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AN INTERFACE BETWEEN A MINICOMPUTER AND A
SCANNING MICRODENSITOMETER

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AN INTERFACE BETWEEN A MINICOMPUTER AND A SCANNING MICRODENSITOMETER

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In 1977, a hardware interface was constructed connecting the Interdata model 7/32 computer in the NBS image processing facility to an Optronics film scanner, hereafter called the Photomation. This scanner is a drum type, having servo drive for rotation with a shaft-encoder pickoff for X increments and a stepping motor and lead screw for Y increments. A microdensitometer head with interchangeable aperture settings measures density at each location on the object plane. Automatic analog circuitry sets zero and full scale every drum revolution, and an analog-to-digital converter produces eight-bit data for each point (pixel). In practice, the computer receives data for X and density, and outputs data for Y.

The purpose of the interface is to allow programmers to send necessary control information to the Photomation and to read data from it. The user interface to the Photomation is through a software driver that is part of the computer operating system and is therefore beyond the scope of this report. The programming information contained herein is primarily of interest to the writer of the OS driver.

The Photomation hardware itself will perform several tasks for the programmer. It is possible to send Y increment commands which will count motor steps. Y direction mechanical end stops may be set manually and the computer will sense when they have been hit. An X skip field may also be set by the computer to tell the Photomation to skip a number of pixels before beginning data transfer. A rotary (manual) switch on the Photomation determines resolution in the X direction (25, 50, 100, or 200 micrometers per datum). Y resolution is determined by software, as each carriage step is 12.5 micrometers regardless of the setting of the resolution switch. This same switch chooses a speed for drum rotation, and the position of the switch can be read by the computer. An error signal is generated if the switch is changed during operation of the scanner.

Photomation Programming

The Photomation interface responds to the usual Interdata I/O instructions. The following description shows the assignment of status and command bits.

SENSE STATUS

Bit 8, 9, 10. Raster switch: These three bits, taken together, indicate the setting of the Photomation raster switch.

Bit Pattern	Meaning
000	12.5 micrometers
001	25 micrometers
010	50 micrometers
011	100 micrometers
100	200 micrometers

Bit 11. Overrun: When this bit is set it indicates that the Photomation has detected an error condition. This can be caused by hitting an end stop, or by failing to read a datum before the Photomation produced another.

Bit 12. Busy: Indicates to the Interdata that data are not ready to be transferred. Indicates to the Photomation that the Interdata wants more data. For detailed information, read the section on logic circuit description in this report. The notes on busy contained there must be read before programming the interface.

Bit 13. Examine Status: This bit is set to indicate any error condition. It is the logical OR of the conditions "overrun," described above, and "switch moved," caused by the raster switch being moved.

Bit 14. Carriage Busy: This bit is set during carriage motion (Y direction).

Bit 15. Drum up to Speed: This bit is set when the drum is not up to speed, or whenever other inoperant conditions exist (such as power off) in the Photomation.

OUTPUT COMMAND

Bit 8, 9. Interrupt Arm, Disable, Disarm as per Standard Interdata Conventions.

Bit 10. Halfword Mode: Indicates to the computer that the interface is in halfword mode.

Bit 11. Clear: Generates a Photomation clear command. This command is required any time the Photomation has been powered up, has generated an error condition, or is at the end of an X scan. The data hardware must receive at least one clear command per revolution. The clear command also resets the raster switch comparator register so

that it remembers that switch setting as the current one. Upon detecting a change in switch setting, issue a clear.

Bits 12-15. Operation Code: When any of these bits is set, and bit 11 is reset, these bits are understood to be a Photomation Op code as defined in the Photomation Manual.

WRITE DATA (ALWAYS USE WRITE HALFWORD)

All data bits are used to load the Photomation count register. This register is used for stepper motor counts for Y incrementing and for skip field counts during data taking. The write halfword instruction loads this register. This register is loaded with the two's complement of the desired count. Do not load it with a positive number. If this is accidentally done, issue a clear command to free the scanner.

READ DATA

The rightmost eight data bits represent the digitized density at each pixel. A read data instruction will input only these data. The leftmost eight bits represent Photomation (not interface) status. These may be read using a read halfword instruction. The only information in this status byte not available from the Sense Status instruction is the identity of an end stop which has been hit. The overrun status will indicate an end stop but not tell you which one. The assignment of bits in Photomation status may be determined from the Photomation Manual.

Typical Programming Sequences for the Photomation Interface

Travel in the Y Direction:

Issue a clear, setting board in halfword mode.
Write data using the two's complement of the Y travel desired as data.
Sense status to check for end-stop condition.
Output command with proper Photomation op code for Y direction desired.

Data Gathering Using Busy Loop:

Issue a clear, setting board in halfword mode.
Write data using two's complement of the X skip desired as data.
Read data to set busy bit. Ignore the data.
Output command with proper Photomation op code for read; place board in byte mode.
Loop waiting for busy bit to go away.
Read data and store it. Loop clocking data on busy until done.
Issue clear to terminate read operation.

Data Gathering Using Selector Channel (SELCH):

Issue a clear, setting board in halfword mode.
Write data using two's complement of the X skip desired as data.
Read data to set busy bit. Ignore the data.
Write data to set up SELCH registers for boundaries of transfer.
Output command to Photomation with op code for read; place board
in byte mode.
Output command to start SELCH.
Upon SELCH termination, issue clear to terminate read operation.

Logic Circuit Description:

Refer to sheet 1 of the logic drawing. ULM data outputs are wired directly to Photomation data inputs. This sixteen wire connection is detailed by the wire list on this drawing. ULM data inputs are wired to Photomation data outputs through 7400 type gates used to strobe the data into the computer during a read instruction. The wire list shows the identity and connections of these gates. Photomation bits are numbered in reverse order from Interdata bits; that is, the Interdata's most significant bit is labelled bit 0 and the Photomation's most significant bit is labelled bit 15. The Interdata input strobe signal is derived from ULM signal DRG10.

The remainder of the signals on this drawing are used for control. The Photomation requires 400 ns low-going pulses as control strobes. These are generated by 74123 one-shots. Photomation's EX6 "load data" (into photomation count/offset register) is driven by the ULM DAG10 signal. This allows writing of data in one stroke from the Interdata to the photomation by use of a write halfword instruction. The Photomation "general clear" signal, EX4, is generated either when the Interdata issues a command instruction with data bit 11 set (CMG11 and OD111), or when a hard clear (SCLRO) comes from the Interdata hardware.

The Photomation "execute" command, EX7, is driven by any command instruction with data bit 11 reset when any of the four low-order command bits (12-15) are set (Photomation op-code present). This causes the Photomation to execute the command represented by the op-code present on the lines.

The Interdata sync return line has been cut on the ULM board to allow return sync to be generated by the Photomation. An OBRS signal from the Photomation is ORed with other sync sources to allow a return under all circumstances. EX6 and EX4 signals do not generate OBRS and therefore are separately included in sync.

Refer to sheet 2 of the logic drawing. Photomation signal ES0 is wired directly to ULM status input SI151, Device unavailable.

Photomation signal ES3 is inverted and wired to ULM status input SI141, EOM (Meaning--Carriage busy). Photomation signal ES7 is wired directly to ULM status input SI111 (Meaning--Data overrun). Three Photomation signals are wired directly to ULM status inputs to indicated raster switch setting: ID02 to SI081, ID01 to SI091, and ID00 to SI101. (Note reverse notation as with data lines.)

A backup register has been built for the raster switch settings. This causes a status change and an interrupt if the raster switch setting is changed. A three bit register is loaded from the switch settings whenever a clear command is issued or whenever an interrupt caused by raster switch setting is acknowledged. A binary comparator continuously compares the register contents with the switch setting. Any difference causes the ULM status input SI131, Examine, to go high. Examine is also raised by overrun status, the same one which is reported by SI111.

Interrupts are generated to the processor in the case of examine, device unavailable, or carriage busy changing state. Examine and Device Unavailable cause interrupts when setting. Carriage busy causes an interrupt on carriage stopping.

Notes on Busy:

Scan data transfers take place with a handshake between the ULM and the Photomation, and with a separate handshake between the ULM and the Interdata. The flip-flop is used to coordinate these transactions as follows: Assume the flip-flop is reset. This shows buffer busy (IBF) to the Photomation and not busy to the Interdata (Status bit SI121). The Interdata then executes a read data cycle (through programmed I/O or SELCH) and issues DRG10. This reads the Photomation data into the computer and sets the flip-flop. This shows buffer empty to the Photomation and busy to the Interdata. When new Photomation data is ready, the Photomation signal EST is issued, resetting the flip-flop and starting a new cycle. The Photomation generates overrun whenever IBF is high (buffer full) and another datum is ready.

It is necessary to start a sequence of data transfers in the correct state. Therefore, YOU MUST ISSUE A READ DATA INSTRUCTION BEFORE STARTING ANY BLOCK TRANSFERS.

This ensures that the flip-flop indicates buffer empty to the Photomation and busy to the Interdata. At this point, a read command to the Photomation followed by a "busy loop" or SELCH start will leave the computer hung waiting for the first EST from the Photomation. This may be delayed if the Photomation has been programmed to skip a large field before data taking. If this preliminary read is not done, overrun will occur.

The entire logic circuit is constructed of SN7400 series TTL integrated circuits mounted on an MDB Systems wire-wrap ULM (Universal Logic Module). Packaged TTL terminators (220 ohms to +5 volts; 330 ohms to ground) are used on every line coming from the Photomation.

INTEGRATE INPUT DATA
 ID000 → ID070
 SEE TABLE BELOW FOR TIMING
 ID080 → ID150

INTEGRATE OUTPUT
 DATA 00001 → 0D151

DATA INPUT SYSTEM (SEE TABLE BELOW)
 DE LINES

DATA INPUT SYSTEM (SEE TABLE BELOW)
 DE LINES

DATA INPUT SYSTEM (SEE TABLE BELOW)
 DE LINES

DATA INPUT SYSTEM (SEE TABLE BELOW)
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DATA INPUT SYSTEM (SEE TABLE BELOW)
 DE LINES

DATA INPUT SYSTEM (SEE TABLE BELOW)
 DE LINES

SEE WIRE LIST FOR PULL-OUT OF THIS CONNECTION

WRITE DATA LAG

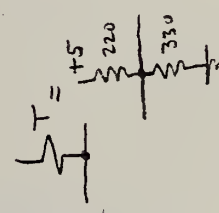
BIT 11 SET, CMG

BIT 11 SET, CMG

ECHO FOR ENG EXT AT TRAILING EDGE

STORAGE DATE CONNECTIONS JK, L, M, H

DATE	TIME	SIGNAL	MDB TERMINATOR
16	1007	10000	445
17	1006	10010	466
18	1005	10020	467
19	1004	10030	450
20	1003	10040	451
21	1002	10050	434
22	1001	10060	434
23	1000	10070	428
24	1000	10080	423
25	1000	10090	423
26	1000	10100	422
27	1000	10110	424
28	1000	10120	419
29	1000	10130	412
30	1000	10140	412
31	1000	10150	410



ONE-SHOT CRT	CHIP	TIMING TIME	RES	CAP	J9	K9	REPIN	CHIP
1	J10	400NS	10KΩ	100pF	7	15	14	6
2	K10	400NS	00	00	7	15	14	6
2	K10	100NS	5KΩ	50pF	15	14	14	14

LOCATED ON ULM - SUPPLIED PARTS

MDB SYSTEMS ULM BOARD

DATA AND OUTPUT CIRCUITRY

NOTE: CUT AT 15B2 F
 SO MDB (MAYBE) N
 IN LENS

OD111 (CLEAR CMD)
 X99 FOUND AT F11-4

SHT 1 14178 11-5

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6. SUPPLEMENTARY NOTES

5. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)

This publication describes the hardware interface between the Optronics Photomation film scanner and an Interdata computer. Description of operation, programming information, and circuit diagrams are included.

7. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)

Artificial intelligence; computer interface; image processing; optical scanning

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