

FEATURES

Microcontroller Interface

- Supports high-speed processors (e.g., 16-MHz 8051, 16-MHz 68HC11)
- Supports multiplexed/non-multiplexed address and data bus
- Supports interrupt- or polled-processor interface
- Provides microcontroller access to six external switch settings
- Four-level power-down capability when idle, automatic power-up when command is received
- Supports host- and disk-interrupt pins

Formatter Interface

- Supports NRZ disk data rates up to 32 Mbits/second
- Works with all disk encoding schemes
- Disk interfaces supported include ST506/412, ESDI and SMD
- Supports non-interleaved operations
- User-modifiable RAM-based disk formatter control store (31 x 4 bytes)
- Multiple WCS branch and WCS data field branch capability
- Variable split data field support for constant-density-recording formats
- Full-track multi-sector transfer capability with no microcontroller intervention

(cont.)

High-Performance PC XT/AT Disk Controller

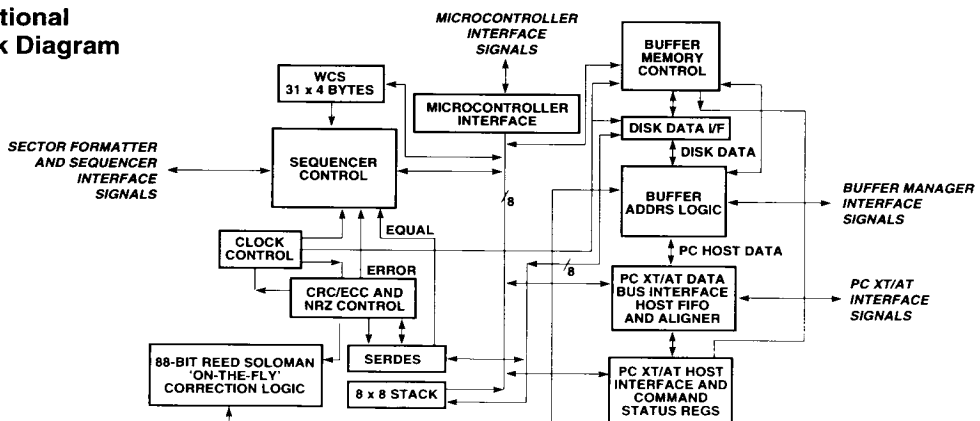
OVERVIEW

The CL-SH360 is a VLSI component that provides the majority of the hardware necessary to build a PC Winchester disk controller. It is typically configured with buffer memory and a microcontroller — with system RAM and ROM — to create a complete intelligent PC Winchester disk controller. The device combines an advanced Winchester disk formatter, a dual-port buffer memory manager, and extensive hardware support, including direct bus connection with 24-mA drivers.

A static RAM (SRAM) buffer is controlled by the CL-SH360 memory manager. It supports disk data rates up to 32 Mbits/second, and simultaneously provides the handshake for PC-bus-programmed I/O or DMA data transfer at rates up to 4 Mwords/second.

(cont.)

**Functional
Block Diagram**



November 1993 /

FEATURES (cont.)

Formatter Interface (cont.)

- Scheduled WCS access
- User-programmable sector length up to a full track
- 16-bit CRC and 88-bit ECC polynomial with 'on-the-fly' hardware correction circuitry
- Flexible sector-level defect handling
- Buffer-derived ID field during format
- Two index timeout circuit for sector searches
- Programmable read synchronization timeout

Buffer Manager

- Dual-port circular buffer control with access priority resolver
- Direct-buffer addressing up to 64K bytes of static RAM
- Fixed and variable buffer segmentation support
- Scheduled microcontroller write/read to/from buffer
- Supports internal division of buffer clock by one, two, three and four for ease of implementation
- Supports buffer memory throughput to 12 Mbytes/second
- Provides host overrun control
- Dual-buffer-chip enables for 64K buffers

PC XT/AT and Other Compatible Interface

- True real-time hardware and software compatibility with PC XT/AT and other compatible computers

- Direct bus interface logic with on-chip 24-mA drivers
- Supports 8- as well as 16-bit host bus transfer
- Supports any host speed with programmable and auto-wait-state generation
- PC XT/AT DMA handshake logic handles transfer to/from buffer memory at rates up to 4 Mwords/second
- Demand Mode DMA handshake logic (EISA Type 'B')
- Buffer data transfer supported under DMA or programmed I/O for both PC XT and PC AT
- FIFOs provided to synchronize buffer RAM access with the PC bus and formatter
- Emulates the IBM® task file for PC AT and IBM command descriptor block for PC XT
- Provides logic to speed-up command response
- Provides logic for daisy-chaining two XT- or AT-embedded drives
- Support of AT Master/Slave DASP* and PDIAG* Signals
- Separate status for bus reset and host program reset

Technology

- 100-pin PQFP and VQFP packages
- Advanced, low-power, double-metal CMOS technology

OVERVIEW (cont.)

The CL-SH360 Disk Formatter consists of a serializer/deserializer, a flexible RAM-based Sequencer, 16-bit CRC polynomial and an 88-bit Reed-Solomon ECC generator with on-the-fly hardware correction capability. The Formatter also supports variable split data fields for constant density recording formats.

The CL-SH360 is designed to work with a local processor. It has multiplexed or non-multiplexed address and data bus similar to that provided by the

Intel® 8051 and Motorola® 68HC11 family of controllers. The local processor interface also supports separate host and disk interrupt pins.

The CL-SH360 has a highly sophisticated power management capability. It supports four levels of power-down when idle in full support of the ATA Specification. The extremely low power requirements of the CL-SH360 make it an ideal choice for laptop or other power-sensitive applications.

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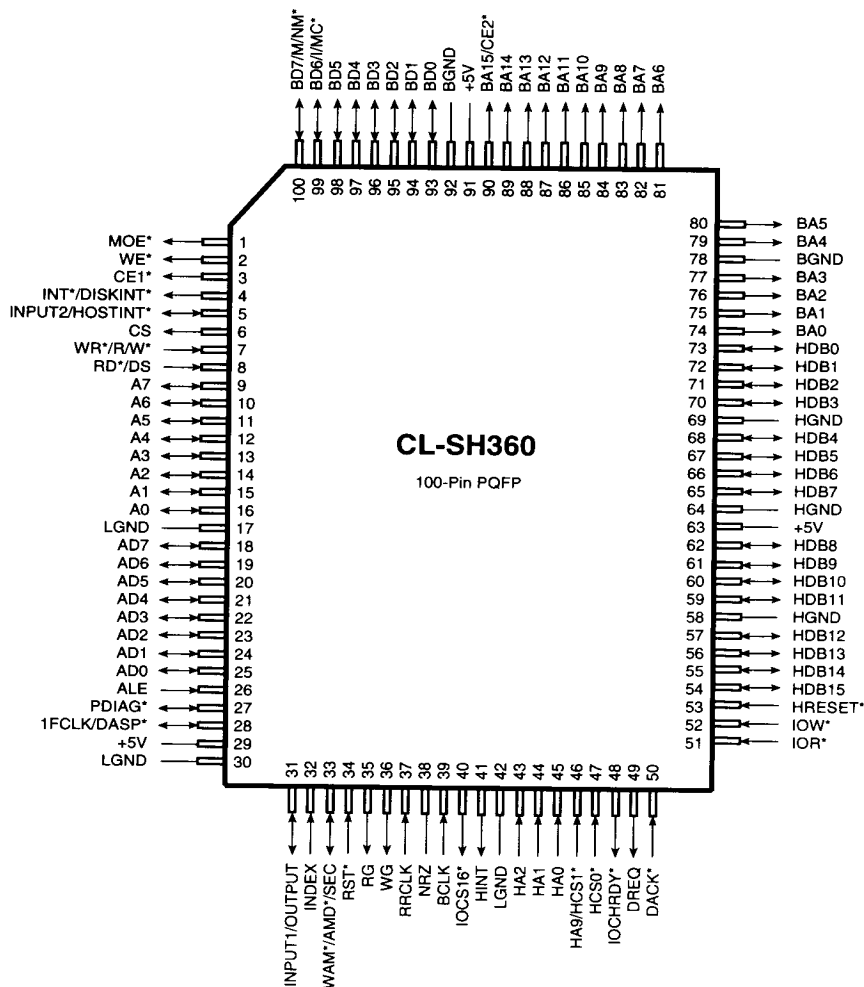
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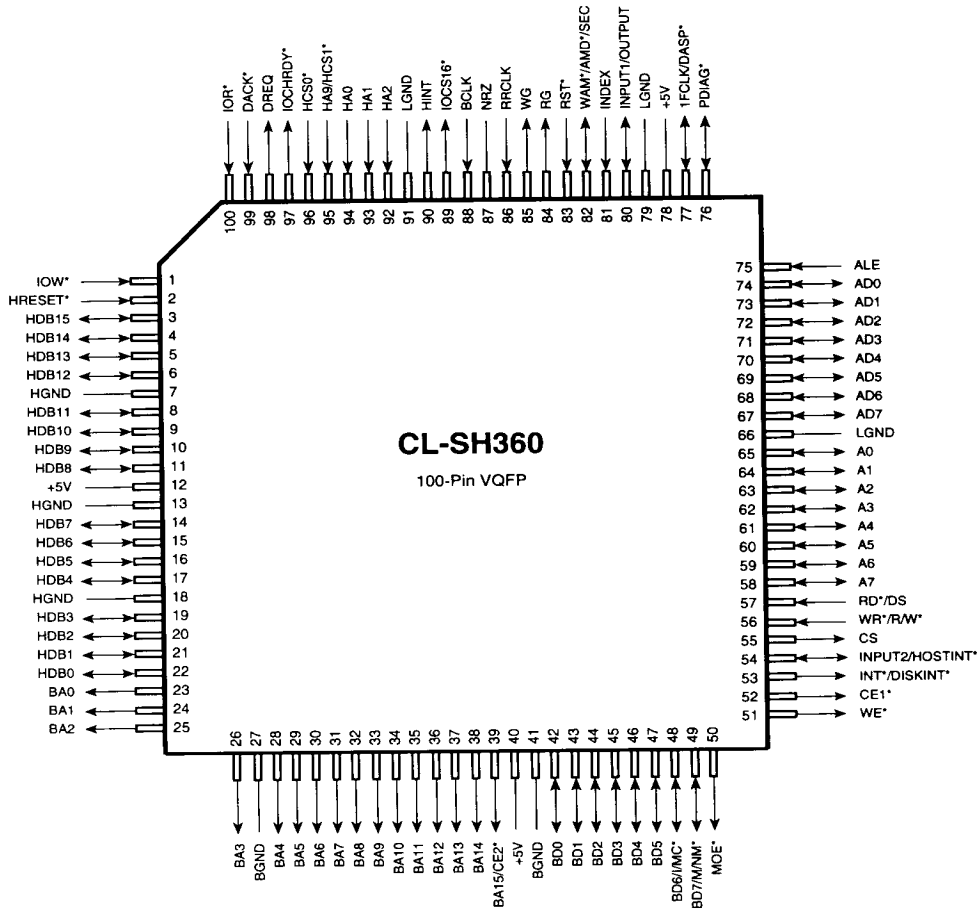
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1. PIN INFORMATION

1.1 Pin Diagram for the 100-Pin Plastic Quad Flat Pack (PQFP)



1.2 Pin Diagram for the 100-Pin Very Low-Profile Quad Flat Pack (VQFP)



2. PIN ASSIGNMENTS

The following conventions are used in the pin assignment table: (I) indicates an input; (O) indicates an output; (I/O) indicates an input/output; (OD) indicates an open-drain output; (Z) indicates a tri-state output or an input/output; (*) denotes a negative-true (active-low) signal.

2.1 100-Pin PQFP and VQFP Pin Assignments

NOTE: Unless otherwise specified, *all* references to pin locations include PQFP/VQFP pin numbers.

Symbol	PQFP No.	VQFP No.	Type	Description
BA15/CE2*	90	39	O	BUFFER ADDRESS LINE 15/BUFFER CHIP ENABLE 2: Bit 15 is for addressing buffer memory or the second 32K buffer chip enable.
BA[14:0]	89-79 77-74	38-28 26-23	O	BUFFER ADDRESS LINES: Bits 14-0 are for addressing buffer memory.
BD7/M/NM*	100	49	I/O	BUFFER DATA BUS/MULTIPLEXED/NON-MULTIPLEXED ADDRESS CONFIGURATION: This is Bit 7 of the 8-bit buffer data bus. The CL-SH360 is initialized to Multiplexed Mode if this input is connected to an external pull-up resistor (~20K ohm) after deassertion of the RST* Signal (Pin 34/83). Otherwise, it is configured in Non-multiplexed Mode.
BD6/I/MC*	99	48	I/O	BUFFER DATA BUS INTEL/MOTOROLA: This is Bit 6 of the 8-bit buffer data bus. The CL-SH360 is initialized to Motorola if this input is connected to an external pull-down resistor (~20K ohm) after deassertion of the RST* (Pin 34/83) Signal. Otherwise, it is configured in Intel Mode.
BD[5:0]	98-93	47-42	I/O	BUFFER DATA BUS: These six signals are Bits 5-0 of the 8-bit buffer data bus.
MOE*	1	50	O	MEMORY OUTPUT ENABLE: This signal is asserted low when a RAM Buffer Operation is active. It is recommended that MOE* be connected to the RAM output enable for high-speed operation.
WE*	2	51	O	WRITE ENABLE: This signal is asserted low when a buffer memory Write Operation is active.
CE1*	3	52	O	BUFFER CHIP ENABLE 1: This signal is the control signal for the full-buffer chip enable or the first 32K chip enable.



2.1 100-Pin PQFP and VQFP Pin Assignments (cont.)

Symbol	PQFP No.	VQFP No.	Type	Description
INT*/DISKINT*	4	53	O,OD	INTERRUPT/DISK INTERRUPT: This is the microcontroller Interrupt*/Disk Interrupt* Pin, programmable for either push-pull or open-drain output circuitry. This pin contains an internal pull-up resistor. The INT*/DISKINT* pull-up can be disabled if the Interrupt Enable Bit (Register 77H, Bit 3) is set, and the Interrupt Pin Pull-up Disable Bit (Register 77H, Bit 4) is set.
INPUT2/HOSTINT*	5	54	I/O	INPUT2/HOST INTERRUPT: This is the microcontroller Host Interrupt* Pin, programmable for either push-pull or open-drain output circuitry. This pin can also be used as an edge-sensitive second input to the sequencer. This pin contains an internal pull-up resistor which can be disabled by setting Bit 4 in Register 4FH.
CS	6	55	I	CHIP SELECT: This signal must be asserted to access the CL-SH360 registers.
WR*/R/W*	7	56	I	WRITE STROBE/READ/WRITE: When the Intel bus control interface is selected (the /IMC* Signal (Pin 99/48) is asserted high), this signal acts as the WR* Signal. When the Write Strobe Signal is asserted low and the CS Signal (Pin 6/55) is asserted high, the data on the AD lines will be written to the specified register. When the Motorola bus control interface is selected (the /IMC* Signal (Pin 99/48) is deasserted low), this signal acts as the R/W* Signal. A high on this input, along with the RD*/DS Signal (Pin 8/57) asserted and the CS Signal (Pin 6/55) asserted high, it indicates a Read Operation. A low on this input, along with the RD*/DS Signal (Pin 8/57) asserted and CS Signal (Pin 6/55) asserted high, it indicates a Write Operation.
RD*/DS	8	57	I	READ STROBE/DATA STROBE: When the Intel bus control interface is selected (the /IMC* Signal (Pin 99/48) is asserted high), this signal acts as the RD* Signal. When the Read Strobe Signal is asserted low and the CS Signal (Pin 6/55) is asserted high, the data from the specified register will be driven onto the AD lines. When the Motorola bus control interface is selected (the /IMC* Signal (Pin 99/48) is deasserted low), this signal acts as the Data Strobe Signal. A high on this input, along with the WR*/R/W* Signal (Pin 7/56) asserted and the CS Signal (Pin 6/55) asserted high, it indicates a Read Operation. A high on this input, along with the WR*/R/W* (Pin 7/56) deasserted and the CS Signal (Pin 6/55) asserted high, it indicates a Write Operation.

2.1 100-Pin PQFP and VQFP Pin Assignments (cont.)

Symbol	PQFP No.	VQFP No.	Type	Description
A[7:0]	9-16	65-58	I/O	LOCAL MICROCONTROLLER ADDRESS BUS: These are non-multiplexed address input or demultiplexed address output lines.
AD[7:0]	18-25	74-67	I/O	LOCAL MICROCONTROLLER ADDRESS/DATA: These are tri-state address/data lines that interface with a multiplexed microcontroller address/data bus.
ALE	26	75	I	ADDRESS LATCH ENABLE: In Multiplexed Mode, this signal will latch the address from the AD bus; A[7:0] are the latched address outputs. When Non-multiplexed Mode is selected, this signal should be driven high, and A[7:0] are the demultiplexed address inputs.
PDIAG*	27	76	I/O	PASS DIAGNOSTICS: This signal is used between two embedded AT drives for communicating drive diagnostic results. This pin contains an internal pull-up resistor that can be disabled by setting Bit 4 in Register 4FH.
1FCLK/DASP*	28	77	I/O	1FCLK/S�AVE PRESENT: The 1FCLK can be used for the ECC corrector circuit. For embedded AT drives, this pin can also function as the Slave Present Signal. This pin contains an internal pull-up resistor that can be disabled by setting Bit 4 in Register 4FH.
INPUT1/ OUTPUT	31	80	I/O	INPUT1/OUTPUT: The state of this pin is sampled by reading Register 7DH, Bit 2. It is also a branch input to the sequencer RAM. When the pin is programmed for outputs, it is controlled by Bit 2 of the Control Field (A0H-BEH) of the Sequencer WCS RAM. This pin contains an internal pull-up resistor. The resistor is disabled when the pin is configured as an output.
INDEX	32	81	I	INDEX: This is an input for the index pulse received from the drive.
WAM*/ AMD*/ SECTOR	33	82	I/O	WRITE ADDRESS MARK/ADDRESS MARK DETECT/ SECTOR: This signal can be configured to operate in Hard or Soft Sector Mode by initializing the Hard/Soft* Sector Mode Control Bit of the Formatter Mode Selection Register (Register 77H, Bit 7). The default is Soft Sector Mode. In Soft Sector Mode, when the RG Signal (Pin 35/84) is asserted, a low-level input on this signal indicates Address Mark detected. Also, in Soft Sector Mode, a 1-bit wide pulse is an output when WG (Pin 36/85) is active and an address mark is to be written. In Hard Sector Mode, this is the input for the sector pulse.

2.1 100-Pin PQFP and VQFP Pin Assignments (cont.)

Symbol	PQFP No.	VQFP No.	Type	Description
RST*	34	83	I	RESET: When this signal is asserted low, it stops all operations within the chip and deasserts the RG Signal (Pin 35/84), the WG Signal (Pin 36/85), and the NRZ Signal (Pin 38/87). All I/O signals and host outputs are set to a high-impedance state. See <i>Register Initialization</i> , Section 3.6.
RG	35	84	O	READ GATE: This signal is asserted when the CL-SH360 is reading NRZ data from the storage device.
WG	36	85	O	WRITE GATE: This signal is asserted when the CL-SH360 is writing NRZ data to the storage device.
RRCLK	37	86	I	READ REFERENCE CLOCK: This is a multiplexed input sourced from the VFO oscillator during a Read Gate; otherwise, it is from the write oscillator. This is the primary clock for the Formatter section and must be present at all times, including during a Reset Operation.
NRZ	38	87	I/O	NRZ: This is a Read Data Input from the disk when the RG Signal (Pin 35/84) is active; this is a Write Data Output to the disk when the WG Signal (Pin 36/85) is active.
BCLK	39	88	I	BUFFER CLOCK: This is a clock input that is used to generate buffer memory access cycles.
IOCS16*	40	89	OD	16-BIT DATA TRANSFER: This signal indicates that a 16-bit data transfer is active on the PC bus.
HINT	41	90	O,Z	HOST INTERRUPT: This signal, when enabled, sends an interrupt to the PC host.
HA[2:0]	43-45	92-94	I	PC BUS ADDRESS LINES: The address lines HA[9,2:0] address the various AT/XT Control, Status, and Data Registers. Only the HA[1:0] lines are used for PC XT operation.
HA9/HCS1*	46	95	I	PC ADDRESS LINE 9 or CHIP SELECT 1: This is a Multiplexed Input Signal. When the HCS1 Mode Enable Bit (Register 52H, Bit 3) is reset, this input is PC Address Line 9; when the bit is set, the input is Host Chip Select 1. When this signal is configured as HCS1*, this input is ignored when the DACK* Signal (Pin 50/99) is asserted low. This pin contains an internal pull-up resistor which can be disabled by setting Bit 4 in Register 4FH.

2.1 100-Pin PQFP and VQFP Pin Assignments (cont.)

Symbol	PQFP No.	VQFP No.	Type	Description
HCS0*	47	96	I	CHIP SELECT 0: When this signal is asserted low, this input selects access to the Control, Status and Data Registers. This input is ignored during DMA data transfers, i.e., when the DACK* Signal (Pin 50/99) is asserted low. This pin contains an internal pull-up resistor. It can be disabled by setting Bit 4 in Register 4FH.
IOCHRDY*	48	97	O	I/O CHANNEL READY: This signal is asserted low to extend host transfer cycles when the controller is not ready to respond.
DREQ	49	98	O,Z	DMA REQUEST: The DMA Request Signal is used during DMA transfer between the host and controller. This signal is issued by the controller to start a DMA transfer.
DACK*	50	99	I	DMA ACKNOWLEDGE: The DMA Acknowledge Signal is used during DMA to complete the DMA handshake for data transfer between the host and the CL-SH360. The signal is active for each transfer on the host bus. This pin contains an internal pull-up resistor.
IOR*	51	100	I	I/O READ STROBE: This signal is asserted low by the host during a Host Read Operation. When this signal is asserted low with the HCS0*/HCS1* or the DACK* Signal, it enables status or data onto the host data bus.
IOW*	52	1	I	I/O WRITE STROBE: This signal is asserted low by the host during a Host Write Operation. When this signal is asserted low with the HCS0*/HCS1* or the DACK* Signal, data from the host data bus is strobed into the CL-SH360.
HRST*	53	2	I	HOST RESET: When this signal is asserted, it initializes the Control/Status Registers and stops any command in process. See <i>Register Initialization</i> , Section 3.6. This pin contains an internal pull-up resistor.
HDB[15:0]	54-57, 59-62, 65-68 70-73	3-6, 8-11 14-17 19-22	I/O,Z	HOST DATA BUS: During PC AT operations, HDB[15:8] are used in conjunction with HDB[7:0] for word transfers between the sector buffer and the host; Bits HDB[7:0] are used for control status and ECC byte access. During PC XT operation, only HDB[7:0] lines are used; the HDB[15:8] lines are tri-stated.

**2.1 100-Pin PQFP and VQFP Pin Assignments (cont.)**

Symbol	PQFP No.	VQFP No.	Type	Description
HGND	58, 64, 69	7, 13 18		HOST GROUND.
BGND	78, 92	27, 41		BUFFER BUS GROUND.
LGND	17, 30, 42	66, 79 91		LOGIC GROUND.
+5V	29, 91, 63	12, 40 78		POWER SUPPLY (+5)

3. REGISTER TABLES

3.1 Buffer Manager Registers

Address	Type*	Description/Function
9FH/BFH	R/W	Buffer Start Address
DFH/FFH	R/W	Buffer End Address
68H	R/W	Scheduled Microcontroller Buffer Data Access
53H	R/W	Buffer Transfer Control
54H	R/W	Buffer Size/Segment Address
59H	R/W	Buffer/PC Reset Register
5AH-5BH	R/W	Disk Address Pointer
5CH-5DH	R/W	Host Address Pointer
5EH-5FH	R/W	PC Stop Pointer
70H	R/W	Microcontroller Buffer Access
73H	W	Auto-Command 'Lock' Release: A write to this register unlocks the Buffer Manager Registers. The registers were locked when the host issued an Auto-Command. The affected registers are 53H, 5C-5FH, 68H and 70H. Also, the Local Microcontroller Power-Down Bit is unlocked (Register 4FH, Bit 5).

3.2 PC Interface Registers

Address	Type	Description/Function
40H-47H 60H-67H	R/W	PC Interface Register File: These registers are for communication between the host PC and local microcontroller.
55H-57H	R/W	PC Interface Registers: These registers are for communication between the host PC and the local microcontroller.
50H	R/W	PC Interrupt Status Register
51H	R/W	PC Interrupt Enable Register
52H	R/W	Miscellaneous Control/Status Register
58H	R/W	PC Mode Control Register

NOTE: Register types are as follows: R/W = Read/Write; R = Read Only; W = Write Only.

3.3 Formatter Registers

Address	Type	Description/Function
4DH	R	Data Latch Register (for read accesses of the data buffer through Registers 68H and 70H)
4EH	R/W	Sector Size Register (for larger than 512-byte data fields)
69H	R	Sector Status Register
69H	W	Increment Sector Count Register
6AH	R/W	Sector Target Register
6BH	R/W	Sector Count Register
6CH	R/W	React Branch Register
6DH	R/W	MSB Sector Remaining Counter
6EH	R/W	LSB Sector Remaining Counter
6FH	R	Revision Register
71H	R/W	Control Register for ECC: Bit 5, which can be set from the RST* Pin or the microcontroller, is the Formatter reset. When set, a constant reset will be asserted that stops all operations within the Formatter and drops RG, WG, WAM and NRZ outputs. This reset also clears the interrupt enables.
72H	R	ECC Syndrome Shift Register
72H	W	Correction Done Reset
74H	R/W	ECC Offset Correction Count (MSB)
75H	R/W	ECC Offset Correction Count (LSB)
76H	R/W	Synchronization Byte-Count Limit
77H	R/W	Formatter Mode Selection
78H	W	Branch Address Register
79H	R	Formatter Status Register
79H	W	Sequencer Start Address Register
7AH	R/W	Operation Control/Status Register
7BH	R/W	WAM Output Timing Control Register

3.3 Formatter Registers (cont.)

Address	Type	Description/Function
7CH	R/W	Synchronous Byte Register (to be compared with NRZ read data): The number of bits to be compared is controlled by Register 7FH.
7DH	R/W	Formatter Interrupt Status Register
7EH	R/W	Formatter Interrupt Enable Register
7FH	W	Clock Control and Sync Compare Register
7FH	R	Stack: When reading, contents of the top of stack are presented to the bus and the stack is rotated.

3.4 Control Registers

Address	Type	Description/Function
48H	R/W	Auxiliary Control Register 0 for mode selection of Formatter and buffer options.
4FH	R/W	Auxiliary Control Register 1 for mode selection of Formatter and local microcontroller interface options.

3.5 Sequencer Registers

Address	Type	Description/Function
80H-9EH	R/W	Next Address Field of the WCS Word: This is the address that the Sequencer will go to after the down-counter has reached zero, and a branch has not been taken.
A0H-BEH	R/W	Control Field of the WCS Word
C0H-DEH	R/W	Count Field of the WCS Word: This sets the initial value of the Sequencer counter when a new state is entered.
E0H-FEH	R/W	Data Field of the WCS Word: This is the source for all overhead bytes of data used by the device during Write Operations. During Read Operations, it is one of the operands to the comparison logic.
49H-4CH	R/W	This allows the microcontroller to access the Current Sequencer Word. There is no protection against access contention between the microcontroller and Sequencer. These registers are for test purposes only.



3.6 Register Initialization

REGISTER	HRST*	RST*	HOST PROG.	REG 59H	REG 59H	REG 71H	REGISTER BIT VALUE								NOTES
Address	(Pin 53/2)	(Pin 34/83)	Reset	(Write)	(Bit 0 = 1)	(Bit 5 = 1)	7	6	5	4	3	2	1	0	
40H/60H							X	X	X	X	X	X	X	X	
41H/61H							X	X	X	X	X	X	X	X	
42H/62H							X	X	X	X	X	X	X	X	
43H/63H							X	X	X	X	X	X	X	X	
44H/64H							X	X	X	X	X	X	X	X	
45H/65H							X	X	X	X	X	X	X	X	
46H/66H	✓	✓	✓				0	0	0	0	0	0	0	0	
47H/67H							X	X	X	X	X	X	X	X	
48H		✓					0	0	0	0	0	0	0	0	1
49H (Test only)		✓				✓	0	0	0	1	1	1	1	1	
4AH (Test only)		✓				✓	0	0	0	0	0	0	0	0	
4BH (Test only)		✓				✓	0	0	0	0	0	0	0	0	
4CH (Test only)		✓				✓	0	0	0	0	0	0	0	0	
4DH		✓				✓	0	0	0	0	0	0	0	0	
4EH		✓					0	0	0	0	0	0	0	0	
4FH							X	X	X	X	X	X	X	X	
50H		✓					X	X	X	0	0	0	0	0	
51H		✓					X	X	X	0	0	0	0	0	
52H		✓					0	0	0	0	0	0	0	0	1
53H		✓					0	0	0	0	0	0	0	0	1
54H		✓					0	0	0	0	0	0	0	0	
55H (XT Mode)	✓	✓	✓				0	0	0	0	0	0	0	0	1
56H (XT Mode)							X	X	X	X	X	X	X	X	
57H (XT Mode)	✓		✓				X	X	X	X	0	0	0	0	
55H (AT Mode)	✓						1	0	0	0	0	0	0	0	1
56H (AT Mode)		✓					X	X	X	0	0	0	0	0	
57H (AT Mode)		✓					X	X	X	0	0	0	0	0	
58H		✓					0	1	0	1	1	0	0	0	
59H		✓					X	X	X	X	X	X	X	1	
5AH		✓		✓	✓		0	0	0	0	0	0	0	0	
5BH		✓		✓	✓		0	0	0	0	0	0	0	0	
5CH		✓		✓	✓		0	0	0	0	0	0	0	0	2
5DH		✓		✓	✓		0	0	0	0	0	0	0	0	2
5EH		✓		✓	✓		0	0	0	0	0	0	0	1	3
5FH		✓		✓	✓		1	1	1	1	1	1	1	1	3

REGISTER	HRST*	RST*	HOST PROG.	REG 59H	REG 59H	REG 71H	REGISTER BIT VALUE								NOTES
Address	(Pin 53/2)	(Pin 34/83)	Reset	(Write)	(Bit 0 = 1)	(Bit 5 = 1)	7	6	5	4	3	2	1	0	
68H		✓		✓	✓		0	0	0	0	0	0	0	0	
69H (Read)		✓					X	X	X	X	X	X	0	0	
6AH		✓					0	0	0	0	0	0	0	0	
6BH		✓					0	0	0	0	0	0	0	0	
6CH		✓				✓	X	X	X	0	0	0	0	0	
6DH		✓					X	X	X	X	0	0	0	0	
6EH		✓					0	0	0	0	0	0	0	0	
6FH							X	X	X	X	X	X	X	X	
70H							X	X	X	X	X	X	X	X	
71H		✓					0	0	1	0	0	0	0	0	1
72H		✓					0	0	0	0	0	0	0	0	
73H							X	X	X	X	X	X	X	X	
74H		✓				✓	0	0	0	0	0	0	0	0	
75H		✓				✓	0	0	0	0	0	0	0	0	
76H		✓					0	0	0	0	0	0	0	0	
77H		✓					0	0	0	0	0	0	0	0	
78H		✓				✓	X	X	X	0	0	0	0	0	
79H (Read)		✓				✓	0	0	0	X	X	X	0	0	1
7AH		✓				✓	0	0	0	0	0	0	0	0	
7BH		✓					0	0	0	0	0	0	0	0	
7CH		✓					0	0	0	0	0	0	0	0	
7DH		✓				✓	X	0	0	0	0	0	0	0	
7EH		✓					X	0	0	0	0	0	0	0	
7FH (Write)		✓					0	0	0	0	0	0	0	0	
9FH		✓			✓		0	0	0	0	0	0	0	0	
BFH		✓			✓		0	0	0	0	0	0	0	0	
DFH		✓			✓		1	1	1	1	1	1	1	1	
FFH		✓			✓		1	1	1	1	1	1	1	1	
80H-9EH							X	X	X	X	X	X	X	X	
A0-BEH							X	X	X	X	X	X	X	X	
C0-DEH							X	X	X	X	X	X	X	X	
E0-FEH							X	X	X	X	X	X	X	X	

- NOTES:** 1) This table only lists reset conditions that are common to all bits in each register. For reset conditions of individual bits in these registers, see the detail register descriptions in Section 5.
2) Registers 5CH and 5DH are also reset by an auto-command.
3) Registers 5EH and 5FH are also set to 01H and FFH, respectively, by an auto-command.

3.7 Register Memory Map

REGISTER ADDRESS - LOWER NIBBLE

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
4	PC INTPT STATUS	PC INTPT ENABLE	MISC CNTRL/STAT	BUF CNTRL/REG	BUF SIZE/REG	HOST STATUS	HOST CNTRL/STATUS REGISTERS	PC MODE	AUX CNTRL REG 0	PC CNTRL	PC MODE	PC CNTRL	PC MODE	PC CNTRL	PC MODE	PC CNTRL
5	PC INTPT STATUS	PC INTPT ENABLE	MISC CNTRL/STAT	BUF CNTRL/REG	BUF SIZE/REG	HOST STATUS	HOST CNTRL/STATUS REGISTERS	PC MODE	AUX CNTRL REG 0	PC CNTRL	PC MODE	PC CNTRL	PC MODE	PC CNTRL	PC MODE	PC CNTRL
6	PC INTPT STATUS	PC INTPT ENABLE	MISC CNTRL/STAT	BUF CNTRL/REG	BUF SIZE/REG	HOST STATUS	HOST CNTRL/STATUS REGISTERS	PC MODE	AUX CNTRL REG 0	PC CNTRL	PC MODE	PC CNTRL	PC MODE	PC CNTRL	PC MODE	PC CNTRL
7	PC INTPT STATUS	PC INTPT ENABLE	MISC CNTRL/STAT	BUF CNTRL/REG	BUF SIZE/REG	HOST STATUS	HOST CNTRL/STATUS REGISTERS	PC MODE	AUX CNTRL REG 0	PC CNTRL	PC MODE	PC CNTRL	PC MODE	PC CNTRL	PC MODE	PC CNTRL
8	PC INTPT STATUS	PC INTPT ENABLE	MISC CNTRL/STAT	BUF CNTRL/REG	BUF SIZE/REG	HOST STATUS	HOST CNTRL/STATUS REGISTERS	PC MODE	AUX CNTRL REG 0	PC CNTRL	PC MODE	PC CNTRL	PC MODE	PC CNTRL	PC MODE	PC CNTRL
9	PC INTPT STATUS	PC INTPT ENABLE	MISC CNTRL/STAT	BUF CNTRL/REG	BUF SIZE/REG	HOST STATUS	HOST CNTRL/STATUS REGISTERS	PC MODE	AUX CNTRL REG 0	PC CNTRL	PC MODE	PC CNTRL	PC MODE	PC CNTRL	PC MODE	PC CNTRL
A	PC INTPT STATUS	PC INTPT ENABLE	MISC CNTRL/STAT	BUF CNTRL/REG	BUF SIZE/REG	HOST STATUS	HOST CNTRL/STATUS REGISTERS	PC MODE	AUX CNTRL REG 0	PC CNTRL	PC MODE	PC CNTRL	PC MODE	PC CNTRL	PC MODE	PC CNTRL
B	PC INTPT STATUS	PC INTPT ENABLE	MISC CNTRL/STAT	BUF CNTRL/REG	BUF SIZE/REG	HOST STATUS	HOST CNTRL/STATUS REGISTERS	PC MODE	AUX CNTRL REG 0	PC CNTRL	PC MODE	PC CNTRL	PC MODE	PC CNTRL	PC MODE	PC CNTRL
C	PC INTPT STATUS	PC INTPT ENABLE	MISC CNTRL/STAT	BUF CNTRL/REG	BUF SIZE/REG	HOST STATUS	HOST CNTRL/STATUS REGISTERS	PC MODE	AUX CNTRL REG 0	PC CNTRL	PC MODE	PC CNTRL	PC MODE	PC CNTRL	PC MODE	PC CNTRL
D	PC INTPT STATUS	PC INTPT ENABLE	MISC CNTRL/STAT	BUF CNTRL/REG	BUF SIZE/REG	HOST STATUS	HOST CNTRL/STATUS REGISTERS	PC MODE	AUX CNTRL REG 0	PC CNTRL	PC MODE	PC CNTRL	PC MODE	PC CNTRL	PC MODE	PC CNTRL
E	PC INTPT STATUS	PC INTPT ENABLE	MISC CNTRL/STAT	BUF CNTRL/REG	BUF SIZE/REG	HOST STATUS	HOST CNTRL/STATUS REGISTERS	PC MODE	AUX CNTRL REG 0	PC CNTRL	PC MODE	PC CNTRL	PC MODE	PC CNTRL	PC MODE	PC CNTRL
F	PC INTPT STATUS	PC INTPT ENABLE	MISC CNTRL/STAT	BUF CNTRL/REG	BUF SIZE/REG	HOST STATUS	HOST CNTRL/STATUS REGISTERS	PC MODE	AUX CNTRL REG 0	PC CNTRL	PC MODE	PC CNTRL	PC MODE	PC CNTRL	PC MODE	PC CNTRL

Optionally Enabled

REGISTER ADDRESS - UPPER NIBBLE

Writable Control Store (WCS)

Next Addr. Field

Ctrl. Field

Count Field

Data Field

4. FUNCTIONAL DESCRIPTION

The CL-SH360 is designed to be used with a low-cost microcontroller that allows it to maintain a 'loose' synchronization with the real-time disk operation. The CL-SH360 maintains 'close' synchronization with the data to and from the disk drive and provides the signals necessary to control this path. Using the CL-SH360 means a lower-total-part count for an intelligent disk drive design with the PC XT/AT interface.

The CL-SH360 has four functional blocks:

- **Microcontroller Interface**
- **Sector Formatter and Sequencer**
- **Buffer Manager Interface**
- **PC XT/AT Interface**

4.1 Microcontroller Interface

The microcontroller-to-CL-SH360 communication path is a multiplexed/non-multiplexed address and data bus similar to that provided by the Intel 8051 and the Motorola 68HC11 class of controllers. The CL-SH360 can use either the Intel or the Motorola method of data control. When the Intel interface is selected, the $WR^*/R/W^*$ Signal (Pin 7/56) acts as a write strobe. In the case of a Write Operation, this write strobe provides the timing and control for the data transfers. Similarly, in the case of a Read Operation, the RD^*/DS Signal (Pin 8/57) acts as a read strobe to provide the timing and control for the data transfers.

The $BD6/I/MC^*$ Signal (Pin 99/48) defaults to Intel Mode after reset, with no external resistor. An external pull-down resistor is required to operate in the Motorola Interface Mode. For the Motorola configuration, the $WR^*/R/W^*$ Signal (Pin 7/56) is used only to determine the direction of the data transfer. When the input to this signal is high, a Read Operation is in progress; when it is low, a Write Operation is in progress. Data timing is derived with respect to the RD^*/DS Signal (Pin 8/57). In the case of a Read Operation, the rising (leading) edge of the RD^*/DS Signal (Pin 8/57) indicates when the CL-SH360 can start driving the data bus. In a Write Operation, the falling (trailing) edge is used by the CL-SH360 to latch the data from the microcontroller address/data bus.

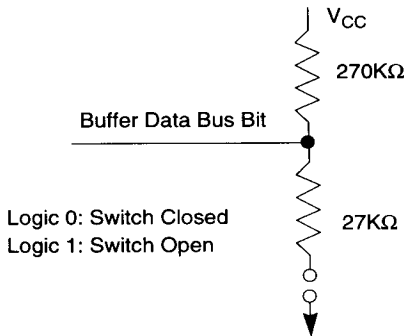
The CL-SH360 uses the $BD7/M/NM^*$ Signal (Pin 100/49) after a reset to select a multiplexed or a non-multiplexed address and data path. The $BD7/M/NM^*$ Signal (Pin 100/49) has an internal pull-down. If this pin is connected to a pull-up resistor after reset, the CL-SH360 will recognize this condition and will automatically select Multiplexed Mode. Following reset, if the $BD7/M/NM^*$ Signal (Pin 100/49) is only connected to the Data Port of the buffer RAM without an external pull-up resistor, the CL-SH360 will recognize the low level (internal pull-down) on this signal and select Non-multiplexed Mode.

The CL-SH360 decodes addresses from 40H to FFH. To prevent erroneous operations, the controller design should reserve the decoding of Addresses 40H to FFH for the controller chip only. The PC Interface Register File is mapped to 40H-47H or 60H-67H. Upon a local reset (RST^* — Pin 34/83), the access to the PC Register File is disabled until the Register File base address is programmed by the local microcontroller; this avoids contention on the read cycle, or errors on the write cycle.

The CL-SH360 has a programmable interrupt circuit. Four interrupt registers provide the status and mask programmability for interrupt sources. The programmable interrupt features include individual masks, a global enable, and an open-drain or push-pull output driver. The interrupt status registers may also be used as a focal point for microcontroller control when the CL-SH360 is being used in a Polled Mode. The interrupt sources are: PC Selection, PC Transfer Done, PC Reset, PC Transfer Overrun, Host Transfer Status Read Detected, Index Past, Sector Past, Disk Data Transfer Detected, ECC/Uncorrectable Error, Sequencer Stopped, Input Detected, and Sequencer Output Detected.

The processor-readable switches are multiplexed with the buffer data bus. These switches must be installed with relatively high-impedance pull-ups and pull-downs so that the resistor impedance does not affect the buffer performance. The processor accesses these switches by reading Registers 68H or 70H, with the MOE^* Disable Bit set (Register 52H, Bit 0).

Switch Example



4.1.1 Access to External Buses

In addition to the normal data transfer operations, the CL-SH360 also supports microcontroller access to the buffer memory by addressing Registers 68H and 70H.

4.1.1.1 Microcontroller Scheduled Access to Buffer

A Register-68H decode is provided for the processor to gain scheduled access to the buffer. The address is generated based upon the contents of the Disk Address Pointer. The Disk Address Pointer will be incremented by a Register 68H access if the Buffer Pointer Auto-Increment Bit is set (Register 48H, Bit 0). The buffer read or write is scheduled by the Buffer Manager. This allows concurrent PC-and-local-microcontroller access to the buffer memory.

The processor-readable switches are also accessible by a Register-68H read. These switches must be installed as earlier described. (High-impedance pullups and pull-downs are recommended so buffer performance is not affected.)

4.1.1.2 Microcontroller Unscheduled Access to Buffer

A Register-70H decode is provided for the processor to gain access to the buffer when there is no PC disk transfer or ECC correction in progress.

The processor-readable switches are also accessed by a Register 70H Read.

4.1.2 Power-Down Mode

The CL-SH360 can support three levels of firmware controlled Power-Down Operation. The level of power-down is selected by mode bits in Register 4FH. The appropriate mode is selected by the local microcontroller. The three levels of power-down in the CL-SH360 can be summarized in the following table:

Register	Mode
4FH, Bit 5	Local Interface
4FH, Bit 6	Host ATA Power-Down
4FH, Bit 7	Host Deep Sleep Mode

The most power-saving level for the host interface is Host Deep Sleep Mode. In this mode, only the assertion of HRST* (Pin 53/2) or RST* (Pin 34/83) will 'wake up' the CL-SH360. It is estimated that power dissipation in this mode will be less than 3 mW.

The next level of power-down is the Host ATA Mode. The CL-SH360 will exit this mode only when the host issues a soft reset by setting the RESET Bit (Bit 2) in the AT Fixed Disk Register (Host Register 3F6), the assertion of HRST* (Pin 53/2), or RST* (Pin 34/83).

The next level is the local interface. The CL-SH360 will recognize a write to the AT Command Register or the XT Controller Select Register, assertion of HRST* (Pin 53/2), RST* (Pin 34/83) or setting the Reset Bit in the AT Fixed Disk Register (Bit 2) and exit this mode. When this mode is exited, the Assertion Bit (Register 4FH, Bit 5) will be 'locked' until the microcontroller has performed the 'unlock' write to Register 73H.

4.2 Sector Formatter and Sequencer

The basic operation of the Sector Formatter is controlled by the contents of the Sequencer Writable Control Store (WCS). A Sequencer program must be entered into the WCS before the CL-SH360 Sector Formatter can function properly. Under firmware control, the Sector Formatter can be made to sequence through different types of operations, such as: 'Read ID', 'Read ID and Read Data', 'Read ID and Write Data', and 'Write ID and Write Data'.

The Sequencer controls the timing relationships between the disk-interface output signals and monitors the disk-interface input lines to branch to different Sequencer locations. The track layout, such as gap lengths, sector size, and sector data fill character, can be flexibly defined in the WCS. The CL-SH360 Sector Formatter also has other registers that can be used to control the definition of the track format such as the SYNC character and the Address Mark.

The WCS consists of 124 bytes, organized as 31 words, each four bytes wide. The WCS can be broken down into Data/Branch, Count, Control, and Next Address Fields.

The Data/Branch Field contains data that may be used to initialize the track format, including gap, ID field, and sector-data-fill characters. This data can also be compared to the NRZ data-in to identify various fields in a sector or to execute sector data comparisons. The contents of this field may also be used as a branch address to tell the Sequencer which address to jump to upon the evaluation of a branch condition.

The Count Field specifies the number of counts that the Sequencer will continue executing the current WCS word. The value that is programmed in the Count Field must be one less than the desired count duration; i.e., if an operation in the WCS is meant to last for two counts, program the Count Field with the number one. The Sequencer counter is decremented once every eight Read/Reference Clock (RD/REF CLK) cycles. When the count reaches zero, the Sequencer will go to the next address.

The next address will be based on the contents of the Next Address Field of the WCS word, unless a branch condition has been programmed and met during the last byte of the current WCS word.

The Control Field is used to generate and initiate all synchronous NRZ-data-handling operations.

The microcontrollers manipulation of the Sequencer revolves around the Start/Status Register (Register 79H), Branch Register (Register 78H), WCS Data/Branch and the React Branch Register (Register 6CH). Writing to Register 79H loads the starting address where the Sequencer is to begin execution, and causes the four bytes at that WCS RAM word to be fetched and written into the Current Sequencer Word Registers. The next address to be fetched is based upon the contents of the Next Address Field in the Sequencer Registers, unless a specified branch condition is met. If the branch condition specified in the Next Address Field is met, the next address to be executed is based upon the contents of Register 78H, the React Register 6CH or the WCS Data Field. Thus, by setting up different branch conditions that are based on external or internal events, the chip can be made to sequence through different operations.

The serial data flow portion of the Sector Formatter consists of a 16-bit CRC, 88-bit ECC and a serializer/deserializer. Data to be written to the disk enters the CL-SH360 in a byte-wide format. It is serialized and processed through a 16-bit CRC, 88-bit ECC generator. An NRZ serial bit stream is then shifted out to the drive. Note that the NRZ-serial-bit stream will include serialized constants required for address marks, gaps, and ID fields, as well as the serialized data and ECC-generated output.

The ECC can be programmed (in the WCS) for 16-bit CRC-CCITT for the ID field and an 88-bit Reed-Solomon polynomial for the data field. The 16-bit CRC-CCITT code can only be used for error detection. If an ECC error is detected after a Read Data Operation, the syndrome is saved in the internal correction registers and the ECC Error Bit (Register 79H, Bit 2) is set. The CL-SH360 has advanced correction logic that can determine the following: if the error is correctable, calculate the



error pattern and its displacement from the beginning of the Data Field, and correct the error in the Buffer RAM. If the Hardware Correction Enable Bit (Register 71H, Bit 0) is set, hardware correction is performed while the next sector is being read. If the error is correctable, the hardware corrects the data and sets the Correction Done Bit (Register 79H, Bit 4). If the error is uncorrectable, the ECC Error and Uncorrectable ECC Error Bits (Register 79H, Bits 2 and 3) are set to prompt the local microcontroller to take appropriate actions. If the Hardware Correction Enable Bit is reset, the ECC Error and Uncorrectable ECC Error Status Bits are set after the Read Data Operation, and the syndrome is transferred to the internal correction register. It is readable by the local microcontroller through Register 72H, and can be read in 8-bit increments for software correction.

The following is the 16-bit CRC-CCITT polynomial:

$$x^{16} + x^{12} + x^5 + 1$$

The 88-bit ECC Reed-Solomon code is a non-interleaved code of degree 8, operating on 10-bit symbols. The code is capable of correcting four 10-bit symbols that are in error. This gives the code the guaranteed ability to correct one 31-bit burst or two 11-bit bursts.

The on-the-fly hardware correction is set at 11 bits. This gives an on-the-fly detection capability of a 51-bit burst or three 11-bit bursts. It is recommended that software correction after retry be limited to a single 22-bit burst or two 11-bit bursts.

The probability of miscorrection for the on-the-fly circuitry is:

$$P_{mc} = \frac{n \times 2^{b1-1}}{2^m}$$

where,

n = sector length in bits, including redundancy bits

$b1$ = correction span in bits

m = total number of redundancy bits.

This provides the automatic on-the-fly hardware a miscorrection probability of approximately 10^{-20} per bit corrected for a 512-byte field (with a single-byte address mark).

The probability of miscorrection for the software correction algorithm is:

$$P_{mch} = \frac{1}{2^m} + \frac{n \times 2^{b2-1}}{2^m} + \frac{n \times (n-b3) \times (2^{b3-1})^2}{2^m}$$

where,

n = sector length in bits, including redundancy bits

$b2$ = single-burst correction span in bits

$b3$ = double-burst correction span in bits

m = total number of redundancy bits.

The CL-SH360 Sector Formatter also has a recirculating stack that is eight bytes deep. By enabling the stack (setting Bit 4 of the WCS Control Field) during a read process, information read from the drive can be pushed onto the stack to be examined later at a lower speed by the microcontroller. This capability can be used to pass the ID field to the microcontroller for defect management, seek verification and other disk controller tasks.

4.2.1 Extended-Data-Handling Operations

The CL-SH360 has the ability to flexibly handle a large variety of different sector configurations. The next four subsections discuss various sector sizes, split data fields, multiple-sector Read/Write Operations with minimal microcontroller intervention, and scheduled access to the WCS by the local microcontroller.

4.2.1.1 Variable Sector Size

The CL-SH360 Sector Formatter has an 8-bit data field length counter loadable from the Count Field of the Sequencer RAM. This field is programmable, and by setting this field to any value from 00H to FFH, a sector length up to 256 bytes can be written to the drive. The value of this counter is always one less than the actual sector length. For sector sizes greater than 256 bytes, several different methods can be used.

The simplest approach is to use as many Sequencer words as required to implement the count for the data field.

The next approach uses the Inhibit Carry Bit in the Operation Control Register (Register 7AH, Bit 7).

By setting the Inhibit Carry Bit and programming the Next Address Field of the Formatter WCS with the most significant bits set to 100 during data transfer, the CL-SH360 Sector Formatter will be inhibited from going to the Next Sequencer Word; another 256 bytes of data will be transferred. The 256-byte count number is programmed in the Sector Size Register (Register 4EH).

A value of zero (from a chip reset) will provide one suppression as described above, (i.e., for 532 bytes, start with sector size set to one, and an initial count of 19).

4.2.1.2 Split Data Field Operation

For high-density drives, it is desirable to have more embedded servo fields on a track to keep the head centered above the track. The Split Data Field Operation allows the data field of a sector to be split into multiple sections so that servo fields can be inserted. Split Data Field can also be used for flaw management. The programmability of the CL-SH360 Sequencer RAM provides flexible handling of split data fields.

There are two methods of handling data splits in the WCS. By resetting the Advance Multisector/Multisector* Control Bit (Register 4FH, Bit 0), the Sequencer will use Bit 3 of the WCS Control Field as the Process Split/Flag Bit to control the split boundaries. Using this bit allows the transfer of data in full blocks or in split format from buffer to disk or disk to buffer. This method requires the microcontroller to update the WCS for every sector Read/Write Operation for proper data split handling.

The byte count of the split data field is specified by the Count Field of the Sequencer RAM. The servo-field sizes of split data fields are also specified by the Sequencer RAM Count Field.

The operation of freezing the ECC generation during a Write Operation or checking for a Split Data Field during a Read Operation is called Split/Freeze ECC. Restarting the ECC circuitry for the remainder of the split data is called Restart ECC/Continue Data Split.

To perform a Split/Freeze ECC Operation, the Process Split Bit of the WCS Data Control Field

should be set in the last Data Transfer Sequencer Word. The CL-SH360 will recognize this operation; at the end of the data transfer count, it freezes the ECC generator and when the Data Transfer Bit of the Sequencer Control Field is set for the next split, it unfreezes the ECC generator and continues the transfer of data to/from the buffer. To further split the data, repeat the operation by setting the Process Split/Flag Bit of the WCS Data Control Field on the last Data Transfer Sequencer Word.

The second method is the Advanced Multisector Read/Write Operation where the splits are embedded in the ID field; by setting the proper flags, the split counts are processed by the Sequencer without the microcontroller having to intervene.

4.2.1.3 Multisector Read/Write Operation

The CL-SH360 supports Multisector Read or Write Operations with minimal microcontroller intervention. This can be accomplished by two methods. The simplest method is to load the next sector ID to be accessed while data transfer is active (Register 79H, Bit 7) for the present sector, and restarting the Read or Write Operation immediately after the end of the present sector.

The second approach uses the Sector Target ID Register and Sector Count Register to transfer multiple sectors to/from the buffer under WCS control. This method is selected by setting the Advanced Multisector/Multisector* Control Bit (Register 4FH, Bit 0). The CL-SH360 will use a number of internal registers to support advanced multisector transfers. These are: the Sector Remaining Register, the Sector Target Register and the Sector Count Register. The Sector Remaining Register controls the number of bytes per sector. This register is loaded by the microcontroller with the length, in bytes, of the data field. The Sector Target Register is loaded by the microcontroller with the starting sector number and the Sector Count Register is loaded with the number of sectors to be processed. Therefore, by proper programming of the WCS and the start address in the Sector Target Register and the number of sectors to be processed in the Sector Count Register, the Sequencer can perform Multisector Read/Write Operations with minimum real-time intervention by the microcontroller.

This method supports Constant Density Recording formats with variable data splits, and an alternate-/skipped-defective-sector scheme with minimal-latency sector operations. The data split counts for each sector are embedded in their ID field. This allows the Sequencer to save these counts via an internal FIFO during the read of an ID and then use these values for proper handling of the data field with no intervention from the microcontroller. The split counts will be 12 bits in length for a maximum data split field length of 4K bytes. In addition, there are three flag bits for defect management and split-count designation. An example of the ID is illustrated in Figure 4-1 on the following page.

4.2.1.3.1 Minimum-Latency Multisector Transfer

For minimum-latency operations, the Sector Count Register (6BH) should be loaded with the maximum number of sectors/track. The firmware reads the first ID field after the head reaches the track; it starts the Sequencer and only checks for good CRC and no defect, and pushes it into the stack. By reading the stack, it can appropriately load the Sector Target (6AH) with the next sector value and program the Disk Pointer (Register 5AH, 5BH) with the correct location of this sector in the buffer. The CL-SH360 will proceed to read/write the full track. At the end of the track, if the Sector Count Register is not equal to zero and the End of Track Bit in the ID Flag/LS Split Count Byte is set, the Sector Target Count Register (6AH) is appropriately reset to zero. The wrap of the Buffer Disk Pointer is controlled by setting the Buffer Start and Buffer End Address Pointers to values corresponding to the size of the track. Therefore, when the Disk Address Pointer (DAP) reaches the Buffer End Address, the DAP will be loaded with the Buffer Start Address. The next sector to be processed is Sector '00H'. This will save a maximum of one revolution before the right sector is reached.

4.2.1.3.2 Start/Stop Multisector Transfer

In a Start/Stop Multisector Operation, the Sector Count Register (6BH) is loaded with the number of sectors to be read or written, and the Sector Target Register (6AH) is loaded with the starting sector value. The Sequencer will start and stop appropriately at the end of the transfer of the last

sector. There are multiple branch conditions that may stop the Sequencer before all the sectors are transferred. For example, if the previous sector ECC error is uncorrectable, the Sequencer will be stopped; if the Defect Bit in the Flag/LS Split Count Byte of the ID field is set, the Sequencer may stop or may take an alternate route in the WCS Map by the means of the React Branch Register (6CH).

4.2.1.4 Scheduled WCS Access

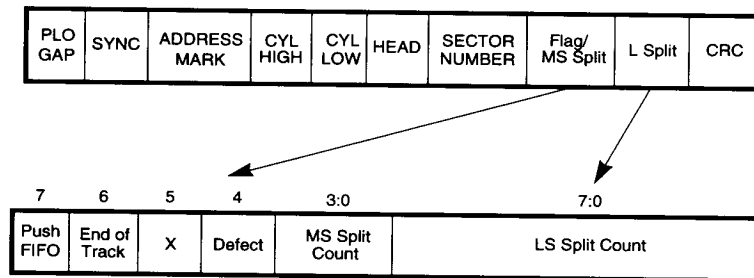
The WCS can be accessed by the microcontroller in a scheduled format. The Mode Bit — Scheduled WCS Access/Enable Bit (Register 7AH, Bit 6) — indicates the type of WCS access. If the Scheduled WCS Access/Enable Bit (Register 7AH, Bit 6) is set, the access to/from the WCS is scheduled through the Status WCS Byte Ready Bit (Register 7AH, Bit 4). When reading the WCS, the address is latched internally; the data is synchronously read from the WCS to an internal holding register, and the WCS Byte Ready Bit (Register 7AH, Bit 4) is set. After this bit is set, the microcontroller may read the next location or the same location again; the data read is the previous address data information and the process repeats. When writing to the WCS, the address and data is latched internally, and the data is synchronously written to the WCS. The WCS Byte Ready Bit (Register 7AH, Bit 4) is set to indicate that it is ready to accept another WCS Write Operation.

4.2.2 Functional Operation

The CL-SH360 performs two basic disk operations, reading NRZ data in and writing NRZ data out. These two operations can be combined easily into the following three major functions: Verify Sector, Format Sector and Disk Data Transfer. The CL-SH360 also performs data transfers to/from the PC. These can be broken down into two major groups: Data Transfer by PIO, and Data Transfer by DMA. These two options will also be discussed.

4.2.2.1 Verify Sector

By setting the Suppress Transfer Bit in the Operation Control Register, (Register 7AH, Bit 5) and performing a Read Operation, the read data will only be verified for good ECC and will not be transferred to the buffer.



Flag/MS Split Count

Bit 7 PUSH FIFO: For Read and Write Operations, if this bit is set when the Advanced Multisector/Multisector* Control Bit (Register 4FH, Bit 0) is set, the Read Gate is asserted, and the Process Split/Flag Bit of the WCS Control Field is set, it pushes the contents of the Read ID Field Flag/MS Split Count value and the following byte LS Split Count value into the internal FIFO; these values are used for the actual split count of the data-field-format operations in the internal FIFO. If this bit is set when Write Gate is asserted and the Process Split/Flag Bit of the WCS Control Field is set, it pushes the content of the WCS Data Field Register into the internal FIFO where these values are used for the actual Split Count of the data field. Therefore, the firmware engineer only changes the WCS Data Field for the proper format of the actual sector. This saves time during format operation.

Bit 6 END OF TRACK: When this bit is set, if there was a good compare and good CRC and the Sector Count Register is not equal to zero, the Sector Target is reset to 00H at the end of the data transfer; the next sector to be read is Sector 00H. This function is used for Minimal Latency Operation, not Start/Stop Operation (explained in Section 4.2.1.3.1).

Bit 5 Not used.

Bit 4 DEFECT: This bit is used to indicate a defective sector. It is used for the Alternate Sector Scheme only where the defective sector is relocated to another location on the disk. This bit will determine the type of action to be taken using the proper WCS branch conditions.

Bits 3:0 These are the upper four bits of the split count for the data field.

LS Split Count

Bits 7:0 These are the lower eight bits of the split count for the data field.

Figure 4-1. Sample ID Field for Multisector Operation

NOTE: This refers to Section 4.2.1.3, *Multisector Read/Write Operation*.

4.2.2.2 Format Sector

To format a track, the ID fields, all gaps (fill, postambles, and preambles), and data fields must be generated. This requires that the read ID field subroutine be changed into a Write Operation, and appropriate gaps inserted. Also, by setting the Suppress Transfer Bit in the Operation Control Register (Register 7AH, Bit 5), the data for the Sector Data Field will be sourced from the Current Sequencer Word Data Field and will not be transferred from the buffer. The ID field bytes can be written from the buffer instead of updated by the local microcontroller. This is accomplished by setting the Data Transfer Bit in the WCS Control Field. This will override the suppress-transfer function for the ID field only.

4.2.2.3 Disk Data Transfer

For disk transfers, a byte is transferred each time the Formatter requires a data transfer (to serialize/deserialize a byte). The direction of transfer is determined by the Buffer/Disk R/W* Transfer Direction Bit (Register 53H, Bit 4). The Disk Address Pointer is used to select the buffer memory location.

For a Disk Read Operation, where disk NRZ data is deserialized and written to the buffer, the Buffer/Disk R/W* Transfer Direction Bit (Register 53H, Bit 4) must be set. When the disk transfer stops, the Disk Data Transfer Bit (Register 79H, Bit 7) is reset.

For a Disk Write Operation, where buffer data is serialized and written out to the disk as NRZ data, the Disk/Buffer R/W* Transfer Direction Bit (Register 53H, Bit 4) is reset. When the disk transfer stops, the Disk Data Transfer Bit (Register 79H, Bit 7) is reset.

4.2.3 Two Index Counter

Another component of the Format Sequencer is the Two Index Counter (TIC). This circuit is used to limit the execution of a Format Sequencer program to one complete revolution of the disk drive. This feature would typically be used to limit the number of the times that the Format Sequencer would attempt to search for the Sector ID Field of a Target Sector.

When the Two Index Detection Mode Enable Bit (Register 48H, Bit 6) is set, the Two Index Detection Mode circuitry is armed or rearmed by the WCS. The detection circuit is armed if the WCS Control Field has both Read Gate and Data Transfer off, and Bit 5 of the Count Field is set. Once the circuit is armed, it remains armed until one of following three events happens: 1) data transfer occurs between the Formatter and buffer; 2) Two Index pulses are detected and the Formatter is stopped; or 3) the Two Index Detection Mode Enable Bit is reset. When the detection circuit is armed, and the Two Index edges are detected, the Two Index Detected Status Bit is set (Register 48H, Bit 3). The status bit remains set until the Two Index Detection Mode is disabled (Register 48, Bit 6). When the Two Index Detected Status Bit is set, it asserts the 'stopped' signal to stop the Formatter Operation; this disarms the detection circuit.

4.2.4 Synchronization Timer

The Synchronization Timer is a circuit used to set a limit on the amount of time that the Format Sequencer is allotted to synchronize itself — or find and match the synchronization byte pattern defined in Register 7CH — with the incoming NRZ data stream. This limit is programmed in the CL-SH360 Synchronization Byte Count Limit Register (76H). This limit is specified in terms of a byte-count limit that can range from 0 to 255. Only one value can be programmed into Register 76H. When the Synchronization Timer is activated by the Format Sequencer program, the value in Register 76H is decremented for each byte time that passes. When the value within Register 76H reaches zero, a time-out occurs. When a time-out error occurs, the Format Sequencer can stop or branch (see Next Address Field Register description). In either case, the Synchronization Time-Out Error Bit (Register 48H, Bit 2) will also be set. The branch source is the WCS Data Field. This bit is reset by a Formatter reset (Register 71H, Bit 5) and a Sequencer start.

The Format Sequencer program can activate the Synchronization Timer by setting the Count/Start Synchronization Timer/Two Index Timer Bit (Bit 5 of the Writable Control Store (WCS) Count Field). This mode is selected when the Read Gate On (Bit 5-6 of the WCS Control Field Register) is set. Once

the timer is activated, the time-out will either stop the Sequencer or branch to a new address. To set-up the branch condition, the WCS Data Field is set to the branch address during Read Gate On. The Synchronization Timer is reset under the following conditions: (1) when the Format Sequencer is reset, or (2) when the serial synchronization detector finds the synchronization character (as defined in Register 7CH) in the incoming NRZ data stream.

This feature would typically be used to limit the amount of time that the Format Sequencer is allowed to search for the Sector Data Field after it successfully completes a Sector-ID-Field comparison. The Synchronization Timer can also be used to limit the amount of time that the Format Sequencer searches for a Sector ID Field after a sector mark is detected in a hard-sectored disk drive.

4.3 Buffer Manager Interface

The third functional logic block of the CL-SH360 is the Buffer Manager interface. This block controls the flow of data between the external RAM data buffer and the CL-SH360 PC interface, the Sector Formatter data path, and the microcontroller buffer memory access ports. The Buffer Manager interface provides the external RAM addressing, timing, and control signals necessary for the CL-SH360 to interface with the RAM data buffer.

4.3.1 SRAM Addressing Operation

The Buffer Manager interface can address up to 64K bytes of static memory. This requires 16 address lines that correspond to the Buffer Manager Address Signals BA[15:0] (PQFP Pins 90-79 and 77-74; VQFP Pins 39-28 and 26-23). The buffer memory address is never placed in a high-impedance state; it is always driven by one of three sources — the Disk Address Pointer (Registers 5AH-5BH), the Host Address Pointer (Registers 5CH-5DH) or the ECC Corrector. These pointers have various initialization conditions, and their starting values can be changed via direct firmware control.

The Disk Address Pointer (Registers 5AH-5BH) is dedicated for disk and microcontroller transfers. Any access to the RAM data buffer by the Sector Formatter selects the value in Registers 5AH-5BH,

(the Disk Address Pointer) that will be driven out on the buffer memory address bus.

When the local microcontroller accesses the buffer memory, the Disk Address Pointer (Registers 5AH-5BH) is also used. Consequently, to prepare for a local microcontroller access to the buffer memory, all disk transfers to or from the CL-SH360 must be terminated before the Disk Address Pointer (Registers 5AH-5BH) is loaded.

The Host Address Pointer (Registers 5CH-5DH) is reserved for transfers between the PC bus and the RAM data buffer. Any access to the RAM data buffer by the PC interface logic selects the value in Registers 5CH-5DH, the Host Address Pointer, and has the CL-SH360 drive this value onto the buffer memory address bus.

The Host Address Pointer (Registers 5CH-5DH) is compared with the Stop Address Pointer (Registers 5EH-5FH) to contain the data transfers to a particular block-boundary value. To translate the value of the Host Address Pointer (Registers 5CH-5DH) into a repeatable block size, the Buffer Size/Segment Address Register (54H) is used to mask the upper address bits of the Host Address Pointer (Registers 5CH-5DH) and the Stop Address Pointer (Registers 5EH-5FH). Consequently, only the lower significant bits that are 'modulo a' block size are used for the comparison. When there is an equal comparison of the Host Address Pointer (Registers 5CH-5DH) and the Stop Address Pointer (Register 5DH-5FH), masked by the Buffer Size/Segment Address Register (54H), then the host transfer is terminated.

Both the Disk Address Pointer (Registers 5AH-5BH) and the Host Address Pointer (Registers 5CH-5DH) are automatically incremented by a count of one after the completion of each access to the RAM data buffer.

4.3.2 Buffer Segmentation

For optimum data flow control, it is often desirable to divide the buffer memory into smaller segments. The CL-SH360 Buffer Manager can support fixed and variable segment sizes. In Fixed Mode, the buffer can be divided into 4K, 8K, 16K, 32K or 64K

segments. For example, with an attached buffer size of 32K and segment sizes of 4K, this would create eight 4K segments: 0000-0FFFH, 1000-1FFFH, 2000-2FFFH, 3000-3FFFH, 4000-4FFFH, 5000-5FFFH, 6000-6FFFH, 7000-7FFFH. When operating in this mode, the Buffer Start Address Registers (9FH/BFH) and the Buffer End Address Registers (DFH/FFH) are loaded with the physical size of the attached static RAM buffer. Each segment can be accessed by setting the upper four bits of the HAP and DAP to the desired segment address. In this configuration, once the address pointer (HAP or DAP) reaches X1FFFH, the next address will roll over to X1000H.

In the second mode, the CL-SH360 provides the ability to generate a variable segment within the buffer memory by providing Buffer Start Address Registers (9FH/BFH) and Buffer End Address Registers (DFH/FFH). By loading the Buffer Start Address Register (5EH-5FH) with the starting segment address and the Buffer End Address Register (5EH-5FH) with the ending segment address, whenever the Disk Address Pointer (DAP — Registers 5AH-5BH) or Host Address Pointer (HAP — Registers 5CH-5DH) are equal to the Buffer End Address Register, they are reloaded with the Buffer Start Address Register value. When operating in this mode, the Buffer Size/Segment Address Register (Register 54H) must be set to the physical size of the attached static RAM buffer.

4.3.3 SRAM Read/Write Access Control

The Buffer Manager accesses the buffer memory data bus to read or to write the contents of the RAM data buffer, or to read the static state of the data bus. The PC host, the Sector Formatter, and the local microcontroller all use unique methods to specify the direction of the access.

For PC host transfers, the read/write control is set by the PC R/W* Transfer Direction Bit (Bit 3) of the Buffer Transfer Control Register (53H). When this bit is set, the data read from the RAM data buffer is transferred through the CL-SH360 chip to the PC host interface. If this bit is reset, then the data is transferred from the PC host interface through the CL-SH360 and written to the RAM data buffer.

In the case of Sector Formatter transfers, the transfer direction is controlled by the Buffer/Disk R/W* Transfer Direction Bit (Bit 4) of the Buffer Transfer Control Register (53H). When this bit is reset, the data read from the RAM data buffer is transferred to the Sector Formatter. To write to the RAM data buffer from the Sector Formatter, this bit must be set.

For microcontroller transfers, the microcontroller control strobe is used to determine the transfer direction. A read of Register 68H (the Scheduled Buffer Data Register) or Register 70H (the Microcontroller Buffer Access Register) results in a read of the RAM data buffer. A write to Register 68H (the Scheduled Buffer Data Register) or Register 70H (the Microcontroller Buffer Access Register) causes a write to the RAM data buffer.

Both a Read and Write Operation commence when the correct address pointer — the Disk Address Pointer (Registers 5AH-5BH), or the Host Address Pointer (Registers 5CH-5DH) — is driven onto the buffer memory address bus.

For a read to the RAM data buffer, the Chip Enable Signal (CE1* — Pin 3/52) is asserted low at the same time as the address is driven onto the address bus. The Memory Output Enable Signal (MOE* — Pin 1/50) is asserted low after the address is driven onto the address bus. This signal should be connected to the SRAM Output Enable(s) to ensure the highest throughput. Data must be provided from the SRAM shortly before the rising (trailing) edge of the Memory Output Enable Signal (MOE* — Pin 1/50). The Write Enable Signal (WE* — Pin 2/51) remains deasserted high throughout the entire SRAM read access.

For a write to the RAM data buffer, the Chip Enable Signal (CE1* — Pin 3/52) is asserted low at the same time as the address is driven onto the address bus; the Write Enable Signal (WE* — Pin 2/51) is asserted low after the address is driven onto the address bus. The Memory Output Enable Signal (MOE* — Pin 1/50) remains deasserted (high) throughout the entire SRAM access. Data is driven from the CL-SH360 to the RAM data buffer shortly after the address. The Write Enable Signal (WE* — Pin 2/51) is deasserted (high) near the

end of the cycle. The CL-SH360 supports two-chip enables for 64K buffers. This mode is controlled by Register 53H, Bit 0, and uses BA15/CE2* (Pin 90/39) as the second chip enable.

4.3.4 SRAM Signal Timing

For both a read and a write access to the RAM data buffer, the correct address pointer (the Disk Address Pointer — Registers 5AH-5BH and the Host Address Pointer — Registers 5CH-5DH) is driven with respect to the falling edge of the BCLK Input Signal (Pin 39/88). For read accesses, the Memory Output Enable Signal (MOE* — Pin 1/50) is asserted low at the falling edge of the BCLK at the same time as the address is driven onto the address bus. For write accesses, the Write Enable Signal (WE* — Pin 2/51) is asserted low one-half BCLK after the address is driven. The Memory Output Enable Signal (MOE* — Pin 1/50) and the Write Enable Signal (WE* — Pin 2/51) are both deasserted (high) on the falling edge of BCLK before the end of the SRAM access. This implies that the total SRAM access time controls the pulse width of these signals. The complete SRAM access time is programmed in terms of BCLK-Input-Signal (Pin 39/88) periods.

In the case of a read access to the RAM data buffer, data is clocked into the CL-SH360 by the rising edge of the Memory Output Enable Signal (MOE* — Pin 1/50). In the case of a write, data is held by the CL-SH360 until the deassertion of the Write Enable Signal (WE* — Pin 2/51).

The theoretical maximum Buffer Manager throughput is 12 Mbytes/second. The actual throughput is a function of the NRZ clock frequency from the disk drive, the SRAM speed used or required, the desired host throughput, the Input-BCLK-Signal (Pin 39/88) frequency, and the BCLK divider selected in the Clock Control Register (Register 7FH).

4.4 PC XT/AT Interface

The CL-SH360 provides the capability for direct connection to the host bus. The host bus drivers can sink up to 24 mA of current and drive a load of up to 300 pF.

4.4.1 PC Transfers

For transfers between the PC bus and buffer memory, data is transferred under DMA or PIO control. Transfers are enabled by setting the DMA Start Bit (Register 53H, Bit 1). The transfer direction is determined by the contents of the PC R/W* Transfer Direction Bit (Register 53H, Bit 3). The contents of the Host Address Pointer are used to address the buffer memory.

During the PC data transfer, the last buffer address that can be accessed is controlled by the PC Stop Pointer. This PC Stop Pointer is compared with the Host Address Pointer, masked by the content of the Buffer Size/Segment Address Register (Register 54H). When a match occurs, the PC Transfer Done Bit (Register 53H, Bit 2) is set, signifying the completion of the transfer to or from the PC bus.

4.4.1.1 PC Direct Memory Access (DMA) Operations

The CL-SH360 operates in DMA Mode for both XT and AT protocols. There are two modes of DMA operation: Single Transfer per Bus Arbitration and Multiple Transfers per Bus Arbitration (EISA Type 'B' Demand Mode). No interrupts to the host are generated during DMA transfers. The three control bits that select DMA Mode are: the AT Host Fixed Disk Register DMAENB (Register 52H, Bit 4), the Demand Mode DMA Enable Bit (Register 53H, Bit 7) and the PIO or DMA Select Bit (Register 58H, Bit 3).

Tables 4-1 and 4-2 on the following page summarize the use of these bits for XT and AT DMA operations.

Table 4-1. XT DMA

Reg 53H, Bit 7	Description
0	During the Data Phase, Single Transfer Mode can occur if the host enables Bit 0 of the Drive/DMA/Interrupt Enable Register.
1	During the Data Phase, Multiple Transfer Mode can occur if the host enables Bit 0 of the Drive/DMA/Interrupt Enable Register.

Table 4-2. AT DMA

Reg. 58H, Bit 3	Reg. 52H, Bit 4	Reg. 53H, Bit 7	Description
1	X	X	No DMA transfers enabled
0	0	0	Single-Transfer DMA enabled through the Data Register (1F0H)
0	0	1	Multiple-Transfer DMA enabled through the Data Register (1F0H)
0	1	0	Single-Transfer DMA enabled if Bit 0 of the Fixed Disk Register (3F6H) is set through the Data Register (1F0H)
0	1	1	Multiple-Transfer DMA enabled if Bit 0 of the Fixed Disk Register (3F6H) is set through the Data Register (1F0H)

NOTE: X = Don't care

4.4.1.1.1 Single-Transfer DMA

In Single-Transfer DMA Mode, the CL-SH360 asserts DREQ (Pin 49/98) for each transfer. Under this mode, the host bus is arbitrated for each transfer, since the DREQ Signal is deasserted in response to the DACK* (Pin 50/99) Signal.

4.4.1.1.2 Multiple-Transfer DMA (EISA Type 'B' Demand Mode)

In Multiple-Transfer DMA Mode, the CL-SH360 asserts DREQ (Pin 49/98) for the length of the transfer, but will deassert DREQ to stop an

overflow/underrun. If a higher-priority DMA device requires the bus, the host can deassert DACK* (Pin 50/99) during the transfer; or, if no other higher-priority device requests the bus, the host may assert DACK* for the length of the transfer.

4.4.2 PC Host Wait States

The CL-SH360 also provides circuitry to extend the host I/O cycle and insert wait states by asserting low the IOCHRDY* Signal (Pin 48/97). This circuit is only active during programmed I/O host transfers. The CL-SH360 inserts wait states in the following two ways:

- 1) It can be programmed in the PC Mode Control (Register 58H, Bits 0 and 1) to insert wait states on any host I/O transfer. This can be used to extend the width of the IOR*/IOW* pulse, in case of a fast CPU with short IOR*/IOW* pulses.
- 2) When the automatic wait-state generation feature is enabled (Register 58H, Bit 2 is set), a wait state will be automatically inserted by asserting low the IOCHRDY* Signal (Pin 48/97) (only during host I/O transfers to/from buffer memory) when the CL-SH360 is not ready for the transfer.

If programmed wait states (see Item 1) are enabled, and if any additional wait states are necessary, the automatic wait-state circuit will be activated. This occurs after the programmed number of wait states have been inserted.

4.4.3 PC Host Auto-Commands

The CL-SH360 has circuitry to increase the speed performance of the disk controller by decoding write commands requiring data transfer from the host to the buffer memory, i.e., Format (5XH), Write Buffer (E8H), Write or Write Long (3XH). The CL-SH360 will automatically start accepting data from the host, without local microcontroller control, when the AT Host Command Register is loaded by the host. If interrupts are enabled, the CL-SH360 then generates an interrupt to the local microcontroller. The Stop Pointer (Registers 5EH and 5FH) is initialized to 01FFH. If the Buffer Stop Pointer Disable (Register 52H, Bit 6) is set, the local microcontroller must initialize the Stop Pointer (Registers 5EH and 5FH) to enable the comparison of the Host Address Pointer (HAP Registers 5CH and 5DH) with the Stop Pointer. The CL-SH360 Sector Formatter will disconnect from the Buffer Manager upon receipt of one of these commands. It will also disable write access by the local microcontroller to Registers 53H, 5CH-5FH, and read/write access to Registers 68H and 70H. Access to these registers will be enabled when the local microcontroller writes to Register 73H. The local microcontroller must write to Register 73H to enable transfers between the Sector Formatter and the buffer memory.

4.4.4 PC Host Long Commands

If Bit 1 of the command byte is set (for read/write long commands), then all buffer memory transfers to/from the host will exceed the Stop Pointer (Registers 5EH and 5FH) by the count of ECC bytes. Initially, the Stop Pointer is set at the end of the data field. When the Host Address Pointer (Registers 5CH and 5DH) matches the Stop Pointer, the internal FIFO will be emptied of the word-width data. The ECC bytes will then be transferred in Byte Mode, and the HAP will be incremented by the number of ECC bytes, as defined in the Host 32-/56-/88-Bit ECC Select (Register 71H, Bit 3-2).

4.4.5 PC Host Master/Slave Operation

The CL-SH360 provides circuitry to support two embedded AT or XT disk controller drives in a system. There are two bits (Bits 1 and 2) in Register 52H for this configuration. The Master/Slave Mode Enable Bit (Register 52H, Bit 1) must be set to enable the two-disk-drive master/slave configuration. The Master/Slave Select Bit (Register 52H, Bit 2) configures the disk drive as a master or slave. For the PC AT — if this bit is set — the disk controller responds as a slave (i.e., it responds when the disk drive number in the AT Host Drive/Head Register [Port 1F6H] is set to a 1). The register files in both controllers, when configured as master and slave, will be written to by the host, no matter which drive is selected in the AT Host Drive/Head Register. However, only the selected disk drive will execute the command. The only exception is during power-up or diagnostic commands; both the master and the slave will run the diagnostics, but the master will return the status for both drives to the host. For the PC XT, the controller responds as a slave if Bit 2 of the host DRV/DMA/IRQ Enable Register is set, and Register 52H, Bit 2 is set.

In addition to these features, the CL-SH360 also provides the local microcontroller with PDIAG* and DASP* support in the Auxiliary Control 1 Register (Register 4FH, Bits 2-1). This register may be programmed by the local microcontroller to implement ATA-compatible multiple-drive operation.

5. DETAILED INTERNAL REGISTER DESCRIPTION

The register tables refer to the following register types: R/W = Read/Write, R = Read only, W = Write only.

5.1 Register 9FH: Buffer Start Address High (BSAH) (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83), or Buffer Manager Reset (Register 59H, Bit 0).

Bits 7-0 This register is the high-order byte of the buffer memory start address.

5.2 Register BFH: Buffer Start Address Low (BSAL) (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83), or Buffer Manager Reset (Register 59H, Bit 0).

Bits 7-0 This register is the low-order byte of the buffer memory start address.

5.3 Register DFH: Buffer End Address High (BEAH) (Read/Write)

This register is set to FFH by the assertion of RST* (Pin 34/83), or Buffer Manager Reset (Register 59H, Bit 0).

Bits 7-0 This register is the high-order byte of the buffer memory end address.

5.4 Register FFH: Buffer End Address Low (BEAL) (Read/Write)

This register is set to FFH by the assertion of RST* (Pin 34/83), or Buffer Manager Reset (Register 59H, Bit 0).

Bits 7-0 This register is the low-order byte of the buffer memory end address.

5.5 Register 48H: Auxiliary Control 0 (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83).

Bit 0	R/W	BUFFER POINTER AUTO-INCREMENT ENABLE: This bit, when set, allows auto-incrementing of the buffer address when the microcontroller reads or writes Register 68H or 70H for buffer accesses.
Bit 1	—	Reserved.

5.5 Register 48H: Auxiliary Control 0 (Read/Write) (cont.)

Bit 2	R	SYNCHRONIZATION TIME-OUT ERROR: This bit is set after the timer limit that is held in the Synchronization Byte-Count Limit Register (Register 76H) has expired, and read synchronization has not occurred. This bit is reset by Register 71H, Bit 5.
Bit 3	R	TWO INDEX DETECTED STATUS: This bit is set when the Two Index Detection circuit has been enabled and Two Index edges have been detected without a data transfer between the formatter and buffer. This bit is reset when the Two Index Detection Mode is disabled (Register 48, Bit 6 = 0) or when the Two Index Detection circuit is armed.
Bit 4	R/W	CLEAR FIXED DISK REGISTER, BIT 0: This bit is used to reset the DMA Enable Control Bit in the Fixed Disk Register (3F6H). To reset the Fixed Disk Register, Bit 0, set and clear this bit. This bit is reset by HRESET (Pin 53/2), RST* (Pin 34/83), and a host-programmed reset.
Bit 5	R	PC HOST PROGRAM RESET: This bit is set by a host program reset. This bit is reset by RST* (Pin 34/83) or by setting the Clear PC Host Program Reset Bit (Register 48H, Bit 7). This bit is set for the duration of the host-program-reset active time.
Bit 6	R/W	TWO INDEX DETECTION MODE ENABLE: When this bit is set, the Two Index Detection Mode is enabled. When the Two Index Detection Mode is enabled, the index detection circuit is armed or rearmed by the WCS. The detection circuit is armed if the WCS Control Field has both Read Gate and Data Transfer off and Bit 5 of the Count Field is set. Once the circuit is armed, it remains armed until one of the following three events happens: 1) data transfer occurs between the formatter and buffer; 2) two index pulses are detected and the formatter is stopped; or 3) the Two Index Detection Mode Enable Bit is reset. When the detection circuit is armed, and Two Index edges are detected, the Two Index Detected Status Bit is set (Register 48H, Bit 3). The Status Bit remains set until the Two Index Detection Mode is disabled. When the Two Index Detected Status Bit is set, it asserts the 'stopped' signal to stop the Formatter Operation. This, in turn, disarms the detection circuit. This bit is reset by RST* (Pin 34/83) and Register 71H, Bit 5.
Bit 7	R	BYTE READY: When this bit is set, it indicates that a scheduled buffer memory access is completed, and that another scheduled buffer memory access may be started.
	W	CLEAR PC HOST PROGRAM RESET: When this bit is set, it will clear the PC Host Program Reset Bit (Register 48H, Bit 5).

5.6 Register 4DH: 68H AND 70H Read Data Register (Read Only)

This register is reset by the assertion of RST* (Pin 34/83) or Register 71H, Bit 5.

Bits 7-0	R	BUFFER DATA SHADOW REGISTER: When the microcontroller reads Registers 68H and 70H, the contents of the buffer memory data bus will be captured in Register 4DH for future reference. This register is reset by assertion of RST* (Pin 34/83) or when the Formatter Reset Bit (Register 71H, Bit 5) is set.
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5.7 Register 4EH: Sector Size (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83).

Bits 7-0	R/W	Writing to this register sets the number of 256-byte data blocks transferred by the Disk Formatter when the Inhibit Carry Bit (Register 7AH, Bit 7) is used. If this register is set (or reset) to 00H, the Inhibit Carry function will be compatible with the CL-SH130. The value programmed, plus one, is the number of the Current Sequencer Count Field underflows that will be inhibited. For a 532-byte data field, set the WCS Count value to 13H (19), the Sector Size (Register 4EH) to 01H, and set the three most-significant bits of the Next Address Field Register of the WCS to 100 when the Data Transfer Bit (WCS Control Field Register, Bit 0) is set. For a 4096-byte data field, set the WCS count value to FFH, the sector size to 0EH (14), and set Inhibit Carry.
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5.8 Register 4FH: Auxiliary Control 1 (Read/Write)

Bit 0	R/W	ADVANCED MULTISECTOR/MULTISECTOR*: When set, the sequencer will use the Sector Remaining Counter, Sector Target and Sector Count Register to control the Multisector Read/Write Operations. This will use the embedded-data-split counts in the ID field and the automatic increment of the sector number to control the multisector operations without the intervention of the microcontroller. When reset, the microcontroller must update the WCS for every sector of a Multisector Read/Write Operation. This bit is reset by the assertion of RST* (Pin 34/83).
Bit 1	R/W	PASS DIAGNOSTICS: This bit controls the PDIAG* (Pin 27/76) function that is used for master/slave operation on embedded AT drives. A read of this bit inputs the state of the pin, while a write of this bit drives the pin.
Bit 2	R/W	SLAVE PRESENT: This bit controls the 1FCLK/DASP* (Pin 28/77) Pin when it is configured to operate as DASP* (Register 7FH, Bits 3 and 4 are not 00). The DASP* function is used for master/slave operations on embedded AT drives. A read of this bit inputs the state of the pin, while a write of this bit drives the pin.

5.8 Register 4FH: Auxiliary Control 1 (Read/Write) (cont.)

Bit 3	R/W	CLEAR XT BUSY ENABLE (PC/XT Mode only): This bit, when set, will allow the automatic clear of the Busy Bit (Register 55H, Bit 7) in the XT Mode when the host reads the Completion Status Byte at the end of all commands. This bit is reset by the assertion of RST* (Pin 34/83).
Bit 4	R/W	DISABLE PIN PULL-UP RESISTORS: This bit, when set, will disable the pull-up resistors on HCS0* (Pin 47/96), HA9/HCS1* (Pin 46/95), INPUT2/HOSTINT* (Pin 5/54), PDIAG* (Pin 27/76), and 1FCLK/DASP* (Pin 28/77).
Bit 5	R/W	LOCAL INTERFACE POWER DOWN: The CL-SH360 will wake up from this mode by a write to the AT Command Register or XT Select Register, or assertion of HRST* (Pin 53/2), RST* (Pin 34/83), or by setting the Reset Bit in the AT Fixed Disk Register (3F6, Bit 2). This bit is locked by a write to the AT Command Register or the XT Select Register. It can be unlocked by a write to Register 73H.
Bit 6	R/W	HOST ATA POWER DOWN: The CL-SH360 will wake up from this mode by assertion of HRST* (Pin 53/2) or RST* (Pin 34/83), or by setting the Reset Bit in the AT Fixed Disk Register (3F6, Bit 2).
Bit 7	R/W	HOST DEEP SLEEP MODE: The CL-SH360 will wake up from this mode by assertion of HRST* (Pin 53/2) or RST* (Pin 34/83).

5.9 Register 50H: PC Interrupt Status (Read Only)

This register is reset by the assertion of HRST* (Pin 53/2), RST* (Pin 34/83), or a host-programmed reset. Bit 4 of this is reset by RST* (Pin 34/83) only. All bits are cleared by a read of this register.

Bit 0	R	PC TRANSFER DONE: When this bit is set, it indicates the completion of a host transfer [i.e., the PC Stop Pointer, (Registers 5EH-5FH), is equal to the Host Address Pointer, (HAP — Registers 5AH and 5BH)]. After this bit is set, the Host Address Pointer will read one byte more than the value of the PC Stop Pointer. This bit is reset when the host writes to the Command Register. In the Master/Slave Mode, this bit is only reset by a write to the Command Register if the DRV Select Bit matches the master/slave select configuration. This bit is the same as Register 53H, Bit 2.
Bit 1	R	PC TRANSFER OVERRUN/UNDERRUN DETECTED: When this bit is set, it indicates that a data transfer between the host and the buffer memory did not function properly. This bit is set when the IOCHRDY* Signal (Pin 48/97) is asserted low, and the rising (trailing) edge of the IOW* Signal (Pin 52/1) or the IOR* Signal (Pin 51/100) was detected. This bit is reset when the host writes to the Command Register.

5.9 Register 50H: PC Interrupt Status (Read Only) (cont.)

Bit 2	R	PC SELECTION DETECTED: In the XT Mode, this bit is set when the host writes to Port 2. In PC AT Mode, this bit is set when the host writes to the AT Command Register (47H/67H).
Bit 3	R	AT STATUS READ DETECTED: In AT Mode, this bit is set if the host reads the Primary Controller/Drive Status Register (1F7H or 177H) the first time following data transfers between the host and the FIFO. It is not set if the host reads the Alternate Controller/Drive Status Register (3F6H). In addition to the reset conditions described above, it is also cleared when the host writes to the Command Register.
Bit 4	R	PC RESET DETECTED: This bit is set by assertion of the Host Reset Signal HRST* (Pin 53/2) or a host-programmed reset, i.e., when the XT Host writes to Port 1 or the AT Host sets the RESET Bit (AT Host Fixed Disk Register, Bit 2). This bit is set for the duration of the host reset condition.
Bit 5	—	Not used; status indeterminate.
Bit 6	—	Not used; status indeterminate.
Bit 7	—	Not used; status indeterminate.

5.10 Register 51H: PC Interrupt Enable (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83).

Bit 0	R/W	PC TRANSFER DONE ENABLE: When this bit is set, it will cause the INT* Signal (Pin 4/53) to be asserted low, when the PC Transfer Done Bit (Register 50H, Bit 0 and Register 53H, Bit 2) is set.
Bit 1	R/W	PC TRANSFER OVERRUN/UNDERRUN ENABLE: When this bit is set, it will cause the INT* Signal (Pin 4/53) to be asserted low, when the PC Transfer Overrun/Underrun Detected Bit (Register 50H, Bit 1) is set.
Bit 2	R/W	PC SELECTION ENABLE: When this bit is set, it will cause the INT* Signal (Pin 4/53) to be asserted low when the PC Selection Detected Bit (Register 50H, Bit 2) is set.
Bit 3	R/W	AT STATUS READ ENABLE: When this bit is set, it will cause the INT* Signal (Pin 4/53) to be asserted low, when the AT Status Read Detected Bit (Register 50H, Bit 3) is set.

5.10 Register 51H: PC Interrupt Enable (Read/Write) (cont.)

Bit 4	R/W	PC RESET ENABLE: When this bit is set, it will cause the INT* Signal (Pin 4/53) to be asserted low, when the PC Reset Detected Bit (Register 50H, Bit 4) is set.
Bit 5	—	Not used; status indeterminate.
Bit 6	—	Not used; status indeterminate.
Bit 7	—	Not used; status indeterminate.

5.11 Register 52H: Miscellaneous Control/Status (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83).

Bit 0	R/W	MOE* DISABLE: When this bit is set, the buffer memory MOE* Signal (Pin 1/50) is disabled from being asserted low. This is intended to support switch reads (via 70H) on the buffer memory data bus. This bit is reset by the assertion of RST* (Pin 34/83).
Bit 1	R/W	MASTER/SLAVE MODE ENABLE: When this bit is set, it enables the ability to daisy-chain two separate XT or AT interfaces together, one configured as master and the other as slave.
Bit 2	R/W	MASTER/SLAVE SELECT: When Bit 1 of Register 52 is set, this bit configures the CL-SH360 as master or slave. When this bit is reset, the CL-SH360 is configured as a master; when set, it is configured as a slave. The master responds to a Drive 0 select, and the slave responds to a Drive 1 select. For the PC AT, on a diagnostic command, both the master and slave respond; only the master is enabled to report status to the host.
Bit 3	R/W	HCS1 MODE ENABLE: (AT Mode only) When this bit is set, Pin 45/94 is the HCS1* Input; when this bit is reset, Pin 46/95 is the PC Address Line 9 Input.
Bit 4	R/W	AT HOST FIXED DISK REGISTER DMAENB: This bit is valid only in the PC AT Mode, and when the DMA Mode is enabled (i.e., Register 58H, Bits 3 and 7 are reset). When this bit is set, it allows Bit 0 of the AT Host Fixed Disk Register to control the enabling of the DMA channel. This bit should be set prior to enabling the DMA Mode (Register 58, Bit 3).
Bit 5	R	AT DMAEN: This bit reflects Bit 0 of the AT Host Fixed Disk Register. The Fixed Disk Register is a write-only host register that the local microcontroller can monitor through this read-only status bit.

5.11 Register 52H: Miscellaneous Control/Status (Read/Write) (cont.)

Bit 6	R/W	BUFFER STOP POINTER DISABLE: When set, this bit disables comparison of the PC Stop Pointer (Registers 5EH and 5FH), until Register 5EH is loaded.
Bit 7	R/W	TEST MODE ENABLE: This bit is reserved by Cirrus Logic for test purposes. The user should program this bit to a logical zero.

5.12 Register 53H: Buffer Transfer Control (Read/Write)

This register is reset by the assertion of HRST* (Pin 53/2), RST* (Pin 34/83), or Buffer Manager Reset (Register 59H, Bit 0), Bit 7 of this register is reset by RST* (Pin 34/83) only.

Bit 0	R/W	DUAL-BUFFER CHIP ENABLE: When this bit is set, it allows BA15/CE2* (Pin 90/39) to operate as a second buffer chip enable for 64K buffers. This means CE1* (Pin 3/52) is connected to the first 32K chip enable and BA15/CE2* (Pin 90/39) to the second 32K chip enable.
Bit 1	R/W	DMA START: When set, the CL-SH360 will start a DMA transfer; the direction of the transfer is programmed in the PC R/W* Transfer Direction (Bit 3).
Bit 2	R	PC TRANSFER DONE: When this bit is set, it indicates the completion of a host transfer (i.e., the PC Stop Pointer, Registers 5EH-5FH, is equal to the Host Address Pointer — Registers 5AH and 5BH). After this bit is set, the Host Address Pointer will read one byte more than the value of the PC Stop Pointer. This bit is the same as Register 50H, Bit 0.
Bit 3	R/W	PC R/W* TRANSFER DIRECTION: This bit indicates the information-transfer direction on the PC bus in both the Programmed I/O (PIO) and DMA Transfer Modes. When this bit is reset, information is transferred to the CL-SH360.
Bit 4	R/W	BUFFER/DISK R/W* TRANSFER DIRECTION: This bit indicates the information-transfer direction to/from the Sector Formatter when a disk data transfer is initiated by the Sector Formatter. When this bit is set, the data-transfer direction is from the Sector Formatter to the buffer memory. When this bit is reset, the data-transfer direction is from the buffer memory to the Sector Formatter.
Bit 5	R/W	BUFFER CHIP ENABLE: When this bit is set, it asserts the CE* Signal (Pin 3/52 or 90/39) until this bit is reset. This bit is used to enable buffer memory for Read/Write Operations. This bit may be set when both the disk and host are idle, and a Read 70H and Write 70H Operation is performed.
Bit 6	R/W	BUFFER OUTPUT ENABLE: When this bit is set, it asserts the MOE* Signal (Pin 1/50). This bit is used for a Read 70 Operation to improve the buffer access time for fast processors.

5.12 Register 53H: Buffer Transfer Control (Read/Write) (cont.)

Bit 7	R/W	DEMAND MODE DMA ENABLE: This bit, when set, enables the DMA logic to assert DREQ (Pin 49/98) for the length of the transfer or de-assert DREQ for underrun/overflow control. In this mode, multiple transfers can occur without arbitrating the host bus. This bit is reset by RST* (Pin 34/83) only.
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5.13 Register 54H: Buffer Size/Segment Address (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83).

Bits 7-0	R/W	This register can operate in two modes. In the first mode, the value stored in this register represents the maximum external static RAM size to be controlled by the CL-SH360. For example, if a 32K buffer is attached, then this register is loaded with 7FH. The HAP and DAP Address Pointers access the buffer using BA0-14. When the HAP or DAP reaches 7FFFH, the pointer will roll over to 0000H on the next access. BA15 will always be zero in this example. In the second mode, this register specifies a buffer segmentation size. The smallest size is 4K. For example, with an attached buffer size of 32K and segment sizes of 4K, this register would be loaded with 0FH. This would create eight 4K segments 0000-0FFFH, 1000-1FFFH, 2000-2FFFH, 3000-3FFFH, 4000-4FFFH, 5000-5FFFH, 6000-6FFFH, 7000-7FFFH. Each segment can be accessed by setting the upper four bits of the HAP and DAP to the desired segment address. In this configuration, once the address pointer reaches XFFFH, the next address will roll over to X000H.
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For an AT interface auto-command sequence, the HAP pointer will be set to 0000H, regardless of the previous segment address.

The following table defines the allowable values that can be programmed into Register 54H.

00H = 256 bytes
01H = 512 bytes
03H = 1K bytes
07H = 2K bytes
0FH = 4K bytes
1FH = 8K bytes
3FH = 16K bytes
7FH = 32K bytes
FFH = 64K bytes

NOTE: This register cannot be modified while the buffer is being accessed.



Registers 55H-57H are XT/AT Registers. Please refer to *Section 7, Local Microcontroller-Host Interface*.

5.14 Register 58H: PC Mode Control (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83).

Bits 1-0	R/W	PC WAIT STATE: These bits specify the number of buffer memory cycles for which IOCHRDY* (Pin 48/97) will be asserted low for programmed I/O (PIO) transfers. These bits are reset by assertion of RST* (Pin 34/83). 00 = no buffer memory cycles 01 = 1-2 buffer memory cycle 10 = 2-3 buffer memory cycles 11 = 3-4 buffer memory cycles
Bit 2	R/W	AUTO-WAIT-STATE GENERATION ENABLE: When this bit is set, wait-states will be generated automatically for programmed I/O transfers between the host and the buffer memory when the CL-SH360 is not ready to transfer data. When auto-wait-state generation is enabled, IOCHRDY* (Pin 48/97) is negated when both the CL-SH360 is ready and the programmed number of wait states in the bus cycle specified by Register 58H, Bits 1-0, are generated. This bit is reset by assertion of RST* (Pin 34/83).
Bit 3	R/W	PIO or DMA SELECT: (PC/AT Mode only) When this bit is set, Programmed I/O(PIO) is selected. When the AT DMA Mode is selected, the PC can handshake the DREQ Line with either a HCS0* or a DACK*. By setting Register 52H, Bit 4, in AT DMA Mode, the PC can directly control the DMAEN of the DMA channel through Bit 0 of the Fixed Disk Register; (the local microcontroller can monitor this bit through Register 52H, Bit 5). This bit is set by assertion of RST* (Pin 34/83).
Bit 4	R/W	ENABLE AUTO-INTERRUPT UPON START OF PC DATA TRANSFER: (PC AT Mode only) When this bit is set, the CL-SH360 generates an interrupt to the host when the local microcontroller initiates a host data transfer. This is done by setting the Start DMA Bit (Register 53H, Bit 1) in the Buffer Transfer Control (Register 53H); or, if this bit is set, it is done by writing to Register 5EH. This bit is set by assertion of RST* (Pin 34/83).
Bit 5	R/W	DISABLE AUTO-COMMAND EXECUTION: When this bit is set, it disables automatic execution of write, write long, write buffer, and format commands. When this bit is set, it also disables the automatic transfer of ECC bytes for read/write long commands. This bit is reset by assertion of RST* (Pin 34/83).
Bit 6	R/W	8-/16-BIT DATA: (PC/AT Mode only) When this is set, it selects 16-bit data transfer to/from the PC. This bit is set by the assertion of RST* (Pin 34/83).

5.14 Register 58H: PC Mode Control (Read/Write) (cont.)

Bit 7	R/W	XT/AT SELECT: This bit controls which host interface is active, XT or AT. When this bit is set, the PC XT Mode is selected. This bit is reset by the assertion of RST* (Pin 34/83).
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5.15 Register 59H: Buffer Manager/PC Reset Control (Read/Write)

Bit 0	R/W	BUFFER MANAGER RESET: When this bit is set, it holds all registers associated with the Buffer Manager and PC functions in the Reset State until this bit is reset. Assertion of RST* (Pin 34/83) will also set this bit. A write to this register resets the Host Address Pointer (HAP) and the Disk Address Pointer (DAP,) Registers 5AH-5DH and sets the PC Stop Pointer (Registers 5EH and 5FH), to a 01FFH.
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CAUTION: Any write to this register also resets the PC Interface Operation. Bit 0 must be reset to execute PC AT auto-commands.

Bits 7-1	—	Reserved.
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5.16 Register 5AH: Disk Address Pointer High (DAPH) (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83) or Buffer Manager Reset (Register 59H, Bit 0).

Bits 7-0	R/W	DISK ADDRESS POINTER HIGH BYTE: These bits are the high-order byte of the buffer memory address for disk and microcontroller accesses.
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5.17 Register 5BH: Disk Address Pointer Low (DAPL) (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83), or the Buffer Manager Reset (Register 59H, Bit 0).

Bits 7-0	R/W	DISK ADDRESS POINTER LOW BYTE: These bits are the low-order byte of the buffer memory address for disk and microcontroller accesses.
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**5.18 Register 5CH: Host Address Pointer High (HAPH) (Read/Write)**

This register is reset by the assertion of RST* (Pin 34/83), or the Buffer Manager Reset (Register 59H, Bit 0).

Bits 7-0	R/W	HOST ADDRESS POINTER HIGH BYTE: These bits are the high-order byte of the buffer memory address for host accesses. This register is also reset when an auto-command is issued.
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5.19 Register 5DH: Host Address Pointer Low (HAPL) (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83), or the Buffer Manager Reset (Register 59H, Bit 0).

Bits 7-0	R/W	HOST ADDRESS POINTER LOW BYTE: These bits are the low-order byte of the buffer memory address for host accesses. This register is also reset when an auto-command is issued.
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5.20 Register 5EH: Stop Pointer High (SPH) (Read/Write)

This register is set to 01H by the assertion of RST* (Pin 34/83), or the Buffer Manager Reset (Register 59H, Bit 0).

Bits 7-0	R/W	STOP POINTER HIGH BYTE: These bits are the high-order byte of the Stop Pointer (SP). It is used to detect the end of the host data transfer. It is compared with the Host Address Pointer (HAP — Register 5CH and 5DH). When they are equal, the Host Transfer Done Bit (Register 50H, Bit 0, Register 53H, Bit 2) is set and the transfer is halted. If a new value is programmed in this register, a new transfer cycle will begin again if the DMA Start Bit (Register 53H, Bit 1) is still set. This register is also set to 01H when one of the auto-commands is issued.
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5.21 Register 5FH: Stop Pointer Low (SPL) (Read/Write)

This register is set to FFH by the assertion of RST* (Pin 34/83), or the Buffer Manager Reset (Register 59H, Bit 0).

Bits 7-0	R/W	STOP POINTER LOW BYTE: These bits are the low-order byte of the Stop Pointer (SP). It is used to detect the end of the host data transfer. It is compared with the Host Address Pointer (HAP — Register 5CH and 5DH). This register is also set to FFH when one of the auto-commands is issued.
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5.22 Register 68H: Scheduled Buffer Access (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83), or Buffer Manager Reset (Register 59H, Bit 0).

Bits 7-0	R/W	
		SCHEDULED BUFFER DATA: This register is used to access the buffer memory (using the Disk Address Pointer), or to access switches on the buffer data bus (using MOE* Disable — Register 52H, Bit 0). Auto-incrementing of the DAP can be enabled by setting the Buffer Pointer Auto-increment Enable (Register 48, Bit 0). If this register is being used to write data to the buffer memory, the following algorithm must be used: 1. First, by program construction or by reading an active value on the Byte Ready Bit (Register 48H, Bit 7), verify that the scheduling mechanism is ready to accept a byte of data. 2. Next, if the DAP is not pointing to the desired buffer memory address, write the desired address to the DAP. 3. Write the byte to this register. Byte Ready will be reset until the byte has been written, and the DAP has been incremented (If Auto-incrementing is enabled). 4. If another byte is desired, repeat this loop. If this register is being used to read data from the buffer memory, the following algorithm must be used: 1. First, by program construction or by reading an active value on the Byte Ready Bit (Register 48H, Bit 7), verify that the scheduling mechanism is ready to read a byte of data. 2. Next, if the DAP is not pointing to the desired buffer memory address, write the desired address to the DAP. 3. Read this register. The data received will be data from a previous Scheduled Read or Scheduled Write Operation. 4. By program construction or by reading an active value on the Byte Ready Bit (Register 48H, Bit 7), verify that the scheduling mechanism is ready to read a byte of data. When the scheduling mechanism is ready to read a byte of data, the desired byte is available to be read. Also, the DAP has been incremented (If auto-incrementing is enabled); therefore, a final read of this register will provide the desired data and trigger another scheduled read. If another byte is desired, repeat this loop; however, the next scheduled read will return the byte from the address pointed to by the incremented DAP (if auto-incrementing is enabled). If switches are used on the buffer data bus, the switches should be pulled up with 270K ohm resistors, and pulled down with 27K ohm resistors. To read the switches, set MOE* Disable, wait a time constant (about 3 μs), and then read this register twice. Note that the normal scheduling mechanism is still used.

5.23 Register 69H: Sector Status Register (Read Only)

This register is reset by the assertion of RST* (Pin 34/83).

Bit 0	R	END OF TRACK: This bit is set when the End of Track Bit in the ID Flag/MS Split Byte is set. It is reset after the read of this register.
Bit 1	R	DEFECT: This bit is set when Defect Bit in the ID Flag/MS Split Byte is set. It is reset after the read of this register.
Bits 7-2	—	Reserved.

5.24 Register 69H: Increment Sector Count Register (Write Only)

Bits 7-0	—	A write to this register increments the Sector Count Register (Register 6BH) by 1. This function is always enabled, even if the sequencer is stopped. The RRCLK (Pin 37/86) must be running in order for the Sector Count Register to increment.
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5.25 Register 6AH: Sector Target Register (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83).

Bits 7-0	R/W	This register is loaded with the starting sector number to be read or written to/ from the disk. The sequencer verifies the target sector by comparing the ID field from the disk with the internal ID values. The Sector Target Register is used as the source for the sector ID search. This register is incremented automatically, after the ECC is processed, for each sector.
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5.26 Register 6BH: Sector Count Register (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83).

Bits 7-0	R/W	This register is loaded with the number of sectors to be processed. At the end of each sector, this register is decremented at the beginning of the 'process ECC time'. Given the proper branch conditions, when this register is equal to 00H, it informs the sequencer of the last sector to be processed and will stop the sequencer at the end of the current sector.
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5.27 Register 6CH: React Branch Register (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83) or Register 71H, Bit 5.

Bits 4-0	R/W	BRANCH ADDRESS: Writing Bits 4-0 will cause the sequencer RAM to jump to this address when a branch condition is programmed and met.
Bits 7-5	—	Reserved.

5.28 Register 6DH: Sector Remaining Counter MSB (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83).

Bits 3-0	R/W	This register is loaded with the length, in bytes, of the sector data field. For AT drives, the normal data length is 512 bytes.
Bits 7-4	—	Reserved.

5.29 Register 6EH: Sector Remaining Counter LSB (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83).

Bits 7-0	R/W	This register is loaded with the length, in bytes, of the sector data field. For an AT drive, the normal data length is 512 bytes.
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5.30 Register 6FH: Revision Register (Read Only)

Bits 7-0	R	This register contains a revision code.
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5.31 Register 70H: Unscheduled Buffer Access (Read/Write)

Bits 7-0	R/W	A Register 70H decode will internally bridge the buffer data bus and the multiplexed data address bus, allowing the microcontroller to access the buffer memory. The DAP Pointer is used to access the buffer. Read data from the buffer will also be latched into Register 4DH. MOE* Disable (Register 52H, Bit 0) allows the static value of the buffer data bus (switch read) to be accessed. To access the buffer through this register, there must be no PC or disk transfers in progress as this is an unscheduled access port. Also, the read or write of this register will automatically increment the Disk Address Pointer if the Buffer Pointer Auto-increment Enable Bit (Register 48H, Bit 0) is set.
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5.32 Register 71H: ECC Control (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83) or Register 71H, Bit 5.

Bit 0	R/W	HARDWARE CORRECTION ENABLE: When set, this bit enables the on-the-fly correction circuitry. Resetting this bit saves the syndrome in the internal correction register, which can be read through Register 72H in 8-bit symbols.																				
Bit 1	R/W	SYNDROME SHIFT CONTROL: The function of this bit depends on Bit 0 of Register 71H. If Bit 0 is set, the internal on-the-fly correction circuitry is enabled, and Bit 1 is a don't care bit. If Bit 0 is reset, the ECC error can be corrected via firmware by reading the 10-byte syndrome from Register 72H in 8-bit segments. Setting Bit 1 will shift the syndrome by eight bits. This bit is cleared automatically after the shift is completed.																				
Bits 3-2	R/W	HOST 32-/56-/88-BIT ECC SELECT: (PC/AT Mode only) This bit is primarily used for long commands. These two bits set the transfer length for the ECC bytes with the host as follows: <table><tr><th>Register 71H</th><th>Bit 3</th><th>Bit 2</th><th></th></tr><tr><td></td><td>0</td><td>0</td><td>32-Bit (4 bytes)</td></tr><tr><td></td><td>0</td><td>1</td><td>88-Bit (11 bytes)</td></tr><tr><td></td><td>1</td><td>0</td><td>56-Bit (7 bytes)</td></tr><tr><td></td><td>1</td><td>1</td><td>—</td></tr></table>	Register 71H	Bit 3	Bit 2			0	0	32-Bit (4 bytes)		0	1	88-Bit (11 bytes)		1	0	56-Bit (7 bytes)		1	1	—
Register 71H	Bit 3	Bit 2																				
	0	0	32-Bit (4 bytes)																			
	0	1	88-Bit (11 bytes)																			
	1	0	56-Bit (7 bytes)																			
	1	1	—																			
NOTE: The formatter always uses 88-bit ECC. These bits are for host 'long' transfers only.																						
Bit 4	R/W	ENABLE SECTOR BRANCH: When set, this bit will cause the sector input to be OR'ed with the index so that the sequencer branch on index-or-sector command may be triggered by either index or sector.																				
Bit 5	R/W	CHIP RESET: Assertion of the RST* Pin will set this bit along with Bit 0 of Register 59H. If this bit is set by the microcontroller, then the Formatter Sequencer is stopped and only the following Formatter Registers are reset: 48H — Bits 2 and 6, 49-4DH, 71H, 74H, 75H, 78-7AH and 7D-7EH.																				
Bit 6	R/W	INPUT2 (Pin 5/54) EDGE TRANSITION DIRECTION: When this bit is reset, the edge trigger is on Input2 is high to low. When this bit is set, the edge trigger is low-to-high. This bit is reset by assertion of RST* only.																				
Bit 7	—	Reserved.																				

5.33 Register 72H: Syndrome Shift Register (Read Only)

This register is reset by the assertion of RST* (Pin 34/83).

Bits 7-0	R	The data read from this register is only valid when the Hardware Correction Enable Bit (Register 71H, Bit 0) is reset. Use this register in conjunction with Register 71H, Bit 1 (Syndrome Shift Control), after a Data Read Operation and an ECC error. The 10-byte syndrome can be read by the local microcontroller, through this register, to attempt a firmware correction.
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5.34 Register 72H: Correction Done Reset (Write Only)

This register is reset by the assertion of RST* (Pin 34/83).

Bits 7-0	W	A write to this register resets the Correction Done Status Bit in Register 79H, Bit 4.
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5.35 Register 73H: Auto-Command 'Lock' Release (Write Only)

Bits 7-0	W	AUTO-COMMAND 'LOCK' RELEASE: A write to this register unlocks the Buffer Manager Registers. The registers were locked when the host issued an auto-command. Register 4FH, Bit 5 (Local Interface Power Down) is locked until a write to Register 73H. The other affected registers are 53H, 5CH-5FH, 68H and 70H.
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5.36 Register 74H: Offset Count Register (MSB) (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83) or Register 71H, Bit 5.

Bits 7-0	R/W	This register contains the high-order byte of the maximum number of shifts to be performed by the hardware, before the error pattern is found. The Offset Registers (Registers 74H and 75H) are to be set to [(number of data bits - 8)/2] + 1. For 512-byte sectors, the offset value is 07FDH.
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5.37 Register 75H: Offset Count Register (LSB) (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83) or Register 71H, Bit 5.

Bits 7-0	R/W	This register contains the low-order byte of the maximum number of shifts to be performed by the hardware before the error pattern is found.
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5.38 Register 76H: Synchronization Byte-Count Limit (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83).

Bits 7-0	R/W	This register holds the byte-count limit for the NRZ read data synchronization timer. This value is programmable from 0 to 255. Refer to the description of the Count/Start Synchronization Timer/Two Index Timer Bit (Bit 5 of the WCS Count Field). When the timer has been activated, the value is decremented for each byte time that passes. If the value reaches zero, the Synchronization Time Out Error Bit (Register 48H, Bit 2) is set. Reading this register provides the running count (if the timer is active), or the programmed limit if the timer is inactive.
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5.39 Register 77H: Formatter Mode Selection (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83).

Bit 0	R/W	ENABLE LOCAL MICROCONTROLLER HOST AND DISK INTERRUPTS: This bit, when set, configures Host Interrupts (Register 50H) to the HOSTINT* (Pin 5/54) and Disk Interrupts (Register 7DH) to the INT*/DISKINT* (Pin 4/53). When this bit is reset, all interrupts affect the INT*/DISKINT* (Pin 4/53).
Bit 1	R/W	PC REGISTER FILE ACCESS ENABLE: When this bit is set, it allows the PC Registers to be accessed by the local microcontroller. The address space is specified by Bit 2. When this bit is reset, Addresses 40H-47H and 60H-67H are available for external system use.
Bit 2	R/W	PC REGISTER FILE DECODE SELECT: When this bit is set (and Bit 1 is set), the PC Register File Address is 40H-47H. (Addresses 60H-67H are available for external system use.) When this bit is reset (and Bit 1 is set), the PC Register File Address is 60H-67H. (Addresses 40H-47H are available for external system use.)
Bit 3	R/W	LOCAL INTERRUPT ENABLE: When this bit is set to a logical 1, it enables local interrupt capability. The individual sources of interrupt can still be disabled by the Interrupt Enable Registers (Registers 51H and 7EH).
Bit 4	R/W	LOCAL INTERRUPT PIN PULL-UP DISABLE: When set, this bit disables the pull-up on the output pin, leaving an open-drain output. This is intended to support multiple-interrupt sources.
Bit 5	R/W	PROGRAMMED CONTROL INDEX: When this bit is set, it simulates an active index condition. This bit can be used in place of INDEX (Pin 32/81).

5.39 Register 77H: Formatter Mode Selection (Read/Write) (cont.)

Bit 6	R/W	SEQUENCER OUTPUT ENABLE: When set, this bit activates the output enable of the Sequencer Input/Output Pin to configure it as an output. The value actually driven will be specified by the Current Sequencer Word Control Field, Bit 2.
Bit 7	R/W	HARD/SMART* SECTOR MODE CONTROL: When reset, this bit selects the Soft Sector Mode. When set, this bit selects the Hard Sector Mode. The Soft Sector Mode selects the WAM*/AMD* functionality on the WAM*/AMD*/SECTOR (Pin 33/82). Note that the sector circuitry, Sector Past (Register 7AH, Bit 1), and sector branch conditions, are now passed to the Address Mark Detect Signal. The Hard Sector Mode selects the sector functionality on the WAM*/AMD*/ SECTOR (Pin 33/82). Note that the sector circuitry, Sector Past (Register 7AH, Bit 1), and Sector Branch Conditions, are now passed to the Sector Signal.

5.40 Register 78H: Branch Address (Write Only)

This register is reset by the assertion of RST* (Pin 34/83) or Register 71H, Bit 5.

Bits 4-0	W	BRANCH ADDRESS: Writing Bits 4-0 will cause the sequencer RAM to jump to this address when a branch condition is programmed and met.
Bits 7-5	—	Reserved.

5.41 Register 79H: Formatter Status (Read Only)

This register is reset by the assertion of RST* (Pin 34/83) or Register 71H, Bit 5.

Bit 0	R	COMPARE EQUAL: This bit is set when the result of the compare operation is equal. The comparison is done between the Read Data and either the Buffer Memory Data or the WCS Data Field, on all bytes where comparison was enabled in the Compare Enable Bit (Bit 1) of the WCS Control Field. Compare Equal is not valid until the Sequencer is in the ECC field.
Bit 1	R	ID CRC ERROR: After the last bit of CRC data is read for the ID field, this bit will be set if all bits in the CRC are not zero. The reset conditions for this bit are: Register 71H, Bit 5; a write to Register 79H, and the beginning of new read/write.
Bit 2	R	ECC ERROR: This bit will be set after the last ECC Data Bit is read if there is a non-zero ECC syndrome indicating a data error. It will be reset when the next sequencer read/write is started. The reset conditions for this bit are: Register 71H, Bit 5; a write to Register 79H, and on the beginning of a new read/write.

5.41 Register 79H: Formatter Status (Read Only) (cont.)

Bit 3	R	UNCORRECTABLE ERROR FOUND: This bit is set when an uncorrectable error is found after an on-the-fly hardware correction process. (Register 71H, Bit 0, must be set. i.e., Hardware Correction is enabled). If Hardware Correction is disabled (Register 71H, Bit 0 is reset), then this bit is set following a read of the last ECC Data Bit, when there is a non-zero ECC syndrome. The reset conditions for this bit are: Register 71H, Bit 5, a write to Register 79H, the load of the Correction Register, and a host-issued auto-command (AT Mode only) if the Hardware Correction Enable Bit (Register 71H, Bit 0) is set. If the Hardware Correction Enable Bit (Register 71H, Bit 0) is reset, this bit is reset when Register 71H, Bit 5, is set and following a write to Register 79H.
Bit 4	R	CORRECTION DONE: This bit is set when a correctable error has been found and the read/write modification to correct the data in the buffer has been completed. The reset conditions for this bit are: Register 71H, Bit 5, the load of the Correction Register and a write to Register 72H.
Bit 5	R	SEQUENCER STOPPED: When this bit is set, it indicates that the sequencer is stopped. i.e., the Sequencer RAM is at Address 1FH. The ECC contents have not been reset, and the RG (Pin 35/84) and WG (Pin 36/85) Signals are reset. This bit is reset by assertion of RST* (Pin 34/83) or Register 71H, Bit 5.
Bit 6	R	BRANCH ACTIVE: This bit is set whenever a branch condition is met. This bit will be reset after a read of this register.
Bit 7	R	DATA TRANSFER STATUS: This bit indicates the status of the Data Transfer Bit (WCS Control Field, Bit 0). It is set whenever data is being transferred between the buffer memory and the disk, regardless of the state of the Suppress Transfer Bit (Register 7AH, Bit 5). It is reset when the Sequencer stops.

5.42 Register 79H: Sequencer Start (Write Only)

This register is reset by the assertion of RST* (Pin 34/83) or Register 71H, Bit 5.

Bits 4-0	W	START ADDRESS: A write to this register will start the Sequencer at the latched address.
Bits 7-5	—	Reserved.

5.43 Register 7AH: Operation Control (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83) or Register 71H, Bit 5.

Bit 0	R	INDEX PAST: The index pulse from the device has been leading-edge-detected since the last time this register was read. Reading of this bit will reset the bit even while the index pulse is present. (Read only).
Bit 1	R	SECTOR PAST: The sector pulse has been leading-edge-detected from the device since the last read of this register. Reading of this bit will reset the bit even while the sector pulse is present. In a Soft Sector Mode configuration, the Address Mark Signal should be at least one byte wide to detect an edge. (Read only).
Bit 2	R	AUTO-COMMAND STATUS: (PC AT Mode only) This bit is set when an auto-command is received and the PC R/W* Transfer Direction (Register 53H, Bit 3) is deasserted. This bit is reset when a write to Register 73H is issued to unlock the Buffer Manager Registers, and for transfers between the Formatter and the buffer sections.
Bit 3	R	SYNC DETECT: This bit is set during a Disk Read Operation when the internal serializer/deserializer has been synchronized with the incoming NRZ data, and the data matches the preprogrammed sync character in Register 7CH. This bit is cleared on the falling (trailing) edge of the RG Signal (Pin 35/84). (Read only).
Bit 4	R	WCS BYTE READY: When this bit is set, it indicates that a scheduled WCS access is completed and that another scheduled WCS access may be started.
Bit 5	R/W	SUPPRESS TRANSFER: When this bit is set, serialized or deserialized data will not be read or written to the buffer (disabling the buffer access mechanism of data transfer — Current Sequencer Word Control Field, Bit 0). During a Write Operation, the NRZ data that is output will consist of the contents of the WCS Data Field. During RG, the incoming data will be compared with the contents of the WCS Data Field, ECC will be verified, but no data will be transferred to the buffer memory.
Bit 6	R/W	SCHEDULED WCS ACCESS/ ENABLE: When this bit is set, the microcontroller uses the WCS Byte Ready Bit (Register 7AH, Bit 4) to access the WCS correctly.
Bit 7	R/W	INHIBIT DATA FIELD CARRY: When this bit is set, the carry/load of the WCS Count Field for the data transfer will be inhibited. Also, the Sector Size Counter will be reinitialized from the Sector Size Register (Register 4EH); this feature is used for large data fields. This bit is reset by the assertion of RST* (Pin 34/83) or Register 71H, Bit 5.

5.44 Register 7BH: WAM Control (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83).

Bit 7-0	R/W	WRITE ADDRESS MARK CONTROL: In Soft Sector Mode, the WAM*/AMD* Signal (Pin 33/82) will be asserted low for each bit-cell time corresponding to the bits set in this register during a Write Address Mark Operation. Output at the WAM*/AMD*/SECTOR Signal (Pin 33/82) is shifted two bits toward the MSB at the output. In Hard Sector Mode, the pin will not be asserted.
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5.45 Register 7CH: AMD Control (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83).

Bit 7-0	R/W	ADDRESS MARK DETECT CONTROL: (Synchronization Byte Pattern) This register is to be compared with NRZ read data when the RG Signal (Pin 35/84) and, if in Soft Sector Mode, the WAM*/AMD*/SECTOR Signal (Pin 33/82) are asserted. A match between this register and the serial NRZ read data input will set the SYNC Detect Bit (Register 7AH, Bit 3), and will cause the bit ring to start at zero and NRZ read data to be gated into the ECC. Only those bits in this register which are enabled by the Clock Control (Register 7FH) will be used for comparison. This register is reset when the RST* (Pin 34/83) is asserted.
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5.46 Register 7DH: Formatter Interrupt Status (Read Only)

This register is reset by the assertion of RST* (Pin 34/83), Register 71H, Bit 5, or a microcontroller read of this register.

Bit 0	R	INDEX PAST: This performs the same function as Register 7AH, Bit 0.
Bit 1	R	SECTOR PAST: This performs the same function as Register 7AH, Bit 1.
Bit 2	R	INPUT DETECTED: This bit will be set by the rising edge of the Input1/Output Signal (Pin 31/80). This bit will be cleared by the microcontroller reading this register.
Bit 3	R	SEQUENCER STOPPED: This performs the same function as Register 79H, Bit 5.
Bit 4	R	ECC ERROR/UNCORRECTABLE ERROR: If the Hardware Correction Enable Bit is set (Register 71H, Bit 0), this bit performs the same function as Register 79H, Bit 3. If the Hardware Correction Enable Bit is reset, this bit performs the same function as Register 79H, Bit 2.

5.46 Register 7DH: Formatter Interrupt Status (Read Only) (cont.)

Bit 5	R	DATA TRANSFER STATUS: This bit will be set by the rising (leading) edge of the Data Transfer Status Bit (Register 79H, Bit 7).
Bit 6	R	SEQUENCER OUTPUT DETECTED: This bit will be set by the rising (leading) edge of the Output Signal (Pin 31/80).
Bit 7	—	Not used; status indeterminate.

5.47 Register 7EH: Formatter Interrupt Enable (Read/Write)

This register is reset by the assertion of RST* (Pin 34/83).

Bit 0	R/W	INDEX ENABLE: When this bit is set, it will allow the INT* Signal to be asserted low when the Index Past Bit (Register 7DH, Bit 0) is set.
Bit 1	R/W	SECTOR ENABLE: When this bit is set, it will allow the INT* Signal to be asserted low when the Sector Past Bit (Register 7DH, Bit 1) is set.
Bit 2	R/W	INPUT DETECTED ENABLE: When this bit is set, it will allow the INT* Signal to be asserted low when the Input Detected Bit (Register 7DH, Bit 2) is set.
Bit 3	R/W	SEQUENCER STOPPED ENABLE: When this bit is set, it will allow the INT* Signal to be asserted low when the Sequencer Stopped Bit (Register 7DH, Bit 3) is set.
Bit 4	R/W	ECC ERROR ENABLE: When this bit is set, it will allow the INT* Signal to be asserted low when the ECC Error/Uncorrectable Error Bit (Register 7DH, Bit 4) is set.
Bit 5	R/W	DATA TRANSFER DETECTED ENABLE: When this bit is set, it will allow the INT* Signal to be asserted low when the Data Transfer Status Bit (Register 7DH, Bit 5) is set.
Bit 6	R/W	SEQUENCER OUTPUT DETECTED ENABLE: When this bit is set, it will allow the INT* Signal to be asserted low when the Sequencer Output Detected Bit (Register 7DH, Bit 6) is set.
Bit 7	—	Not used; status indeterminate

5.48 Register 7FH: Clock Control (Write Only)

This register is reset by the assertion of RST* (Pin 34/83).

Bits 2-0	W	SYNC COMPARE CONTROL: These bits specify the number of bits to be used in the compare for the sync byte programmed in the AMD Control Register (Register 7CH). 000 = Only Bit 7 is compared 001 = Only Bits 7 and 6 are compared 010 = Only Bits 7, 6, and 5 are compared 011 = Only Bits 7, 6, 5, and 4 are compared 100 = Only Bits 7, 6, 5, 4, and 3 are compared 101 = Only Bits 7, 6, 5, 4, 3, and 2 are compared 110 = Only Bits 7, 6, 5, 4, 3, 2, and 1 are compared 111 = All bits are compared
Bits 4-3	R/W	ECC CORRECTOR CLOCK SOURCE: These two bits select the input clock to the ECC correction circuitry as follows: 00 = 1FCLK/DASP* (Pin 28/77) 01 = RRCLK (Pin 37/86) (default after RST*) 10 = BCLK (Pin 39/88) 11 = BCLK (Pin 39/88) divided by 2
Bit 5	W	BUFFER CLOCK DISABLE: The user <i>must</i> program this bit to be reset. When this bit is set, the internal clock will be disabled. It is used for test purposes only.
Bits 7-6	W	BUFFER CLOCK DIVIDE: These bits select the divider value that is applied to BCLK (Pin 39/88) to generate a buffer clock (BUFCLK) 00 = One buffer access cycle per four BCLK cycles 01 = One buffer access cycle per two BCLK cycles 10 = One buffer access cycle per one BCLK cycle 11 = One buffer access cycle per three BCLK cycles Bit 7 is set and Bit 6 is reset when the RST* Signal (Pin 34/83) is asserted low.

5.49 Register 7FH: Top of Stack (Read Only)

Bit 7-0	R	STACK: A read of this register reads the last byte that was enabled [by the Stack Enable Bit (WCS Control Field, Bit 4)] onto the stack. The Address Pointer in 'ring' fashion moves around the 8-byte circular stack. As the byte is read, the Address Pointer moves to the previous location. The data during a read is never 'popped' from the stack; it is not lost or removed, and a continuous read of eight locations would bring one back around to the original location, reading the same data. If 10 bytes in a field were enabled to the stack, the last eight bytes would be captured, as the first two bytes would be overwritten. The first byte read from the stack would be the tenth byte enabled onto the stack. In reverse order, all of the last eight bytes could then be read continuously, in a circular manner.
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6. SEQUENCER RAM FIELD DESCRIPTION

The Sequencer RAM (Addresses 80H-9EH, A0H-BEH, C0H-DEH, and E0H-FEH) may be written to or read from by the microcontroller. If the Scheduled WCS Access/WCS Access Bit (Register 7AH, Bit 6) is reset, then the microcontroller may access the WCS when there is no risk of the contents being accessed by the Sequencer. This is normally true only during data transfers or when the Sequencer is stopped. If the Scheduled WCS Access/WCS Access Bit (Register 7AH, Bit 6) is set, then the microcontroller may access the WCS in a scheduled format where there is no contention problem between microcontroller or Sequencer access. The Sequencer RAM is not initialized during any reset.

6.1 Next Address Field Register Description

6.1.1 Registers 80H-9EH Next Address Field (Read/Write)

Bits 4-0	NEXT ADDRESS: This is the address the Sequencer will go to after the down counter has reached zero and a branch has not been taken. There are 31 possible Next Address locations (00H-1EH). The stopped condition is established by Address 1FH.
Bits 7-5	BRANCH COMMAND: All branch commands are evaluated at the end of execution of the Current Sequencer Word.

NOTE: The branch address can be the Branch Address Register (78H) or the Data/Branch Field or the React Branch Register unless otherwise explicitly stated.

The following are branch commands when the Alternate Branch Command Select Bit (Bit 7) of the WCS Control Field is reset and all of the following conditions are true:

- The Process ECC/CRC Select Bit (Bit 6) of the WCS Count Field is set **and**
- The Read Gate Signal (Pin 35/84) is asserted.
 - 000 = Continue — next address used
 - 001 = Stop on ECC error
 - 010 = Stop on non-equal compare
 - 011 = Stop on non-equal compare or ECC error
 - 100 = Branch on good ECC and equal compare
 - 101 = Branch on ECC error
 - 110 = Branch on non-equal compare
 - 111 = Branch on non-equal compare or ECC error

Branch Commands when the Alternate Branch Command Select Bit (Bit 7) of the WCS Control Field is reset, and if either of the following two conditions are true:

- The Process ECC/CRC Select Bit (Bit 6) of the Writable Control Store (WCS) Count Field is reset **or**
- The Read Gate Signal (Pin 35/84) is deasserted.
 - 000 = Continue — next address used
 - 001 = Stop if INPUT1 is active
 - 010 = Stop if the index or sector is active
 - 011 = Stop on non-equal compare

6.1.1 Registers 80H-9EH Next Address Field (Read/Write) (cont.)

- 100 = Branch on Synchronization Time-out when the WCS Data Transfer is 0 (WCS Control Field, Bit 0).
- 101 = Branch on INPUT1/OUTPUT (Pin 31/80) active.
- 110 = Branch on index or sector active.
- 111 = Branch on non-equal compare.

The following are **branch commands** when the Alternate Branch Command Select Bit (Bit 7) of the WCS Control Field is set **and all** of the following conditions are true:

- The Process ECC/CRC Select Bit (Bit 6) of the WCS Count Field is set **and**
- The Read Gate Signal (Pin 35/84) is asserted.
 - 000 = No Branch.
 - 001 = Stop on bad CRC.
 - Branch on good CRC, bad compare to retry (use the data field for the Branch Register).
 - On good CRC, good compare, and no Defect Bit (use the next address to process the data field).
 - Stop on good CRC, good compare, and the Defect Bit.
 - 010 = Stop on bad CRC.
 - Branch on good CRC, bad compare to retry (use the data field for Branch Register).
 - On good CRC, good compare, and no Defect Bit (use the next address to process the data field).
 - Branch on good CRC, good compare, and the Defect Bit using React Branch Register (Register 6CH) to execute the alternate routine.
 - 011 = Branch on bad CRC or bad compare to retry (use the data field for Branch Register).
 - On good CRC, good compare, and no Defect Bit (use the next address to process the data field).
 - Stop on good CRC, good compare, and Defect Bit.
 - 100 = Branch on bad CRC or bad compare to retry (use the data field for the Branch Register).
 - On good CRC, good compare, and no Defect Bit (use the next address to process the data field).
 - Branch on good CRC, good compare, and Defect Bit using the React Branch Register (Register 6CH) to execute the alternate routine.
 - 101 = Stop on Sector Count Register = 0.
 - Branch on the Sector Count Register not equal to zero and the End of Track Bit is reset. Increment the Sector Target Register and decrement the Sector Count Register (use the data field for the Branch Register).
 - Branch on the Sector Count Register not equal to zero and the End of Track Bit set. Reset the Sector Target Register to zero, and decrement the Sector Count Register (use the data field for the Branch Register).
 - Stop on the Uncorrectable ECC Error set for previous sector if the Hardware Correction Enable Bit (Register 71H, Bit 0) is set.
 - Stop on ECC Error if the Hardware Correction Enable Bit (Register 71H, Bit 0) is reset.
 - 110 = No Branch.
 - 111 = No Branch.

6.1.1 Registers 80H-9EH Next Address Field (Read/Write) (cont.)

The following are **branch commands** when the Alternate Branch Command Select Bit (Bit 7) of the WCS Control Field is set, and **if either** of the following two conditions are true:

- The Process ECC/CRC Select Bit (Bit 6) of the Writable Control Store (WCS) Count Field is reset **or**
- The Read Gate Signal (Pin 35/84) is deasserted.
 - 000 = No branch.
 - 001 = If the Sector Remaining Counter Register (Registers 6DH-6EH) is not equal to zero, freeze ECC and read the next split of data (use the Next Address Field).
or
Branch on Sector Remaining Counter Register = 0 (use the Branch Register 78H).
 - 010 = Sector Count Register = 0 use the Next Address Field.
Branch on the Sector Count Register not equal to zero and the End of Track Bit is reset (use the data field for Branch Register).
Branch on the Sector Count Register not equal to zero and the End of Track Bit set (use the data field for the Branch Register).
 - 011 = No branch.
 - 100 = No branch.
 - 101 = No branch.
 - 110 = Branch on INPUT2/HOSTINT* (Pin 5/54) edge detected.
 - 111 = No branch.

6.2 Count Field Register Description

6.2.1 Registers C0H-DEH Count Field (Read/Write)

Bits 3-0	COUNT: These bits are always used for the initial value of the Sequencer byte counter when a new state is entered. The counter is decremented on Bit Ring 7. When it reaches zero, a new instruction word will be accessed from the Formatter WCS.
Bit 4	COUNT/SECTOR TARGET: When the Data Transfer Bit of the Current Sequencer Word is set, this bit is a Count Bit (for an eight-bit Count Field). When the Data Transfer Bit of the Current Sequencer Word is reset, this bit indicates that the Sector Target Register should be used as the source of comparison with the incoming NRZ data in the Sector ID Byte to verify the correct sector target.
Bit 5	COUNT/START SYNCHRONIZATION TIMER/TWO INDEX TIMER ARM: When the Data Transfer Bit of the Current Sequencer Word is set, this is a Count Bit (for an 8-bit Count Field). START SYNCHRONIZATION TIMER: When this mode is selected, this bit resets and starts the Synchronization Timer. This counter is used to limit the amount of time that Format Sequencer will wait for synchronization with the NRZ Read Data. The Synchronization Byte Count Limit (Register 76H) holds a limit for the counter. If the count limit is exhausted, the current Read Operation will be aborted (the Format Sequencer stopped) and the Synchronization Time-out Error Bit (Register 4FH, Bit 0) will be set. This mode is selected when the Read Gate On Bit (Bits 6-5 of WCS Control Field) is set. THE TWO INDEX TIMER: This mode is selected when the Data Transfer Bit (WCS Control Field, Bit 0), and the Read Gate On Bit (WCS Control Field, Bit 6) are reset, and this bit is set. If Two Index pulses are detected after this circuit has been started, then the Format Sequencer will be stopped.
Bit 6	COUNT/PROCESS ECC/CRC SELECT: When the Data Transfer Bit of the Current Sequencer Word is set, this bit is a Count Bit (for an eight-bit Count Field). If, in the Current Sequencer Word, either the Read Gate On, or Write Gate On Bits are active, and the Data Transfer Bit is off, then this bit selects the CRC function. With this function active, setting this bit initializes the ECC function to the CRC polynomial; when this bit is cleared, the ECC function is initialized to the 88-bit ECC polynomial. When the Data Transfer Bit is off, and the Read Gate On, and Write Gate On Bits (WCS Control Field, Bits 6-5) are reset, this bit treats the incoming NRZ data (if Read Gate is active), or the outgoing NRZ data (if Write Gate is active) as an ECC field.



6.2 Count Field Register Description (cont.)

6.2.1 Registers C0H-DEH Count Field (Read/Write) (cont.)

Bit 7	COUNT/PROCESS AM/EXTENDED COUNT ENABLE: When the Data Transfer Bit of the Current Sequencer Word is set, this is a Count Bit (for an 8-bit Count Field). When the Data Transfer Bit is off, and Read Gate or Write Gate is active, this bit will set the AM active latch internally to define the address mark at the beginning of the ID or data field. When the Data Transfer Bit is off, and the Read Gate or Write Gate are reset, this register becomes a 7-bit Count Field. The counter is decremented on Bit Ring 7. When it reaches zero, a new instruction word will be accessed from the Formatter WCS.
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6.3 Data Field Register Description

6.3.1 Registers E0H-FEH Data Field (Read/Write)

Bits 7-0	DATA: This register is the source for all overhead bytes of data used by the device during Write Operations. During Read Operations, it is one of the operands to the comparison logic. When the Data Transfer Bit is on with the Write Gate asserted, the source for write data will be the external buffer. When Suppress Transfer is on with the Write Gate, the source for write data will be the content of this register. This register can also be the Branch Address source.
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6.4 Control Field Register Description

6.4.1 Registers A0H-BEH Control Field (Read/Write)

Bit 0	DATA TRANSFER: When this bit is set, the Count Field is used as an 8-bit counter. Each byte time that this bit is set, a byte of data will be accessed from the buffer if the Suppress Transfer Bit (Register 7AH, Bit 5) is reset. If Write Gate is active, then a byte of data is read from the buffer (if Suppress Transfer is reset) or from the Data Field (if Suppress Transfer is set); it is then serialized and sent to the NRZ Pin. During format, the ID field bytes can be written from the buffer instead of coming from the WCS Data Field (where they must be updated by the local microcontroller). This is accomplished by setting the Data Transfer Bit in the WCS Control Field. This will override the Suppress Transfer function for the ID field only. If Read Gate is active, then a byte of data is deserialized from the NRZ Pin and is written to the buffer (if Suppress Transfer is reset).
Bit 1	COMPARE ENABLE: When this bit is set and the RG Signal (Pin 35/84) is asserted, it will allow a comparison between Read Data and the WCS Data Field.
Bit 2	OUTPUT: This bit drives the Input/Output Signal (Pin 31/80) and is used to synchronize external logic functions to the state of the WCS.
Bit 3	PROCESS SPLIT/FLAG: If the Advanced Multisector/Multisector* Bit (Bit 0 of Register 4FH) is reset, this bit is used to indicate split or consecutive data field. If the Advanced Multisector/Multisector* Bit (Register 4FH, Bit 0) is set, this bit is used to specify the Flag/LS Split Count in the ID field.
Bit 4	STACK ENABLE: When active, read data is pushed on the 8-byte recirculating stack.

Bits 6-5 **CONTROL FIELD:** Bits 6-5 are encoded as follows:

Encoded Control Field Bits 6-5

Bit 6	Bit 5	Coded As	Description
0	0	No Change	The state of the Write Gate Signal (Pin 36/85) and the Read Gate Signal (Pin 35/84) is not affected.
0	1	Write Gate On	This code is used to assert the Write Gate Signal (Pin 36/85). The Write Gate Signal (Pin 36/85) is asserted during the first count of execution of the Format Sequencer Word with this bit combination set. The Write Gate Signal (Pin 36/85) is not asserted if the Read Gate Signal (Pin 35/84) is already asserted when this bit combination is executed.
1	0	Read Gate On	This code is used to assert the Read Gate Signal (Pin 35/84). The Read Gate Signal is asserted during the first count of the execution of the Format Sequencer Word with this bit combination set. The Read Gate Signal (Pin 35/84) is not asserted if the Write Gate Signal (Pin 36/85) is already asserted. The Read Gate Signal is deasserted at the end of ECC processing, or when the Format Sequencer goes to the stopped state.

6.4.1 Registers A0H-BEH Control Field (Read/Write) (cont.)

Bits 6-5 **CONTROL FIELD:** Bits 6-5 are encoded as follows:

Encoded Control Field Bits 6-5 (cont.)

Bit 6	Bit 5	Coded As	Description
1	1	Write Gate Off	This code is used to deassert the Write Gate Signal (Pin 36/85). The Write Gate Signal (Pin 36/85) is cleared during the last count of the execution of the Format Sequencer word with this bit combination set. The Write Gate Signal (Pin 36/85) is also deasserted when the Format Sequencer comes to a stopped state.

Bit 7 **ALTERNATE BRANCH COMMAND SELECT:** When this bit is set, the branch conditions in the Next Address Field are redefined, as described in Section 6.1.1.

6.5 WCS Worksheet

Microprocessor Register Addresses

Sequencer Address	Branch Address (Reg. 78H)	Next Address Field	Control Field	Count Field	Data/ Branch Field	Comments
0		80	A0	C0	E0	
1		81	A1	C1	E1	
2		82	A2	C2	E2	
3		83	A3	C3	E3	
4		84	A4	C4	E4	
5		85	A5	C5	E5	
6		86	A6	C6	E6	
7		87	A7	C7	E7	
8		88	A8	C8	E8	
9		89	A9	C9	E9	
A		8A	AA	CA	EA	
B		8B	AB	CB	EB	
C		8C	AC	CC	EC	
D		8D	AD	CD	ED	
E		8E	AE	CE	EE	
F		8F	AF	CF	EF	
10		90	B0	D0	F0	
11		91	B1	D1	F1	
12		92	B2	D2	F2	
13		93	B3	D3	F3	
14		94	B4	D4	F4	
15		95	B5	D5	F5	
16		96	B6	D6	F6	
17		97	B7	D7	F7	
18		98	B8	D8	F8	
19		99	B9	D9	F9	
1A		9A	BA	DA	FA	
1B		9B	BB	DB	FB	
1C		9C	BC	DC	FC	
1D		9D	BD	DD	FD	
1E		9E	BE	DE	FE	

React Address = **(Reg. 6CH)**

ALB BRANCH = 0

IF (RG x ECC) = 1

000 = CONTINUE, NEXT ADDRESS USED

001 = STOP ON ECC ERROR

010 = STOP ON COMPARISON NOT EQUAL

011 = STOP ON COMPARISON NOT EQUAL OR ECC ERROR

100 = BRANCH ON GOOD ECC AND COMPARISON EQUAL

101 = BRANCH ON ECC ERROR

110 = BRANCH ON COMPARISON NOT EQUAL

111 = BRANCH ON COMPARISON NOT EQUAL OR ECC ERROR

0 = DATA XFER

1 = COMP EN

2 = OUTPUT

3 = PROCESS SPLIT/FLAG

4 = STACK EN

BITS 6, 5

00 = NO CHANGE

01 = WRT GATE ON

10 = READ GATE ON

11 = WRT GATE OFF

7 = ALT BRANCH SELECT

IF (RG x ECC) = 0

000 = CONTINUE, NEXT ADDRESS USED

001 = STOP ON INPUT 1 HIGH

010 = STOP IF INDEX OR SECTOR RISING (LEADING) EDGE DETECTED

011 = STOP ON COMPARISON NOT EQUAL

100 = BRANCH ON SYNCHRONIZATION TIMEOUT WHEN WCS DATA TRANSFER BIT IS RESET

101 = BRANCH ON INPUT HIGH

110 = BRANCH ON INDEX OR SECTOR RISING (LEADING) EDGE DETECTED

111 = BRANCH ON COMPARISON NOT EQUAL

BITS 3-0 = CNT

4 = CNT/SEC TARGET

5 = CNT/TWO INDEX

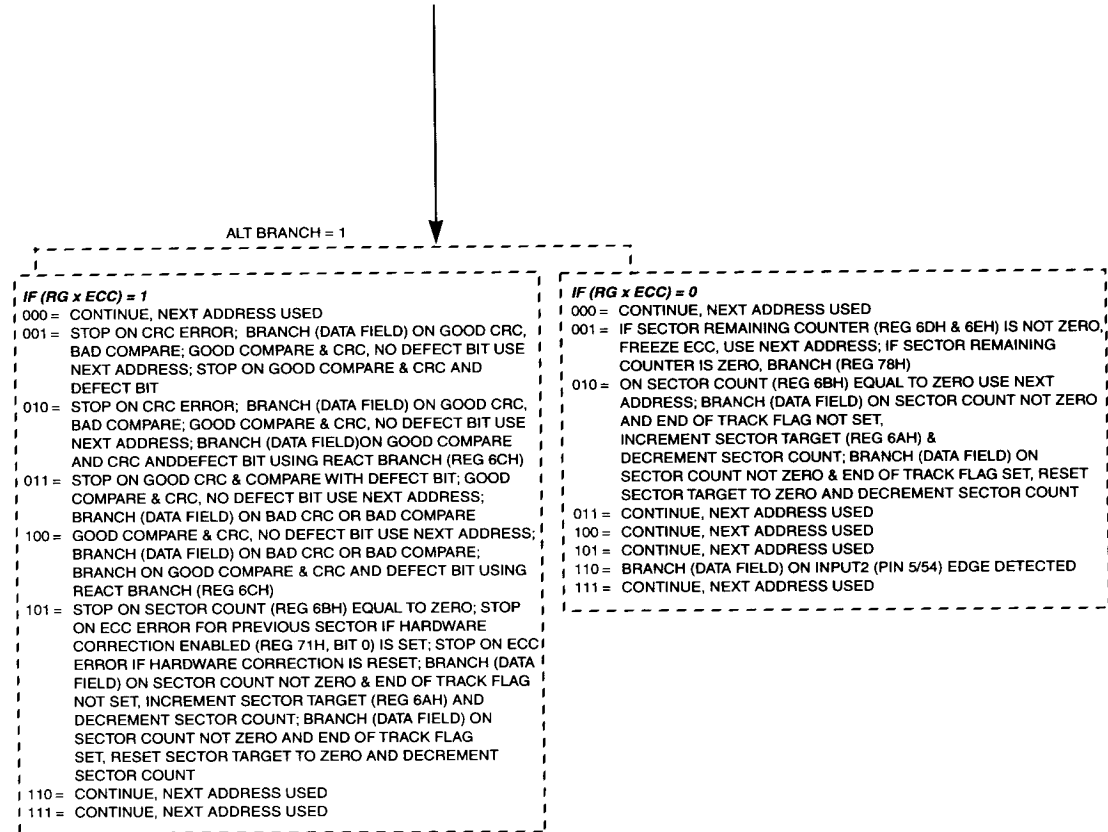
6 = CNT/PROCESS

7 = CNT/AM/EXT CNT

BITS 7-0 = DATA/ BRANCH ADDR

NEXT PAGE FOR ALT BRANCH = 1

6.5 WCS Worksheet (cont.)



6.6 WCS Worksheet Example

The following map shows a format (F), read (R), and write (W) example with the following assumptions:

- Split data format, with up to two splits
- ID field contains Sync, Cylinder High, Cylinder Low, Head, Sector, Flag/Split (four bytes), and CRC (two bytes)
- Data field contains Sync (three bytes, one for each data split), three data splits, and ECC bytes (11 bytes)
- The Sequencer start address is 0

Microprocessor Register Addresses									
Seq. Addr.	Branch Addr. (Reg. 78H)	Next Addr. Field	Control Field		Count Field		Data/Branch Field		Comments
0	80	C0	A0	00	C0	20	E0	01	Start; Wait for Index/Sector, Two Index Timer
1	81	02(F),03(R,W)	A1	00	C1	Delay	E1	00	Delay after Index/Sector
2	82	04	A2	20	C2	4A	E2	00	Write Gate On, Select CRC, Write PLO
3	83	04	A3	40	C3	61	E3	00	Read Gate On, Select CRC/Sync Timer, AM
4	84	05	A4	12	C4	80	E4	00	ID Field Sync, Enable Stack/Compare
5	85	06	A5	12	C5	00	E5	00	CYL High
6	86	07	A6	12	C6	00	E6	00	CYL Low
7	87	08	A7	12	C7	00	E7	00	Head
8	88	09	A8	12	C8	10	E8	00	Sector
9	89	0A	A9	08	C9	00	E9	00	Sector Target Reg., Enable Stack/Compare
A	8A	0B	AA	00	CA	00	EA	00	Flag/MS Split1
B	8B	0C	AB	08	CB	00	EB	00	LS Split1
C	8C	0D	AC	00	CC	00	EC	00	Flag/MS Split2
D	8D	0E(R),76(W),17(F)	AD	80	CD	41	ED	00	LS Split2
E	8E	0F	AE	00	CE	01	EE	00	Evaluate CRC/Write CRC
F	8F	10	AF	40	CF	21	EF	00	Delay Past Write Splice
10	90	11	B0	12	D0	80	F0	00	Read Gate On, Sync Timer
11	14	91	32	B1	81	D1	Don't care	F1	Data Sync
12	92	13	B2	60	D2	01	F2	00	Data Transfer
13	93	16(F,W),0E(R)	B3	00	D3	9F	F3	00	Write Gate Off for Write/Format, Delay Read
14	94	B5	B4	80	D4	4B	F4	00	Servo Delay, Extended Count Enable
15	95	5F	B5	E0	D5	02	F5	00	Evaluate ECC and Decision Point
16	96	10	B6	20	D6	0A	F6	00	Write Gate Off, Stop if Sector Count Zero
17	97	16	B7	60	D7	02	F7	00	Write Gate On, Write PLO Field
18	98		B8		D8		F8		Write Gate Off, Post ID Pad
19	99		B9		D9		F9		
1A	9A		BA		DA		FA		
1B	9B		BB		DB		FB		
1C	9C		BC		DC		FC		
1D	9D		BD		DD		FD		
1E	9E		BE		DE		FE		

7. LOCAL MICROCONTROLLER-HOST INTERFACE

The local microcontroller interface to the host is programmed through a set of command, status, and control registers. Many of these registers are shared for XT and AT applications. In general, these registers may be accessed at any time, except when noted. The interface is configured to XT or AT on power-up only. The host resets will not change this configuration.

7.1 XT-Local Microcontroller Interface

The Local XT Register File has eight Command/General-Purpose and three Control/Status Registers. These registers may be accessed by the local microcontroller after setting the XT/AT Mode Bit to 1 (see the PC Mode Control Register). The registers are as follows:

Address	Read	Write
40H or 60H	Command/General Byte 0	Command/General Byte 0
41H or 61H	Command/General Byte 1	Command/General Byte 1
42H or 62H	Command/General Byte 2	Command/General Byte 2
43H or 63H	Command/General Byte 3	Command/General Byte 3
45H or 65H	Command/General Byte 4	Command/General Byte 4
44H or 64H	Command/General Byte 5	Command/General Byte 5
46H or 66H	General Byte 6	General Byte 6
47H or 67H	General Byte 7	General Byte 7
55H	Mode/Status	Mode/Status
56H	Drive Type	Drive Type
57H	DRV/DMA/IRQ Status	Not Used

7.1.1 XT Registers 40H-47H (60H-67H): Command/General-Purpose (Read/Write)

The Command/General-Purpose Registers allow the local microcontroller to transfer bytes between the host and the disk controller without going through the buffer memory. These registers are used to receive the six command or configuration bytes and to send sense status or command-completion status. The local microcontroller is locked out of these registers during transfers with the host involving these registers. Host access to these registers is controlled by the local microcontroller through the XT Mode/Status Register. All the command/general-purpose registers are read/written by the local microcontroller. However, for the host access, the read/write direction is controlled by the I/O* Bit in the XT Mode/Status Register. These registers are not initialized on any reset.

7.1.2 XT Register 55H: Mode/Status (Read/Write)

The Mode/Status Register contains control and status for the XT interface. All transfers between the host and the Local Register File are controlled by this register. In addition, the local microcontroller may set or reset the state of the XT interface through this register. This register is reset by the assertion of HRST* (Pin 53/2), RST* (Pin 34/83), or a host-programmed reset. The register contains the following bits:

Bits 2-0	R/W	LRTC0:2: The Local Register Transfer Count (LRTC) Bits set the number of bytes to be transferred between the host and the Local Register File. Up to eight bytes may be transferred each time. These bits contain the transfer length minus one (i.e., LRTC0:2 = 0 for transfer of 1). The Local Register File Transfer Address Pointer always starts with Register 0 and is incremented on each byte transfer. A read of these bits represents the number of bytes to be transferred.
Bit 3	R/W	LRTRNS: The Local Register File Transfer Request (LRTRNS) Bit generates a transfer between the host and the register file when set to 1 by the local microcontroller. This bit will be reset when the host transfer is complete. The local microcontroller should not access the Local Register File, Registers 0-7, when this bit is set. This bit may be set only when there are no active transfers between the host and buffer memory (i.e., when the BTRNS Bit [Bit 4] = 0).
Bit 4	R	BTRNS: The Buffer Transfer (BTRNS) Bit represents the state of host buffer memory access. When this bit is set, it indicates that transfers are active between the host and buffer memory. When set, the local microcontroller may not transfer bytes between the Local Register File and the host.
Bit 5	R/W	I/O*: This bit determines the direction of transfer being requested when BTRNS or LRTRNS is asserted (see Table 7-1 on the following page).
Bit 6	R/W	C/D*: This bit determines the type of information being requested — command or data (see Table 7-1 on the following page).
Bit 7	R/W	BUSY: The Busy Bit indicates that the controller is busy executing a command. The Busy Bit is set during the selection phase by the host; it is reset at the end of the command during the Status Phase, when the host reads the Status Byte.

Table 7-1. PC/XT I/O Bus Phases Table

BUSY	C/D*	I/O*	State of Controller	Direction of Transfer
0	X	X	Idle	
1	0	0	Data Phase	PC to Controller
1	0	1	Data Phase	Controller to PC
1	1	0	Command Phase	PC to Controller
1	1	1	Status Phase	Controller to PC

NOTE: X = Don't care.

7.1.3 XT Register 56H: Drive Type (Read/Write)

The Drive Type Register is read/write and may be accessed by the local microcontroller at any time. Generally, this register contains information required by the XT BIOS driver to configure the physical attributes of the drive (i.e., cylinders, heads, sectors/track). From the host, this register appears as a read-only register. This register is not affected by any reset. In PC/XT Master/Slave Mode, only four bits of this register are driven to the host. For the master, Bits 0-3 are driven. For the slave, Bits 4-7 are driven. If the CL-SH360 is not configured for Master/Slave Mode, then all eight bits of this register are driven to the host. This register is not affected by any reset.

7.1.4 XT Register 57H: DRV/DMA/IRQ (Read Only)

The DRV/MA/IRQ Status Register reflects the state of the DRV/DMA/IRQ Enable Register written to by the host. This read-only register can be accessed at any time. This register is reset when the HRST* (Pin 53/2) is asserted or under a host program reset.

Bit 0	R	DMAEN: The DMA Request Enable Bit allows driving of the host DREQ Signal during Data Mode transfers.
Bit 1	R	IRQEN: The Interrupt Enable Bit controls the enable for the tri-stated host signal HINT. When the Interrupt Enable Bit is reset, no interrupts will be issued to the host processor. When set, this allows the controller to interrupt the host at the command completion phase.
Bit 2	R	DRV: In Master/Slave Mode, this bit enables the host to select a controller prior to issuing a command. If not in Master/Slave Mode, this bit is a don't care.
Bits 7-3	—	Not Used.

7.2 AT Local Microcontroller Interface

The Local AT Register File has eight Command and three Control/Status Registers. These registers may be accessed by the local microcontroller after setting the XT/AT Mode Bit to 0 (see the PC Mode Control Register). These registers are not initialized on any reset, except the Drive/Head Register. The registers are:

Address	Read	Write
40H or 60H	Error Status	Error Status
41H or 61H	Features	Features
42H or 62H	Sector Count	Sector Count
43H or 63H	Sector Number	Sector Number
44H or 64H	Cylinder High	Cylinder High
45H or 65H	Cylinder Low	Cylinder Low
46H or 66H	Drive/Head Number	Drive/Head Number
47H or 67H	Command	Command
55H	Control/Status	Control/Status
56H	Drive 0 Status	Drive 0 Status
57H	Drive 1 Status	Drive 1 Status

7.2.1 AT Register 40H (60H): Error Status Register (Read/Write)

The Error Status Register contains detailed error status of the last command failure. This register is also used to set controller diagnostic errors during the diagnostic command or on power-up. When an error occurs, this register is loaded and the error bit is set in the Control/Status Register. The Error Bit is cleared whenever the host writes to the AT Command Register.

7.2.2 AT Register 41H (61H): Features Register (Read/Write)

This register is command-specific and may be used to enable and disable features of the interface.

7.2.3 AT Register 42H (62H): Sector Count Register (Read/Write)

The Sector Count Register specifies the number of sectors to be transferred during a read/write sector command. This register is decremented by the local microcontroller as each sector is transferred. If this register is loaded with 0, then 256 sectors are transferred.

7.2.4 AT Register 43H (63H): Sector Number Register (Read/Write)

The Sector Number Register contains the starting sector number for the current read/write sector command. This register is incremented by the local microcontroller as each sector is transferred between the host and controller.

7.2.5 AT Register 44H (64H): Cylinder High Register (Read/Write)

The Cylinder Low Register contains the lower eight bits of the disk cylinder address. This register, in conjunction with the Cylinder High Register, constitutes a 16-bit cylinder address. This register is incremented by the local microcontroller as each cylinder boundary is crossed.

7.2.6 AT Register 45H (65H): Cylinder Low Register (Read/Write)

The Cylinder High Register contains the upper eight bits of the disk cylinder address. This register, in conjunction with the Cylinder Low Register, constitutes a 16-bit cylinder address. If the lower cylinder overflows, this register is incremented by the local microcontroller as each cylinder boundary is crossed.

7.2.7 AT Register 46H (66H): Drive/Head Register (Read/Write)

The Drive/Head Register contains the sector size, drive and head number. The local microcontroller increments the head address as each track boundary is crossed. This register is reset by HRST* (Pin 53/2), RST* (Pin 34/83), host-programmed reset, or a diagnostic command (90H). The format of the register is:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
EXT		Sector Size		DRV#	Head Number		

7.2.8 AT Register 47H (67H): Command Register (Read/Write)

The host processor issues a new command to the disk controller through this register. The controller must be 'idle' and all other registers must be set up prior to loading the Command Register. The host may abort the current data transfer and start a new command by writing to the Command Register when the data request bit is set.

7.2.9 AT Register 55H: Control/Status Register (Read/Write)

This register is reset when the RST* (Pin 34/83) or HRST* (Pin 53/2) is asserted or under host program reset, except Bits 1, 2, and 3; these are reset by HRST* (Pin 53/2) only.

Bit 0	R/W	ERROR: The Error Bit is set when an error occurred on the last command or power-up diagnostics. The error code is stored in the Error Status Register. This Error Bit is cleared whenever the host writes to the AT Command Register.
Bit 1	R	INTEN*: The Interrupt Enable (INTEN) reflects Bit 1 of the AT Host Fixed Disk Register. This register is a write-only host register that the local microcontroller can monitor. When this bit is reset, the tri-state interrupt line to the host bus is enabled.
Bit 2	R	RESET: The Reset Bit reflects the status of Bit 2 of the AT Host Fixed Disk Register. This register is a write-only host register that the local microcontroller can monitor. When this bit is set, the host is issuing a programmed reset to the controller. This condition can be sensed by the local microcontroller through the PC Reset Detected Bit (Register 50H, Bit 4) being set after a local interrupt.
Bit 3	R	HD3EN: The Head 3 Enable/Reduced Write Current (HD3EN) Bit reflects Bit 3 of the Fixed Disk Register. This register is a write-only host register that the local microcontroller can monitor. When this bit is set, the controller uses the head 3 line on the control cable to the drive as a head-select bit and not the reduced write current. This condition may not be used in all controller designs, since this function is only present in the ST 506/412 Disk Interface.
Bit 4	R/W	INT: The Interrupt Request (INT) Bit allows the local microcontroller to set an interrupt to the host by writing a one to this bit. The read of this bit returns the status of the PC interrupt line, HINT (Pin 41/90). If interrupt is enabled, the controller asserts the HINT Signal to request each sector of data transfer between the host and the FIFO. HINT is deasserted at the end of every sector transfer except the final sector. At the end of the last sector transfer, HINT remains asserted to indicate the end of a multiple-sector transfer, until the interrupt is serviced by the host. However, if an error occurs during multiple-sector transfers, the HINT Signal is asserted upon the error detection and stays asserted through the end of the last sector transfer.
Bit 5	R/W	CDATA: The Corrected Data (CDATA) Bit is set whenever a sector read from the disk had a correctable ECC error on the previous read sector transfer. The CDATA Bit is cleared whenever the host writes to AT Command Register.
Bit 6	R	BTRNS: The Buffer Transfer (BTRNS) Bit indicates the state of host buffer memory access. When this bit is set, it indicates that transfers are active between the host and the buffer memory. In a disk read, this bit is reset when the last data is transferred to the host. In a disk write, this bit is reset when the last data is transferred to the buffer memory.

7.2.9 AT Register 55H: Control/Status Register (Read/Write) (cont.)

Bit 7	R/W	BUSY: The Busy Bit indicates that the controller is executing a command. The Busy Bit is set by the host writing to the Command Register. The Busy Bit is automatically cleared on the last sector of a read command after the FIFO has been filled and DREQ is asserted. The definition of the last sector is: the only sector in the case of a single-sector read, the actual last sector of a multi-sector read if no errors, or the sector in error regardless of the sector count (a sector in error is indicated by the assertion of Register 55H, Bit 0). This bit is also set when a diagnostic command is issued, the host writes to the Command Register, or when RST* (Pin 34/83), HRST* (Pin 53/2), or a host-programmed reset is active.
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7.2.10 AT Register 56H: Drive 0 Control/Status Register (Read/Write)

The Drive 0 Status Register contains drive-related status information that is part of the Host Control/Status Register when drive 0 is selected in the Drive Number Field of the Drive/Head Register. This may be accessed by the local microcontroller at any time. The XT/AT Mode Bit must be set to 0 for AT operation. This register is reset by assertion of RST* (Pin 34/83).

Bit 0	R/W	SKCOMP0: The Seek Complete (SKCOMP0) Bit reflects the state of the Seek Complete Signal from disk drive 0. When the drive is not seeking, this bit is set.
Bit 1	R/W	FAULT0: The Write/Fault (FAULT0) Bit reflects the state of the Write Fault Signal from disk drive 0. When this bit is set, it indicates that the drive is unsafe for access.
Bit 2	R/W	READY0: The Ready (READY0) Bit reflects the state of the Ready Signal from disk drive 0. When this bit is set, the drive is present but may not be ready for read/write transfers.
Bit 3	R/W	RWC0: The Reduced Write Current (RWC0) Bit reflects the state of the Reduced Write Current Signal from disk drive 0. When this bit is set, the current to the drive write heads has been reduced.
Bit 4	R/W	OVERRIDE HD3EN0: When this bit is set, the HD3EN Bit of the AT Host Fixed Disk Register for disk drive 0 is forced to logical 1.
Bits 7-5		Reserved.

7.2.11 AT Register 57H: Drive 1 Control/Status Register (Read/Write)

The Drive 1 Status Register contains drive-related status information that is part of the Host Control/Status Register when Drive 1 is selected in the Drive Number Field of the Drive/Head Register. This may be accessed by the local register at any time. The XT/AT Mode Bit must be set to 0 for AT operation. This register is reset by assertion of RST* (Pin 34/83).

Bit 0	R/W	SKCOMP1: The Seek Complete (SKCOMP1) Bit reflects the state of the Seek Complete Signal from disk drive 1. When the drive is not seeking, this bit is set.
Bit 1	R/W	FAULT1: The Write/Fault (FAULT1) Bit reflects the state of the Write Fault Signal from disk drive 1. When this bit is set, it indicates that the drive is unsafe for access.
Bit 2	R/W	READY1: The Ready (READY1) Bit reflects the state of the Ready Signal from disk drive 1. When this bit is set, the drive is present but may not be ready for read/write transfers.
Bit 3	R/W	RWC1: The Reduced Write Current (RWC1) Bit reflects the state of the Reduced Write Current Signal from disk drive 1. When this bit is set, the current to the drive write heads has been reduced.
Bit 4	R/W	OVERRIDE HD3EN1: When this bit is set, the HD3EN Bit of the AT Host Fixed Disk Register for disk drive 1 is forced to logical 1.
Bits 7-5		Reserved.

8. PC DISK CONTROLLER INTERFACE DESCRIPTION

8.1 XT Disk Controller Interface Description

The CL-SH360 supports the standard XT hardware/BIOS protocol and the additional ability to daisy-chain two embedded drives. The XT interface between the host and the disk over the IBM XT I/O channel is through a combination of I/O ports and DMA data transfers. These registers can be accessed by the XT host when the XT/AT Select Bit (Register 58H, Bit 7) is set. There are three read ports and four write ports. The ports are as follows: Read/Write Data, Status, Programmed Reset, Drive Type, and DRV/DMA/IRQ Enable.

DACK*	HCS0*	HA1	HA0	IOR* = 0	OW* = 0
0	X	X	X	Read Data	Write Data
1	0	0	0	Read Data	Write Data
1	0	0	1	Status	Program Reset
1	0	1	0	Drive Type	Select
1	0	1	1	Not Used	DRV/DMA/IRQ Enable

NOTE: X = Don't Care.

8.1.1 Read Data Register (Port 0 Read)

Data transferred from the controller to the host originates from this register. Data is defined as sector bytes, configuration, and command-completion information. This data is transferred by either programmed I/O or DMA. However, DMA data transfers may only occur if the controller is in the Data Mode (see the Status Register).

8.1.2 Write Data Register (Port 0 Write)

Data transferred from the host to the controller goes through this register. Data is defined as command, sector-byte, and configuration information. This data is transferred either by programmed I/O or DMA. However, DMA transfers may only occur if the controller is in the Data Mode (see the Status Register).

8.1.3 Status Register (Port 1 Read)

The Status Register contains information regarding the present state of the controller. This read-only register contains the following bits:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	0	INTRQ	DMARQ	BUSY	C/D*	I/O*	REQ

Bit 0	REQ	REQUEST: When this bit is set, it indicates that the controller is ready to send or receive a byte. The type and transfer direction of this byte depends on the state of the controller, as defined by the C/D* and I/O* Status Bits. The Request Bit is set and cleared for each byte transferred between the host and the controller. This bit is valid even if the data transfers are being done by DMA.
Bit 1	I/O*	I/O*: This bit determines the requested transfer direction when the REQ Bit (Bit 0) is asserted (see Table 8-1).
Bit 2	C/D*	C/D*: This bit determines the type of information being requested, i.e., command, data, or status (see Table 8-1).
Bit 3	BUSY	BUSY: This bit indicates that the controller is executing a command. When this bit is set, no new commands are accepted until the controller goes idle by resetting the Busy Bit. The Busy Bit is set during the Selection Phase and reset at the end of the command.
Bit 4	DMARQ	DMA REQUEST: This bit is set only during the data transfers between the host and the controller, i.e., C/D* = 0, and REQ = 1. In addition, the controller must be programmed to generate DMA transfers by setting the DMAEN Bit in DMA/IRQ Enable Register. This bit is the direct image of the DREQ line on the host bus interface. This bit is set for each byte transfer and cleared by the host bus signal, DACK*.
Bit 5	INTRQ	INTERRUPT REQUEST: This bit indicates that an interrupt has been issued to the host. This bit directly reflects the Host Bus Signal HINT (Pin 41/90). This bit is set during the Command Completion Phase. During this phase, the Completion Status Byte is available to the host. In order for the Interrupt Request Bit to be set, the host must set the INTEN Bit in DMA/IRQ Enable Register before the Command Completion Phase. The Interrupt Request Bit may only be cleared by the host resetting the INTEN Bit in the DMA/IRQ Enable Register.
Bits 7-6	—	Not used; will read 0.

Table 8-1. PC XT I/O Bus Phases

BUSY	C/D*	I/O*	State of Controller	Direction of Transfer
0	X	X	Idle	
1	0	0	Data Phase	PC to Controller
1	0	1	Data Phase	Controller to PC
1	1	0	Command Phase	PC to Controller
1	1	1	Status Phase	Controller to PC

NOTE: X = Don't care.

8.1.4 Reset Register (Port 1 Write)

The host may reset the controller at any time by issuing an I/O write to Port 1. This will immediately cause the controller to enter the idle state if the controller is busy.

8.1.5 Drive Type Register (Port 2 Read)

The Drive Type Register contains information used by the host to identify the drive characteristics. The information contained in this register is written by the local microcontroller. This read-only register is used by the host BIOS driver program.

8.1.6 Controller Select Register (Port 2 Write)

The controller Select Register is a write-only register that starts the command process. When the controller is idle and the host processor issues a port write to this address, the controller becomes 'busy' and enters the Command Phase. Any data can be written to this register to cause the disk controller to become busy. A write to this port when the controller is busy has no effect.

8.1.7 DRV/DMA/IRQ Enable Register (Port 3 Write)

The DRV/DMA/IRQ Enable Register allows the host to control both DMA transfers and interrupts to the host; for the embedded dual-drive configuration (optional), it allows host control of the selected drive through the DRV Bit. This write-only register can be loaded at any time. The DMAEN Bit allows the disk controller to drive the host DREQ Signal during data phase transfers. The DREQ Signal is set and cleared on each data transfer, forming an interlocked handshake. The DMA Request Enable Bit should be enabled immediately following the 'select' sequence and disabled at the Command Completion Phase. The INTEN Bit controls the enable for the tri-stated host HINT Signal. When the INTEN Bit is reset, no interrupts will be issued to the host processor. When set, this allows the disk controller to interrupt the host at the Command Completion Phase. To reset the interrupt once it is set, the host must reset the INTEN Bit. The DRV/ DMA/IRQ Enable Register Bit definition is shown below. Bits 7-3 are don't care bits, but it is recommended that these bits to be set to logical zero.

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
X	X	X	X	X	DRV	INTEN	DMAEN

NOTE: X = Don't Care.

8.2 AT Disk Controller Interface Description

The AT host processor communicates with the disk controller through a series of read/write registers. Register access is accomplished through programmed I/O or DMA (read/write data only). These registers include Data, Error Status, Features, Sector Count, Sector Number, Cylinder Address, Drive/Head Number, Controller/Drive Status, Fixed Disk, and Digital Input. All registers are eight bits, except the Read/Write Data, which can be 8/16 bits.

Table 8-2. HCS1* Mode Disabled (Register 52H, Bit 3, is reset; Pin 46/95 is HA9)

DREQ	BUSY	HCS0*	HA9	HA2	HA1	HA0	IOR*	IOW*
1	1	0	0	0	0	0	Read Data	Write Data
X	0	0	0	0	0	1	Error Status	Features
X	0	0	0	0	1	0	Sector Count	Sector Count
X	0	0	0	0	1	1	Sector Number	Sector Number
X	0	0	0	1	0	0	Cylinder Low	Cylinder Low
X	0	0	0	1	0	1	Cylinder High	Cylinder High
X	0	0	0	1	1	0	Drive/Head Number	Drive/Head Number
X	0	0	0	1	1	1	Contr./Drive Status	Command
0	1	0	0	X	X	X	Contr./Drive Status	Not Allowed
X	X	0	1	1	1	0	Alternate Status	Fixed Disk
X	X	0	1	1	1	1	Digital Input	Not Used

Table 8-3. HCS1* Mode Enabled (Register 52H, Bit 3 is set; Pin 46/95 is HCS1*)

DREQ	BUSY	HCS0*	HCS1*	HA2	HA1	HA0	IOR*	IOW*
1	1	0	1	0	0	0	Read Data	Write Data
X	0	0	1	0	0	1	Error Status	Features
X	0	0	1	0	1	0	Sector Count	Sector Count
X	0	0	1	0	1	1	Sector Number	Sector Number
X	0	0	1	1	0	0	Cylinder Low	Cylinder Low
X	0	0	1	1	0	1	Cylinder High	Cylinder High
X	0	0	1	1	1	0	Drive/Head Number	Drive/Head Number
X	0	0	1	1	1	1	Contr./Drive Status	Command
0	1	0	1	X	X	X	Contr./Drive Status	Not Allowed
X	X	1	0	1	1	0	Alternate Status	Fixed Disk
X	X	1	0	1	1	1	Digital Input	Not Used

8.2.1 Read Data Register (Read Only)

The Read Data Register transfers sector and ECC data from the buffer to the host. This register is 16 bits wide except when transferring read ECC data, when it is eight bits. The host processor may only access this register during data transfers when the Data Request Bit (DRQ) is set (see Controller/Drive Status Register).

8.2.2 Write Data Register (Write Only)

The Write Data Register transfers sector and ECC data from the host to the buffer. This register is 16 bits wide except when transferring write ECC data, when it is eight bits. The host processor may only access this register during data transfers when the Data Request Bit (DRQ) is set (see the Controller/Drive Status Register).

8.2.3 Error Status Register (Read Only)

The local microcontroller can write detailed error status of the last command failure to this register. This register is also used to set controller diagnostic errors during the diagnostic command or on power-up. When an error occurs, this register is loaded and the Error Bit is set in the Controller/Drive Status Register (see Controller/Drive Status Register). The Error Bit is cleared whenever the host writes to the Command Register. This register may only be read when the Busy Bit is not set (see the Controller/Drive Status Register).

8.2.4 Features Register (Write Only)

The Features Register is command specific and may be used to enable or disable features of the interface. An example would be using the Set Features Command to enable and disable caching. This register was previously called the Write Precompensation Register. This register may only be written when the Busy Bit is not set (see the Controller/Drive Status Register).

8.2.5 Sector Count Register (Read/Write)

The Sector Count Register specifies the number of sectors to be transferred during a read/write sector command. This register is decremented by the local microcontroller as each sector is transferred. If this register is loaded with 0, then 256 sectors are transferred. This register may only be accessed when the Busy Bit is not set (see the Controller/Drive Status Register).

8.2.6 Sector Number Register (Read/Write)

The Sector Number Register contains the starting sector number for the current read/write sector command. This register is incremented by the local microcontroller as each sector is transferred between the host and the controller. This register may only be accessed when the Busy Bit is not set (see the Controller/Drive Status Register).

8.2.7 Cylinder Low Register (Read/Write)

The Cylinder Low Register contains the lower eight bits of the disk cylinder address. This register, in conjunction with the Cylinder High Register, constitutes a 16-bit cylinder address. This register may only be accessed when the Busy Bit is not set (see the Controller/Drive Status Register).

8.2.8 Cylinder High Register (Read/Write)

The Cylinder High Register contains the upper eight bits of the disk cylinder address. This register, in conjunction with the Cylinder Low Register, constitutes a 16-bit cylinder address. This register may only be accessed when the Busy Bit is not set (see the Controller/Drive Status Register).

8.2.9 Drive/Head Register (Read/Write)

The Drive/Head Register contains the sector size, drive and head number. This register may only be accessed when the Busy Bit is not set (see the Controller/Drive Status Register).

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
EXT	Sector Size		DRV #	Head Number			

Bit 7, the Extension Bit, is used to extend the data field by up to 11 bytes when using ECC codes. CRC is not appended to data field when EXT = 1; the data field becomes 'sector size + ECC' bytes long. This register is reset when RST* (Pin 34/83) or HRST* (Pin 53/2) is asserted. It is also reset when an AT host sets Fixed Disk Register, Bit 2 or when the Diagnostic Command is issued by the host.

8.2.10 Controller/Drive Status Register (Read Only)

The Controller/Drive Status Register specifies the state of the controller/drive. This register may be accessed at any time; however, when the Busy Bit is set, no other bits in the register are valid. Also by reading this register, any pending interrupts to the host are cleared.

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
BUSY	READY	FAULT	SKCOMPL	DREQ	CDATA	INDEX	ERROR

Bit 0	ERROR	ERROR BIT: This is set when an error occurred on the last command or power-up diagnostics. The Error Bit is cleared whenever the host writes to the Command Register. The error code is stored in the Error Register.
Bit 1	INDEX	INDEX SIGNAL: This reflects the Index Signal from the selected disk drive. This signal goes active once per revolution of the disk. This bit will not be set if the drive is not ready (Bit 6 is reset).
Bit 2	CDATA	CORRECTED DATA BIT: This bit is set, whenever, on the previous read sector transfer, a sector read off the disk had a correctable ECC error. The corrected data bit is cleared whenever the host writes to the Command Register.
Bit 3	DREQ	DATA REQUEST: The Data Request Bit is set for data transfers to/from the sector buffer. This includes both sector and ECC data. The controller is considered busy whenever the DREQ or Busy Bits are set. Also, when the Data Request Bit is set, the host processor may read/write any of the registers, including the Command Register.
Bit 4	SKCOMPL	SEEK COMPLETE: The Seek Complete Bit reflects the state of the Seek Complete Signal from the selected disk drive. When the drive is not seeking, this bit is set.
Bit 5	FAULT	WRITE FAULT: The Write Fault Bit reflects the state of the Write Fault Signal from the selected disk drive. When this bit is set, it indicates that the drive is unsafe for read/write access.
Bit 6	READY	READY: The Ready Bit reflects the state of the Ready Signal from the selected disk drive. When this bit is set, the drive is present but may not be ready for read/write transfers.
Bit 7	BUSY	BUSY: When the Busy Bit is set, the controller is executing a command. Also, when this bit is set, the host processor may not read or write any other registers except the Controller/Drive Status, Alternate Controller/Drive Status, Fixed Disk, or Digital Input registers. This bit is set when RST* or HRST* Pin is asserted. It is also set when an AT host sets Fixed Disk Register, Bit 2, or when the Command Register is loaded by the host.

8.2.11 Command Register (Write Only)

The host processor issues a new command to the disk controller through this register. The controller must be idle and all other registers must be set up prior to loading the Command Register. The host may abort the current data transfer and start a new data command by writing to the Command Register when the Data Request Bit is set.

8.2.12 Alternate Controller/Drive Status Register (Read Only)

The Alternate Controller/Drive Status Register contains the same bit definition as the Controller/Drive Status Register. This register is used for systems that do not want to reset pending interrupts by reading the Controller/Drive Status Register. This register may be read at any time.

8.2.13 Fixed Disk Register (Write Only)

The Fixed Disk Register is a control register to select Head Mode, reset the controller, and enable interrupts and AT DMA Mode. The DMA Enable Bit (Bit 0) is an extra feature that the CL-SH360 supports for the AT that is not part of the generic AT interface. This feature allows a DMA channel to be multiplexed between multiple peripherals directly by the PC without local microcontroller intervention. To enable this feature, first the DMA Mode must be selected (Register 58H, Bit 3); second, the Enable DMA Control Bit through the Miscellaneous Control/Status Register (Register 52H, Bit 4) must be set. With these two control bits set, then the Fixed Disk Register Bit 0 controls the DMA Enable of the DMA channel. The bit definition of the Fixed Disk Register is shown below; Bits 7-4 are don't care bits, but it is recommended that the user program these bits to logical zero. This register is reset when HRST* (Pin 53/2) or RST* (Pin 34/83) is asserted.

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
X	X	X	X	HD3EN	RESET	INTEN*	DMAEN

8.2.14 Digital Input Register (Read Only)

The Digital Input Register is a diagnostic loopback register that contains Write Gate, Head Select 3/Reduced Write Current, Head Select 2, Head Select 1, Head Select 0, Drive Select drive 1, and Drive Select drive 0. These bits reflect the state of signals on the disk control cable. The host may read this register at any time. When the host reads this register, only Bits 6-0 are driven; Bit 7 is tri-stated. Note that Bit 6 is not initialized by any host interface hard or soft reset. Bits 5-0 are reset in the same manner as the Drive/Head Register.

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
HiZ	WGate*	H3/RWC*	H2*	H1*	H0*	DS1*	DS0*

NOTE: HiZ denotes high impedance.

9. ELECTRICAL SPECIFICATIONS

9.1 Absolute Maximum Ratings

Ambient temperature under bias	0° C to 70° C
Storage temperature.....	-65° C to 150° C
Voltage on any pin with respect to ground	GND -0.5 to $V_{CC} + 0.5$ Volts
Power dissipation	0.50 Watt
Power supply voltage	7 Volts

NOTE: Stress above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

9.2 DC Characteristics

Symbol	Parameter	MIN	MAX	Units	Conditions
V_{CC}	Power Supply Voltage	4.5	5.5	V	Operating
V_{IL}	Input Low Voltage	-0.5	0.8	V	
V_{IH}	Input High Voltage	2.0	$V_{CC} + 0.5$	V	
V_{OL}^1	Output Low Voltage		0.4	V	$I_{OL} = 2 \text{ mA}^3$
V_{OL}^2	Output Low Voltage		0.5	V	$I_{OL} = 24 \text{ mA}$
V_{OH}	Output High Voltage	3.5		V	$I_{OH} = -400 \mu\text{A}$
I_L	Input Leakage	-10	10	μA	$0 < V_{IN} < V_{CC}$
C_{IN}	Input Capacitance		10	pF	
C_{OUT}	Output Capacitance		10	pF	

NOTES: 1) All output pins except for PC Signals.

2) PC Outputs.

3) $I_{OL} = 4 \text{ mA}$ for RG and WG.

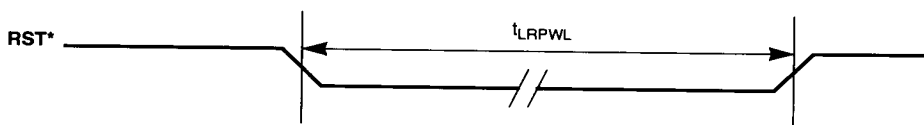
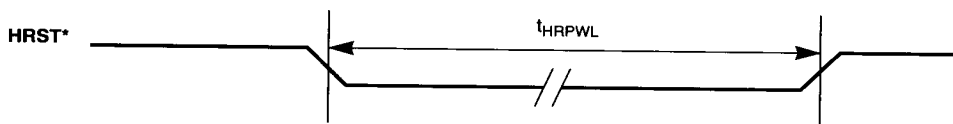
9.3 AC Characteristics/Timing Information

9.3.1 Index of Timing Information

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Table 9-1. RESET Assertion Timing

Symbol	Parameter	MIN	MAX	Units
t_{HRPWL}	HRST* pulse width low	500		ns
t_{LRPWL}	RST* pulse width low	10		μ s



Figures 9-1a. and 9-1b. RESET Assertion Timings

Table 9-2. Microprocessor Interface Timing Parameters

Symbol	Parameter	MIN	MAX	Units
t_A	ALE Width	20		ns
t_{AR}	Address Valid to RD* ↓ or DS ↑	15		ns
t_R	RD* Width	60		ns
a_S	Address Valid to ALE ↓	5		ns
a_H	ALE ↓ to Address Invalid	5		ns
c_S	CS Valid to RD* ↓ or DS ↑	5		ns
c_H	RD* ↑ or DS ↓ to CS ↓	0		ns
t_{DA}	RD* ↓ or DS ↑ to Read Data Valid		40	ns
t_{DS}	DS Width	60		ns
t_{DH}	RD* ↑ to Read Data Invalid	0	15	ns
t_{SRW}	R/W* valid to DS ↑	5		ns
t_{HRW}	DS ↓ to R/W* Invalid	5		ns
t_{AL}	AD[7:0] Valid to A[7:0]		20	ns

NOTES: ↑ indicates rising edge. ↓ indicates falling edge.

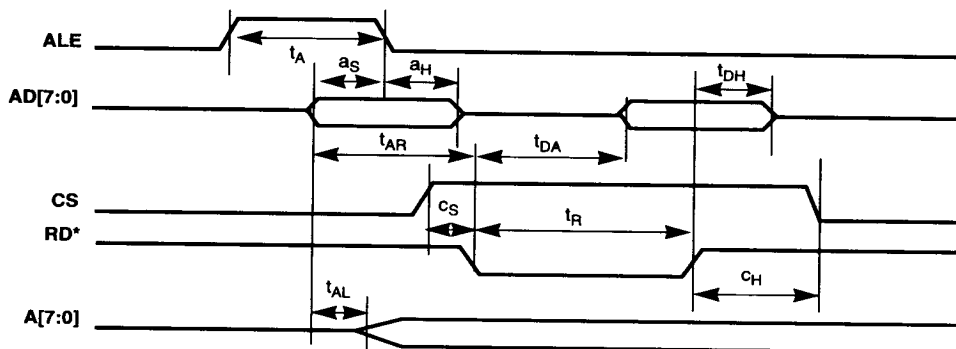


Figure 9-2a. Multiplexed Intel Register Read Timing

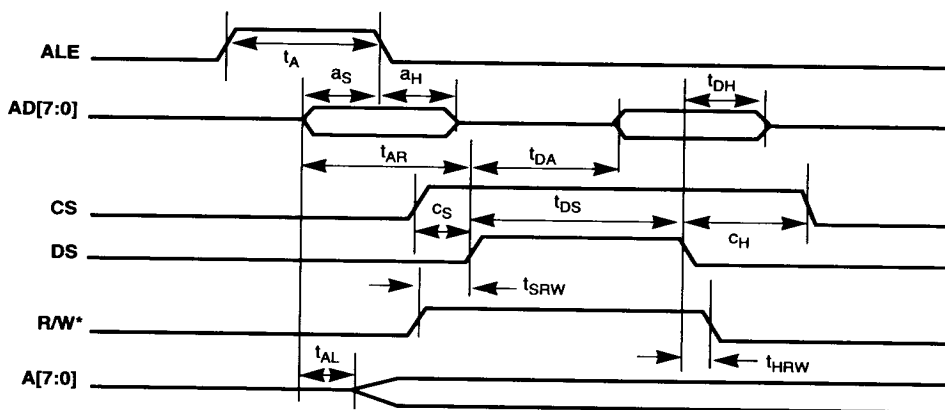


Figure 9-2b. Multiplexed Motorola Register Read Timing

Table 9-3. Microprocessor Interface Timing Parameters

Symbol	Parameter	MIN	MAX	Units
t_A	ALE Width	20		ns
t_{Aw}	Address valid to WR* ↓ or DS ↑	15		ns
t_w	WR* Width	50		ns
a_S	Address Valid to ALE ↓	5		ns
a_H	ALE ↓ to Address Invalid	5		ns
c_S	CS Valid to WR* ↓ or DS ↑	5		ns
c_H	WR* ↑ or DS ↓ to CS ↓	0		ns
w_{DS}	Write Data Valid to WR* ↑ or DS ↓	20		ns
w_{DH}	WR* ↑ or DS ↓ to Write Data Invalid	10		ns
t_{DS}	DS width	60		ns
t_{SRW}	R/W* valid to DS ↑	5		ns
t_{HRW}	DS ↓ to R/W* invalid	5		ns
t_{AL}	AD[7:0] Valid to A[7:0]		20	ns

NOTES: ↑ indicates rising edge. ↓ indicates falling edge.

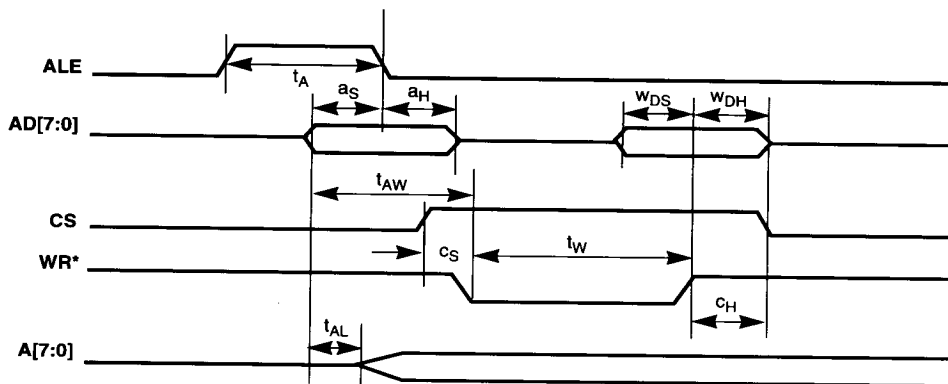


Figure 9-3a. Multiplexed Intel Register Write Timing

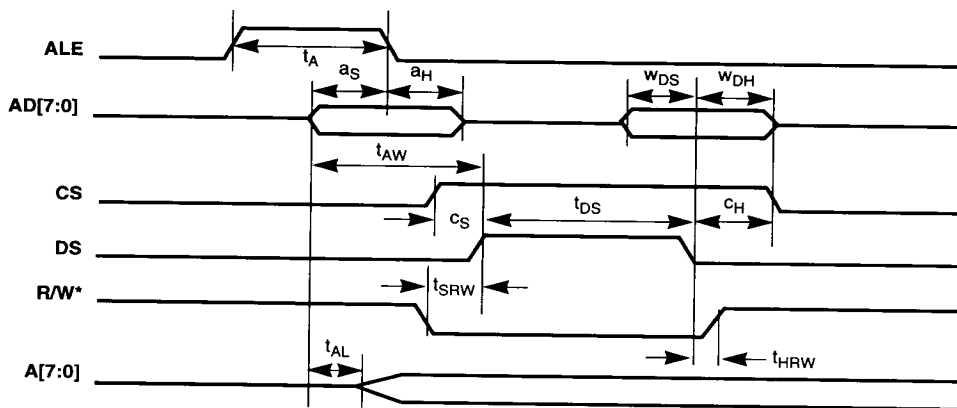


Figure 9-3b. Multiplexed Motorola Register Write Timing

Table 9-4. Microprocessor Interface Timing Parameters

Symbol	Parameter	MIN	MAX	Units
t_E	DS Pulse Width	60		ns
t_{AS}	Address Valid to DS $\uparrow\uparrow$	25		ns
t_{AH}	DS $\downarrow\downarrow$ to Address Invalid	0		ns
CS_{f1}	CS $\uparrow\uparrow$ to DS $\uparrow\uparrow$	10		ns
C_H	DS $\downarrow\downarrow$ to CS $\downarrow\downarrow$	0		ns
t_{DA}	DS $\uparrow\uparrow$ to Read Data Valid		40	ns
t_{DH}	DS $\downarrow\downarrow$ to Read Data Invalid	0	25	ns
wd_S	Write Data Valid to DS $\downarrow\downarrow$	20		ns
wd_H	DS $\downarrow\downarrow$ to Write Data Invalid	10		ns
t_{SRW}	R/W* Valid to DS $\uparrow\uparrow$	5		ns
t_{HRW}	DS $\downarrow\downarrow$ to R/W* Invalid	5		ns

NOTES: $\uparrow\uparrow$ indicates rising edge. $\downarrow\downarrow$ indicates falling edge.

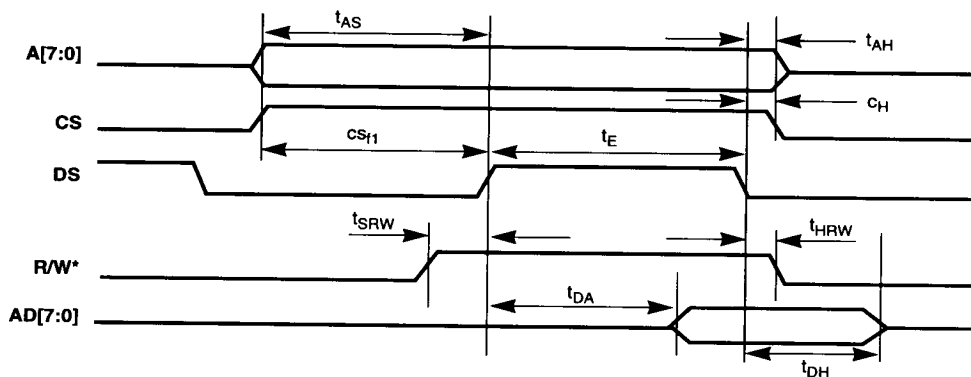


Figure 9-4a. Non-Multiplexed Register Read Timing

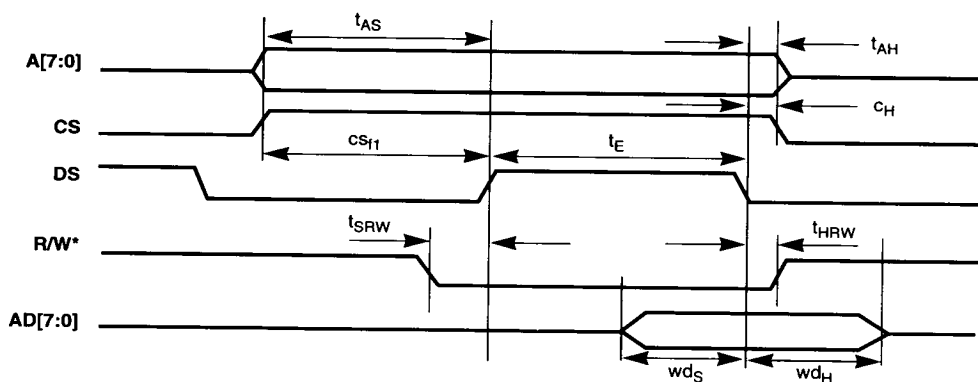


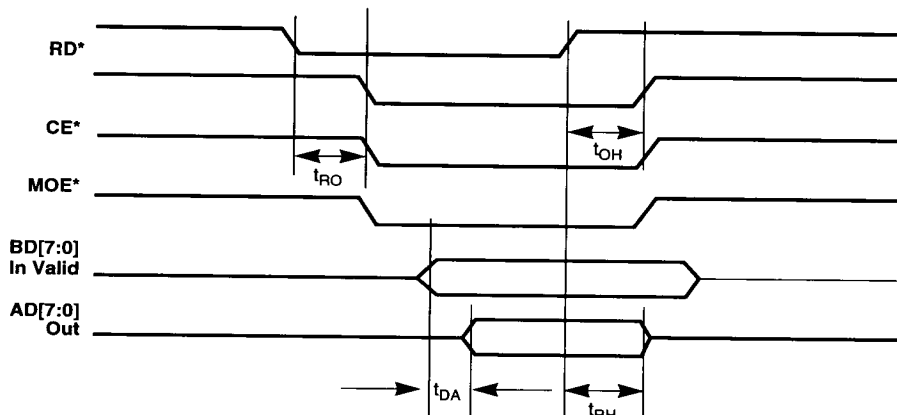
Figure 9-4b. Non-Multiplexed Register Write Timing

Table 9-5. Register 70H Access Timing Parameters

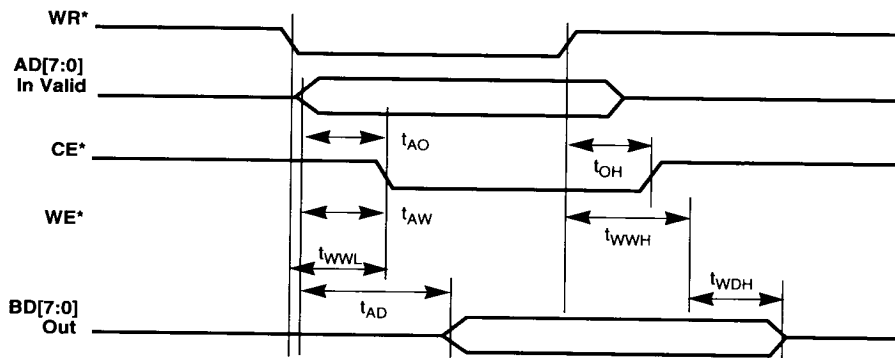
Symbol	Parameter	MIN	MAX	Units
t_{RO}	$RD^* \downarrow$ or $WR^* \downarrow$ to $MOE^* \downarrow$ or $CE^* \downarrow$		40	ns
t_{DA}	BD[7:0] In Valid to AD[7:0] Out		55	ns
t_{RH}	$RD^* \uparrow$ to AD[7:0] Invalid		50	ns
t_{OH}	$RD^* \uparrow$ or $WR^* \uparrow$ to $MOE^* \uparrow$ or $CE^* \uparrow$		40	ns
t_{AW}	AD[7:0] In Valid to $WE^* \downarrow$		55	ns
t_{AO}	AD[7:0] In Valid to $CE^* \downarrow$		55	ns
t_{AD}	AD[7:0] In Valid to BD[7:0] Out		55	ns
t_{WWL}	$WR^* \downarrow$ to $WE^* \downarrow$		40	ns
t_{WWH}	$WR^* \uparrow$ to $WE^* \uparrow$		40	ns
t_{WDH}	$WE^* \uparrow$ to BD[7:0] Out Invalid	10		ns

NOTES: $\uparrow$ indicates rising edge. $\downarrow$ indicates falling edge.

Read Register 70H Timing



Write Register 70H Timing



Figures 9-5a. and 9-5b. Register 70H Access Timing Parameters

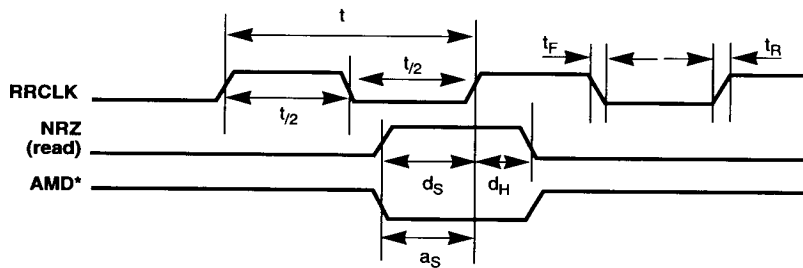
Table 9-6. Disk Read/Write Timing Parameters

Symbol	Parameter	MIN	MAX	Units
t	RRCLK/1FCLK Period	31.25		ns
$t_{1/2}$	RRCLK/1FCLK High/Low Time	12.5		ns
$t_R = t_F$	RRCLK/1FCLK Rise and Fall Time		5	ns
d_S	NRZ In Valid to RRCLK $\uparrow\uparrow$	10		ns
d_H	RRCLK $\uparrow\uparrow$ to NRZ In Invalid	5		ns
a_S^1	AMD* Valid to RRCLK $\uparrow\uparrow$	10		ns
d_V	RRCLK $\uparrow\uparrow$ to NRZ Out	8	25	ns
w_V^1	RRCLK $\uparrow\uparrow$ to WAM* Out	8	25	ns

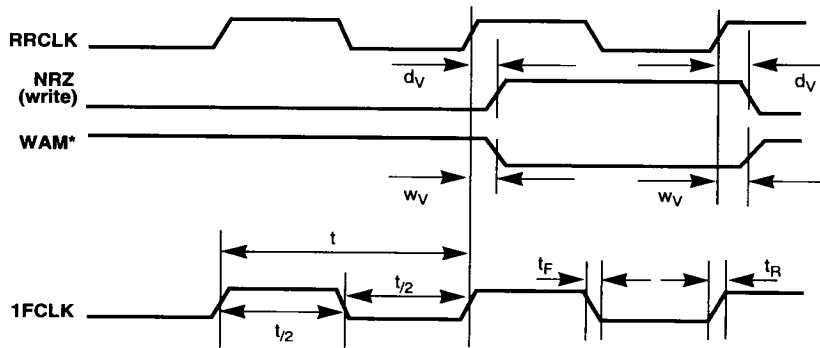
NOTES: $\uparrow\uparrow$ indicates rising edge. $\downarrow\downarrow$ indicates falling edge.

(1) These specifications are only applicable in the Soft Sector Mode.

Disk Read Timing



Disk Write Timing



Figures 9-6a. and 9-6b. Disk Read/Write Timing Parameters

Table 9-7. Buffer Memory Read/Write Timing Parameters

Symbol	Parameter	MIN	MAX	Units	Conditions
t_B	BCLK Period	25		ns	
$t_{B/2}$	BCLK Low/High Time	12		ns	
$t_{Bf}=t_{Bf}$	BCLK Rise and Fall Time		5	ns	
a_V	BCLK $\Downarrow$ To Address Valid		80	ns	
d_{OV}	WE* $\Downarrow$ to Data Out Valid		20	ns	
d_{OH}	WE* $\Uparrow$ to Data Out Invalid	5		ns	
w_V	Address Valid to WE* $\Downarrow$	$b_{ACC}-w_W-w_H$		ns	
w_H	WE* $\Uparrow$ to Address Hold	5	20	ns	
c_W	CE* Low Time	b_{ACC}		ns	
d_{IS}	Data In Valid to MOE* $\Uparrow$	10		ns	
d_{IH}	MOE* $\Uparrow$ to Data In Invalid	5		ns	
b_{ACC}	Buffer Access period	1 BUFCLK period		ns	
w_W	WE* Low Time	BCLK High Time		ns	Divide By 1 Mode
		1 BCLK Period		ns	Divide By 2 Mode
		2 BCLK Period		ns	Divide By 3 Mode
		3 BCLK Period		ns	Divide By 4 Mode
m_W	MOE* Low Time	1 BUFCLK period		ns	

NOTES: $\Uparrow$ indicates rising edge. $\Downarrow$ indicates falling edge.
 BUFCLK = NUMCYC (Programmed in Register 7FH) * BCLK.
 The total SRAM access time is a function of BUFCLK.
 The a_V value is only intended for testing purposes.

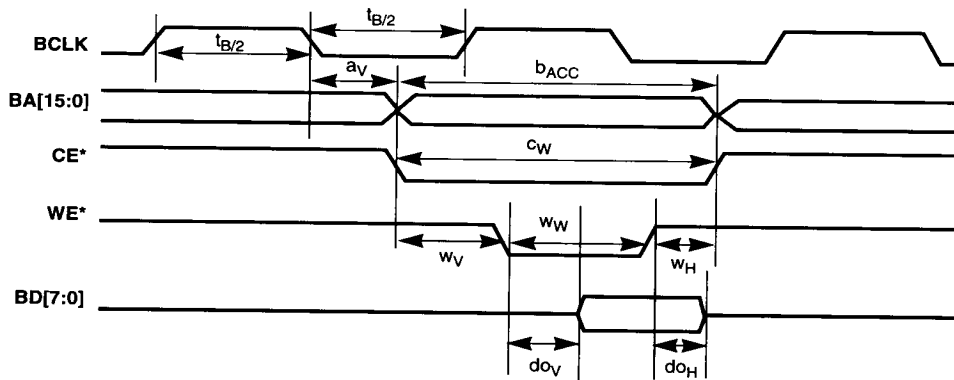
BUFFER READ

Read Access Time = $b_{ACC} - d_{IS}$ (MIN).
 Minimum Output Enable = m_W .

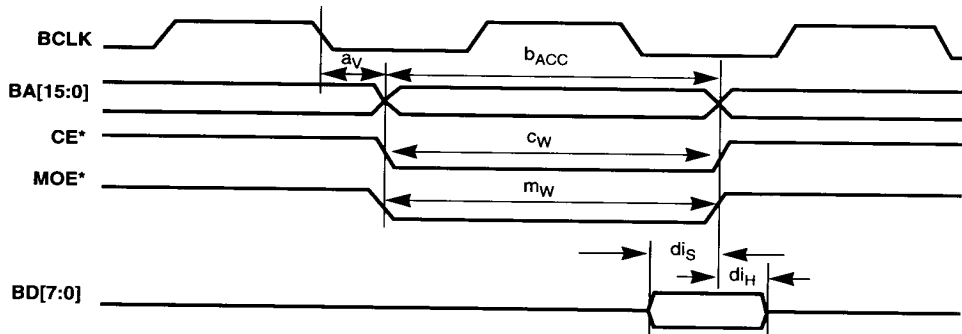
BUFFER WRITE

Write Address Set-Up to WE* Low = $b_{ACC} - w_W - w_H$ (MAX).
 Data Set-Up to WE* High = $w_W - d_{OV}$.
 Minimum Write Enable Pulse Width = w_W .
 Write Access Time = $b_{ACC} - w_H$ (MAX).

Write Cycle



Read Cycle



Figures 9-7a. and 9-7b. Buffer Memory Read/Write Timing Parameters

Table 9—8. Host-PC-Programmed I/O Timing Parameters

Symbol	Parameter	MIN	MAX	Units
cs16 _L	HCS0* Low, HA[2:0], HA9/HCS1* to IOCS16* Low		20	ns
adr _{SET}	HCS0*, HA[2:0], HA9/HCS1* Set-up to IOR*/IOW* Low	30		ns
adr _{HLD}	HCS0*, HA[2:0], HA9/HCS1* Hold from IOR*/IOW* High	10		ns
ioch _L	IOR*/IOW* Low to IOCHRDY Low		25	ns
ioch _{TW}	IOCHRDY Pulse Width	0	5*BUFCLK	ns
rd _{TA}	IOR* Low to HDB[15:0] Valid		60	ns
rd _{HLD}	IOR* High to HDB[15:0] Invalid	5		ns
rd _{TRI}	IOR* High to HDB[15:0] Tri-state		30	ns
wd _S	HDB[15:0] Set-up to IOW* High	40		ns
wd _{HLD}	HDB[15:0] Hold from IOW* High	10		ns
rw _{PULSE}	IOR*/IOW* Pulse Width	80		ns

NOTE: BUFCLK is the internal Buffer Clock that indicates the period of Buffer Access Cycles derived from BCLK in the appropriate Divide By Mode (Register 7FH, Bits 6 and 7). The minimum Buffer Access Cycle is 83.33 ns.

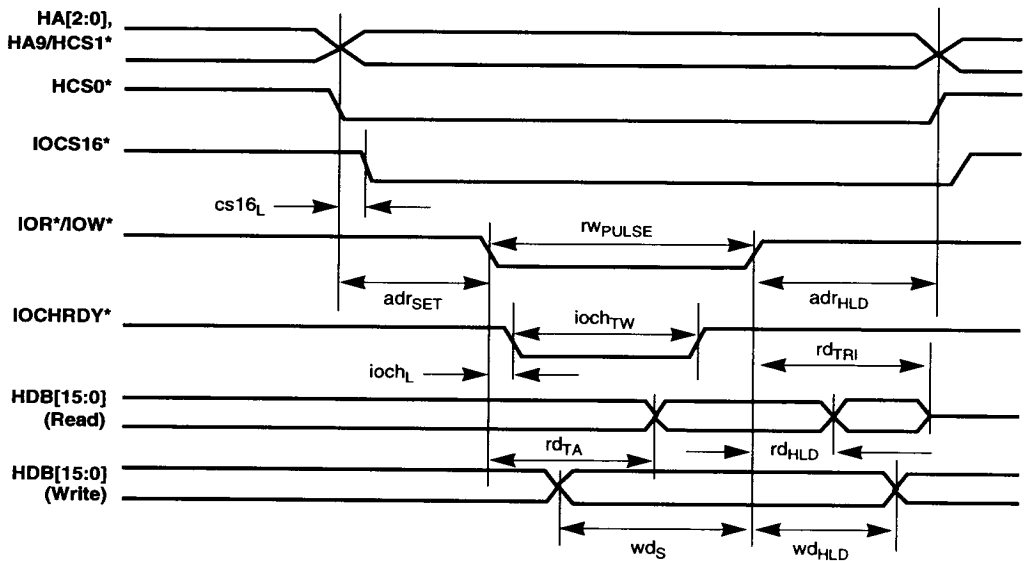


Figure 9-8. Programmed I/O, 8-/16-Bit Host Interface Timing

Table 9–9. Host DMA 8-/16-Bit Interface Timing (Single-Transfer Mode)

Symbol	Parameter	MIN	MAX	Units
dreq _L	DREQ Low from DACK* Low		60	ns
dma _{SET}	DACK* Low to IOR*/IOW* Low	10		ns
dma _{HLD}	DACK* Hold from IOR*/IOW* High	10		ns
rd _{TA}	IOR* Low to HDB[15:0] Valid		50	ns
rd _{HLD}	IOR* High to HDB[15:0] Invalid	5		ns
rd _{TRI}	IOR* High to HDB[15:0] Tri-state		30	ns
wd _S	HDB[15:0] Set-up to IOW* High	20		ns
wd _{HLD}	HDB[15:0] Hold from IOW* High	10		ns
rwPULSE	IOR*/IOW* Pulse Width	80		ns

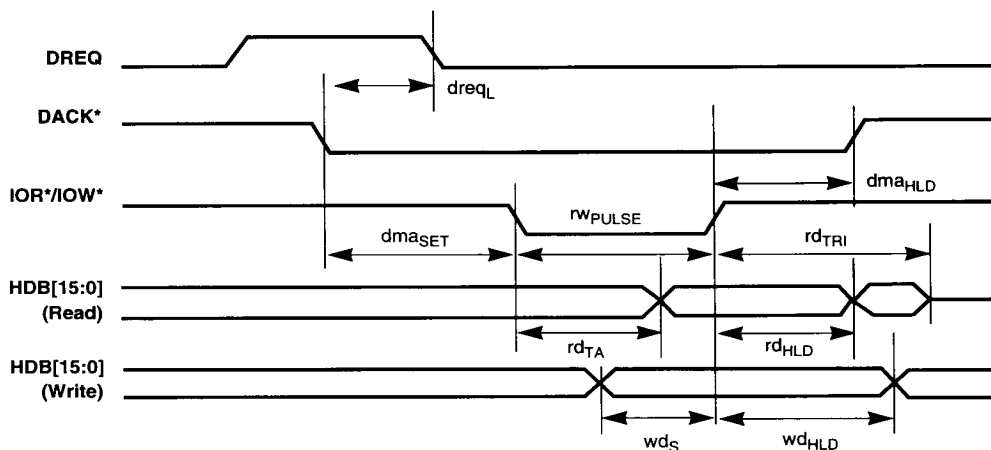

Figure 9–9. Host DMA 8-/16-Bit Interface Timing (Single-Transfer Mode)

Table 9–10. Host DMA 8-/16-Bit Interface Timing Parameters

Symbol	Parameter	MIN	MAX	Units
dreq _L	DREQ Low from IOR*/IOW* Low		60	ns
dma _{SET}	DACK* Low to IOR*/IOW* Low	10		ns
dma _{HLD}	DACK* Hold from IOR*/IOW* High	10		ns
rw _H	IOR*/IOW* High	50		ns
rd _{TA}	IOR* Low to HDB[15:0] Valid		50	ns
rd _{HLD}	IOR* High to HDB[15:0] Invalid	5		ns
rd _{TRI}	IOR* High to HDB[15:0] Tri-state		30	ns
wd _S	HDB[15:0] Set-up to IOW* High	20		ns
wd _{HLD}	HDB[15:0] Hold from IOW* High	10		ns
rw _{PULSE}	IOR*/IOW* Pulse Width	80		ns

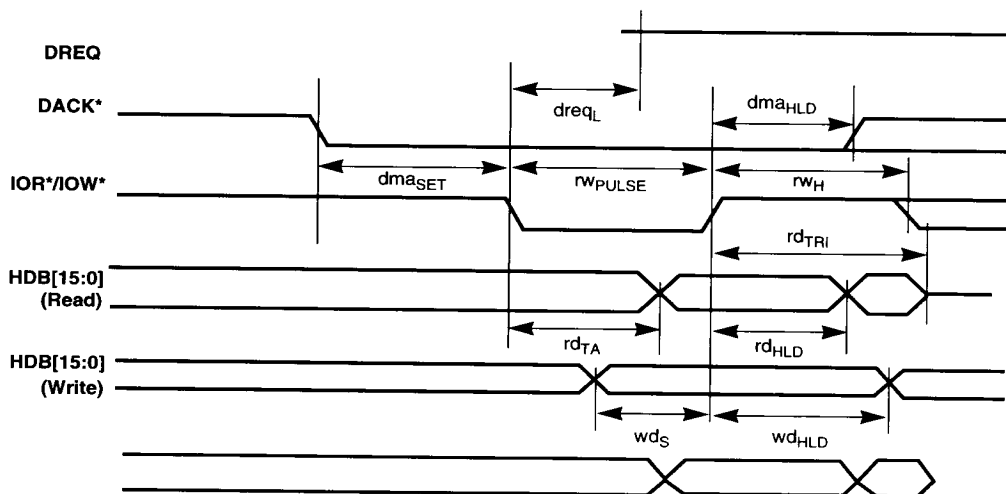
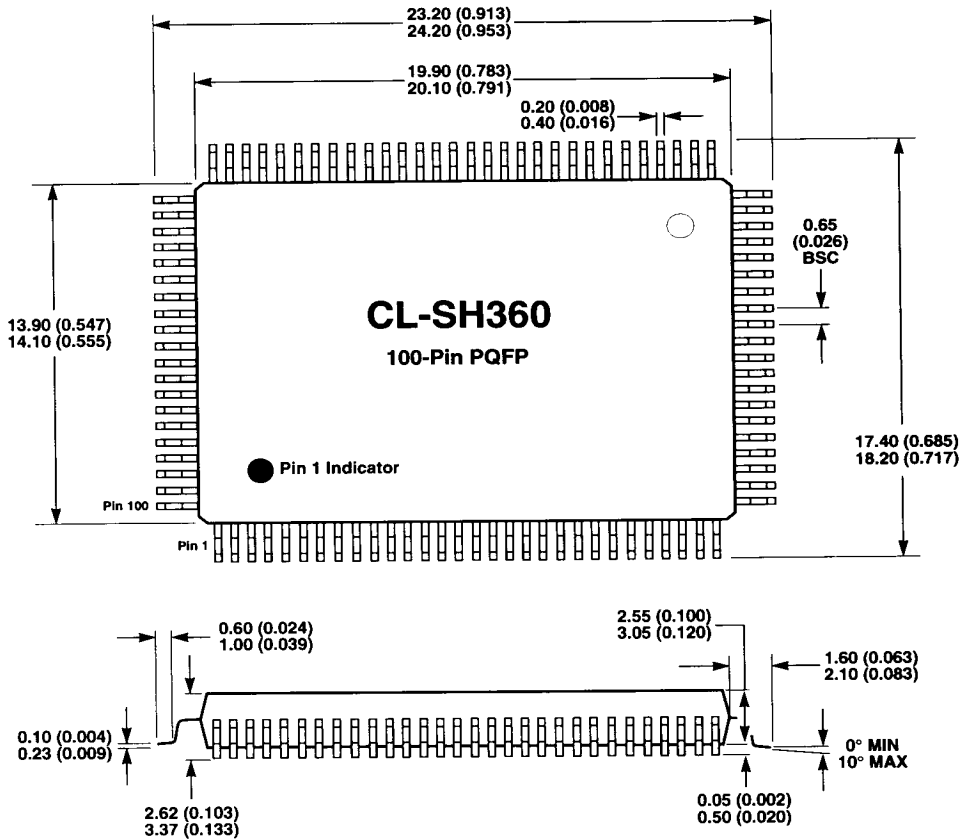


Figure 9–10. Host DMA 8-/16-Bit Interface Timing (Demand Mode)

10. SAMPLE PACKAGE

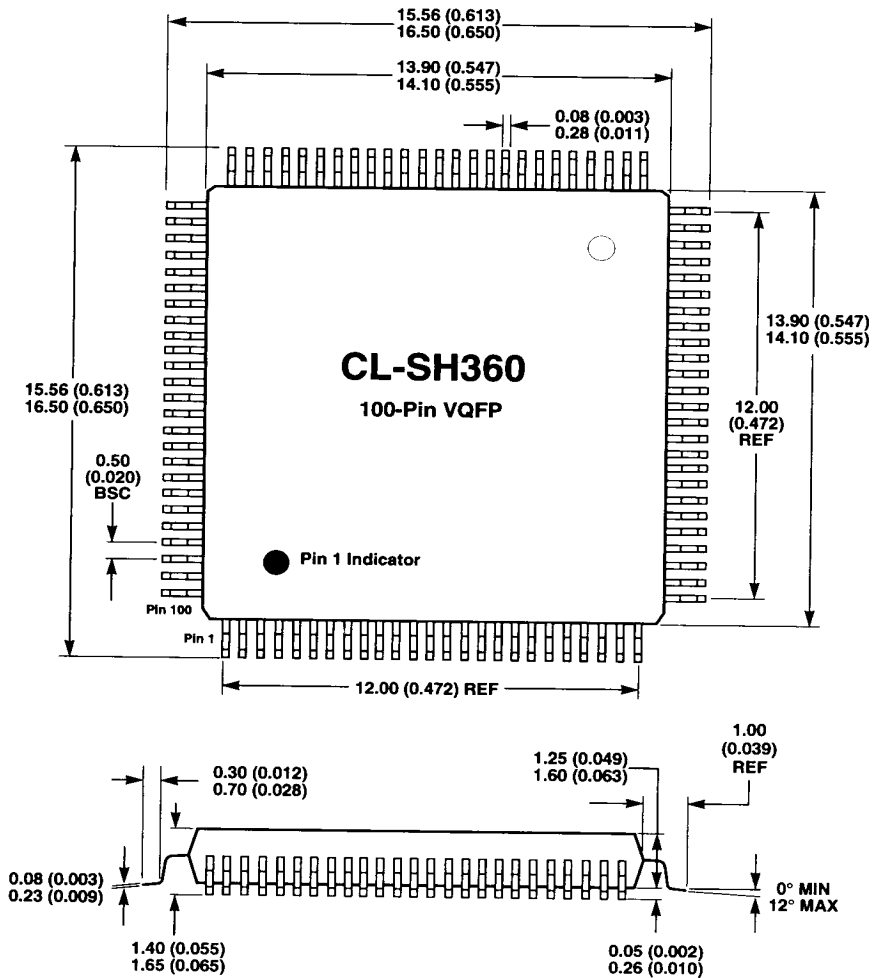
10.1 100-Pin PQFP Package Dimensions



NOTES:

- 1) Dimensions are in millimeters (inches).
- 2) Before beginning any new design with this device, please contact Cirrus Logic for the latest package information.

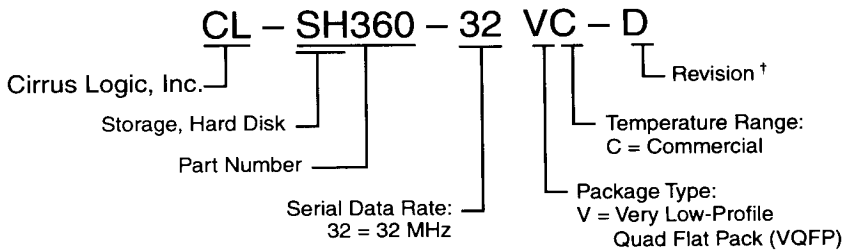
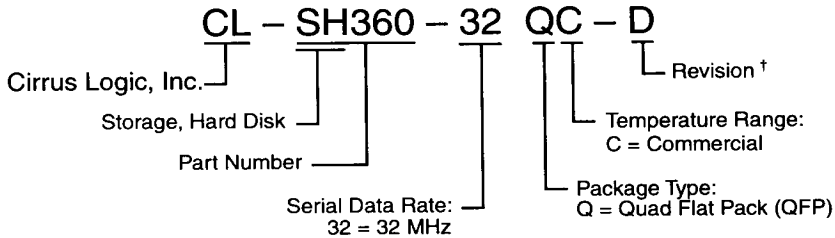
10.2 100-Pin VQFP Package Dimensions



NOTES:

- 1) Dimensions are in millimeters (inches).
- 2) Before beginning any new design with this device, please contact Cirrus Logic for the latest package information.

11. ORDERING INFORMATION



[†] Contact Cirrus Logic, Inc. for up-to-date information on revisions.

NOTE: See Section 5.30, *Register 6FH: Revision Register*.