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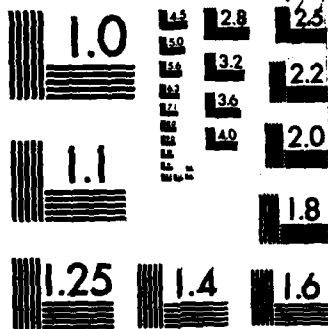
SRI CAMERA EXPERIMENT CONTROLLER/INTERFACE(U) SRI
INTERNATIONAL MENLO PARK CA 5 DAMRON MAR 82
SRI-3878-82-QR1-IM4 N00014-82-C-0092

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SRI International



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SRI CAMERA EXPERIMENT CONTROLLER/INTERFACE

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SRI Project 3878

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-- 22 - KEYWORDS: (U) LASER ;(U) INTERNAL WAVES ;(U) OPTICAL
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-- 23 - TECHNICAL OBJECTIVE: (U) CONTINUE PROVIDING TECHNICAL SUPPORT TO
THE DARPA LIDEX PROGRAM.

-- 24 - APPROACH: (U) PARTICIPATE IN THE LIDEX PROGRAM BY COLLECTING AND
REDUCING SEA TRUTH DATA IN SUPPORT OF LIDAR TESTS, TO CONTINUE WITH THE
DEVELOPMENT, TESTING, AND USE OF INSTRUMENTATION FOR IN-SITU
MEASUREMENTS OF OPTICAL DATA ON SEA WATER PARTICULARLY FOR TOWED
OPERATIONS AND TO CONTINUE TO PROVIDE TECHNICAL CONSULTATION AND
PLANNING TO THE LIDEX PROGRAM.

-- 25 - PROGRESS: (U) A SEA TRUTH INSTRUMENTATION SUITE HAS BEEN DEVELOPED
IN A FORM APPROPRIATE FOR MEASURING OPTICAL PARAMETERS OF SEAWATER OF
INTEREST TO LIDAR APPLICATIONS FROM A DRIFTING VESSEL. THESE SEA TRUTH
PARAMETERS INCLUDE BEAM SPREAD FUNCTION, BACKSCATTER COEFFICIENT, AND
DIFFUSE ATTENUATION COEFFICIENT. IN ADDITION, A COMPUTERIZED DATA
COLLECTION SYSTEM HAS BEEN ACQUIRED AS WELL AS DEVELOPMENT OF A REAL-
TIME ANALYSIS SYSTEM.

-- 37 - DESCRIPTORS: (U) ATTENUATION ;(U) COEFFICIENTS ;(U) COMPUTER
APPLICATIONS ;(U) DATA ACQUISITION ;(U) DIFFUSION ;(U) DRIFT ;(U)
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-- (U) OCEANOGRAPHY ;(U) OPERATION ;(U) OPTICAL ANALYSIS ;(U) OPTICAL
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I INTRODUCTION

The camera experiment controller interface provides communications between an HP9845 desk-top computer and a digital camera instrumentation set. It is used with two cameras in separate experiments. One camera is in an underwater housing used for measurement of beam spread function. The second camera is used aboard the vessel at the output focal plane of an optical spectrograph. The digital camera set includes the 100 x 100 pixel digital Reticon camera with its RS250 controller, the ITT microchannel plate (MCP) image intensifier with its electronic gate or shutter, and a Graflex strobe light source*. The interface sends all the electronic signals needed to control the instrumentation set. The HP9845, in turn, programs the interface with the timings required for the desired experiment. The HP9845 also reads out image data stored in a 16K x 8-bit memory in the interface. Thus, two independent levels of operation take place in the interface: control of the camera experiment; and data communication between the HP9845 and digital camera. Both levels of operation are discussed below. *in the document*

A. Interface Control of Reticon Instrumentation Set

The three experimental instruments to which the interface is directly connected are a Graflex strobe unit, an ITT MCP image intensifier and a Reticon RS250 camera controller. In addition, the interface monitors the output of a photodiode "light meter" that provides a measure of illumination level for control of camera exposure. The interface can send the following signals to the following instruments :

<u>Instrument</u>	<u>Signal</u>
Graflex Strobe	Fire strobe (-150 V)
ITT Image Intensifier	Gate on (+5 V)/Gate off (0 V) Intensifier Gain (0 - +10 V)
Reticon RS250	ESTART (begin frame acquisition) ECLK (external timing signal)

*The strobe light source is used for beam spread function (BSF) measurements. In the case of the Fiber Optic Spectrometer System for Underwater Measurements (FOSSUM), this stroboscopic light source is not used.

To send these signals at the appropriate times, the HP9845 loads information into eight registers (Reg 0-7) of the interface. During experiment control, the interface examines each register once per microsecond to determine if any signals need to be sent. Reg. 0 contains an 8-bit number which sets the gain of the image intensifier. Reg. 1 is a cutoff value to protect the image intensifier from over-exposure conditions. When the product of the intensifier gain (Reg. 0) and the digital value of the photodiode "light meter" mentioned above exceeds the value stored in Reg. 1, the experiment is automatically turned off. The other six registers (Reg. 2-7) contain a time in microseconds at which an experimental function should occur. Each microsecond these registers are compared with the experiment clock and a function is executed when the register value equals the experiment clock value. The functions of these six registers are listed here:

<u>Reg.</u>	<u>Function</u>
2	ESTART1 - time at which first (dark) image frame is acquired. This frame is used to clear the data memory.
3	Intensifier Gate On - time at which the intensifier gate is turned on.
4	Experiment Reset time - time at which the experiment clock is reset and starts counting up again. This time cannot exceed 16.5 seconds.
5	Strobe Start Time - time at which the strobe is fired. Typical strobe duration in 3 ms.
6	ESTART2 - time at which the second image frame is acquired.
7	Intensifier Gate off - time at which the intensifier gate is turned off.

There are two rules which govern the execution of any of Reg 2 through 7. First, the experiment clock starts with a value of 8 microseconds, so any register which has a value less than 8 will never equal the experiment clock value and, therefore, never initiate an execution of a function. The register values should never be 0. The second rule is that if all six timing registers are less than the experiment clock value the experiment execution automatically stops after a single execution of the experiment.

Some examples will show how this experiment control works. Suppose the experiment is to set off the strobe and record a picture (single-frame mode). The registers could be loaded with the following values:

<u>Reg.</u>	<u>Value</u>
0	Arbitrary (decided by light level)
1	Arbitrary
2	ESTART1 - 10 μ s
3	Intensifier on - 11000 μ s
4	Reset time - 6 μ s (not executed)
5	Strobe start time - 11001 μ s
6	ESTART 2 - 15001 μ s
7	Intensifier off - 15000 μ s

Using the two rules listed, it can be seen that a frame will be acquired starting 10 μ s to clear the CCD array. It should be noted that it takes 11 msec to transfer an image from Reticon to HP9845. When the CCD is clear, the intensifier will be turned on and the strobe flashed. The image of the flash will be recorded 15 ms later, right after the intensifier is turned off. Note that since the reset time is less than 8 μ s, it is not executed. Therefore, when the experiment clock exceeds all the register values, the experiment stops.

Now suppose a continuous frame mode were desired, with a frame to be recorded every 50 msec. The registers would be set as follows:

<u>Reg.</u>	<u>Value</u>
0	Arbitrary (depends on light level)
1	Arbitrary
2	ESTART1 - 6 μ s
3	Intensifier on - 2000 μ s

4	Reset time - 50,008 μ s
5	Strobe start time - 2001 μ s
6	ESTART2 - 5500 μ s
7	Intensifier off - 5450 μ s

In this second example, it can be seen that the ESTART1 command is never executed and that the process repeats every time the experiment clock reaches 50008 μ s. The process will stop only when the HP9845 resets the interface.

Another feature of the interface is the recording of the photodiode "light meter" data value in the 16K memory of the interface. When the interface is not recording image data, it continuously places the photodiode value into a known memory address. When the strobe function in Reg. 5 is executed, the photodiode values are recorded every 8 μ s into an array in the memory. This allows the acquisition of a time history of the ambient light level. Since other procedures permit the strobe to be fired without the camera taking a picture or the intensifier being turned on, it is possible to find the light level to which the intensifier will be exposed without turning on the camera intensifier. The following register values permit use of the photo diode as a light meter:

<u>Reg.</u>	<u>Value</u>
0	0
1	0
2	ESTART1 - 2 μ s
3	Intensifer on - 2 μ s
4	Reset time - 2 μ s
5	Strobe time - 10 μ s

- 6 ESTART2 - 50,000 μ s
- 7 Intensifier off - 2 μ s

The interface register values can be reset while the experiment clock is running. This would allow, for instance, modification of the intensifier gain during image acquisition. The interface also has an external synch switch and connector. When switched on, the experiment clock will not commence until the synch connector receives a "true" level TTL signal longer than one microsecond.

B. HP9845 Communication with the Interface

The HP9845 presents 16 output lines to the interface and receives 16 inputs lines from the interface via the HP98032A 16-bit interface. The interface provides the proper signals to "talk" to the HP9845. The words which the HP9845 sends to the interface contain instructions and data. The lower order byte contains data (when applicable); the high order byte contains 8-bits of instructions for the interface. The high order byte looks like this:

<u>Bit</u>	<u>Instruction</u>
15	Load data from HP to latch
14	Load data from latch to HP (with bit 8 on, set up for DMA)
13	Load data from register to latch
12	Load data from latch to register
11	EXECUTE EXPERIMENT

	<u>Bit 12 or 13 on</u>	<u>Bit 14 on</u>	<u>Bit 15 on</u>
10	MSB Register	Latch Byte 3	Latch Byte 3
11	Register	Latch Byte 2	Latch Byte 2
12	LSB Register	DMA	_____

The instruction set above allows the HP9845 to move data a byte at a time through a 24-bit wide "latch" into one of the interface's 8 registers (Reg. 0-7). It fills the latch with three low-order data bytes then fills one of the registers with the latch. The instruction set also allows the HP9845 to read any of the interface's registers. This is accomplished by loading the latch with the desired register and then reading out the latch to the HP9845. Since the latch is 24-bits wide, it takes three reads for the HP9845 to completely read the latch. After the registers have been loaded with the proper timings and values, the experiment will start when the interface receives a word with bit 11 on.

The image data and the time history of the photodiode are transferred to the HP9845 via DMA. First the HP9845 must send a word with bits 14 and 8 on. It must next input in DMA format 10,010 or 16,384 words. 10,010 words are input when only the image is desired; 16,384 words are input when the photodiode time history is desired as well. The value of the CTLO line in the HP98032A interface determines how many words will be input. DMA's may occur while an experiment is taking place, but recording image data takes priority over the interface memory. Data transferred via DMA has only the low-order byte valid.

The following subprogram illustrates the four basic operations--loading the interface registers (cf., "Hp_to_registers"), reading the interface registers back into the HP (cf., "Registers_to_hp"), starting the experiment (cf., "Execute"), and reading in a picture via DMA (cf., "Dma_picture"). Two subprograms also convert real variables with timings stored in them into integer variables that can be sent to the interface and vice versa.

```

3950 REM
3960 REM
3970 REM
3980 SUB Hprc(Info,Do_pixel_corrct)
3990 REM
4000 REM This routine drives the HP98032A interface and talks to the
4010 REM SRI control box, the so-called HPRC. Values of Info cause
4020 REM different actions to happen.
4030 REM
4040 REM Info = 1 --> Run Experiment
4050 REM Info = 2 --> Load Timings
4060 REM Info = 3 --> Load Gain
4070 REM Info = 4 --> DMA into Raw_data
4080 REM
4090 REM Note that in loading the timings or the gain, this routine
4100 REM automatically recalls the loaded values for verification.
4110 REM The recalled values are placed back into Timings and the
4120 REM calling routine is responsible for handling an error in
4130 REM loading the Timings variables. The Do_pixel_corrct para-
4140 REM meter fixes the odd pixels for the SRI camera which is
4150 REM missing output from its odd pixels.
4160 REM
4170 COM INTEGER Select_code,Raw_data(*),Packed_data(*),Dark_data(*)
4180 COM REAL Timings(8),Correct_data(*),Vign_data(*)
4190 COM Start_time$(14)
4200 INTEGER I,J,K,First,Last,Toggle(16),Time(8,3),Word
4210 REAL Test_time
4220 FOR I=0 TO 14
4230 Toggle(I)=2^I
4240 NEXT I
4250 Toggle(15)=-32768
4260 IF Info=1 THEN
4270 GOSUB Execute
4280 ELSE
4290 IF Info=2 THEN
4300 GOSUB Load_times
4310 ELSE
4320 IF Info=3 THEN
4330 GOSUB Load_gain
4340 ELSE
4350 IF Info=4 THEN
4360 GOSUB Dma_picture
4370 END IF
4380 END IF
4390 END IF
4400 END IF
4410 SUBEXIT
4420 Execute: |
4430 WRITE IO Select_code,5;Toggle(0)
4440 WRITE BIN Select_code;Toggle(1)
4450 OUTPUT 9;"R"
4460 ENTER 9;Start_time$
4470 SUBEXIT
4480 Load_times: |
4490 First=2
4500 Last=7
4510 GOSUB Load_values
4520 SUBEXIT
4530 Load_gain: |
4540 First=0
4550 Last=1
4560 GOSUB Load_values
4570 SUBEXIT

```

```

4580 Use_picture: 1
4590 WRITE IO Select_code,5;Toggle(8)
4600 Word=BINIOR(Toggle(14),Toggle(8))
4610 WRITE BIN Select_code;Word
4620 ENTER Select_code MDMA 10010 NOFORMAT;Raw_data(*)
4630 WRITE IO Select_code,5;Toggle(8)
4640 IF Do_pixel_corrct=1 THEN
4650   FOR I=0 TO 99
4660     FOR J=0 TO 96 STEP 2
4670       Raw_data(I,J+1)=(Raw_data(I,J)+Raw_data(I,J+2))/2
4680     NEXT J
4690   NEXT I
4700 END IF
4710 SUBEXIT
4720 Load_values: 1
4730 GOSUB Timings_to_time
4740 GOSUB Hp_to_register
4750 GOSUB Register_to_hp
4760 RETURN
4770 Hp_to_register: 1
4780 FOR I=First TO Last
4790   FOR J=0 TO 2
4800     Word=BINIOR(BINIOR(Toggle(15),Time(I,J)),Toggle(J+8))
4810     WRITE BIN Select_code;Word
4820   NEXT J
4830   Word=BINIOR(I*2^8,Toggle(13))
4840   WRITE BIN Select_code;Word
4850 NEXT I
4860 RETURN
4870 Register_to_hp: 1
4880 FOR I=First TO Last
4890   Word=BINIOR(I*2^8,Toggle(12))
4900   WRITE BIN Select_code;Word
4910   Word=BINIOR(Toggle(14),Toggle(9))
4920   WRITE BIN Select_code;Word
4930   J=READBIN(Select_code)
4940   Timings(I)=0
4950   FOR K=0 TO 14
4960     IF BIT(J,K)=1 THEN Timings(I)=Timings(I)+Toggle(K)
4970   NEXT K
4980   IF BIT(J,15)=1 THEN Timings(I)=Timings(I)+2^15
4990   Word=BINIOR(Toggle(14),Toggle(10))
5000   WRITE BIN Select_code;Word
5010   Timings(I)=Timings(I)+BINAND(255,READBIN(Select_code))*2^16
5020 NEXT I
5030 RETURN
5040 Timings_to_time: 1
5050 FOR K=First TO Last
5060   Test_time=Timings(K)
5070   FOR I=2 TO 0 STEP -1
5080     Time(K,I)=0
5090     FOR J=I+8+7 TO I+8 STEP -1
5100       IF Test_time-2^J)=0 THEN
5110         Time(K,I)=BINIOR(Time(K,I),Toggle(J-I+8))
5120         Test_time=Test_time-2^J
5130       END IF
5140     NEXT J
5150   NEXT I
5160 NEXT K
5170 RETURN
5180 SUBEND
5190 REM
5200 REM

```

