (SLA) for the mechanical design of the flight package and to E. C. Wittwer (SLA) for supervising the construction of the unit.

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APPENDIX A SCHEMATIC DIAGRAMS

Fig. A-1. PHA data accumulator and parallel-to-serial converter.

Fig. A-2. Time history and PHA data handling and timing logic.

Fig. A-3. Time history data packing logic.

Fig. A-4. Schematic of the 2048-x 16-bit main memory.

CD4001AR U1 THRU U10
 CD4001AR U11 THRU U100
 CD4001AR U101
 CD4001AR U102, U103
 CD4001AR U104, U105, U106
 U107, U108, U109

- REF 1
- 1) ALL LATCH A INPUTS FROM SHEET 3
 - 2) ALL LATCH B INPUTS FROM SHEET 3
 - 3) ALL LATCH C INPUTS FROM SHEET 3
 - 4) ALL PHA INPUTS FROM SHEET 3

ALL OUTPUTS
 TO SHEET 13

Fig. A-5. The pre-memory.

Fig. A-6. The T-register.

CD4023AK U1, U4
 CD4013AK U2, U11
 CD4011AK U3, U4, U5, U6
 CD4012AK U7, U8
 CD4040AK U9
 CD4049AK U10
 CD4049AK U12

Fig. A-7. Memory gamma file management logic.

Fig. A-8. Gamma event trigger logic. Timing and M counter logic.

CD4040BK U1, U7, U13
 CD4069BK U2, U3, U8, U9,
 CD4013BK U14, U15
 CD4049BK U10, U10
 CD4011BK U5, U11, U17
 CD4011BK U6, U12, U16

Fig. A-9. Gamma event trigger logic.
 Square root generator.

Fig. A-10. Gamma event trigger logic.
Comparator logic.

CD4015A U1, U2
 CD4019A U3, U4, U5, U6
 CD4013A U7, U8, U9, U10
 CD4011A U11, U12, U13
 CD4007A U14, U15, U16
 CD4007A U17, U18, U19
 CD4007A U20, U21, U22
 CD4007A U23, U24, U25
 CD4007A U26, U27, U28
 CD4007A U29, U30, U31
 CD4007A U32, U33, U34
 CD4007A U35, U36, U37
 CD4007A U38, U39, U40
 CD4007A U41, U42, U43
 CD4007A U44, U45, U46
 CD4007A U47, U48, U49
 CD4007A U50, U51, U52
 CD4007A U53, U54, U55
 CD4007A U56, U57, U58
 CD4007A U59, U60, U61
 CD4007A U62, U63, U64
 CD4007A U65, U66, U67
 CD4007A U68, U69, U70
 CD4007A U71, U72, U73
 CD4007A U74, U75, U76
 CD4007A U77, U78, U79
 CD4007A U80, U81, U82
 CD4007A U83, U84, U85
 CD4007A U86, U87, U88
 CD4007A U89, U90, U91
 CD4007A U92, U93, U94
 CD4007A U95, U96, U97
 CD4007A U98, U99, U100
 CD4007A U101, U102, U103
 CD4007A U104, U105, U106
 CD4007A U107, U108, U109
 CD4007A U110, U111, U112
 CD4007A U113, U114, U115
 CD4007A U116, U117, U118
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 CD4007A U146, U147, U148
 CD4007A U149, U150, U151
 CD4007A U152, U153, U154
 CD4007A U155, U156, U157
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 CD4007A U200, U201, U202
 CD4007A U203, U204, U205
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 CD4007A U266, U267, U268
 CD4007A U269, U270, U271
 CD4007A U272, U273, U274
 CD4007A U275, U276, U277
 CD4007A U278, U279, U280
 CD4007A U281, U282, U283
 CD4007A U284, U285, U286
 CD4007A U287, U288, U289
 CD4007A U290, U291, U292
 CD4007A U293, U294, U295
 CD4007A U296, U297, U298
 CD4007A U299, U300, U301
 CD4007A U302, U303, U304
 CD4007A U305, U306, U307
 CD4007A U308, U309, U310
 CD4007A U311, U312, U313
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 CD4007A U326, U327, U328
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 CD4007A U356, U357, U358
 CD4007A U359, U360, U361
 CD4007A U362, U363, U364
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 CD4007A U485, U486, U487
 CD4007A U488, U489, U490
 CD4007A U491, U492, U493
 CD4007A U494, U495, U496
 CD4007A U497, U498, U499
 CD4007A U500, U501, U502
 CD4007A U503, U504, U505
 CD4007A U506, U507, U508
 CD4007A U509, U510, U511
 CD4007A U512, U513, U514
 CD4007A U515, U516, U517
 CD4007A U518, U519, U520
 CD4007A U521, U522, U523
 CD4007A U524, U525, U526
 CD4007A U527, U528, U529
 CD4007A U530, U531, U532
 CD4007A U533, U534, U535
 CD4007A U536, U537, U538
 CD4007A U539, U540, U541
 CD4007A U542, U543, U544
 CD4007A U545, U546, U547
 CD4007A U548, U549, U550
 CD4007A U551, U552, U553
 CD4007A U554, U555, U556
 CD4007A U557, U558, U559
 CD4007A U560, U561, U562
 CD4007A U563, U564, U565
 CD4007A U566, U567, U568
 CD4007A U569, U570, U571
 CD4007A U572, U573, U574
 CD4007A U575, U576, U577
 CD4007A U578, U579, U580
 CD4007A U581, U582, U583
 CD4007A U584, U585, U586
 CD4007A U587, U588, U589
 CD4007A U590, U591, U592
 CD4007A U593, U594, U595
 CD4007A U596, U597, U598
 CD4007A U599, U600, U601
 CD4007A U602, U603, U604
 CD4007A U605, U606, U607
 CD4007A U608, U609, U610
 CD4007A U611, U612, U613
 CD4007A U614, U615, U616
 CD4007A U617, U618, U619
 CD4007A U620, U621, U622
 CD4007A U623, U624, U625
 CD4007A U626, U627, U628
 CD4007A U629, U630, U631
 CD4007A U632, U633, U634
 CD4007A U635, U636, U637
 CD4007A U638, U639, U640
 CD4007A U641, U642, U643
 CD4007A U644, U645, U646
 CD4007A U647, U648, U649
 CD4007A U650, U651, U652
 CD4007A U653, U654, U655
 CD4007A U656, U657, U658
 CD4007A U659, U660, U661
 CD4007A U662, U663, U664
 CD4007A U665, U666, U667
 CD4007A U668, U669, U670
 CD4007A U671, U672, U673
 CD4007A U674, U675, U676
 CD4007A U677, U678, U679
 CD4007A U680, U681, U682
 CD4007A U683, U684, U685
 CD4007A U686, U687, U688
 CD4007A U689, U690, U691
 CD4007A U692, U693, U694
 CD4007A U695, U696, U697
 CD4007A U698, U699, U700
 CD4007A U701, U702, U703
 CD4007A U704, U705, U706
 CD4007A U707, U708, U709
 CD4007A U710, U711, U712
 CD4007A U713, U714, U715
 CD4007A U716, U717, U718
 CD4007A U719, U720, U721
 CD4007A U722, U723, U724
 CD4007A U725, U726, U727
 CD4007A U728, U729, U730
 CD4007A U731, U732, U733
 CD4007A U734, U735, U736
 CD4007A U737, U738, U739
 CD4007A U740, U741, U742
 CD4007A U743, U744, U745
 CD4007A U746, U747, U748
 CD4007A U749, U750, U751
 CD4007A U752, U753, U754
 CD4007A U755, U756, U757
 CD4007A U758, U759, U760
 CD4007A U761, U762, U763
 CD4007A U764, U765, U766
 CD4007A U767, U768, U769
 CD4007A U770, U771, U772
 CD4007A U773, U774, U775
 CD4007A U776, U777, U778
 CD4007A U779, U780, U781
 CD4007A U782, U783, U784
 CD4007A U785, U786, U787
 CD4007A U788, U789, U790
 CD4007A U791, U792, U793
 CD4007A U794, U795, U796
 CD4007A U797, U798, U799
 CD4007A U800, U801, U802
 CD4007A U803, U804, U805
 CD4007A U806, U807, U808
 CD4007A U809, U810, U811
 CD4007A U812, U813, U814
 CD4007A U815, U816, U817
 CD4007A U818, U819, U820
 CD4007A U821, U822, U823
 CD4007A U824, U825, U826
 CD4007A U827, U828, U829
 CD4007A U830, U831, U832
 CD4007A U833, U834, U835
 CD4007A U836, U837, U838
 CD4007A U839, U840, U841
 CD4007A U842, U843, U844
 CD4007A U845, U846, U847
 CD4007A U848, U849, U850
 CD4007A U851, U852, U853
 CD4007A U854, U855, U856
 CD4007A U857, U858, U859
 CD4007A U860, U861, U862
 CD4007A U863, U864, U865
 CD4007A U866, U867, U868
 CD4007A U869, U870, U871
 CD4007A U872, U873, U874
 CD4007A U875, U876, U877
 CD4007A U878, U879, U880
 CD4007A U881, U882, U883
 CD4007A U884, U885, U886
 CD4007A U887, U888, U889
 CD4007A U890, U891, U892
 CD4007A U893, U894, U895
 CD4007A U896, U897, U898
 CD4007A U899, U900, U901
 CD4007A U902, U903, U904
 CD4007A U905, U906, U907
 CD4007A U908, U909, U910
 CD4007A U911, U912, U913
 CD4007A U914, U915, U916
 CD4007A U917, U918, U919
 CD4007A U920, U921, U922
 CD4007A U923, U924, U925
 CD4007A U926, U927, U928
 CD4007A U929, U930, U931
 CD4007A U932, U933, U934
 CD4007A U935, U936, U937
 CD4007A U938, U939, U940
 CD4007A U941, U942, U943
 CD4007A U944, U945, U946
 CD4007A U947, U948, U949
 CD4007A U950, U951, U952
 CD4007A U953, U954, U955
 CD4007A U956, U957, U958
 CD4007A U959, U960, U961
 CD4007A U962, U963, U964
 CD4007A U965, U966, U967
 CD4007A U968, U969, U970
 CD4007A U971, U972, U973
 CD4007A U974, U975, U976
 CD4007A U977, U978, U979
 CD4007A U980, U981, U982
 CD4007A U983, U984, U985
 CD4007A U986, U987, U988
 CD4007A U989, U990, U991
 CD4007A U992, U993, U994
 CD4007A U995, U996, U997
 CD4007A U998, U999, U1000

Fig. A-12. Flare data serial interface and data merge.

Fig. A-14. Serial command interface logic.

AS114
 LM139 U1, U2, U3
 CD4050A U4
 CD4049A U5

Fig. A-15. LASL/SSL interface circuits.

Fig. A-16. LASL/spacecraft and LASL/SSL interface circuits.

NOTES

- 1.) IN ORDER TO AVOID ERROR, J1 IS FEMALE AND J2 IS MALE.
- 2.) CASE GROUND
- 3.) SIGNAL COMMON

Fig. A-17. Interface connectors.

TABLE B-I

T-REGISTER BIT DESCRIPTION

Octal 8-Bit Word										Octal 8-Bit Word					
2 ¹⁵	2 ¹⁴	2 ¹³	2 ¹²	2 ¹¹	2 ¹⁰	2 ⁹	2 ⁸	2 ⁷	2 ⁶	2 ⁵	2 ⁴	2 ³	2 ²	2 ¹	2 ⁰
Word															
1	Sync. Word 1							SY	323 331						
2	Sync. Word 2							NC	316 303						
3	Command Register Status								ABC DEF (TABLE X)						
4	Memory Data Ident.							GA	307 301						
								FZ	306 262						
								FI	306 261						
	CAL. 1 (0, 0, 0, 0, ...)								000 000						
	CAL. 2 (1, 1, 1, 1, ...)								377 377						
	CAL. 3 (1, 0, 1, 0, ...)								125 125						
	CAL. 4 (0, 1, 0, 1, ...)								252 252						
5	Time (High Order 16 Bits)								TABLE XIV						
6	Time (Low Order 16 Bits)								TABLE XV						
7	Flags Status								OOG HJK (TABLE XII)						
8	Flags Status								OOG HJK (TABLE XII)						
9	γ-Mem. File Counter/PG Accum.								TABLE XVII/TABLE XVI						
10	PG Accum. (Low Order 16 Bits)								TABLE XVI						
11	Command Register Status								ABC DEF (TABLE X)						
12	Memory Data Ident.							GA	307 301						
								FZ	306 262						
								FI	306 261						
	CAL. 1 (0, 0, 0, 0, ...)								000 000						
	CAL. 2 (1, 1, 1, 1, ...)								377 377						
	CAL. 3 (1, 0, 1, 0, ...)								125 125						
	CAL. 4 (0, 1, 0, 1, ...)								252 252						
13	Time (High Order 16 Bits)								TABLE XIV						
14	Time (Low Order 16 Bits)								TABLE XV						
15	Sync. Word 1							SY	323 331						
16	Sync. Word 2							NC	316 03						

TABLE B-II

T-REG. WORD 1, WORD 2,

(REPEATED IN WORD 15, WORD 16)

BIT	SYNC. WORD 1	BIT	SYNC. WORD 2
2 ⁰	1	2 ⁰	1
2 ¹	0	2 ¹	1
2 ²	0	2 ²	0
2 ³	1	2 ³	0
2 ⁴	1	2 ⁴	0
2 ⁵	0	2 ⁵	0
2 ⁶	1	2 ⁶	1
2 ⁷	1	2 ⁷	1
2 ⁸	1	2 ⁸	0
2 ⁹	1	2 ⁹	1
2 ¹⁰	0	2 ¹⁰	1
2 ¹¹	0	2 ¹¹	1
2 ¹²	1	2 ¹²	0
2 ¹³	0	2 ¹³	0
2 ¹⁴	1	2 ¹⁴	1
2 ¹⁵	1	2 ¹⁵	1

T-REGISTER DESCRIPTION

APPENDIX B

TABLE B-III
T-REGISTER WORDS 3 AND 11

Command Register Status

2 ¹⁵ 2 ¹⁴ 2 ¹³ 2 ¹² 2 ¹¹ 2 ¹⁰ 2 ⁹ 2 ⁸ 2 ⁷ 2 ⁶ 2 ⁵ 2 ⁴ 2 ³ 2 ² 2 ¹ 2 ⁰														
BIT	NAME				DESCRIPTION (BIT = 1)									
2 ¹⁵	Command MRO				Force a Memory Read-out									
2 ¹⁴	Command IFC				Perform In-Flight Cal.									
2 ¹³	SC-7 Ena./Dis.				Toggle Command which Enables or Disables SC-7									
2 ¹²	IFC Ena./Dis.				Toggle Command which Enables or Disables the IFC Circuit									
2 ¹¹	Reset Flags				Initialize all Priority Flags									
2 ¹⁰	MRO Select				Toggle Command									
2 ⁹	MRO Select				Toggle Command (2 ¹⁰ and 2 ⁹ are used to select one of four MRO modes)									
2 ⁸	Priority Mode Sel.				Toggle Command used to Select One of Two Priority Modes									
2 ⁷	Cal. Select				Toggle Command									
2 ⁶	Cal. Select				Toggle Command (2 ⁷ and 2 ⁶ are used to select one of four in-flight cal. modes)									
2 ⁵	γ-Trig. 3 Ena./Dis.				Toggle Command used to Enable or Disable the T _C = 2 sec Gamma Event Trig.									
2 ⁴	γ-Trig. 2 Ena./Dis.				Toggle Command used to Enable or Disable the T _B = 1 sec Gamma Event Trig.									
2 ³	γ-Trig. 1 Ena./Dis.				Toggle Command used to Enable or Disable the T _A = 1/4 sec Gamma Event Trig.									
2 ²	K-Select 3				Toggle Command used to Select K = 1 or K = 2 for the T _C = 2 sec γ-Event Trig.									
2 ¹	K-Select 2				Toggle Command used to Select K = 1 or K = 2 for the T _B = 1 sec γ-Event Trig.									
2 ⁰	K-Select 1				Toggle Command used to Select K = 1 or K = 2 for the T _A = 1/4 sec γ-Event Trig.									

TABLE B-IV
T-REGISTER WORDS 3 AND 11

Command Register Status																			
Octal 8-Bit Word								Octal 8-Bit Word											
2 ¹⁵	2 ¹⁴	2 ¹³	2 ¹²	2 ¹¹	2 ¹⁰	2 ⁹	2 ⁸	2 ⁷	2 ⁶	2 ⁵	2 ⁴	2 ³	2 ²	2 ¹	2 ⁰				
A		B			C			D		E			F						
<hr/>																			
A								Command IFC				Command MRO							
0 B C D E F								---				---							
1								True				---							
2								---				True							
<hr/>																			
B								Reset Flags				IFC Ena./Dis.				SC-7 Ena./Dis.			
A 0 C D E F								---				---				---			
. 1								True				---				---			
. 2								---				Toggle				---			
. 3								True				Toggle				---			
. 4								---				---				Toggle			
. 5								True				---				Toggle			
. 6								---				Toggle				Toggle			
. 7								True				Toggle				Toggle			
<hr/>																			
C								Priority Mode Sel.				MRO Sel. (2 ⁹)				MRO Sel. (2 ¹⁰)			
A B 0 D E F								---				---				---			
. . 1 . . .								Toggle				---				---			
. . 2 . . .								---				Toggle				---			
. . 3 . . .								Toggle				Toggle				---			
. . 4 . . .								---				---				Toggle			
. . 5 . . .								Toggle				---				Toggle			
. . 6 . . .								---				Toggle				Toggle			
. . 7 . . .								Toggle				Toggle				Toggle			
<hr/>																			
D								Cal. Sel. (2 ⁶)				Cal. Sel. (2 ⁷)							
A B C 0 E F								---				---							
. . . 1 . .								Toggle				---							
. . . 2 . .								---				Toggle							
. . . 3 . .								Toggle				Toggle							
<hr/>																			
E								Y-Trig. 1 Ena./Dis.				Y-Trig. 2 Ena./Dis.				Y-Trig. 3 Ena./Dis.			
A B C D 0 F								---				---				---			
. . . . 1 .								Toggle				---				---			
. . . . 2 .								---				Toggle				---			
. . . . 3 .								Toggle				Toggle				---			
. . . . 4 .								---				---				Toggle			
. . . . 5 .								Toggle				---				Toggle			
. . . . 6 .								---				Toggle				Toggle			
. . . . 7 .								Toggle				Toggle				Toggle			
<hr/>																			
F								K-Select 1				K-Select 2				K-Select 3			
A B C D E 0								---				---				---			
. 1								Toggle				---				---			
. 2								---				Toggle				---			
. 3								Toggle				Toggle				---			
. 4								---				---				Toggle			
. 5								Toggle				---				Toggle			
. 6								---				Toggle				Toggle			
. 7								Toggle				Toggle				Toggle			

TABLE B-V

T-REG. WORD 4

(REPEATED IN WORD 12)

MEMORY DATA IDENT. (ID)

BIT	γ -EVENT	FLARE 2	FLARE 1
2^0	1	0	1
2^1	0	1	0
2^2	0	0	0
2^3	0	0	0
2^4	0	1	1
2^5	0	1	1
2^6	1	0	0
2^7	1	1	1
2^8	1	0	0
2^9	1	1	1
2^{10}	1	1	1
2^{11}	0	0	0
2^{12}	0	0	0
2^{13}	0	0	0
2^{14}	1	1	1
2^{15}	1	1	1

T-REGISTER WORD 7

FLAGS STATUS WORD

BIT	DESCRIPTION
2 ⁰	GAMMA EVENT FLAG
2 ¹	FLARE 2 FLAG
2 ²	FLARE 1 FLAG
2 ³	RATIO FLAG
2 ⁴	(NOT ASSIGNED)
2 ⁵	(NOT ASSIGNED)
2 ⁶	IFC ENA./DIS. FLAG
2 ⁷	SC-7 ENA./DIS. FLAG
2 ⁸	CAL. STATUS
2 ⁹	CAL. STATUS
2 ¹⁰	CAL. STATUS
2 ¹¹	(NOT ASSIGNED)
2 ¹²	(NOT ASSIGNED)
2 ¹³	(NOT ASSIGNED)
2 ¹⁴	(NOT ASSIGNED)
2 ¹⁵	(NOT ASSIGNED)

T-REGISTER WORDS 7 AND 8

Flags Status															
Octal 8-Bit Word								Octal 8-Bit Word							
2 ¹⁵	2 ¹⁴	2 ¹³	2 ¹²	2 ¹¹	2 ¹⁰	2 ⁹	2 ⁸	2 ⁷	2 ⁶	2 ⁵	2 ⁴	2 ³	2 ²	2 ¹	2 ⁰
0		0		G		H		J		K					
<hr/>															
G								(2 ⁸ , 2 ⁹ , 2 ¹⁰) Cal. Mode Status							
0 0 0 H J K								Cal. 1 Mode							
. . 1 . . .								Cal. 2 Mode							
. . 2 . . .								Cal. 3 Mode							
. . 4 . . .								Cal. 4 Mode							
<hr/>															
H								(2 ⁶) IFC Ena./Dis.				(2 ⁷) SC-7 Ena./Dis.			
0 0 G 0 J K								Disabled				Disabled			
0 0 G 1 J K								Enabled				Disabled			
0 0 G 2 J K								Disabled				Enabled			
0 0 G 3 J K								Enabled				Enabled			
<hr/>															
J								(2 ³) Ratio Flag				(2 ⁴ , 2 ⁵)			
0 0 G H 0 K								No				0, 0			
. . . . 1 .								Yes							
<hr/>															
K								Gamma Event Flag (2 ⁰) Flare 2 Flag (2 ¹) Flare 1 Flag (2 ²)							
0 0 G H J 0								No				No			
. . . . 1								Yes				No			
. . . . 2								No				Yes			
. . . . 4								No				Yes			

TABLE B-VIII

COARSE TIME (HIGH ORDER 16 BITS)

BIT	DAYS	HOURS	MINUTES	SECONDS
2 ¹⁵	3	00	49	04
2 ¹⁴	1	12	24	32
2 ¹³		18	12	16
2 ¹²		09	06	08
2 ¹¹		04	33	04
2 ¹⁰		02	16	32
2 ⁹		01	08	16
2 ⁸			34	08
2 ⁷			17	04
2 ⁶			08	32
2 ⁵			04	16
2 ⁴			02	08
2 ³			01	04
2 ²				32
2 ¹				16
2 ⁰				08

TABLE B-IX

FINE TIME (LOW ORDER 16 BITS)

BIT	SECONDS															
	10 ⁰	10 ⁻¹	10 ⁻²	10 ⁻³	10 ⁻⁴	10 ⁻⁵	10 ⁻⁶	10 ⁻⁷	10 ⁻⁸							
2 ¹⁵	4	0														
2 ¹⁴	2	0														
2 ¹³	1	0														
2 ¹²	0	5	0													
2 ¹¹	0	2	5	0												
2 ¹⁰	0	1	2	5	0											
2 ⁹	0	0	6	2	5	0										
2 ⁸	0	0	3	1	2	5	0									
2 ⁷	0	0	1	5	6	2	5	0								
2 ⁶	0	0	0	7	8	1	2	5	0							
2 ⁵	0	0	0	3	9	0	6	2	5							
2 ⁴	0	0	0	1	9	5	3	1	2							
2 ³	0	0	0	0	9	7	6	5	6							
2 ²	0	0	0	0	4	8	8	2	8							
2 ¹	0	0	0	0	2	4	4	1	4							
2 ⁰	0	0	0	0	1	2	2	0	7							

TABLE B-X
T-REGISTER WORDS 9 AND 10

PG ACCUMULATOR		
	BIT	COUNTS/SECOND
WORD 9	2^3	5 2 4 2 8 8
	2^2	2 6 2 1 4 4
	2^1	1 3 1 0 7 2
	2^0	6 5 5 3 6
WORD 10	2^{15}	3 2 7 6 8
	2^{14}	1 6 3 8 4
	2^{13}	8 1 9 2
	2^{12}	4 0 9 6
	2^{11}	2 0 4 8
	2^{10}	1 0 2 4
	2^9	5 1 2
	2^8	2 5 6
	2^7	1 2 8
	2^6	6 4
	2^5	3 2
	2^4	1 6
	2^3	8
	2^2	4
	2^1	2
	2^0	1

NOTE: 20 bits permits a maximum of 1 048 575 counts; ($2^{20} - 1$).

TABLE B-XI
T-REGISTER WORD 9

Y-Mem. File Counter								PG Accum. (High Order 4 Bits)							
2 ¹⁵	2 ¹⁴	2 ¹³	2 ¹²	2 ¹¹	2 ¹⁰	2 ⁹	2 ⁸	2 ⁷	2 ⁶	2 ⁵	2 ⁴	2 ³	2 ²	2 ¹	2 ⁰
0		0				A		0		B				C	
Octal 8-Bit Word								See Table B-X							

A	Y-Memory File Counter
0 0 0 0 B C	File No. 0
0 0 1 . . .	File No. 1
0 0 2 . . .	File No. 2
0 0 3 . . .	File No. 3
0 0 4 . . .	File No. 4
0 0 5 . . .	File No. 5
0 0 6 . . .	File No. 6
0 0 7 . . .	File No. 7

PRE-MEMORY AND MAIN MEMORY CONFIGURATION SEQUENCE
FOLLOWING A GAMMA EVENT TRIGGER

Fig. C-1.

Memory configuration after a gamma event trigger and just prior to entering data into the main memory.

Fig. C-2.

Memory configuration just after transfer of first gamma memory file into the main memory.

Fig. C-3.

Memory configuration just prior to entering the 2nd gamma memory file into the main memory.

Fig. C-4.

Memory configuration after transfer of the 2nd gamma memory file into the main memory.