DP83816 10/100 Mb/s Integrated PCI Ethernet Media Access Controller and Physical Layer (MacPhyter-II™)

1 Device Overview

1.1 Features

- IEEE 802.3 Compliant, PCI V2.2 Media Access Controller (MAC) and Bus Interface Unit (BIU) Supports Traditional Data Rates of 10 Mb/s Ethernet and 100 Mb/s Fast Ethernet (Through Internal PHY)
- Bus Master – Burst Sizes of up to 128 Dwords (512 Bytes)
- BIU Compliant With PC 97 and PC 98 Hardware Design Guides, PC 99 Hardware Design Guide Draft, ACPI v1.0, PCI Power Management Specification v1.1, OnNow Device Class Power Management Reference Specification – Network Device Class v1.0a
- Wake on LAN (WoL) Support Compliant With PC98, PC99, SecureOn, and OnNow, Including Directed Packets, Magic Packet™ VLAN Packets, ARP Packets, Pattern Match Packets, and PHY Status Change
- Clkrun Function for PCI Mobile Design Guide
- Virtual LAN (VLAN) and Long Frame Support
- Support for IEEE 802.3× Full-Duplex Flow Control
- Extremely Flexible Rx Packet Filtration Including: Single Address Perfect Filter With MSb Masking, Broadcast, 512 Entry Multicast and Unicast Hash Table, Deep Packet Pattern Matching for up to Four Unique Patterns
- Statistics Gathered for Support of RFC 1213 (MIB II), RFC 1398 (Ether-Like MIB), IEEE 802.3 LME, Reducing CPU Overhead for Management
- Internal 2KB Transmit and 2KB Receive Data FIFOs
- Serial EEPROM Port With Auto-Load of Configuration Data From EEPROM at Power On
- Flash or PROM Interface for Remote Boot Support
- Fully Integrated IEEE 802.3 3.3-V CMOS Physical Layer
- IEEE 802.3 10BASE-T Transceiver With Integrated Filters IEEE 802.3u 100BASE-TX Transceiver
- Fully integrated ANSI X3.263 Compliant TP-PMD Physical Sublayer With Adaptive Equalization and Baseline Wander Compensation
- IEEE 802.3u Auto-Negotiation – Advertised Features Configurable Through EEPROM
- Full-Duplex Support for 10- and 100-Mb/s Data Rates
- Single 25-MHz Reference Clock
- 144-pin LQFP Package
- Low-Power 3.3-V CMOS Design With Typical Consumption of 383 mW Operating, 297 mW During WoL, and 53 mW During Sleep Mode
- IEEE 802.3u MII for Connecting Alternative External Physical Layer Devices
- 3.3-V Signaling With 5-V Tolerant I/O

1.2 Applications

- PC Motherboards
- PCI Network Interface Cards
- Embedded Systems

1.3 Description

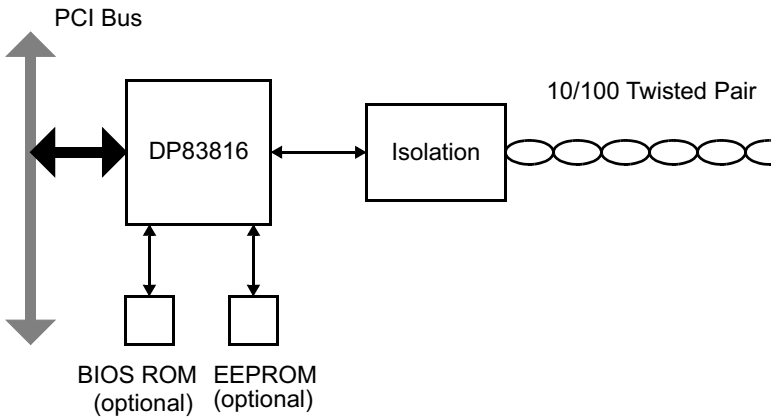
The DP83816 device is a single-chip 10/100 Mb/s ethernet controller for the PCI bus. It is targeted at low-cost, high-volume PC motherboards, adapter cards, and embedded systems. The DP83816 device fully implements the V2.2 33-MHz PCI bus interface for host communications with power management support. Packet descriptors and data are transferred via bus-mastering, reducing the burden on the host CPU. The DP83816 device can support full-duplex 10/100 Mb/s transmission and reception with minimum interframe gap.

Device Information[1]

PART NUMBER	PACKAGE	BODY SIZE (NOM)
DP83816	LQFP (144)	20.00 mm × 20.00 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

1.4 System Diagram



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2 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision D (September 2005) to Revision E	Page
• Added *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section.	1
• Changed the *Thermal Information* table values	11

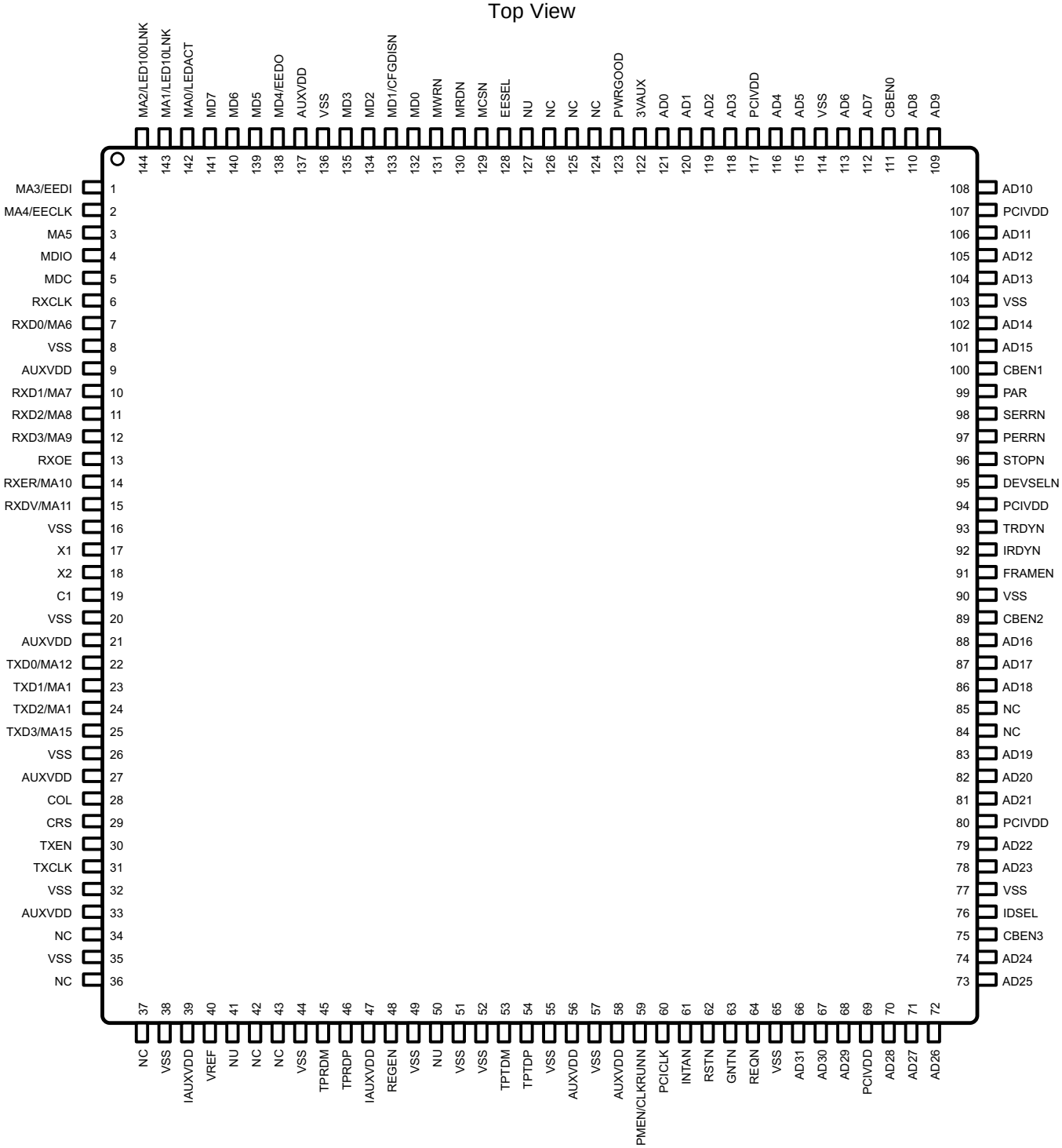
3 Pin Configuration and Functions

The DP83816 pins are classified into the following interface categories (pins of each interface are described in Section 3.1.

- PCI bus interface
- Media independent interface
- 10/100 Mb/s PMD interface
- BIOS ROM and flash interface
- Clock interface
- LED Interface
- Serial EEPROM interface
- Special connections
- Power supply pins

All DP83816 signal pins are I/O cells regardless of the particular use. The tables in Section 3.1 define the functionality of the I/O cells for each pin.

PGE Package
144-Pin LQFP
Top View



NC – No internal connection
NU – Make no external connection

3.1 Pin Attributes

Table 3-1. Pin Functions, PCI Bus Interface

PIN		TYPE(1)	DESCRIPTION
NAME	NO.		
3VAUX	122	I, PD	**PCI Auxiliary Voltage Sense:** This pin is used to sense the presence of a 3.3-V auxiliary supply to define the PME support available. For pin connection, see Section 6.2.1.4.
AD[31–0]	66, 67, 68, 70. 71, 72, 73, 74, 78, 79, 81, 82, 83, 86, 87, 88,101, 102, 104, 105, 106, 108, 109, 110, 112, 113, 115, 116, 118, 119, 120, 121	I/O	**Address and Data:** Multiplexed address and data bus. As a bus master, the DP83816 device drives address during the first bus phase. During subsequent phases, the DP83816 device either reads or writes data, expecting the target to increment its address pointer. As a bus target, the DP83816 device decodes each address on the bus and responds if it is the target being addressed.
CBEN[3–0]	75, 89, 100, 111	I/O	**Bus Command and Byte Enable:** During the address phase, these signals define the *bus command* or the type of bus transaction that takes place. During the data phase these pins indicate which byte lanes contain valid data. CBEN[0] applies to byte 0 (bits 7–0) and CBEN[3] applies to byte 3 (bits 31–24) in the little-endian mode. In big-endian mode, CBEN[3] applies to byte 0 (bits 31–24) and CBEN[0] applies to byte 3 (bits 7–0).
PCICLK	60	I	**Clock:** This PCI bus clock provides timing for all bus phases. The rising edge defines the start of each phase. The clock frequency ranges from 0 to 33 MHz.
DEVSELN	95	I/O	**Device Select:** As a bus master, the DP83816 device samples this signal to ensure that the destination address for the data transfer is recognized by a PCI target. As a target, the DP83816 device asserts this signal low when it recognizes its address after FRAMEN is asserted.
FRAMEN	91	I/O	**Frame:** As a bus master, this signal is asserted low to indicate the beginning and duration of a bus transaction. Data transfer takes place when this signal is asserted. The signal is de-asserted before the transaction is in its final phase. As a target, the device monitors this signal before decoding the address to check if the current transaction is addressed.
GNTN	63	I	**Grant:** This signal is asserted low to indicate to the DP83816 device that it has been granted ownership of the bus by the central arbiter. This input is used when the DP83816 device is acting as a bus master.
IDSEL	76	I	**Initialization Device Select:** This pin is sampled by the DP83816 device to identify when configuration read and write accesses are intended.
INTAN	61	O, OD	**Interrupt A:** This signal is asserted low when an interrupt condition occurs as defined in the interrupt status, interrupt mask, and interrupt enable registers.
IRDYN	92	I/O	**Initiator Ready:** When the DP83816 device is a bus master, this signal is asserted low when the DP83816 device is ready to complete the current data-phase transaction. This signal is used in conjunction with the TRYDN signal. A data transaction takes place at the rising edge of PCICLK when both IRDYN and TRDYN are asserted low. When the DP83816 device is a target, this signal indicates that the master has put the data on the bus.
PAR	99	I/O	**Parity:** This signal indicates even parity across AD[31–0] and CBEN[3–0] including the PAR pin. As a master, PAR is asserted during address and write-data phases. As a target, PAR is asserted during read-data phases.
PERRN	97	I/O	**Parity Error:** The DP83816 device as a master or target asserts this signal low to indicate a parity error on any incoming data (except for special cycles). As a bus master, the device monitors this signal on all write operations (except for special cycles).
REQN	64	O	**Request:** The DP83816 device asserts this signal low to request ownership of the bus from the central arbiter.
RSTN	62	I	**Reset:** When this signal is asserted, all PCI bus outputs of the DP83816 device are in te high-impedance state and the device is put into a known state.
SERRN	98	I/O	**System Error:** This signal, if enabled, is asserted low by the DP83816 device during address parity errors and system errors.
STOPN	96	I/O	**Stop:** This signal is asserted low by the target device to request the master device to stop the current transaction.

(1) I = input, O = output, I/O = input/output, OD = open-drain, PD = pulldown

Table 3-1. Pin Functions, PCI Bus Interface (continued)

PIN		TYPE(1)	DESCRIPTION
NAME	NO.		
TRDYN	93	I/O	**Target Ready:** When the DP83816 device is a bus master, this signal indicates that the target is ready for the data during write operation or with the data during read operation. When the DP83816 device is a target, this signal is asserted low when the (target) device is ready to complete the current data-phase transaction. This signal is used in conjunction with the IRDYN signal. Data transaction takes place at the rising edge of PCICLK when both IRDYN and TRDYN are asserted low.
PMEN/ CLKRUNN	59	I/O, OD	**Power Management Event and Clock Run Function:** This pin is a dual-function pin. The function of this pin is determined by the CLKRUN_EN bit 0 of the CLKRUN Control and Status register (CCSR). Default operation of this pin is PMEN. **Power Management Event:** This signal is asserted low by the DP83816 device to indicate that a power management event has occurred. For pin connection, see Section 6.2.1.4. **Clock Run Function:** In this mode, this pin is used to indicate when the PCICLK will be stopped.
PWRGOOD	123	I, PD	**PCI Bus Power Good:** Connected to PCI bus 3.3-V power, this pin is used to sense the presence of PCI bus power during the D3 power-management state.

Table 3-2. Pin Functions, Media Independent Interface(1)

PIN		TYPE(2)	DESCRIPTION
NAME	NO.		
COL	28	I	**Collision Detect:** The COL signal is asserted high asynchronously by the external PMD on detection of a collision on the medium. It remains asserted as long as the collision condition persists.
CRS	29	I	**Carrier Sense:** This signal is asserted high asynchronously by the external PMD on detection of a non-idle medium.
MDC	5	O	**Management Data Clock:** Clock signal with a maximum rate of 2.5 MHz used to transfer management data for the external PMD on the MDIO pin.
MDIO	4	I/O	**Management Data I/O:** Bidirectional signal used to transfer management information for the external PMD. (See Section 5.4.1.4 for details on connections when MII is used.)
RXCLK	6	I	**Receive Clock:** A continuous clock, sourced by an external PMD device, that is recovered from the incoming data. During 100-Mb/s operation RXCLK is 25 MHz, and during 10 Mb/s RXCLK is 2.5 MHz.
RXD3/MA9 RXD2/MA8 RXD1/MA7 RXD0/MA6	12 11 10 7	I/O	**I: BIOS ROM Address:** During external BIOS ROM access, these signals become part of the ROM address. **O: Receive Data:** Sourced from an external PMD, that contains data aligned on nibble boundaries and are driven synchronous to RXCLK. RXD3 is the most-significant bit and RXD0 is the least-significant bit.
RXDV/MA11	15	I/O	**I: Receive Data Valid:** Indicates that the external PMD is presenting recovered and decoded nibbles on the RXD signals, and that RXCLK is synchronous to the recovered data in 100-Mb/s operation. This signal encompasses the frame, starting with the start-of-frame delimiter (JK) and excluding any end-of-frame delimiter (TR). **O: BIOS ROM Address:** During external BIOS ROM access, this signal becomes part of the ROM address.
RXER/MA10	14	I/O	**I: Receive Error:** Asserted high synchronously by the external PMD whenever it detects a media error and RXDV is asserted in 100-Mb/s operation. **O: BIOS ROM Address:** During external BIOS ROM access, this signal becomes part of the ROM address.
RXOE	13	O	**Receive Output Enable:** Used to disable an external PMD while the BIOS ROM is being accessed.
TXCLK	31	I	**Transmit Clock:** A continuous clock that is sourced by the external PMD. During 100-Mb/s operation this is 25 MHz ±100 ppm. During 10-Mb/s operation this clock is 2.5 MHz ±100 ppm.
TXD3/MA15 TXD2/MA1 TXD1/MA1 TXD0/MA12	25 24 23 22	O	**Transmit Data:** Signals which are driven synchronously to the TXCLK for transmission to the external PMD. TXD3 is the most-significant bit and TXD0 is the least-significant bit. **BIOS ROM Address:** During external BIOS ROM access, these signals become part of the ROM address.
TXEN	30	O	**Transmit Enable:** This signal is synchronous to TXCLK and provides precise framing for data carried on TXD[3–0] for the external PMD. It is asserted when TXD[3–0] contains valid data to be transmitted.

(1) MII is normally in the high-impedance state, unless enabled by CFG: EXT_PHY. See *Section 5.6.3.2*.
(2) I = input, O = output, I/O = input/output

Table 3-3. Pin Functions, 10/100-Mb/s PMD Interface

PIN		TYPE(1)	DESCRIPTION
NAME	NO.		
TPTDP TPTDM	54 53	I/O	**Transmit Data:** Differential common-output driver. This differential common output is configurable to either 10BASE-T or 100BASE-TX signaling: *10BASE-T:* Transmission of Manchester-encoded 10BASE-T packet data as well as link pulses (including fast link pulses for auto-negotiation purposes). *100BASE-TX:* Transmission of ANSI X3T12 compliant MLT-3 data. The DP83816 device automatically configures this common output driver for the proper signal type as a result of either forced configuration or auto-negotiation.
TPRDP TPRDM	46 45	I/O	**Receive Data:** Differential common-input buffer. This differential common input can be configured to accept either 100BASE-TX or 10BASE-T signaling: *10BASE-T:* Reception of Manchester-encoded 10BASE-T packet data as well as normal link pulses and fast link pulses for auto-negotiation purposes. *100BASE-TX:* Reception of ANSI X3T12 compliant scrambled MLT-3 data. The DP83816 device automatically configures this common input buffer to accept the proper signal type as a result of either forced configuration or auto-negotiation.

(1) I/O = input/output

Table 3-4. Pin Functions, BIOS ROM(1) or Flash Interface

PIN		TYPE(2)	DESCRIPTION
NAME	NO.		
MCSN	129	O	**BIOS ROM or Flash Chip Select:** During a BIOS ROM or flash access, this signal is used to select the ROM device.
MD7, MD6 MD5, MD4/EEDO, MD3 MD2, MD1/CFGDISN, MD0	141, 140, 139, 138, 135, 134, 133, 132	I/O, PD I/O, PU	**BIOS ROM or Flash Data Bus:** During a BIOS ROM or flash access, these signals are used to transfer data to or from the ROM or flash device.
MA5, MA4/EECLK, MA3/EEDI, MA2/LED100LNK, MA1/LED10LNK, MA0/LEDACT	3, 2, 1, 144, 143, 142	O	BIOS ROM or Flash Address: During a BIOS ROM or flash access, these signals are used to drive the ROM or flash address.
MWRN	131	O	**BIOS ROM or Flash Write:** During a BIOS ROM or flash access, this signal is used to enable data to be written to the flash device.
MRDN	130	O	**BIOS ROM or Flash Read:** During a BIOS ROM or flash access, this signal is used to enable data to be read from the flash device.

(1) The DP83816 device supports the NM27LV010 EPROM for the BIOS ROM interface device.
(2) O = output, I/O = input/output, PD = pulldown, PU = pullup

Table 3-5. Pin Functions, Clock Interface

PIN		TYPE(1)	DESCRIPTION
NAME	NO.		
X1	17	I	**Crystal or Oscillator Input:** This pin is the primary clock reference input for the DP83816 device and must be connected to a 25-MHz 0.005% (50-ppm) clock source. The DP83816 device supports either an external crystal resonator connected across pins X1 and X2, or an external CMOS-level oscillator source connected to pin X1 only.
X2	18	O	**Crystal Output:** This pin is used in conjunction with the X1 pin to connect to an external 25-MHz crystal resonator device. This pin must be left unconnected if an external CMOS oscillator clock source is used. For more information, see the definition for pin X1.

(1) I = input, O = output

Table 3-6. Pin Functions, LED Interface

PIN		TYPE(1)	DESCRIPTION
NAME	NO.		
LEDACT/MA0	142	O	**TX/RX Activity:** This pin is an output indicating transmit/receive activity. This pin is driven low to indicate active transmission or reception, and can be used to drive a low-current LED (<6 mA). The activity event is stretched to a minimum duration of approximately 50 ms.
LED100LNK/MA2	144	O	**100 Mb/s Link:** This pin is an output indicating the 100-Mb/s link status. This pin is driven low to indicate good-link status for 100-Mb/s operation, and can be used to drive a low-current LED (<6 mA).
LED10LNK/MA1	143	O	**10 Mb/s Link:** This pin is an output indicating the 10-Mb/s link status. This pin is driven low to indicate good-link status for 10-Mb/s operation, and can be used to drive a low-current LED (<6 mA).

(1) O = output

Table 3-7. Pin Functions, Serial EEPROM Interface(1)

PIN		TYPE(2)	DESCRIPTION
NAME	NO.		
EESEL	128	O	**EEPROM Chip Select:** This signal is used to enable an external EEPROM device.
EECLK/MA4	2	O	**EEPROM Clock:** During an EEPROM access (EESEL asserted), this pin is an output used to drive the serial clock to an external EEPROM device.
EEDI/MA3	1	O	**EEPROM Data In:** During an EEPROM access (EESEL asserted), this pin is an output used to drive opcode, address, and data to an external serial EEPROM device.
EEDO/MD4	138	I, PU	**EEPROM Data Out:** During an EEPROM access (EESEL asserted), this pin is an input used to retrieve EEPROM serial-read data.
MD1/CFGDISN	133	I/O	**Configuration Disable:** When pulled low at power-on time, disables the loading of configuration data from the EEPROM. Use 1 kΩ to ground to disable configuration loading.

(1) The DP83816 device supports NM93C46 for the EEPROM device.
(2) I = input, O = output, I/O = input/output, PU = pullup

Table 3-8. Pin Functions, Special Connections

PIN		TYPE(1)	DESCRIPTION
NAME	NO.		
VREF	40	I	**Band-Gap Reference:** External current reference resistor for internal PHY band-gap circuitry. The value of this resistor is 10 kΩ 1% metal film (100 ppm/°C) which must be connected from the VREF pin to analog ground.
NC	34, 42, 43, 36, 37, 84, 85,124, 125, 126	—	No connect
NU	41, 50, 127	—	These pins are reserved and cannot be connected to any external logic or net.
REGEN	48	PD	Reserved and must not be connected to any external logic or net.

(1) I = input, PU = pulldown

Table 3-9. Pin Functions, Power Supply Pins

PIN		TYPE(1)	DESCRIPTION
NAME	NO.		
C1	19	I	Connect to GND through 10-µF and 0.1-µF external capacitors in parallel.
IAUXVDD	39, 47	I	Connect to isolated Aux 3.3-V supply VDD
AUXVDD	9, 21, 27, 33, 56, 58, 137	I	Connect to Aux 3.3-V supply VDD
PCIVDD	69, 80, 94, 107, 117	I	PCI VDD – connect to PCI bus 3.3-V VDD
VSS	8, 16, 20, 26, 32, 35, 38, 44, 49, 51, 52, 55, 57, 65, 77, 90, 103, 114, 136	I	VSS

(1) I = input

4 Specifications

4.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

		MIN	MAX	UNIT
V_{DD}	Supply voltage	–0.5	3.6	V
V_{IN}	DC input voltage	–0.5	5.5	V
V_{OUT}	DC output voltage	–0.5	V_{DD} + 0.5	V
P_D	Power dissipation		504	mW
T_{stg}	Storage temperature	–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

4.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)(2)	±1000	V
		Machine model	±200	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) R_{ZAP} = 1.5 kΩ, C_{ZAP} = 120 pF

4.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
V_{DD}	Supply voltage	3.3		0.3	V
T_A	Normal operating temperature	0		70	°C

4.4 Thermal Information

THERMAL METRIC(1)		DP83816 PGE (LQFP) 144 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	47.2	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	10.5	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	28.3	°C/W
ψ_{JT}	Junction-to-top characterization parameter	0.2	°C/W
ψ_{JB}	Junction-to-board characterization parameter	27.8	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, SPRA953.

4.5 Electrical Characteristics – DC Specifications

T_A = 0°C to 70°C, V_{DD} = 3.3 V ±0.3 V (unless otherwise specified)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{OH}	Minimum high-level output voltage	I_{OH} = –6 mA (1)	V_{DD} – 0.5			V
V_{OL}	Maximum low-level output voltage	I_{OL} = 6 mA (1)			0.4	V
V_{IH}	Minimum high-level input voltage	See (1)	2			V
V_{IL}	Maximum low-level input voltage	See (1)			0.8	V
I_{IN}	Input current	V_{IN} = V_{DD} or GND	–10		10	µA
I_{OZ}	Output leakage current	V_{OUT} = V_{DD} or GND, high-impedance state	–10		10	µA
I_{DD}	Operating supply current	I_{OUT} = 0 mA (2)		116	140	mA
	WOL standby			90	105	mA
	Sleep mode			16	20	mA
R_{INdiff}	Differential input resistance	From TPRDP to TPRDM	5	6		kΩ
V_{TPTD_100}	100-Mb/s transmit voltage	From TPTDP to TPTDM	0.95	1	1.05	V
$V_{TPTDsym}$	100-Mb/s transmit voltage symmetry	From TPTDP to TPTDM		±2%		
V_{TPTD_10}	10-Mb/s transmit voltage	From TPTDP to TPTDM	2.2	2.5	2.8	V
C_{IN}	CMOS input capacitance			8		pF
C_{OUT}	CMOS output capacitance			8		pF
SD_{THon}	100BASE-TX signal detect turnon threshold	From TPRDP to TPRDM			1000	mV diff pk-pk
SD_{THoff}	100BASE-TX signal detect turnoff threshold	From TPRDP to TPRDM	200			mV diff pk-pk
V_{TH1}	10BASE-T receive threshold	From TPRDP to TPRDM	300		585	mV

(1) These values ensure 3.3-V and 5-V compatibility.
(2) For I_{DD} measurements, outputs are not loaded.

4.6 AC Timing Requirements

PARAMETER			MIN	TYP	MAX	UNIT
PCI CLOCK TIMING (See Figure 4-1)						
t_1	PCICLK low time		12			ns
t_2	PCICLK high time		12			ns
t_3	PCICLK cycle time		30		∞	ns
CLOCK TIMING (See Figure 4-2)						
t_1	X1 low time		16			ns
t_2	X1 high time		16			ns
t_3	X1 cycle time		40		40	ns
POWER-ON RESET (PCI ACTIVE) (See Figure 4-3)						
t_1	RSTN active duration from PCICLK stable		1			ms
t_2	Reset disable to first PCI cycle	EE enabled	1500			µs
		EE disabled	1			
NON-POWER-ON RESET (See Figure 4-4)						
t_1	RSTN to output float				40	ns
POR PCI INACTIVE (See Figure 4-5)						
t_1	VDD stable to EE access VDD indicates the digital supply (AUX power plane, except PCI bus power)				60	µs
t_2	EE configuration load duration				2000	µs

AC Timing Requirements *(continued)*

	PARAMETER	MIN	TYP	MAX	UNIT
PCI BUS CYCLES (See Figure 4-6 through Figure 4-14)					
t_1	Input setup time	7			ns
t_2	Input hold time	0			ns
t_3	Output valid delay	2		11	ns
t_4	Output float delay (t_{off} time)			28	ns
t_5	Output valid delay for REQN – point to point	2		12	ns
t_6	Input setup time for GNTN – point to point	10			ns
EEPROM AUTO-LOAD (See Figure 4-15)					
t_1	EECLK cycle time	4			µs
t_2	EECLK delay from EESEL valid	1			µs
t_3	EECLK low to EESEL invalid	2			µs
t_4	EECLK to EEDO valid			2	µs
t_5	EEDI setup time to EECLK	2			µs
t_6	EEDI hold time from EECLK	2			µs
BOOT PROM OR FLASH (See Figure 4-16)					
t_1	Data setup time to MRDN invalid	20			ns
t_2	Address setup time to MRDN valid		30		ns
t_3	Address hold time from MRDN invalid		0		ns
t_4	Address invalid from MWRN valid		180		ns
t_5	MRDN pulse duration		180		ns
t_6	Data hold time from MRDN invalid	0			ns
t_7	Data invalid from MWRN invalid		60		ns
t_8	Data valid to MWRN valid		30		ns
t_9	Address setup time to MWRN valid		30		ns
t_{10}	MRDN invalid to MWRN valid	150			ns
t_{11}	MWRN pulse width		150		ns
t_{12}	Address and MRDN cycle time		210		ns
t_{13}	MCSN valid to MRDN valid		30		ns
t_{14}	MCSN invalid to MRDN invalid		0		ns
t_{15}	MCSN valid to MWRN valid		30		ns
t_{16}	MWRN invalid to MCSN invalid		30		ns
t_{17}	MCSN valid to address valid		0		ns
100BASE-TX TRANSMIT (See Figure 4-17)					
T2.8.1	100-Mb/s TPTDP, TPTDM rise and fall times	3	4	6	ns
	100-Mb/s rise and fall mismatch			500	ps
T2.8.2	100 Mb/s TPTDP, TPTDM transmit jitter			1.4	ns
10BASE-T TRANSMIT END OF PACKET (See Figure 4-18)					
T2.14.1	End-of-packet high time (with 0 ending bit)	300			ns
T2.14.2	End-of-packet high time (with 1 ending bit)	250			ns
10-Mb/s JABBER TIMING (See Figure 4-19)					
T2.18.1	Jabber activation time		85		ms
T2.18.2	Jabber deactivation time		500		ms
10BASE-T NORMAL LINK PULSE (See Figure 4-20)					
T2.19.1	Pulse duration		100		ns
T2.19.2	Pulse period		16		ms

AC Timing Requirements *(continued)*

PARAMETER		MIN	TYP	MAX	UNIT
AUTO-NEGOTIATION FAST LINK PULSE (FLP) (See Figure 4-21)					
T2.20.1	Clock data-pulse duration		100		ns
T2.20.2	Clock-pulse to clock-pulse period		125		µs
T2.20.3	Clock-pulse to data-pulse period		62.5		µs
T2.20.4	Burst duration		2		ms
T2.20.5	FLP-burst to FLP-burst period		16		ms
MEDIA-INDEPENDENT INTERFACE (MII) (See Figure 4-22)					
t_1	MDC to MDIO valid	0		300	ns
t_2	MDIO to MDC setup	10		10	ns
t_3	MDIO from MDC hold	10			ns
t_4	RXD to RXCLK setup	10			ns
t_5	RXD from RXCLK hold	10			ns
t_6	RXDV, RXER to RXCLK setup	10			ns
t_7	RXDV, RXER from RXCLK hold	10			ns
t_8	TXCLK to TXD valid	0		25	ns
t_9	TXCLK to TXEN valid	0		25	ns

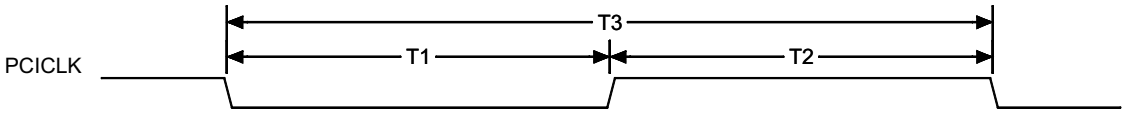


Figure 4-1. PCI Clock Timing (see *PCI CLOCK TIMING* in Section 4.6)

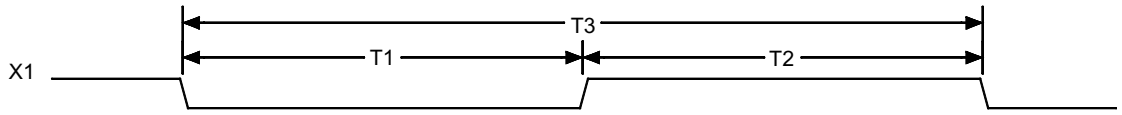
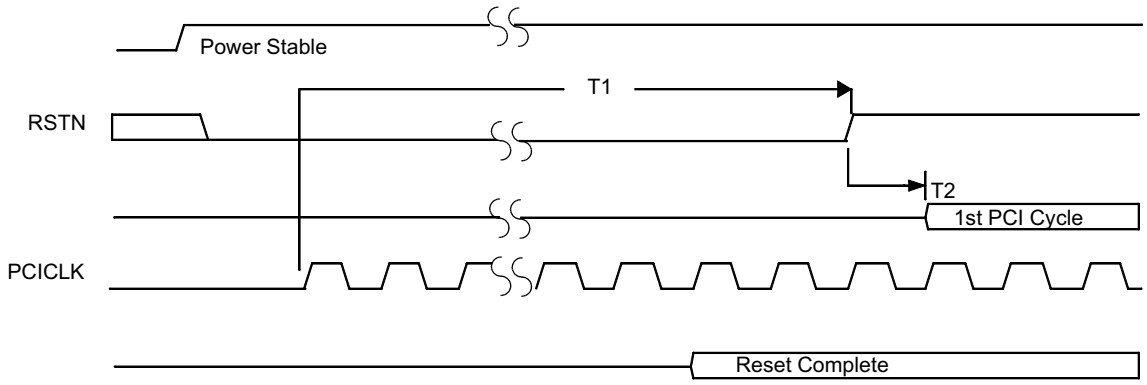


Figure 4-2. Clock Timing (see *CLOCK TIMING* in Section 4.6)

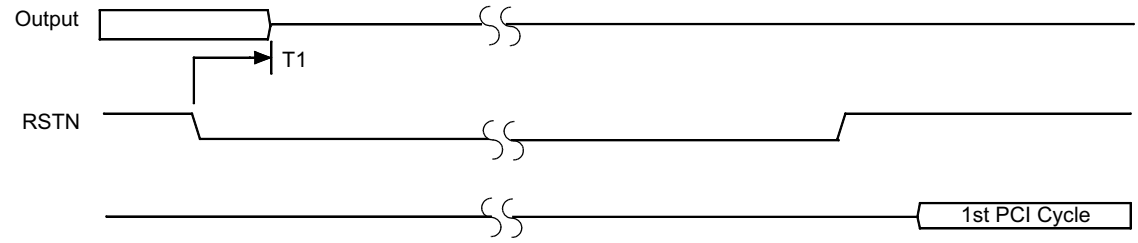


Note: Minimum reset complete time is a function of the PCI-, transmit-, and receive-clock frequencies.

Note: Minimum access after reset is dependent on PCI clock frequency. Accesses to the DP83816 device during this period are ignored.

Note: EE is disabled for non-power-on reset.

Figure 4-3. Power-On Reset (PCI Active) (see *POWER-ON RESET (PCI ACTIVE)* in Section 4.6)



Note: Minimum reset-complete time is a function of the PCI-, transmit-, and receive-clock frequencies.

Figure 4-4. Non-Power-On Reset (see *NON-POWER-ON RESET)* in Section 4.6)

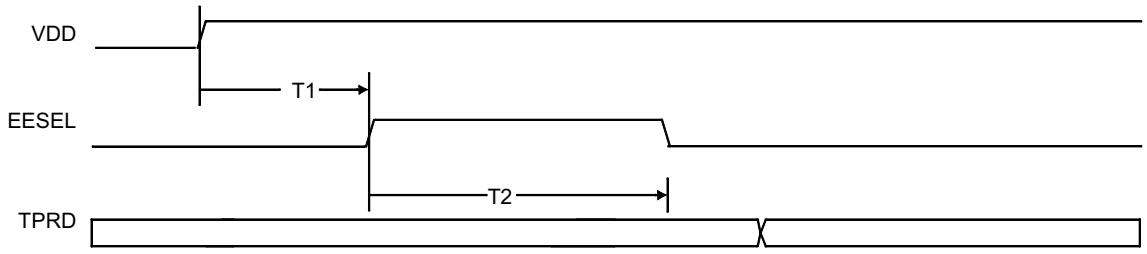


Figure 4-5. POR PCI Inactive (see *POR PCI INACTIVE* in Section 4.6)

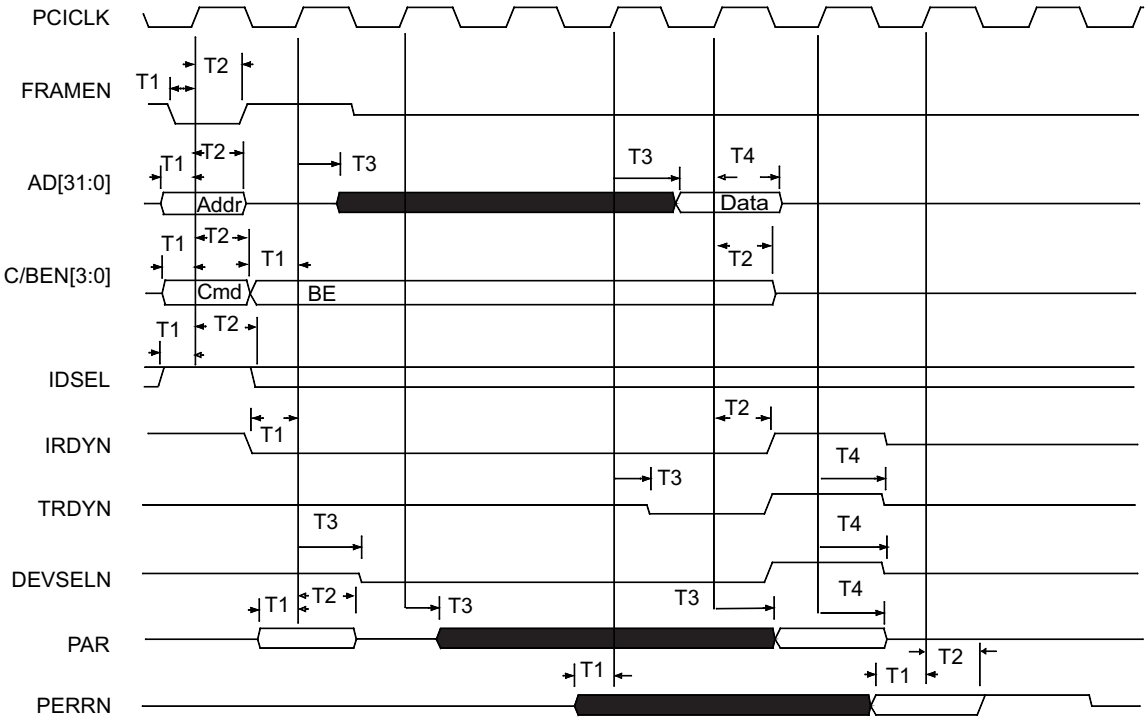


Figure 4-6. PCI Configuration Read (see *PCI BUS CYCLES* in Section 4.6)

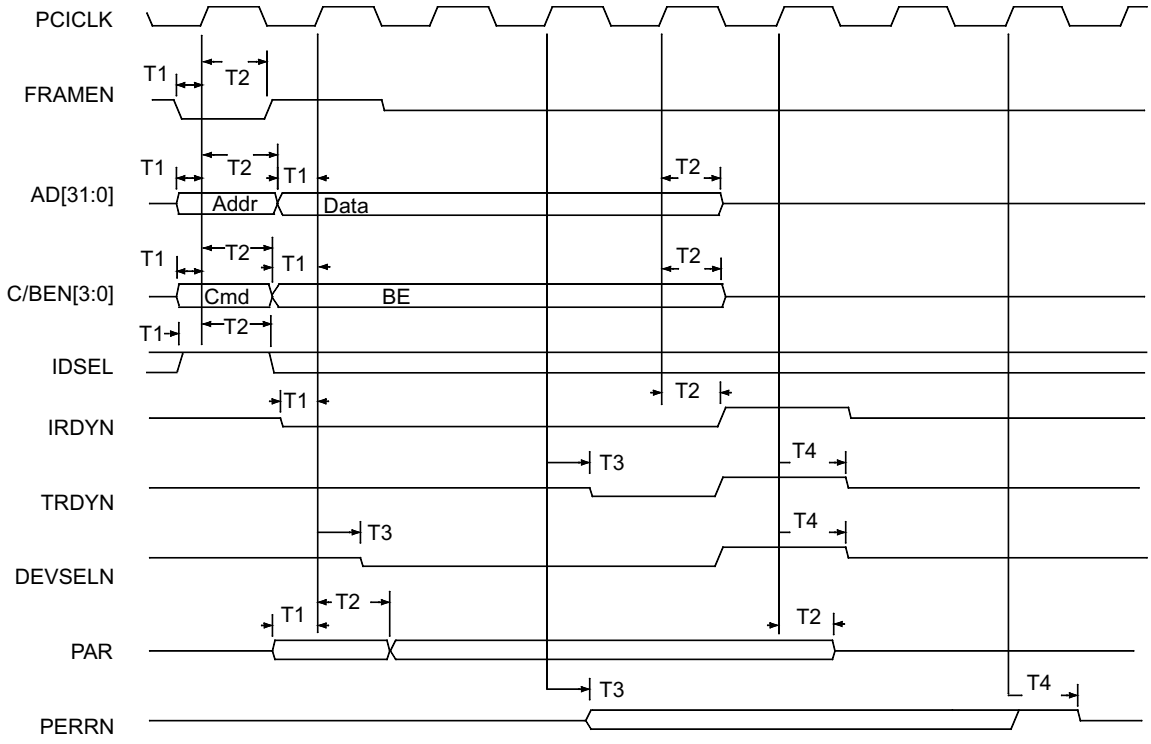


Figure 4-7. PCI Configuration Write (see *PCI BUS CYCLES* in Section 4.6)

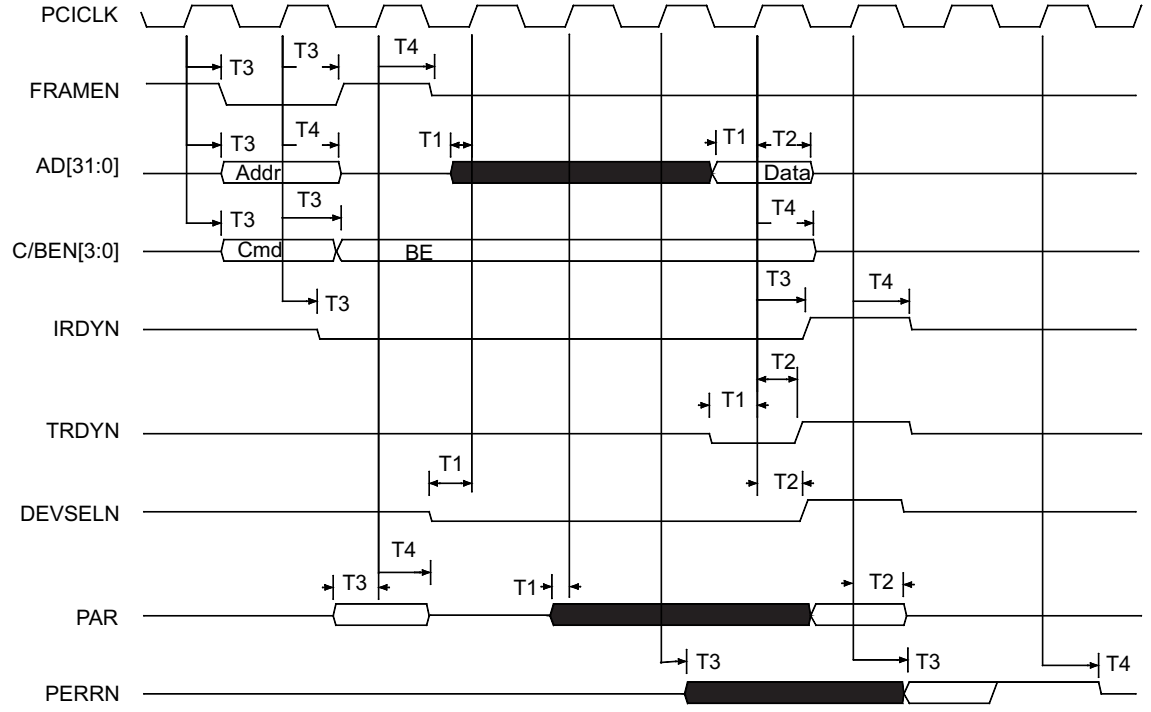


Figure 4-8. PCI Bus Master Read (see *PCI BUS CYCLES* in Section 4.6)

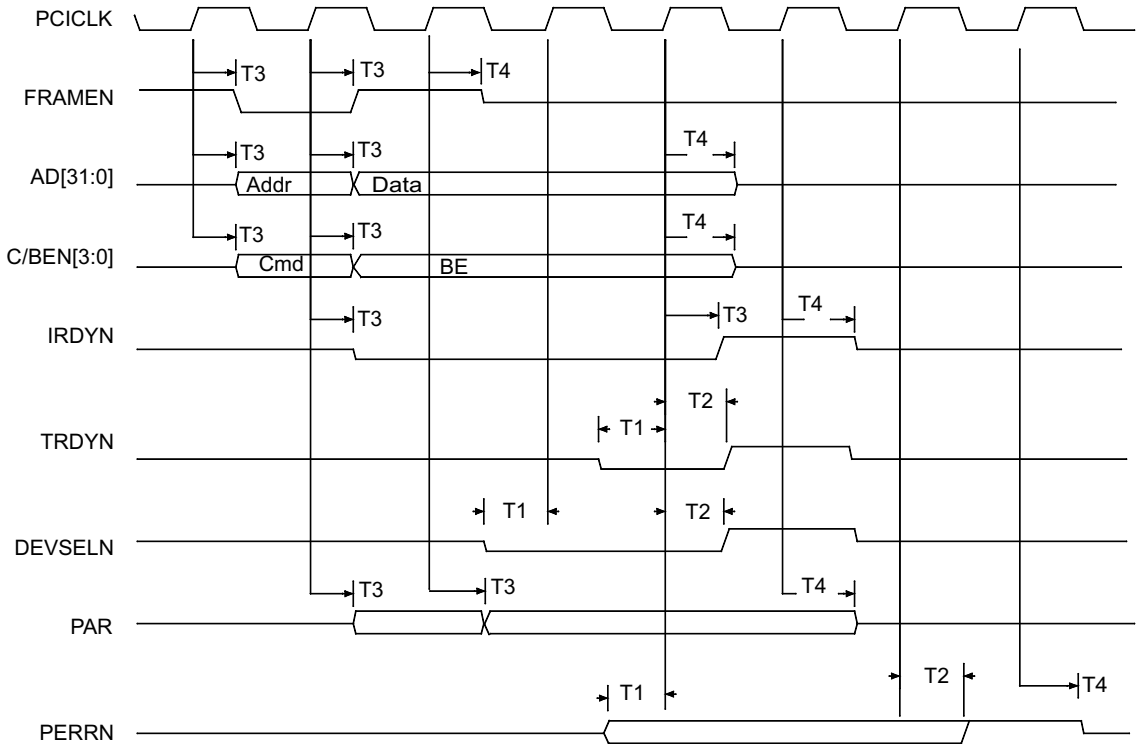


Figure 4-9. PCI Bus Master Write (see *PCI BUS CYCLES* in Section 4.6)

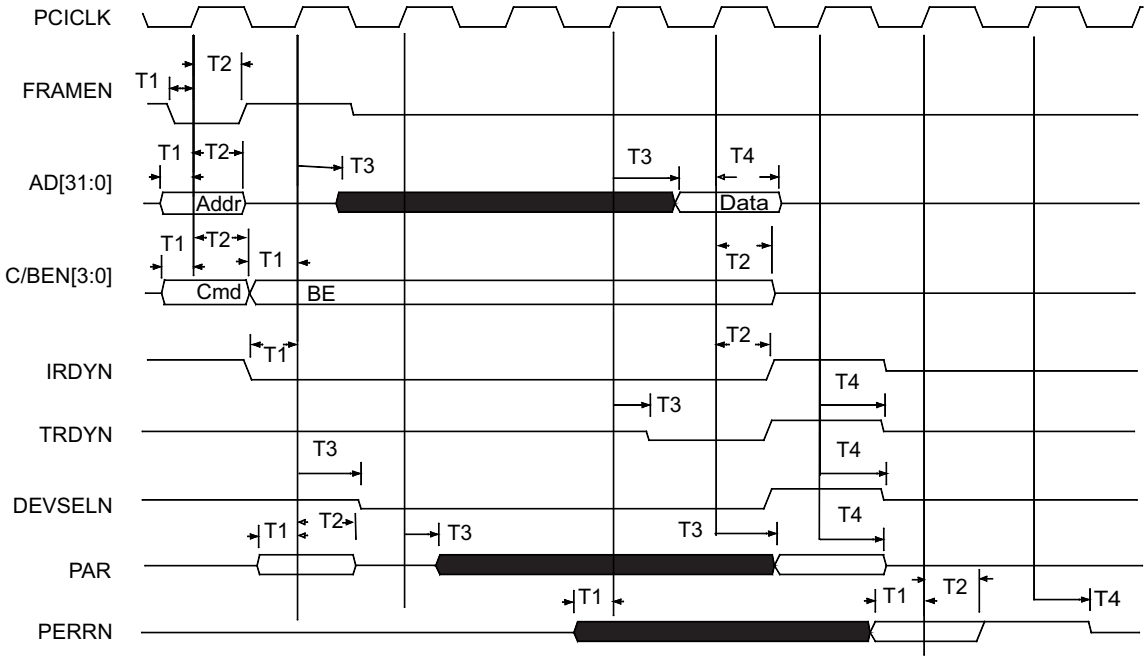


Figure 4-10. PCI Target Read (see *PCI BUS CYCLES* in Section 4.6)

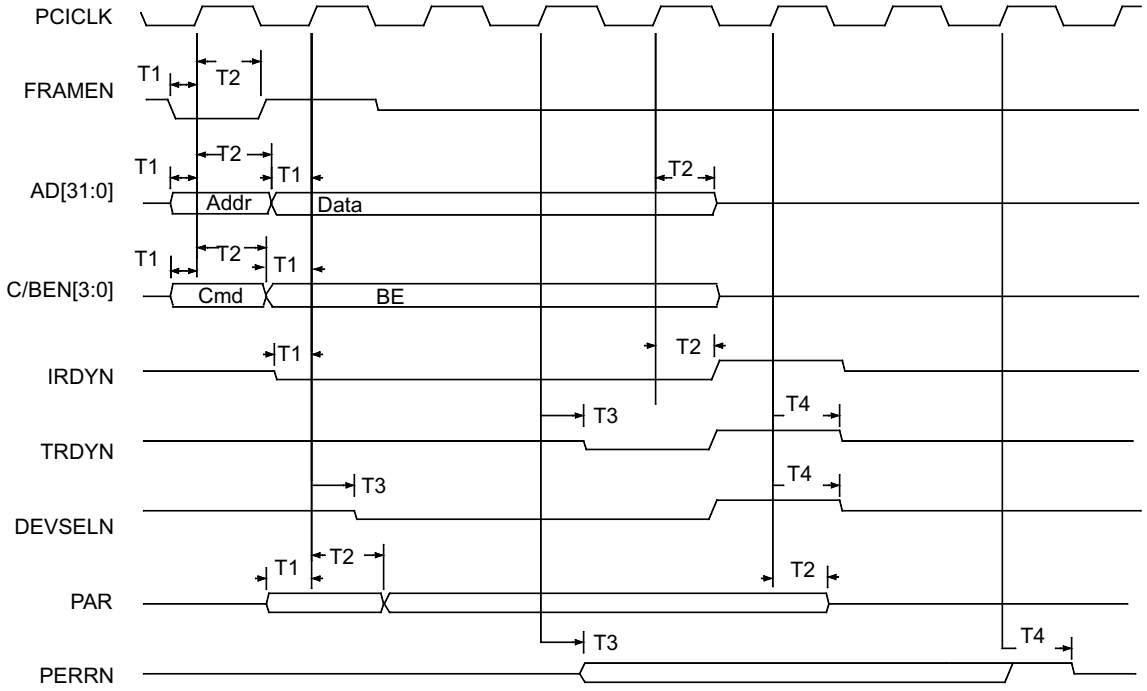


Figure 4-11. PCI Target Write (see *PCI BUS CYCLES* in Section 4.6)

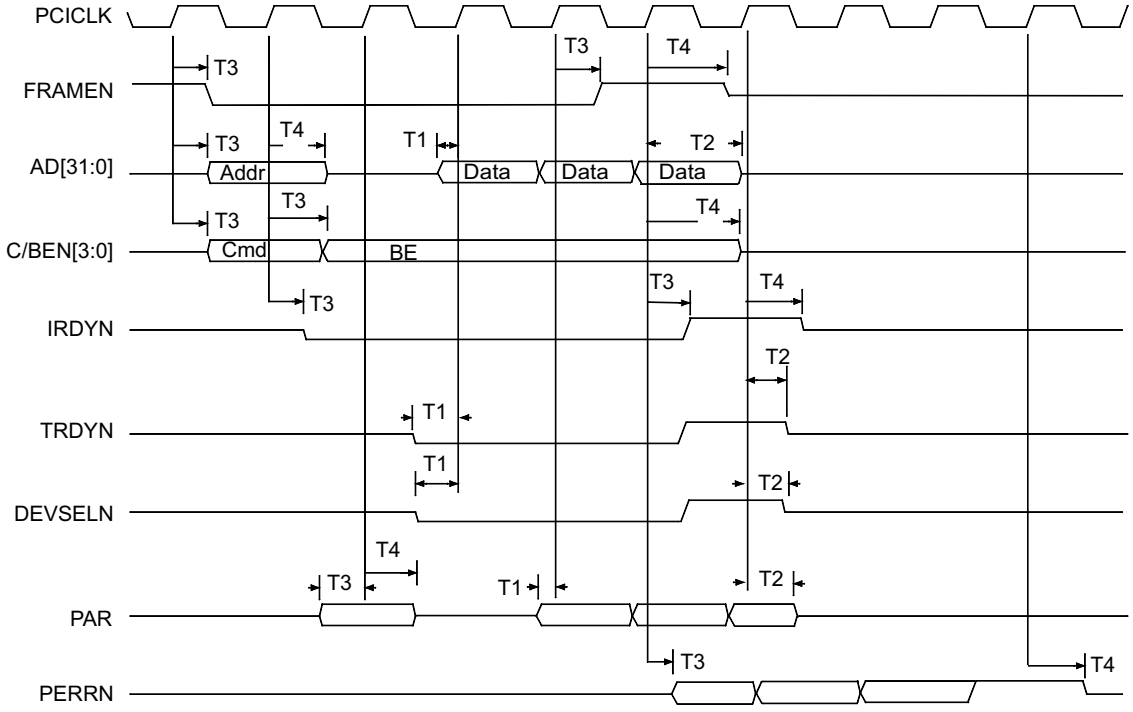


Figure 4-12. PCI Bus Master Burst Read (see *PCI BUS CYCLES* in Section 4.6)

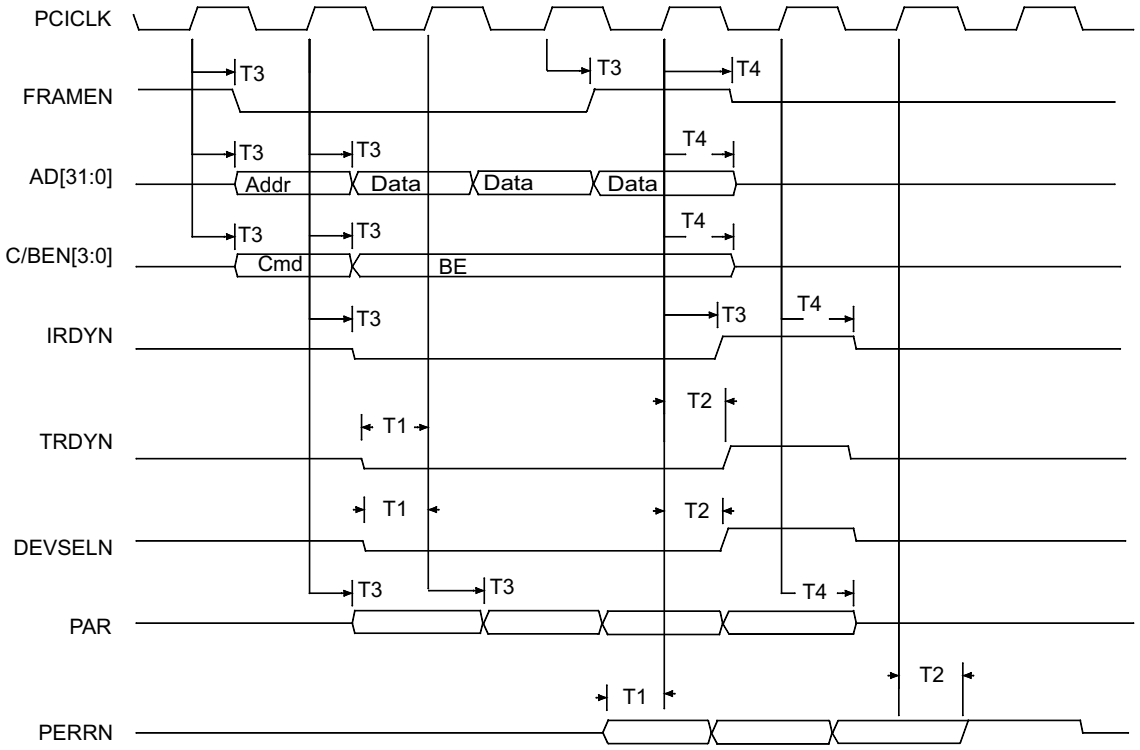


Figure 4-13. PCI Bus Master Burst Write (see *PCI BUS CYCLES* in Section 4.6)

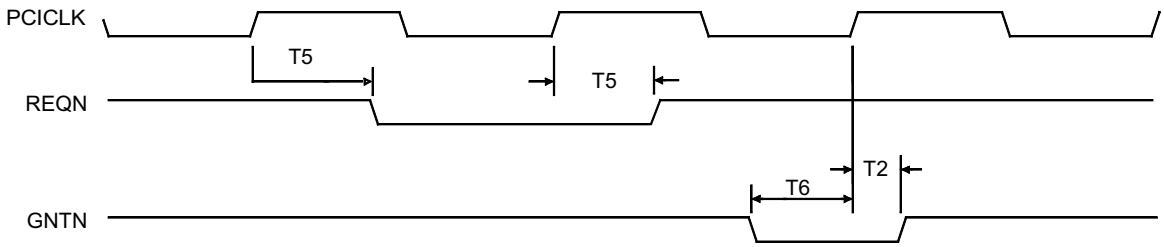


Figure 4-14. PCI Bus Arbitration (see *PCI BUS CYCLES* in Section 4.6)

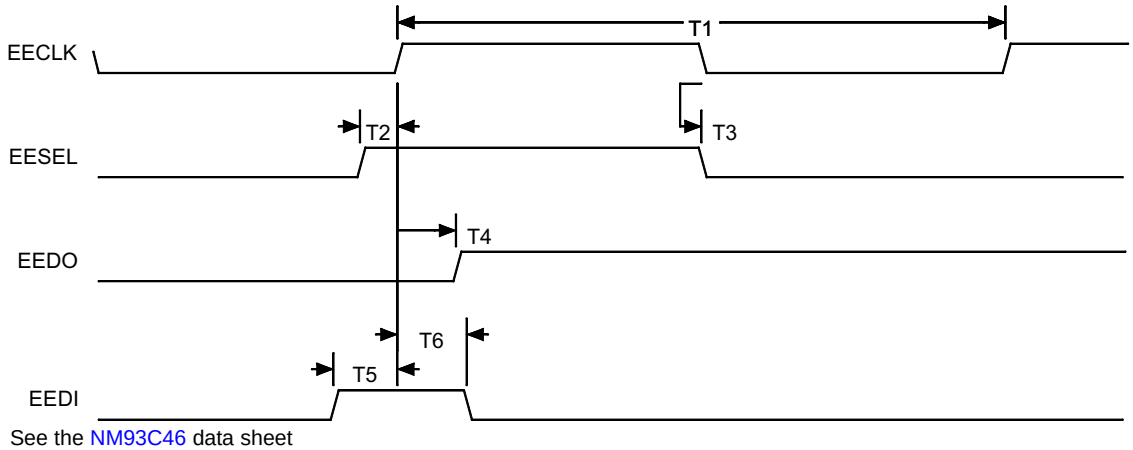
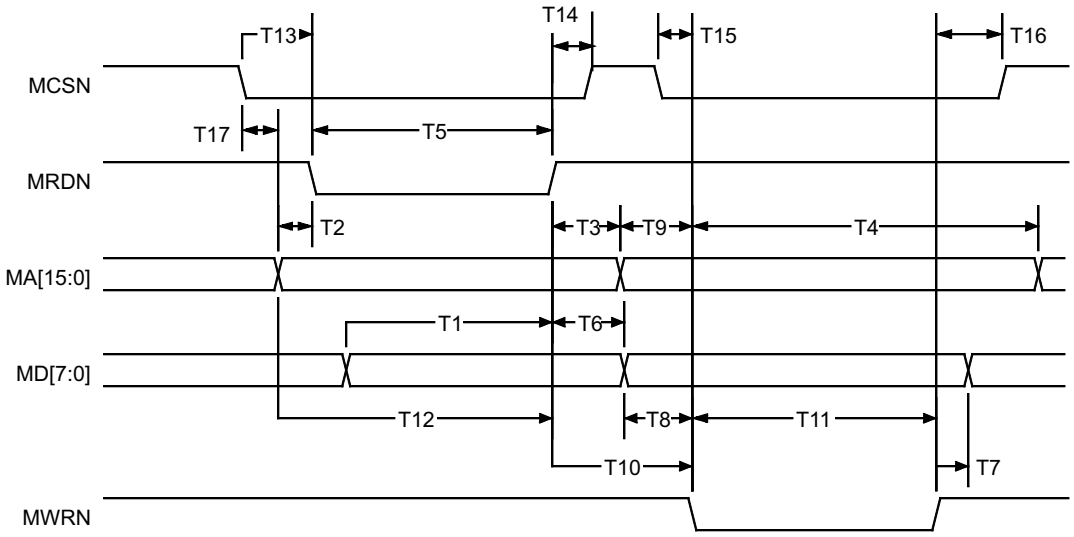
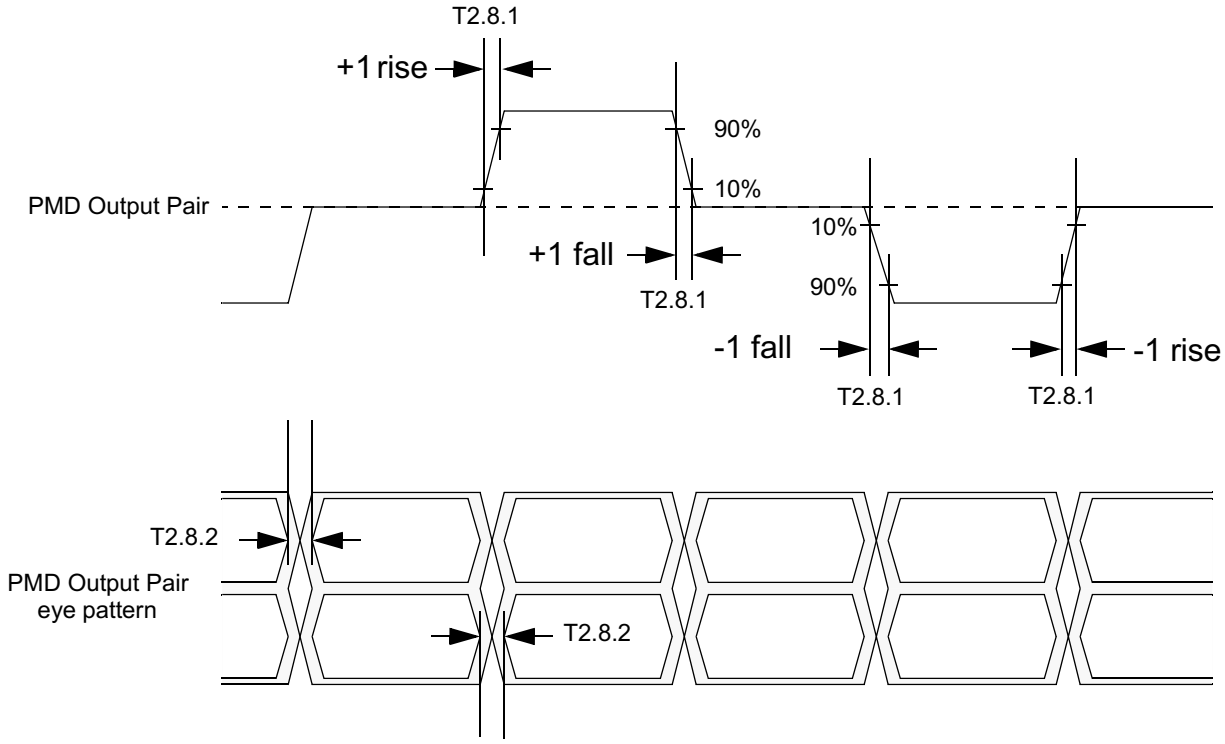


Figure 4-15. EEPROM Auto-Load (see *EEPROM AUTO-LOAD* in Section 4.6)



Note: Timings are based on a 30-ns clock period.

Figure 4-16. Boot PROM or Flash (see *BOOT PROM OR FLASH* in Section 4.6)



Note: Normal mismatch is the difference between the maximum and minimum of all rise and fall times.

Note: Rise and fall times taken at 10% and 90% of the +1 or –1 amplitude.

Note: Carrier sense on delay is determined by measuring the time from the first bit of the J code group to the assertion of carrier sense.

Note: 1 bit time = 10 ns in 100-Mb/s mode.

Note: The ideal window recognition region is ±4 ns.

Figure 4-17. 100BASE-TX Transmit (see *100BASE-TX TRANSMIT* in Section 4.6)

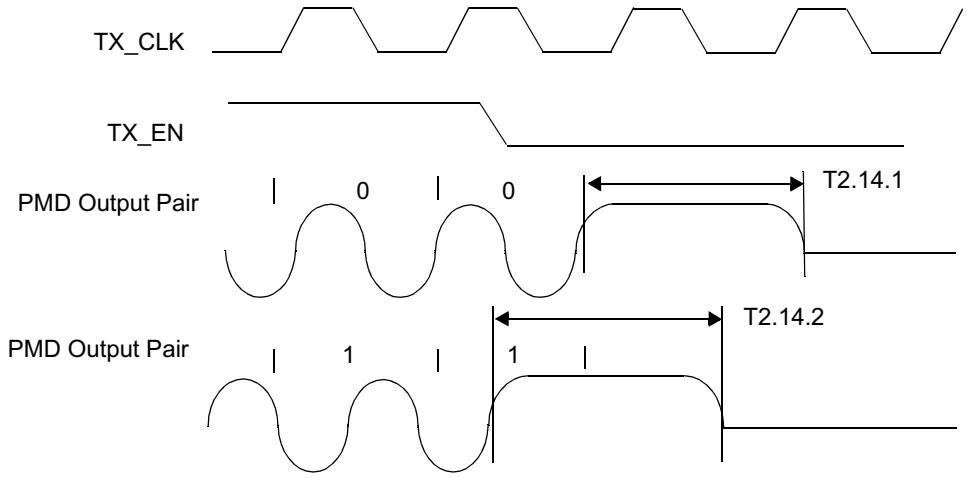


Figure 4-18. 10BASE-T Transmit End of Packet (see *10BASE-T TRANSMIT END OF PACKET* in Section 4.6)

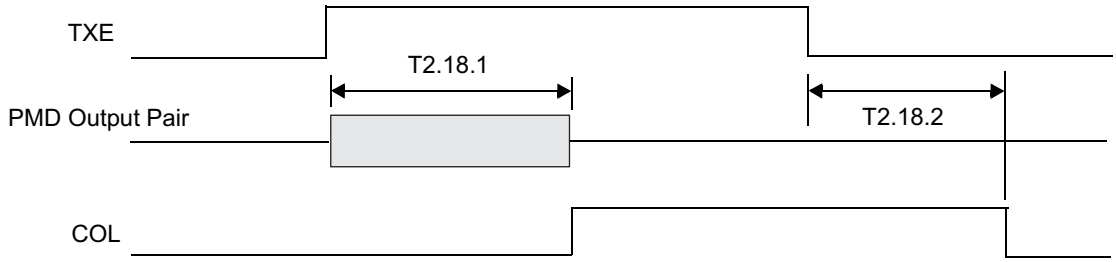
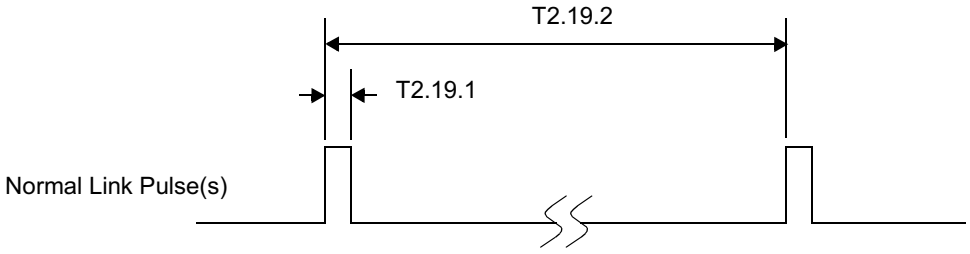
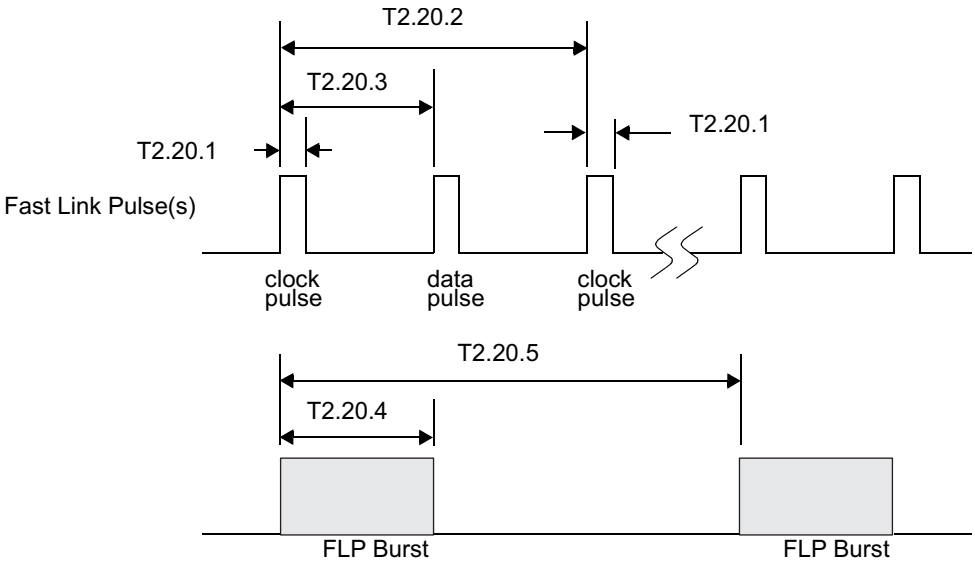


Figure 4-19. 10-Mb/s Jabber Timing (see *10-Mb/s JABBER TIMING* in Section 4.6)



Note: These specifications represent both transmit and receive timings.

Figure 4-20. 10BASE-T Normal Link Pulse (see *10BASE-T NORMAL LINK PULSE* in Section 4.6)



Note: These specifications represent both transmit and receive timings.

Figure 4-21. Auto-Negotiation Fast Link Pulse (FLP) (see *AUTO-NEGOTIATION FAST LINK PULSE (FLP)* in Section 4.6)

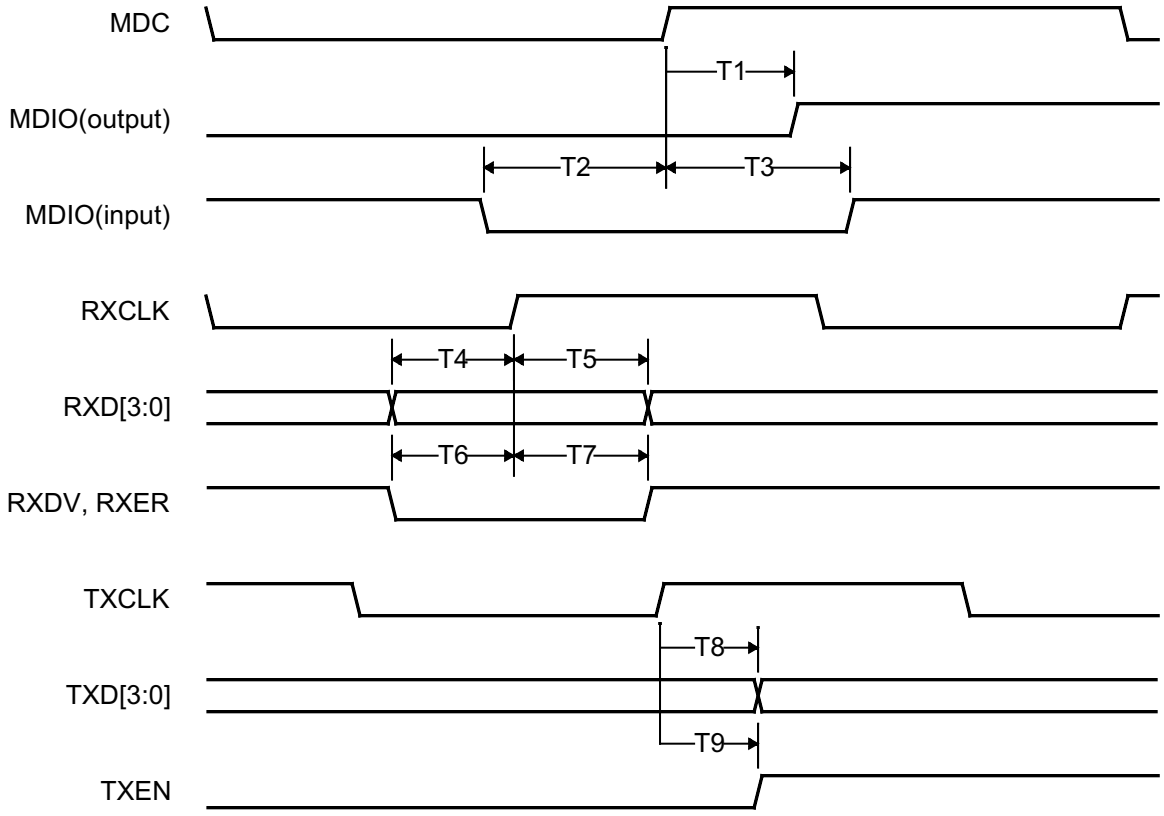


Figure 4-22. Media Independent Interface (MII) (see *MEDIA-INDEPENDENT INTERFACE (MII)* in Section 4.6)

5 Detailed Description

5.1 Overview

The DP83816 device consists of a MAC and BIU (media access controller and bus interface unit), a physical layer interface, SRAM, and miscellaneous support logic. The MAC and BIU include the PCI bus, BIOS ROM and EEPROM interfaces, and an 802.3 MAC. The physical layer interface used is a single-port version of the 3.3-V DsPhyterII.internal memory consists of one 0.5KB and two 2KB SRAM blocks.

5.2 Functional Block Diagram

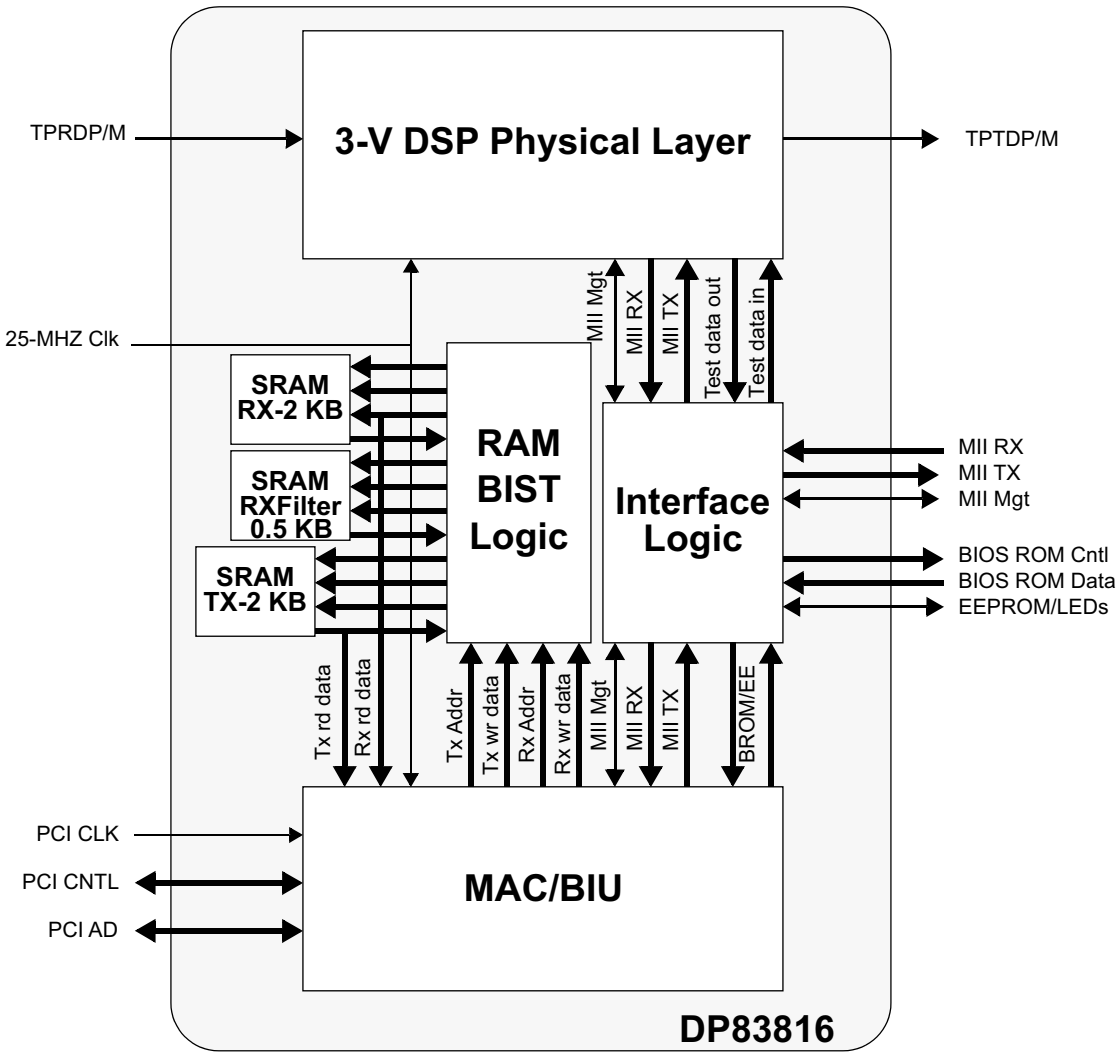


Figure 5-1. DP83816 Functional Block Diagram

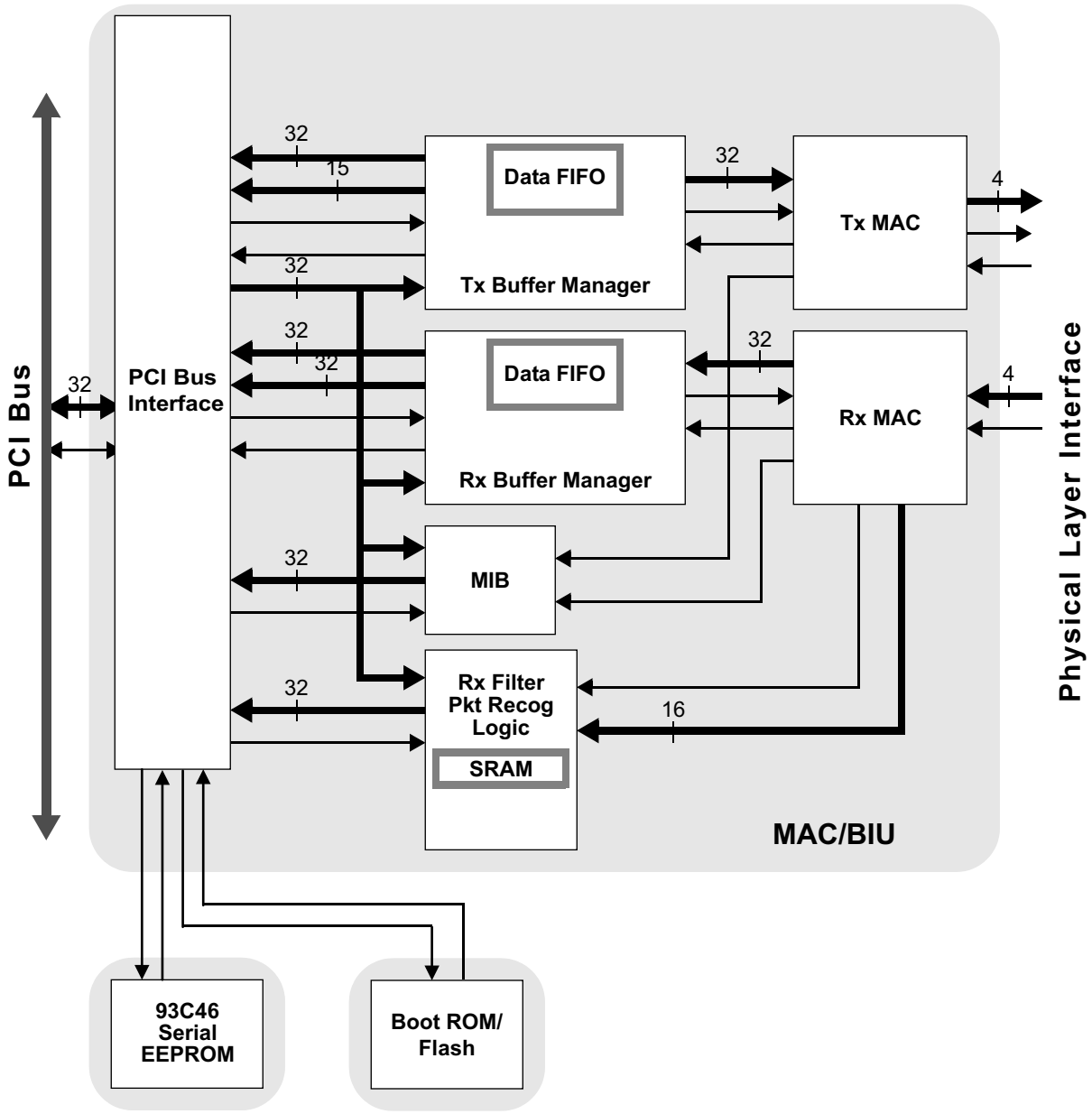


Figure 5-2. MAC and BIU Functional Block Diagram

5.3 Feature Description

This section includes information on the various configurable features available with the DP83816 device. The configuration features described include:

- MAC and BIU
- Wake on LAN
- Receive filter logic
- CLKRUNN function
- Physical layer
- Auto-negotiation
- LED interface
- PHY loopback

5.3.1 MAC and BIU

The MAC and BIU design has been optimized to improve logic efficiency and enhanced to add features consistent with current market needs and specification compliance. The MAC and BIU design blocks are discussed in this section.

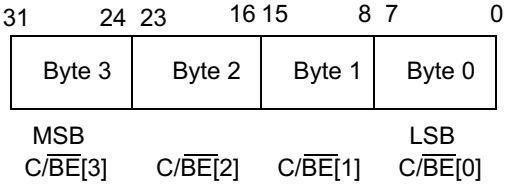
5.3.1.1 PCI Bus Interface

This block implements PCI v2.2 bus protocols and configuration space. The block supports bus master reads and writes to CPU memory and CPU access to on-chip register space. Additional functions provided include: configuration control, serial EEPROM access with auto configuration load, interrupt control, and power management control with support for PME or CLKRUN functionality.

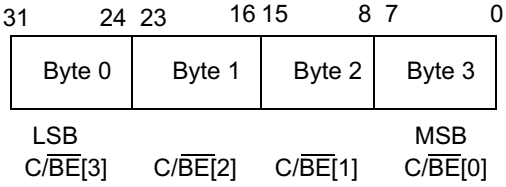
5.3.1.1.1 Byte Ordering

The DP83816 device can be configured to order the bytes of data on the AD[31:0] bus to conform to little endian or big endian ordering through the use of configuration register, bit 0 (CFG:BEM). By default, the device is in little endian ordering. Byte ordering only affects data FIFOs. Register information remains bit aligned (that is, AD[31] maps to bit 31 in any register space, AD[0] maps to bit 0, and so forth).

Little Endian (CFG:BEM = 0): The byte orientation for receive and transmit data in system memory is as follows:



Big Endian (CFG:BEM = 1): The byte orientation for receive and transmit data in system memory is as follows:



5.3.1.1.2 PCI Bus Interrupt Control

PCI bus interrupts for the DP83816 device are asynchronously performed by asserting pin INTAN. This pin is an open-drain output. The source of the interrupt can be determined by reading the Interrupt Status Register (ISR). One or more bits in the ISR are set, denoting all currently pending interrupts.

CAUTION

Reading of the ISR clears ALL bits. Masking of specified interrupts can be accomplished by using the Interrupt Mask Register (IMR).

5.3.1.1.3 Timer

The Latency Timer described in CFGLAT:LAT defines the minimum number of bus clocks that the device holds the bus.= When the device gains control of the bus and issues FRAMEN, the latency timer begins counting down. If GNTN is de-asserted before the DP83816 device has finished with the bus, the device maintains ownership of the bus until the timer reaches zero (or has finished the bus transfer). The timer is an 8-bit counter.

5.3.1.2 Tx MAC

This block implements the transmit portion of 802.3 media access control. The Tx MAC retrieves packet data from the Tx buffer manager and sends it out through the transmit portion. Additionally, the Tx MAC provides MIB control information for transmit packets.

5.3.1.3 Rx MAC

This block implements the receive portion of 802.3 media access control. The Rx MAC retrieves packet data from the receive portion and sends it to the Rx buffer manager. Additionally, the Rx MAC provides MIB control information and packet address data for the Rx filter.

5.3.2 Wake on LAN

The Wake on LAN logic provides several mechanisms for bringing the DP83816 device out of a low-power state. Wake on ARP, wake on broadcast, wake on multicast hash and wake on PHY Interrupt are enabled by setting the corresponding bit in the wake command and status register, WCSR. Before the hardware is programmed to a low-power state, the software must write a null receive descriptor pointer to the receive descriptor pointer register (RXDP) to ensure wake packets are buffered in the RX fifo. See the description of the RXDP register for this procedure.

When a qualifying packet is received, the Wake on LAN logic generates a Wake event and pulses the PMEN PCI signal to request a power management state change. The software must then bring the hardware out of low-power mode and, if the power management state was D3hot, reinitialize Configuration Register space. A Wake interrupt can also be generated which alerts the software that a Wake event has occurred and a packet was received. The software must then write a valid receive descriptor pointer to RXDP. The incoming packet can then be transferred into host memory for processing. Note that the wake packet is retained for processing - this is a feature of the DP83816 device. In addition to the above Wake on LAN features, the DP83816 device also provides Wake on Pattern Matching, Wake on DA match and Wake on Magic Packet.

5.3.3 Wake on Pattern Matching

Wake on Pattern Matching is an extension of the Pattern Matching feature provided by the receive filter logic. When one or more of the Wake on Pattern Match bits are set in the WCSR, a packet generates a wake event if it matches the associated pattern buffer. The pattern count and the pattern buffer memory are accessed in the same way as in Pattern Matching for packet acceptance. The minimum pattern count is 2 bytes and the maximum pattern count is 64 bytes for patterns 0 and 1, and 128 bytes for patterns 2 and 3. Packets are compared on a byte by byte basis and bytes may be masked in pattern memory, thus allowing for don't cares. See Section 5.5.2 for programming examples.

5.3.4 CLKRUNN Function

CLKRUNN is a dual-function optional signal. It is used by the central PCI clock resource to indicate clock status (that is, PCI clock running normally or slowed or stopped), and it is used by PCI devices to request that the central resource restart the PCI clock or keep it running normally.

In the DP83816 device, CLKRUNN shares a pin with PMEN (pin 59). This means the chip cannot be simultaneously PCI power management and PCI Mobile Design Guide- compliant; however, it is unlikely that a system would use both of these functions simultaneously. The function of the PMEN/CLKRUNN pin is selected with the CLKRUN_EN bit of CCSR.

CCSR bits 15 and 8 (PMESTS and PMEEN) are mirrored from PCI configuration space to allow them to be accessed by software. The functionality of these bits is the same as in the PCI configuration register PMCSR.

As an output, CLKRUNN is open-drain like PMEN, that is, it can only drive low. CLKRUNN is an input unless one of the following two conditions occurs:

- The system drives CLKRUNN high, but the DP83816 device is not ready for the PCI clock to be stopped.
- The PCI clock is stopped or slowed (CLKRUNN is pulled high by the system) and the DP83816 device requires the use of the PCI bus.

Situation 1 is a “clock continue” event and can occur if the DP83816 device has not completed a pending packet transmit or receive. Situation 2 is a “clock start” event and can occur if the DP83816 device has been programmed to a WOL state and it receives a wake packet, or the PCI clock has simply been stopped and the receiver has data ready to DMA. In either of these situations, the DP83816 device asserts CLKRUNN until it detects two rising edges of the PCI clock; it then releases assertion of CLKRUNN. At this point, the central resource is driving CLKRUNN low, and cannot drive it high again until at least four rising edges of the PCI clock have occurred since the initial CLKRUNN assertion by the DP83816 device. Also in either situation, the DP83816 device must have detected CLKRUNN de-asserted for two consecutive rising edges of the PCI clock before it is allowed to assert CLKRUNN.

NOTE

- If a clock start or continue event has completed but a PCI interrupt has not been serviced yet, the CLKRUN logic does not prevent the system from stopping the PCI clock.
- If PMEEN is not set, the DP83816 device cannot assert CLKRUNN to request a clock start or continue. In this case, if the system is going to stop the PCI clock, software must shut down the internal PHY to prevent receive errors.
- If another CLKRUN-enabled device in the system encounters a clock start or continue event, the cycle of assertions and de-assertions of CLKRUNN causes the DP83816 clock multiplexer to switch the clock to the RX block back and forth between the PCI clock and the X1 clock until the event completes.

5.3.5 Physical Layer

The DP83816 device has a full featured physical layer device with integrated PMD sub-layers to support both 10BASE-T and 100BASE-TX Ethernet protocols. The physical layer is designed for easy implementation of 10/100 Mb/s Ethernet home or office solutions. It interfaces directly to twisted pair media via an external transformer. The physical layer uses on-chip digital signal processing (DSP) technology and digital PLLs for robust performance under all operating conditions, enhanced noise immunity, and lower external component count when compared to analog solutions.

5.3.5.1 Half Duplex vs Full Duplex

The DP83816 device supports both half and full duplex operation at both 10 Mb/s and 100 Mb/s speeds.

Half-duplex is the standard, traditional mode of operation which relies on the CSMA/CD protocol to handle collisions and network access. In half-duplex mode, CRS responds to both transmit and receive activity to maintain compliance with IEEE 802.3 specification.

Because the DP83816 device is designed to support simultaneous transmit and receive activity it is capable of supporting fullduplex switched applications with a throughput of up to 200 Mb/s per port when operating in 100BASE-TX mode. Because the CSMA/CD protocol does not apply to full-duplex operation, the DP83816 device disables its own internal collision sensing and reporting functions.

It is important to understand that while full auto-negotiation with the use of fast link pulse code words can interpret and configure to support full-duplex, parallel detection can not recognize the difference between full and half-duplex from a fixed 10 Mb/s or 100 Mb/s link partner over twisted pair. Therefore, as specified in 802.3u, if a far-end link partner is transmitting forced full duplex 100BASE-TX for example, the parallel detection state machine in the receiving station would be unable to detect the full duplex capability of the far-end link partner and would negotiate to a half duplex 100BASE-TX configuration (same scenario for 10 Mb/s).

For full duplex operation, the following register bits must also be set:

- TXCFG:CSI (Carrier Sense Ignore)
- TXCFG:HBI (HeartBeat Ignore)
- RXCFG:ATX (Accept Transmit Packets)

Additionally, the auto-negotiation select bits in the configuration register must show full duplex support:

- CFG:ANEG_SEL

5.3.6 Auto-Negotiation

The auto-negotiation function provides a mechanism for exchanging configuration information between two ends of a link segment and automatically selecting the highest performance mode of operation supported by both devices. Fast link pulse (FLP) bursts provide the signaling used to communicate auto-negotiation abilities between two devices at each end of a link segment. For further detail regarding auto-negotiation, see Clause 28 of the IEEE 802.3u specification. The DP83816 device supports four different Ethernet protocols (10 Mb/s half-duplex, 10 Mb/s full-duplex, 100 Mb/s half-duplex, and 100 Mb/s full-duplex), so the inclusion of auto-negotiation ensures that the highest-performance protocol is selected based on the advertised ability of the link partner. The auto-negotiation function within the DP83816 device is controlled by internal register access. Auto-negotiation is set at power up or reset, and also when a link status (up or valid) change occurs.

5.3.6.1 Auto-Negotiation Register Control

When auto-negotiation is enabled, the DP83816 device transmits the abilities programmed into the auto-negotiation advertisement register (ANAR) through FLP Bursts. Any combination of 10 Mb/s, 100 Mb/s, half-duplex, and full-duplex modes may be selected. The default setting of bits [8:5] in the ANAR and bit 12 in the BMCR register are determined at power-up.

The BMCR provides software with a mechanism to control the operation of the DP83816 device. Bits 1 and 2 of the PHYSTS register are only valid if auto-negotiation is disabled or after Auto-Negotiation is complete. The auto-negotiation protocol compares the contents of the ANLPAR and ANAR registers and uses the results to automatically configure to the highest performance protocol common to the local and far-end port. The results of auto-negotiation may be accessed in register C0h (PHYSTS), bit 4: auto-negotiation Complete, bit 2: duplex status and bit 1: Speed status.

Auto-Negotiation Priority Resolution:

1. 100BASE-TX Full Duplex (Highest Priority)
2. 100BASE-TX Half Duplex
3. 10BASE-T Full Duplex
4. 10BASE-T Half Duplex (Lowest Priority)

The basic mode control register (BMCR) provides control for enabling, disabling, and restarting the auto-negotiation process. When auto-negotiation is disabled the speed selection bit in the BMCR (bit 13) controls switching between 10 Mb/s or 100 Mb/s operation, and the duplex mode bit (bit 8) controls switching between full duplex operation and half duplex operation. The speed selection and duplex mode bits have no effect on the mode of operation when the auto-negotiation enable bit (bit 12) is set.

The basic mode status register (BMSR) indicates the set of available abilities for technology types, Auto-negotiation ability, and extended register capability. These bits are permanently set to indicate the full functionality of the DP83816 device (only the 100BASE-T4 bit is not set because the DP83816 device does not support that function).

The BMSR also provides status on:

- Auto-Negotiation complete (bit 5)
- Link Partner advertising that a remote fault has occurred (bit 4)
- Valid link has been established (bit 2)
- Support for Management Frame Preamble suppression (bit 6)

The Auto-Negotiation Advertisement Register (ANAR) indicates the auto-negotiation abilities to be advertised by the DP83816 device. All available abilities are transmitted by default, but any ability can be suppressed by writing to the ANAR. Updating the ANAR to suppress an ability is one way for a management agent to change (force) the technology that is used.

The Auto-Negotiation Link Partner Ability Register (ANLPAR) is used to receive the base link code word as well as all next page code words during the negotiation. Furthermore, the ANLPAR is updated to either 0081h or 0021h for parallel detection to either 100 Mb/s or 10 Mb/s, respectively.

The auto-negotiation expansion register (ANER) indicates additional auto-negotiation status. The ANER provides status on:

- Parallel detect fault occurrence (bit 4)
- Link Partner support of the next page function (bit 3)
- DP83816 support of the next page function (bit 2). The DP83816 device supports the next page function.
- Current page being exchanged by auto-negotiation has been received (bit1)
- Link Partner support of auto-negotiation (bit 0)

5.3.6.2 Auto-Negotiation Parallel Detection

The DP83816 device supports the parallel-detection function as defined in the IEEE 802.3u specification. Parallel detection requires both the 10 Mb/s and 100 Mb/s receivers to monitor the receive signal and report link status to the auto-negotiation function. Auto-negotiation uses this information to configure the correct technology in the event that the link partner does not support auto-negotiation yet is transmitting link signals that the 100BASE-TX or 10BASE-T PMAs (physical medium attachments) recognize as valid link signals.

If the DP83816 device completes auto-negotiation as a result of Parallel Detection, bits 5 and 7 within the ANLPAR register are updated to reflect the mode of operation present in the link partner. Note that bits 4:0 of the ANLPAR are also set to 00001 based on a successful parallel detection to indicate a valid 802.3 selector field. Software may determine that negotiation completed through parallel detection by reading the ANER (98h) register with bit 0, link partner auto-negotiation Able bit, being reset to a zero, when the auto-negotiation complete bit, bit 5 of the BMSR (84h) register is set to 1. If configured for parallel detect mode, and any condition other than a single good link occurs, then the parallel detect fault bit, bit 4 of the ANER register (98h), is set to 1.

5.3.6.3 Auto-Negotiation Restart

When auto-negotiation has completed, it may be restarted at any time by setting bit 9 (restart auto-negotiation) of the BMCR to one. If the mode configured by a successful auto-negotiation loses a valid link, then the auto-negotiation process resumes and attempst to determine the configuration for the link. This function ensures that a valid configuration is maintained if the cable becomes disconnected.

A renegotiation request from any entity, such as a management agent, causes the DP83816 device to halt any transmit data and link pulse activity until the break_link_timer expires (≈ 1500 ms). Consequently, the link partner goes into link fail and normal auto-negotiation resumes. The DP83816 device resumes auto-negotiation after the break_link_timer has expired by issuing FLP (fast link pulse) bursts.

5.3.6.4 Enabling Auto-Negotiation Through Software

It is important to note that if the DP83816 device has been initialized on power-up as a non-auto-negotiating device (forced technology), and it is then required that auto-negotiation or re-auto-negotiation be initiated through software, bit 12 (auto-negotiation enable) of the basic mode control register must first be cleared and then set for any auto-negotiation function to take effect.

5.3.6.5 Auto-Negotiation Complete Time

Parallel detection and auto-negotiation take approximately 2–3 seconds to complete. In addition, auto-negotiation with next page should take approximately 2–3 seconds to complete, depending on the number of next pages sent.

See Clause 28 of the IEEE 802.3u standard for a full description of the individual timers related to auto-negotiation.

5.3.7 LED Interfaces

The DP83816 device has parallel outputs to indicate the status of activity (transmit or receive), 100 Mb/s link, and 10 Mb/s link.

The LEDACT pin indicates the presence of transmit or receive activity. The standard CMOS driver goes low when RX or TX activity is detected in either 10-Mb/s or 100-Mb/s operation.

The LED100LNK pin indicates a good link at the 100-Mb/s data rate. The standard CMOS driver goes low when this occurs. In 100BASE-T mode, link is established as a result of input receive amplitude compliant with TP-PMD specifications which result in internal generation of signal detect. This signal asserts after the internal signal detect has remained asserted for a minimum of 500 µs. The signal de-asserts immediately following the de-assertion of the internal signal detect.

The LED10LNK pin indicates a good link at the 10-Mb/s data rate. The standard CMOS driver goes low when this occurs. The 10-Mb/s Link is established as a result of the reception of at least seven consecutive normal Link Pulses or the reception of a valid 10BASE-T packet. This causes the assertion of this signal. The signal de-asserts in accordance with the Link Loss Timer as specified in IEEE 802.3.

The DP83816 LED pins are capable of 6 mA. Connection of these LED pins should ensure this is not overloaded. Using 2-mA LED devices the connection for the LEDs could be as shown in Figure 5-3.

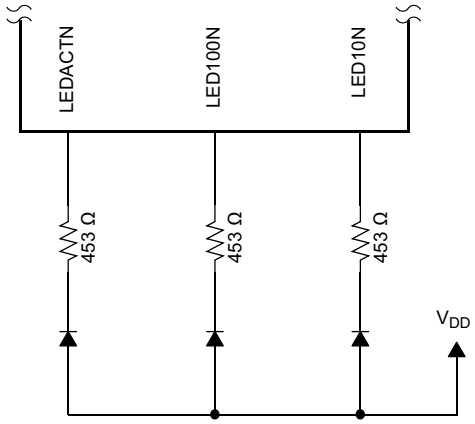


Figure 5-3. LED Loading Example

5.3.7.1 Status Information

The 10-Mb/s link is established as a result of the reception of at least seven consecutive normal link pulses or the reception of a valid 10BASE-T packet. LED10LNK de-asserts in accordance with the link loss timer specified in IEEE 802.3.

The 100BASE-T Link is established as a result of an input receive amplitude compliant with TP-PMD specifications, which results in the internal generation of signal detect. LED100LNK asserts after the internal signal detect has remained asserted for a minimum of 500 µs. LED100LNK de-asserts immediately following the de-assertion of the internal signal detect.

5.3.8 PHY Loopback

The DP83816 device includes a PHY loopback test mode for easy board diagnostics. The Loopback mode is selected through bit 14 (Loopback) of the basic mode control register (BMCR). Writing 1 to this bit enables transmit data to be routed to the receive path early in the physical layer cell. Loopback status may be checked in bit 3 of the PHY status register (C0h). While in loopback mode, the data is not transmitted onto the media. This is true for either 10-Mb/s or 100-Mb/s data.

In 100BASE-TX loopback mode the data is routed through the PCS and PMA layers into the PMD sublayer before it is looped back. Therefore, in addition to serving as a board diagnostic, this mode serves as quick functional verification of the device.

NOTE

A Mac Loopback can be performed through setting bit 29 (Mac Loopback) in the Tx Configuration Register.

5.4 Device Functional Modes

5.4.1 802.3u MII

The DP83816 device incorporates the media independent interface (MII) as specified in Clause 22 of the IEEE 802.3u standard. This interface may be used to connect 10/100 Mb/s PHY devices. This section describes the MII configuration steps as well as the serial MII management interface and nibble wide MII data interface.

5.4.1.1 MII Access Configuration

The DP83816 device must be specifically configured for accessing the MII. This is done by first connecting pin 133 (MD1/CFGDISN) to GND through a 1-kΩ resistor. Then setting bit 12 (EXT_PHY) of the CFG register (offset 04h) to 1. See Section 5.5.3.2. When this bit is set, the internal PHY is automatically disabled, as reported by bit 9 (PHY_DIS) of the CFG register. The MII must then be initialized, as described in *Serial Management Access Protocol*, before the external PHY can be detected.

If external MII is not selected through the register setting as described, then the internal PHY is used and the MII pins of the MacPhyter-II can be left unconnected.

5.4.1.2 MII Serial Management

The MII serial management interface allows for the configuration and control of PHY registers, gathering of status, error information, and the determination of the type and capabilities of the attached PHYs.

The MII serial management specification defines a set of thirty-two 16-bit status and control registers that are accessible through the management interface pins MDC and MDIO. A description of the serial management interface access and access protocol follows.

5.4.1.3 MII Serial Management Access

Management access to the PHYs is done through management data clock (MDC) and management data input/output (MDIO). MDC has a maximum clock rate of 25 MHz and no minimum rate. The MDIO line is bi-directional and may be shared by up to 32 devices.

The internal PHY counts as one of these 32 devices. The internal PHY has the advantage of having direct register access but can also be controlled exactly like a PHY, with a default address of 1Fh, connected to the MII.

Access and control of the MDC and MDIO pins is done via the MII/EEPROM Access Register (MEAR). The clock (MDC) is created by alternating writes of 0 then 1 to the MDC bit (bit 6). Control of data direction is done by the MDDIR bit (bit 5). Data is either recorded or written by the MDIO bit (bit 4). Setting the MDDIR bit to a 1 allows the DP83816 device to drive the MDIO pin. Setting the MDDIR bit to a 0 allows the MDIO bit to reflect the value of the MDIO pin. See Section 5.5.3.3.

This bit-bang access of the MDC and MDIO pins thus requires 64 accesses to the MEAR register to complete a single PHY register transaction. Because a PHY device is typically self configuring and adaptive this serial management access is usually only required at initialization time and therefore is not time critical.

5.4.1.4 Serial Management Access Protocol

The serial control interface clock (MDC) has a maximum clock rate of 25 MHz and no minimum rate. The MDIO line is bi-directional and may be shared by up to 32 devices. The MDIO frame format is shown in Table 5-1. If external PHY devices may be attached and removed from the MII there should be a 15 kΩ pulldown resistor on the MDIO signal.

If the PHY is always to be connected, then there should be a 1.5-kΩ pullup resistor which, during IDLE and turnaround, pulls MDIO high. To initialize the MDIO interface, the DP83816 device sends a sequence of 32 contiguous logic ones on MDIO provides the PHYs with a sequence that can be used to establish synchronization. This preamble may be generated either by driving MDIO high for 32 consecutive MDC clock cycles, or by simply allowing the MDIO pullup resistor to pull the MDIO pin high during which time 32 MDC clock cycles are provided. In addition 32 MDC clock cycles should be used to re-sync the device if an invalid start, opcode, or turnaround bit is detected.

Table 5-1. Typical MDIO Frame Format

MII Management Serial Protocol	<idle><start><op code><device add><reg addr><turnaround><data><idle>
Read Operation	<idle><01><10><AAAAA><RRRRR><Z0><xxxx xxxx xxxx xxxx><idle>
Write Operation	<idle><01><01><AAAAA><RRRRR><10><xxxx xxxx xxxx xxxx><idle>

The Start code is indicated by a <01> pattern. This assures the MDIO line transitions from the default idle line state.

Turnaround is defined as an idle bit time inserted between the Register Address field and the Data field. To avoid contention during a read transaction, no device shall actively drive the MDIO signal during the first bit of Turnaround. The addressed PHY drives the MDIO with a zero for the second bit of turnaround and follows this with the required data. Figure 5-4 shows the timing relationship between MDC and the MDIO as driven and received by the DP83816 device and a PHY for a typical register read access.

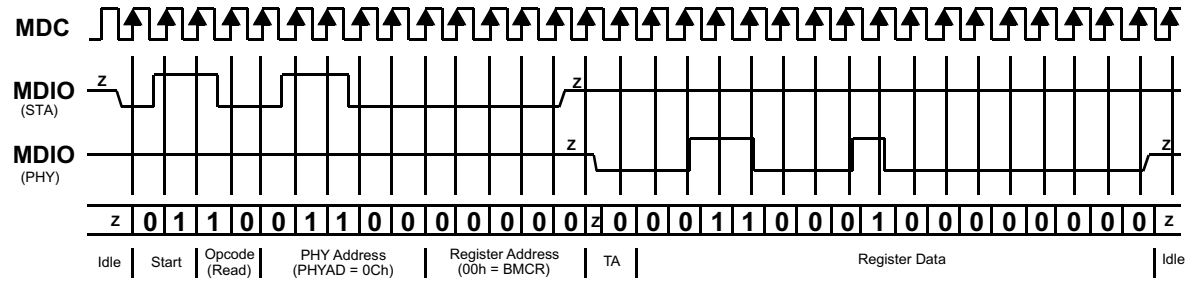


Figure 5-4. Typical MDC and MDIO Read Operation

For write transactions, the DP83816 device writes data to the addressed PHY thus eliminating the requirement for MDIO turnaround. The turnaround time is filled by the DP83816 device by inserting <10>. Figure 5-5 shows the timing relationship for a typical MII register write access.

5.4.1.5 Nibble-wide MII Data Interface

Clause 22 of the IEEE 802.3u specification defines the media independent interface. This interface include separate dedicated receive and transmit busses. These two data busses, along with various control and indication signals, allow for the simultaneous exchange of data between the DP83816 device and PHYs.

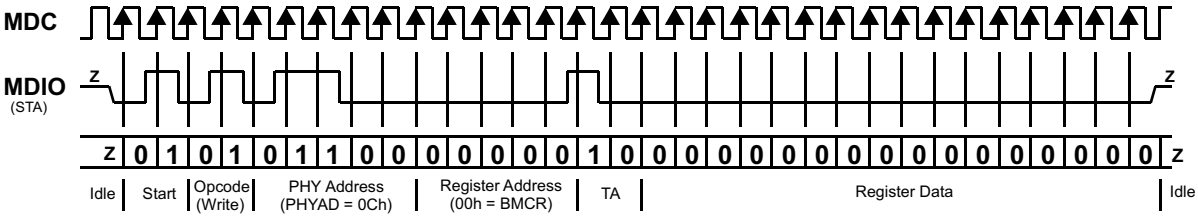


Figure 5-5. Typical MDC and MDIO Write Operation

The receive interface consists of a nibble wide data bus RXD[3:0], a receive error signal RXER, a receive data valid flag RXDV, and a receive clock RXCLK for synchronous transfer of the data. The receive clock can operate at 2.5 MHz to support 10-Mb/s operation modes or at 25 MHz to support 100-Mb/s operational modes.

The transmit interface consists of a nibble wide data bus TXD[3:0], a transmit enable control signal TXEN, and a transmit clock TXCLK which runs at 2.5 MHz or 25 MHz.

Additionally, the MII includes the carrier sense signal CRS, as well as a collision detect signal COL. The CRS signal asserts to indicate the reception of data from the network or as a function of transmit data in half duplex mode. The COL signal asserts as an indication of a collision which can occur during half-duplex operation when both a transmit and receive operation occur simultaneously.

5.4.1.6 Collision Detection

For half duplex, a 10BASE-T or 100BASE-TX collision is detected when the receive and transmit channels are active simultaneously. Collisions are reported by the COL signal on the MII.

If the PHY is transmitting in 10-Mb/s mode when a collision is detected, the collision is not reported until seven bits have been received while in the collision state. This prevents a collision being reported incorrectly due to noise on the network. The COL signal remains set for the duration of the collision.

If a collision occurs during a receive operation, it is immediately reported by the COL signal.

When heartbeat is enabled (only applicable to 10-Mb/s operation), approximately 1 µs after the transmission of each packet, a Signal Quality Error (SQE) signal of approximately 10 bit times is generated (internally) to indicate successful transmission. SQE is reported as a pulse on the COL signal of the MII.

5.4.1.7 Carrier Sense

Carrier sense (CRS) is asserted due to receive activity when valid data is detected during 10-Mb/s operation. During 100-Mb/s operation, CRS is asserted when a valid link (SD) and two non-contiguous zeros are detected.

For 10- or 100-Mb/s half-duplex operation, CRS is asserted during either packet transmission or reception.

For 10- or 100-Mb/s full duplex operation, CRS is asserted only due to receive activity.

CRS is de-asserted following an end of packet.

5.4.2 Sleep Mode

Sleep mode is a system-level function that allows a device to be placed in a lower power mode than WOL mode. In sleep mode, the device is not able to detect wake events or signal the system that it needs service.

5.4.2.1 Entering Sleep Mode

The following steps are required to enter sleep mode:

1. Disable the receiver by writing a 1 to the receiver disable bit in the command register (CR:RXD).
2. Write 0 to the receive descriptor pointer register (RXDP)
3. Force the receiver to reread the descriptor pointer by writing a 1 to the receiver enable bit in the command register (CR:RXE).
4. Do not configure any wake events in WCSR.
5. Write a 0 to PME enable, and set the desired power state in PMCSR. These can be done in one operation. An ACPI-compatible operating system should handle this step.
6. If the power management state is D3cold, the system asserts PCI reset, stops the PCI clock, and removes power from the PCI bus.

5.4.2.2 Exiting Sleep Mode

The following steps are required to bring the DP83816 device out of Sleep Mode:

1. If the power management state is D3cold, the system asserts PCI reset, restores PCI bus power, and restarts the PCI clock. This also returns the power state to D0. The PCI configuration registers (that is. base addresses, bus master enable, and so forth) must be reinitialized.
2. Write a 0 to power state bits [0:1] in the PMCSR (in case the sleep power state was not D3hot or D3cold).
3. If the sleep power state was D3hot or D3cold, reinitialize addresses, bus master enable, and so forth). An ACPI-compatible operating system should handle this step. Note that operational registers are not accessible until this step is completed.
4. Disable the receiver by writing a 1 to the receiver disable bit in the command register (CR:RXD).
5. Write a valid receive descriptor pointer to the receive descriptor pointer register (RXDP)
6. Enable the receiver by writing a 1 to the receiver enable bit in the command register (CR:RXE).

5.5 Programming

5.5.1 Architecture

This section describes the operations within each transceiver module, 100BASE-TX and 10BASE-T. Each operation consists of several functional blocks and described in the following:

- 100BASE-TX Transmitter
- 100BASE-TX Receiver
- 10BASE-T Transceiver Module

- Buffer Management

5.5.1.1 100BASE-TX Transmitter

The 100BASE-TX transmitter consists of several functional blocks which convert synchronous 4-bit nibble data, to a scrambled MLT-3 125-Mb/s serial data stream. Because the 100BASE-TX TP-PMD is integrated, the differential output pins, TPTDP and TPTDM, can be directly routed to the magnetics.

The block diagram in Figure 5-6 provides an overview of each functional block within the 100BASE-TX transmit section.

The Transmitter section consists of the following functional blocks:

- Code-group Encoder and Injection block (bypass option)
- Scrambler block (bypass option)
- NRZ to NRZI encoder block
- Binary to MLT-3 converter and common driver

The bypass option for the functional blocks within the 100BASE-TX transmitter provides flexibility for applications such as 100-Mb/s repeaters where data conversion is not always required. The DP83816 device implements the 100BASETX transmit state machine diagram as specified in the IEEE 802.3u Standard, Clause 24.

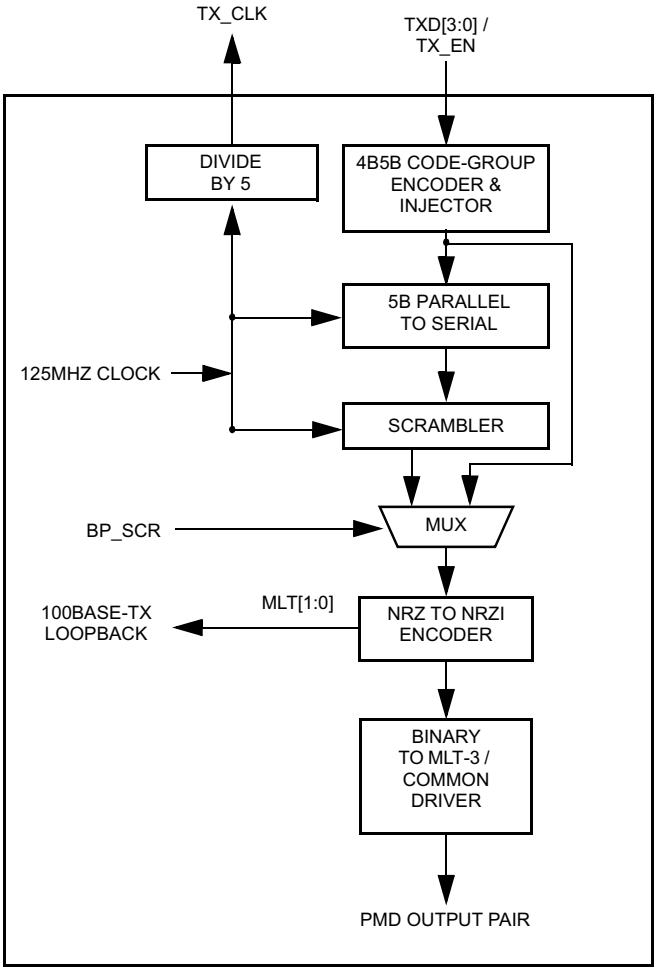


Figure 5-6. 100BASE-TX Transmit Block Diagram

5.5.1.1.1 Code-group Encoding and Injection

The code-group encoder converts 4-bit (4B) nibble data generated by the MAC into 5-bit (5B) code-groups for transmission. This conversion is required to allow control data to be combined with packet data code-groups. See Table 5-2 for 4B to 5B code-group mapping details. The code-group encoder substitutes the first 8-bits of the MAC preamble with a J/K code-group pair (11000 10001) on transmission.

The code-group encoder continues to replace subsequent 4B preamble and data nibbles with corresponding 5B code-groups. At the end of the transmit packet, on the de-assertion of Transmit Enable signal from the MAC, the code-group encoder injects the T/R code-group pair (01101 00111) indicating the end of frame.

After the T/R code-group pair, the code-group encoder continuously injects IDLEs into the transmit data stream until the next transmit packet is detected (re-assertion of Transmit Enable).

5.5.1.1.2 Scrambler

The scrambler is required to control the radiated emissions at the media connector and on the twisted pair cable (for 100BASE-TX applications). By scrambling the data, the total energy launched onto the cable is randomly distributed over a wide frequency range. Without the scrambler, energy levels at the PMD and on the cable could peak beyond FCC limitations at frequencies related to repeating 5B sequences (that is, continuous transmission of IDLEs).

The scrambler is configured as a closed loop linear feedback shift register (LFSR) with an 11-bit polynomial. The output of the closed loop LFSR is XORed with the serial NRZ data from the code-group encoder. The result is a scrambled data stream with sufficient randomization to decrease radiated emissions at certain frequencies by as much as 20 dB.

5.5.1.1.3 NRZ to NRZI Encoder

After the transmit data stream has been serialized and scrambled, the data must be NRZI encoded to comply with the TP-PMD standard for 100BASE-TX transmission over Category-5 un-shielded twisted pair cable. There is no ability to bypass this block within the DP83816 device.

5.5.1.1.4 Binary to MLT-3 Convertor and Common Driver

The Binary to MLT-3 conversion is accomplished by converting the serial binary data stream output from the NRZI encoder into two binary data streams with alternately phased logic one events. These two binary streams are then fed to the twisted pair output driver which converts the voltage to current and alternately drives either side of the transmit transformer primary winding, resulting in a minimal current (20 mA max) MLT-3 signal. See Figure 5-7.

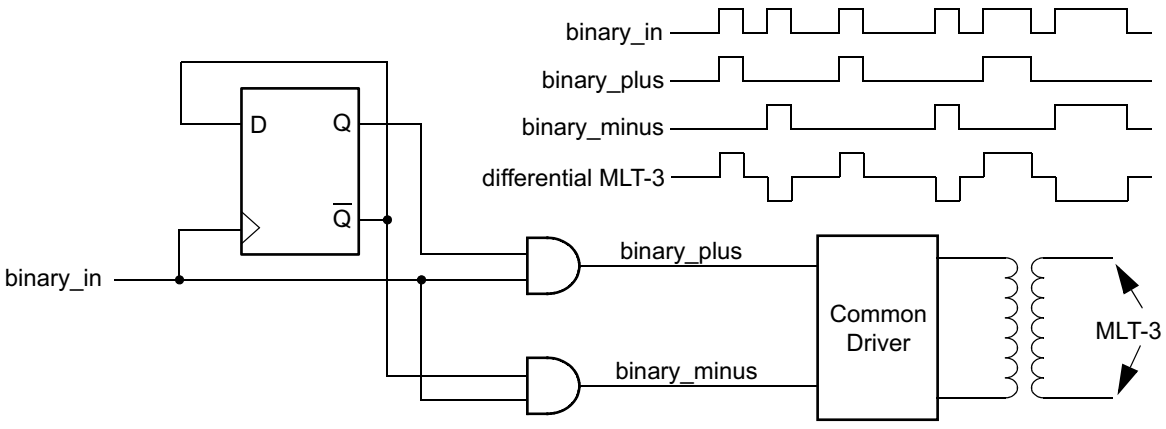


Figure 5-7. Binary to MLT-3 Conversion

Table 5-2. 4B5B Code-Group Encoding and Decoding

NAME	PCS 5B CODE-GROUP	DESCRIPTION OR 4B VALUE
DATA CODES		
0	11110	0000
1	01001	0001
2	10100	0010
3	10101	0011
4	01010	0100
5	10110	0101
6	01110	0110
7	01111	0111
8	10010	1000
9	10011	1001
A	10110	1010
B	10111	1011
C	11010	1100
D	11011	1101
E	11100	1110
F	11101	1111
IDLE AND CONTROL CODES		
H	00100	HALT code-group - Error code
I	11111	Inter-Packet IDLE - 0000
J	11000	First Start of Packet - 0101
K	10001	Second Start of Packet - 0101
T	01101	First End of Packet - 0000
R	00111	Second End of Packet - 0000
INVALID CODES		
V	00000	
V	00001	
V	00010	
V	00011	
V	00101	
V	00110	
V	01000	
V	01100	
V	10000	
V	11001	

The 100BASE-TX MLT-3 signal sourced by the TPTDM and TPTDP common-driver output pins is slew rate controlled. This should be considered when selecting ac-coupling magnetics to ensure TP-PMD Standard compliant transition times (3 ns ≤ Tr < 5 ns).

The 100BASE-TX transmit TP-PMD function within the DP83816 device is capable of sourcing only MLT-3 encoded data. Binary output from the TPTDM and TPTDP outputs is not possible in 100-Mb/s mode.

5.5.1.2 100BASE-TX Receiver

The 100BASE-TX receiver consists of several functional blocks which convert the scrambled MLT-3 125-Mb/s serial data stream to synchronous 4-bit nibble data that is provided to the MAC. Because the 100BASE-TX TP-PMD is integrated, the differential input pins, TPRDP and TPRDM, can be directly routed from the ac-coupling magnetics.

See Figure 5-8 for a block diagram of the 100BASE-TX receive function. This provides an overview of each functional block within the 100BASE-TX receive section.

The Receive section consists of the following functional blocks:

- ADC
- Input and BLW Compensation
- Signal Detect
- Digital Adaptive Equalization
- MLT-3 to Binary Decoder
- Clock Recovery Module
- NRZI to NRZ Decoder
- Serial to Parallel
- De-scrambler (bypass option)
- Code Group Alignment
- 4B/5B Decoder (bypass option)
- Link Integrity Monitor
- Bad SSD Detection

The bypass option for the functional blocks within the 100BASE-TX receiver provides flexibility for applications such as 100-Mb/s repeaters where data conversion is not always required.

5.5.1.2.1 Input and Base Line Wander Compensation

Unlike the DP83223V Twister, the DP83816 device requires no external attenuation circuitry at its receive inputs, TPRDP and TPRDM. It accepts TP-PMD compliant waveforms directly, requiring only a 100-Ω termination plus a simple 1:1 transformer.

The DP83816 device is completely ANSI TP-PMD compliant and includes Base Line Wander (BLW) compensation. The BLW compensation block can successfully recover the TP-PMD defined *killer* pattern and pass it to the digital adaptive equalization block.

BLW can generally be defined as the change in the average dc content, over time, of an ac-coupled digital transmission over a given transmission medium (that is, copper wire).

BLW results from the interaction between the low-frequency components of a transmitted bit stream and the frequency response of the ac-coupling components within the transmission system. If the low-frequency content of the digital bit stream goes below the low-frequency pole of the ac-coupling transformers, then the droop characteristics of the transformers dominate, resulting in potentially serious BLW.

The digital oscilloscope plot provided in Figure 5-9 illustrates the severity of the BLW event that can theoretically be generated during 100BASE-TX packet transmission. This event consists of approximately 800 mV of dc offset for a period of 120 µs. Left uncompensated, events such as this can cause packet loss.

5.5.1.2.2 Signal Detect

The signal detect function of the DP83816 device is incorporated to meet the specifications mandated by the ANSI FDDI TP-PMD Standard as well as the IEEE 802.3 100BASE-TX Standard for both voltage thresholds and timing parameters.

Note that the reception of normal 10BASE-T link pulses and fast link pulses per IEEE 802.3u Auto-Negotiation by the 100BASE-TX receiver do not cause the DP83816 device to assert signal detect.

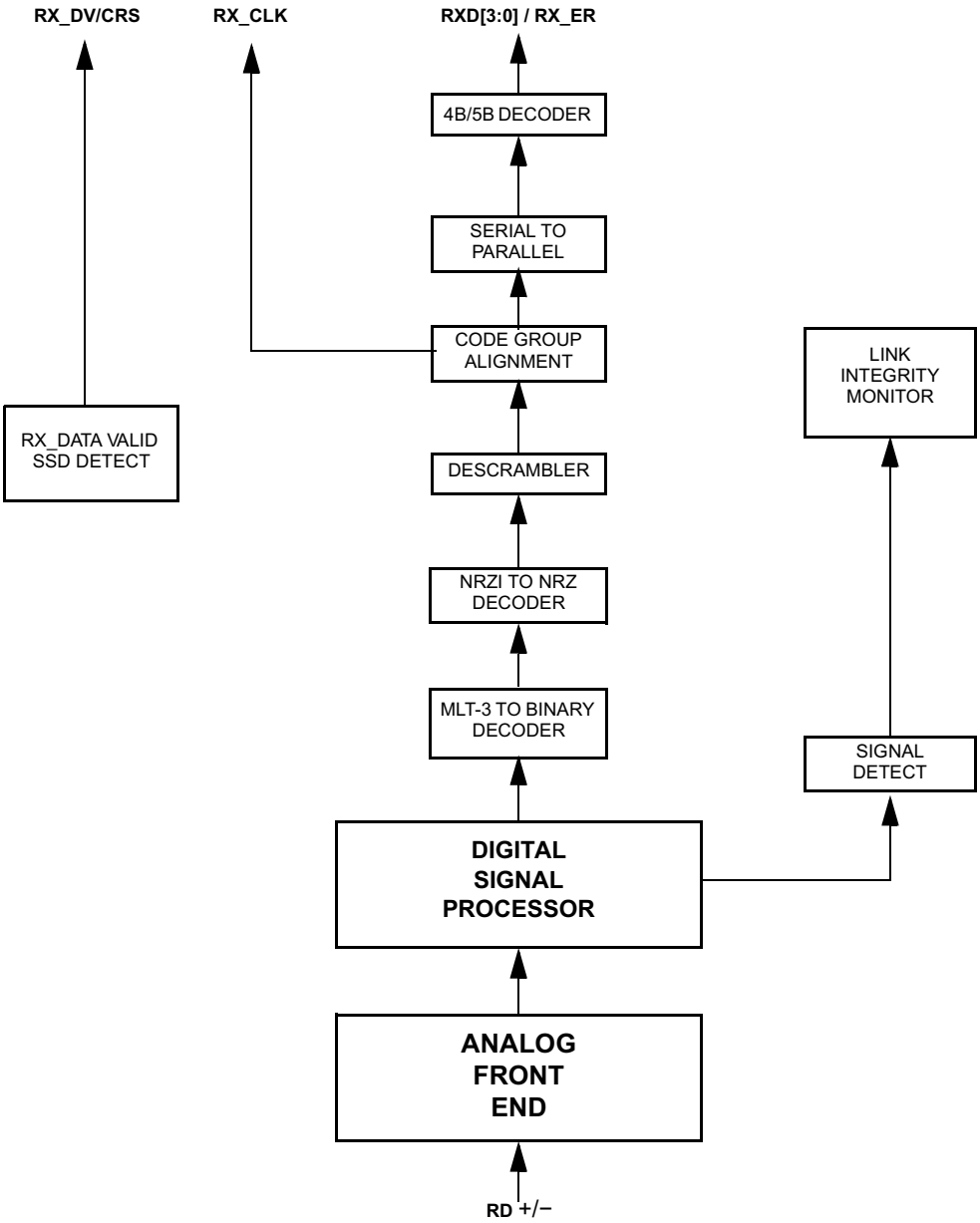


Figure 5-8. 100BASE-TX Receive Block Diagram

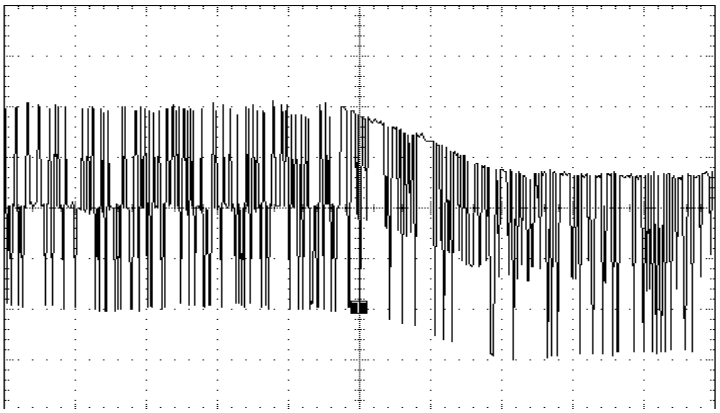


Figure 5-9. 100BASE-TX BLW Event Diagram

5.5.1.2.3 Digital Adaptive Equalization

When transmitting data at high speeds over copper twisted pair cable, frequency dependent attenuation becomes a concern. In high-speed twisted pair signaling, the frequency content of the transmitted signal can vary greatly during normal operation based primarily on the randomness of the scrambled data stream. This variation in signal attenuation caused by frequency variations must be compensated for to ensure the integrity of the transmission.

To ensure quality transmission when employing MLT-3 encoding, the compensation must be able to adapt to various cable lengths and cable types depending on the installed environment. The selection of long cable lengths for a given implementation requires significant compensation, which overcompensates for shorter, less attenuating lengths. Conversely, the selection of short or intermediate cable lengths requiring less compensation causes serious undercompensation for longer-length cables. Therefore, the compensation or equalization must be adaptive to ensure proper conditioning of the received signal independent of the cable length.

The DP83816 device uses an extremely robust equalization scheme referred to herein as *digital adaptive equalization*. Traditional designs use a pseudo adaptive equalization scheme that determines the approximate cable length by monitoring signal attenuation at certain frequencies. This attenuation value was compared to the internal receive input reference voltage. This comparison would indicate the amount of equalization to use. Although this scheme is used successfully on the DP83223V twister, it is sensitive to transformer mismatch, resistor variation and process induced offset. The DP83223V also required an external attenuation network to help match the incoming signal amplitude to the internal reference.

The Digital Equalizer removes ISI (Inter Symbol Interference) from the receive data stream by continuously adapting to provide a filter with the inverse frequency response of the channel. When used in conjunction with a gain stage, this enables the receive *eye pattern* to be opened sufficiently to allow very reliable data recovery.

Traditionally, *adaptive* equalizers selected 1 of N filters in an attempt to match the cables characteristics. This approach typically leaves holes at certain cable lengths, where the performance of the equalizer is not optimized. The DP83816 equalizer is truly adaptive.

The curves given in Figure 5-10 illustrate attenuation at certain frequencies for given cable lengths. This is derived from the worst-case frequency versus attenuation figures as specified in the EIA/TIA Bulletin TSB-36. These curves indicate the significant variations in signal attenuation that must be compensated for by the receive adaptive equalization circuit.

Figure 5-11 represents a scrambled IDLE transmitted over zero meters of cable as measured at the AII (Active Input Interface) of the receiver. Figure 5-12 and Figure 5-13 represent the signal degradation over 50 and 100 meters of category V cable respectively, also measured at the AII. These plots show the extreme degradation of signal integrity and indicate the requirement for a robust adaptive equalizer.

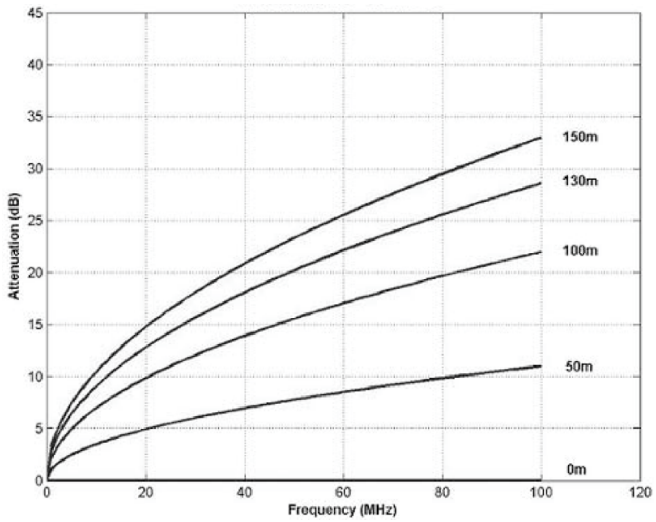


Figure 5-10. EIA/TIA Attenuation vs Frequency for 0, 50, 100, 130 and 150 Meters of CAT V Cable

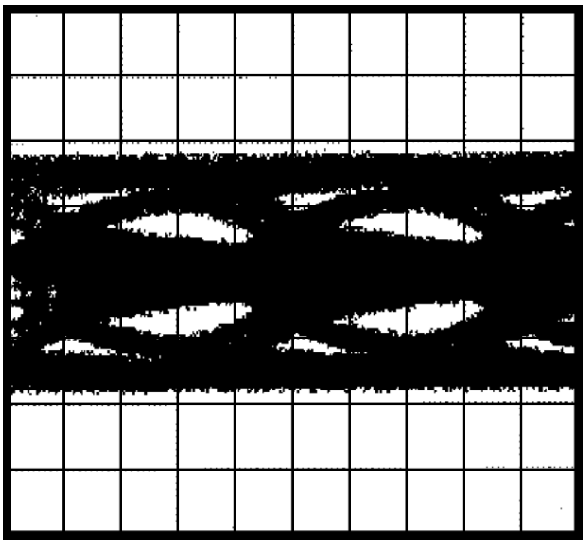


Figure 5-11. MLT-3 Signal Measured at AII After 0 Meters of CAT V Cable

5.5.1.2.4 Line Quality Monitor

It is possible to determine the amount of Equalization being used by accessing certain test registers with the DSP engine. This provides a crude indication of connected cable length. This function allows for a quick and simple verification of the line quality in that any significant deviation from an expected register value (based on a known cable length) would indicate that the signal quality has deviated from the expected nominal case.

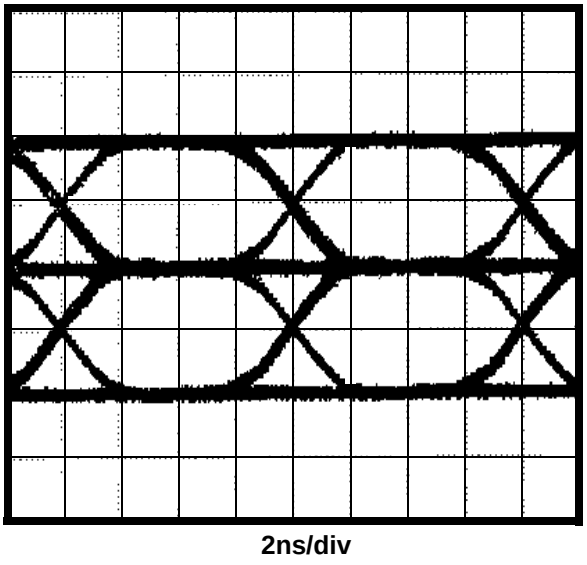


Figure 5-12. MLT-3 Signal Measured at AII After 50 Meters of CAT V Cable

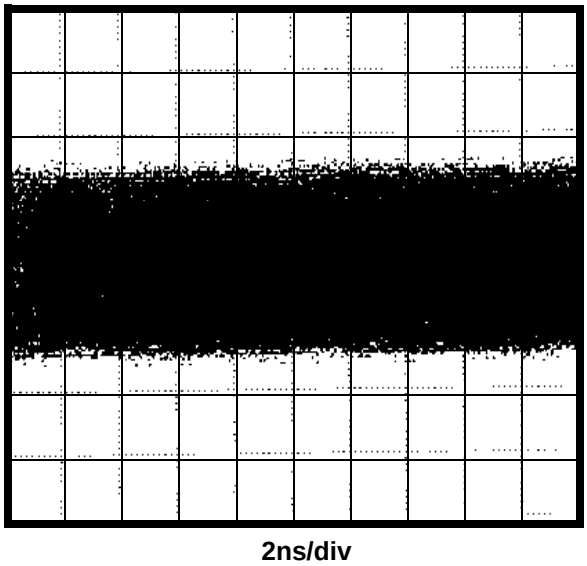


Figure 5-13. MLT-3 Signal Measured at AII After 100 Meters of CAT V Cable

5.5.1.2.5 MLT-3 to NRZI Decoder

The DP83816 device decodes the MLT-3 information from the Digital Adaptive Equalizer block to binary NRZI data.

5.5.1.2.6 Clock Recovery Module

The Clock Recovery Module (CRM) accepts 125-Mb/s MLT-3 data from the equalizer. The DPLL locks onto the 125-Mb/s data stream and extracts a 125-MHz recovered clock. The extracted and synchronized clock and data are used as required by the synchronous receive operations as generally depicted in Figure 5-8.

The CRM is implemented using an advanced all digital Phase Locked Loop (PLL) architecture that replaces sensitive analog circuitry. Using digital PLL circuitry allows the DP83816 device to be manufactured and specified to tighter tolerances.

5.5.1.2.7 NRZI to NRZ

In a typical application, the NRZI to NRZ decoder is required to present NRZ formatted data to the de-scrambler (or to the code-group alignment block, if the de-scrambler is bypassed, or directly to the PCS, if the receiver is bypassed).

5.5.1.2.8 Serial to Parallel

The 100BASE-TX receiver includes a Serial to Parallel converter which supplies 5-bit wide data symbols to the PCS Rx state machine.

5.5.1.2.9 Descrambler

A serial de-scrambler is used to de-scramble the received NRZ data. The de-scrambler has to generate an identical data scrambling sequence (N) to recover the original unscrambled data (UD) from the scrambled data (SD) as represented in the equations:

$$SD = (UD \oplus N) \quad (1)$$

$$UD = (SD \oplus N) \quad (2)$$

Synchronization of the de-scrambler to the original scrambling sequence (N) is achieved based on the knowledge that the incoming scrambled data stream consists of scrambled IDLE data. After the de-scrambler has recognized 12 consecutive IDLE code-groups, where an unscrambled IDLE code-group in 5B NRZ is equal to five consecutive ones (11111), it synchronizes to the receive data stream and generates unscrambled data in the form of unaligned 5B code groups.

To maintain synchronization, the de-scrambler must continuously monitor the validity of the unscrambled data that it generates. To ensure this, a line state monitor and a hold timer are used to constantly monitor the synchronization status. On synchronization of the de-scrambler, the hold timer starts a 722-µs countdown. On detection of sufficient IDLE code-groups (58 bit times) within the 722 µs period, the hold timer resets and begins a new countdown. This monitoring operation continues indefinitely, given a properly operating network connection with good signal integrity. If the line state monitor does not recognize sufficient unscrambled IDLE code-groups within the 722 µs period, the entire de-scrambler is forced out of the current state of synchronization and reset to re-acquire synchronization.

5.5.1.2.10 Code-group Alignment

The code-group alignment module operates on unaligned 5-bit data from the de-scrambler (or, if the de-scrambler is bypassed, directly from the NRZI/NRZ decoder) and converts it into 5B code-group data (5 bits). Code-group alignment occurs after the J/K code-group pair is detected. When the J/K code-group pair (11000 10001) is detected, subsequent data is aligned on a fixed boundary.

5.5.1.2.11 4B/5B Decoder

The code-group decoder functions as a look up table that translates incoming 5B code-groups into 4B nibbles. The code-group decoder first detects the J/K code-group pair preceded by IDLE code-groups and replaces the J/K with MAC preamble. Specifically, the J/K 10-bit code-group pair is replaced by the nibble pair (0101 0101). All subsequent 5B code-groups are converted to the corresponding 4B nibbles for the duration of the entire packet. This conversion ceases on the detection of the T/R code-group pair denoting the End of Stream Delimiter (ESD) or with the reception of a minimum of two IDLE code-groups.

5.5.1.2.12 100BASE-TX Link Integrity Monitor

The 100 Base-TX Link monitor ensures that a valid and stable link is established before enabling both the Transmit and Receive PCS layer.

Signal detect must be valid for 395 µs to allow the link monitor to enter the *Link Up* state, and enable the transmit and receive functions.

Signal detect can be forced active by setting Bit 1 of the PCSR.

Signal detect can be optionally ANDed with the de-scrambler locked indication by setting bit 8 of the PCSR. When this option is enabled, then descrambler *locked* is required to enter the Link Up state, but only Signal detect is required to maintain the link in the link Up state

5.5.1.2.13 Bad SSD Detection

A Bad Start of Stream Delimiter (Bad SSD) is any transition from consecutive idle code-groups to non-idle code-groups which is not prefixed by the code-group pair J/K.

If this condition is detected, the DP83816 device asserts RXER and presents RXD[3:0] = 1110 to the MAC for the cycles that correspond to received 5B code-groups until at least two IDLE code groups are detected. In addition, the False Carrier Event Counter is incremented by one.

When at least two IDLE code groups are detected, the error is reported to the MAC.

5.5.1.3 10BASE-T Transceiver Module

The 10BASE-T Transceiver Module is IEEE 802.3 compliant. It includes the receiver, transmitter, collision, heartbeat, loopback, jabber, and link integrity functions, as defined in the standard. An external filter is not required on the 10BASE-T interface because this is integrated inside the DP83816 device. This section focuses on the general 10BASE-T system level operation.

5.5.1.3.1 Operational Modes

The DP83816 device has two basic 10BASE-T operational modes:

- **Half-Duplex Mode** – In half-duplex mode, the DP83816 device functions as a standard IEEE 802.3 10BASE-T transceiver supporting the CSMA/CD protocol.
- **Full-Duplex Mode** – In full-duplex mode, the DP83816 device is capable of simultaneously transmitting and receiving without reporting a collision. The DP83816 10-Mb/s ENDEC is designed to encode and decode simultaneously.

5.5.1.3.2 Smart Squelch

The smart squelch is responsible for determining when valid data is present on the differential receive inputs (TPRDP and TPRDM). The DP83816 device implements an intelligent receive squelch to ensure that impulse noise on the receive inputs is not mistaken for a valid signal. Smart squelch operation is independent of the 10BASE-T operational mode.

The squelch circuitry employs a combination of amplitude and timing measurements (as specified in the IEEE 802.3 10BASE-T standard) to determine the validity of data on the twisted pair inputs (see Figure 5-14).

The signal at the start of packet is checked by the smart squelch, and any pulses not exceeding the squelch level (either positive or negative, depending on polarity) are rejected. When this first squelch level is overcome correctly, the opposite squelch level must then be exceeded within 150 ns. Finally, the signal must again exceed the original squelch level within a 150 ns to ensure that the input waveform is not rejected. This checking procedure results in the loss of typically three preamble bits at the beginning of each packet.

Only after all these conditions have been satisfied is a control signal generated to indicate to the remainder of the circuitry that valid data is present. At this time, the smart squelch circuitry is reset.

Valid data is considered to be present until the squelch level has not been generated for a time longer than 150 ns, indicating the End of Packet. When good data has been detected the squelch levels are reduced to minimize the effect of noise causing premature End of Packet detection.

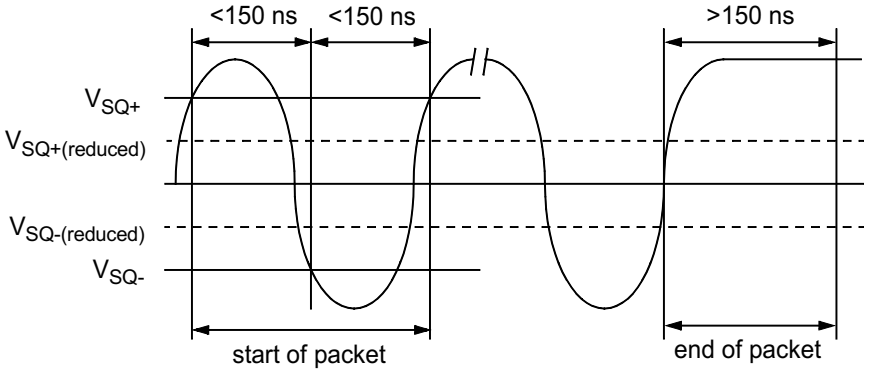


Figure 5-14. 10BASE-T Twisted Pair Smart Squelch Operation

5.5.1.3.3 Collision Detection

When in Half Duplex, a 10BASE-T collision is detected when the receive and transmit channels are active simultaneously. Collisions are reported to the MAC. Collisions are also reported when a jabber condition is detected.

If the ENDEC is receiving when a collision is detected it is reported immediately (through the COL signal).

When heartbeat is enabled, approximately 1 µs after the transmission of each packet, a Signal Quality Error (SQE) signal of approximately 10 bit times is generated to indicate successful transmission.

The SQE test is inhibited when the physical layer is set in full duplex mode. SQE can also be inhibited by setting the HEARTBEAT_DIS bit in the TBTSCR register.

5.5.1.3.4 Normal Link Pulse Detection and Generation

The link pulse generator produces pulses as defined in the IEEE 802.3 10BASE-T standard. Each link pulse is nominally 100 ns in duration and transmitted every 16 ms in the absence of transmit data.

Link pulses are used to check the integrity of the connection with the remote end. If valid link pulses are not received, the link detector disables the 10BASE-T twisted pair transmitter, receiver and collision detection functions.

When the link integrity function is disabled (FORCE_LINK_10 of the TBTSCR register), good link is forced, and the 10BASE-T transceiver operates regardless of the presence of link pulses.

5.5.1.3.5 Jabber Function

The jabber function monitors the DP83816 output and disables the transmitter if it attempts to transmit a packet of longer than legal size. A jabber timer monitors the transmitter and disables the transmission if the transmitter is active for approximately 20–30 ms.

When disabled by the jabber function, the transmitter stays disabled for the entire time that the internal transmit enable of the ENDEC module is asserted. This signal has to be de-asserted for approximately 400 ms–600 ms (the *unjab* time) before the jabber function re-enables the transmit outputs.

The Jabber function is only meaningful in 10BASE-T mode.

5.5.1.3.6 Automatic Link Polarity Detection

The DP83816 10BASE-T transceiver module incorporates an automatic link polarity detection circuit. When seven consecutive link pulses or three consecutive receive packets with inverted End-of-Packet pulses are received, bad polarity is reported.

A polarity reversal can be caused by a wiring error at either end of the cable, usually at the Main Distribution Frame (MDF) or patch panel in the wiring closet.

The bad polarity condition is latched. The DP83816 10BASE-T transceiver module corrects for this error internally and continues to decode received data correctly. This eliminates the need to correct the wiring error immediately.

5.5.1.3.7 10BASE-T Internal Loopback

When the LOOPBACK bit in the BMCR register is set, 10BASE-T transmit data is looped back in the ENDEC to the receive channel. The transmit drivers and receive input circuitry are disabled in transceiver loopback mode, isolating the transceiver from the network.

Loopback is used for diagnostic testing of the data path through the transceiver without transmitting on the network or being interrupted by receive traffic. This loopback function causes the data to loopback just prior to the 10BASE-T output driver buffers such that the entire transceiver path is tested.

5.5.1.3.8 Transmit and Receive Filtering

External 10BASE-T filters are not required when using the DP83816 device, as the required signal conditioning is integrated into the device.

Only isolation and step-up transformers and impedance matching resistors are required for the 10BASE-T transmit and receive interface. The internal transmit filtering ensures that all the harmonics in the transmit signal are attenuated by at least 30 dB.

5.5.1.3.9 Transmitter

The encoder begins operation when the transmit enable input to the physical layer is asserted and converts NRZ data to pre-emphasized Manchester data for the transceiver. For the duration of assertion, the serialized transmit data is encoded for the transmit-driver pair (TPTDP and TPTDM). The last transition is always positive; it occurs at the center of the bit cell if the last bit is a one, or at the end of the bit cell if the last bit is a zero.

5.5.1.3.10 Receiver

The decoder consists of a differential receiver and a PLL to separate a Manchester encoded data stream into internal clock signals and data. The differential input must be externally terminated with a differential 100-Ω termination network to accommodate UTP cable. The internal impedance of TPRDP and TPRDM (typically 1.1 kΩ) is in parallel with two 54.9-Ω resistors to approximate the 100-Ω termination.

The decoder detects the end of a frame when no more mid-bit transitions are detected.

5.5.1.3.11 Far End Fault Indication

Auto-Negotiation provides a mechanism for transferring information from the Local Station to the Link Partner that a remote fault has occurred for 100BASE-TX.

A remote fault is an error in the link that one station can detect while the other cannot. An example of this is a disconnected fiber at the transmitter of a station. This station receives valid data and detects that the link is good though the link integrity monitor, but is not able to detect that its transmission is not propagating to the other station.

If three or more FEFI IDLE patterns are detected by the DP83816 device, then bit 4 of the basic mode status register is set to one until read by management, additionally bit 7 of the PHY status register is also set.

The first FEFI IDLE pattern may contain more than 84 ones as the pattern may have started during a normal IDLE transmission, which is actually quite likely to occur. However, because FEFI is a repeating pattern, this does not cause a problem with the FEFI function.

NOTE

Receipt of the FEFI IDLE pattern does not cause a Carrier Sense error to be reported.

If the FEFI function has been disabled via FEFI_EN (bit 3) of the PCSR Configuration register, then the DP83816 device does not send the FEFI IDLE pattern.

5.5.1.4 Buffer Management

The buffer management scheme used on the DP83816 allows quick, simple and efficient use of the frame buffer memory. Frames are saved in similar formats for both transmit and receive. The buffer management scheme also uses separate buffers and descriptors for packet information. This allows effective transfers of data from the receive buffer to the transmit buffer by simply transferring the descriptor from the receive queue to the transmit queue.

The format of the descriptors allows the packets to be saved in a number of configurations. A packet can be stored in memory with a single descriptor per single packet, or multiple descriptors per single packet. This flexibility allows the user to configure the DP83816 device to maximize efficiency. Architecture of the specific buffer memory of the system, as well as the nature of network traffic, determines the most-suitable configuration of packet descriptors and fragments. See the Buffer Management Section 5.5.5 for more information.***

5.5.1.4.1 Tx Buffer Manager

This block DMAs packet data from PCI memory space and places it in the 2KB transmit FIFO, and pulls data from the FIFO to send to the Tx MAC. Multiple packets (4) may be present in the FIFO, allowing packets to be transmitted with minimum interframe gap. The way in which the FIFO is emptied and filled is controlled by the FIFO threshold values in the TXCFG register: FLTH (Tx Fill Threshold) and DRTH (Tx Drain Threshold). These values determine how full or empty the FIFO must be before the device requests the bus. Additionally, when the DP83816 device requests the bus, it attempts to empty or fill the FIFO as allowed by the MXDMA setting in the TXCFG register.

5.5.1.4.2 Rx Buffer Manager

This block retrieves packet data from the Rx MAC and places it in the 2KB receive data FIFO, and pulls data from the FIFO for DMA to PCI memory space. The Rx buffer manager maintains a status FIFO, allowing up to 4 packets to reside in the FIFO at once. Similar to the transmit FIFO, the receive FIFO is controlled by the FIFO threshold value in the RXCFG register: DRTH (Rx Drain Threshold). This value determines the number of long words written into the FIFO from the MAC unit before a DMA request for system memory access occurs. When the DP83816 device gets the bus, it continues to transfer the long words from the FIFO until the data in the FIFO is less than one long word, or has reached the end of the packet, or the max DMA burst size is reached (RXCFG:MXDMA).

5.5.1.4.3 Packet Recognition

The Receive packet filter and recognition logic allows software to control which packets are accepted based on destination address and packet type. Address recognition logic includes support for broadcast, multicast hash, and unicast addresses. The packet recognition logic includes support for WOL, Pause, and programmable pattern recognition.

The standard 802.3 Ethernet packet consists of the following fields: Preamble (PA), Start of Frame Delimiter (SFD), Destination Address (DA), Source Address (SA), Length (LEN), Data and Frame Check Sequence (FCS). All fields are fixed length except for the data field. During reception, the PA, SFD and FCS are stripped. During transmission, the DP83816 device generates and appends the PA, SFD and FCS.

Table 5-3. Ethernet Packet Format

PA	SFD	DA	SA	LEN	Data	FCS
60b	4b	6B	6B	2B	46B–1500B	4B

Note: B = Bytes
b = bits

5.5.1.4.4 MIB

The MIB block contains counters to track certain media events required by the management specifications RFC 1213 (MIB II), RFC 1398 (Ether-like MIB), and IEEE 802.3 LME. The counters provided are for events which are either difficult or impossible to be intercepted directly by software. Not all counters are implemented, however required counters can be calculated from the counters provided.

5.5.2 Receive Filter Logic

The receive filter logic supports a variety of techniques for qualifying incoming packets. The most-basic filtering options include accept all broadcast, accept all multicast and accept all unicast packets. These options are enabled by setting the corresponding bit in the receive filter control register, RFCR. accept on perfect match, accept on pattern match, accept on multicast hash and accept on unicast hash are more robust in their filtering capabilities, but require additional programming of the receive filter registers and the internal filter RAM.

5.5.2.1 Packet Filtering

When the PME enable bit is set to 1, incoming packets are filtered based on settings in the receive filter control register (RFCR - offset 48h in operational registers) and the wake command and status register (WCSR - offset 40h in operational registers). In other words, a packet must pass both filters to be accepted. This is a desirable feature in WOL mode, because it prevents non-wake packets from filling the receive FIFO. However, it is not desirable in normal operating mode because it does not allow non-wake packets from being received. Therefore, the driver should ensure that the PME enable bit is set to 0 for normal operation.

5.5.2.2 Accept on Perfect Match

When enabled, the perfect match register is used to compare against the DA for packet acceptance. The perfect match register is a 6-byte register accessed indirectly through the RFCR. The address of the internal receive filter register to be accessed is programmed through bits 8:0 of the RFCR. The receive filter data register, RFDR, is used for reading or writing the actual data.

RX Filter Address:	000h - Perfect Match octets 1-0
	002h - Perfect Match octets 3-2
	004h - Perfect Match octets 5-4

Octet 0 of the perfect match register corresponds to the first octet of the packet as it appears on the wire. Octet 5 corresponds to the last octet of the DA as it appears on the wire.

The following steps are required to program the RFCR to accept packets on a perfect match of the DA.

Example: Destination Address of 08-00-17-07-28-55

iow l $RFCR (0000)	perfect match register, octets 1-0
iow l $RFDR (0008)	write address, octets 1-0
iow l $RFCR (0002)	perfect match register, octets 3-2
iow l $RFDR (0717)	write address, octets 3-2
iow l $RFCR (0004)	perfect match register, octets 5-4
iow l $RFDR (5528)	write address, octets 5-4
iow l $RFDR	
($RFEN\|$APM)	enable filtering, perfect match

5.5.2.3 Accept on Pattern Match

The receive filter logic provides access to 4 separate internal RAM-based pattern buffers to be used as additional perfect match address registers. Pattern buffers 0 and 1 are 64 bytes deep, allowing perfect match on the first 64 bytes of a packet, and pattern buffers 2 and 3 are 128 bytes deep, allowing perfect match on the first 128 bytes of a packet.

When one or more of the pattern match enable bits are set in the RFCR, a packet is accepted if it matches the associated pattern buffer. As indicated above, the pattern buffers are 64 and 128 bytes deep organized as 32 or 64 words, where a word is 18 bits. Bits 17 and 18 of a respective word are mask bits for byte 0 and byte 1 of the 16-bit data word (bits 15:0). An incoming packet is compared to each enabled pattern buffer on a byte by byte basis for a specified count. Masking a pattern byte results in a byte match regardless of its value (a don't care). A count value must be programmed for each pattern buffer to be used for comparison. The minimum valid count is 2 (2 bytes) and the maximum valid count is 32 for pattern buffers 0 and 1, and 64 for pattern buffers 2 and 3. The pattern count registers are internal receive filter registers accessed through the RFCR and the RFDR The Receive Filter memory is also accessed through the RFCR and the RFDR. A memory map of the internal pattern RAM is shown in Figure 5-15.

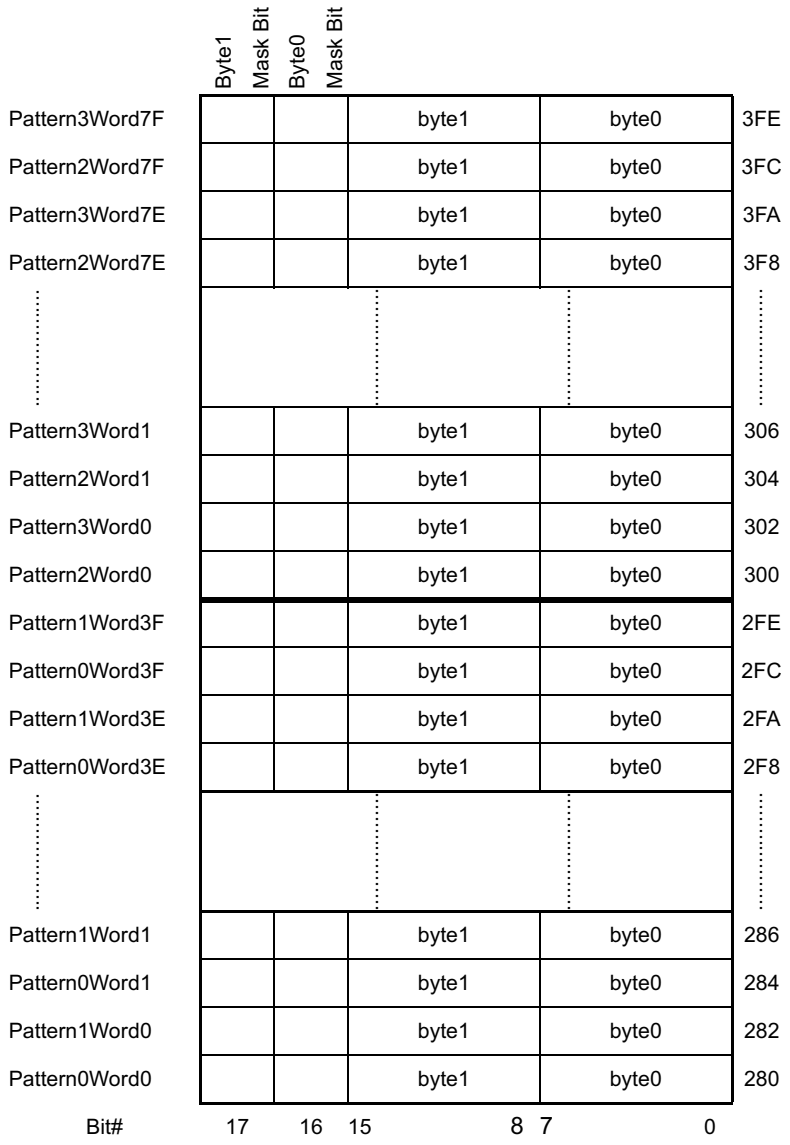


Figure 5-15. Pattern Buffer Memory – 180h Words (Word = 18 Bits)

Example: Pattern match on the following destination addresses:

02-00-03-01-04-02

12-10-13-11-14-12

22-20-23-21-24-22

32-30-33-31-34-32

set $PATBUF01 = 280

set $PATBUF23 = 300

write counts

iow l $RFCR (0006) # pattern count registers 1, 0

iow l $RFDR (0406) # count 1 = 4, count 0= 6

iow l $RFCR (0008) # pattern count registers 3, 2

iow l $RFDR (0406) # count 3 = 4, count 2 = 6

```
# write data pattern into buffer 0
iow l $RFCR ($PATBUF01)
iow l $RFDR (0002)
iow l $RFCR ($PATBUF01 + 4)
iow l $RFDR (0103)
iow l $RFCR ($PATBUF01 + 8)
iow l $RFDR (0204)
# write data pattern into buffer 1
iow l $RFCR ($PATBUF01 + 2)
iow l $RFDR (1012)
iow l $RFCR ($PATBUF01 + 6)
iow l $RFDR (1113)
iow l $RFCR ($PATBUF01 + a)
iow l $RFDR (1214)
# write data pattern into buffer 2
iow l $RFCR ($PATBUF23)
iow l $RFDR (2022)
iow l $RFCR ($PATBUF23 + 4)
iow l $RFDR (2123)
iow l $RFCR ($PATBUF23 + 8)
iow l $RFDR (2224)
# write data pattern into buffer 3
iow l $RFCR ($PATBUF23 +2)
iow l $RFDR (3032)
iow l $RFCR ($PATBUF23 + 6)
iow l $RFDR (3133)
iow l $RFCR ($PATBUF23 + a)
iow l $RFDR (3234)

#enable receive filter on all patterns
iow l $RFCR ($RFEN|$APAT0|$APAT1|$APAT2|$APAT3)
```

Example of how to mask out a byte in a pattern:

```
# write data pattern into buffer 0
iow l $RFCR ($PATBUF01)
iow l $RFDR (10002)            #mask byte 0 (value = 02)
iow l $RFCR ($PATBUF01 + 4)
iow l $RFDR (20103)            #mask byte 1 (value = 01)
iow l $RFCR ($PATBUF01 + 8)
iow l $RFDR (30204)            #mask byte 0 and 1
```

5.5.2.4 Accept on Multicast or Unicast Hash

Multicast and unicast addresses may be further qualified by use of the receive filter hash functions. An internal 512 bit (64 byte) RAM-based hash table is used to perform imperfect filtering of multicast or unicast packets. By enabling either multicast hashing or unicast hashing in the RFCR, the receive filter logic uses the nine least-significant bits of the destination address' CRC as an index into the Hash Table memory. The upper 4 bits represent the word address and the lower 5 bits select the bit within the word. If the corresponding bit is set, then the packet is accepted, otherwise the packet is rejected. The hash table memory is accessed through the RFCR and the RFDR. See Figure 5-16 for a memory map. Example code for setting or clearing a bit in the hash table follows.

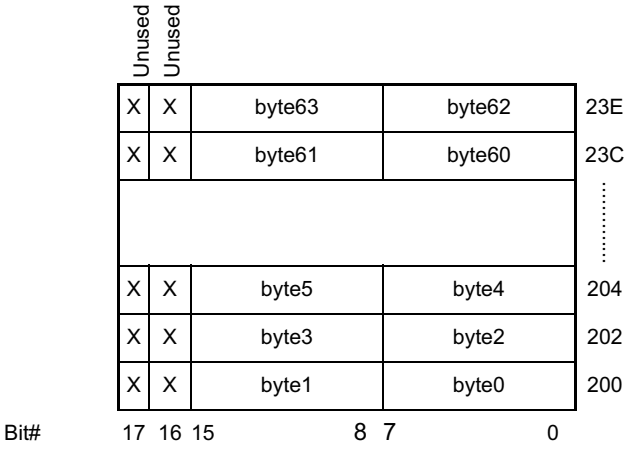


Figure 5-16. Hash Table Memory - 40h Bytes Addressed on Word Boundaries

```
set HASH_TABLE = 200

crc $DA                                  # compute the CRC of the destination address
set index = ($crc >> 3)
set bit = ($crc & 01f)                   # lower 5 bits select which bit in 32 bit word

# write word address into RFCR
 iow l $RFCR ($HASH_TABLE + $index)

# select bit to set/clear
 if ($bit > f) set bit = ($bit - 010h)    # use 16 bit register interface into 32bit RAM
 set hash_bit = (0001 << $bit)

# read indexed word from table
 ior l $RFDR
 if ($SetBit) then
        set hash_word = ($rc | $hash_bit)
        iow l $RFDR ($hash_word)
else
        set hash_bit = (~$hash_bit)
        set hash_word = ($rc & $hash_bit)
        iow l $RFDR ($hash_word)‘
endif
iow l $RFCR ($RFEN|$MHEN|$UHEN)          # enable multicast and/or unicast
                                         # address hashing
```

5.5.3 Wake-On-LAN (WoL) Mode

WoL mode is a system-level function that allows a network device to alert the system that a wake event has occurred. It works in conjunction with the PCI power management states detailed in the previous section. The DP83816 device supports several wake events including, but not limited to, wake on PHY Interrupt (that is, link change), wake on Magic Packet, and wake on pattern match. The supported wake events appear in the device's Wake Command and Status Register (WCSR).

5.5.3.1 Definitions of Terms in WOL Mode

The following lists contains definitions of terms used in the WoL section:

- Power management – a PCI specification that defines power-saving states of PCI devices and systems. A spec-compliant device implements two PCI Configuration registers to control and report status for its power management function.
- Wake event – an event that causes a PCI device in power management mode to signal the system.
- PME enable (PMEEN) – bit 8 of the power management control and status register (PMCSR - offset 44h in the PCI configuration space). Setting this bit to 1 allows the device to assert the PMEN pin when it detects a wake event.
- Sleep mode – a device is in sleep mode if it is programmed to a power management state other than the fully operational state and is not allowed to signal a wake event to the system. In this mode, the PME Enable bit is 0.
- WoL mode – a device is in WoL mode if it is programmed to a power management state other than the fully operational state and is allowed to signal a wake event to the system. In this mode, the PME Enable bit is 1.
- PMEN (pin59) – this pin is similar in function to a system interrupt (INTAN pin). When asserted, it signals the system that a wake event has occurred.
- PME status – bit 15 of PMCSR. When 1, indicates the device detected a wake event. If PME Enable is also set to 1, the device asserts PMEN whenever PME Status is 1. Software writes a 1 to this bit to clear it.
- Magic Packet – a specific packet of information sent to remotely wake up a sleeping or powered off PC on a network, it is handled in the LAN controller. The Magic Packet must contain a specific data sequence which can be located anywhere within the packet but must be preceded by a synchronization stream. The packet must also meet the basic requirements for the LAN technology chosen (for example, ethernet frame). The specific data sequence consists of 16 duplications of the MAC address of the machine to be awakened. The synchronization stream is defined as 6 bytes of FFh.
- ACPI-compatible operating system – An operating system that takes advantage of the PCI power management interface. These include Windows 98 (when installed with ACPI), Windows 2000, and Windows ME (when installed with ACPI).

5.5.3.2 Entering WoL Mode

The following steps are required to place the DP83816 device into WoL mode:

1. Disable the receiver by writing a 1 to the receiver disable bit 3 (RXD) in the command register (CR - offset 00h in operational registers).
2. Write 0 to the receive descriptor pointer register (RXDP - offset 30h in operational registers) to reset the receive pointer.
3. Enable the receiver (now in *silent receive* mode) by writing a 1 to the receiver enable bit 2 in the command register (CR:RXE).
4. Configure the receive filter control register (RFCR) to enable the receive filter (RFCR:RFEN - bit 31) and accept the desired type of wakeup packets. Note that the receive filter enable bit must be set to 1 for wake on PHY Interrupt as well.
5. If wake on PHY Interrupt is desired, additionally configure registers MICR (offset C4h in operational registers) and MISR (offset C8h in operational registers).
6. Configure the wake command and status register (WCSR) with the desired type of wake events. An ACPI-compatible operating system should notify the driver of these events.
7. Write a 1 to PME enable, and set the desired power state in PMCSR. These can be done in one operation, or PME Enable can be written first. An ACPI-compatible operating system should handle this step.

8. If the power management state is D3cold, the system asserts PCI reset, stops the PCI clock, and removes power from the PCI bus.

The following two examples show the corresponding register settings for wake on Magic Packet mode and wake on PHY Interrupt mode respectively:

Entering Wake on Magic Packet Mode

1. CR = 00000008h (disable the receiver)
2. RXDP = 00000000h (reset the receive pointer)
3. CR = 00000004h (enable the receiver)
4. RFCR = F0000000h (enables the receive filter and allows broadcast, multicast and unicast packets to be received - a Magic Packet could be any of those.)
5. WCSR = 00000200h (sets the wake on Magic Packet bit)
6. PMCSR = 00008103h (clears the PME status bit 15, sets the PME enable bit 8 and sets the power state bits [1:0] to D3hot)

Entering Wake on PHY Interrupt Mode

1. CR = 00000008h (disable the receiver)
2. RXDP = 00000000h (reset the receive pointer)
3. CR = 00000004h (enable the receiver)
4. RFCR = 80000000h (enables the receive filter)
5. MICR = 00000002h (sets the interrupt enable bit 1)
6. MISR = 00000000h (unmasks the change of link status event)
7. WCSR = 00000001h (sets the wake on PHY interrupt bit)
8. PMCSR = 00008103h (clears the PME status bit 15, sets the PME enable bit 8 and sets the power state bits [1:0] to D3hot)

5.5.3.3 Wake Events

If the device detects a wake event while in WOL mode, it asserts the PMEN pin low to signal the system that a wake event has occurred. The system should then bring the device out of WOL mode as described below.

5.5.3.4 Exiting WOL Mode

The following steps are required to bring the device out of WOL mode (with or without an accompanying wake event):

1. If the power management state is D3cold, the system asserts PCI reset, restores PCI bus power, and restarts the PCI clock. This also returns the power state to D0. The PCI configuration registers (that is, base addresses, bus master enable, and so forth) must be reinitialized.
2. Write a 0 to Power State bits [0:1] in the PMCSR (in case the WOL Power State was not D3hot or D3cold) and PME enable. These can be done in one operation, or Power State can be written first. Turning off PME Enable causes the device to de-assert the PMEN pin, if it was asserted.
3. If the WOL power state was D3hot or D3cold, reinitialize the PCI configuration registers (that is, base addresses, bus master enable, and so forth). An ACPI-compatible operating system should handle this step. Note that operational registers are not accessible until this step is completed.
4. If a wake event occurred, read the WCSR to determine what the event was.
5. Write a 1 to PME status. This clear any wake event in the device. An ACPI-compatible operating system performs this write to the PMCSR; a driver can perform this write using the clockrun control and status register (CCSR).
6. If the wake event was a PHY interrupt from an internal PHY, clear the event in the PHY registers. See the MISR in Section 5.6.4.11.

7. Clear all bits in WCSR.
8. Disable the receiver by writing a 1 to the receiver disable bit in the command register (CR:RXD).
9. Reconfigure RFCR as appropriate for normal operation.
10. Write a valid receive descriptor pointer to the receive descriptor pointer register (RXDP).
11. Enable the receiver by writing a 1 to the receiver enable bit in the command register (CR:RXE). If the wake event was a packet, this is now emptied from the receive FIFO through DMA.

5.5.4 Power Management

The power management specification presents a low-level hardware interface to PCI devices for the purpose of saving power. The DP83816 device supports power states D0, D1, D2, D3hot, and D3cold as defined in the PCI power management specification. These states provide increasing power reduction in the order they are listed. Table 5-4 lists the different power management modes and the methods of power reduction in DP83816 devices.

Table 5-4. Power Management Modes

POWER STATE	PME ENABLE (PMEEN)	WAKE CONDITIONS	POWER MANAGEMENT MODE	PCICLK	PHYSICAL LAYER CELL
D0	(SW sets to 0)	Unconfigured	Normal	On	On
D1	Don't Care	Don't Care	WOL	On	On
D2	Don't Care	Don't Care	WOL	May be Off	On
D3hot	Off	Don't Care	Sleep	May be Off	Off
D3hot	Don't Care	Unconfigured	Sleep	May be Off	Off
D3hot	On	Configured	WOL	May be Off	On
D3cold	Off	Don't Care	Sleep	Off	Off
D3cold	Don't Care	Unconfigured	Sleep	Off	Off
D3cold	On	Configured	WOL	Off	On

5.5.4.1 D0 State

The D0 state is the normal operational state of the device. The PME Enable bit should be set to 0 to prevent packet filtering based on the settings in the wake control and status register (WCSR). It is also advisable to turn off all WOL conditions in WCSR to prevent unnecessary PME interrupts.

5.5.4.2 D1 State

The D1 state is the least-power-saving power management state, and might not be used by the operating system. The device only responds to PCI configuration transactions and therefore does not transmit data. The only bus activity the device can initiate is the assertion of the PMEN pin (assuming the PME enable bit is set to 1); no DMA activity or interrupts occurs. The device continues to receive packets up to the limit of the receive FIFO size. On returning to the D0 state, the system must re-enable I/O and memory space in the device and turn on bus master capability.

5.5.4.3 D2 State

The D2 state has the same features as the D1 state, and the system may turn off the PCI clock, further reducing power. The device continues to receive packets up to the limit of the receive FIFO size. Like the D1 state, the D2 state might not be used by the operating system.

5.5.4.4 D3hot State

The D3hot state is often known as the standby state. If the PME Enable bit is 0, or WOL is unconfigured, the device saves power by turning off the physical layer cell (PHY). The system may turn off the PCI clock. To receive packets in the D3hot state, both WOL mode and PME Enable must be turned on. Like the D2 and D1 states, the device responds to PCI configuration transactions as long as the PCI clock is running.

When the device exits the D3hot state, all PCI configuration registers except for the PME enable and PME status bits are reset to their default values. This means the operating system must reinitialize PCI configuration registers of the device with valid base addresses, and so forth. If PME enable or WOL mode were not turned on, the device must be fully reinitialized.

5.5.4.5 D3cold State

The D3cold state is the highest power-saving state; it is often known as the hibernate state. The PCI bus is turned off, as is the PCI clock. If the PME enable bit or WOL is turned off, the PHY is turned off. This allows the device to consume the least amount of power. The device must be fully reinitialized after exiting this mode.

5.5.5 Buffer Management

The buffer management scheme used on the DP83816 device allows quick, simple and efficient use of the frame buffer memory. Frames are saved in similar formats for both transmit and receive. The buffer management scheme also uses separate buffers and descriptors for packet information. This allows effective transfers of data from the receive buffer to the transmit buffer by simply transferring the descriptor from the receive queue to the transmit queue.

The format of the descriptors allows the packets to be saved in a number of configurations. A packet can be stored in memory with a single descriptor and a single packet fragment, or multiple descriptors each with a single fragment. This flexibility allows the user to configure the DP83816 device to maximize efficiency. Architecture of the specific system's buffer memory, as well as the nature of network traffic, determines the most-suitable configuration of packet descriptors and fragments.

5.5.5.1 Overview

The buffer management design has the following goals:

- Simplicity
- Efficient use of the PCI bus (the overhead of the buffer management technique is minimal)
- Low CPU utilization
- Flexibility

Descriptors may be either per-packet or per-packet-fragment. Each descriptor may describe one packet fragment. Receive and transmit descriptors are symmetrical.

5.5.5.1.1 Descriptor Format

The DP83816 device uses a symmetrical format for transmit and receive descriptors. In bridging and switching applications this symmetry allows software to forward packets by simply moving the list of descriptors that describe a single received packet from the receive list of one MAC to the transmit list of another. Descriptors must be aligned on an even long word (32-bit) boundary.

Table 5-5. DP83816 Device Descriptor Format

OFFSET	TAG	DESCRIPTION
0000h	link	32-bit *link* field to the next descriptor in the linked list. Bits 1-0 must be 0, as descriptors must be aligned on 32-bit boundaries.
0004h	cmdsts	32-bit Command and Status field (bit-encoded).
0008h	bufptr	32-bit pointer to the first fragment or buffer. In transmit descriptors, the buffer can begin on any byte boundary. In receive descriptors, the buffer must be aligned on a 32-bit boundary.

The original DP83810A descriptor format supported multiple fragments per descriptor. The DP83816 device only supports a single fragment per descriptor. By default, the DP83816 device uses the descriptor format shown in Table 5-5. By setting CFG:EUPHCOMP, software may force compatibility with the previous DP83810A Descriptor format (although still only single fragment descriptors are supported). When CFG:EUPHCOMP is set, then bufptr is at offset 0Ch, and the 32-bit bufcnt field at offset 08h is ignored.

Some of the bit definitions in the cmdsts field are common to both receive and transmit descriptors:

Table 5-6. cmdsts Common Bit Definitions

BIT	TAG	DESCRIPTION	USAGE
31	OWN	Descriptor ownership	Set to 1 by the data producer of the descriptor to transfer ownership to the data consumer of the descriptor. Set to 0 by the data consumer of the descriptor to return ownership to the data producer of the descriptor. For transmit descriptors, the driver is the data producer, and the DP83816 device is the data consumer. For receive descriptors, the DP83816 device is the data producer, and the driver is the data consumer.
30	MORE	More descriptors	Set to 1 to indicate that this is NOT the last descriptor in a packet (there are MORE to follow). When 0, this descriptor is the last descriptor in a packet. Completion status bits are only valid when this bit is zero.
29	INTR	Interrupt	Set to 1 by software to request a *descriptor interrupt* when the DP83816 device transfers the ownership of this descriptor back to software.
28	SUPCRC INCCRC	Suppress CRC/ Include CRC	In transmit descriptors, this indicates that CRC should not be appended by the MAC. On receives, this bit is always set, as the CRC is always copied to the end of the buffer by the hardware.
27	OK	Packet OK	In the last descriptor in a packet, this bit indicates that the packet was either sent or received successfully.
26-16	—		The usage of these bits differ in receive and transmit descriptors. See below for details.
15-12			(reserved)
11-0	SIZE	Descriptor Byte Count	Set to the size in bytes of the data.

Table 5-7. Transmit Status Bit Definitions

BIT	TAG	DESCRIPTION	USAGE
26	TXA	Transmit Abort	Transmission of this packet was aborted.
25	TFU	Transmit FIFO Underrun	Transmit FIFO was exhausted during the transmission of this packet.
24	CRS	Carrier Sense Lost	Carrier was lost during the transmission of this packet. This condition is not reported if TXCFG:CSI is set.
23	TD	Transmit Deferred	Transmission of this packet was deferred.
22	ED	Excessive Deferral	The length of deferral during the transmission of this packet was excessive (> 3.2 ms), indicating transmission failure.
21	OWC	Out of Window Collision	The MAC encountered an out-of-window collision during the transmission of this packet.
20	EC	Excessive Collisions	The number of collisions during the transmission of this packet was excessive, indicating transmission failure. If TXCFG register ECRETRY=0, this bit is set after 16 collisions. If TXCFG register ECRETRY=1, this bit is set after 4 Excessive Collision events (64 collisions).

Table 5-7. Transmit Status Bit Definitions (continued)

BIT	TAG	DESCRIPTION	USAGE
19-16	CCNT	Collision Count	If TXCFG register ECRETRY=0, this field indicates the number of collisions encountered during the transmission of this packet. If TXCFG register ECRETRY=1, CCNT[3:2] = Excessive Collisions (0-3) CCNT[1] = Multiple Collisions CCNT[0] = Single Collision Note that Excessive Collisions indicate 16 attempts failed, while multiple and single collisions indicate collisions in addition to any excessive collisions. For example,a collision count of 33 includes two Excessive Collisions and also sets the Single Collision bit.

Table 5-8. Receive Status Bit Definitions

BIT	TAG	DESCRIPTION	USAGE
26	RXA	Receive Aborted	Set to 1 by the DP83816 device when the receive was aborted, the value of this bit always equals RXO. Exists for backward compatibility.
25	RXO	Receive Overrun	Set to 1 by the DP83816 device to indicate that a receive overrun condition occurred. RXA is also set.
24-23	DEST	Destination Class	When the receive filter is enabled, these bits indicate the destination address class as follows: 00 - Packet was rejected 01 - Destination is a Unicast address 10 - Destination is a Multicast address 11 - Destination is a Broadcast address If the Receive Filter is enabled, 00 indicates that the packet was rejected. Normally packets that are rejected do not cause any bus activity, nor do they consume receive descriptors. However, this condition could occur if the packet is rejected by the Receive Filter later in the packet than the receive drain threshold (RXCFG:DRTH). **Note:** The DEST bits may not represent a correct DA class for runt packets received with less than 6 bytes.
22	LONG	Too Long Packet Received	If RXCFG:ALP=0, this flag indicates that the size of the receive packet exceeded 1518 bytes. If RXCFG:ALP=1, this flag indicates that the size of the receive packet exceeded 2046 bytes.
21	RUNT	Runt Packet Received	The size of the receive packet was less than 64 bytes (inc. CRC).
20	ISE	Invalid Symbol Error	(100 Mb/s only) An invalid symbol was encountered during the reception of this packet.
19	CRCE	CRC Error	The CRC appended to the end of this packet was invalid.
18	FAE	Frame Alignment Error	The packet did not contain an integral number of octets.
17	LBP	Loopback Packet	The packet is the result of a loopback transmission.
16	COL	Collision Activity	The receive packet had a collision during reception.

5.5.5.1.2 Single Descriptor Packets

To represent a packet in a single descriptor, the MORE bit in the cmdsts field is set to 0.

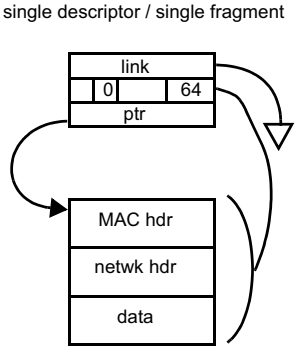


Figure 5-17. Single Descriptor Packets

5.5.5.1.3 Multiple Descriptor Packets

A single packet may also cross descriptor boundaries. This is indicated by setting the MORE bit in all descriptors except the last one in the packet. Ethernet applications (bridges, switches, routers, and so forth) can optimize memory utilization by using a single small buffer per receive descriptor, and allowing the DP83816 hardware to use the minimum number of buffers necessary to store an incoming packet.

5.5.5.1.4 Descriptor Lists

Descriptors are organized in linked lists using the link field. The system designer may also choose to implement a *ring* of descriptors by linking the last descriptor in the list back to the first. A list of descriptors may represent any number of packets or packet fragments.

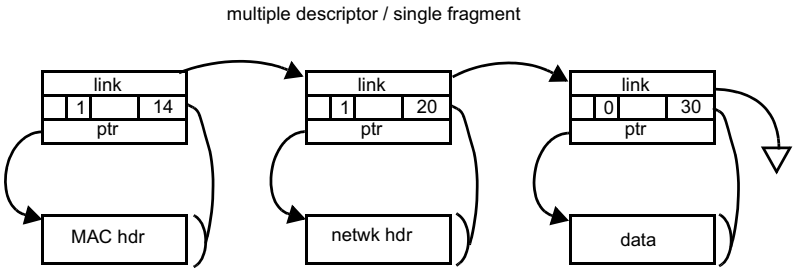


Figure 5-18. Multiple Descriptor Packets

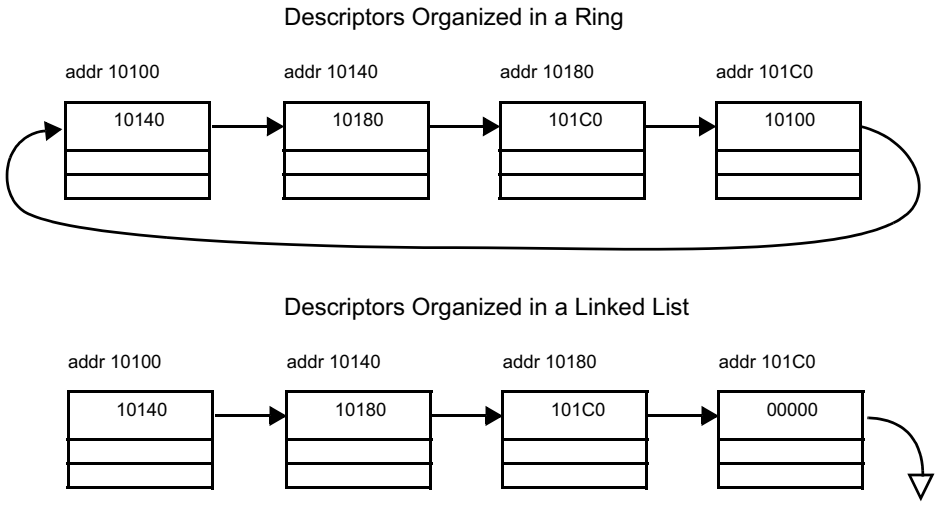


Figure 5-19. List and Ring Descriptor Organization

5.5.5.2 Transmit Architecture

Figure 5-20 illustrates the transmit architecture of the DP83816 10/100 ethernet controller.

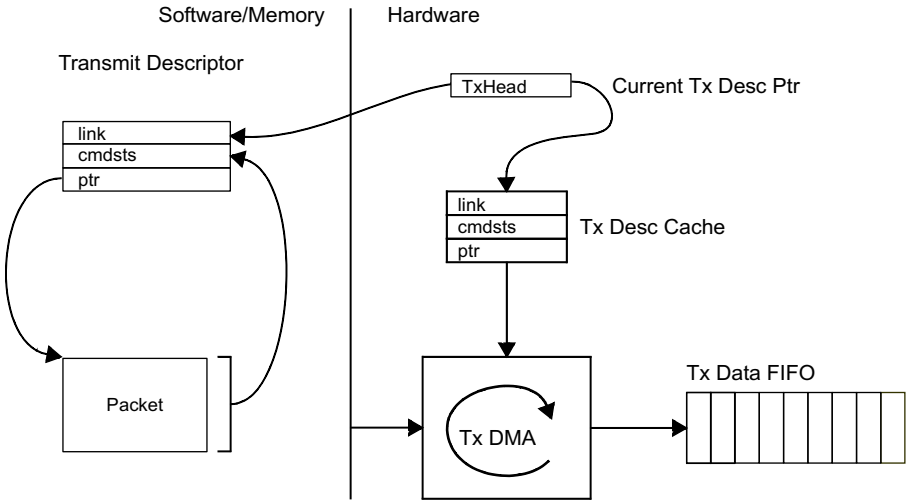


Figure 5-20. Transmit Architecture

When the CR:TXE bit is set to 1 (regardless of the current state), and the DP83816 transmitter is idle, then the DP83816 device reads the contents of the current transmit descriptor into the TxDescCache. The DP83816 TxDescCache can hold a single fragment pointer and count combination.

5.5.5.2.1 Transmit State Machine

The transmit state machine has the following states:

txIdle	The transmit state machine is idle.
txDescRefr	Waiting for the *refresh* transfer of the link field of a completed descriptor from the PCI bus.
txDescRead	Waiting for the transfer of a complete descriptor from the PCI bus into the TxDescriptorCache.
txFifoBlock	Waiting for free space in the TxDataFIFO to reach TxFillThreshold.

txFragRead	Waiting for the transfer of a fragment (or portion of a fragment) from the PCI bus to the TxDataFIFO.
txDescWrite	Waiting for the completion of the write of the cmdsts field of an intermediate transmit descriptor (cmdsts.MORE == 1) to host memory.
txAdvance	(transitory state) Examine the link field of the current descriptor and advance to the next descriptor if link is not NULL.

The transmit state machine manipulates the following internal data spaces:

TXDP	A 32-bit register that points to the current transmit descriptor.
CTDD	An internal bit flag that is set when the current transmit descriptor has been completed, and ownership has been returned to the driver. It is cleared whenever TXDP is loaded with a new value (either by the state machine, or the driver).
TxDescCache	An internal data space equal to the size of the maximum transmit descriptor supported.
descCnt	Count of bytes remaining in the current descriptor
fragPtr	Pointer to the next unread byte in the current fragment.
txFifoCnt	Current amount of data in the txDataFifo in bytes.
txFifoAvail	Current amount of free space in the txDataFifo in bytes (size of the txDataFifo – txFifoCnt).

Inputs to the transmit state machine include the following events:

CR:TXE	Driver asserts the TXE bit in the command register (similar to SONIC).
XferDone	Completion of a PCI bus transfer request.
FifoAvail	TxFifoAvail is greater than TxFillThreshold.

Table 5-9. Transmit State Tables

STATE	EVENT	NEXT STATE	ACTIONS
txIdle	CR:TXE && !CTDD	txDescRead	Start a burst transfer at address TXDP and a length derived from TXCFG.
	CR:TXE && CTDD	txDescRefr	Start a burst transfer to refresh the link field of the current descriptor.
txDescRefr	XferDone	txAdvance	
txDescRead	XferDone && OWN	txFIFOblock	
	XferDone && !OWN	txIdle	Set ISR:TXIDLE.
txFIFOblock	FifoAvail	txFragRead	Start a burst transfer into the TxDataFIFO from fragPtr. The length is the minimum of txFifoAvail and descCnt. Decrement descCnt accordingly.
	(descCnt == 0) && MORE	txDescWrite	Start a burst transfer to write the status back to the descriptor, clearing the OWN bit.
	(descCnt == 0) && !MORE	txAdvance	Write the value of TXDP to the txDataFIFO as a handle.
txFragRead	XferDone	txFIFOblock	
txDescWrite	XferDone	txAdvance	
txAdvance	link != NULL	txDescRead	TXDP <- txDescCache.link. Clear CTDD. Start a burst transfer at address TXDP with a length derived from TXCFG.
	link == NULL	txIdle	Set CTDD. Set ISR:TXIDLE. Clear CR:TXE.

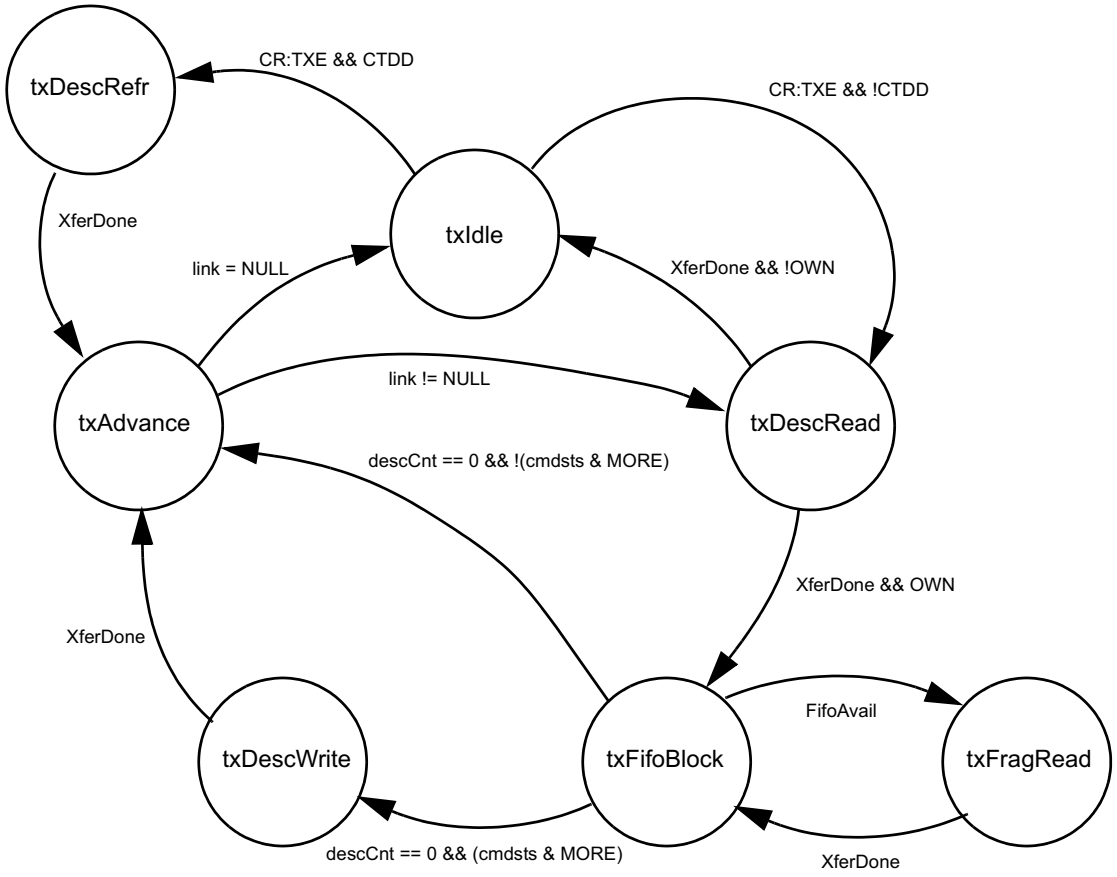


Figure 5-21. Transmit State Diagram

5.5.5.2.2 Transmit Data Flow

In the DP83816 transmit architecture, packet transmission involves the following steps:

1. The device driver receives packets from an upper layer.
2. An available DP83816 transmit descriptor is allocated. The fragment information is copied from the NOS specific data structures to the DP83816 transmit descriptor.
3. The driver adds this descriptor to the internal list of transmit descriptors awaiting transmission and sets the OWN bit.

4. If the internal list was empty (this descriptor represents the only outstanding transmit packet), then the driver must set the TXDP register to the address of this descriptor, else the driver appends this descriptor to the end of the list.
5. The driver sets the TXE bit in the CR register to insure that the transmit state machine is active.
6. If idle, the transmit state machine reads the descriptor into the TxDescriptorCache.
7. The state machine then moves through the fragment described within the descriptor, filling the TxDataFifo with data. The hardware handles all aspects of byte alignment; no alignment is assumed. Fragments may start and/or end on any byte address. The transmit state machine uses the fragment pointer and the SIZE field from the cmdsts field of the current descriptor to keep the TxDataFifo full. It also uses the MORE bit and the SIZE field from the cmdsts field of the current descriptor to know when packet boundaries occur.
8. When a packet has completed transmission (successful or unsuccessful), the state machine updates the upper half of the cmdsts field of the current descriptor in main memory, relinquishing ownership, and indicating the packet completion status. This update is done by a bus master transaction that transfers only the upper 2 bytes to the descriptor being updated. If more than one descriptor was used to describe the packet, then completion status is updated only in the last descriptor. Intermediate descriptors only have the OWN bits modified.
9. If the link field of the descriptor is non-zero, the state machine advances to the next descriptor and continues.
10. If the link field is NULL, the transmit state machine suspends, waiting for the TXE bit in the CR register to be set. If the TXDP register is written to, the CTDD flag is cleared. When the TXE bit is set, the state machine examines CTDD. If CTDD is set, the state machine refreshes the link field of the current descriptor. It then follows the link field to any new descriptors that have been added to the end of the list. If CTDD is clear (implying that TXDP has been written to), the state machine starts by reading in the descriptor pointed to by TXDP.

5.5.5.3 Receive Architecture

The receive architecture is as *symmetrical* to the transmit architecture as possible. The receive buffer manager prefetches receive descriptors to prepare for incoming packets. When the amount of receive data in the RxDataFIFO is more than the RxDrainThreshold, or the RxDataFIFO contains a complete packet, then the state machine begins filling received buffers in host memory.

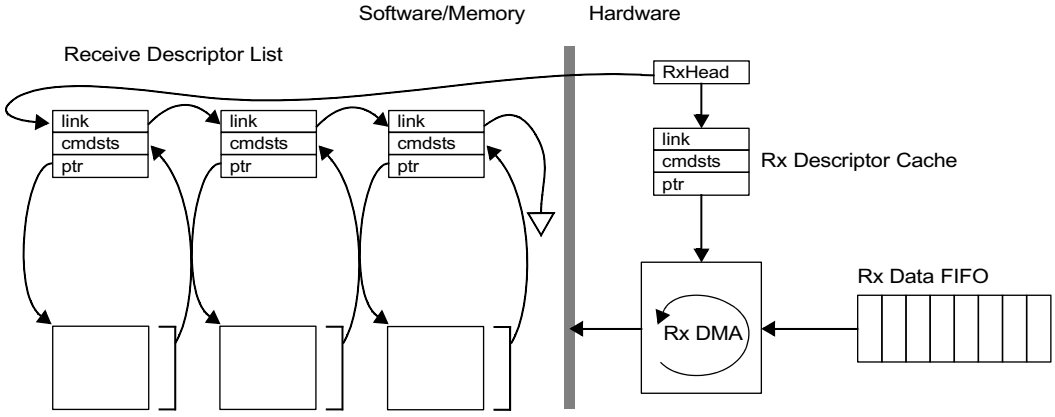


Figure 5-22. Receive Architecture

When the RXE bit is set to 1 in the CR register (regardless of the current state), and the DP83816 receive state machine is idle, then DP83816 device reads the contents of the descriptor referenced by RXDP into the Rx descriptor cache. The Rx descriptor cache allows the DP83816 device to read an entire descriptor in a single burst, and reduces the number of bus accesses required for fragment information to 1. The DP83816 Rx Descriptor Cache holds a single buffer pointer and count combination.

5.5.5.3.1 Receive State Machine

The receive state machine has the following states:

rxidle	The receive state machine is idle.
rxDescRefr	Waiting for the *refresh* transfer of the link field of a completed descriptor from the PCI bus.
rxDescRead	Waiting for the transfer of a descriptor from the PCI bus into the RxDescCache.
rxFifoBlock	Waiting for the amount of data in the RxDataFifo to reach the RxDrainThreshold or to represent a complete packet.
rxFragWrite	Waiting for the transfer of data from the RxDataFIFO via the PCI bus to host memory.
rxDescWrite	Waiting for the completion of the write of the cmdsts field of a receive descriptor.

The receive state machine manipulates the following internal data spaces:

RXD[	A 32-bit register that points to the current receive descriptor.
CRDD	An internal bit flag that is set when the current receive descriptor has been completed, and ownership has been returned to the driver. It is cleared whenever RXDP is loaded with a new value (either by the state machine, or the driver).
RxDescCache	An internal data space equal to the size of the maximum receive descriptor supported.
descCnt	Count of bytes available for storing receive data in all fragments described by the current descriptor.
fragPtr	Pointer to the next unwritten byte in the current fragment.
rxPktCnt	Number of packets in the rxDataFifo. Incremented by the MAC (the fill side of the FIFO). Decremented by the receive state machine as packets are processed.
rxPktBytes	Number of bytes in the current packet being drained from the rxDataFifo, that are in fact currently in the rxDataFifo (Note: For packets that contain more bytes than the FIFO's size, this number will never be greater than the FIFO size).

Inputs to the receive state machine include the following events:

CR:RXE	The RXE bit in the Command Register has been set.
XferDone	Completion of a PCI bus transfer request.
FifoReady	(rxPktCnt > 0) or (rxPktBytes > rxDrainThreshold)... in other words, if we have a complete packet in the FIFO (regardless of size), or the number of bytes that we do have is greater than the rxDrainThreshold, then we are ready to begin draining the rxDataFifo.

Table 5-10. Receive State Tables

STATE	EVENT	NEXT STATE	ACTIONS
rxIdle	CR:RXE && !CRDD	rxDescRead	Start a burst transfer at address RXDP and a length derived from RXCFG.
	CR:RXE && CRDD	rxDescRefr	Start a burst transfer to refresh the link field of the current descriptor.
rxDescRefr	XferDone	rxAdvance	
rxDescRead	XferDone && !OWN	rxFIFOblock	
	XferDone && OWN	rxIdle	Set ISR:RXIDLE.
rxFIFOblock	FifoReady	rxFragWrite	Start a burst transfer from the RxDataFIFO to host memory at fragPtr. The length is the minimum of rxPktBytes, and descCnt. Decrement descCnt accordingly.
	(descCnt == 0) && (rxPktBytes > 0)	rxDescWrite	Start a burst transfer to write the status back to the descriptor, setting the OWN bit, and setting the MORE bit. The PHY/PCI bus controller will continue the packet in the next descriptor.

Table 5-10. Receive State Tables (continued)

STATE	EVENT	NEXT STATE	ACTIONS
	rxPktBytes == 0	rxDescWrite	Start a transfer to write the cmdsts back to the descriptor, setting the OWN bit and clearing the MORE bit, and filling in the final receive status (CRC, FAE, SIZE, and so forth).
rxFragWrite	XferDone	rxFIFOblock	
rxDescWrite	XferDone	rxAdvance	
rxAdvance	link!= NULL	rxDescRead	RXDP <- rxDescCache.link. Clear CRDD. Start a burst transfer at address RXDP with a length derived from RXCFG:MXDMA.
	link == NULL	rxIdle	Set CRDD. Set ISR:RXIDLE.

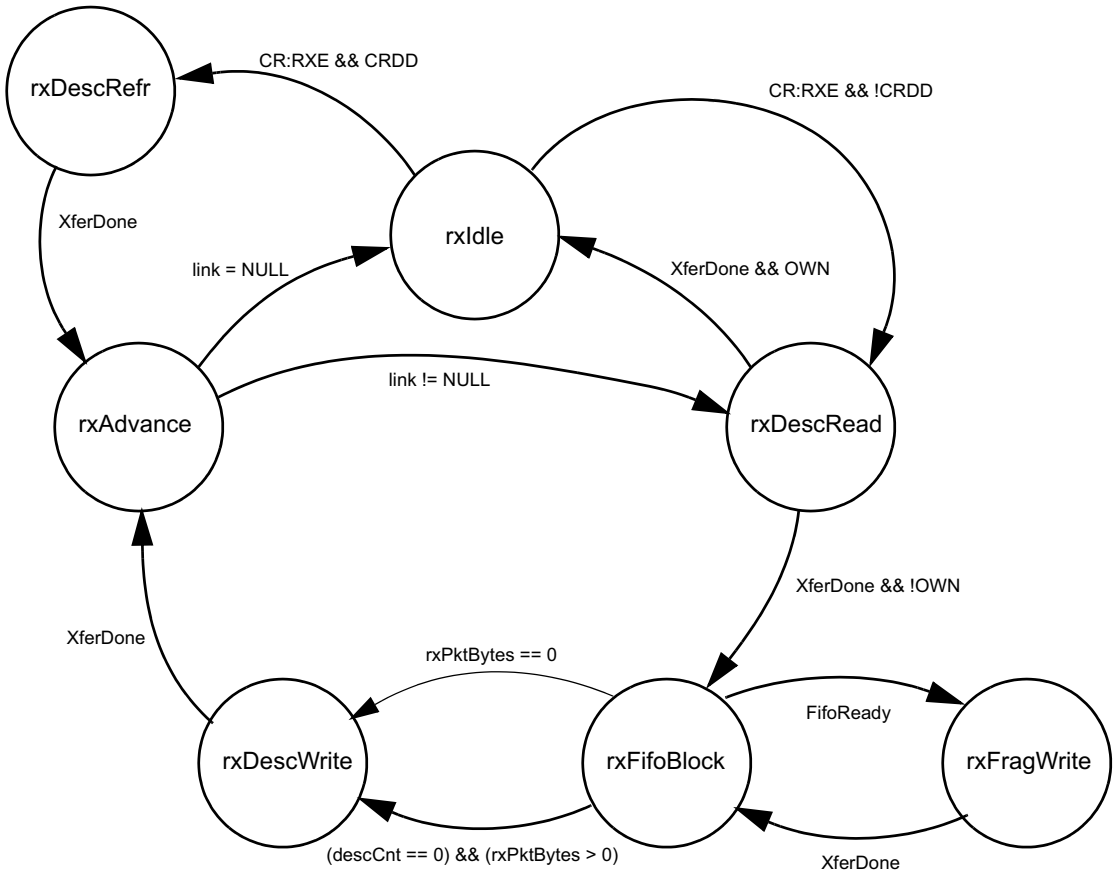


Figure 5-23. Receive State Diagram

5.5.5.3.2 Receive Data Flow

With a bus mastering architecture, some number of buffers and descriptors for received packets must be pre-allocated when the DP83816 device is initialized. The number allocated directly affects system tolerance to interrupt latency. The more buffers that you pre-allocate, the longer the system can survive an incoming burst without losing receive packets if receive descriptor processing is delayed or preempted. Buffers sizes should be allocated in 32-byte multiples.

1. Prior to packet reception, receive buffers must be described in a receive descriptor list (or ring, if preferred). In each descriptor, the driver assigns ownership to the hardware by clearing the OWN bit. Receive descriptors may describe a single buffer.
2. The address of the first descriptor in this list is then written to the RXDP register. As packets arrive, they are placed in available buffers. A single packet may occupy one or more receive descriptors, as required by the application. The device reads in the first descriptor into the RxDescCache.

3. As data arrives in the RxDataFIFO, the receive buffer management state machine places the data in the receive buffer described by the descriptor. This continues until either the end of packet is reached, or the descriptor byte count for this descriptor is reached.
4. If end of packet was reached, the status in the descriptor (in main memory) is updated by setting the OWN bit and clearing the MORE bit, by updating the receive status bits as indicated by the MAC, and by updating the SIZE field. The status bits in cmdsts are only valid in the last descriptor of a packet (with the MORE bit clear). Also for the last descriptor of a packet, the SIZE field is updated to reflect the actual amount of data written to the buffer (which may be less the full buffer size allocated by the descriptor).

If the receive buffer management state machine runs out of descriptors while receiving a packet, data is buffered in the receive FIFO. If the FIFO overflows, the driver is interrupted with an RxOVR error.

5.6 Register Block

This section includes information on the registers in the DP83816 device. The registers are classified by the following categories:

- Configuration registers
- Operational registers
- Internal PHY registers

5.6.1 Register Definition

In the register definitions under the *default* heading, the following definitions hold true:

- **R/W** = **R**ead **W**rite access
- **RO** = **R**ead **O**nly access
- **WO** = **W**rite **O**nly access

5.6.2 Configuration Registers

The DP83816 device implements a PCI version 2.2 configuration register space. This allows a PCI BIOS to soft-configure the DP83816 device. Software Reset has no effect on configuration registers. Hardware Reset returns all configuration registers to their hardware reset state. For all unused registers, writes are ignored, and reads return 0.

Table 5-11. Configuration Register Map

OFFSET	TAG	DESCRIPTION	ACCESS
00h	CFGID	Configuration Identification Register	RO
04h	CFGCS	Configuration Command and Status Register	R/W
08h	CFGRID	Configuration Revision ID Register	RO
0Ch	CFGLAT	Configuration Latency Timer Register	RO
10h	CFGIOA	Configuration IO Base Address Register	R/W
14h	CFGMA	Configuration Memory Address Register	R/W
18h–28h	RESERVED	RESERVED (reads return zero)	RO
2Ch	CFGSID	Configuration Subsystem Identification Register	RO
30h	CFGROM	Boot ROM configuration register	R/W
34h	CAPPTR	Capabilities Pointer Register	RO
38h	RESERVED	RESERVED (reads return zero)	RO
3Ch	CFGINT	Configuration Interrupt Select Register	R/W
40h	PMCAP	Power Management Capabilities Register	RO
44h	PMCSR	Power Management Control and Status Register	R/W
48h–FFh	RESERVED	RESERVED (reads return zero)	RO

5.6.2.1 Configuration Identification Register (CFGID)

This register identifies the DP83816 controller to PCI system software.

Table 5-12. Configuration Identification Register (CFGID) Address 00h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31:16	DEVID	<0000 0000 0010 0000>, RO	**Device ID** This field is read-only and is set to the device ID assigned to the DP83816 device, which is 0020h.
15:0	VENID	<0001 0000 0000 1011>, RO	**Vendor ID** This field is read-only and is set to a value of 100Bh which is the PCI Vendor ID.

5.6.2.2 Configuration Command and Status Register (CFGCS)

The CFGCS register has two parts. The upper 16-bits (31-16) are devoted to device status. A status bit is reset whenever the register is written, and the corresponding bit location is a 1. The lower 16-bits (15-0) are devoted to command and are used to configure and control the device.

Table 5-13. Configuration Command and Status Register (CFGCS) Address 04h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31	DPERR	<02900000h>0, R/W	**Detected Parity Error** See the description in the PCI V2.2 specification.
30	SSERR	0, R/W	**Signaled SERR** See the description in the PCI V2.2 specification.
29	RMABT	0, R/W	**Received Master Abort** See the description in the PCI V2.2 specification.
28	RTABT	0, R/W	**Received Target Abort** See the description in the PCI V2.2 specification.
27	STABT	0, R/W	**Sent Target Abort** See the description in the PCI V2.2 specification.
26:25	DSTIM	<01>, R/W	**DEVSELN Timing** This field is always set to 01, indicating that DP83816 device supports medium DEVSELN timing.
24	DPD	0, R/W	**Data Parity Detected** See the description in the PCI V2.2 specification.
23	FBB	1, R/W	**Fast Back-to-Back Capable** The DP83816 device sets this bit to 1.
22:21	RESERVED	<00>, RO	**RESERVED** (reads return 0)
20	NCPEN	1, R/W	**New Capabilities Enable** When set, this bit indicates that the Capabilities Pointer contains a valid value and new capabilities such as power management are supported. When clear, new capabilities (CAPPTR, PMCAP, PMCS) are disabled. This bit is loaded from a strap option, MD0 pin 132. A subsequent load of the configuration data from the EEPROM overwrites any pre-existing value.
19:16	RESERVED	<0000>, RO	**RESERVED** (reads return 0)
15:10	RESERVED	<0000 00>, RO	**RESERVED** (reads return 0)
9	FBBEN	0, R/W	**Fast Back-to-Back Enable** Set to 1 by the PCI BIOS to enable the DP83816 device to do Fast Back-to-Back transfers (FBB transfers as a master is not implemented in the current revision).
8	SERREN	0, R/W	**SERRN Enable** When SERREN and PERRSP are set, the DP83816 device generates SERRN during target cycles when an address parity error is detected from the system. Also, when SERREN and PERRSP are set and CFG:PESEL is reset, master cycles detecting data parity errors generate SERRN.
7	RESERVED	0, RO	**RESERVED** (reads return 0)

Table 5-13. Configuration Command and Status Register (CFGCS) Address 04h (continued)

BIT	BIT NAME	DEFAULT	DESCRIPTION
6	PERRSP	0, R/W	**Parity Error Response** When set, the DP83816 device asserts PERRN on the detection of a data parity error when acting as the target, and samples PERRN when acting as the initiator. Also, setting PERRSP allows SERREN to enable the assertion of SERRN. When reset, all address and data parity errors are ignored and neither SERRN nor PERRN are asserted.
5:3	RESERVED	<00 0>, RO	**RESERVED** (reads return 0)
2	BMEN	0, R/W	**Bus Master Enable** When set, the DP83816 device is allowed to act as a PCI bus master. When reset, the DP83816 device is prohibited from acting as a PCI bus master.
1	MSEN	0, R/W	**Memory Space Address** When set, the DP83816 device responds to memory space accesses. When reset, the DP83816 device ignores memory space accesses.
0	I/OSEN	0, R/W	**I/O Space Access** When set, the DP83816 device responds to I/O space accesses. When reset, the DP83816 device ignores I/O space accesses.

5.6.2.3 Configuration Revision ID Register (CFGRID)

This register stores the silicon revision number, revision number of software interface specification and lets the configuration software know that it is an Ethernet controller in the class of network controllers.

Table 5-14. Configuration Revision ID Register (CFFRID) Address 08h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31:24	BASECL	<0000 0010>, RO	**Base Class** Returns 02h which specifies a network controller.
23:16	SUBCL	<0000 0000>, RO	**Sub Class** Returns 00h which specifies an Ethernet controller.
15:8	PROGIF	<0000 0000>, RO	**Programming IF** Returns 00h, which specifies the first release of the DP83816 software interface specification.
7:0	REVID	<0000 0000>, RO	**Silicon Revision** Returns 00h which specifies the silicon revision.

5.6.2.4 Configuration Latency Timer Register (CFGLAT)

This register gives status and controls such miscellaneous functions as BIST, Latency timer and Cache line size.

Table 5-15. Configuration Latency Timer Register (CFGLAT) Address 0Ch

BIT	BIT NAME	DEFAULT	DESCRIPTION
31	BISTCAP	0, R/W	**BIST Capable** Reads always return 0.
30	BISTEN	0, RO	**BIST Enable** Reads return a 0, writes are ignored.
29:16	RESERVED	<00 0000 0000 0000>, RO	**RESERVED** Reads return a 0, writes are ignored.
15:8	LAT	<0000 0000>, R/W	**Latency Timer** Set by software to the number of PCI clocks that the DP83816 device may hold the PCI bus.
7:0	CLS	<0000 0000>, R/W	**Cache Line Size** Ignored by the DP83816 device.

DP83816 bus master operations:
Independent of cache line size, the DP83816 device uses the following PCI commands for bus mastered transfers:

0110 - Mem read for all read cycles,
0111 - Mem write for all write cycles.

5.6.2.5 Configuration I/O Base Address Register (CFGIOA)

This register specifies the base I/O address which is required to build an address map during configuration. It also specifies the number of bytes required as well as an indication that it can be mapped into I/O space.

Table 5-16. Configuration I/O Base Address Register (CFGIOA) Address 10h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31:8	IOBASE	<0000 0000 0000 0000 0000 0000>, R/W	**Base I/O Address** This is set by software to the base I/O address for the Operational Register Map.
7:2	IOSIZE	<0000 00>, RO	**Size indication** Read back as 0. This allows the PCI bridge to determine that the DP83816 device requires 256 bytes of I/O space.
1	RESERVED	0, RO	**RESERVED** (reads return 0).
0	IOIND	1, RO	**I/O Space Indicator** Set to 1 by the DP83816 device to indicate that the DP83816 device is capable of being mapped into I/O space. Read Only.

5.6.2.6 Configuration Memory Address Register (CFGMA)

This register specifies the base memory address which is required to build an address map during configuration. It also specifies the number of bytes required as well as an indication that it can be mapped into memory space.

Table 5-17. Configuration Memory Address Register (CFGMA) Address 14h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31:12	MEMBASE	<0000 0000 0000 0000 0000>, R/W	**Memory Base Address** This is set by software to the base address for the operational register map.
11:4	MEMSIZE	<0000 0000>, RO	**Memory Size** These bits return 0, which indicates that the DP83816 requires 4096 bytes of memory space (the minimum recommended allocation).
3	MEMPF	0, RO	**Prefetchable** Set to 0 by the DP83816 device. Read-only.
2:1	MEMLOC	<00>, RO	**Location Selection** Set to 00 by the DP83816 device. This indicates that the base register is 32-bits wide and can be placed anywhere in the 32-bit memory space. Read Only.
0	MEMIND	0, RO	**Memory Space Indicator** Set to 0 by the DP83816 device to indicate that the DP83816 device is capable of being mapped into memory space. Read Only.

5.6.2.7 Configuration Subsystem Identification Register (CFGSID)

The CFGSID allows system software to distinguish between different subsystems based on the same PCI silicon. The values in this register can be loaded from the EEPROM if configuration is enabled.

Table 5-18. Configuration Subsystem Identification Register (CFGSID) Address 2Ch

BIT	BIT NAME	DEFAULT	DESCRIPTION
31:16	SDEVID	<0000 0000 0000 0000>, RO	**Subsystem Device ID** Set to 0 by the DP83816 device.
15:0	SVENID	<0000 0000 0000 0000>, RO	**Subsystem Vendor ID** Set to 0 by the DP83816 device.

5.6.2.8 Boot ROM Configuration Register (CFGROM)

Table 5-19. Boot ROM Configuration Register (CFGROM) Address 30h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31:16	ROMBASE	<0000 0000 0000 0000>, RO	**ROM Base Address** Set to the base address for the boot ROM.
15:11	ROMSIZE	<0000 0>, RO	**ROM Size** Set to 0 indicating a requirement for 64K bytes of Boot ROM space. Read only.
10:1	RESERVED	0, RO	**RESERVED** (reads return 0)
0	ROMEN	0, RO	**ROM Enable** This is used by the PCI BIOS to enable accesses to boot ROM. This allows the DP83816 device to share the address decode logic between the boot ROM and itself. The BIOS copies the contents of the boot ROM to system RAM before executing it. Set to 1 enables the address decode for boot ROM disabling access to operational target registers.

5.6.2.9 Capabilities Pointer Register (CAPPTR)

This register stores the capabilities linked list offset into the PCI configuration space.

Table 5-20. Capabilities Pointer Register (CAPPTR) Address 34h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31:8	RESERVED	0, RO	**RESERVED** (reads return 0)
7:0	CLOFS	<0000 0100>, RO	**Capabilities List Offset** Offset into PCI configuration space for the location of the first item in the Capabilities Linked List, set to 40h to point to the PMCAP register.

5.6.2.10 Configuration Interrupt Select Register (CFGINT)

This register stores the interrupt line number as identified by the POST software that is connected to the interrupt controller, as well as the DP83816 desired settings for maximum latency and minimum grant. Maximum latency and minimum latency can be loaded from the EEPROM.

Table 5-21. Configuration Interrupt Select Register (CFGINT) Address 3Ch

BIT	BIT NAME	DEFAULT	DESCRIPTION
31:24	MXLAT	<0011 0100>, R/W	**Maximum Latency** The DP83816 desired setting for Max Latency. The DP83816 device initializes this field to 52d (13 µs). The value in this register can be loaded from the EEPROM.
23:16	MNGNT	<0000 1011>, R/W	**Minimum Grant** The DP83816 desired setting for minimum grant. The DP83816 device initializes this field to 11d (2.75 µs). The value in this register can be loaded from the EEPROM.
15:8	IPIN	<0000 0001>, RO	**Interrupt Pin** Read Only, always return 0000 0001 (INTA).
7:0	ILINE	<0000 0000>, R/W	**Interrupt Line** Set to which line on the interrupt controller that the DP83816 interrupt pin is connected to.

5.6.2.11 Power Management Capabilities Register (PMCAP)

This register provides information on the capabilities of the functions related to power management. This register also contains a pointer to the next item in the capabilities list and the capability ID for power management. This register is only visible if CFGCS[4] is set.

Table 5-22. Power Management Capabilities Register (PMCAP) Address 40h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31:27	PMES	<1111 1>, R/W	**PME Support** This 5-bit field indicates the power states in which DP83816 device may assert PMEN. A 1 indicates PMEN is enabled for that state, a 0 indicates PMEN is inhibited in that state. XXXX1 - PMEN can be asserted from state D0 XXX1X - PMEN can be asserted from state D1 XX1XX - PMEN can be asserted from state D2 X1XXX - PMEN can be asserted from state D3hot 1XXXX - PMEN can be asserted from state D3cold The DP83816 device only reports PME support for D3cold if auxiliary power is detected on the 3VAUX pin. In addition, this value can be loaded from the EEPROM when in the D3cold state.
26	D2S	1, R/W	**D2 Support** This bit is set to a 1 when the DP83816 device supports the D2 state.
25	D1S	1, R/W	**D1 Support** This bit is set to a 1 when the DP83816 supports the D1 state.
24:22	AUX_ CURRENT	<1 10>, R/W	Aux_Current This 3 bit field reports the 3.3Vaux auxiliary current requirements for the PCI function. If PMEN generation from D3cold is not supported by the function(PMCAP[31]), this field returns a value of 000b when read. **Bit** **3.3Vaux** **24 23 22** b 1 1 0 320 mA 0 0 0 0 (self powered)
21	DSI	0, R/W	**Device Specific Initialization** This bit is set to 1 to indicate to the system that initialization of the DP83816 device is required (beyond the standard PCI configuration header) before the generic class device driver is able to use it. A 1 indicates that the DP83816 device requires a DSI sequence following transition to the D0 uninitialized state. This bit can be loaded from the EEPROM.
20	RESERVED	0, RO	**RESERVED** (reads return 0)
19	PMEC	0, RO	**PME Clock** Returns 0 to indicate PCI clock not needed for PMEN.
18:16	PMV	<010>, RO	**Power Management Version** This bit field indicates compliance to a specific PM specification rev level. Currently set to 010b.
15:8	NLIPTR	<0000 0000>, RO	**Next List Item Pointer** Offset into PCI configuration space for the location of the next item in the Capabilities Linked List. Returns 00h as no other capabilities are offered.
7:0	CAPID	<0000 0001>, RO	**Capability ID** Always returns 01h for Power Management ID.

5.6.2.12 Power Management Control and Status Register (PMCSR)

This register contains PM control and status information.

Table 5-23. Power Management Control and Status Register (PMCSR) Address 44h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31:24	RESERVED	0, RO	**RESERVED** Reads return 0.
23:16	BSE	<0000 0000>, RO	**Bridge Support Extensions** Unused – reads return 0.
15	PMESTS	0, RO	**PME Status** Sticky bit which represents the state of the PME logic, regardless of the state of the PMEEN bit.
14:9	RESERVED	0, RO	**RESERVED** (reads return 0)
8	PMEEN	0, R/W	**PME Enable** When set to 1, this bit enables the assertion of the PME function on the PMEN pin. When 0, the PMEN pin is forced to be inactive. This value can be loaded from the EEPROM.
7:2	RESERVED	0, RO	**RESERVED** (reads return 0)
1:0	PSTATE	<00>, R/W	**Power State** This 2 bit field is used to determine the current power state of the DP83816 device, and to set a new power state. 00–D0 10 - D2 01–D1 11 - D3hot/cold

5.6.3 Operational Registers

The DP83816 device provides the following set of operational registers mapped into PCI memory space or I/O space. Writes to reserved register locations are ignored. Reads to reserved register locations return undefined values.

Table 5-24. Operational Register Map

OFFSET	TAG	DESCRIPTION	ACCESS
MAC and BIU REGISTERS			
00h	CR	Command Register	R/W
04h	CFG	Configuration Register	R/W
08h	MEAR	EEPROM Access Register	R/W
0Ch	PTSCR	PCI Test Control Register	R/W
10h	ISR	Interrupt Status Register	RO
14h	IMR	Interrupt Mask Register	R/W
18h	IER	Interrupt Enable Register	R/W
1Ch	IHR	Interrupt Holdoff Register	R/W
20h	TXDP	Transmit Descriptor Pointer Register	R/W
24h	TXCFG	Transmit Configuration Register	R/W
28h–2Ch	Reserved	Reserved	
30h	RXDP	Receive Descriptor Pointer Register	R/W
34h	RXCFG	Receive Configuration Register	R/W
38	Reserved	Reserved	
3Ch	CCSR	CLKRUN Control and Status Register	R/W
40h	WCSR	Wake on LAN Control and Status Register	R/W
44h	PCR	Pause Control and Status Register	R/W
48h	RFCR	Receive Filter and Match Control Register	R/W

Table 5-24. Operational Register Map (continued)

OFFSET	TAG	DESCRIPTION	ACCESS
4Ch	RFDR	Receive Filter and Match Data Register	R/W
50h	BRAR	Boot ROM Address	R/W
54h	BRDR	Boot ROM Data	R/W
58h	SRR	Silicon Revision Register	RO
5Ch	MIBC	Management Information Base Control Register	R/W
60–78h	MIB	Management Information Base Data Registers	RO
7Ch	Reserved	Reserved	
INTERNAL PHY REGISTERS			
80h	BMCR	Basic Mode Control Register	R/W
84h	BMSR	Basic Mode Status Register	RO
88h	PHYIDR1	PHY Identifier Register No. 1	RO
8Ch	PHYIDR2	PHY Identifier Register No. 2	RO
90h	ANAR	Auto-Negotiation Advertisement Register	R/W
94h	ANLPAR	Auto-Negotiation Link Partner Ability Register	R/W
98h	ANER	Auto-Negotiation Expansion Register	R/W
9Ch	ANNPTR	Auto-Negotiation Next Page TX	R/W
A0-BCh	Reserved	Reserved	
C0h	PHYSTS	PHY Status Register	RO
C4h	MICR	MII Interrupt Control Register	R/W
C8h	MISR	MII Interrupt Status Register	R/W
CCh	Reserved	Reserved	
D0h	FCSCR	False Carrier Sense Counter Register	R/W
D4h	RECR	Receive Error Counter Register	R/W
D8h	PCSR	100 Mb/s PCS Configuration and Status Register	R/W
DCh–E0h	Reserved	Reserved	
E4h	PHYCR	PHY Control Register	R/W
E8h	TBTSCR	10Base-T Status and Control Register	R/W
ECh-FCh	Reserved	Reserved	

5.6.3.1 Command Register (CR)

This register is used for issuing commands to the DP83816 device. These commands are issued by setting the corresponding bits for the function. A global software reset along with individual reset and enable or disable for transmitter and receiver are provided here.

Table 5-25. Command Register (CR) Address 0000h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31-9	RESERVED	0, RO	**RESERVED** (reads return 0)
8	RST	0, R/W	**Reset** Set to 1 to force the DP83816 device to a soft reset state which disables the transmitter and receiver, reinitializes the FIFOs, and resets all affected registers to their soft reset state. This operation implies both a TXR and a RXR. This bit reads back a 1 during the reset operation, and be cleared to 0 by the hardware when the reset operation is complete. EEPROM configuration information is not loaded here.
7	SWI	0, R/W	**Software Interrupt** Setting this bit to a 1 forces the DP83816 device to generate a hardware interrupt. This interrupt is mask-able via the IMR.
6	RESERVED	0, RO	**RESERVED** (reads return 0)

Table 5-25. Command Register (CR) Address 0000h (continued)

BIT	BIT NAME	DEFAULT	DESCRIPTION
5	RXR	0, R/W	**Receiver Reset** When set to a 1, this bit causes the current packet reception to be aborted, the receive data and status FIFOs to be flushed, and the receive state machine to enter the idle state (RXE goes to 0). This is a write-only bit and is always read back as 0.
4	TXR	0, R/W	**Transmit Reset** When set to a 1, this bit causes the current transmission to be aborted, the transmit data and status FIFOs to be flushed, and the transmit state machine to enter the idle state (TXE goes to 0). This is a write-only bit and is always read back as 0.
3	RXD	0, R/W	**Receiver Disable** Disable the receive state machine after any current packets in progress. When this operation has been completed the RXE bit is cleared to 0. This is a write-only bit and is always read back as 0. The driver should not set both RXD and RXE in the same write, the RXE is ignored, and RXD has precedence.
2	RXE	0, R/W	**Receiver Enable** When set to a 1, and the receive state machine is idle, then the receive machine becomes active. This bit reads back as a 1 whenever the receive state machine is active. After initial power-up, software must insure that the receiver has completely reset before setting this bit (See ISR:RXRCMP).
1	TXD	0, R/W	**Transmit Disable** When set to a 1, halts the transmitter after the completion of the current packet. This is a write-only bit and is always read back as 0. The driver should not set both TXD and TXE in the same write, because TXE is ignored, and TXD has precedence.
0	TXE	0, R/W	**Transmit Enable** When set to a 1, and the transmit state machine is idle, then the transmit state machine becomes active. This bit reads back as a 1 whenever the transmit state machine is active. After initial power-up, software must insure that the transmitter has completely reset before setting this bit (See ISR:TXRCMP).

5.6.3.2 Configuration and Media Status Register (CFG)

This register allows configuration of a variety of device and PHY options, and provides PHY status information.

Table 5-26. Configuration and Media Status Register (CFG) Address 0004h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31	LNKSTS	0, RO	**Link Status** Link status of the internal PHY. Asserted when link is good.
30	SPEED100	0, RO	**Speed 100 Mb/s** Speed 100-Mb/s indicator for internal PHY. Asserted when speed is set or has negotiated to 100 Mb/s. De-asserted when speed has been set or negotiated to 10 Mb/s.
29	FDUP	0, RO	**Full Duplex** Full Duplex indicator for internal PHY. Asserted when duplex mode is set or has negotiated to FULL. De- asserted when duplex mode has been set or negotiated to HALF.
28	POL	0, RO	**10-Mb/s Polarity Indication** Twisted pair polarity indicator for internal PHY. Asserted when operating and 10 Mb/s and the polarity have been detected as reversed. De-asserted when polarity is normal or PHY is operating at 100 Mb/s.
27	ANEG_DN	0, RO	**Auto-negotiation Done** Auto-negotiation done indicator from internal PHY. Asserted when auto-negotiation process has completed or is not active.
26-24	RESERVED	0, RO	**RESERVED** (reads return 0)
23-18	PHY_CFG	0, RO	**PHY Configuration** Miscellaneous internal PHY Power-On-Reset configuration control bits.
17	PINT_ACEN	0, R/W	**PHY Interrupt Auto Clear Enable** When set to a 1, this bit allows the PHY interrupt source to be automatically cleared whenever the ISR is read. When this bit is 0, the PHY interrupt source must be manually cleared via access of the PHY registers.

Table 5-26. Configuration and Media Status Register (CFG) Address 0004h (continued)

BIT	BIT NAME	DEFAULT	DESCRIPTION
16	PAUSE_ADV	0, R/W	**Pause Advertise** This bit is loaded from EEPROM at power-up and is used to configure the internal PHY to advertise the capability of 802.3x pause during auto-negotiation. Setting this bit to 1 causes the pause function to be advertised if the PHY has also been configured to advertise full-duplex capability (See the ANEG_SEL bits in this table).
15-13	ANEG_SEL	<000>, R/W	**Auto-negotiation Select** These bits are loaded from EEPROM at power-up and are used to define the default state of the internal PHY auto-negotiation logic. These bits are encoded as follows: 000 Auto-negotiation disabled, force 10 Mb/s half-duplex 010 Auto-negotiation disabled, force 100 Mb/s half-duplex 100 Auto-negotiation disabled, force 10 Mb/s full-duplex 110 Auto-negotiation disabled, force 100 Mb/s full-duplex 001 Auto-negotiation enabled, advertise 10 Mb/s half- and full-duplex 011 Auto-negotiation enabled, advertise 10/100 Mb/s half-duplex 101 Auto-negotiation enabled, advertise 100 Mb/s half- and full-duplex 111 Auto-negotiation enabled, advertise 10/100 Mb/s half- and full-duplex
12	EXT_PHY	0, R/W	**External PHY Support** Act as a stand-alone MAC. When set, this bit enables the MII and disables the internal PHY (sets bit 9).
11	RESERVED	0, RO	**RESERVED** (reads return 0)
10	PHY_RST	0, R/W	**Reset internal PHY** Asserts reset to internal PHY. Can be used to cause PHY to reload options from the CFG register. This bit does not self clear when set.
9	PHY_DIS	0, R/W	**Disable internal PHY** When set to a 1, this bit forces the internal PHY to its low-power state.
8	EUPHCOMP	0, R/W	**DP83810 Descriptor Compatibility** When set, the DP83816 device uses DP83810 compatible (but single-fragment) descriptor format. Descriptors are four 32-bit words in length, but the fragment count field is ignored. When clear, the DP83816 device only fetches three 32-bit words in descriptor fetches with the third word being the fragment pointer.
7	REQALG	0, R/W	PCI Bus Request Algorithm Selects mode for making requests for the PCI bus. When set to 0 (default), the DP83816 device uses an aggressive request scheme. When set to 1, the DP83816 device uses a more conservative scheme.
6	SB	0, R/W	**Single Back-off** Setting this bit to 1 forces the transmitter back-off state machine to always back-off for a single 802.3 slot time instead of following the 802.3 random back-off algorithm. A 0 (default) allows normal transmitter back-off operation.
5	POW	0, R/W	**Program Out of Window Timer** This bit controls when the Out of Window collision timer begins counting its 512 bit slot time. A 0 causes the timer to start after the SFD is received. A 1 causes the timer to start after the first bit of the preamble is received.
4	EXD	0, R/W	**Excessive Deferral Timer disable** Setting this bit to 1 inhibits transmit errors due to excessive deferral. This inhibits the setting of the ED status, and the logging of the TxExcessiveDeferral MIB counter.
3	PESEL	0, R/W	**Parity Error Detection Action** This bit controls the assertion of SERR when a data parity error is detected while the DP83816 device is acting as the bus master. When set, parity errors do not result in the assertion of SERR. When reset, parity errors result in the assertion of SERR, indicating a system error. This bit should be set to a one by software if the driver can handle recovery from and reporting of data parity errors.
2	BROM_DIS	0, R/W	**Disable Boot ROM interface** When set to 1, this bit inhibits the operation of the Boot ROM interface logic.
1	RESERVED	0, RO	**RESERVED** (reads return 0)
0	BEM	0, R/W	**Big Endian Mode** When set, the DP83816 device performs bus-mastered data transfers in big-endian mode. Note that access to register space is unaffected by the setting of this bit. .

5.6.3.3 EEPROM Access Register (MEAR)

The EEPROM access register provides an interface for software access to the NMC9306 style EEPROM The default values given assume that the EEDO line has a pullup resistor to VDD.

Table 5-27. EEPROM Access Register (MEAR) Address 0008h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31-7	RESERVED	0, RO	**RESERVED** (reads return 0)
6	MDC	0, R/W	**MII Management Clock** Controls the value of the MDC pin. When set, the MDC pin is 1; when clear the MDC pin is 0.
5	MDDIR	0, R/W	**MII Management Direction** Controls the direction of the MDIO pin. When set, the DP83816 device drives the MDIO pin. When clear, the MDIO bit reflects the current state of the MDIO pin.
4	MDIO	0, R/W	**MII Management Data** Software access to the MDIO pin (see MDDIR above).
3	EESEL	0, R/W	**EEPROM Chip Select** Controls the value of the EESEL pin. When set, the EESEL pin is 1; when clear the EESEL pin is 0.
2	EECLK	0, R/W	**EEPROM Serial Clock** Controls the value of the EECLK pin. When set, the EECLK pin is 1; when clear the EECLK pin is 0.
1	EEDO	1, RO	**EEPROM Data Out** Returns the current state of the EEDO pin. When set, the EEDO pin is 1; when clear the EEDO pin is 0.
0	EEDI	0, R/W	**EEPROM Data In** Controls the value of the EEDI pin.

5.6.3.3.1 EEPROM Map

Table 5-28. EEPROM Register Map

EEPROM ADDRESS	CONFIGURATION and OPERATION REGISTER BITS	DEFAULT VALUE (16 BITS)
0000h	CFGSID[0:15]	D008h
0001h	CFGSID[16:31]	0400h
0002h	CFGINT[24:31], CFGINT[16:23]	2CD0h
0003h	CFGCS[20], PMCAP[31], PMCAP[21], PMCSR[8], CFG[13:16], CFG[18:23], CR[2], SOPAS[0]	CF82h
0004h	SOPAS[1:16]	0000h
0005h	SOPAS[17:32]	0000h
0006h	SOPAS[33:47], PMATCH[0]	000Nh(1)
0007h	PMATCH[1:16]	NNNNh(1)
0008h	PMATCH[17:32]	NNNNh(1)
0009h	PMATCH[33:47], WCSR[0]	NNNNh(1)
000Ah	WCSR[1:4], WCSR[9:10], RFCR[20], RFCR[22], RFCR[27:31], 000b (3 bits)	A098h
000Bh	checksum value	XX55(2)

(1) N denotes the value is dependent on the ethernet MAC ID Number.
(2) X denotes the value is dependent on the checksum value.

PMATCH[47:0] can be accessed through the combination of the RFCR (offset 0048h) and RFDR (offset 004Ch) registers. PMATCH holds the Ethernet address info. See Section 5.5.2.2.

The lower 8 bits of the checksum value should be 55h. For the upper 8 bits, add the top 8 data bits to the lower 8 data bits for each address. Sum the resultant 8 bit values for all addresses and then add 55h. Take the 2's complement of the final sum. This 2's complement number should be the upper 8 bits of the checksum value in the last address.

As an example, consider an EEPROM with two addresses. EEPROM address 0000h contains the data 1234h. EEPROM address 0001h contains the data 5678h.

12h + 34h = 46h

56h + 78h = CEh

46h + CEh + 55h = 69h

The 2's complement of 69h is 97h so the checksum value entered into EEPROM address 0002h would be 9755h.

5.6.3.4 PCI Test Control Register (PTSCR)

Table 5-29. PCI Test Control Register (PTSCR) Address 000Ch

BIT	BIT NAME	DEFAULT	DESCRIPTION
31:13	RESERVED	0, RO	**RESERVED** (reads return 0)
12	RESERVED	0, RO	**Reserved for TI internal use only.** Must be written as a 0 otherwise.
11	RESERVED	0, RO	**RESERVED** (reads return 0)
10	RBIST_RST	0, R/W	**SRAM BIST Reset** Setting this bit to 1 allows the SRAM BIST engine to be reset.
9:8	RESERVED	0, RO	**Reserved for TI internal use only.** Must be written as a 00 otherwise.
7	RBIST_EN	0, R/W	**SRAM BIST Enable** Setting this bit to 1 starts the SRAM BIST engine.
6	RBIST_DONE	0, RO	**SRAM BIST Done** This bit is set to one when the BIST has completed its current test. It is cleared when either the BIST is active or disabled.
5	RBIST_RXFAIL	0, RO	**RX FIFO BIST Fail** This bit is set to 1 if the SRAM BIST detects a failure in the RX FIFO SRAM.
4	RBIST_TXFAIL	0, RO	**TX FIFO Fail** This bit is set to 1 if the SRAM BIST detects a failure in the TX FIFO SRAM.
3	RBIST_RXFFAIL	0, RO	**RX Filter RAM BIST Fail** This bit is set to 1 if the SRAM BIST detects a failure in the RX Filter SRAM.
2	EELOAD_EN	0, R/W	**Enable EEPROM Load** This bit is set to a 1 to manually initiate a load of configuration information from EEPROM. A 1 is returned while the configuration load from EEPROM is active (approximately 1500 µs).
1	EEBIST_EN	0, R/W	**Enable EEPROM BIST** This bit is set to a 1 to initiate EEPROM BIST, which verifies the EEPROM data and checksum without reloading configuration values to the device. A 1 is returned while the EEPROM BIST is active.
0	EEBIST_FAIL	0, RO	**EE BIST Fail indication** This bit is set to a 1 on completion of the EEPROM BIST (EEBIST_EN returns 0) if the BIST logic encountered an invalid checksum.

5.6.3.5 Interrupt Status Register (ISR)

This register indicates the source of an interrupt when the INTA pin goes active. Enabling the corresponding bits in the interrupt mask register (IMR) allows bits in this register to produce an interrupt. When an interrupt is active, one or more bits in this register are set to 1. The interrupt status register reflects all current pending interrupts, regardless of the state of the corresponding mask bit in the IMR. Reading the ISR clears all interrupts. Writing to the ISR has no effect.

Table 5-30. Interrupt Status Register (ISR) Address 0010h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31:26	RESERVED	0, RO	**RESERVED** (reads return 0)
25	TXRCMP	1, RO	**Transmit Reset Complete** Indicates that a requested transmit reset operation is complete.
24	RXRCMP	1, RO	**Receive Reset Complete** Indicates that a requested receive reset operation is complete.
23	DPERR	0, RO	**Detected Parity Error** This bit is set whenever CFGCS:DPERR is set, but cleared (like all other ISR bits) when the ISR register is read.
22	SSERR	0, RO	**Signaled System Error** The DP83816 device signaled a system error on the PCI bus.
21	RMABT	0, RO	**Received Master Abort** The DP83816 device received a master abort generated as a result of target not responding.
20	RTABT	0, RO	**Received Target Abort** The DP83816 device received a target abort on the PCI bus.
19:17	RESERVED	0, RO	**RESERVED** (reads return 0)
16	RXSOVR	0, RO	**Rx Status FIFO Overrun** Set when an overrun condition occurs on the Rx Status FIFO.
15	HIBERR	1, RO	**High-Bits Error Set** A logical OR of bits 25-16.
14	PHY	0, RO	**PHY interrupt** Set to 1 when internal PHY generates an interrupt.
13	PME	0, RO	**Power Management Event** Set when WOL conditioned detected.
12	SWI	0, RO	**Software Interrupt** Set whenever the SWI bit in the CR register is set.
11	MIB	0, RO	**MIB Service** Set when one of the enabled management statistics has reached its interrupt threshold. (See **Section 4.2.24)**
10	TXURN	0, RO	**Tx Underrun** Set when a transmit data FIFO underrun condition occurs.
9	TXIDLE	0, RO	**Tx Idle** This event is signaled when the transmit state machine enters the idle state from a non-idle state. This happens whenever the state machine encounters an end-of-list condition (NULL link field or a descriptor with OWN clear).
8	TXERR	0, RO	**Tx Packet Error** This event is signaled after the last transmit descriptor in a failed transmission attempt has been updated with valid status.
7	TXDESC	0, RO	**Tx Descriptor** This event is signaled after a transmit descriptor when the INTR bit in the CMDSTS field has been updated.
6	TXOK	0, RO	**Tx Packet OK** This event is signaled after the last transmit descriptor in a successful transmission attempt has been updated with valid status.
5	RXORN	0, RO	**Rx Overrun** Set when a receive data FIFO overrun condition occurs.
4	RXIDLE	0, RO	**Rx Idle** This event is signaled when the receive state machine enters the idle state from a running state. This happens whenever the state machine encounters an end-of-list condition (NULL link field or a descriptor with OWN set).
3	RXEARLY	0, RO	**Rx Early Threshold** Indicates that the initial Rx Drain Threshold has been met by the incoming packet, and the transfer of the number of bytes specified by the DRTH field in the RXCFG register has been completed by the receive DMA engine. This interrupt condition occurs only once per packet.

Table 5-30. Interrupt Status Register (ISR) Address 0010h (continued)

BIT	BIT NAME	DEFAULT	DESCRIPTION
2	RXERR	0, RO	**Rx Packet Error** This event is signaled after the last receive descriptor in a failed packet reception has been updated with valid status.
1	RXDESC	0, RO	**Rx Descriptor** This event is signaled after a receive descriptor with the INTR bit set in the CMDSTS field has been updated.
0	RXOK	0, RO	**Rx OK** Set by the receive state machine following the update of the last receive descriptor in a good packet.

5.6.3.6 Interrupt Mask Register (IMR)

This register masks the interrupts that can be generated from the ISR. Writing a 1 to the bit enables the corresponding interrupt. During a hardware reset, all mask bits are cleared. Setting a mask bit allows the corresponding bit in the ISR to cause an interrupt. ISR bits are always set to 1, however, if the condition is present, regardless of the state of the corresponding mask bit.

Table 5-31. Interrupt Mask Register (IMR) Address 0014h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31:26	RESERVED	0, RO	**RESERVED** (reads return 0)
25	TXRCMP	0, R/W	**Transmit Reset Complete** When this bit is 0, the corresponding bit in the ISR does not cause an interrupt.
24	RXRCMP	0, R/W	**Receive Reset Complete** When this bit is 0, the corresponding bit in the ISR does not cause an interrupt.
23	DPERR	0, R/W	**Detected Parity Error** When this bit is 0, the corresponding bit in the ISR does not cause an interrupt.
22	SSERR	0, R/W	**Signaled System Error** When this bit is 0, the corresponding bit in the ISR does not cause an interrupt.
21	RMABT	0, R/W	**Received Master Abort** When this bit is 0, the corresponding bit in the ISR does not cause an interrupt.
20	RTABT	0, R/W	**Received Target Abort** When this bit is 0, the corresponding bit in the ISR does not cause an interrupt.
19:17	RESERVED	0, RO	**RESERVED** (reads return 0)
16	RXSOVR	0, R/W	**Rx Status FIFO Overrun** When this bit is 0, the corresponding bit in the ISR does not cause an interrupt.
15	HIERR	0, R/W	**High Bits Error** When this bit is 0, the corresponding bit in the ISR does not cause an interrupt.
14	PHY	0, R/W	**PHY interrupt** When this bit is 0, the corresponding bit in the ISR does not cause an interrupt.
13	PME	0, R/W	**Power Management Event** When this bit is 0, the corresponding bit in the ISR does not cause an interrupt.
12	SWI	0, R/W	**Software Interrupt** When this bit is 0, the corresponding bit in the ISR does not cause an interrupt.
11	MIB	0, R/W	**MIB Service** When this bit is 0, the corresponding bit in the ISR does not cause an interrupt.
10	TXURN	0, R/W	**Tx Underrun** When this bit is 0, the corresponding bit in the ISR does not cause an interrupt.
9	TXIDLE	0, R/W	**Tx Idle** When this bit is 0, the corresponding bit in the ISR does not cause an interrupt.
8	TXERR	0, R/W	**Tx Packet Error** When this bit is 0, the corresponding bit in the ISR does not cause an interrupt.
7	TXDESC	0, R/W	**Tx Descriptor** When this bit is 0, the corresponding bit in the ISR does not cause an interrupt.

Table 5-31. Interrupt Mask Register (IMR) Address 0014h (continued)

BIT	BIT NAME	DEFAULT	DESCRIPTION
6	TXOK	0, R/W	**Tx Packet OK** When this bit is 0, the corresponding bit in the ISR does not cause an interrupt.
5	RXORN	0, R/W	**Rx Overrun** When this bit is 0, the corresponding bit in the ISR does not cause an interrupt.
4	RXIDLE	0, R/W	**Rx Idle** When this bit is 0, the corresponding bit in the ISR does not cause an interrupt.
3	RXEARLY	0, R/W	**Rx Early Threshold** When this bit is 0, the corresponding bit in the ISR does not cause an interrupt.
2	RXERR	0, R/W	**Rx Packet Error** When this bit is 0, the corresponding bit in the ISR does not cause an interrupt.
1	RXDESC	0, R/W	**Rx Descriptor** When this bit is 0, the corresponding bit in the ISR does not cause an interrupt.
0	RXOK	0, R/W	**Rx OK** When this bit is 0, the corresponding bit in the ISR does not cause an interrupt.

5.6.3.7 Interrupt Enable Register (IER)

The interrupt enable register controls the hardware INTR signal.

Table 5-32. Interrupt Enable Register (IER) Address 0018h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31:1	RESERVED	0, RO	**RESERVED** (reads return 0)
0	IE	0, R/W	**Interrupt Enable** When set to 1, the hardware INTR signal is enabled. When set to 0, the hardware INTR signal is masked, and no interrupts are generated. The setting of this bit has no effect on the ISR or IMR. This provides the ability to disable the hardware interrupt to the host with a single access (eliminating the need for a read-modify-write cycle). The actual enabling of interrupts can be delayed based on the Interrupt Holdoff Register defined in the following section. If IE = 0, the interrupt holdoff timer does not start.

5.6.3.8 Interrupt Holdoff Register (IHR)

The interrupt holdoff register provides interrupt holdoff support. This allows interrupts to be delayed based on a programmable delay timer.

Table 5-33. Interrupt Holdoff Register (IHR) Address 001Ch

BIT	BIT NAME	DEFAULT	DESCRIPTION
31:9	RESERVED	0, RO	**RESERVED** (reads return 0)
8	IHCTL	0, R/W	**Interrupt Holdoff Control** If this bit is set, the interrupt holdoff timer starts when the first interrupt event occurs and interrupts are enabled. When this bit is not set, the interrupt holdoff timer starts as soon as the timer is loaded and interrupts are enabled. In other words, when not set, the timer delays the interrupt enable.
7:0	IH	<0000 0000>, R/W	**Interrupt Holdoff** The register contains a counter value for use in preventing interrupt assertion for a programmed amount of time. When the ISR is read, the interrupt holdoff timer is loaded with this value. It begins to count down to 0 based on the setting of the IHCTL bit. When it reaches 0, interrupts are enabled. The counter value is in units of 100 µs.

When Interrupts are enabled IE = 1, and IH contains a value other than 00h, IHCTL determines when the Interrupt Holdoff timer begins its countdown as such:

IHCTL = 1: The timer does not begin until an interrupt event occurs.

The reporting of an interrupt event is delayed for a fixed amount of time from when the interrupt occurs.

IHCTL = 0: The timer begins immediately without waiting for an interrupt event.

The reporting of an interrupt event is delayed for a non-fixed amount of time from when the interrupt occurs

When IH = 00h (default), there is no delay applied regardless of what IHCTL is set to.

5.6.3.9 Transmit Descriptor Pointer Register (TXDP)

This register points to the current transmit descriptor.

Table 5-34. Transmit Descriptor Pointer Register (TXDP) Address 0020h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31:2	TXDP	<0000 0000 0000 0000 0000 0000 0000 00>, R/W	**Transmit Descriptor Pointer** The current value of the transmit descriptor pointer. When the transmit state machine is idle, software must set TXDP to the address of a completed transmit descriptor. While the transmit state machine is active, TXDP follows the state machine as it advances through a linked list of active descriptors. If the link field of the current transmit descriptor is NULL (signifying the end of the list), TXDP does not advance, but remains on the current descriptor. Any subsequent writes to the TXE bit of the CR register cause the transmit state machine to reread the link field of the current descriptor to check for new descriptors that may have been appended to the end of the list. Transmit descriptors must be aligned on an even 32-bit boundary in host memory (A1-A0 must be 0).
1:0	RESERVED	0, RO	**RESERVED** (reads return 0)

5.6.3.10 Transmit Configuration Register (TXCFG)

This register defines the transmit configuration for the DP83816 device. It controls such functions as loopback, heartbeat, auto transmit padding, programmable Interframe Gap, fill and drain Thresholds, and maximum DMA burst size.

Table 5-35. Transmit Configuration Register (TXCFG) Address 0024h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31	CSI	0, R/W	**Carrier Sense Ignore** Setting this bit to 1 causes the transmitter to ignore carrier sense activity, which inhibits reporting of CRS status to the transmit status register. When this bit is 0 (default), the transmitter monitors the CRS signal during transmission and reflects valid status in the transmit status register and MIB counter block. This bit must be set to enable full-duplex operation.
30	HBI	0, R/W	**HeartBeat Ignore** Setting this bit to 1 causes the transmitter to ignore the heartbeat (CD) pulse which follows the packet transmission and inhibits logging of TXSQEErrors in the MIB counter block. When this bit is set to 0 (default), the transmitter monitors the heartbeat pulse and log TXSQEErrors to the MIB counter block. This bit must be set to enable full-duplex operation
29	MLB	0, R/W	**MAC Loopback** Setting this bit to a 1 places the DP83816 MAC into a loopback state which routes all transmit traffic to the receiver, and disables the transmit and receive interfaces of the MII. A 0 in this bit allows normal MAC operation. The transmitter and receiver must be disabled before enabling the loopback mode. (Packets received during MLB mode reflect loopback status in the receive cmdsts.LBP field of the descriptor.)
28	ATP	0, R/W	**Automatic Transmit Padding** Setting this bit to 1 causes the MAC to automatically pad small (runt) transmit packets to the Ethernet minimum size of 64 bytes. This allows driver software to transfer only actual packet data. Setting this bit to 0 disables the automatic padding function, forcing software to control runt padding.

Table 5-35. Transmit Configuration Register (TXCFG) Address 0024h (continued)

BIT	BIT NAME	DEFAULT	DESCRIPTION
27–26	IFG	<00>, R/W	**Interframe Gap Time** This field allows the user to adjust the interframe gap time below the standard 9.6 µs at 10 Mb/s and 960 ns at 100 Mb/s. The time can be programmed from 9.6 µs to 8.4 µs at 10 Mb/s and 960 ns to 840 ns at 100 Mb/s. Note that any value other than zero may violate the IEEE 802.3 standard. The formula for the interframe gap is: 9.6 µs – 0.4 (IFG[1:0]) µs at 10 Mb/s 960 ns – 40 (IFG[1:0]) ns at 100 Mb/s
25:24	RESERVED	<00>, R/W	**Reserved for TI internal use only.** Must be written as a 00 otherwise.
23	ECRETRY	0, R/W	**Excessive Collision Retry Enable** This bit enables automatic retries of excessive collisions. If set, the transmitter retries the packet up to four excessive collision counts, for a total of 64 attempts. If the packet still does not complete successfully, then the transmission is aborted after the 64th attempt. If this bit is not set, then the transmit is aborted after the 16th attempt. Note that setting this bit changes how collisions are reported in the status field of the transmit descriptor.
22:20	MXDMA	<000>, R/W	**Max DMA Burst Size per Tx DMA Burst** This field sets the maximum size of transmit DMA data bursts according to the following table: 000 = 128 32-bit words (512 bytes) 001 = 1 32-bit word (4 bytes) 010 = 2 32-bit words (8 bytes) 011 = 4 32-bit words (16 bytes) 100 = 8 32-bit words (32 bytes) 101 = 16 32-bit words (64 bytes) 110 = 32 32-bit words (128 bytes) 111 = 64 32-bit words (256 bytes) **NOTE:** The MXDMA setting value must not be greater than the TXCFG:FLTH (Tx Fill Threshold) value.
19	RESERVED	0, RO	**RESERVED** (reads return 0)
18	RESERVED	1, R/W	**Reserved for TI internal use only.** Must be set to 1. Setting this bit to 0 selects a non-standard back-off algorithm that could increase the likelihood of excessive collisions.
17:14	RESERVED	0, RO	**RESERVED** (reads return 0)
13:8	FLTH	<00 0001>, R/W	**Tx Fill Threshold** Specifies the fill threshold in units of 32 bytes. When the number of available bytes in the transmit FIFO reaches this level, the transmit bus master state machine is allowed to request the PCI bus for transmit packet fragment reads. A value of 0 in this field produces unexpected results and must not be used. **NOTE:** The FLTH value should be greater than the TXCFG:MXDMA value, but less than (txFIFOsize–TXCFG:DRTH). To prevent FIFO pointer overlap internal to the device, the sum of the FLTH and TXCFG:DRTH values should not exceed 2016 Bytes.
7:6	RESERVED	0, RO	**RESERVED** (reads return 0)
5:0	DRTH	<00 0010>, R/W	**Tx Drain Threshold** Specifies the drain threshold in units of 32 bytes. When the number of bytes in the FIFO reaches this level (or the FIFO contains at least one complete packet), the MAC transmit state machine begins the transmission of a packet. **NOTE:** To prevent a deadlock condition from occurring, the DRTH value should always be less than (txFIFOsize–TXCFG:FLTH). A value of 0 in this field produces unexpected results and must not be used. Also, to prevent FIFO pointer overlap internal to the device, the sum of the DRTH and TXCFG:FLTH values should not exceed 2016 Bytes.

5.6.3.11 Receive Descriptor Pointer Register (RXDP)

This register points to the current receive descriptor.

Table 5-36. Receive Descriptor Pointer Register (RXDP) Address 0030h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31:2	RXDP	<0000 0000 0000 0000 0000 0000 0000 00>, R/W	**Receive Descriptor Pointer** The current value of the receive descriptor pointer. When the receive state machine is idle, software must set RXDP to the address of an available receive descriptor. While the receive state machine is active, RXDP follows the state machine as it advances through a linked list of available descriptors. If the link field of the current receive descriptor is NULL (signifying the end of the list), RXDP does not advance, but remains on the current descriptor. Any subsequent writes to the RXE bit of the CR register cause the receive state machine to reread the link field of the current descriptor to check for new descriptors that may have been appended to the end of the list. Software should not write to this register unless the receive state machine is idle. Receive descriptors must be aligned on 32-bit boundaries (A1–A0 must be zero). A 0 written to RXDP followed by a subsequent write to RXE causes the receiver to enter silent RX mode, for use during WOL. In this mode packets are received and buffered in FIFO, but no DMA to system memory occurs. The packet data may be recovered from the FIFO by writing a valid descriptor address to RXDP and then strobing RXE.
1:0	RESERVED	0, RO	**RESERVED** (reads return 0)

5.6.3.12 Receive Configuration Register (RXCFG)

This register is used to set the receive configuration for the DP83816 device. Receive properties such as accepting error packets, runt packets, setting the receive drain threshold and so forth, are controlled here.

Table 5-37. Receive Configuration Register (RXCFG) Address 0034h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31	AEP	0, R/W	**Accept Errored Packets** When set to 1, all packets with CRC, alignment, and/or collision errors are accepted. When set to 0, all packets with CRC, alignment, and/or collision errors are rejected if possible. Note that depending on the type of error, some packets may be received with errors, regardless of the setting of AEP. These errors are indicated in the CMDSTS field of the last descriptor in the packet.
30	ARP	0, R/W	**Accept Runt Packets** When set to 1, all packets under 64 bytes in length without errors are accepted. When this bit is 0, all packets less than 64 bytes in length are rejected if possible.
29	RESERVED	0, RO	**RESERVED** (reads return 0)
28	ATX	0, R/W	**Accept Transmit Packets** When set to 1, data received simultaneously to a local transmission (such as during a PMD loopback or full duplex operation) is accepted as valid received data. Additionally, when set to 1, the receiver ignores collision activity. When set to 0 (default), all data receive simultaneous to a local transmit is rejected. This bit must be set to 1 for PMD loopback and full duplex operation.
27	ALP	0, R/W	**Accept Long Packets** When set to 1, all packets > 1518 bytes in length and <= 2046 bytes are treated as normal receive packets, and are not tagged as long or error packets. All packets > 2046 bytes in length are truncated at 2046 bytes and either rejected from the FIFO, or tagged as long packets. Care must be taken when accepting long packets to ensure that buffers provided are of adequate length. When ALP is set to 0, packets larger than 1518 bytes (CRC inclusive) are truncated at 1514 bytes and rejected if possible.
26	RESERVED	0, RO	**RESERVED** (reads return 0)
25:23	RESERVED	0, RO	**RESERVED** (reads return 0)

Table 5-37. Receive Configuration Register (RXCFG) Address 0034h (continued)

BIT	BIT NAME	DEFAULT	DESCRIPTION
22:20	MXDMA	<000>, R/W	**Max DMA Burst Size per Rx DMA Burst** This field sets the maximum size of receive DMA data bursts according to the following table: 000 = 128 32-bit words (512 bytes) 001 = 1 32-bit word (4 bytes) 010 = 2 32-bit words (8 bytes) 011 = 4 32-bit words (16 bytes) 100 = 8 32-bit words (32 bytes) 101 = 16 32-bit words (64 bytes) 110 = 32 32-bit words (128 bytes) 111 = 64 32-bit words (256 bytes)
19:6	RESERVED	0, RO	**RESERVED** (reads return 0)
5:1	DRTH	<0 001>, R/W	**Rx Drain Threshold** Specifies the drain threshold in units of 8 bytes. When the number of bytes in the receive FIFO reaches this value (times 8), or the FIFO contains a complete packet, the receive bus master state machine begins the transfer of data from the FIFO to host memory. Care must be taken when setting DRTH to a value lower than the number of bytes needed to determine if packet should be accepted or rejected. In this case, the packet might be rejected after the bus master operation to begin transferring the packet into memory has begun. When this occurs, neither the OK bit or any error status bit in the cmdsts of the descriptor is set. A value of 0 is invalid, and the results are undefined. This value is also used to compare with the accumulated packet length for early receive indication. When the accumulated packet length meets or exceeds the DRTH value, the RXEARLY interrupt condition is generated.
0	RESERVED	0, RO	**RESERVED** (reads return 0)

5.6.3.13 CLKRUN Control and Status Register (CCSR)

This register mirrors the read and write control of the PMESTS and PMEEN from the PCI configuration register PMCSR and controls whether the chip is in the CLKRUNN or PMEN mode.

Table 5-38. CLKRUN Control and Status Register (CCSR) Address 003Ch

BIT	BIT NAME	DEFAULT	DESCRIPTION
31:16	RESERVED	0, RO	**RESERVED** (reads return 0)
15	PMESTS	0, R/W	**PME Status** Sticky bit which represents the state of the PME and CLKRUN logic, regardless of the state of the PMEEN bit. Mirrored from PCI configuration register PMCSR. Writing a 1 to this bit clears it.
14:9	RESERVED	0, RO	**RESERVED** (reads return 0)
8	PMEEN	0, R/W	**PME Enable** When set to 1, this bit enables the assertion of the PMEN/CLKRUNN pin. When 0, the PMEN/CLKRUNN pin is forced to be inactive. This value can be loaded from the EEPROM. Mirrored from PCI configuration register PMCSR.
7:1	RESERVED	0, RO	**RESERVED** (reads return 0)
0	CLKRUN_EN	0, R/W	**Clkrun Enable** When set to 1, this bit enables the CLKRUNN functionality of the PMEN/CLKRUNN pin. When 0, normal PMEN functionality is active.

5.6.3.14 Wake Command and Status Register (WCSR)

The WCSR register is used to configure and control and monitor the DP83816 WoL logic. The WoL logic is used to monitor the incoming packet stream while in a low-power state, and provide a wake event to the system if the desired packet type, contents, or Link change are detected.

Table 5-39. Wake Command and Status Register (WCSR) Address 0040h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31	MPR	0, R/W	**Magic Packet Received** Set to 1 if a Magic Packet has been detected and the WKMAG bit is set. RO, cleared on read.
30	PATM3	0, R/W	**Pattern 3 match** Associated bit set to 1 if a pattern 3 match is detected and the WKPAT3 bit is set. RO, cleared on read.
29	PATM2	0, R/W	**Pattern 2 match** Associated bit set to 1 if a pattern 2 match is detected and the WKPAT2 bit is set. RO, cleared on read.
28	PATM1	0, R/W	**Pattern 1 match** Associated bit set to 1 if a pattern 1 match is detected and the WKPAT1 bit is set. RO, cleared on read.
27	PATM0	0, R/W	**Pattern 0 match** Associated bit set to 1 if a pattern 0 match is detected and the WKPAT0 bit is set. RO, cleared on read.
26	ARPR	0, R/W	**ARP Received** Set to 1 if an ARP packet has been detected and the WKARP bit is set. RO, cleared on read.
25	BCASTR	0, R/W	**Broadcast Received** Set to 1 if a broadcast packet has been detected and the WKBCP bit is set. RO, cleared on read.
24	MCASTR	0, R/W	**Multicast Received** Set to 1 if a multicast packet has been detected and the WKMCP bit is set. RO, cleared on read.
23	UCASTR	0, R/W	**Unicast Received** Set to 1 if a unicast packet has been detected the WKUCP bit is set. RO, cleared on read.
22	PHYINT	0, R/W	**PHY Interrupt** Set to 1 if a PHY interrupt was detected and the WKPHY bit is set. RO, cleared on read.
21	RESERVED	0, RO	**RESERVED** (reads return 0)
20	SOHACK	0, R/W	**SecureOn Hack Attempt** Set to 1 if the MPSOE and WKMAG bits are set, and a Magic Packet is receive with an invalid SecureOn password value. RO, Cleared on read.
19:11	RESERVED	0, RO	**RESERVED** (reads return 0)
10	MPSOE	0, R/W	**Magic Packet SecureOn Enable** Enable Magic Packet SecureOn feature. Only applicable when bit 9 is set.
9	WKMAG	0, R/W	**Wake on Magic Packet** Enable wake on Magic Packet detection.
8	WKPAT3	0, R/W	**Wake on Pattern 3 match** Enable wake on match of pattern 3.
7	WKPAT2	0, R/W	**Wake on Pattern 2 match** Enable wake on match of pattern 2.
6	WKPAT1	0, R/W	**Wake on Pattern 1 match** Enable wake on match of pattern 1.
5	WKPAT0	0, R/W	**Wake on Pattern 0 match** Enable wake on match of pattern 0.
4	WKARP	0, R/W	**Wake on ARP** Enable wake on ARP packet detection.
3	WKBCP	0, R/W	**Wake on Broadcast** Enable wake on broadcast packet detection.

Table 5-39. Wake Command and Status Register (WCSR) Address 0040h (continued)

BIT	BIT NAME	DEFAULT	DESCRIPTION
2	WKMCP	0, R/W	**Wake on Multicast** Enable wake on multicast packet detection.
1	WKUCP	0, R/W	**Wake on Unicast** Enable wake on unicast packet detection.
0	WKPHY	0, R/W	**Wake on PHY Interrupt** Enable wake on PHY Interrupt. The PHY interrupt can be programmed for Link Change and a variety of other Physical Layer events.

5.6.3.15 Pause Control and Status Register (PCR)

The PCR register is used to control and monitor the DP83816 pause-frame reception logic. The pause-frame reception logic is used to accept 802.3x pause frames, extract the pause length value, and initiate a TX MAC pause interval of the specified number of slot times.

Table 5-40. Pause Control and Status Register (PCR) Address 0044h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31	PSEN	0, R/W	**Pause Enable** Manually enables reception of 802.3x pause frames This bit is ORed with the PSNEG bit to enable pause reception. If pause reception has been enabled via PSEN bit (PSEN = 1), setting this bit to 0 causes any active pause interval to be terminated.
30	PS_MCAST	0, R/W	**Pause on Multicast** When set to 1, this bit enables reception of 802.3x pause frames which use the 802.3x designated multicast address in the DA (01-80-C2-00-00-01). When this mode is enabled, the RX filter logic performs a perfect match on the above multicast address. No other address filtration modes (including multicast hash) are required for pause frame reception.
29	PS_DA	0, R/W	**Pause on DA** When set to 1, this bit enables reception of a pause frame based on a DA match with either the perfect match register, or one of the pattern match buffers.
28:24	RESERVED	0, RO	**RESERVED** (reads return 0)
23	PS_ACT	0, RO	**Pause Active** This bit is set to a 1 when the TX MAC logic is actively timing a pause interval.
22	PS_RCVD	0, RO	**Pause Frame Received** This bit is set to a 1 when a pause frame has been received. This bit remains set until the TX MAC has completed the pause interval.
21	PSNEG	0, RO	**Pause Negotiated** Status bit indicating that the 802.3x pause function has been enabled via auto-negotiation. This bit is only set if the DP83816 device advertises pause capable by setting bit 16 in the CFG register.
20:17	RESERVED	0, RO	**RESERVED** (reads return 0)
16	MLD_EN	0, WO	**Manual Load Enable** Setting this bit to 1 causes the value of bits 15–0 to be written to the pause count register. This write operation causes pause count interval to be manually initiated. This bit is not sticky, and reads always return 0.
15:0	PAUSE_CNT	<0000 0000 0000 0000>, R/W	**Pause Counter Value** READ: These bits represent the current real-time value of the TX MAC pause counter register. WRITE: If no pause count interval is in progress (PS_RCVD=0, PS_ACT=0), and MLD_EN=1 this value is written to the pause count register, and causes pause count interval to be manually initiated.

5.6.3.16 Receive Filter and Match Control Register (RFCR)

The RFCR register is used to control and configure the DP83816 receive-filter control logic. The receive-filter control logic is used to configure destination address filtering of incoming packets.

Table 5-41. Receive Filter and Match Control Register (RFCR) Address 0048h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31	RFEN	0, R/W	**Rx Filter Enable** When this bit is set to 1, the Rx Filter is enabled to qualify incoming packets. When set to a 0, receive packet filtering is disabled (that is, all receive packets are rejected). This bit must be 0 for the other bits in this register to be configured.
30	AAB	0, R/W	**Accept All Broadcast** When set to a 1, this bit causes all broadcast address packets to be accepted. When set to 0, no broadcast address packets are accepted.
29	AAM	0, R/W	**Accept All Multicast** When set to a 1, this bit causes all multicast address packets to be accepted. When set to 0, multicast destination addresses must have the appropriate bit set in the multicast hash table mask in order for the packet to be accepted.
28	AAU	0, R/W	**Accept All Unicast** When set to a 1, this bit causes all unicast address packets to be accepted. When set to 0, the destination address must match the node address value specified through some other means in order for the packet to be accepted.
27	APM	0, R/W	**Accept on Perfect Match** When set to 1, this bit allows the perfect match register to be used to compare against the DA for packet acceptance. When this bit is 0, the perfect match register contents are not used for DA comparison.
26:23	APAT	<000 0>, R/W	**Accept on Pattern Match** When one or more of these bits is set to 1, a packet is accepted if the first n bytes (n is the value defined in the associated pattern count register) match the associated pattern buffer memory contents. When a bit is set to 0, the associated pattern buffer is not used for packet acceptance.
22	AARP	0, R/W	**Accept ARP Packets** When set to 1, this bit allows all ARP packets (packets with a TYPE and LEN field set to 806h) to be accepted, regardless of the DA value. When set to 0, ARP packets are treated as normal packets and must meet other DA match criteria for acceptance.
21	MHEN	0, R/W	**Multicast Hash Enable** When set to 1, this bit allows hash table comparison for multicast addresses; that is, a hash table hit for a multicast-addressed packet is accepted. When set to 0, multicast hash hits are not used for packet acceptance.
20	UHEN	0, R/W	**Unicast Hash Enable** When set to 1, this bit allows hash table comparison for unicast addresses; that is, a hash table hit for a unicast addressed packet is accepted. When set to 0, unicast hash hits are not used for packet acceptance.
19	ULM	0, R/W	U/L bit Mask When set to 1, this bit causes the U/L bit (2nd MSb) of the DA to be ignored during comparison with the perfect match register.
18:10	RESERVED	0, RO	**RESERVED** (reads return 0)

Table 5-41. Receive Filter and Match Control Register (RFCR) Address 0048h (continued)

BIT	BIT NAME	DEFAULT	DESCRIPTION
9:0	RFADDR	<00 0000 0000>, R/W	**Receive Filter Extended Register Address** Selects which internal receive filter register is accessible via RFDR: Perfect Match Register (PMATCH) 000h - PMATCH octets 1-0 002h - PMATCH octets 3-2 004h - PMATCH octets 5-4 Pattern Count Registers (PCOUNT) 006h - PCOUNT1, PCOUNT0 008h - PCOUNT3, PCOUNT2 SecureOn Password Register (SOPAS) 00Ah - SOPAS octets 1-0 00Ch - SOPAS octets 3-2 00Eh - SOPAS octets 5-4 Filter Memory 200h-3FE - Rx filter memory (Hash table and pattern buffers)

5.6.3.17 Receive Filter and Match Data Register (RFDR)

The RFDR register is used for reading from and writing to the internal receive filter registers, the pattern buffer memory, and the hash table memory.

Table 5-42. Receive Filter and Match Data Register (RFDR) Address 004Ch

BIT	BIT NAME	DEFAULT	DESCRIPTION
31:18	RESERVED	0, RO	**RESERVED** (reads return 0)
17:16	BMASK	<00>, R/W	**Byte mask** Used as byte mask values for pattern match template data.
15:0	RFDATA	<0000 0000 0000 0000>, R/W	**Receive Filter Data**

5.6.3.18 Boot ROM Address Register (BRAR)

The BRAR is used to set up the address for an access to an external ROM and FLASH device.

Table 5-43. Boot ROM Address Register (BRAR) Address 0050h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31	AUTOINC	1, R/W	**Auto-Increment** When set, the contents of ADDR auto-increment with every 32-bit access to the BRDR register.
30:16	RESERVED	0, RO	**RESERVED** (reads return 0)
15:0	ADDR	<1111 1111 1111 1111>, R/W	**Boot ROM Address** 16-bit address used to access the external Boot ROM.

5.6.3.19 Boot ROM Data Register (BRDR)

The BRDR is used to read and write ROM and FLASH data from the data from/to an external ROM and FLASH device.

Table 5-44. Boot ROM Data Register (BRDR) Address 0054h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31:0	DATA	0, R/W	**Boot ROM Data** Access port to external Boot ROM. Software can use BRAR and BRDR to read (and write if FLASH memory is used) the external Boot ROM. All accesses must be 32-bits wide and aligned on 32-bit boundaries.

5.6.3.20 Silicon Revision Register (SRR)

Table 5-45. Silicon Revision Register (SRR) Address 0058h

BIT	BIT NAME	DEFAULT	DESCRIPTION
31:16	RESERVED	0, RO	**RESERVED** (reads return 0)
15:0	ADDR	<0000 0101 0000 0101>, RO	**Revision Level** SRR register value for the DP83816 silicon. Hex: DP83816AVNG 00000505h

5.6.3.21 Management Information Base Control Register (MIBC)

The MIBC register is used to control access to the statistics block and the warning bits and to control the collection of management information statistics.

Table 5-46. Management Information Base Control Register (MIBC) Address 005ch

BIT	BIT NAME	DEFAULT	DESCRIPTION
31:4	RESERVED	0, RO	**RESERVED** (reads return 0)
3	MIBS	0, R/W	**MIB Counter Strobe** Writing a 1 to this bit location causes the counters in all enabled blocks to increment by 1, providing a single-step test function. The MIBS bit is always read back as 0. **This bit is used for test purposes only and should be set to 0 for normal counter operation.**
2	ACLR	0, WO	**Clear all counters** When set to a 1, this bit forces all counters to be reset to 0. This bit is always read back as 0.
1	FRZ	1, R/W	**Freeze all counters** When set to a 1, this bit forces count values to be frozen such that a read of the statistic block represents management statistics at a given instant in time. When set to 0, the counters increment normally and may be read individually while counting. While frozen, events are not recorded.
0	WRN	0, RO	**Warning Test Indicator** This field is read only. This bit is set to 1 when statistic counters have reached their respective overflow warning condition. WRN is cleared after one or more of the statistic counters have been cleared.

5.6.3.22 Management Information Base Registers

The counters provide a set of statistics compliant with the following management specifications: MIB II, Ether-like MIB, and IEEE MIB. The values provided are accessed through the various registers as shown below. All MIB counters are cleared to 0 when read.

Due to cost and space limitations, the counter bit widths provided in the DP83816 MIB are less than the bit widths called for in the above specifications. It is assumed that management agent software maintains a set of fully compliant statistic values (*software* counters), utilizing the hardware counters to reduce the frequency at which these *software* counters must be updated. Sizes for specific hardware statistic counters were chosen such that the count values do not roll over in less than 15 ms if incremented at the theoretical maximum rates described in the above specifications. However, given that the theoretical maximum counter rates do not represent realistic network traffic and events, the actual rollover rates for the hardware counters are more likely to be on the order of several seconds. The hardware counters are updated automatically by the MAC on the occurrence of each event.

Table 5-47. MIB Registers

OFFSET	TAG	SIZE	WARNING (MS BITS)	DESCRIPTION
0060h	RXErroredPkts	16	8	Packets received with errors. This counter is incremented for each packet received with errors. This count includes packets which are automatically rejected from the FIFO due to both wire errors and FIFO overruns.
0064h	RXFCSErrors	8	4	Packets received with frame check sequence errors. This counter is incremented for each packet received with a Frame Check Sequence error (bad CRC). **Note:** For the MII interface, an FCS error is defined as a resulting invalid CRC after CRS goes invalid and an even number of bytes have been received.
0068h	RXMsdPktErrors	8	4	Packets missed due to FIFO overruns. This counter is incremented for each receive aborted due to data or status FIFO overruns (insufficient buffer space).
006Ch	RXFAErrors	8	4	Packets received with frame alignment errors. This counter is incremented for each packet received with a Frame Check Sequence error (bad CRC). **Note:** For the MII interface, an FAE error is defined as a resulting invalid CRC on the last full octet, and an odd number of nibbles have been received (Dribble nibble condition with a bad CRC).
0070h	RXSymbolErrors	8	4	Packets received with one or more symbol errors. This counter is incremented for each packet received with one or more symbol errors detected. **Note:** For the MII interface, a symbol error is indicated by the RXER signal becoming active for one or more clocks while the RXDV signal is active (during valid data reception).
0074h	RXFrameTooLong	4	2	Packets received with length greater than 1518 bytes (too long packets). This counter is incremented for each packet received with greater than the 802.3 standard maximum length of 1518 bytes.
0078h	TXSQEErrors	4	2	Loss of collision heartbeat during transmission. This counter is incremented when the collision heartbeat pulse is not detected by the PMD after a transmission.

5.6.4 Internal PHY Registers

The Internal PHY registers are only 16 bits wide. Bits [31:16] are not used. In the following register definitions under the *default* heading, the following definitions hold true:

- R/W = Read/write access
- RO = Read-only access
- LL = Latched low and held until read, based on the occurrence of the corresponding event
- LH = Latched high and held until read, based on the occurrence of the corresponding event
- SC = Register sets on event occurrence and self-clears when event ends
- P = Register bit is permanently set to a default value
- COR = Clear on read

5.6.4.1 Basic Mode Control Register (BMCR)

Table 5-48. Basic Mode Control Register (BMCR) Address 0080h

BIT	BIT NAME	DEFAULT	DESCRIPTION
15	Reset	0, R/W	**Reset:** Default: 0, R/W / SC 1 = Initiate software Reset / Reset in Process 0 = Normal operation This self-clearing bit returns a value of one until the reset process is complete. A reset causes all PHY registers to return to their default values (in some cases registers defaults are defined by related bits in the CFG register, offset 04h).
14	Loopback	0, R/W	**Loopback:** Default: 0 1 = Loopback enabled 0 = Normal operation The loopback function enables MII transmit data to be routed to the MII receive data path. Setting this bit may cause the de-scrambler to lose synchronization and produce a 500 µs *dead time* before any valid data appears at the MII receive outputs.
13	Speed Selection	0, R/W	**Speed Select:** Default: dependent on the setting of the ANEG_SEL bits in the CFG register When auto-negotiation is disabled writing to this bit allows the port speed to be selected. 1 = 100 Mb/s 0 = 10 Mb/s
12	Auto-Negotiation Enable	0, R/W	**Auto-Negotiation Enable:** Default: dependent on the setting of the ANEG_SEL bits in the CFG register 1 = Auto-Negotiation Enabled - bits 8 and 13 of this register are ignored when this bit is set. 0 = Auto-Negotiation Disabled - bits 8 and 13 determine the port speed and duplex mode.
11	Power Down	0, R/W	**Power Down:** Default: 0 1 = Power down 0 = Normal operation Setting this bit powers down the port.
10	Isolate	0, R/W	**Isolate:** Default: 0 1 = Isolates the port from the MII with the exception of the serial management. 0 = Normal operation
9	Restart Auto-Negotiation	0, R/W	**Restart Auto-Negotiation:** Default: 0, R/W / SC 1 = Restart Auto-Negotiation 0 = Normal operation When this bit is set, it re-initiates the Auto-Negotiation process. If Auto-Negotiation is disabled (bit 12 =0), this bit is ignored. This bit is self-clearing and retains a value of 1 until auto-negotiation is initiated, whereupon it self-clears. Operation of the Auto-Negotiation process is not affected by the management entity clearing this bit.
8	Duplex Mode	0, R/W	**Duplex Mode:** Default: dependent on the setting of the ANEG_SEL bits in the CFG register. When auto-negotiation is disabled writing to this bit allows the port Duplex capability to be selected. 1 = Full Duplex operation 0 = Half Duplex operation
7	Collision Test	0, R/W	**Collision Test:** Default: 0 1 = Collision test enabled 0 = Normal operation When set, this bit causes the COL signal to be asserted in response to the assertion of TXEN within 512-bit times. The COL signal is de-asserted within 4-bit times in response to the de-assertion of TXEN.
6:0	RESERVED	0, RO	**RESERVED** (reads return 0)

5.6.4.2 Basic Mode Status Register (BMSR)

Table 5-49. Basic Mode Status Register (BMSR) Address 0084h

BIT	BIT NAME	DEFAULT	DESCRIPTION
15	100BASE-T4	<7849h>, RO	**100BASE-T4 Capable:** 0 = Device not able to perform 100BASE-T4 mode.
14	100BASE-TX Full Duplex	1, RO	**100BASE-TX Full Duplex Capable:** 1 = Device able to perform 100BASE-TX in full duplex mode
13	100BASE-TX Half Duplex	1, RO	**100BASE-TX Half Duplex Capable:** 1 = Device able to perform 100BASE-TX in half duplex mode.
12	10BASE-T Full Duplex	1, RO	**10BASE-T Full Duplex Capable:** 1 = Device able to perform 10BASE-T in full duplex mode
11	10BASE-T Half Duplex	1, RO	**10BASE-T Half Duplex Capable:** 1 = Device able to perform 10BASE-T in half duplex mode
10:7	RESERVED	0, RO	**RESERVED** (reads return 0)
6	Preamble Suppression	1, RO	**Preamble suppression Capable:** 1 = Device able to perform management transaction with preamble suppressed, 32-bits of preamble needed only once after reset, invalid opcode or invalid turnaround. 0 = Normal management operation
5	Auto- Negotiation Complete	0, RO	**Auto-Negotiation Complete:** 1 = Auto-Negotiation process complete 0 = Auto-Negotiation process not complete
4	Remote Fault	0, LH	**Remote Fault:** 1 = Remote Fault condition detected (cleared on read or by reset). Fault criteria: Far End Fault Indication or notification from Link Partner of Remote Fault. 0 = No remote fault condition detected
3	Auto- Negotiation Ability	1, RO	**Auto Configuration Ability:** 1 = Device is able to perform Auto-Negotiation 0 = Device is not able to perform Auto-Negotiation
2	Link Status	0, LL	**Link Status:** 1 = Valid link established (for either 10- or 100-Mb/s operation) 0 = Link not established The criteria for link validity is implementation specific. The occurrence of a link failure condition causes the Link Status bit to clear. When cleared, this bit may only be set by establishing a good link condition and a read via the management interface.
1	Jabber Detect	0, LH	**Jabber Detect:** 1 = Jabber condition detected 0 = No Jabber This bit is implemented with a latching function, such that the occurrence of a jabber condition causes it to set until it is cleared by a read to this register by the management interface or by a reset. This bit only has meaning in 10-Mb/s mode.
0	Extended Capability	1, RO	**Extended Capability:** 1 = Extended register capabilities 0 = Basic register set capabilities only

5.6.4.3 PHY Identifier Register No. 1 (PHYIDR1)

The PHY identifier registers No. 1 and No. 2 together form a unique identifier for the PHY section of this device. The identifier consists of a concatenation of the organizationally unique identifier (OUI), the vendor model number and the model revision number. A PHY may return a value of zero in each of the 32 bits of the PHY Identifier if desired. The PHY Identifier is intended to support network management. Texas Instruments' IEEE-assigned OUI is 080017h.

Table 5-50. PHY Identifier Register No. 1 (PHYIDR1) Address 0088h

BIT	BIT NAME	DEFAULT	DESCRIPTION
15:0	OUI_MSB	<0010 0000 0000 0000> , RO	**OUI Most-Significant Bits:** Bits 3 to 18 of the OUI (080017h) are stored in bits 15 to 0 of this register. The most-significant two bits of the OUI are ignored (the IEEE standard refers to these as bits 1 and 2).

5.6.4.4 PHY Identifier Register No. 2 (PHYIDR2)

Table 5-51. PHY Identifier Register No. 2 (PHYIDR2) Address 008Ch

BIT	BIT NAME	DEFAULT	DESCRIPTION
15:10	OUI_LSB	<01 0111>, RO	**OUI Least-Significant Bits:** Bits 19 to 24 of the OUI (080017h) are mapped to bits 15 to 10 of this register respectively.
9:4	VNDR_MDL	<00 0010> , RO	**Vendor Model Number:** The six bits of vendor model number are mapped to bits 9 to 4 (most-significant bit to bit 9).
3:0	mdl_rev	<0001>, RO	**Model Revision Number:** Four bits of the vendor model revision number are mapped to bits 3 to 0 (most-significant bit to bit 3). This field is incremented for all major device changes.

5.6.4.5 Auto-Negotiation Advertisement Register (ANAR)

This register contains the advertised abilities of this device as they are transmitted to its link partner during auto-negotiation.

Table 5-52. Auto-Negotiation Advertisement Register (ANAR) Address 0090h

BIT	BIT NAME	DEFAULT	DESCRIPTION
15	NP	0, R/W	**Next Page Indication:** 0 = Next Page Transfer not desired 1 = Next Page Transfer desired
14	RESERVED	0, RO	**Reserved by IEEE:** Writes ignored, Read as 0
13	RF	0, R/W	**Remote Fault:** 1 = Advertises that this device has detected a Remote Fault 0 = No Remote Fault detected
12:11	RESERVED	0, RO	**Reserved for Future IEEE use:** Write as 0, Read as 0
10	PAUSE	0, R/W	**PAUSE:** 1 = Advertise that the DTE (MAC) has implemented both the optional MAC control sublayer and the pause function as specified in clause 31 and annex 31B of 802.3u. 0 = No MAC based full duplex flow control
9	T4	0, RO	**100BASE-T4 Support:** 1= 100BASE-T4 is supported by the local device 0 = 100BASE-T4 not supported
8	TX_FD	1, R/W	**100BASE-TX Full Duplex Support:** 1 = 100BASE-TX Full Duplex is supported by the local device 0 = 100BASE-TX Full Duplex not supported
7	TX_HD	1, R/W	**100BASE-TX Support:** 1 = 100BASE-TX is supported by the local device 0 = 100BASE-TX not supported
6	10_FD	1. R/W	**10BASE-T Full Duplex Support:** 1 = 10BASE-T Full Duplex is supported by the local device 0 = 10BASE-T Full Duplex not supported
5	10_HD	1, R/W	**10BASE-T Support:** 1 = 10BASE-T is supported by the local device 0 = 10BASE-T not supported
4:0	Selector	<0 0001>, RO	**Protocol Selection Bits:** These bits contain the binary encoded protocol selector supported by this port. <00001> indicates that this device supports IEEE 802.3u.

5.6.4.6 Auto-Negotiation Link Partner Ability Register (ANLPAR)

This register contains the advertised abilities of the link partner as received during auto-negotiation. The content changes after the successful auto-negotiation if next-pages are supported.

Table 5-53. Auto-Negotiation Link Partner Ability Register (ANLPAR) Address 0094h

BIT	BIT NAME	DEFAULT	DESCRIPTION
15	NP	0, RO	**Next Page Indication:** 0 = Link Partner does not desire Next Page Transfer 1 = Link Partner desires Next Page Transfer
14	ACK	0, RO	**Acknowledge:** 1 = Link Partner acknowledges reception of the ability data word 0 = Not acknowledged The auto-negotiation state machine of the device automatically controls this bit based on the incoming FLP bursts.
13	RF	0, RO	**Remote Fault:** 1 = Remote Fault indicated by Link Partner 0 = No Remote Fault indicated by Link Partner.
12:10	RESERVED	0, RO	**Reserved for Future IEEE use:** Write as 0, Read as 0
9	T4	0, RO	**100BASE-T4 Support:** 1= 100BASE-T4 is supported by the Link Partner 0 = 100BASE-T4 not supported by the Link Partner
8	TX_FD	0, RO	**100BASE-TX Full Duplex Support:** 1 = 100BASE-TX Full Duplex is supported b the Link Partner 0 = 100BASE-TX Full Duplex not supported by the Link Partner
7	TX_HD	0, RO	**100BASE-TX Support:** 1 = 100BASE-TX is supported by the Link Partner 0 = 100BASE-TX not supported by the Link Partner
6	10_FD	0, RO	**10BASE-T Full Duplex Support:** 1 = 10BASE-T Full Duplex is supported by the local device 0 = 10BASE-T Full Duplex not supported
5	10_HD	0, RO	**10BASE-T Support:** 1 = 10BASE-T is supported by the Link Partner 0 = 10BASE-T not supported by the Link Partner
4:0	Selector	0, RO	**Protocol Selection Bits:** Link Partners's binary encoded protocol selector.

5.6.4.7 Auto-Negotiate Expansion Register (ANER)

This register contains additional local device and link partner status information.

Table 5-54. Auto-Negotiate Expansion Register (ANER) Address 0098h

BIT	BIT NAME	DEFAULT	DESCRIPTION
15:5	RESERVED	0, RO	**RESERVED** (reads return 0)
4	PDF	0, RO	**Parallel Detection Fault:** 1 = A fault has been detected via the Parallel Detection function 0 = A fault has not been detected
3	LLP_NP_ABLE	0, RO	**Link Partner Next Page Able:** 1 = Link Partner does support Next Page 0 = Link Partner does not support Next Page.
2	NP_ABLE	1, RO	**Next Page Able:** 1 = Indicates local device is able to send additional “Next Pages”
1	PAGE_RX	0, RO/COR	**Link Code Word Page Received:** 1= Link Code Word has been received, cleared on a read 0 = Link Code Word has not been received
0	LP_AN_ABLE	0, RO	**Link Partner Auto-Negotiation Able:** 1 = Indicates that the Link Partner supports Auto-Negotiation 0 = Indicates that the Link Partner does not support Auto-Negotiation

5.6.4.8 Auto-Negotiation Next Page Transmit Register (ANNPTR)

This register contains the next page information sent by this device to its link partner during auto-negotiation.

Table 5-55. Auto-Negotiation Next Page Transmit Register (ANNPTR) Address 009Ch

BIT	BIT NAME	DEFAULT	DESCRIPTION
15	NP	0, RO	**Next Page Indication:** 1 = No other next-page transfer desired 0 = Another next-page desired
14	RESERVED	0, RO	**RESERVED** (reads return 0)
13	MP	1, RO	**Message Page:** 1 = Message Page 0 = Unformatted Page
12	ACK2	0, RO	**Acknowledge2:** 1 = Will comply with message 0 = Cannot comply with message
11	TOG_TX	0, RO	**Toggle:** 1= Value of toggle bit in previously transmitted Link Code Word was 0 0 = Value of toggle bit in previously transmitted Link Code Word was 1 Toggle is used by the Arbitration function within Auto-Negotiation to ensure synchronization with the Link Partner during Next Page exchange. This bit shall always take the opposite value of the Toggle bit in the previously exchanged Link Code Word.
10:0	CODE	<000 0000 0001>, RO	**Code Field:** This field represents the code field of the next page transmission. If the MP bit is set (bit 13 of this register), then the code shall be interpreted as a *Message Page*, as defined in annex 28C of IEEE 802.3u. Otherwise, the code shall be interpreted as an *Unformatted Page*, and the interpretation is application-specific. The default value of the CODE represents a Null Page as defined in Annex 28C of IEEE 802.3u.

5.6.4.9 PHY Status Register (PHYSTS)

This register provides a single location within the register set for quick access to commonly accessed information.

Table 5-56. PHY Status Register (PHYSTS) Address 00C0h

BIT	BIT NAME	DEFAULT	DESCRIPTION
15:14	RESERVED	0, RO	**RESERVED** (reads return 0)
13	Receive Error Latch	0, RO	**Receive Error Latch:** This bit is cleared on a read of the RECR register. 1 = Receive error event has occurred since last read of RXERCNT (address 0xD4) 0 = No receive error event has occurred
12	Polarity Status	0, RO	**Polarity Status:** This bit is a duplication of bit 4 in the TBTSCR register. This bit is cleared on a read of the TBTSCR register, but not on a read of the PHYSTS register. 1 = Inverted Polarity detected 0 = Correct Polarity detected
11	False Carrier Sense Latch	0, RO/LH	**False Carrier Sense Latch:** This bit is cleared on a read of the FCSCR register. 1 = False Carrier event has occurred since last read of FCSCR (address 0xD0) 0 = No False Carrier event has occurred
10	Signal Detect	0, RO/LL	**Signal Detect:** 100BASE-TX unconditional Signal Detect from PMD.
9	De-scrambler Lock	0, RO/LL	**De-scrambler Lock:** 100BASE-TX De-scrambler Lock from PMD.
8	Page Received	0, RO	Link Code Word Page Received: This is a duplicate of the Page Received bit in the ANER register, but this bit is not cleared on a read of the PHYSTS register. 1 = A new Link Code Word Page has been received. Cleared on read of the ANER (address 0x98, bit 1) 0 = Link Code Word Page has not been received
7	MII Interrupt	0, RO/LH	**MII Interrupt Pending** 1 = Indicates that an internal interrupt is pending, cleared by the current read 0 = No interrupt pending
6	Remote Fault	0, RO	**Remote Fault:** 1 = Remote Fault condition detected (cleared on read of BMSR (address 0x84) register or by reset). Fault criteria: notification from Link Partner of Remote Fault via Auto-Negotiation 0 = No remote fault condition detected
5	Jabber Detect	0, RO	**Jabber Detect:** This bit only has meaning in 10-Mb/s mode This bit is a duplicate of the Jabber Detect bit in the BMSR register, except that it is not cleared on a read of the PHYSTS register. 1 = Jabber condition detected 0 = No Jabber
4	Auto-Neg. Complete	0, RO	**Auto-Negotiation Complete:** 1 = Auto-Negotiation complete 0 = Auto-Negotiation not complete
3	Loopback Status	0, RO	**Loopback:** 1 = Loopback enabled 0 = Normal operation
2	Duplex Status	0, RO	**Duplex:** This bit indicates duplex status and is determined from Auto-Negotiation or Forced Modes. 1 = Full duplex mode 0 = Half duplex mode **Note:** This bit is only valid if Auto-Negotiation is enabled and complete and there is a valid link or if Auto-Negotiation is disabled and there is a valid link.

Table 5-56. PHY Status Register (PHYSTS) Address 00C0h (continued)

BIT	BIT NAME	DEFAULT	DESCRIPTION
1	Speed Status	0, RO	**Speed10:** This bit indicates the status of the speed and is determined from Auto-Negotiation or Forced Modes. 1 = 10-Mb/s mode 0 = 100-Mb/s mode **Note:** This bit is only valid if Auto-Negotiation is enabled and complete and there is a valid link or if Auto-Negotiation is disabled and there is a valid link.
0	Link Status	0, RO	**Link Status:** This bit is a duplicate of the Link Status bit in the BMSR register, except that it is not cleared on a read of the PHYSTS register. 1 = Valid link established (for either 10- or 100-Mb/s operation) 0 = Link not established

5.6.4.10 MII Interrupt Control Register (MICR)

This register implements the MII interrupt PHY specific control register. Sources for interrupt generation include: link state change, jabber event, remote fault, auto-negotiation complete or any of the counters becoming half-full. Note that the TINT bit operates independently of the INTEN bit. In other words, INTEN does not need to be active to generate the test interrupt.

Table 5-57. MII Interrupt Control Register (MICR) Address 00C4h

BIT	BIT NAME	DEFAULT	DESCRIPTION
15:2	RESERVED	0, RO	**RESERVED** (reads return 0)
1	INTEN	0, R/W	**Interrupt Enable:** 1 = Enable event based interrupts 0 = Disable event based interrupts
0	TINT	0, R/W	**Test Interrupt:** Forces the PHY to generate an interrupt at the end of each management read to facilitate interrupt testing. 1 = Generate an interrupt 0 = Do not generate interrupt

5.6.4.11 MII Interrupt Status and Misc. Control Register (MISR)

This register implements the MII interrupt PHY control and status information. These interrupts are PHY based events. When any of these events occurs and its respective bit is not masked, and MICR:INTEN is enabled, the interrupt is signaled in ISR:PHY.

Table 5-58. Register Description

BIT	BIT NAME	DEFAULT	DESCRIPTION
15	MINT	0, RO/COR	**MII Interrupt Pending:** 1 = Indicates that an interrupt is pending and is cleared by the current read. 0 = no interrupt pending
14	MSK_LINK	0, R/W	**Mask Link:** When this bit is 0, the change of link status event causes the interrupt to be seen by the ISR.
13	MSK_JAB	0, R/W	**Mask Jabber:** When this bit is 0, the Jabber event causes the interrupt to be seen by the ISR.
12	MSK_RF	0, R/W	**Mask Remote Fault:** When this bit is 0, the Remote Fault event causes the interrupt to be seen by the ISR.
11	MSK_ANC	0, R/W	**Mask Auto-Neg. Complete:** When this bit is 0, the Auto-negotiation complete event causes the interrupt to be seen by the ISR.
10	MSK_FHF	0, R/W	**Mask False Carrier Half Full:** When this bit is 0, the False Carrier Counter Register half-full event causes the interrupt to be seen by the ISR.

Table 5-58. Register Description (continued)

BIT	BIT NAME	DEFAULT	DESCRIPTION
9	MSK_RHF	0, R/W	**Mask Rx Error Half Full:** When this bit is 0, the Receive Error Counter Register half-full events cause the interrupt to be seen by the ISR.
8:0	RESERVED	0, RO	**RESERVED** (reads return 0)

5.6.4.12 False Carrier Sense Counter Register (FCSCR)

This counter provides information required to implement the *FalseCarriers* attribute within the MAU managed object class of Clause 30 of the IEEE 802.3u specification.

Table 5-59. False Carrier Sense Counter Register (FCSCR) Address 00D0h

BIT	BIT NAME	DEFAULT	DESCRIPTION
15:8	RESERVED	0, RO	**RESERVED** (reads return 0)
7:0	FCSCNT[7:0]	<0000 0000>, R/W / COR	**False Carrier Event Counter:** This 8-bit counter increments on every false carrier event. This counter sticks when it reaches its max count (FFh).

5.6.4.13 Receiver Error Counter Register (RECR)

This counter provides information required to implement the *SymbolErrorDuringCarrier* attribute within the PHY managed object class of Clause 30 of the IEEE 802.3u specification.

Table 5-60. Receiver Error Counter Register (RECR) Address 00D4h

BIT	BIT NAME	DEFAULT	DESCRIPTION
15:8	RESERVED	0, RO	**RESERVED** (reads return 0)
7:0	RXERCNT[7:0]	<0000 0000>, R/W / COR	**RXER Counter:** This 8-bit counter increments for each receive error detected. when a valid carrier is present and there is at least one occurrence of an invalid data symbol. This event can increment only once per valid carrier event. If a collision is present, the attribute does not increment. The counter sticks when it reaches its max count.

5.6.4.14 100-Mb/s PCS Configuration and Status Register (PCSR)

Table 5-61. 100-Mb/s PCS Configuration and Status Register (PCSR) Address 00D8h

BIT	BIT NAME	DEFAULT	DESCRIPTION
15:13	RESERVED	0, RO	**RESERVED** (reads return 0)
12	BYP_4B5B	0, R/W	Bypass 4B/5B Encoding: 1 = 4B5B encoder functions bypassed 0 = Normal 4B5B operation
11	FREE_CLK	0, R/W	**Receive Clock:** 1 = RX_CK is free-running 0 = RX_CK phase adjusted based on alignment
10	TQ_EN	0, R/W	**100-Mb/s True-Quiet Mode Enable:** 1 = Transmit True Quiet Mode 0 = Normal Transmit Mode
9	SD_FORCE_B	0, R/W	**Signal Detect Force:** 1 = Forces Signal Detection 0 = Normal SD operation
8	SD_OPTION	0, R/W	**Signal Detect Option:** 1 = Enhanced signal detect algorithm 0 = Reduced signal detect algorithm
7:6	RESERVED	0, RO	**RESERVED** (reads return 0)

Table 5-61. 100-Mb/s PCS Configuration and Status Register (PCSR) Address 00D8h (continued)

BIT	BIT NAME	DEFAULT	DESCRIPTION
5	FORCE_100_OK	0, R/W	**Force 100-Mb/s Good Link:** 1 = Forces 100-Mb/s good link 0 = Normal 100-Mb/s operation
4:3	RESERVED	0, RO	**RESERVED** (reads return 0)
2	NRZI_BYPASS	0, R/W	**NRZI Bypass Enable:** 1 = NRZI Bypass Enabled 0 = NRZI Bypass Disabled
1:0	RESERVED	0, RO	**RESERVED** (reads return 0)

5.6.4.15 PHY Control Register (PHYCR)

Table 5-62. PHY Control Register (PHYCR) Address 00E4h

BIT	BIT NAME	DEFAULT	DESCRIPTION
15:12	RESERVED	0, RO	**RESERVED** (reads return 0)
11	PSR_15	0, R/W	**BIST Sequence select:** Selects length of LFSR used in BIST
			1 = PSR15 selected 0 = PSR9 selected
10	BIST_STATUS	0, R/W	BIST Test Status: Default: 0, LL/RO
			1 = BIST pass 0 = BIST fail. Latched, cleared by write to BIST start bit.
9	BIST_START	0, R/W	BIST Start: BIST runs continuously until stopped. Minimum time to run should be 1 ms.
			1 = BIST start 0 = BIST stop
8	BP_STRETCH	0, R/W	**Bypass LED Stretching:** This bypasses the LED stretching, and the LEDs reflect the internal value. 1 = Bypass LED stretching 0 = Normal operation
7	PAUSE_STS	0, RO	**Pause Compare Status:** 0 = Local Device and the Link Partner are not Pause capable 1 = Local Device and the Link Partner are both Pause capable
6:5	RESERVED	0, RO	**RESERVED** (reads return 0)
4:0	PHYADDR[4:0]	<1 1111>, R/W	**PHY Address:** PHY address for the port.

5.6.4.16 10BASE-T Status and Control Register (TBTSCR)

Table 5-63. 10BASE-T Status and Control Register (TBTSCR) Address 00E8h

BIT	BIT NAME	DEFAULT	DESCRIPTION
15:9	RESERVED	<0000 10>, R/W	**RESERVED**
8	LOOPBACK_10_DIS	0, R/W	**10BASE-T Loopback Disable:** This bit is ORed with bit 14 (Loopback) in the BMCR. 1 = 10-Mb/s loopback is enabled 0 = 10-Mb/s loopback is disabled
7	LP_DIS	0, R/W	**Normal Link Pulse Disable:** 1 = Transmission of NLPs is disabled 0 = Transmission of NLPs is enabled
6	FORCE_LINK_10	0, R/W	Force good 10-Mb/s link 1 = Forced good 10-Mb/s link 0 = Normal link status
5	FORCE_POL_COR	0, R/W	Force 10-Mb/s polarity correction: 1 = Force inverted polarity 0 = Normal polarity
4	POLARITY	0, R/W	10 Mb/s polarity status: RO/LH This bit is a duplication of bit 12 in the PHYSTS register. Both bits are cleared on a read of either register. 1 = Inverted Polarity detected 0 = Correct Polarity detected
3	AUTOPOL_DIS	0, R/W	Auto Polarity Detection & Correction Disable: 1 = Polarity Sense & Correction disabled 0 = Polarity Sense & Correction enabled
2	RESERVED	1, RO	**RESERVED:** This bit must be written as a one.
1	HEARTBEAT_DIS	0, R/W	Heartbeat disable: This bit only has influence in half-duplex 10-Mb/s mode. 1 = Heartbeat function disabled 0 = Heartbeat function enabled When the device is operating at 100 Mb/s or configured for full-duplex, this bit is ignored – the heartbeat function is disabled.
0	JABBER_DIS	0, R/W	Jabber disable: Applicable only in 10BASE-T Full Duplex. 1 = Jabber function disabled 0 = Jabber function enabled

6 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

6.1 Application Information

The DP83816 device is a MAC layer integrated with a physical layer Ethernet transceiver. Typical operating voltage is 3.3 V with power consumption less than 500 mW. When using the device for Ethernet applications, it is necessary to meet certain requirements for normal operation of the DP83816 device. The following typical application and design requirements can be used for selecting appropriate component values for the DP83816 device.

6.2 Typical Application

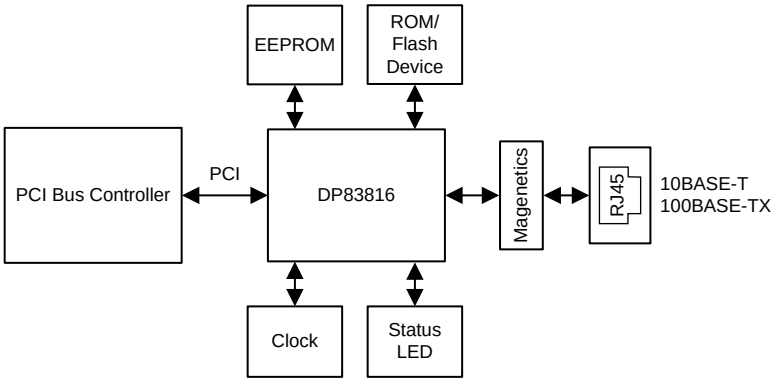


Figure 6-1. Typical Application Schematic

6.2.1 Design Requirements

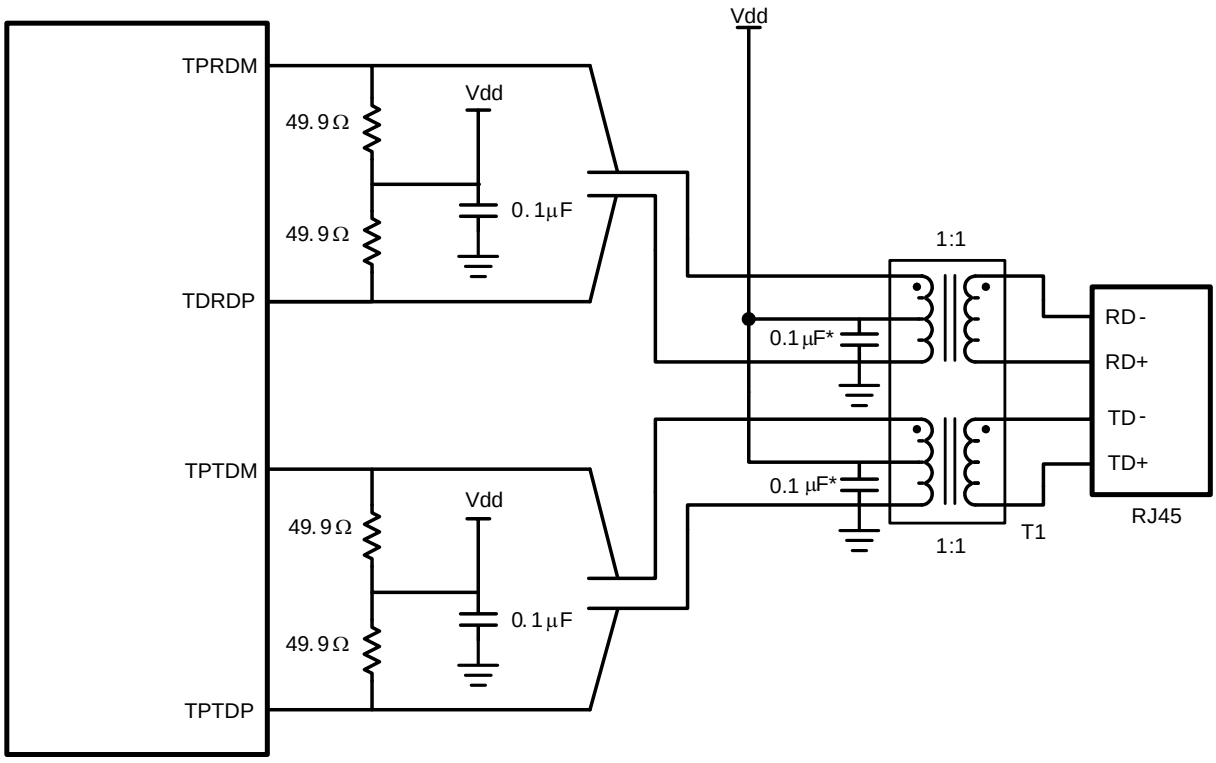
The design requirements for the DP83816 device are:

- V_{IN} = 3.3 V
- V_{OUT} = V_{CC} – 0.5 V
- Clock Input = 25 MHz

6.2.1.1 TPI Network Circuit

Figure 6-2 shows the recommended circuit for a 10/100-Mb/s twisted pair interface. Following is a partial list of recommended transformers. It is important that the user realize that variations with PCB and component characteristics require that the application be tested to ensure that the circuit meets the requirements of the intended application.

- Pulse H1102
- Pulse H2019
- Pulse J0011D21
- Pulse J0011D21B



* Place capacitors close to the transformer center taps.

Figure 6-2. 10/100-Mb/s Twisted Pair Interface

NOTE

See the following regarding Figure 6-2:

- Common mode chokes may be required.
- Center tap is pulled to VDD.
- Place resistor and capacitors close to the device.
- All values are typical and are ±1%.

6.2.1.2 Clock IN (X1) Recommendations

The DP83816 device supports an external CMOS level oscillator source or a crystal resonator device.

6.2.1.2.1 Oscillator

If an external clock source is used, X1 should be tied to the clock source and X2 should be left floating.

The CMOS oscillator specifications for the DP83816 device are listed in Table 6-1.

Table 6-1. 25-MHz Oscillator Specification

PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
Frequency			25		MHz
Frequency Tolerance	Operational Temperature			50	ppm
Frequency Stability	1 year aging			50	ppm
Rise and Fall Time	20%–80%			6	ns
Jitter	Short term			800(1)	psec
Jitter	Long term			800(1)	psec
Symmetry	Duty Cycle	40%		60%	

(1) This limit is provided as a guideline for component selection and **not** ensured by production testing. See SNLA091, *PHYTER 100 Base-TX Reference Clock Jitter Tolerance*, for details on jitter performance.

6.2.1.2.2 Crystal

A 25-MHz, parallel, 20-pF load crystal resonator should be used if a crystal source is desired. Figure 6-3 shows a typical connection for a crystal resonator circuit. The load capacitor values vary with the crystal vendors; check with the vendor for the recommended loads.

The oscillator circuit is designed to drive a parallel resonance AT cut crystal with a minimum drive level of 100 µW and a maximum of 500 µW. If a crystal is specified for a lower drive level, a current limiting resistor should be placed in series between X2 and the crystal.

As a starting point for evaluating an oscillator circuit, if the requirements for the crystal are not known, set CL1 and CL2 at 33 pF, and set R1 at 0 Ω.

Specification for 25-MHz crystal are listed in Table 6-2.

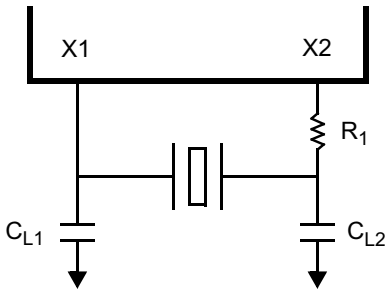


Figure 6-3. Crystal Oscillator Circuit

Table 6-2. 25-MHz Crystal Specification

PARAMETER	CONDITION	MIN	TYP	MAX	UNIT
Frequency			25		MHz
Frequency Tolerance	Operational Temperature			50	ppm
Frequency Stability	1 year aging			50	ppm
Load Capacitance		25		40	pF

6.2.1.3 Magnetics

The magnetics have a large impact on the PHY performance as well. While several components are listed below, others may be compatible following the requirements listed in Table 6-3. TI recommends that the magnetics include both an isolation transformer and an integrated common mode choke to reduce EMI. When doing the layout, do not run signals under the magnetics. This could cause unwanted noise crosstalk. Likewise void the planes under discrete magnetics, this helps prevent common-mode noise coupling. To save board space and reduce component count, an RJ-45 with integrated magnetics may be used.

Table 6-3. Magnetics Requirements

PARAMETER	CONDITION	TYP	UNIT
Turn Ratio	±2%	1:1	—
Insertion Loss	1–100 MHz	–1	dB
Return Loss	1–30 MHz	–16	dB
	30–60 MHz	–12	dB
	60–80 MHz	10	dB
Differential to Common Rejection Ratio	1–50MHz	–30	dB
	50–150 MHz	–20	dB
Crosstalk	30 MHz	–35	dB
	60 MHz	–30	dB
Isolation	HPOT	1,500	dB

6.2.1.4 Pin Configuration for Power Management

See Table 6-4 for proper pin connection for power management configuration:

Table 6-4. PM Pin Configuration

PIN NAME	PIN NO.	POWER MGT	NO POWER MGT
PMEN	59	*PME#	3.3V
3VAUX	122	*3.3Vaux	GND

6.2.2 Detailed Design Procedure

6.2.2.1 MAC Interface (MII)

The media independent interface (MII) connects the DP83816 MacPhyter-II to an external PHY device. On the MII signals, the IEEE specification states the bus should be 68-Ω impedance.

6.2.2.1.1 Termination Requirement

To reduce digital signal energy, 50-Ω series termination resistors are recommended for all MII output signals (including RXCLK, TXCLK, and RX Data signals.)

6.2.2.1.2 Recommended Maximum Trace Length

Although MII is a synchronous bus architecture, there are a number of factors limiting signal trace lengths. With a longer trace, the signal becomes more attenuated at the destination and thus more susceptible to noise interference. Longer traces also act as antennas, and if run on the surface layer, can increase EMI radiation. If a long trace is running near and adjacent to a noisy signal, the unwanted signals could be coupled in as cross talk. TI recommends keeping the signal trace lengths as short as possible. Ideally, keep the traces under 6 inches. Trace length matching, to within 2 inches on the MII bus is recommended. Significant differences in the trace lengths can cause data timing issues. As with any high-speed data signal, good design practices dictate that impedance should be maintained and stubs should be avoided throughout the entire data path.

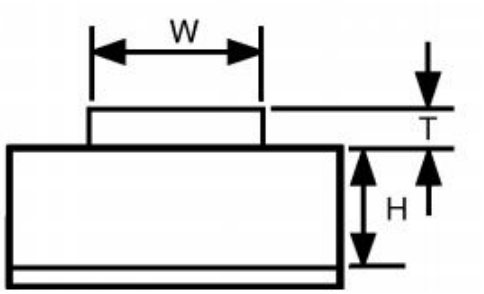
6.2.2.2 Calculating Impedance

The following equations can be used to calculate the differential impedance of the board. For microstrip traces, a solid ground plane is needed under the signal traces. The ground plane helps keep the EMI localized and the trace impedance continuous. Because stripline traces are typically sandwiched between the ground and supply planes, they have the advantage of lower EMI radiation and less noise coupling. The trade off of using strip line is lower propagation speed.

6.2.2.2.1 Microstrip Impedance – Single-Ended

Figure 6-4 illustrates the single-ended microstrip impedance. Use Equation 3 to calculate Z_o.

$$Z_o = \left(\frac{87}{\sqrt{E_r + (1.41)}}\right) \ln\left(5.98 \frac{H}{0.8\,W + T}\right) \quad (3)$$



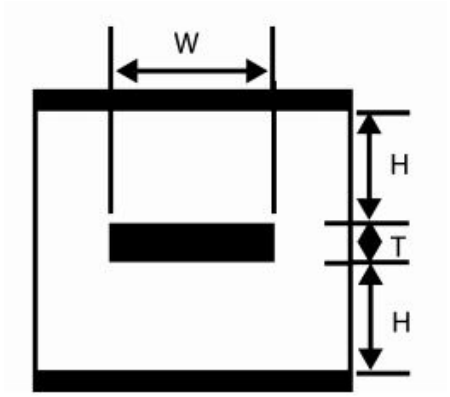
W = Width of the trace
H = Height of dielectric above the return plane
T = Trace thickness
Er = Relative permittivity of the dielectric

Figure 6-4. Microstrip Impedance – Single-Ended

6.2.2.2.2 Stripline Impedance – Single-Ended

Figure 6-5 illustrates the single-ended stripline impedance. Use Equation 4 to calculate Z_o.

$$Z_o = \left(\frac{60}{\sqrt{E_r}}\right) \ln\left(1.98 \times \left(\frac{2\ \times H + T}{0.8\ \times W + T}\right)\right) \quad (4)$$



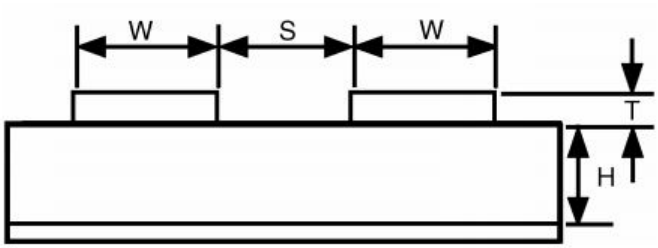
W = Width of the trace
H = Height of dielectric above the return plane
T = Trace thickness
Er = Relative permittivity of the dielectric

Figure 6-5. Stripline Impedance – Single-Ended

6.2.2.2.3 Microstrip Impedance – Differential

Figure 6-6 illustrates the differential microstrip impedance. Use Equation 5 to calculate Z_{diff}.

$$Z_{diff} = 2 \times Z_o \times \left(1 - 0.48\left(e^{\left(-0.96\frac{S}{H}\right)}\right)\right) \quad (5)$$



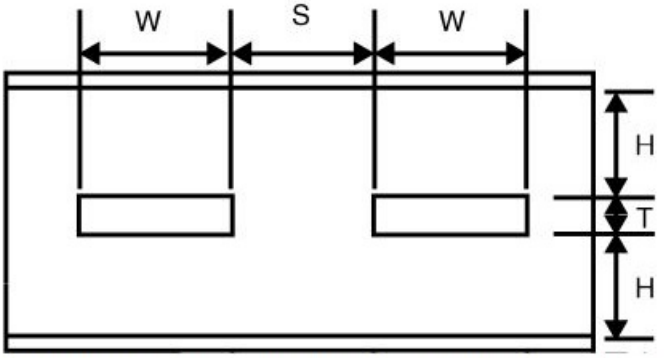
W = Width of the trace
H = Height of dielectric above the return plane
T = Trace thickness
Er = Relative permittivity of the dielectric

Figure 6-6. Microstrip Impedance – Differential

6.2.2.2.4 Stripline Impedance – Differential

Figure 6-7 illustrates the differential stripline impedance. Use Equation 6 to calculate Z_{diff}.

$$Z_{diff} = 2 \times Z_o \left(1 - 0.347 \left(e^{\left(-2.9\frac{S}{H}\right)}\right)\right) \quad (6)$$



W = Width of the trace
H = Height of dielectric above the return plane
T = Trace thickness
Er = Relative permittivity of the dielectric

Figure 6-7. Stripline Impedance – Differential

6.2.3 Application Curves

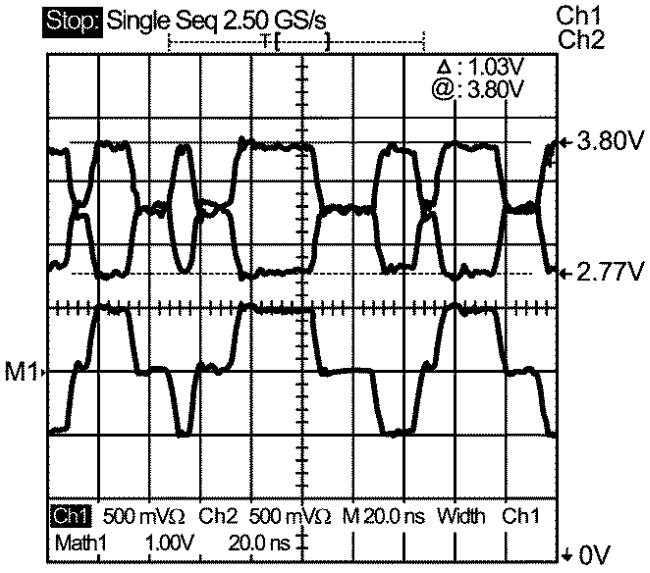


Figure 6-8. Sample 100-Mb/s Waveform (MLT-3)

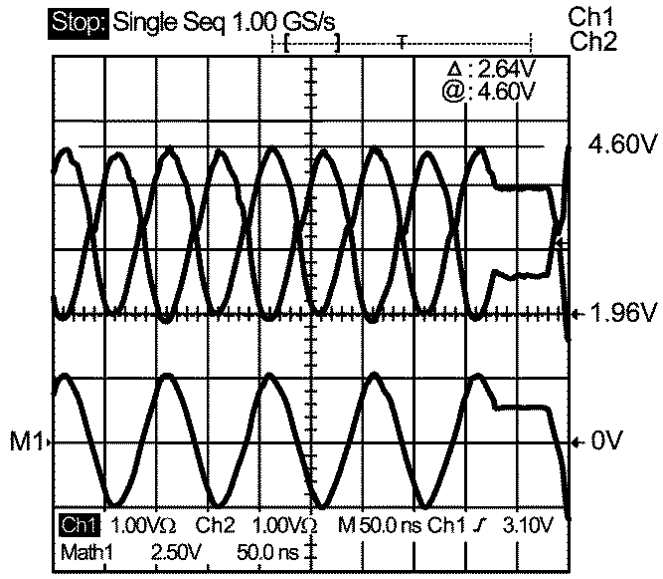


Figure 6-9. Sample 10-Mb/s Waveform

7 Power Supply Recommendations

The device V_{DD} supply pins should be bypassed with low-impedance 0.1-µF surface mount capacitors. To reduce EMI, the capacitors should be places as close as possible to the component V_{DD} supply pins, preferably between the supply pins and the vias connecting to the power plane. In some systems it may be desirable to add 0-Ω resistors in series with supply pins, as the resistor pads provide flexibility if adding EMI beads becomes necessary to meet system level certification testing requirements (see Figure 8-4). TI recommends the PCB have at least one solid ground plane and one solid V_{DD} plane to provide a low-impedance power source to the component. This also provides a low-impedance return path for non-differential digital bus and clock signals. A 10.0-µF capacitor should also be placed near the DP83816 device for local bulk bypassing between the V_{DD} and ground planes.

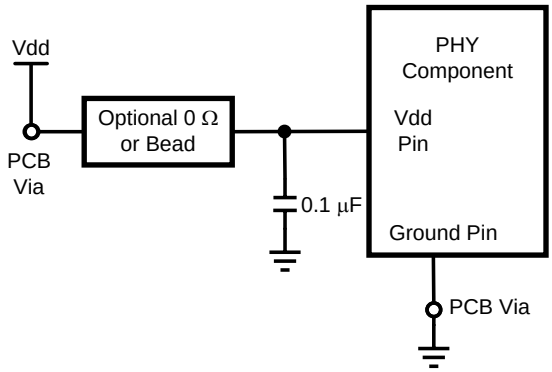


Figure 7-1. V_{DD} Bypass Layout

8 Layout

8.1 Layout Guidelines

TI recommends placing the 49.9-Ω,1% termination resistors, and 0.1-µF decoupling capacitor near the TPTDP, TPRDM and TPTDP, TPRDM pins. Connect the termination resistors to the V_{DD} plane with a via close to the resistors.

Stubs should be avoided on all signal traces, especially the differential signal pairs. See Figure 8-1. Within the pairs (for example, TPTDP and TPTDM) the trace lengths should be run parallel to each other and matched in length. Matched lengths minimize delay differences, avoiding an increase in common mode noise and increased EMI. See Figure 8-1.

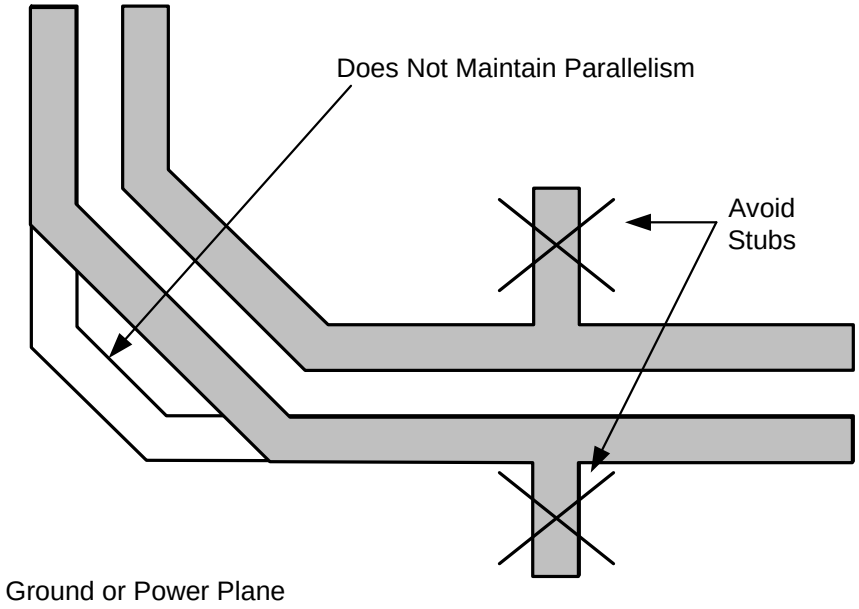


Figure 8-1. Differential Signal Pair - Stubs

Ideally, there should be no crossover or via on the signal paths. Vias present impedance discontinuities and should be minimized. Route an entire trace pair on a single layer if possible. PCB trace lengths should be kept as short as possible.

Signal traces should not be run such that they cross a plane split. See Figure 8-2. A signal crossing a plane split may cause unpredictable return path currents and would likely impact signal quality as well, potentially creating EMI problems.

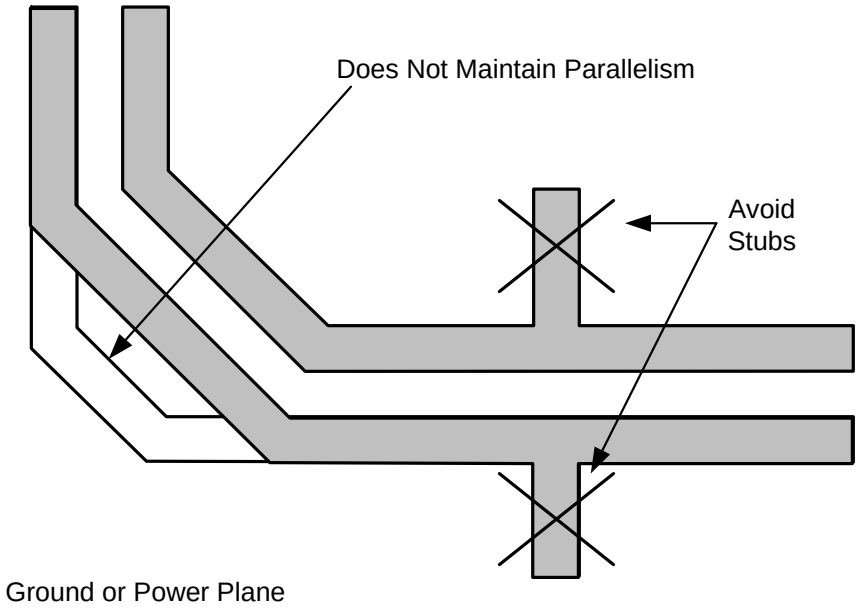


Figure 8-2. Differential Signal Pair-Plane Crossing

MDI signal traces should have 50 Ω to ground or 100-Ω differential controlled impedance. Many tools are available online to calculate this.

8.1.1 PCB Layer Stacking

To meet signal integrity and performance requirements, at minimum a 4-layer PCB is recommended for implementing PHYTER components in end user systems. The following layer stack-ups are recommended for four, six, and eight-layer boards, although other options are possible.

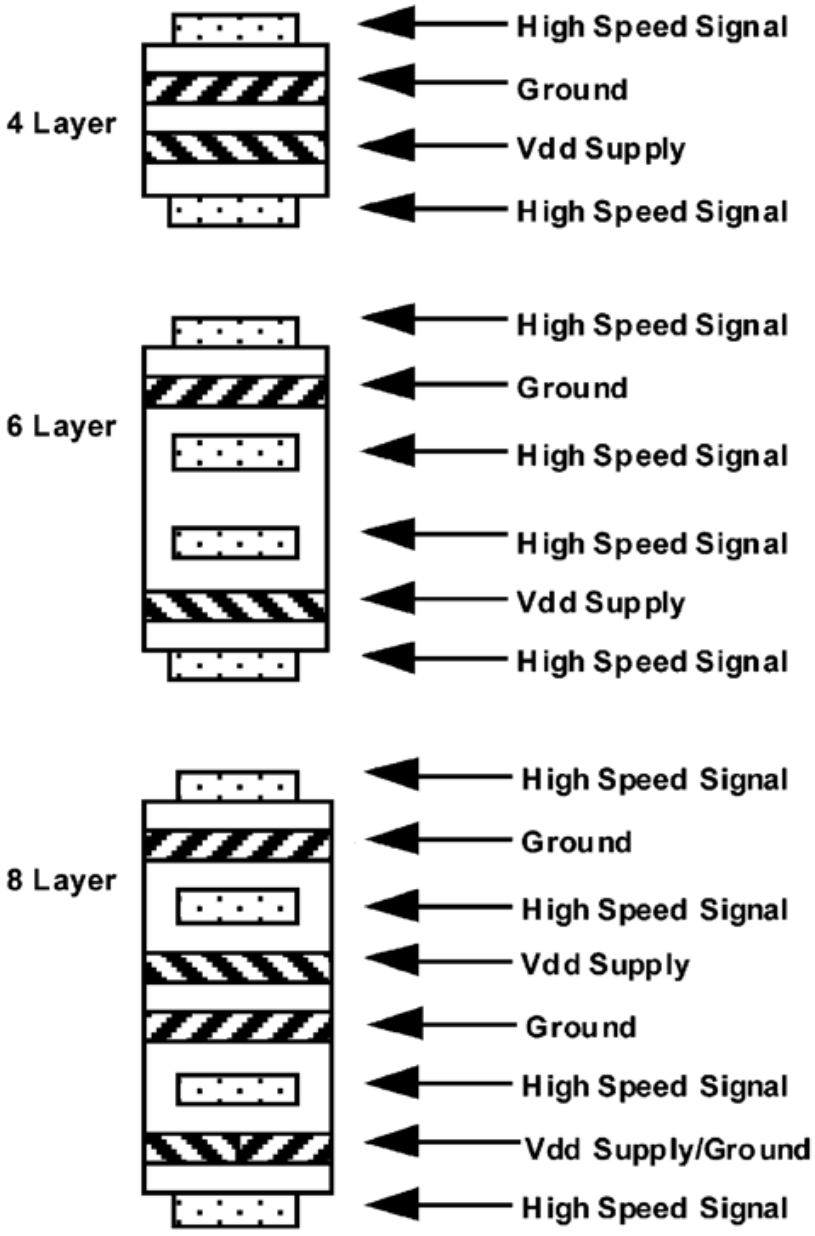


Figure 8-3. PCB Stripline Layer Stacking

Within a PCB it may be desirable to run traces using different methods, microstrip vs. stripline, depending on the location of the signal on the PCB. For example, it may be desirable to change layer stacking where an isolated chassis ground plane is used. Figure 8-4 illustrates alternative PCB stacking options.

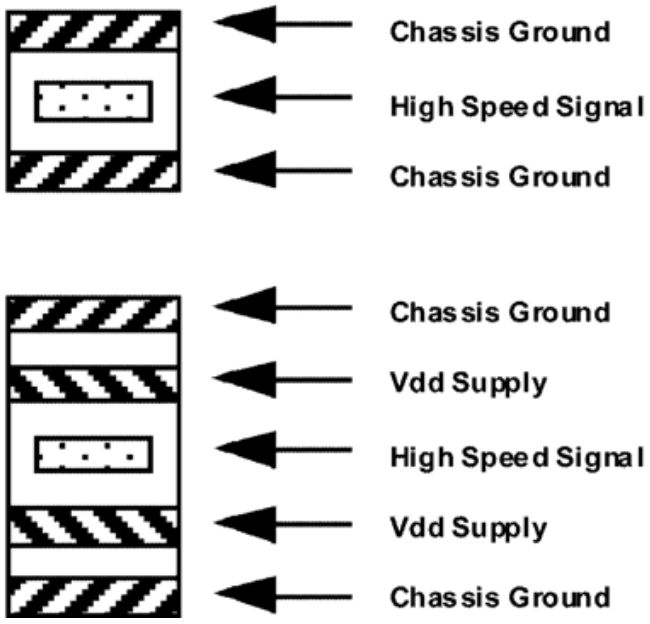


Figure 8-4. Alternative PCB Stripline Layer Stacking

8.2 Layout Example

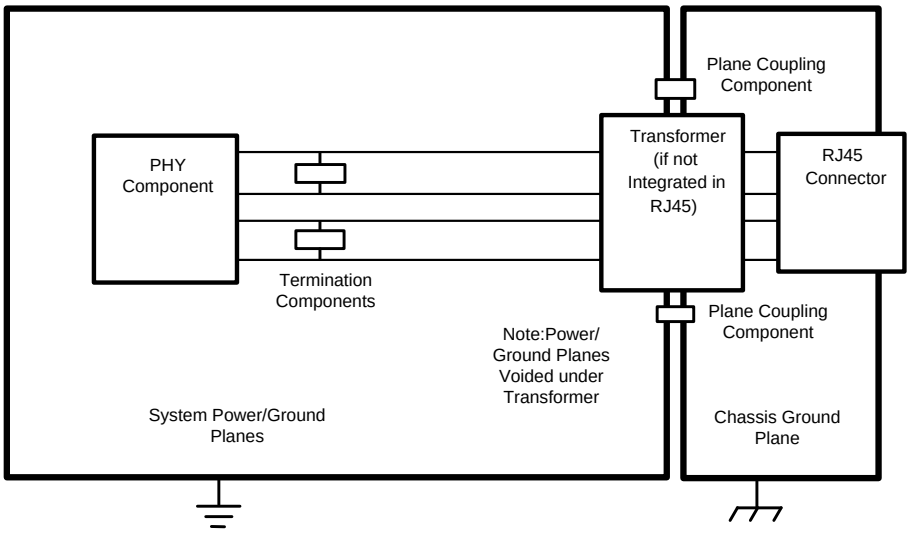


Figure 8-5. Layout Example

9 Device and Documentation Support

9.1 Documentation Support

9.1.1 Related Documentation

For related documentation see the following:

- *AN-1351 MAC Address Programming for DP83816 MacPHYTER-II and DP83815 MacPHYTER*, SNLA070
- *AN-1323 Updating DP83815 MacPHYTER Hardware Designs to DP83816 MacPHYTER-II*, SNLA063
- *AN-1287 DP83815 MacPHYTER and DP83816 MacPHYTER-II High Data Rate Stress Testing*, SNLA057
- *AN-1548 PHYTER 100 Base-TX Reference Clock Jitter Tolerance* SNLA091

9.2 Trademarks

Magic Packet is a trademark of Advanced Micro Devices, Inc.
All other trademarks are the property of their respective owners.

9.3 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

9.4 Glossary

TI Glossary This glossary lists and explains terms, acronyms, and definitions.

10 Mechanical Packaging and Orderable Information

10.1 Packaging Information

The following pages include mechanical packaging and orderable information. This information is the most-current data available for the designated device. This data is subject to change without notice and without revision of this document. For browser-based versions of this data sheet, see the left-hand navigation pane.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
DP83816AVNG	NRND	LQFP	PGE	144	60	TBD	Call TI	Call TI	0 to 70	DP83816AVNG	
DP83816AVNG/NOPB	NRND	LQFP	PGE	144	60	Green (RoHS & no Sb/Br)	SN	Level-3-260C-168 HR	0 to 70	DP83816AVNG	

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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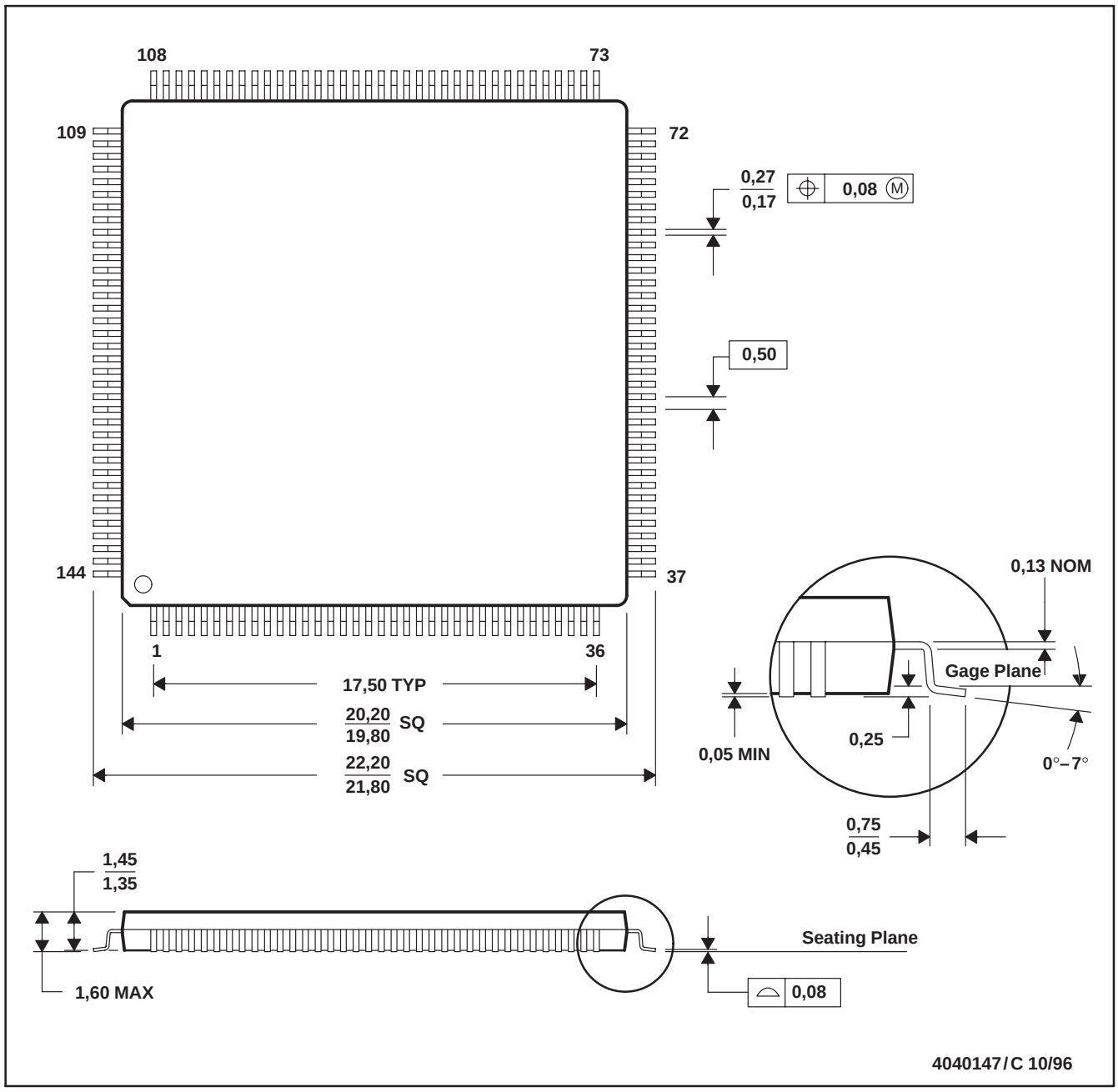
PGE (S-PQFP-G144) **PLASTIC QUAD FLATPACK**



NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS-026

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