



# W8811AF/W88112F ATAPI CD-ROM Decoder & Controller

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# W88111AF/W88112F

## ATAPI CD-ROM Decoder & Controller

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### GENERAL DESCRIPTION

The Winbond W88111AF/W88112F supports ATAPI CD-ROM specification (SFF 8020). Some ATAPI operations are executed by hardware to minimize system overhead, including ATAPI command and packet transfer, data transfer, ATAPI Soft Reset command, and Executive Drive Diagnostics command. It also features shadow drive support.

The Winbond W88111AF/W88112F supports various types of microprocessors, DRAMs, and DSPs.

The W88111AF/W88112F supports up to 12/20-fold drive speed. It also supports CD-ROM, CD-ROM/XA, CD-I, Video-CD, Photo-CD, and CD-Plus formats.

The functions of W88111AF/W88112F include CD-ROM data de-scrambling, real-time error correction of Layer 3 Reed-Solomon Product-like Code (RSPC), error detection, and data transfer to the host.

The W88111AF/W88112F features real-time ECC correction of one byte per P-word and Q-word. It can also perform repeated ECC passes to increase the reliability of data.

The W88111AF/W88112F supports up to 1Mbytes of DRAM. It also supports ring-control-register to add flexibility of external RAM control.

The host interface of W88111AF/W88112F supports data transfer using PIO, single word DMA, and multi-word DMA modes. There is an 8-byte FIFO to improve the IDE interface throughput.

The W88111AF/W88112F supports multi-block-transfer from external RAM to the host.

- \* The W88112F supports accelerated error correction/detection to improve system performance.
- \* The W88112F supports automatic target header search, automatic header comparison, and decoder interrupt status collection to reduce firmware overhead.

### W88111AF/W88112F GENERAL FEATURES

- ⇒ Supports ATAPI CD-ROM standard (SFF 8020)
- ⇒ Supports CD-ROM, CD-ROM/XA, CD-I, Video-CD, Photo-CD, and CD-Plus formats
- ⇒ Supports drive speed up to 12-fold
- ⇒ Supports various types of microprocessors and DSPs
- ⇒ Supports various types of industry-standard DRAMs
- ⇒ Supports ring-control-register to add flexibility of DRAM control
- ⇒ Supports CD-ROM data descrambling
- ⇒ Supports real-time correction of one byte error per P-word and Q-word
- ⇒ Supports error detection of CD-ROM data
- ⇒ Supports repeated error correction and error detection passes
- ⇒ 8-byte FIFO to improve IDE interface throughput
- ⇒ Data transfer to host in PIO, single word DMA, and multi-word DMA modes
- ⇒ Multi-block transfer
- ⇒ 100-pin PQFP

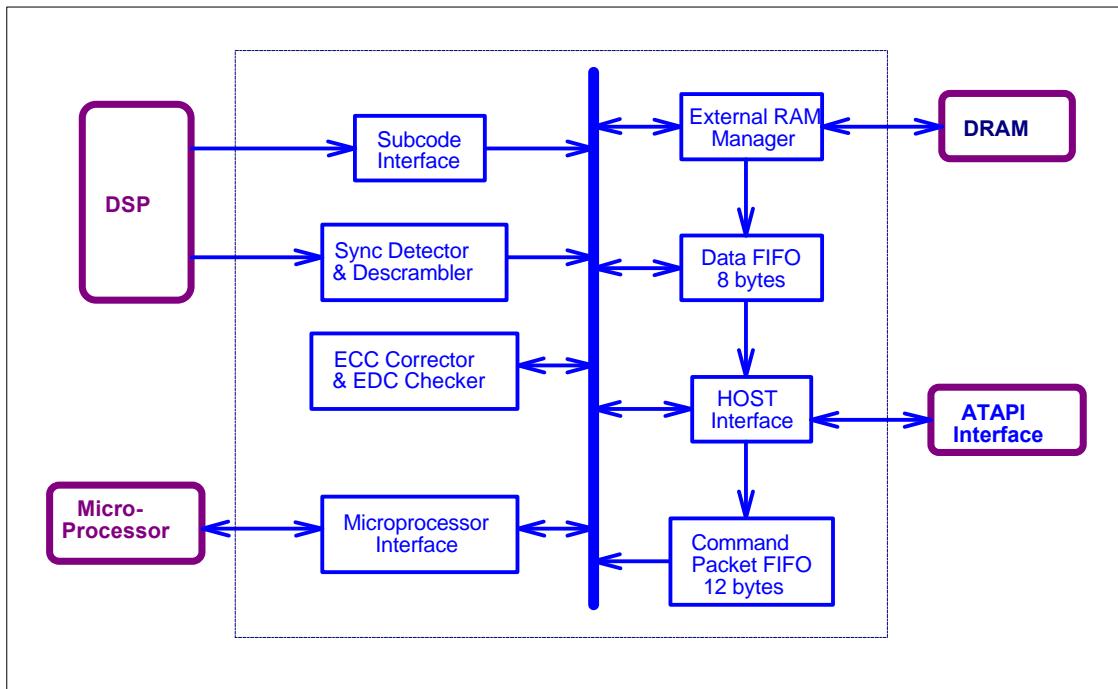
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## W88112F ENHANCED FEATURES

- ⇒ Supports drive speed up to 20-fold with 45ns DRAM
- ⇒ Up to 33% acceleration of error correction/detection
- ⇒ Automatic target header search
- ⇒ Automatic header comparison
- ⇒ Decoder interrupt status collection
- ⇒ Status valid timing control for high drive speed

## BLOCK DIAGRAM



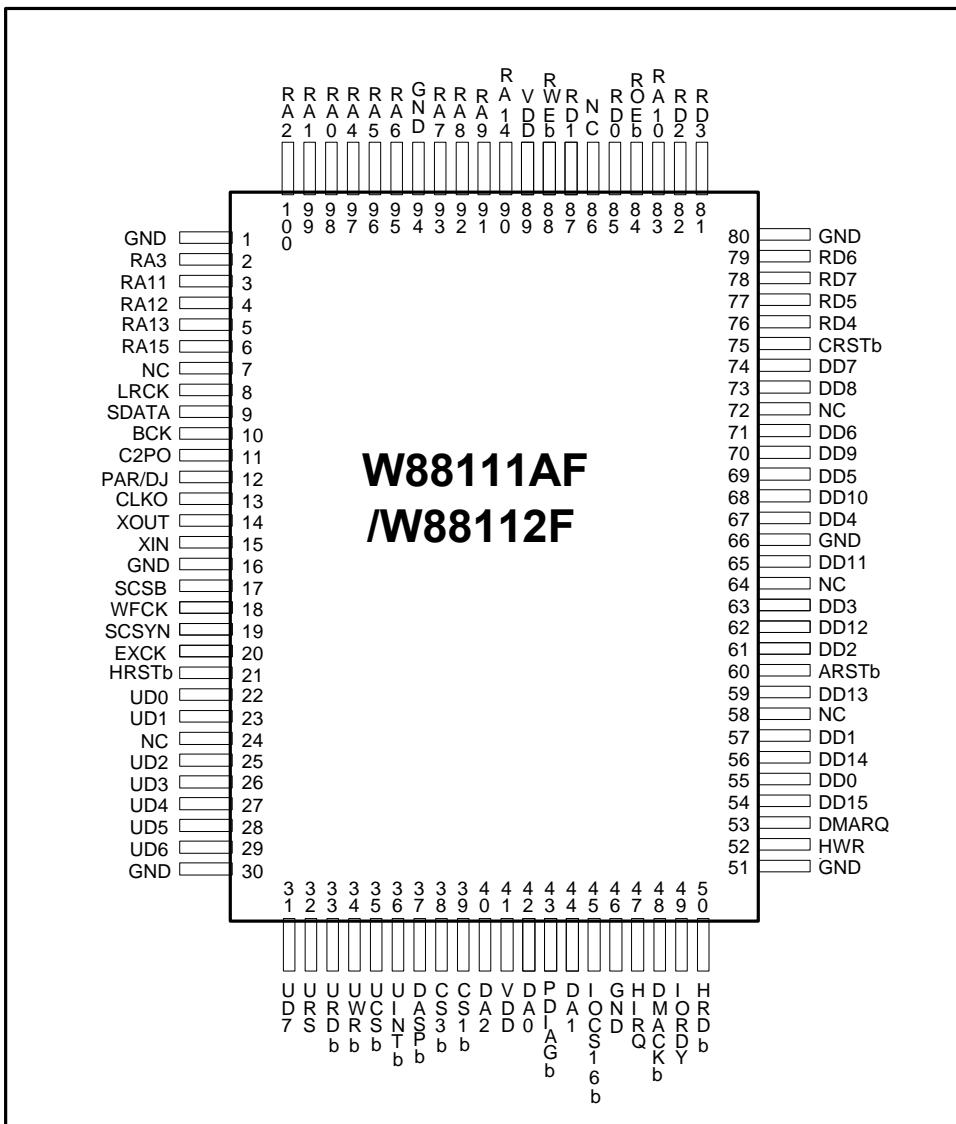


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## PIN CONFIGURATION





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## PIN DESCRIPTIONS

The following convention is used in the pin description table below:

- (I) denotes an input
- (O) denotes an output
- (OZ) denotes a tri-state output
- (OD) denotes an open-drain output
- (I/O) denotes a bi-directional signal

## Miscellaneous Pins

NAME	NO.	TYPE	PIN DESCRIPTION
PAR/PJ	12	I/O	RAM Parity Data/Drive Jumper - As a RAM parity bit when PJSEL (19h.6) is high and as a drive select jumper when PJSEL is low.
CLKO	13	O	Clock Output - If CLKOS (1Ah.3) is low, CLKO pin will supply clock signal of one-half the crystal frequency. If CLKOS is high, CLKO pin will supply normal crystal frequency.
XIN	15	I	Crystal Input/Output - Normally, XIN and XOUT are connected to a crystal.
XOUT	14	O	
HRSTb	21	I	Host Reset - A pin receives reset signal from the host.
ARSTb	60	OD	ATAPI Reset - After receiving an ATAPI Soft Reset command, this pin becomes active-low when ARSTEN (2Fh.3) is enabled.
CRSTb	75	I	Chip Reset - Forcing this input low to reset the whole chip.
VDD	41, 89		Power Supply Pin - 5.0V ± 5%
GND	1, 16, 30, 46, 51, 66, 80, 94		Ground Pin
NC	7, 24, 58, 64, 72, 86		No Connected Pin

## Micro-controller Interface

NAME	NO.	TYPE	PIN DESCRIPTION
UD[7:0]	22, 23, 25, 26, 27, 28, 29, 31	I/OZ	Microprocessor Data Bus - Bi-directional processor data lines.
URS	32	I	Register Select - To select address register or internal register.
URDb	33	I	Microprocessor Read Strobe - A low-active signal.
UWRb	34	I	Microprocessor Write Strobe - A low-active signal.
UCSb	35	I	Microprocessor Chip Select - A low-active signal.



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UINTb	36	OD	Microprocessor Interrupt - A signal can be externally wired-OR with other interrupt sources.
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## Host Interface

NAME	NO.	TYPE	PIN DESCRIPTION
DD[15:0]	54, 56, 59, 62, 65, 68, 70, 73, 74, 71, 69, 67, 63, 61, 57, 55	I/OZ	Host Data Bus - Signals enable data transfer between the host and W88111AF/W88112F.
DA[2:0]	40, 44, 42	I	Host Address Bus - Signals to access various ATAPI registers.
DASPb	37	I/OD	Drive Active/Drive 1 Present - A time-multiplexed signal indicating whether a drive is active, or Drive 1 is present.
CS3b	38	I	Host Chip Select 1 - A signal used to select the host Control Block Registers.
CS1b	39	I	Host Chip Select 0 - A signal used to select the host Command Block Registers.
PDIAGb	43	I/OD	Passed Diagnostics - A signal asserted by Drive 1 to indicate to Drive 0 that diagnostics is completed.
IOCS16b	45	OD	16-bit I/O Select - During PIO transfer, this signal becomes active-high to indicate a 16-bit data transfer.
HIRQ	47	OZ	Host Interrupt - A signal to request an interrupt service from host.
DMACKb	48	I	DMA Acknowledge - A signal used for DMA transfer by the host when DMARQ is ready.
IORDY	49	OZ	I/O Channel Ready - When W88111AF/W88112F is not ready for a data transfer request, this signal is negated for extension of the host data transfer cycle within any host register access.
HRDb	50	I	Host I/O Read - The read strobe signal.
HWRb	52	I	Host I/O Write - The write strobe signal.
DMARQ	53	OZ	DMA Request - A signal asserted for DMA data transfer when W88111AF/W88112F is ready to transfer data to or from the host.

## ATAPI Register Definition

ADDRESSES					FUNCTIONS	
CS1b	CS3b	DA2	DA1	DA0	Read	Write
Control block registers						
N	A	1	1	0	Alternate status	Device control



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Command block registers					
A	N	0	0	0	Data
A	N	0	0	1	ATAPI Error Register
A	N	0	1	0	ATAPI Interrupt Reason Register
A	N	0	1	1	Reserved for SAM TAG Bytes
A	N	1	0	0	ATAPI Byte Count Register (bits 0-7)
A	N	1	0	1	ATAPI Byte Count Register (bits 8-15)
A	N	1	1	0	Drive Select
A	N	1	1	1	ATAPI Status
					ATA Command

Note : A = signal asserted, N = signal negated

## DSP Interface

NAME	NO.	TYPE	PIN DESCRIPTION
LRCK	8	I	L/R Channel Clock - Left and right channels are distinguished by this signal.
SDATA	9	I	Serial Data - Serial data from DSP is received from this input.
BCK	10	I	Bit Clock - Bit clock from DSP is received from this input.
C2PO	11	I	C2 Pointer - C2 error flag from DSP is received from this input.

## Subcode Interface

NAME	NO.	TYPE	PIN DESCRIPTION
SCSD	17	I	Subcode Serial Data - Subcode serial data from DSP is received from this input.
WFCK	18	I	Write Frame Clock - Write frame clock from DSP is received from this input.
SCSYN	19	I	Subcode Sync - Subcode sync from DSP is received from this input.
EXCK	20	I/O	External Clock - A pin programmed as input or output to supply bit clock for subcode.

## External RAM Interface

NAME	NO.	TYPE	PIN DESCRIPTION
ROEb	84	O	External RAM Output Enable - External RAM read strobe.
RWEb	88	O	External RAM Write Enable - External RAM write strobe.



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RD[7:0]	78, 79, 77, 76, 81, 82, 87, 85	I/O	RAM Data Bus - Data bus for external RAM.
RA[9:0]	91, 92, 93, 95, 96, 97, 2, 100, 99, 98	O	RAM Address Bus - Address bus for external RAM.
RA[13:10]	5, 4, 3, 83	O	External RAM Column Address Strobe - External RAM column address strobe.
RA[15:14]	6, 90	O	External RAM Row Address Strobe - External RAM row address strobe.

### REGISTERS DESCRIPTION

#### IR - Index Register (read/write)

When URS(pin 32) is low, the Index Register can be accessed by the microprocessor. The value in IR specifies which internal register to be accessed by microprocessor when URS(pin 32) is high. Note that the 4 least significant bits of IR will increase following each read or write to any register except for PFAR(00h). Since IR does not automatically increase from 00h to 01h, consecutive reads to address 00h will repeatedly read register PFAR(00h). This feature accelerates read operation of ATAPI Command Packet.

#### PFAR - Packet FIFO Access Register - (read 00h)

While SCoD(20h.2) is high, the ATAPI Command Packet issued from host is received by the 12-byte Packet FIFO. Flag TENDb(01h.6) is used to check if the Packet FIFO is full. The microprocessor can read the ATAPI Command Packet by repeatedly read register PFAR(00h). Once the FIFO becomes empty, the value FFh will be returned if microprocessor read PFAR.

The Packet FIFO can also be used to receive command parameter less than 12 bytes. First, the control bit SCoD(20h.2) is set high to select the Packet FIFO to be addressed by the ATAPI Data port. When DRQ(37h.3) changes from 0 to 1, the lower 4 bits of ATBLO(34h) is latched as the FIFO threshold. Upon the number of bytes in the FIFO reaches the threshold, flag TENDb(01h.6) becomes active-low and flag FPKT(30h.1) becomes active-high. Once FPKT becomes high, any data writes to the ATAPI Data port is rejected.

#### INTCTL - Interrupt Control Register - (write 01h)

##### Bit 7: PFNEEN - Packet FIFO Not Empty Interrupt Enable

UINTb(pin 36) is activated when PFNEb(01h.7) becomes active-low if this bit is high.

##### Bit 6: TENDEN - Transfer End Interrupt Enable

UINTb(pin36) is activated when TENDb(01h.6) becomes active-low if this bit is high. TENDEN is also automatically enabled if the host issues the Packet Command(A0h) while HIIEN(2Eh.7) is high and drive is selected.

##### Bit 5: SRIEN - Sector Ready Interrupt Enable

UINTb(pin36) is activated when SRLb(01h.5) becomes active-low if this bit is high.

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## Bits 4, 3, 2: Reserved

### Bit 1: DTEN - Data Transfer Enable

Set DTEN high enables the data transfer logic. This bit should be set before any of the following data transfers is triggered:

- Host write to the Packet FIFO
- Host read from external RAM
- Host read from DF0 to DF7

In order to reduce the interference of microprocessor, DTEN is also automatically enabled during the following operation:

- Trigger ADTT(17h.2)
- Host issues ATAPI Packet Command(A0h) while APKTEN(18h.7) is enabled and drive is selected

## Bit 0: Reserved

## INTREA - Interrupt Reason Register - (read 01h)

### Bit 7: PFNEb - Packet FIFO Not Empty Interrupt Flag

This bit becomes active-low after Packet FIFO receives any data issued by the host through ATAPI Data port. UINTb(pin 36) is activated when PFNEb becomes active-low if PFNEEN(01h.7) is enabled. PFNEb is deactivated after the last byte is read by microprocessor through register PFAR(00h).

### Bit 6: TENDb - Transfer End Interrupt Flag

This bit becomes active-low at the end of the following data transfers:

- Host writes to the Packet FIFO
- Host read from external RAM
- Host read from registers DF0(40h) to DF7(47h)

Flags TDIR(30h.5) and FPKT(30h.1) can be used to determine which type of transfer end occurs. UINTb(pin36) is activated when TENDb becomes active-low if TENDEN(01h.6) is enabled. Writing any value to register TACK(07h) deactivates this flag.

### Bit 5: SRIb - Sector Ready Interrupt Flag

This bit is used to indicate that one sector is ready to be accessed. Reading register STAT3(0Fh) deactivates SRIb.

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### **Bit 4: HCIb - Host Command Interrupt Flag**

This bit is activated by the following events:

- Host issues ATAPI Soft Reset Command, if ARSTIEN(2Fh.1) is enabled
- Host issues command to a non-exist slave drive, if SHIEN(2Eh.2) is enabled
- Host issues Execute Drive Diagnostics Command, if HIIEN(2Eh.7) is enabled
- ATAC(2Fh.6) becomes active-high, if HIIEN(2Eh.7) is enabled
- Host set bit SRST in ATAPI Device Control Register, if HIIEN(2Eh.7) is enabled

### **Bit 3: TBSYb - Transfer Busy Flag**

This bit becomes active-low when the data transfer to host is triggered by the following events:

- Writing any value to register THTRG(06h)
- Setting bit ADTT(17h.2) high

After host reads the last byte to be transferred, TBSYb is deactivated.

### **Bit 2: MBTIb - Multi-Block Transfer Interrupt Flag**

This bit is activated by the following events:

- RPINT(30h.3) becomes active-high while RPIEN(2Ah.5) is enabled
- MBTI(30h.4) becomes active-high while MBKIEN(13h.2) is enabled

The microprocessor can read register MISS2(30h) to tell which event occurs.

### **Bit 1: DFRDYb - Data FIFO Ready**

After data transfer is triggered, the 8-byte Data FIFO is automatically filled. This bit is used to indicate that the Data FIFO is ready to be read by the host.

### **Bit 0: SCIb - Subcode Interrupt Flag**

If SCIEN(2Ch.4) is enabled, this bit becomes active-low when one of the following events occurs:

- ISS(22h.0) becomes active-high
- NESBK(22h.1) becomes active-high
- MSS(22h.2) becomes active-high

When Subcode Interrupt is activated, the microprocessor can read register SUBSTA(22h) to determine the reason of interrupt. Writing register SCIACK(22h) deactivates Subcode Interrupt.

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### **TBCL/TBCH - Transfer Byte/Word Counter - (read/write 02h/03h)**

Before triggering data transfer, the number of bytes or words to be transferred should be set through 12-bit Transfer Byte/Word Counter. The number of **bytes** minus 1 should be written to this counter while using 8-bit data transfer. The number of **words** minus 1 should be written to this counter while using 16-bit data transfer. After host reads one byte or word, the counter is decreased by one till Transfer End Interrupt is activated when this counter becomes zero.

### **TACL/TACH - Transfer Address Counter - (write 04h/05h)**

Before triggering data transfer, the external RAM address of data to be transferred should be set through 16-bit Transfer Address Counter. This number in this counter specifies the first available data address relative to the beginning of the block. The block number should also be specified through Transfer Block registers TBL/TBH(24h/25h). After one byte/word is read by host, TACL/TACH are increased to the next available data address.

### **TBL/TBH - Transfer Block Register - (read/write 24h/25h)**

Before triggering data transfer, the external RAM block of data to be transferred should be set through Transfer Block Registers. TBL/TBH form a 9-bit register that is used to specify the first RAM block to be transferred, while TACL/TACH(04h/ 05h) specify the starting address relative to the beginning of this RAM block. The RAM block number in TBL/TBH is not increased automatically at the end of each transfer unless multi-block transfer is used by specifying register MBTC0(12h).

### **THTRG - Transfer to Host Trigger Register - (write 06h)**

This register is used to trigger data transfer regardless of what value is written.

When bit UDTs(1Fh.6) is low, the data transfer from external RAM to the host after THTRG is triggered. Triggering THTRG automatically fills the Data FIFO and then flag DFRDYb(01h.1) becomes active-low when the Data FIFO becomes ready.

When bit UDTs(1Fh.6) is high, the path of data transfer is from registers DF0-DF7(40h-47h) to the host. In this case, the data count, less than 8, should be set using registers TBCL(02h) before triggering THTRG and bit UDTT(1Fh.7) should be set to 1 followed by 0 after triggering THTRG.

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### **TACK - Transfer Acknowledge - (write 07h)**

Writing register TACK deactivates TENDb(01h.6) and its corresponding microprocessor interrupt regardless of what data is written.

### **HEAD0 to HEAD3 - Header Registers - (read 03h to 07h)**

These four registers are used to hold the information of Header Bytes of each sector. Header Registers should be read soon after STAVAb(0F.7) becomes active-low. Note that the header bytes are untrustful if wrong mode is set while ECC is enabled. If the bit SHDEN(0Bh.0) is enabled, registers HEAD0-3 are used to hold subheader bytes instead.

### **BIAL/BIAH - Buffering Initial Address Register - (write 08h/09h)**

Before enabling the external RAM buffering, BIAL/BIAH should be set to control the location of the first byte follows data sync for each data sector. The RAM block for buffering is controlled by the number in registers DDBL/DDBH(28h/29h) plus one. For convenience of following data transfer, the microprocessor should set proper value to BIAH/BIAL(FF,F0h for mode-1 and FF,E8h for mode-2) after the mode is determined so that the first user data byte will locate at offset 00h of each data block.

### **BACL, BACH - Buffering Address Counter - (read 0Ah/0Bh)**

After enabling the external RAM buffering, Buffering Write Counter are automatically increased by two, beginning from the value specified by BIAL/BIAH, every time a data word is buffered.

### **EIAL/EIAH - ECC Initial Address Register- (read 08h/09h, write 0Ch/0Dh)**

EIAL/EIAH are used to hold the initial address offset of the data block to be corrected. The content of BIAL/BIAH(08h/09h) will be automatically loaded to EIAL/EIAH at the beginning of each data sync, making it unnecessary to read or write EIAL/EIAH during normal operation. The RAM block for ECC is controlled by the number in registers DDBL/DDBH(28h/29h).

**SCBL/SCBH - Subcode Block Register - (read/write 26h/27h)**

SCBL/SCBH form a 9-bit register that contains a block number of the latest available subcode data that can be read by the host. The number in SCBL/SCBH plus 1 points to the RAM block that is buffering incoming subcode. The number in SCBL/SCBH is increased by one at the end of subcode block buffering.

**DDBL/DDBH - Decoded Data Block Register - (read/write 28h/29h)**

DDBL/DDBH form a 9-bit register that contains the number of the latest available decoded data block after decoder interrupt occurs. This block number should be used to specify TBL/TBH(24h/25h) before triggering data transfer to the host. This decoded-data-block-number plus 1 points to the DRAM block that is buffering incoming serial data and increases by one at the end of each data block buffering.

**CTRL0 - Control Register 0 - (write 0Ah)****Bit 7: DECEN - Decoding Logic Enable**

Setting this bit high enables the decoding logic.

**Bit 5: EDCEN - Error Detect and Correct Enable**

Setting this bit high enables the ECC and EDC logic.

**Bit 4: ACEN - Automatic Correction Enable**

When this bit is set high during MODE 2 ECC, the type of error correction is automatically determined by the setting of the FORM bit in the subheader byte. When this bit is low during MODE 2 ECC, the type of error correction is controlled by F2RQ(0Bh.2).

**Bit 2: BUFEN - Buffering Enable**

Setting this bit high enables incoming DSP data buffering. When this bit is high, the values of register HEAD0-3(04h-07h) and SUBH0-3(14h-17h) are retrieved from external RAM rather than from incoming serial data. When BUFEN is low, any setting of QCEN or PCEN is meaningless.

**Bit 1: QCEN - Q-codeword Correction Enable**

When this bit is high, Q-codeword RSPC correction logic is enabled.

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### **Bit 0: PCEN - P-codeword Correction Enable**

When this bit is high, P-codeword RSPC correction logic is enabled.

### **Bit 6,3: Reserved**

DECEN 0Ah.7	BUFEN 0Ah.2	EDCEN 0Ah.5	QCEN 0Ah.1	PCEN 0Ah.0	Decoder Mode	Operation Flow
1	1	1	1	1	Q-P correction	$Q \rightarrow P \rightarrow CRC$
1	1	1	1	0	Q-correction	$Q \rightarrow CRC$
1	1	1	0	1	P-correction	$P \rightarrow CRC$
1	1	1	0	0	Write-only	CRC
1	0	0	0	0	Disk-monitor	no buffering
0	X	X	X	X	Decoder disable	no operation

## **CTRL1 - Control Register 1 - (write 0Bh)**

### **Bit 7: SIEN - Sync Insertion Enable**

When this bit is high, the sector boundary is determined by internal sync insertion logic.

### **Bit 6: SDEN - Sync Detection Enable**

When this bit is high, the sector boundary is determined by incoming serial data.

### **Bit 5: DSCREN - Descrambler Enable**

Setting this bit high enables the descrambling logic.

### **Bit 4: CWEN - Corrected Data Write Enable**

Setting this bit high enables corrected data to be written to the external RAM.

### **Bit 3: M2RQ - Mode 2 ECC Request**

Setting this bit high enables the mode 2 ECC correction logic. Mode 1 ECC correction will be performed if this bit is low.

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### **Bit 2: F2RQ - Form 2 Request**

Setting this bit high requests the data to be processed by the mode-2 form-2 format if M2RQ(0Bh.3) is high.

### **Bit 1: MCRQ - Mode Byte Check Request**

When this bit is high, ECC logic will check the 4th header byte with the setting of M2RQ(0Bh.3) to determine if ECC correction needs to be performed.

### **Bit 0: SHDEN - Subheader Switch Enable**

When this bit is high, registers HEAD0-3 are used to provide subheader bytes.

## **STAT0 - Status Register 0 - (read 0Ch)**

### **Bit 7: CRCOK - Cyclic Redundancy Check OK**

This bit is used to indicate whether the Cyclic Redundancy Check of the latest available sector is passed.

### **Bit 6: ILSYN - Illegal Sync Pattern**

If SDEN(0Bh.6) is high, this bit becomes high when a sync pattern is detected less than 2352 bytes after last sync pattern was detected/inserted.

### **Bit 5: NOSYN - No Sync Pattern**

If SIEN(0Bh.7) is high, this bit becomes high when a sync pattern is not detected at 2352 bytes after last sync pattern was detected/inserted.

### **Bit 4: LBKF - Long Block Flag**

If SIEN(0Bh.7) is low, this bit becomes high when a sync pattern is not detected at 2352 bytes after last sync pattern was detected/inserted.

### **Bit 3: WSHORT - Word Short**

This bit becomes high when the incoming serial data rate is too high to be processed by W88111AF/W88112F.

### **Bit 2: SBKF - Short Block Flag**

If SDEN(0Bh.6) is low, this bit becomes high when a sync pattern is detected less than 2352 bytes after last sync pattern was detected/inserted.

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Status Flag	SIEN (0Bh.7)	SDEN (0Bh.6)	Internal Operation
ILSYN(0Ch.6)	x	1	re-synchronize internal sync logic
NOSYN(0Ch.5)	1	x	internal sync logic provide internal sector boundary
LBKF(0Ch.4)	0	x	internal sync logic do not provide internal sector boundary
SBKF(0Ch.2)	x	0	do not re-synchronize internal sync logic

### **Bit 1: FDIF - Fast Decoder Interrupt Flag**

If FDIEN(10h.3) is enabled, this bit becomes high when the Header/Subheader bytes are ready after ECC is complete and before CRC is complete. Meanwhile, UINTb(pin 36) and STAVAb(0Fh.7) become active-low thus accelerate the following microprocessor operations. FDIF is deactivated when CRC is complete. UINTb(pin 36) also becomes low-active when CRC is complete. So if FDIEN(10h.3) is enabled, CRCVAb(10h.7) should be used to determine whether the CRCOK(0Ch.7) is available when interrupt becomes active.

### **Bit 0: UEBK - Incorrectable Errors in Block**

This bit is used to indicate that at least one data is corrected in the latest available data block.

### **STAT1 - Status Register 1 - (read 0Dh)**

#### **Bit 4: HDERA - Header Erasure**

This bit is high if there is at least one erasure flag detected in header bytes excluding mode byte. Erasure in mode byte will cause RMOD3-0(0Eh.7-4) all become high.

#### **Bit 0: SHDERA - Subheader Erasure**

This bit is high if erasure flags are detected for both bytes in at least one subheader byte-pairs.

Erasures are latched from pin C2PO if BUFEN(0Ah.2) is disabled. Otherwise, header and subheader bytes are retrieved from external RAM while the following sector is being buffered.

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### **DHTACK - DRAM to Host Transfer Acknowledge - (write 0Eh)**

Writing DHTACK, regardless of what data is written, deactivates TENDb(0Eh.6) caused by data-transfer-end from external RAM to the host.

### **STAT2 - Status Register 2 - (read 0Eh)**

#### **Bit 7-4: RMOD[3:0] - Raw Mode Bit**

RMOD[2:0] are directly latched from bit 2-0 from the 4th header byte and RMOD3 is high if any one of the other 5 bits in the mode byte is high. RMOD3 is also high if a mode byte erasure is detected.

#### **Bit 3: MODE2 - Mode 2 Selected Flag**

This bit reflects the setting of M2RQ(0Bh.3).

#### **Bit 2: NOCOR - No Correction**

If ECC logic is enabled by bit EDCEN(0Ah.5), and QCEN(0Ah.1) or PCEN(0Ah.0), this bit becomes high if ECC logic is interrupted the followings:

- CWEN(0Bh.4) is disabled.
- Mode mismatch is detected while MCRQ(0Bh.1) is enabled.
- Mode erasure is detected while MCRQ(0Bh.1) is enabled. A mode erasure occurs if the incoming C2PO flag is set for the fourth header byte, indicating unreliable mode data.
- Form 2 enabled while ECC logic is set to mode 2. Form 2 blocks should not be corrected. Form 2 can be enabled by control bit F2RQ(0Bh.2), or by the Form bit in the Subheader byte if ACEN(0Ah.4) is enabled.
- Form bit erasure while ECC logic is set to mode 2 and ACEN is enabled. A form bit erasure is detected if the incoming C2PO flags are set for both Form bits in the Subheader bytes.
- ILSYN(0Ch.6) becomes high while SDEN(0Bh.6) is enabled.

#### **Bit 1: RFERA - Raw Form Erasure**

This bit becomes high when a form bit erasure was detected. A form bit erasure is detected if the incoming C2PO flags are set for both Form bits in the Submode bytes(bit 5 in byte 18 and 22). RFERA becomes valid when SRIb(01h.5) becomes active-low, and remains valid until the next block sync.

#### **Bit 0: RFORM - Raw Form Bit**

This bit is high if the Form bit is high in the Submode bytes of the incoming serial data. RFORM becomes valid when flag SRIb(01h.5) becomes active-low, and remains valid until the next block sync.

**FRST - Firmware Reset Register - (write 0Fh)**

Writing register FRST, regardless of what value is written, reset most of the W88111AF/W88112F logic except the followings:

- Register CCTL1 (1Ah) and output pin CLKO
- Register DSPSL (1Bh)
- Register HICL1 (20h)
- Register SICL0 (21h)
- Register RAMCF (2Ah)
- Register MEMCF (2Bh)
- Register SICL1 (2Ch)
- Register MISCO (2Eh)
- Register MISS1 (2Fh)
- Register MISCI (2Fh.7-5,3-0)
- Bit DRV in the ATAPI Drive Select Register
- Bits SRST and nIEN in the ATAPI Device Control Register

Flag FRST (2Fh.1) is set by firmware reset.

**STAT3 - Status Register 3 - (read 0Fh)****Bit 7: STAVAb - Valid Status Valid**

This bit is used to indicate that the header, pointer, and status registers about decoder logic are available.

**Bit 5: ECF - Error Corrected Flag**

This bit is used to indicate that there is at least one byte was corrected in the latest available block.

**Bit 4: EINC - ECC Incomplete Flag**

If EINCEN (10h.1) is enabled, EINC becomes high when correction of the following block is triggered before that of the previous block is complete. SRlb(01h.5) becomes active-low when EINC becomes high if EINCEN is enabled.

**Bit 1: C2DF - C2 Detected in Block Flag**

If C2WEN (10h.2) is high, C2DF becomes high when there is at least one C2PO flag was detected in the previous block.

**Bit 6,3,2,0: Reserved****CTRLW - Control-Write Register - (write 10h)****Bit 7: Define 0****Bit 6: SWEN - Synchronized Write Enable**

If this bit is high, the change of BUFEN (0Ah.2) will be synchronized to the end of next sector sync. The buffering of C2PO flags is also controlled by SWEN if C2WEN (10h.2) and BUFEN (0AH.2) are both enabled.

**Bit 5: SDSS - Subcode and DSP Sync Synchronization**

This bit provides synchronization of CD-DA format data. If this bit is high, the writing of incoming serial data to the external RAM will start at the first left-channel lower-byte following the end of subcode block.

**Bit 4: DCKEN - DSP Clock Enable**

If this bit is high, clock from DSP is used by internal decoder logic. DCKEN should be set high before DECEN (0Ah.7) is set high.

**Bit 3: FDIEN - Fast Decoder Interrupt Enable**

If FDIEN (10h.3) is set high, the following events occur when the Header/Subheader bytes are ready after ECC is complete and before CRC is complete:

- FDIF (0Ch.1)  $\leftarrow 1$
- STAVAb (0Fh.7)  $\leftarrow 0$
- SRlb (01h.5)  $\leftarrow 0$

Read register STAT3 (0Fh) de-activates the above SRlb(01h.5) to 1.

If FDIEN (10h.3) is set high, the following events occur when CRC is complete:

- FDIF (0Ch.1)  $\leftarrow 0$
- CRCVAb (10h.7)  $\leftarrow 0$
- SRlb (01h.5)  $\leftarrow 0$
- CRCOK (0Ch.7) becomes available

Read register STAT4 (10h) de-activates the above SRlb to 1.

SRlb(01h.5) becomes active-low upon fast interrupt and CRC ends if FDIEN is enabled. CRCVAb should be used to determine whether CRCOK is ready when SRlb becomes active-low.

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### **Bit 2: C2WEN - C2 Flag Write Enable**

If this bit is set high and BUFEN (0Ah.2) is high, the C2 flags of incoming serial data will be latched into the external RAM. This operation is synchronized to the end of sync if SWEN (10h.6) is high.

### **Bit 1: DRST - Decoder Reset**

Setting this bit high resets decoding logic. DRST is automatically cleared by itself.

### **Bit 0: EINCEN - ECC Incomplete Interrupt Enable**

If this bit is set high, EINC (0Fh.4) becomes high when correction of the following block is triggered before the correction of the previous block is complete.

## **STAT4 - Status Register 4 - (read 10h)**

### **Bit 7: CRCVAb - CRC Valid**

If FDIEN (10h.3) is enabled, CRCVAb becomes active-low when CRC is complete. Reading this register deactivates SRIb(01h.5) caused by completion of CRC if FDIEN is enabled.

### **Bit 6-0: Reserved**

## **CRTRG - Correction Retry Trigger - (write 11h)**

Writing register CRTRG, regardless of what data is written, triggers the decoding logic to perform another correction sequence to the same block.

### **Bit 7-1: Reserved**

### **Bit 0: CRRL - Correction Retry Register Load**

Setting this bit high while writing register CRTRG (11h) re-loads the setting of EDCEN (0Ah.5), QCEN (0Ah.1), or PCEN (0Ah.0) to decoding logic.

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Decoder Parameter	Updated at the end of sync	Updated by writing CRRL
EDCEN (0Ah.5)	yes	yes
QCEN (0Ah.1)	yes	yes
PCEN (0Ah.0)	yes	yes
ACEN (0Ah.4)	yes	no
BUFEN (0Ah.2)	yes	no
M2RQ (0Bh.3)	yes	no
F2RQ (0Bh.2)	yes	no
MCRQ (0Bh.1)	yes	no
FDIEN (10h.3)	yes	no

### MBTC0 - Multi-Block Transfer Control 0 - (read/write 12h)

This register is available for W88111AF only to specify the behavior of multi-block transfer logic. The host interface supports multi-block transfer without microprocessor intervention by following sequence:

- MBC[4:0] ← the number of block to be transferred minus 1 (ex. 3)
- TBCL (02h), TBCH (03h) ← the number of bytes/words to be transferred in each block minus 1 (ex. 1175)
- TACL (04h), TACH (05h) ← the starting point of the block (ex. F4h, FFh)
- TBL (24h), TBH (25h) ← the RAM block number of the first block to be transferred (ex. 5)
- ATBLO (34h), ATBLH (35h) ← the total bytes to be transferred (ex. 9408)
- ADTT (17h.4) ← 1

PS: STBCEN (18h.3) should not be set in multi-block transfer operation.

When ADTT is set, host will receive HIRQ, check status, and then start to read data.

After the last bytes/words of one block (except the last one) is read by the host, the following hardware sequence is executed:

- TBCL (02h), TBCH (03h) ← reload
- TACL (04h), TACH (05h) ← reload
- TBL (24h), TBH (25h) ← auto-increment
- MBC[4:0] ← auto-decrement

TENDb only becomes active at the end of data transfer of the last block.

### Bit 7: MBVAb - Multi-Block Counter Valid Flag

This bit is used to indicate that Multi-Block Counter MBC[4:0] is stable enough to be monitored by microprocessor.

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**Bit 6: MBINC - Multi-Block Increment Flag**

This bit becomes active-high if microprocessor sets INCMBC (13h.0) and multi-block number increment has not completed.

**Bit 4-0: MBC[4:0] - Multi-Block Counter**

Before triggering multi-block transfer, the number of blocks to be transferred minus 1 should be written to MBC[4:0]. Single block transfer is performed if MBC[4:0] is zero.

**MBTC1 - Multi-Block Transfer Control 1 - (read/write 13h)****Bit 7-3: Reserved****Bit 2: MBTIEN - Multi-Block Transfer Interrupt Enable**

If MBTIEN and MBTFEN are both enabled, UINTb will activate at the end of data transfer of each block if the block count in MBC[4:0] is not zero.

**Bit 1: MBTFEN - Multi-Block Transfer Interrupt Flag Enable**

If this bit is high, MBTI (30h.4) will be activated at the end of data transfer of each block if the block count in MBC[4:0] is not zero.

**Bit 0: INCMBC - Increment Multi-Block Counter**

Setting this bit high increases Multi-Block Counter MBC[4:0] by one. This function is useful in data transfer to host by DMA mode. Because data count is not specified in DMA mode transfer, the number of block to be transferred can be increased when a new block becomes available before the transfer is completed.

**ECTRL - Enhanced Control Register - (write 14h)****Bit 7-2: Reserved****Bit 1: IR7F - Provide Flag UTYB at IR7**

When this bit is high, flag UTYB (1Fh.7) can be monitored by read bit-7 of the Index Register.

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### Bit 0: DISAI - Disable Auto-Increment

When this bit is high, the automatic increment of the RACU/RACH/RACL address counter is disabled. Note that DISAI should be 0 before RFTRG (2Ah.6) is triggered.

### SUBH0 to SUBH3 - Subheader Registers - (read 14h to 17h)

These registers are used to hold the information of subheader bytes. If BUFEN(0Ah.2) is disabled, subheader bytes are latched from incoming serial data. If BUFEN(0Ah.2) is enabled, subheader bytes are retrieved from the external RAM.

### ASTRG - Automatic Sequence Trigger Register (write 17h)

The following bits will clear themselves after the triggered operation is completed.

#### Bit 7: Reserved

#### Bit 6: CSRT - Clear Soft Reset Trigger

Setting this bit high clears bit SRST in the ATAPI Device Control Register.

#### Bit 5: DSCT - Disk Seek Complete Trigger

If ABYEN (18h.1) is high, setting DSCT high triggers the following operations:

- Set BSY
- DSC (37h.4)  $\leftarrow$  1
- Clear BSY

If ABYEN (18h.1) is low, setting DSCT high sets DSC(37h.4) to 1.

#### Bit 4: SIGT - ATAPI Signature Trigger

Setting this bit high initializes the Task Registers with ATAPI signature.

- ATFEA (31h)  $\leftarrow$  00h
- ATERR (31h)  $\leftarrow$  01h
- ATINT (32h)  $\leftarrow$  01h
- ATSPA (33h)  $\leftarrow$  01h
- ATBLO (34h)  $\leftarrow$  14h
- ATBHI (35h)  $\leftarrow$  EBh
- ATSTA (37h)  $\leftarrow$  00h

Note that register ATDRS (36h) is not cleared by triggering SIGT to abide by the ATAPI protocol.

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### **Bit 3: CPFT - Clear Packet FIFO Trigger**

Setting this bit high clears the Packet FIFO.

### **Bit 2: ADTT - Automatic Data Transfer Trigger**

If PIO (1Fh.2) is high, setting ADTT high triggers the following PIO Data Transfer sequence:

- Set BSY
- DTEN (01h.2)  $\leftarrow 1$
- SCoD (20h.2)  $\leftarrow 0$
- ATINT (32h)  $\leftarrow 02h$
- If STBCEN (18h.3) is enabled, then ATBLO/ATBHI  $\leftarrow (TBCL,H+1) \times 2$

The data transfer logic will start to fill the Data FIFO automatically. The following sequence will be executed when DFRDYb (01h.1) become active-low:

- DRQ (37h.3)  $\leftarrow 1$
- Clear BSY
- HIRQ (2Eh.3)  $\leftarrow 1$

After detecting the interrupt, the host will check the status and then read the data.

STBCEN (18h.3) should not be used for Automatic Multiple Block Transfer. Instead, ATBLO, ATBHI should be set by firmware to:  $(MBKC+1) \times (TBCL,H+1) \times 2$

If PIO (1Fh.2) is low, setting ADRTG high triggers the following DMA Data Read sequence:

- Set BSY
- DTEN (01h.1)  $\leftarrow 1$
- SCoD (20h.2)  $\leftarrow 0$
- ATINT (32h)  $\leftarrow 02h$

### **Bit 1: DRQT - DRQ Trigger**

If bit PIO (1Fh.2) is high, setting this bit high triggers the following hardware sequence:

- DRQ (37h.3)  $\leftarrow 1$
- BSY  $\leftarrow 0$
- HIRQ (2Eh.3)  $\leftarrow 1$

When bit PIO is low (DMA mode), this bit should not be triggered.

### **Bit 0: SCT - Status Completion Trigger**

Setting this bit high triggers the following hardware sequence:

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- CHECK (37h.0)  $\leftarrow$  ACHECK (3Eh.0)
- CORR (37h.2)  $\leftarrow$  ACORR (3Eh.2)
- DRDY (37h.6)  $\leftarrow$  ADRDY (3EH.6)
- ATINT (32h)  $\leftarrow$  03h
- Clear BSY
- HIRQ (2Eh.3)  $\leftarrow$  1
- APKTEN (18h.7)  $\leftarrow$  1, if AUTOEN (18h.4) is high
- ASCEN (18h.5)  $\leftarrow$  0

After detecting the interrupt, the host reads the ATAPI Status Register and if necessary, the Error Register for the command completion status.

## **ASCTRL - Automatic Sequence Control register - (read/write 18h)**

### **Bit 7: APKTEN - Automatic Packet Transfer Enable**

Setting this bit high enables Automatic Packet Transfer logic. When APKTEN is high, the following hardware sequence is performed if host issues opcode A0h to the ATA Command Register if drive has been selected:

- Set BSY (37h.7)
- APKT (30h.0)  $\leftarrow$  1
- Clear Packet FIFO
- ATERR (31h)  $\leftarrow$  00h
- ATINT (32h)  $\leftarrow$  01h
- DTEN (01h.1)  $\leftarrow$  1
- TENDEN (01h.6)  $\leftarrow$  1, if HIIEN (2Eh.7) is high
- SCoD (20h.2)  $\leftarrow$  1
- CHECK (37h.0)  $\leftarrow$  0
- CORR (37h.2)  $\leftarrow$  0
- DRQ (37h.3)  $\leftarrow$  1
- DSC (37h.4)  $\leftarrow$  1, if ASDSC (3Dh.4) is high
- DRDY(37h.6)  $\leftarrow$  1
- HIRQ (2Eh,3)  $\leftarrow$  1, if A0IEN (18h.0) is high
- APKTEN  $\leftarrow$  0
- Clear BSY (37h.7)

ATAC (2Fh.6) will not be activated during Automatic Packet Transfers.

When the drive becomes ready after BSY is cleared, the host starts to issue 12-byte ATAPI Command Packet. Reception of the 6th packet word activates the following events.

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- FPKT (30h.1)  $\leftarrow$  1
- TENDb (01h.6)  $\leftarrow$  0
- Pin UINTb activate if TENDEN (01h.6) has been enabled

Writing any value to register TACK (07h) deactivates APKT, TENDb, and corresponding interrupt.

### Bit 6: ADCEN - Automatic DRQ Clearing Enable

When this bit is high, DRQ (37h.3) is cleared to 0 and BSY (37h.7) is set to 1 after the end of following transfers:

- Host reads from external RAM
- Host reads from DF0-DF7
- Host writes to Command Packet FIFO

### Bit 5: ASCEN - Automatic Status Completion Enable

When this bit is high, Status Completion is performed after the end of the following transfers:

- Host reads from external RAM
- Host reads from DF0-DF7
- Host writes to Command Packet FIFO

ADCEN (18h.6) should be enabled when ASCEN is enabled to provide clearing of DRQ (37h.3) and setting of BSY (37h.7). If both ADCEN and ASCEN are enabled, the following hardware sequence is executed at the end of one of the above data transfers:

- Set BSY
- DRQ (37h.3)  $\leftarrow$  0
- CHECK (37h.0)  $\leftarrow$  ACHECK (3Eh.0)
- CORR (37h.2)  $\leftarrow$  ACORR (3Eh.2)
- DRDY (37h.6)  $\leftarrow$  ADRDY (3Eh.6)
- ATINT (32h)  $\leftarrow$  03h
- Clear BSY
- HIRQ (2Eh.3)  $\leftarrow$  1
- APKTEN (18h.7)  $\leftarrow$  1, if AUTOEN (18h.4) is high
- ASCEN (18h.5)  $\leftarrow$  0

After detecting the interrupt, the host reads the ATAPI Status Register and if necessary, the Error Register for the command completion status.

### Bit 4: AUTOEN - Automatic APKTEN Set After Status Completion Enable

When this bit is high, APKTEN (18h.7) will be set after Automatic Status Completion sequence triggered by either SCT (17h.0) or ASCEN (18h.5).

### Bit 3: STBCEN - Set Transfer Byte Count Enable

When this bit is high, the value  $(TBCL,H+1) \times 2$  is loaded into ATBLO and ATBHI when ADTT (17h.2) is triggered and PIO (1Fh.2) has been set high. STBCEN should not be set for Multiple Block Transfer. Instead, ATBLO/ATBHI should be set by firmware to:  $(MBKC+1) \times (TBCL,H+2)$ .

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### **Bit 1: ABYEN - Automatic BSY Set Enable**

When this bit is high, the following sequence is executed when Disk Seek Complete is triggered by DSCT (17h.5):

- Set BSY
- DSC (37h.4)  $\leftarrow 1$
- Clear BSY
- DSCT  $\leftarrow 0$

### **Bit 0: A0IEN - A0h Command Interrupt Enable**

If this bit is high and APKTEN (18h.7) has been enabled, HIRQ (2Eh.3) becomes active-high after an opcode A0h is issued to ATA Command Register.

## **CCTL0 - Clock Control Register 0 - (write 19h)**

### **Bit 7: CKSTP - Clock Stop**

Setting this bit high stops the internal clock and the clock output at pin CLKO.

CKSTP is de-activated by the following events:

- Chip reset or host reset or firmware reset
- Command write from the host while the drive is selected
- Host issues Diagnostic Command, regardless of drive selection
- Host issues command to shadow drive if SHDRV (3Fh.6) is enabled
- Host sets bit SRST in ATAPI Device Control Register high, regardless of drive selection

### **Bit 6: PJSEL - Parity/Jumper Select**

When this pin is high, pin PAR/JP is used as buffer RAM Parity Pin. When this pin is low, the inverted value of pin PAR/JP is sampled into control bit DRV1b (2Eh.4). The timing of sampling is controlled by JPSS (19h.5).

### **Bit 5: JPSS - Jumper Sampling Select**

This bit is used to control the sampling of pin PAR/JP if PJSEL (19h.6) is low. When JPSS is high, pin PAR/JP is sampled while chip reset is active. When this bit is low, PAR/JP is sampled while chip reset or host reset are active.

### **Bit 4: Reserved**

### **Bit 3-0: CKS[3:0] - Clock Skew Control**

CKS[3:0] are used to control the duty cycle of the internal clock.

**CCTL1 - Clock Control Register 1 - (write 1Ah)****Bit 7: FLOW - Flow Control**

This bit is used to control pin IORDY according to the status of 8-byte Data FIFO. It should be set high for 8-bit DRAM and low for 4-bit DRAM. FLOW is de-activated by chip reset or host reset.

**Bit 6: TSYNC - Test Synchronization Control**

When this bit is high, the detected/inserted DSP data sync can be monitored from CLKO (pin 13).

**Bit 5, 4: Reserved****Bit 3: CLKOS - Pin CLKO Select**

When CLKOS is low, CLKO pin supplies clock signal of one-half the crystal frequency. When this bit CLKOS is high, CLKO pin supplies normal crystal frequency.

**Bit 2, 1: Reserved****Bit 0: XTALD2 - Crystal Divided by 2**

The internal clock frequency is half of crystal frequency if this bit is high.

**VER - Version Register - (read 1Ah)**

This register is used to hold the version number. The current version of W88111AF is 1Bh. The current version of W88112F is 2Ah.

**DSPSL - DSP Selection Register - (write 1Bh)****Bit 7: C2ML - C2 MSB to LSB**

When this bit is high, the sequence of erasures from C2PO(pin 11) is from MSB to LSB.

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**Bit 6: S16O - Select 16 Offset**

The incoming serial data is latched one clock after LRCK changes if this bit is high.

**Bit 5: LCHP - Left Channel Polarity**

The incoming serial data is latched as left channel when pin LRCK is high if this bit is high.

**Bit 4: SFT8 - Shift 8 Clocks**

The incoming serial data is latched by delay 8 clocks if this bit is high.

**Bit 3: Reserved****Bit 2: SEL16 - Select 16 Bits Per Channel**

The incoming serial data is latched 16 times per channel if this bit is high.

**Bit 1: DIR - Data Direction**

Setting this bit high selects the direction of data from SDATA(pin 9) from MSB to LSB.

**Bit 0: EDGE - Latching Edge Select**

Setting this bit high selects the rising edge of BCK for latching data from pin SDATA(pin 9).

**C2BEB - C2 Block Error Byte - (read 1Bh)**

The Block Error Byte is the OR of all the C2 Error Flag bytes.

**RACL, RACH, and RACU - RAM Address Counter - (write 1Ch, 1Dh, 2Dh)**

Before accessing the external RAM through registers RAMRD/RAMWR, microprocessor should set these address registers to specify the logical address of data. The microprocessor should write the RAM starting address into the counter while busy flag UTRY(1Fh.7) is low. Then this counter increases automatically each time when a byte is read or written.

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### **RAMWR - RAM Write Register - (write 1Eh)**

To gain access to external RAM, the microprocessor should first wait for flag UTY (1Fh.7) to become low, then set the address through RACL (1Ch), RACH (1Dh), and RACU (2Dh).

Writing data into register RAMWR triggers the following sequence:

- Data is transferred from the microprocessor to register RAMWR.
- Data is transferred from RAMWR to the RAM located by the address counter.
- RACL, RACH, and RACU increases by one
- Clear flag UTY

### **RAMRD - RAM Read Register - (read 1Eh)**

To gain access to external RAM, the microprocessor should first wait for flag UTY (1Fh.7) to become low, , then set the address through RACL (1Ch), RACH (1Dh), and RACU (2Dh).

Writing data into register RAMRD triggers the following sequence:

- Data previously stored in RAMRD is transferred to the microprocessor.
- RAM data located by the address counter is transferred to the RAMRD register.
- RACL, RACH, and RACU increases by one
- Clear flag UTY

Note that the first data read from RAMRD is invalid.

### **HICL0 - Host Interface Control Register - (write 1Fh)**

#### **Bit 7: UDTs - Microprocessor Data Transfer Select**

Setting UDTs to high enables microprocessor writes to data registers DF0-DF7(40h-47h) and data transfers from DF0-DF7 to the host.

#### **Bit 6: UDTT - Microprocessor Data Transfer Trigger**

Change from 0 to 1 of UDTT triggers the data transfer from DF0-DF7 to the host. This type of transfer is efficient for up to 8-byte data transfer. The host will receive data from DF0 to DF7 after the following sequence.

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- DTEN (01h.1)  $\leftarrow$  1
- Loading the number of bytes/words minus 1 to TBCL and TBCH
- UDT5 (1Fh.6)  $\leftarrow$  1
- Writing registers DF0-7
- Writing any value to register THTRG (06h)
- Set UDTT (1Fh.7) high
- Set UDTT (1Fh.7) low

The end of data transfer can be monitored by TENDb (01h.6). The corresponding interrupt can be cleared by writing any value to TACK (07h) if TENDEN (01h.6) is enabled. However, DFRDYb (01h.1) is meaningless because DATA FIFO is not used. Register TACL (04h) and TACH (05h) are useless in this case.

### Bit 5: H16S - Host 16-bit Data Select

To abide by ATAPI protocol, this bit should be high to select 16-bit data transfer between W88111AF/W88112F and host.

### Bit 4: LAEN - Latch Enable

If this bit is high, host address and chip-select signals will be latched when pins HRD<sub>b</sub> or HWR<sub>b</sub> change from high to low.

### Bit 3: MDMA - Multi-word DMA mode

Setting this bit high enables multi-word DMA mode if PIO (1Fh.2) is low.

### Bit 2: PIO - PIO/DMA mode select

Setting this bit high causes data transfer to/from host using PIO mode.

### Bit 1: WDMA - Host write DMA mode

Setting this bit high select data transfer direction of DMA is from host to device.

### Bit 0: Defined 0

## STAT5 - Status Register 5 - (read 1Fh)

### Bit 7: UTRY - Microprocessor to RAM Transfer Busy

When the microprocessor-to-RAM transfer is not complete, this bit is high.

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## **Bit 6-2: Reserved**

### **Bit 1: WDMAF - Host Write DMA Mode Flag**

This bit WDMA (1Fh.1) is high if the DMA transfer is from host to device.

## **Bit 0: Reserved**

## **HICTL1 - Host Interface Control Register - (write 20h)**

### **Bit 7 : Define 0**

### **Bit 6: PDIAGEN - Pin PDIAGb Enable**

Setting this bit high causes pin PDIAGb to the active-low state. PDIAGEN is automatically de-activated, causing pin PDIAGb to be high-impedance, by the following events:

- Reception of Execute Drive Diagnostics Command (ATA opcode 90h)
- Reception of ATA Soft Reset (SRST)
- Chip reset or Host reset

### **Bit 5: DASPEN - Pin DASPb Enable**

Setting this bit high causes pin DASPb activated. DASPEN is automatically de-activated, causing pin DASPb to be high-impedance, by the following events:

- Reception of Execute Drive Diagnostics Command (ATA opcode 90h)
- Reception of ATA Soft Reset (SRST)
- Chip reset or Host reset

### **Bit 4: CLRBSY - Clear BSY**

Setting this bit high causes the flag BSY in the ATAPI Status Register to become low if APKT (30h.0) is not high.

### **Bit 3: SETBSY - Set BSY**

Setting this bit high causes the flag BSY in the ATAPI Status Register to become high if APKT(30h.0) is not high.

### **Bit 2: SCoD - Select Command-Packet or Data**

The data received from ATAPI Data port is stored in Packet FIFO if this bit is high.

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**Bit 1: RDYEN - Pin IORDY Enable**

Setting this bit high enables IORDY(pin 49) to work with HRDb(pin 50).

**Bit 0: IO16EN - Pin IOCS16b Enable**

Setting this bit high allows pin IOCS16b to become active-low when 16-bit data access is in use. H16S(1Fh.5) must also be enabled to make use of 16-bit data transfer.

**SICL0 - Subcode Interface Control Register 0 - (write 21h)****Bit 7-4: Reserved****Bit 3: PQENB - P-data or Q-data Enable**

Bits 7 and 6 of subcode data are written to the external RAM if this bit is low.

**Bit 2-0: SUBCS[2:0] - Subcode Clock Select**

These bits are used to select subcode clock rate.

SUBCS[2:0]	Disk Speed	Subcode Block Rate
0	1 fold	75 sectors/sec
1	2 fold	150 sectors/sec
2	4 fold	300 sectors/sec
3	-	reserved
4	6 fold	450 sectors/sec
5	8 fold	600 sectors/sec
6	-	reserved
7	-	reserved

**SCIACK - Subcode Interrupt Acknowledge - (write 22h)**

Writing any value to this register de-activates SCIb(01h.0) and the corresponding microprocessors interrupt caused by MSS, NESBK, or ISS if SCIEN (2CH.4) is enabled.

**SUBSTA - Subcode Status Register - (read 22h)****Bits 7-3: Reserved****Bit 2: MSS - Missing Subcode Sync**

A missing-subcode-sync sets MSS high and negates SCIb (01h.0). A microprocessor interrupt is also activated if SCIEN (2Ch.4) is enabled.

**Bit 1: NESBK - Normal End of Subcode Block**

A normal-subcode-block-end sets NESBK high and negates SCIb (01h.0). A microprocessor interrupt is also activated if SCIEN (2Ch.4) is enabled.

**Bit 0: ISS - Illegal Subcode Sync**

An illegal-subcode-sync sets ISS high and negates SCIb (01h.0). A microprocessor interrupt is activated also if SCIEN (2Ch.4) is enabled.

**RAMCF - RAM Configuration Register - (read/write 2Ah)****Bit 7: RFTYP - Refresh Type**

The refresh mode of DRAM is CAS-before-RAS if this bit is high. The refresh mode of DRAM is RAS-only if this bit is low.

**Bit 6: RFTRG - RAM Filling Trigger**

Setting this bit high triggers the DRAM filling. All locations in the external RAM will be filled with the value in register RAMWR (1Eh). The value (ex:00h) should be written to registers RACL, RACU, and RACH before triggering RFTRG. RFC (2Ah.5) will change from 0 to 1 when all RAM locations have been filled. After RAM Filling has completed, the microprocessor should clear RFTRG to 0.

**Bit 5: RFC - RAM Fill Completion Flag (read only)**

RFC (2Ah.5) will change from 0 to 1 when all RAM locations have been filled with the value in register RAMWR (1Eh). RFC will return to 0 when RFTRG is disabled.

**Bit 5: RPIEN - RAM Parity Interrupt Enable (write only)**

Setting this bit high enables RAM-parity-interrupt to activate pin UINTb.

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**Bit 4: SWAP - Host High-Low Swap**

Setting this bit high causes the host access of high/low byte to be swapped.

**Bit 3: RPEN - RAM Parity Check Logic Enable**

Setting this bit high enables RAM-parity-check logic. If RPEN is high, RPINT (30h.3) becomes active-high when a parity error is detected. RPINT and the interrupt can be cleared by writing any value to register RAMCF (2Ah).

**Bit 2-0: RTC[2:0] - External RAM Type Configuration Bits**

The external RAM should be appropriately configured by these three bits according to its specification. RTC[2:0] are de-activated by chip reset or host reset, but are not changed by firmware reset.

RTC[2:0]	RAM Configuration
0, 4, 5, 7	reserved
1	256K x 4-bit x 1
2	256K x 4-bit x 2 128K x 8-bit x 1, 8-Row 9-Column
3	128K x 8-bit x 1, 9-Row 8-Column
6	1 Meg x 4-bit x 2

**MEMCF - Memory Layout Configuration Register - (write 2Bh)****Bits 7-4: Reserved****Bit 3: DFRST - Data FIFO Reset**

Setting this bit high resets Data FIFO.

**Bit 2: FRDY - Fast Pin IORDY Enable**

Setting this bit high accelerates the de-assertion of IORDY without referring pin HRDb.

**Bit 1-0: RLC[1:0] - External RAM Layout Configuration Bits**

The memory layout configuration should be set as shown in the following table:

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RLC[1:0]	Data Information	Data Block Size
0, 1	--	reserved
2	Sync pattern, Header, User Data, EDC, ECC, Subcode	C00h
3	Sync pattern, Header, User Data, EDC, ECC, Subcode, C2 Flags	A00h

### **SICCTL1 - Subcode Interface Control Register 1 - (write 2Ch)**

#### **Bit 7: SBXCK - Subcode External Clock**

The external clock from pin EXCK is used by the subcode logic if this bit is high.

#### **Bit 6: SCEN - Subcode Enable**

Setting this bit high enables the subcode logic.

#### **Bit 5: CD2SC - Clock Divided By 2 For Subcode Logic**

The subcode clock is divided by two if this bit is high.

#### **Bit 4: SCIEN - Subcode Interrupt Enable**

Setting this bit high enables subcode interrupts.

#### **Bit 3: EXINV - External Clock Invert Select**

If EXOP (2Ch.2) is high, setting this bit high selects an inverted clock output at pin EXCK.

#### **Bit 2: EXOP - Pin EXCK Operation**

Setting this bit high sets pin EXCK as an output.

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**Bit 1-0: SCF[1:0] - Subcode Format Select**

SCF[1:0]	Subcode Format
0	SMD0 (Philips)
1	SMD1 (EIAJ-1)
2	SMD2 (EIAJ-2)
3	Reserved

**MISC0 - Miscellaneous Control Register 0 - (write 2Eh)****Bit 7: HIIEN - Host Interface Interrupt Enable**

Setting this bit high enables the microprocessor interrupt of the host interface. Host interface interrupt occurs at the following conditions:

- SRST (Device Control Register) is written as 1 after 0 to either master or slave drive.
- Execute Drive Diagnostics Command is written to either master or slave drive.
- Any opcode is written to the ATAPI Command Register while the drive is selected except:  
(1) command opcode is 08h, (2) command opcode is A0h and APKTEN (18h.7) is high.

IDE interface interrupt is cleared by the following:

- Chip reset or host reset
- Reading register 37h
- Writing 1 to CLRBSY (20h.4)

**Bit 6: Reserved****Bit 5: DRVEb - Drive Selection Enable**

Setting this bit low enables selection of the drive if bit DRV in ATAPI Drive Select Register matches the setting of MDRV (2Eh.4).

**Bit 4: MDRV - Master Drive**

Setting this bit high sets the drive to be selected when bit DRV in the ATAPI Drive Select Register is set to 0 (Master Drive).

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### **Bit 3 : HIRQ - Host Interrupt Request**

Set this bit high asserts interrupt at pin HIRQ if the drive is selected and nIEN is enabled in the ATAPI Device Control Register. HIRQ is also automatically set by the following:

- Automatic Packet Transfer sequence (see APKTE, 18h.7)
- Automatic Status Completion sequence (see SCT, 18h.0 and ASCEN, 18h.5)

IRQ is automatically de-activated by the following:

- Chip reset or host reset
- Set bit SRST in the ATAPI Device Control Register high
- Host issue ATA command while the drive is selected
- Host read ATAPI Status Register while the drive is selected

### **Bit 2: SHIEN - Shadow Command Interrupt Enable**

Setting this bit high enables the microprocessor interrupt for the shadow command. Pin UNTb becomes low-active when SHDC (2Fh.5) becomes high-active if SHIEN is enabled.

### **Bit 1, 0: Reserved**

## **MISS0 - Miscellaneous Status Register 0 - (read 2Eh)**

### **Bit 5: SRUb - Status Register Updated Flag**

This bit becomes high when the ATAPI Status Register is updated by the following:

- Microprocessor writes to 37h
- Microprocessor triggers DSCT (17h.5)
- Microprocessor triggers SCT (17h.0)
- Automatic Status Completion occurs if ASCEN (18h.5) is enabled
- Reception of A0h command if APKTE (18h.7) is enabled
- Chip reset or host reset

### **Bit 4: MDRVf - Master Drive Flag**

This bit is high if the drive is configured as Master. This bit is low if the drive is configured as Slave.

### **Bit 3: HINTF - Host Interrupt Flag**

This bit reflects the status of the source of pin HIRQ.

### **Bit 2: nIEN - Bit nIEN in Device Control Register**

This bit reflects the value of bit nIEN in ATAPI Device Control Register.

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**Bit 1: PDIAGb - Pin PDIAGb Flag**

This bit reflects the status of pin PDIAGb.

**Bit 0: DASPb - Pin DASPb Flag**

This bit reflects the status of pin DASPb.

**MISC1 - Miscellaneous Control Register 1 (write 2Fh)****Bit 7: ARRC - ATAPI Register Read Control**

When this bit is high, the ATAPI registers can be read regardless of the value of BSY if the drive is selected.

**Bit 6: SARRC - Shadow Drive ATAPI Register Read Control**

When this bit is high, the Shadow ATAPI registers can be read regardless of the value of BSY if the shadow drive is selected.

**Bit 5,4: These two bits should be write 0s after power-on.****Bit 3: ARSTEN - ATAPI Soft Reset Pin Enable**

When this bit is high, pin ARSTb is enabled as output signal. The timing of pin ARSTb signal is also controlled by ARSTS (2Fh.2).

**Bit 2: ARSTS - Pin ARSTb Timing Select**

When this bit is high, pin ARSTb (if enabled) becomes active-low if host writes an ATAPI Soft Reset Command. Writing any value to register ARSTACK (30h) de-activates pin ARSTb. When this bit is low, pin ARSTb (if enabled) becomes active-low if host writes an ATAPI Soft Reset Command and automatically de-activates itself after 256 system clock.

**Bit 1: ARSTIEN - ATAPI Soft Reset Interrupt Enable**

When this bit is high, pin UNTb becomes active-low whenever host writes an ATAPI Soft Reset Command.

**Bit 0: ARWC - ATAPI Register Write Control**

Host writes to ATAPI registers (except Device Control Register) will not take effect when ARWC and BSY are high, if BSY is not set by the following commands:

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- Opcode 90h is written to ATA Command Register while the drive is selected.
- Opcode 90h is written to ATA Command Register while the shadow drive is selected if SHDRV (3Fh.6) is high.

## **MISS1 - Miscellaneous Status Register 0 - (read 2Fh)**

### **Bit 7: SRST - Soft Reset Flag**

This bit becomes high when host writes 1 to bit SRST in the ATAPI Device Control Register if either master or slave drive is selected. When SRST becomes high, the following events will be executed:

- BSY (37h.7)  $\leftarrow$  1
- Initialize ATAPI signature
- PDIAGEN (20h.6)  $\leftarrow$  0 and disables pin PDIAGb to high-impedance state
- Disable pin DASPb to high-impedance state if DASPSS (3Fh.0) is low. Negates DASPb if DASPSS (3Fh.0) is high.
- CKSTP (19h.7)  $\leftarrow$  0
- Activates host interrupt to the microprocessor if HIIEN (2Eh.7) is high.
- HIRQ (2Eh.3)  $\leftarrow$  0

IDE interrupt is cleared by read register ATCMD(37h) or write CLRBSY((20h.4). SRST is de-activated by read register MISS1 (2Fh) after SRST is set to low by host.

### **Bit 6: ATAC - ATAPI Command**

If the drive is selected, this bit becomes high when any command is written to the ATAPI Command Register except the following opcode are received.

- opcode is 90h
- opcode is 08h
- opcode is A0h and APKTEN (18h.7) is high

ATAC is de-activated by the following:

- Chip reset or host reset
- Reading register ATCMD (37h)
- Writing 1 to CLRBSY (20h.4)

### **Bit 5: DIAG - Execute Drive Diagnostics Command**

This bit becomes high if Execute Drive Diagnostics Command (opcode 90h) has been written to either master or slave drive. Meanwhile, the following events will be executed:

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- BSY(37h.7) ← 1
- PDIAGEN (20h.6) ← 0 and disables pin PDIAGb to high-impedance state
- CKSTP (19h.7) ← 0
- ATAPI Error Register ← 01h
- ATAPI Feature Register ← 00h
- ATAPI Interrupt Reason Register ← 01h
- ATAPI SAM Tag Byte ← 01h
- ATAPI Byte Counter Register Low/High ← 00h
- ATAPI Drive Select Register ← 00h
- Clear ATAPI Status Register except bit BSY and SERVICE
- Activates host interrupt to the microprocessor if HIIEN (2Eh.7) is enabled

### Bit 4: SHDC - Shadow Command Flag

This bit becomes high when the host writes a command to a non-existent slave drive. Meanwhile, **UINTb** becomes low-active if **SHIEN** (2Eh.2) is enabled. **ATAC** is de-activated by the following:

- Chip reset or host reset
- Reading register **ATCMD** (37h)
- Writing 1 to **CLRBSY** (20h.4)

### Bit 3: ARST - ATAPI Soft Reset Flag

This bit becomes high when ATAPI Soft Reset command (opcode 08h) is written to either master or slave drive. **ARST** is de-activated by writing any value to register **ARSTACK** (30h).

### Bit 2: RST - Reset Flag

This bit is high when the chip is currently being reset by chip reset, host reset, or firmware reset.

### Bit 1: FRST - Firmware Reset Flag

This bit is high if the current or most recent reset was firmware reset. The first read of register **MISS1** (2Fh) following the end of the firmware reset clears **FRST** to 0.

### Bit 0: HRST - Chip reset or host reset Flag

This bit is high if the current or most recent reset was activated by chip reset or host reset. The **BSY** flag is set whenever chip reset or host reset is activated. The first read of register **MISS1** (2Fh) following the end of the chip reset or host reset clears **HRST** to 0.

### ARSTACK - ATAPI Soft Reset Acknowledge (write 30h)

Writing any value to register **ARSTACK** triggers the following events:

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- Clears ARST (2Fh.3)
- Deactivates pin ARSTb if ARSTEN (2Fh.3) and ARSTS (2Fh.2) are enabled
- Deactivates UINTb if ARSTIEN (2Fh.1) is enabled

### MISS2 - Miscellaneous Status Register 0 (read 30h)

#### Bit 7: SRSTD - Soft Reset with DRQ

This bit becomes high if host activates SRST in the ATAPI Device Control Register while DRQ is high and the drive is selected. This bit is updated each time the SRST changes from 0 to 1.

#### Bit 6: CMDC - Command Conflict

This bit becomes high if one of the following events occurs while BSY is high:

- Host writes any opcode to ATAPI Command Register while drive is selected.
- Host writes any opcode to ATAPI Command Register while shadow drive is selected and SHDRV (3Fh.6) is enabled.
- Host writes opcode 90h (Execute Drive Diagnostics) to ATAPI Command Register.

CMDC is updated each time the host writes the ATAPI Command Register.

#### Bit 5: TDIR - Data Transfer Direction

If TDIR is high when TENDb (01h.6) changes from 1 to 0, the interrupt is caused by completion of data transfer from external RAM to host. TDIR is low if activation of TENDb (01h.6) is caused by completion of data transfer from host to the Packet FIFO.

#### Bit 4: MBTI - Multi-block Transfer Interrupt

This flag indicates the end of each block transfer while the Multi-block transfer is used.

#### Bit 3: RPINT - RAM Parity Interrupt Flag

This bit becomes high if a parity error has been detected in the external RAM when RPEN (2Ah.3) is high. RPINT and the interrupt can be cleared by writing any value to register RAMCF (2Ah).

#### Bit 2: CRST - Chip Reset Flag

This bit is set high by chip reset. The first read of register MISS2 (30h) following the end of the chip reset clears CRST to 0.

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### **Bit 1: FPKT -Full Packet Flag**

This bit becomes high if the host has written the number of data bytes indicated in register ATBLO ( less than 12 bytes), or the host has written a 12-byte command packet. If CoD (32h.0) is low when DRQ (37h.3) changes from 0 to 1, the count in ATBLO is latched as a threshold value for FPKT logic. If CoD is high when DRQ (37h.3) change from 0 to 1, the threshold value of FPKT logic is set as 12. Whenever the number of bytes in the Packet FIFO equals the threshold value, flag FPKT becomes high. To receive data from host using Packet FIFO, CoD (32h.0) and ATBLO (32h) should be updated before DRQ changes from 0 to 1.

### **Bit 0: APK - Automatic Packet Transfer Flag**

This bit is set to 1 when host writes opcode A0h to ATA Command Register if drive is selected and APKTE (18h.7) has been enabled. When APK is high, BSY is controlled by the Automatic Packet Transfer logic. Hence, setting of CLRBSY (20h.4) and SETBSY (20h.4) is of no effect. APK is de-activated by writing any value to register TACK(07h). APK is de-activated by chip reset or host reset but is not changed by firmware reset.

### **ATERR - ATAPI Error Register (write 31h)**

This register is set as 01h by the following:

- Chip reset or host reset
- SRST
- Execute Drive Diagnostics Command
- Triggering SIGT (17h.4)

### **ATFEA - ATAPI Feature Register (read 31h)**

This register is de-activated by the following:

- Chip reset or host reset
- SRST
- Execute Drive Diagnostics Command
- Triggering SIGT (17h.4)

### **ATINT - ATAPI Interrupt Reason Register (read/write 32h)**

This register is set as 01h by the following:

- Chip reset or host reset
- SRST
- Execute Drive Diagnostics Command
- Triggering SIGT (17h.4)

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### **ATSPA - ATAPI SAM Tag Bytes Register (read/write 33h)**

This register is set as 01h by the following:

- Chip reset or host reset
- SRST
- Execute Drive Diagnostics Command
- Triggering SIGT (17h.4)

### **ATBLO - ATAPI Byte Count Low (read/write 34h)**

This register is set as 14h by chip reset, host reset, SRST or triggering SIGT (17h.4).

This register is set as 00h by Execute Drive Diagnostics Command.

### **ATBHI - ATAPI Byte Count High (read/write 35h)**

This register is set as EBh by chip reset, host reset, SRST or triggering SIGT (17h.4).

This register is set as 00h by Execute Drive Diagnostics Command.

### **ATDRS - ATAPI Drive Select (read/write 36h)**

This register is set as 00h by the following:

- Chip reset or host reset
- SRST
- Execute Drive Diagnostics Command

Note that this register is not changed by triggering SIGT (17h.4).

### **ATSTA - ATAPI Status Register (read 38h, write 37h)**

This register is set as x0000000b by chip reset, host reset. This register is set as x00x0000b by SRST, Execute Drive Diagnostics Command, or triggering SIGT (17h.4). Note that BSY is not changed by writing register ATSTA (37h).

### **ATCMD - ATAPI Command Register (read 37h)**

This register is used to latch the command opcode written from host without default value.

**ASSTA - ATAPI Shadow Status Register - (write 38h)****Bit 0: SCHECK - Shadow Check Bit**

If configured as a Master drive, the firmware should set SCHECK following each host write to ATCMD to comply with ATAPI specification. Bit-7 of Shadow Status Register is the same as BSY of Status Register. Bit 6-1 of Shadow Status Register are all 0s. SCHECK is de-activated by chip reset, host reset, or host writes to Command Register regardless of which drive is selected.

**ASERR - ATAPI Shadow Error Register - (write 39h)****Bit 2: SABRT - Shadow ABRT Bit**

The microprocessor should set SABRT following each host write to ATCMD to comply with ATAPI specification if configured as a master drive. The other bits of Shadow Error Register are all 0s..

**APKSTA - Status Register for Automatic Packet Transfer - (write 3Dh)****Bit 4: ADSC - Disk Seek Complete for Automatic Packet Transfer**

The value of ADSC is the value of bit DSC in ATAPI Status Register during Automatic Packet Command Transfers.

**ASCSTA - Status Register for Automatic Status Completion - (write 3Eh)****Bit 6: ADRDY - Drive Ready for Automatic Status Completion**

The value of ADRDY is the value of bit DRDY in the ATAPI Status Register during Automatic Status Completion.

**Bit 2: ACORR - Correctable Error for Automatic Status Completion**

The value of ACORR is the value of bit CORR in the ATAPI Status Register during Automatic Status Completion. CORR is de-activated by chip reset, host reset, or firmware reset.

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### **Bit 0: ACHECK - Check for Automatic Status Completion**

The value of ACHECK is the value of bit CHECK in the ATAPI Status Register during Automatic Status Completion. CHECK is de-activated by chip reset, host reset, or firmware reset.

## **SHDC - Shadow Drive Control Register**

### **Bit 7: Reserved**

### **Bit 6: SHDRV - Shadow Drive Enable**

Setting this bit high enables Shadow Register support for the non-existent Slave Drive.

### **Bit 5: SHDRV1 - Shadow Drive Enable Latch**

Microprocessor should set SHDRV1 high at least 450 milliseconds after chip reset or host reset to latch the setting of SHDRV (3Fh.6) from pin DASPb if configured as a master drive.

### **Bit 4,3: Reserved**

### **Bit 2: DASPS2 - DASP Select 2**

Setting this bit high enables DASPEN (20h.5) during host reset. DASPS2 should normally be 0 to comply with ATAPI specification.

### **Bit 1: DASPS1 - DASP Select 1**

Setting this bit high enables DASPEN (20h.5) following end of host reset.

### **Bit 0: DASPSS - DASP SRST Select**

Setting this bit high enables DASPEN (20h.5) following the end of soft reset (SRST).

## **DF0 to DF7 - uP to Host Data Transfer Registers - (write 40h to 47h)**

If UDTT (1Fh.7) and UDT5 (1Fh.6) are properly programmed, DF0-7 can be used to transfer data from microprocessor to the host. The microprocessor can write data to DF0-7 respectively. Then the host reads these data from ATAPI Data Register. Note that DF0 reads first, and DF7 reads last.

**Ring Control Registers - (read/write 50h to 57h)**

These eight registers add flexibility to the block control of external memory that is controlled by RTC[2:0] initially. Once one of these eight registers is set, all eight registers should be set to take full control of block configuration of the external memory.

**DTRBL/DTRBH - Data Transfer Ring Base Register - (read/write 50h/51h)**

Data Transfer Ring Base Register and Data Transfer Ring Ceiling Register treat the external memory as a ring while transferring data to the host. Data Transfer Ring Base Register specifies the base block number of this ring.

**DTRCL/DTRCH - Data Transfer Ring Ceiling Register - (read/write 52h/53h)**

Data Transfer Ring Base Register and Data Transfer Ring Ceiling Register treat the external memory as a ring while transferring data to the host. Data Transfer Ring Base Register specifies the ceiling block number of this ring. The first block to be transferred is specified by TBL/TBH (24h/25h). The further data transfer after the end of Data Transfer Ceiling block will access data in Data Transfer Base block.

**WBRBL/WBRBH - Write Buffer Ring Base Register - (read/write 54h/55h)**

Write Buffer Ring Base Register and Write Buffer Ring Ceiling Register treat the external memory as a ring while buffering the serial data from DSP. Write Buffer Ring Base Register specifies the base block number of this ring.

**WBRCL/WBRCH - Write Buffer Ring Ceiling Register - (read/write 56h/57h)**

Write Buffer Ring Base Register and Write Buffer Ring Ceiling Register treat the external memory as a ring while buffering the serial data from DSP. Write Buffer Ring Base Register specifies the base block number of this ring. The first block to be buffered is specified by DDBL/DDBH(28h/29h). Further serial data buffering after the end of Write Buffer Ceiling block will buffer serial data into the Write Buffer Base block.

**SCTC - Subcode Timer Control Register - (write 5Ah)**

If SBXCK (2Ch.7) and CD2SC (2Ch.5) are both 0, the clock used by subcode logic clock is controlled by SUBCS[2:0] unless any non-zero value is written into register SCTC (5Ah). The value of register SCTC should be calculated as follows:

$$(N + 2) \times tc \times dsf = 11.3 / 2$$

where **tc** is the internal clock period(ex: 50nS for 20MHz crystal),

**dsf** is the disk speed factor(ex: 4 for 4-fold speed drive).

**TARCTL - Target Control Register - (write 80h)**

This register is used to control the automatic target search and header comparison. Since these control bits are not changed by closing decoder, there is no need to write it every time before enabling the decoder.

**Bit 7: TARGEN - Target Function Enable**

Setting this bit high enables target search function but does not enable decoder simultaneously. The operation of target search is triggered by changing DECEN(0Ah.7) from low to high. Then the decoder generates first interrupt after the decoding of target sector is finished, as specified by Target Header Registers (84h-86h). The mode of correction is determined by the previous setting of registers CTRL0(0Ah) and CTRL1(0Bh).

**Bit 6: DSCEN - Decoding Sector Counting Enable**

Setting this bit high enables the Decoding-Sector-Counter to increase by one every time the decoding of a sector is finished. The decoder will stop and deactivate DECEN(0Ah.7) when the value in Decoding-Sector-Counter reach the threshold value specified by Decoding-Sector-Threshold-Register.

**Bit 1: TNFEN - Target Not Found Interrupt Enable**

Setting this bit high enables Target-Not-Found-Interrupt-Flag, TNFI(80h.1), to be reflected on Decoder Interrupt Flag, DECIb (01h.5).

**Bit 0: HCEEN - Header Compare Error Interrupt Enable**

Setting this bit high enables Header-Compare-Error-Interrupt-Flag, HCEI(80h.0), to be reflected on Decoder-Interrupt-Flag, DECIb (01h.5).

**TARSTA - Target Status Register - (read 80h)****Bit 7: VALb - Status Valid Flag**

This bit is a direct copy of flag STAVAb(0Fh.7).

**Bit 6: STAERR - Status Error Flag**

This bit becomes high if any status bit error occurs when its corresponding mask bit enabled. It also deactivates DECEN (0AH.7) and stops the decoder automatically. Flag STAERR is deactivated by reading register TARSTA (80h).

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### **Bit 1: TNFI - Target Not Found Interrupt**

This bit, if enabled by TNFEN (80h.1), becomes high and activates DECIb (01h.5) if the headers of incoming data do not match the target after  $N$  successive sector comparisons.  $N$  is the number specified by Target-Search-Limit-Register (83h). This interrupt also deactivates DECEN (0AH.7) and stops the decoder automatically. Flag TNFI is deactivated by reading register TARSTA (80h).

### **Bit 0: HCEI - Header Compare Error Interrupt**

After target is found, the number in Target-Header-Register (84h-86h) will automatically increase after decoding of its corresponding sector is finished. Once the headers of following sector do not match the updated target, flag HCEI becomes high and activates DECIb (01h.5) if HCEEN (80h.0) is enabled. This error condition also deactivates DECEN (0AH.7) and stops the decoder automatically. Flag HCEI is deactivated by reading register TARSTA (80h).

### **DSTH/DSTL - Decoding Sector Threshold Register - (write 82h/81h)**

If both TARGEN(80h.7) and DSCEN (80h.6) are enabled, this register specified the threshold number of successive sectors minus one to be decoded after header is targeted. The comparison result of this threshold number with the number in Decoding-Sector-Counter is used to disable the decoding function. The initial value of DSTH/DSTL is FF,FFh after chip reset, firmware reset and decoder reset. Note that threshold value should not be set as 00h.

### **DSCH/DSCL - Decoding Sector Counter - (read 82h/81h)**

If both TARGEN(80h.7) and DSCEN (80h.6) are enabled, the value in Decoding-Sector-Counter is cleared to 00,00h when DECEN (0Ah.7) changes from 0 to 1. Once the target header is found, this counter increases by one after the decoding of a sector is finished. The decoder will stop and deactivate DECEN (0Ah.7) when the value in Decoding-Sector-Counter reach the threshold value specified by Decoding-Sector-Threshold-Register.

### **TSL - Target Search Limit Register - (write 83h)**

This register specified the limited number of target search cycle. If  $N$  is the number specified by this register, flag TNFI (80h.1) becomes high if the headers of incoming data do not match the target after  $N$  successive sectors. Since this value is not changed by closing decoder, there is no need to write it every time before enabling the decoder. The initial value of TSL after chip reset, firmware reset and decoder reset is FFh.

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### **TSC - Target Search Counter - (read 83h)**

If TARFEN (80h.7) is enabled, this register is cleared to 00,00h whenever DECEN (0Ah.7) changes from low to high. After the decoder is enabled, the number of sectors have been searched can be monitored by reading TSC.

### **Target Header Register - (read/write 84h-86h)**

Target-Header-Register (84h-86h) are used to hold the header information of target sector. If TARGEN (80h.7) is enabled, the operation of target search is triggered by changing DECEN (0Ah.7) from low to high. After target is found, the number in Target-Header-Register (84h-86h) will automatically increase after decoding of its corresponding sector is finished. Once the headers of following sector do not match the updated target, flag HCEI becomes high and activates DEClb (01h.5) if HCEEN (80h.0) is enabled.

### **TMIN - Target Minute Register - (read/write 84h)**

This register is used to hold the MINUTE information of target sector.

### **TSEC - Target Second Register - (read/write 85h)**

This register is used to hold the SECOND information of target sector.

### **TFRAM - Target Frame Register - (read/write 86h)**

This register is used to hold the FRAME information of target sector.

### **FEACTL - Feature Control Register - (write 88h)**

#### **Bit 7: ACEON - Acceleration On**

Setting this bit high turns on the acceleration function of error correction/detection so that the system performance is highly improved. This acceleration function is on by default for W88112F.

#### **Bit 6: ACEOFF - Acceleration Off**

Setting this bit low turns off the acceleration function of error correction/detection.

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### **Bit 5: VALCTL - Valid Timing Control**

Setting this bit high changes the available time of Status-Registers (0Ch-0Fh). The STAVAb (0Fh.7) becomes active-low after a sector decoding is finished and becomes high till the Header-Register (04h-07h) are updated when error detection of next sector starts. This function provides efficient time for decoder-interrupt-service-routine executed by microprocessor with high disk speed.

### **Bit 4-0: Reserved**

## **Status Mask Register - (write 8Ch-8Fh)**

If any following mask bit is enabled, the flag STAERR (80h.6) becomes high when the corresponding status bit in Status-Register (0Ch-0Fh) becomes active.

### **STA0M - Status 0 Mask Register - (write 8Ch)**

**Bit 7 - CRCOK Mask**

**Bit 6 - ILSYN Mask**

**Bit 5 - NOSYN Mask**

**Bit 4 - LBLK Mask**

**Bit 3 - WSHORT Mask**

**Bit 2 - SBLK Mask**

**Bit 0 - UCEBLK Mask**

## **STA1M - Status 1 Mask Register - (write 8Dh)**

**Bit 4: HDERA Mask**

**Bit 0: SHDER Mask**



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### **STA2M - Status 2 Mask Register - (write 8Eh)**

**Bit 2: NOCOR Mask**

**Bit 1: RFERA Mask**

### **STA3M - Status 3 Mask Register - (write 8Fh)**

**Bit 5: CBLK Mask**

**Bit 4: ECCINC Mask**

**Bit 1: C2BLK Mask**



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## REGISTER TABLE

INDEX	type	NAME	BIT0	BIT1	BIT2	BIT3	BIT4	BIT5	BIT6	BIT7
-	r/w	IR	index							
00h	r	PFAR	b0	b1	b2	b3	b4	b5	b6	b7
01h	w	INTCTL	0	dten	0	0	0	srien	tenden	pfneen
01h	r	INTREA	scib	dfrdyb	mbtib	tbsyb	hcib	srib	tend	pfne
02h	r/w	TBCL	b0	b1	b2	b3	b4	b5	b6	b7
03h	w	TBCH	b8	b9	b10	b11	0	0	0	0
03h	r	TBCH	b8	b9	b10	b11	dtei	dtei	dtei	dtei
04h	w	TACL	a0	a1	a2	a3	a4	a5	a6	a7
05h	w	TACH	a8	a9	a10	a11	a12	a13	a14	a15
06h	w	THTRG	data unused							
07h	w	TACK	data unused							
04h	r	HEAD0	header minutes (bcd)							
05h	r	HEAD1	header second (bcd)							
06h	r	HEAD2	header frames (bcd)							
07h	r	HEAD3	header mode (bcd)							
08h	w	BIAL	a0	a1	a2	a3	a4	a5	a6	a7
09h	w	BIAH	a8	a9	a10	a11	a12	a13	a14	a15
08h	r	EIAL	a0	a1	a2	a3	a4	a5	a6	a7
09h	r	EIAH	a8	a9	a10	a11	a12	a13	a14	a15
0Ah	w	CTRL0	pcen	qcen	bufen	0	acen	edcen	0	decen
0Bh	w	CTRL1	shden	mcrq	f2rq	m2rq	cwen	dscren	sden	sien
0Ah	r	BACL	a0	a1	a2	a3	a4	a5	a6	a7
0Bh	r	BACH	a8	a9	a10	a11	a12	a13	a14	a15
0Ch	w	EIAL	a0	a1	a2	a3	a4	a5	a6	a7
0Dh	w	EIAH	a8	a9	a10	a11	a12	a13	a14	a15
0Ch	r	STAT0	uceblk	fdif	sbkf	wshort	lbkf	nosyn	ilsyn	crcok
0Dh	r	STAT1	shdera	0	0	0	hderra	0	0	0
0Eh	w	DHTACK	data unused							
0Eh	r	STAT2	rform	rfera	nocor	mode2	rmod0	rmod1	rmod2	rmod3
0Fh	w	FRST	data unused							
0Fh	r	STAT3	0	c2df	0	0	einc	ecf	0	stavab
10h	w	CTRLW	eincen	drst	c2wen	fdien	dcken	sdss	swen	0
10h	r	STAT4	0	0	0	0	0	0	0	crcvab
11h	w	CRTRG	crll	data unused						
12h	w	MBTC0	mbc0	mbc1	mbc2	mbc3	mbc4	0	0	0
12h	r	MBTC0	mbc0	mbc1	mbc2	mbc3	mbc4	0	mbinc	mbvab



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13h	r/w	MBTC1	incmbc	mbtfen	mbtien	0	0	0	0	0			
14h	w	ECTRL	disai	ir7f	0	0	0	0	0	0			
14h	r	SUBHO	subheader(file)										
15h	r	SUBH1	subheader(channel)										
16h	r	SUBH2	subheader(submode)										
17h	r	SUBH3	subheader(coding)										
17h	w	ASTRG	sct	drqt	adtt	cpft	sigt	dsct	csrt	0			
18h	r/w	ASCTRL	pktien	abyen	0	stbcen	autoen	ascen	adcen	apkten			
19h	w	CCTL0	csk0	cks1	csk2	csk3	0	jpss	pjsel	ckstp			
1Ah	w	CCTL1	xtald2	0	0	clkos	0	0	tsync	flow			
1Ah	r	VER	b0	b1	b2	b3	b4	b5	b6	b7			
1Bh	w	DSPSL	edge	dir	sel16	0	sft8	lchp	s16o	c2ml			
1Bh	r	C2BEB	b0	b1	b2	b3	b4	b5	b6	b7			
1Ch	w	RACL	a0	a1	a2	a3	a4	a5	a6	a7			
1Dh	w	RACH	a8	a9	a10	a11	a12	a13	a14	a15			
2Dh	w	RACU	a16	a17	a18	a19	0	0	0	0			
1Eh	w	RAMWR	b0	b1	b2	b3	b4	b5	b6	b7			
1Eh	r	RAMRD	b0	b1	b2	b3	b4	b5	b6	b7			
1Fh	w	HICTL0	0	wdma	pio	mdma	laen	h16s	udts	udtt			
1Fh	r	STAT5	0	wdmaf	0	0	0	0	0	utby			
20h	w	HICTL1	io16en	rdyen	scod	setbsy	clrbsy	daspen	pdiagen	0			
21h	w	SICTL0	subcs0	subcs1	subcs2	pqenb	0	0	0	0			
22h	w	SCIACK	data unused										
22h	r	SUBSTA	iss	nesbk	mss	data unused							
24h	r/w	TBL	b0	b1	b2	b3	b4	b5	b6	b7			
25h	r/w	TBH	b8	data unused									
26h	r/w	SCBL	b0	b1	b2	b3	b4	b5	b6	b7			
27h	r/w	SCBH	b8	data unused									
28h	r/w	DDBL	b0	b1	b2	b3	b4	b5	b6	b7			
29h	r/w	DDBH	b0	data unused									
2Ah	w	RAMCF	rtc0	rtc1	rtc2	rpen	swap	rpien	rftrg	rftyp			
2Ah	r	RAMCF	rtc0	rtc1	rtc2	rpen	swap	rfc	rftrg	rftyp			
2Bh	w	MEMCF	rlc0	rlc1	frdy	dfrst	0	0	casc0	casc1			
2Ch	w	SICTL1	scf0	scf1	exop	exinv	scien	cd2sc	scen	sbxck			
2Eh	w	MISC0	0	0	0	hirq	mdrv	drveb	0	hiien			
2Eh	r	MISS0	daspb	pdiagb	1	hintf	mdrvf	srub	1	1			
2Fh	w	MISC1	arwc	arstien	arsts	arsten	0	0	sarrc	arrc			
2Fh	r	MISS1	hrst	frst	rst	arst	shdc	diag	atac	srst			
30h	w	ARSTACK	data unused										



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30h	r	MISS2	apkt	fpkt	crst	rpint	mbti	tdir	cmdc	srstd
31h	w	ATERR	ili	eom	abrt	mcr	b4	b5	b6	b7
31h	r	ATFEA	dma	0	0	0	0	0	0	0
32h	r/w	ATINT	cod	io	0	0	0	0	0	0
33h	r/w	ATSPA	1	0	0	0	0	0	0	0
34h	r/w	ATBLO	b0	b1	b2	b3	b4	b5	b6	b7
35h	r/w	ATBHI	b0	b1	b2	b3	b4	b5	b6	b7
36h	r/w	ATDRS	0	0	0	0	drv	1	1	1
37h	w	ATSTA	check	0	corr	drq	dsc	0	drdy	0
37h	r	ATCMD	b0	b1	b2	b3	b4	b5	b6	b7
38h	w	ASERR	scheck	0	0	0	0	0	0	0
38h	r	ATERR	check	0	corr	drq	dsc	b5	drdy	bsy
39h	w	ASERR	0	0	sabrt	0	0	0	0	0
39h	r	ATERR	ili	eom	abrt	mcr	b4	b5	b6	b7
3Dh	w	APKSTA	0	0	0	0	adsc	0	0	0
3Eh	w	ASCSTA	acheck	0	acorr	0	0	0	adrady	0
3Fh	r/w	SHDC	daspss	daspss1	daspss2	0	0	shdrv1	shdrv	0
40h-47h	w	DF0-DF7	d0	d1	d2	d3	d4	d5	d6	d7
50h	r/w	DTRBL	d0	d1	d2	d3	d4	d5	d6	d7
51h	r/w	DTRBH	d8	data unused						
52h	r/w	DTRCL	d0	d1	d2	d3	d4	d5	d6	d7
53h	r/w	DTRCH	d8	data unused						
54h	r/w	WBRBL	d0	d1	d2	d3	d4	d5	d6	d7
55h	r/w	WBRBH	d8	data unused						
56h	r/w	WBRCL	d0	d1	d2	d3	d4	d5	d6	d7
57h	r/w	WBRCH	d8	data unused						
5Ah	w	SCTC	d0	d1	d2	d3	d4	d5	d6	d7

***The following registers are only available on W88112F***

INDEX	TYPE	NAME	BIT0	BIT1	BIT2	BIT3	BIT4	BIT5	BIT6	BIT7
80h	w	TARCTL	hceen	tnfen	0	0	0	0	dscen	targen
80h	r	TARSTA	hcei	tnfi	0	0	0	0	staerr	valb
81h	w	DSTL	b0	b1	b2	b3	b4	b5	b6	b7
82h	w	DSTH	b8	b9	b10	b11	b12	b13	b14	b15
81h	r	DSCL	b0	b1	b2	b3	b4	b5	b6	b7
82h	r	DSCH	b8	b9	b10	b11	b12	b13	b14	b15
83h	w	TSL	b0	b1	b2	b3	b4	b5	b6	b7
83h	r	TSC	b0	b1	b2	b3	b4	b5	b6	b7
84h	r/w	TMIN	(bcd)							



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85h	r/w	TSEC	(bcd)							
86h	r/w	TFRAM	(bcd)							
88h	w	FEACTL	0	0	0	0	0	valctl	aceoff	aceon
8ch	w	STA0M	uceblkm	0	sblkm	wshortm	lblkm	nosynm	ilsynm	crcokm
8dh	w	STA1M	shderam	0	0	0	hderam	0	0	0
8eh	w	STA2M	0	rferam	nocorm	0	0	0	0	0
9fh	w	STA3M	c2blkm	0	0	0	eccincm	cblkm	0	0



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## D.C. CHARACTERISTICS

( $T_A = 0^\circ\text{C}$  TO  $70^\circ\text{C}$ ,  $V_{DD} = 5\text{V}\pm5\%$ ,  $V_{ss} = 0\text{V}$ )

SYM	PARAMETER	MIN	MAX	UNIT	CONDITION
$V_{OH}$	Output HIGH Voltage	2.4		V	$I_{OH}=400\mu\text{A}$
$V_{OL}$	Output LOW Voltage		0.4	V	$I_{OL}=6$ or $16\text{mA}$ (Note 1)
$V_{IH1}$	Input HIGH Voltage	$0.7\times VDD$	$VDD+0.5$	V	UD[7:0], DD[15:0], RD[7:0], DASPb, PAR/DJ, PDIAGb, EXCK
$V_{IL1}$	Input LOW Voltage	-0.5	$0.3\times VDD$	V	
$V_{IH2}$	Input HIGH Voltage	2	$VDD+0.5$	V	LRCK, SDATA, BCK, C2PO, SCSD, WFCK, SCSYN, HRSTb, URS, URDb, UWRb, UCSb, CS3b, CS1b, DA[2:0], DMACKb, HRDb, HWRb, CRSTb
$V_{IL2}$	Input LOW Voltage	-0.5	0.8	V	
$I_{LI1}$	Input Leakage Current	-10	10	$\mu\text{A}$	
$I_{LI2}$	Input Leakage Current	-133.2	-400.6	$\mu\text{A}$	Pins with Pullup Resistor at PAD = 0V (Notes 3)
$I_{LO1}$	Output Leakage Current	-10	10	$\mu\text{A}$	
$I_{LO2}$	Output Leakage Current	-133.2	-400.6	$\mu\text{A}$	Pins with Pullup Resistor at PAD = 0V (Notes 3)

Notes:

1. Output current (IOL) Capabilities:

6mA: RA[15:0], PAR/DJ, CLKO, UD[7:0], RD[7:0], PDIAGb

16mA: DD[15:0], DASPb, HIRQ, DMARQ, UINTb, EXCK, IORDY, IOCS16b, ARSTb

2. The chip contains internal resistance between XIN and XOUT

3. The chip contains internal pullup resistance between VDD and the following pins:

Input: HA[2:0], DMACKb, HRDb, HWRb, CS1b, CS3b

Output: ROEb, UINTb

Bi-directional: DD[15:0], RD[7:0], UD[7:0], PAR/DJ, DASPb, PDIAGb, EXCK

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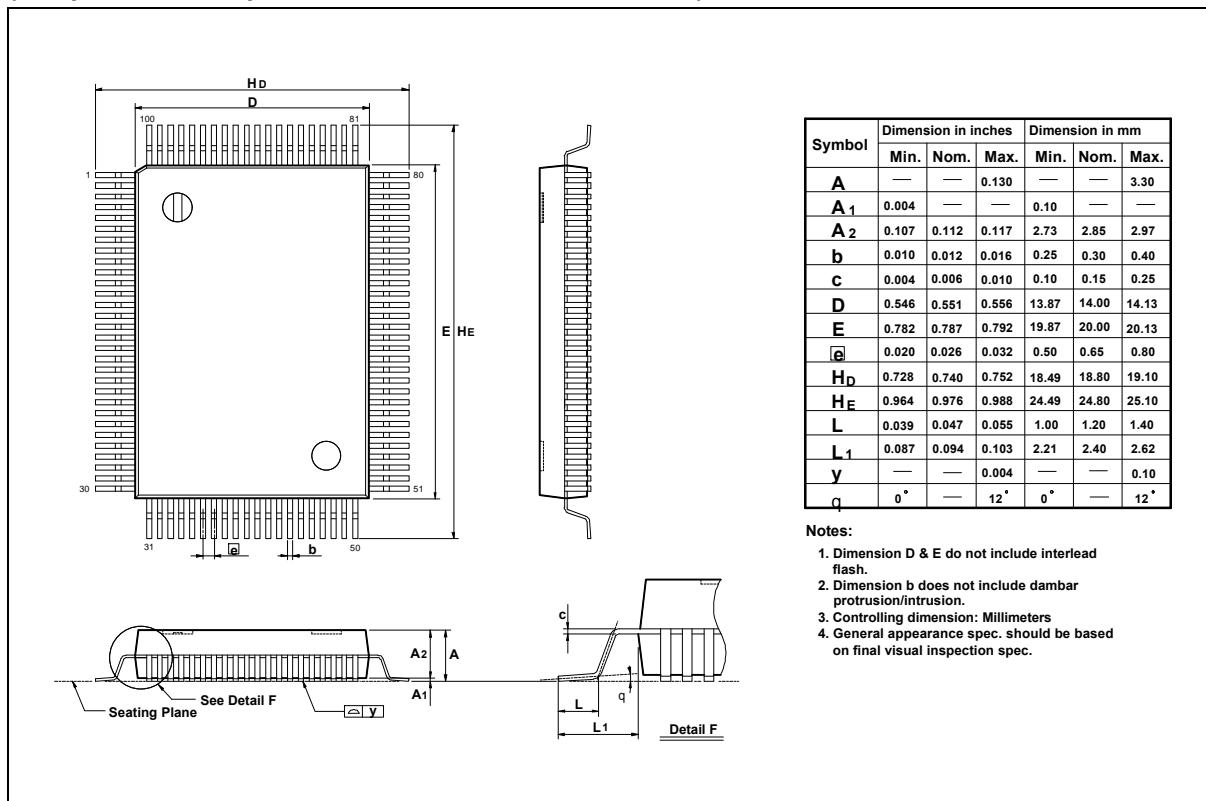
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**ORDERING INSTRUCTION**

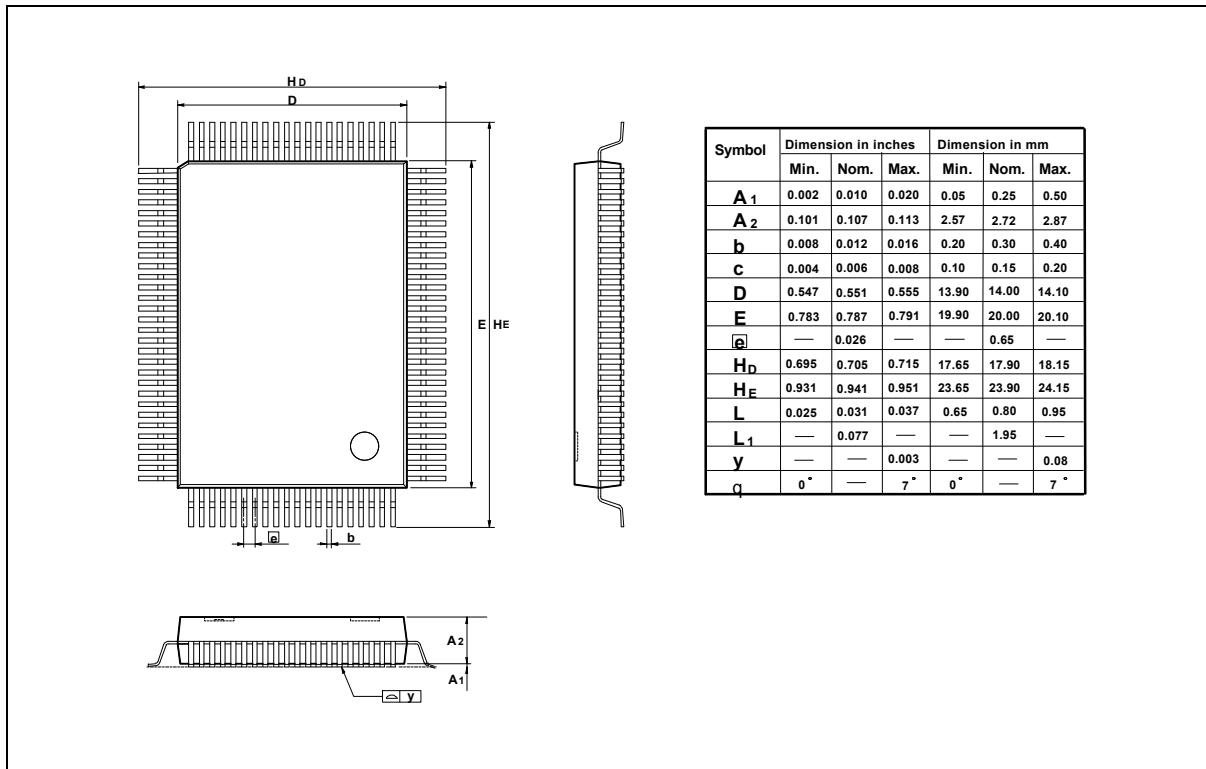
PART NO.	PACKAGE	FOOTPRINT (=L1X2)
W88111AF	PQFP 100	4.8mm
W88111AF-L	PQFP 100	3.9mm
W88111AD	TQFP 100	2.0mm
W88112F	PQFP 100	4.8mm
W88112D	TQFP 100	2.0mm

**PACKAGE DIMENSIONS**

(100-pin QFP, Footprint = 4.8mm, W88111AF/W88112F)



This specification is subject to change without notice.

**Preliminary/Confidential**
**(100-pin QFP, Footprint = 3.9mm, W88111AF-L)**


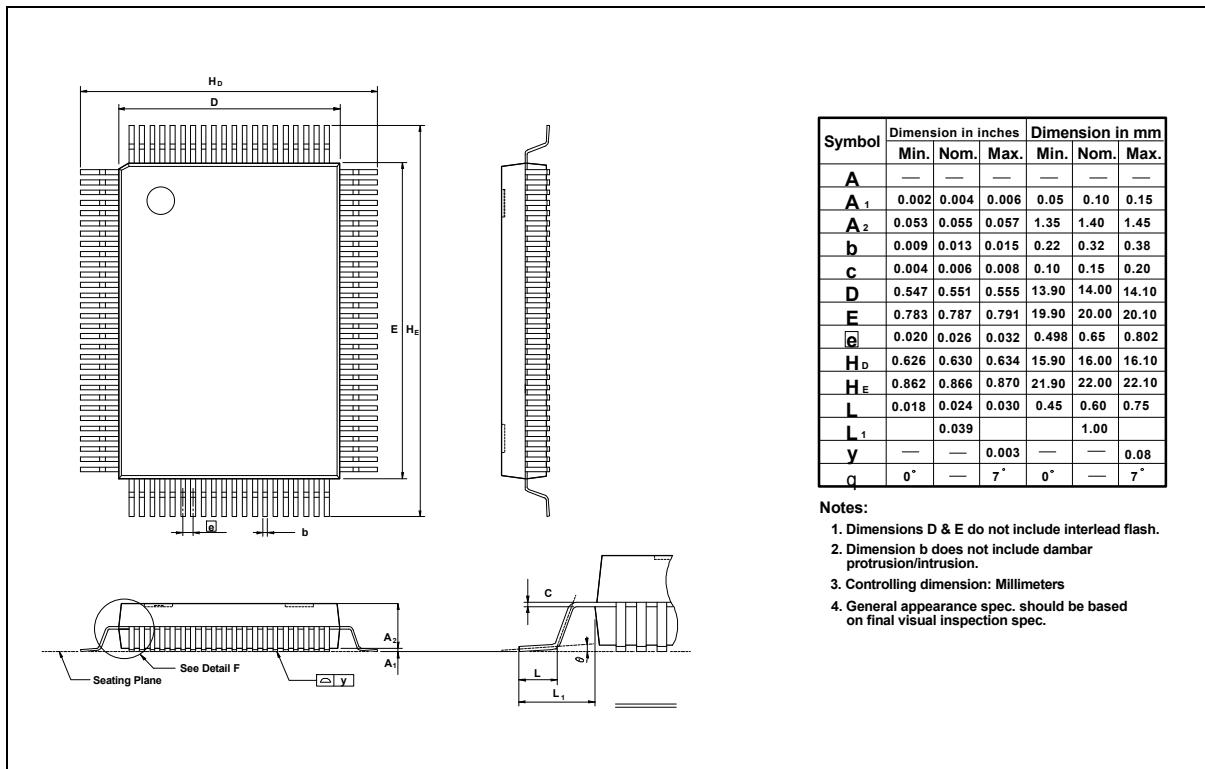


# W88111AF/W88112F ATAPI CD-ROM Decoder & Controller

This specification is subject to change without notice.

Preliminary/Confidential

(100-pin TQFP, Footprint = 2.0mm, W88111AD/W88112D)



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Note: All data and specifications are subject to change without notice.