HARVARD UNIVERSITY

HARVARD COLLEGE OBSERVATORY

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Computer Assisted Performance Tests of the Lyman Alpha Coronagraph

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ABSTRACT

Preflight calibration and performance tests of the Lyman Alpha Coronagraph rocket instrument in the laboratory, with the experiment in its flight configuration and illumination levels near those expected during flight, have been successfully carried out using a pulse code modulation (PCM) telemetry system simulator interfaced in real-time to a PDP 11/10 computer system. Post-acquisition data reduction programs developed and implemented on the same computer system aided in the interpretation of test and calibration data. The Lyman Alpha Coronagraph instrument was flown successfully on April 13, 1979 and February 16, 1980.

1. INTRODUCTION AND SUMMARY

The Lyman Alpha Coronagraph is a new rocket instrument designed to measure the wavelength distribution and absolute intensity of resonantly scattered Lyman alpha radiation from the solar corona for spatial elements from 1.3 to 4.0 solar radii from sun center. The detailed scientific objectives have been provided elsewhere. The first measurements of Lyman alpha radiation beyond 2 solar radii were obtained using this instrument on April 13, 1979. Additional measurements coincident with a solar eclipse were carried out on February 16, 1980.

Under this grant a telemetry system simulator, which served as an electronic interface between our flight data handling system and an existing PDP 11/10 computer, was designed, built and tested. Pre-flight coronagraph instrument performance tests were carried out using this laboratory test system. It was possible to operate the instrument at flight scanning rates and flight data rates, permitting verification of the basic instrument integrity in a highly reliable and cost efficient manner.

II. THE PCM SIMULATOR

The pulse code modulation (PCM) telemetry system simulator is a laboratory electronic interface module which links the Lyman Alpha Coronagraph instrument's on-board data-handling system to a PDP 11/10 computer which in turn simulates a ground-based data-recording system. The PCM simulator distributes data from the instrument to each of 38 predetermined telemetry channels in the identical manner as the flight PCM telemetry system. The PCM

simulator is built on two 4.5" x 6" wire-wrap cards. It requires two power supplies and consumes about 0.75 A. A block schematic diagram of the PCM simulator is shown in Figure 1. Table I shows a page or frame of telemetry and the allocation of the data channels. Data channels are identified by word, subframe pairs, e.g. scientific data A is transmitted along word 4, subframe 0; it is also available redundantly along (8,0) and (6,8). The data are sampled 12.8 msec later from the instrument controller and, once again, scientific data A, to use the same example, will be transmitted along (4,16), (8,16) and (6,24).

III. THE COMPUTER SYSTEM

Highly reliable calibration and performance tests of the Lyman Alpha Coronagraph instrument in flight configuration are possible through the interface of the PCM telemetry simulator to a PDP 11/10 computer system. A PDP 11/10 system consists of a central processor unit with 16K bytes memory, 2 DEC-tape drives, and video-graphic display terminal with hard copy capability. An assembly language program written for the purpose permits selective real-time sampling of any or all of the telemetry channels from the PCM. The numerical values of the selected data channels can be displayed immediately after data acquisition. The option exists to integrate the data from any desired number of consecutive wavelength scans in which case the data stored and displayed will represent the accumulated values in each channel. At the option of the experimenter, this data can be permanently stored in designated files on magnetic tape.

A versatile Fortran program has been written to read the magnetic tape record of calibration and performance tests and carry out further analysis. Any portion of the data from a specified telemetry channel, averaged over any desired interval, may be displayed graphically on a video screen. The data may be integrated over a specified range. A comparison table of all or part of the data from various designated channels can be produced. The program is able to perform various search and display operations and is readily adapted to other common data reduction functions.

IV. COMPUTER ASSISTED PERFORMANCE TESTS

In March 1979 and January 1980 calibration and performance tests were performed on the Lyman Alpha Coronagraph in flight configuration. Illumination levels at the expected solar intensity were used. Figure 2 shows the spectral line profile obtained during one of the many tests that were conducted on 10 January 1980. It is representative of the illumination level expected at 3 $R_\odot$. The data has been averaged over 10 frames. Table II shows a portion of the corresponding output. The leftmost column indicates the main frame number (one spectral scan consists of 512 frames). In addition to the intensity detector count which appears in columns labelled 4,0 and 5,0, the grating shaft angle encoder is shown in columns marked 4,0 and 8,0, and the mirror shaft angle encoder value is displayed in columns marked 4,2 and 8,2.

The integrated test system: Lyman Alpha Coronagraph instrument, PCM simulator, and PDP 11/10 computer, proved to be a direct, powerful and

immediate mode whereby flight configuration performance tests could be carried out accurately and independently of the flight telemetry system which is only available at the launch site. The two successful flights of the Lyman Alpha Coronagraph have reaffirmed its value.

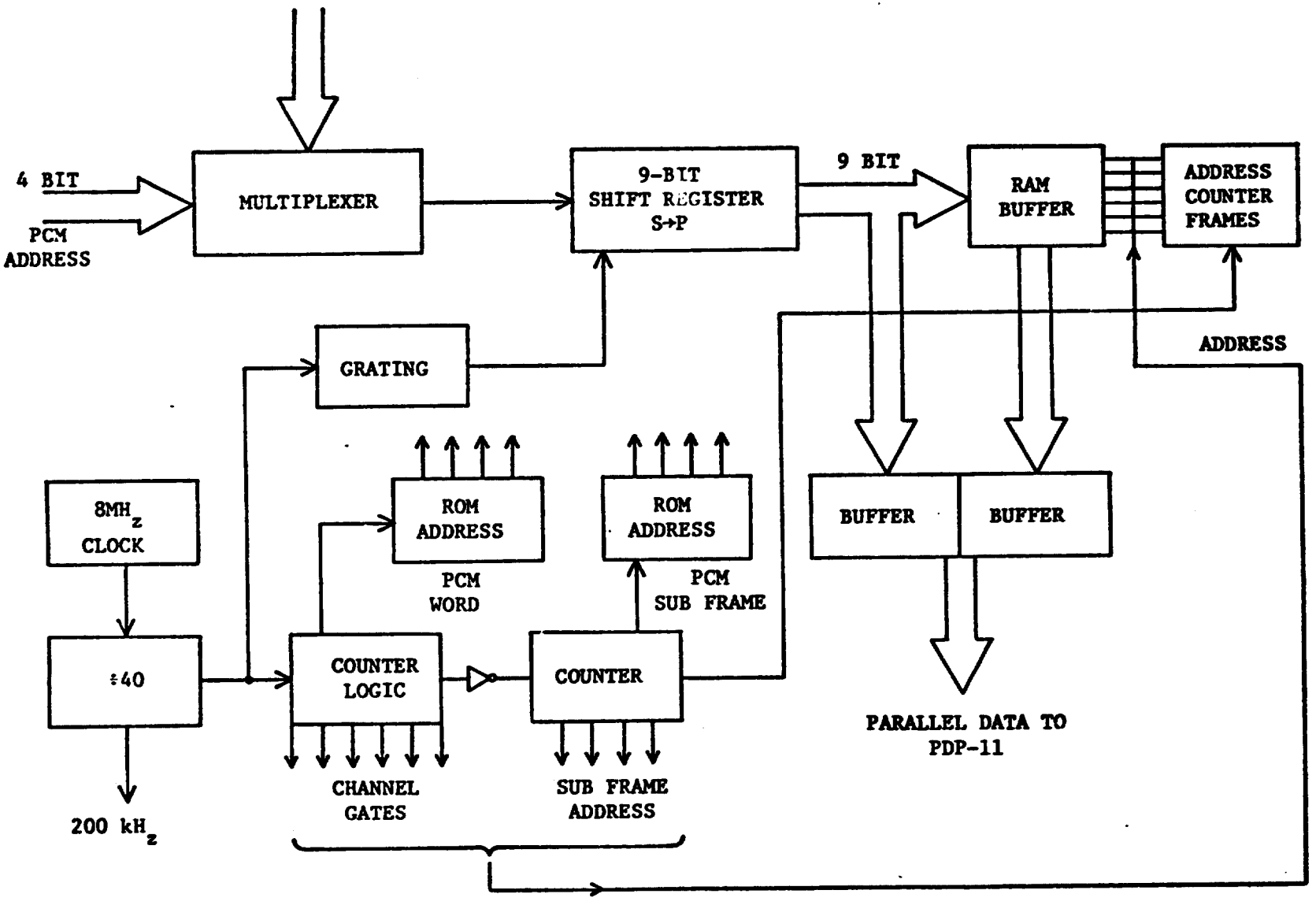

Figure 1. Telemetry System Simulator

TLM SUB FRAME	DIGITAL DATA						ANALOG DATA	
	WORD 4	WORD 5	WORD 6	WORD 15(7)	WORD 8	WORD 9	WORD 10	TLM SUB FRAME WORD 10 ONLY
0.16	Sci. Data A	Sci. Data B		Sci. Data B	Sci. Data A	Sci. Data B	Full Scale Ref.	0
1.17	Grating SAE	Grt. Step. Ctr.	Housekeeping D1		Grating SAE	Grt. Stp. Ctr.	Ground Ref.	1
2.18	Mirror SAE	Mir. Step Ctr. A	Housekeeping D3		Mirror SAE	Mir. Step Ctr. A	Stby Batt. E	2
3.19	Mem A out				Mem A out	Housekeeping D2	H.V. Monitor	3
4.20	Mem B out	Mir. Step Ctr. B			Mem B out	Mir. Step Ctr. B	Pressure	4
5.21							+10 V	5
6.22							-10 V	6
7.23							Primary Batt. E	7
8.24	Housekeeping D3	Housekeeping D2	Sci. Data A		Housekeeping D1		Primary Batt. I	8
9.25	Housekeeping D1				Housekeeping D3		Slit Temp.	9
10.26							Mir. Temp.	10
11.27							Occ. Temp.	11
12.28							+7V H.V. Primary	12
13.29							Grt. Position	13
14.30							Mir. Position	14
15.31							U.V. Lamp I	15
							TLM Clock ON	16
							-	17
							Grat. Dr. Temp.	18
	Data Bus A	Data Bus B	Data Bus A	Data Bus B	Data Bus A	Data Bus B	Spares ↓	• • • 31

Revised 12/13/79

Table I. Lyman Alpha Coronagraph Telemetry Channel Assignments

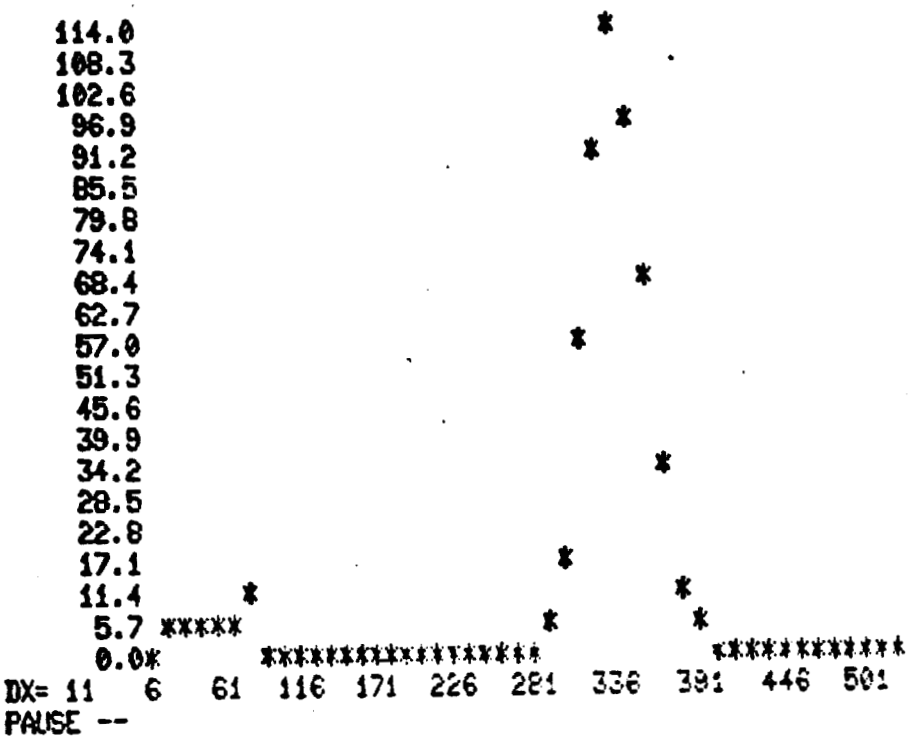

Figure 2. Instrumental Line Profile of
Rocket Lyman Alpha Coronagraph
(1/10/80)

Frame Number	Counts (4,0)	Counts (5,0)	Grating (4,1)	Grating (8,1)	Mirror (4,2)	Mirror (8,2)
315	97	97	136	136	64	64
316	94	94	137	137	64	64
317	106	106	137	137	64	64
318	95	94	137	137	64	64
319	100	100	138	138	64	64
320	107	107	139	139	64	64
321	108	108	139	139	64	64
322	95	95	139	140	64	64
323	114	114	140	140	64	64
324	112	112	141	141	64	64
325	134	134	141	141	64	64
326	140	140	142	142	64	64
327	103	103	142	142	64	64
328	100	100	143	143	64	64
329	125	125	143	143	64	64
330	116	116	143	143	64	64
331	111	111	144	144	64	64
332	109	109	145	145	64	64
333	90	90	145	145	64	64
334	109	109	145	145	64	64
335	102	102	146	146	64	64
336	102	102	147	147	64	64
337	100	100	147	147	64	64
338	88					
338	88	88	147	147	64	64
339	83	83	148	148	64	64
340	67	67	149	149	64	64
341	94	94	149	149	64	64
342	79	79	151	151	64	64
343	79	76	150	150	64	64
344	86	86	151	151	64	64
345	72	72	151	151	64	64
346	68	68	151	151	64	64
347	72	72	152	152	64	64
348	59	59	153	153	64	64
349	53	53	153	153	64	64
350	59	59	153	153	64	64
351	71	71	154	154	64	64
352	51	51	155	155	64	64
353	40	40	155	155	64	64
354	56	56	155	155	64	64
355	32	32	156	156	64	64
356	47	47	157	157	64	64
357	46	46	157	157	64	64
358	47	47	157	157	64	64
359	31	31	158	158	64	64
360	26	26	159	159	64	64
361	30	30	159	159	64	64
362	18	18	159	159	64	64
363	22	22	160	160	64	64
364	25	25	161	161	64	64
365	21	21	161	161	64	64
366	21	21	161	161	64	64
367	9	9	162	162	64	64
368	13	13	163	163	64	64
369	17	17	163	163	64	64
370	13	13	163	163	64	64
371	8	8	164	164	64	64
372	8	8	165	165	64	64
373	7	7	165	165	64	64
374	5	5	165	165	64	64
375	6	6	166	166	64	64
376	3	3	167	167	64	64
377	5	5	167	167	64	64
378	5	5	167	167	64	64
379	4	4	168	168	64	64
380	3	3	169	169	64	64
381	3	3	169	169	64	64
382	2	2	169	171	64	64
383	1	1	170	170	64	64
384	6	6	171			

Table II. Record of Data from Telemetry Simulator