MxL86289I

Ethernet PHY

8-Port 2.5 Gigabit Ethernet PHY

MxL86289I

Data Sheet

Revision 1.1, 2025-09-26
Reference ID 621380

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102	**Section 5.2 PHY-specific Management Registers**: • Removed **Internal Test Modes CDIAG and ABIST (Register 0.31)**.
211	**Section 6.4 Vendor Specific 1 Device Registers**: • Added **USXGMII Status Register (Register 30.19)**.
260	**Table 59 Product and Package Naming**: • Changed shipping format information and ordering part number.

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Table of Contents

Table of Contents . . . 5
List of Figures . . . 8
List of Tables . . . 9
Preface . . . 11
1 Product Overview . . . 12
1.1 Features . . . 13
1.2 Block Diagram . . . 16
2 External Signals . . . 17
2.1 Logic Symbol . . . 17
2.2 External Signal Description . . . 18
2.2.1 Ball Diagram . . . 18
2.2.2 Abbreviations . . . 20
2.2.3 Input/Output Signals . . . 21
2.2.3.1 Ethernet Twisted Pair Interface . . . 21
2.2.3.2 USXGMII Interface . . . 23
2.2.3.3 MDIO Interface . . . 24
2.2.3.4 QSPI Interface . . . 25
2.2.3.5 I^2C Interface . . . 27
2.2.3.6 Reset Interface . . . 28
2.2.3.7 LED/UART/JTAG Interface . . . 29
2.2.3.8 Miscellaneous Signals . . . 34
2.2.3.9 Power Supply for GPHY . . . 36
2.2.3.10 Power Supply for USXGMII . . . 38
2.2.3.11 Power Supply for TPI (AFE) . . . 39
2.2.3.12 Ground . . . 40
3 Functional Description . . . 41
3.1 Power Supply, Clock, and Reset . . . 41
3.1.1 Power Supply . . . 41
3.1.2 Clock . . . 41
3.1.3 Reset Generation . . . 41
3.1.4 Power-On Sequence . . . 41
3.1.5 Configuration by Pin Strapping . . . 42
3.2 MDIO Slave Interface . . . 44
3.3 Configuration via MDIO Management Interface . . . 45
3.4 I^2C Master Interface . . . 46
3.5 Quad Serial Peripheral Interface . . . 47
3.5.1 Supported Flash Memory Devices . . . 47
3.6 GPIO Mapping . . . 49
3.7 Ethernet PHY Interface . . . 51
3.7.1 Twisted Pair Interface . . . 51
3.7.2 Transformerless Ethernet . . . 51
3.7.3 Auto-Negotiation . . . 52
3.7.4 Auto-Downspeed . . . 52
3.7.5 Polarity Reversal Correction . . . 52
3.7.6 Auto-Crossover Correction . . . 52
3.7.7 RJ45 Tab Up or Tab Down Configuration . . . 53

3.7.8 Wake-on-LAN . . . 55
3.8 Ethernet SerDes Interface . . . 56
3.8.1 Ethernet SerDes Interface Configuration at Power On . . . 56
3.9 LED Interface . . . 57
3.9.1 LED . . . 57
3.9.2 LED Configuration . . . 57
3.9.3 LED Brightness Control . . . 59
3.10 Precision Time Protocol . . . 60
3.10.1 PTP Configuration . . . 60
3.11 Pulse Per Second . . . 61
3.11.1 PPS Configuration . . . 61
3.12 Synchronous Ethernet . . . 62
3.12.1 SyncE Configuration . . . 62
3.13 Smart-AZ . . . 63
3.14 Preemption . . . 64
3.15 Power Management . . . 65
3.15.1 Power States . . . 65
3.15.2 RESET PWRUP . . . 65
3.15.3 POWER DOWN State . . . 65
3.15.4 SCAN (ANEG) State . . . 66
3.15.5 PING (ANEG) State . . . 66
3.15.6 Low-Power State . . . 66
3.15.7 NORMAL State . . . 70
3.15.8 Low Power IDLE State - Energy-Efficient Ethernet . . . 71
3.16 Firmware Upgrade . . . 72

4 MDIO and MMD Register Interface Description . . . 73
4.1 MDIO-specific Terminology . . . 73
4.2 Register Naming and Numbering . . . 74
4.2.1 Register Numbering . . . 74
4.2.2 Register Naming . . . 74
4.2.3 Examples . . . 74
4.3 MMD Devices Present in MxL86289I . . . 75
4.4 Responsibilities of the STA . . . 76
4.5 MDIO Access Protocols to Read / Write Registers . . . 77

5 MDIO Registers Detailed Description . . . 78
5.1 Standard Management Registers . . . 79
5.1.1 Standard Management Register Descriptions . . . 80
5.2 PHY-specific Management Registers . . . 102
5.2.1 PHY-specific Management Register Descriptions . . . 103

6 MMD Registers Detailed Description . . . 120
6.1 Standard PMAPMD Registers for MMD=0x01 . . . 121
6.1.1 PMAPMD Register Descriptions . . . 123
6.2 Standard PCS Registers . . . 162
6.2.1 PCS Register Descriptions . . . 163
6.3 Standard Auto-Negotiation Registers for MMD=0x07 . . . 182
6.3.1 ANEG Register Descriptions . . . 183
6.4 Vendor Specific 1 Device Registers . . . 211
6.4.1 VSPEC1 Register Descriptions . . . 212
6.5 Vendor Specific 2 Device Registers . . . 229
6.5.1 VSPEC2 Register Descriptions . . . 230

7 Electrical Characteristics . . . 237
7.1 Absolute Maximum Ratings . . . 237
7.2 Operating Range . . . 239
7.3 Typical Power Consumption . . . 240
7.4 Maximum Thermal Design Power . . . 240
7.5 Maximum Current . . . 240
7.6 DC Characteristics . . . 242
7.6.1 Digital Interfaces . . . 242
7.6.2 Twisted Pair Interface . . . 242
7.6.3 Built-in Temperature Sensor . . . 243
7.7 AC Characteristics . . . 244
7.7.1 Power Up Sequence . . . 244
7.7.2 Input Clock . . . 246
7.7.3 Power Supply Rail Requirements . . . 246
7.7.3.1 V_P AC and DC Power Supply Recommendations . . . 247
7.7.3.2 V_{PH} AC and DC Power Supply Recommendations . . . 248
7.7.4 MDIO Slave Interface . . . 249
7.7.5 Quad Serial Peripheral Interface (QSPI) . . . 250
7.7.6 I^2C Interface . . . 251
7.7.7 JTAG Interface . . . 252
7.7.8 USXGMII Interface Characteristics . . . 253
7.7.8.1 USXGMII Transmit Characteristics . . . 253
7.7.8.2 USXGMII Receive Characteristics . . . 253
7.7.9 Crystal Specification . . . 254
7.8 External Circuitry . . . 255
7.8.1 Twisted-Pair Common-Mode Rejection and Termination Circuitry . . . 255
7.8.2 Transformer (Magnetics) . . . 256
7.8.3 RJ45 Plug . . . 257
8 Package Outline . . . 258
9 Product Ordering Information . . . 260
Literature References . . . 261
Standards References . . . 261
Terminology . . . 262

List of Figures

Figure 1 MxL86289I Block Diagram . . . 16
Figure 2 MxL86289I External Signal Overview . . . 17
Figure 3 Ball Diagram for PG-FCLBGA-256 (Top View) . . . 19
Figure 4 MDIO Slave . . . 44
Figure 5 MDIO Access Timing . . . 45
Figure 6 Twisted-Pair Interface of MxL86289I Including Transformer and RJ45 Plug . . . 51
Figure 7 External Circuitry for the Transformerless Ethernet Application . . . 51
Figure 8 RJ45 Tab Up or Tab Down Configuration . . . 54
Figure 9 WoL Application Block Diagram . . . 55
Figure 10 LED Connection Options to Ground or Power Supply . . . 57
Figure 11 Connection of a Dual Color LED and Configuring Pin Strap Value . . . 58
Figure 12 Connection of a Single Color LED and Configuring Pin Strap Value . . . 58
Figure 13 LED Brightness Control by Controlling LED Output Enable/Disable . . . 59
Figure 14 State Diagram for Power Down State Management . . . 65
Figure 15 Low Power Sequence . . . 67
Figure 16 EEE Low Power Idle Sequence . . . 71
Figure 17 Input/Output Waveform for AC Tests . . . 244
Figure 18 Timing Diagram for the Reset Sequence . . . 245
Figure 19 DC and AC Characteristics for V_P Supply . . . 247
Figure 20 DC and AC Characteristics for V_{PH} Supply . . . 248
Figure 21 Timing Diagram for the MDIO Slave Interface . . . 249
Figure 22 QSPI Master Interface Timing . . . 250
Figure 23 I^2C Timing . . . 251
Figure 24 Test Interface Timing . . . 252
Figure 25 Twisted Pair Common-Mode Rejection and Termination Circuitry . . . 255
Figure 26 Schematic of an Ethernet Transformer Device . . . 256
Figure 27 PG-FCLBGA-256 13 mm x 13 mm Package Outline . . . 259

List of Tables

Table 1 Ball Diagram Color Codes . . . 18
Table 2 Abbreviations for Pin Type . . . 20
Table 3 Abbreviations for Buffer Type . . . 20
Table 4 Ethernet Twisted Pair Interface Signals . . . 21
Table 5 USXGMII Interface Signals . . . 23
Table 6 MDIO Management Interface Signals . . . 24
Table 7 QSPI Management Interface Signals . . . 25
Table 8 I^2C Management Interface Signals . . . 27
Table 9 Reset Signals . . . 28
Table 10 LED and Debug Interface Signals . . . 29
Table 11 Miscellaneous Signals . . . 34
Table 12 Power Supply Pins for GPHY . . . 36
Table 13 Power Supply Pins for USXGMII . . . 38
Table 14 Power Supply Pins for TPI (AFE) . . . 39
Table 15 Ground Pins . . . 40
Table 16 Pin Names Used for Pin Strapping . . . 42
Table 17 Pin Strapping Configuration Description . . . 42
Table 18 MDIO Ready Timing . . . 45
Table 19 Supported Flash Memory Devices . . . 47
Table 20 Flash Command and Timing . . . 48
Table 21 GPIO Mapping . . . 49
Table 22 Supported Twisted Pair Mappings on a Cat 5 or Better Cable . . . 53
Table 23 Programming Sequence for the Wake-on-LAN Functionality . . . 55
Table 24 Ethernet SerDes Interface Feature List . . . 56
Table 25 Low Power State Entry and Exit Sequence . . . 68
Table 26 MDIO/MMD Devices Present in MxL86289I . . . 75
Table 27 Register Access Type . . . 78
Table 28 Registers Overview- Standard Management Registers . . . 79
Table 29 Registers Overview- PHY-specific Management Registers . . . 102
Table 30 Register Access Type . . . 120
Table 31 Registers Overview- Standard PMAPMD Registers . . . 121
Table 32 Registers Overview- Standard PCS Registers . . . 162
Table 33 Registers Overview- Standard Auto-Negotiation Registers . . . 182
Table 34 Registers Overview- Vendor Specific 1 Device Registers . . . 211
Table 35 Registers Overview- Vendor Specific 2 Device Registers . . . 229
Table 36 Absolute Maximum Ratings . . . 237
Table 37 Operating Range . . . 239
Table 38 Typical Power Consumption . . . 240
Table 39 Maximum Power Consumption . . . 240
Table 40 Maximum Current Per Rail . . . 241
Table 41 DC Characteristics of the GPIO Interfaces (VDDP = 3.3 V) . . . 242
Table 42 DC Characteristics of the GPIO Interfaces (VDDP = 1.8 V) . . . 242
Table 43 Temperature Sensor Characteristics . . . 243
Table 44 Power Supply Timings . . . 245
Table 45 AC Characteristics of Input Clock on XTAL1 Pin . . . 246
Table 46 AC Characteristics of the Power Supply . . . 246
Table 47 Timing Characteristics of the MDIO Slave Interface . . . 249
Table 48 QSPI Interface Timing Parameters . . . 250
Table 49 I^2C Timing . . . 251

Table 50 Test Interface Clock 252
Table 51 JTAG Timing 252
Table 52 Transmit Characteristics of the USXGMII 253
Table 53 Receive Characteristics of the USXGMII 253
Table 54 Specification of the Crystal 254
Table 55 Electrical Characteristics for Common-Mode Rejection and Termination Circuitry 255
Table 56 Electrical Characteristics for Supported Transformers (Magnetics) 256
Table 57 Electrical Characteristics for Supported RJ45 Plugs 257
Table 58 JEDEC Thermal Resistance Package Parameter - Compact 2-R Model Network 258
Table 59 Product and Package Naming 260

Preface

This Data Sheet describes the features and system architecture of the Ethernet PHY MxL86289I, which is an 8-Port 2.5 Gigabit Ethernet PHY. In addition, the MxL86289I supports the industrial temperature range.

Document Conventions

In the interest of brevity, this document uses short names to represent full product names.

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Organization of this Document

- **Chapter 1**, **Product Overview**
  This chapter provides an overview of the MxL86289I.
- **Chapter 2**, **External Signals**
  This chapter provides a pinout of the MxL86289I device package.
- **Chapter 3**, **Functional Description**
  This chapter provides the functional description for the MxL86289I.
- **Chapter 4**, **MDIO and MMD Register Interface Description**
  This chapter describes the MDIO and MMD registers available to support the MxL86289I feature set.
- **Chapter 5**, **MDIO Registers Detailed Description**
  This chapter describes the fields and reset values of the MDIO registers.
- **Chapter 6**, **MMD Registers Detailed Description**
  This chapter describes the fields and reset values of the MMD registers.
- **Chapter 7**, **Electrical Characteristics**
  This chapter provides the electrical characteristics for the MxL86289I.
- **Chapter 8**, **Package Outline**
  This chapter provides a package outline for the MxL86289I.
- **Chapter 9**, **Product Ordering Information**
  This chapter provides the product ordering details for the MxL86289I.
- **Standards References**

1 Product Overview

The MxL86289I device is a low power multi-port Ethernet PHY transceiver integrated circuit with two 10G Ethernet SerDes interfaces. The MxL86289I has eight integrated Ethernet BASE-T PHYs which support four data rates: 2500, 1000, 100, and 10 Mbps.

On the Ethernet Twisted Pair Interface (TPI), the MxL86289I is compliant with the standards from IEEE 802.3 referenced in **[2]**:

- 2.5GBASE-T (IEEE 802.3 Clause 126, NBASE-T)
- 1000BASE-T (IEEE 802.3 Clause 40)
- 100BASE-TX (IEEE 802.3 Clause 25)
- 10BASE-Te (IEEE 802.3 Clause 14)

This interface supports the Energy-Efficient Ethernet (EEE) feature to reduce idle mode power consumption. Power saving at the system level is also possible with the wake-on-LAN feature. A low-EMI line driver with integrated termination facilitates the PCB design.

With reference to the Open System Interconnection (OSI) model, the MxL86289I implements eight layer 1 physical media access devices, and each is connected to a layer 2 MAC using a SerDes data interface, and an MDIO management interface.

The MxL86289I provides two Ethernet SerDes data interfaces to connect to a MAC processor with multi-port (4 x 2.5G) USXGMII interface using an MDIO slave interface for management.

The MxL86289I supports the Precision Time Protocol (PTP) and Synchronous Ethernet (SyncE).

The MxL86289I supports a standard MDIO management interface as defined in IEEE 802.3 Clause 22 and Clause 45 **[2]**. The MDIO serial interface is operable with a clock running up to 25 MHz. It allows a management entity (the external chip implementing the MAC) to access standard MDIO/MMD registers to control the MxL86289I's behavior, or to read the link status. The MxL86289I is also configurable via pin strapping.

The MxL86289I is capable of driving up to 16 LEDs (two per BASE-T port). Each LED is independently programmable to indicate the link speed and traffic activities. Several indication schemes are selectable.

External supplies of 0.85 V, 1.2 V, 1.8 V, and 3.3 V are required to power the MxL86289I device.

The MxL86289I uses a ball grid array package (type BGA 16 x16 matrix, size 13 mm x 13 mm).

1.1 Features

This section provides an overview of the features supported by the MxL86289I.

Communication Interfaces

- The eight Ethernet BASE-T interfaces support:
  - Ethernet modes and standards
    2.5GBASE-T (IEEE 802.3, NBASE-T), 1000BASE-T (IEEE 802.3), 100BASE-TX (IEEE 802.3), and 10BASE-Te (IEEE 802.3)
  - Ethernet twisted pair copper cable of category Cat5 or higher
  - Low EMI voltage mode line driver with integrated termination resistors
  - Transformerless Ethernet for backplane applications
  - Auto-Negotiation (ANEG) with extended next page support
  - Auto-MDIX and polarity correction
  - Auto-Downspeed (ADS)
  - 100BASE-TX EEE, 1000BASE-T EEE, 2.5GBASE-T EEE, and power down mode
  - Cable diagnostics: cable open/short detection and cable length estimation
  - Wake-on-LAN (WoL)
  - Precision Time Stamping (PTS), implementing standard IEEE 1588v2
  - Jumbo frames of up to 10 kB
- Two Ethernet SerDes interfaces, where each interface supports:
  - 10G-USXGMII
  - The PHY complies with all of the required features specified in the Cisco USXGMII Multiport Copper PHY Specification **[7]** and Cisco USXGMII Single-port Copper PHY Specification **[8]**
  - Back channel equalization, auto-negotiation, Forward Error Correction (FEC)
  - Clock and Data Recovery (CDR), no clock forwarding required
  - Clause 37 auto-negotiation
  - Packet Control Header (PCH) over Preamble
- The management interface supports the communication between the Station Manager (STA, per IEEE 802.3) and the MxL86289I using:
  - A Management Data Input/Output (MDIO) slave interface providing access to the standard registers in the MMD
  - An MDIO interface clock of up to 25 MHz
  - 3 MDIO message frame types as described in IEEE 802.3: Clause 22, Clause 22 Extended, and Clause 45 **[2]**
- The Quad SPI master interface connecting to serial external Quad-SPI flash memory supports:
  - Programmable interface clock: maximum 101 MHz
  - Internal firmware code access from external Quad-SPI flash memory
  - Write access to the Quad-SPI flash memory
  - Different Quad-SPI flash memory sizes up to 512 MB
  - Secure firmware upgrade of the flash memory
- One instance of the I^2C master interface controlling external devices supports these speed modes:
  - Standard mode (<100 Kbps)
  - Fast mode (<400 Kbps)
  - Fast mode plus (<1000 Kbps)
  - High speed mode (<3.4 Mbps)
- The JTAG interface supports:
  - Boundary scan
  - Test and debug interface
  - Shared pins with GPIO functions
- The LED interface supports:
  - Programmable LED

  - Up to two LEDs per BASE-T port
  - Single and dual color LEDs
  - Connection of LED to ground or 3.3 V
  - Several LED indication schemes (link/activity, duplex/collision, and link speed)
  - Configuration of LED indication via MDIO registers
  - Control of LED brightness via software driver API
  - Alternative configuration of LED pins as GPIO for custom indication
- Supports two external interrupts:
  - Configurable as output to an external controller
  - Configurable as input from external device(s)
  - Configurable edge, level, and polarity

Flash and Flashless Mode

- In flash mode, an external QSPI memory device is required to store the firmware
- In flashless mode, the firmware is downloaded from a host MAC SoC via the MDIO interface:
  - Broadcast firmware download support
  - Secure firmware download

Clocking, Timing, and Time Stamping Features

- The input reference clock options are:
  - 25 MHz crystal operation
  - 25 MHz direct from an external oscillator
  - An external CML/LVPECL reference clock operating at 50 MHz or 156.25 MHz
- SyncE, implementing standard ITU-T G.8262/Y.1362
- PTP, according to standard IEEE 1588v2
- Four general purpose clock pins GPC0, GPC1, GPC2, and GPC3 shared with GPIO for several usage options, configurable by API:
  - To input or output the Synchronous Ethernet reference clock SyncE: 2.048 MHz, 1.544 MHz
  - To input or output the precise time stamping signals (PTP)
  - To output the pulse per second signal (PPS)

1588 Time Stamp

- Ethernet packet time stamping as IEEE 1588 (v1 and v2) and IEEE 802.1AS-REV
- PTP over Ethernet and PTP over UDP over IPv4/IPv6
- It is possible to adjust time and frequency of the system reference time.
- Auxiliary time stamp snapshot for the time synchronization with other chips via the GPIO type signal
- 1 pulse per second (PPS) output programmable for start, stop, pulse width, and interval
- 1-step time stamping in Tx direction
- 2-step time stamp (16-entries in FIFO per Ethernet port) in Tx direction

Synchronous Ethernet (SyncE)

- Synchronous Ethernet according to ITU-T G.8262/Y.1362.
- Supports EEC-1 (2.048 MHz), EEC-2 (1.544 MHz), and 8 kHz reference clock input.
- Supports regeneration of these reference clocks as output.

Preemption

- Recognize preemption packet types defined in IEEE 802.3br.
- Forwarding of premption packets
- PCH support of preemption packets

Other Features

- Temperature Sensor (warning, interrupt, reset, and auto-downspeed)

Power Supply

- 3.3 V, 1.8 V, 1.2 V, and 0.85 V external power sources

1.2 Block Diagram

Figure 1 shows the block diagram of the MxL86289I. The main interfaces are:

- Data interface to SoC/MAC processor, using USXGMII
- Slave control interface driven by a SoC/MAC processor, using MDIO slave
- Master control interface using I^2C master
- Interrupt signal MDINT allowing the MxL86289I to notify the SoC/MAC processor about a change of status
- LED control
- Twisted pair interfaces (TPI)
- Master Quad Serial Peripheral Interface (QSPI) interface

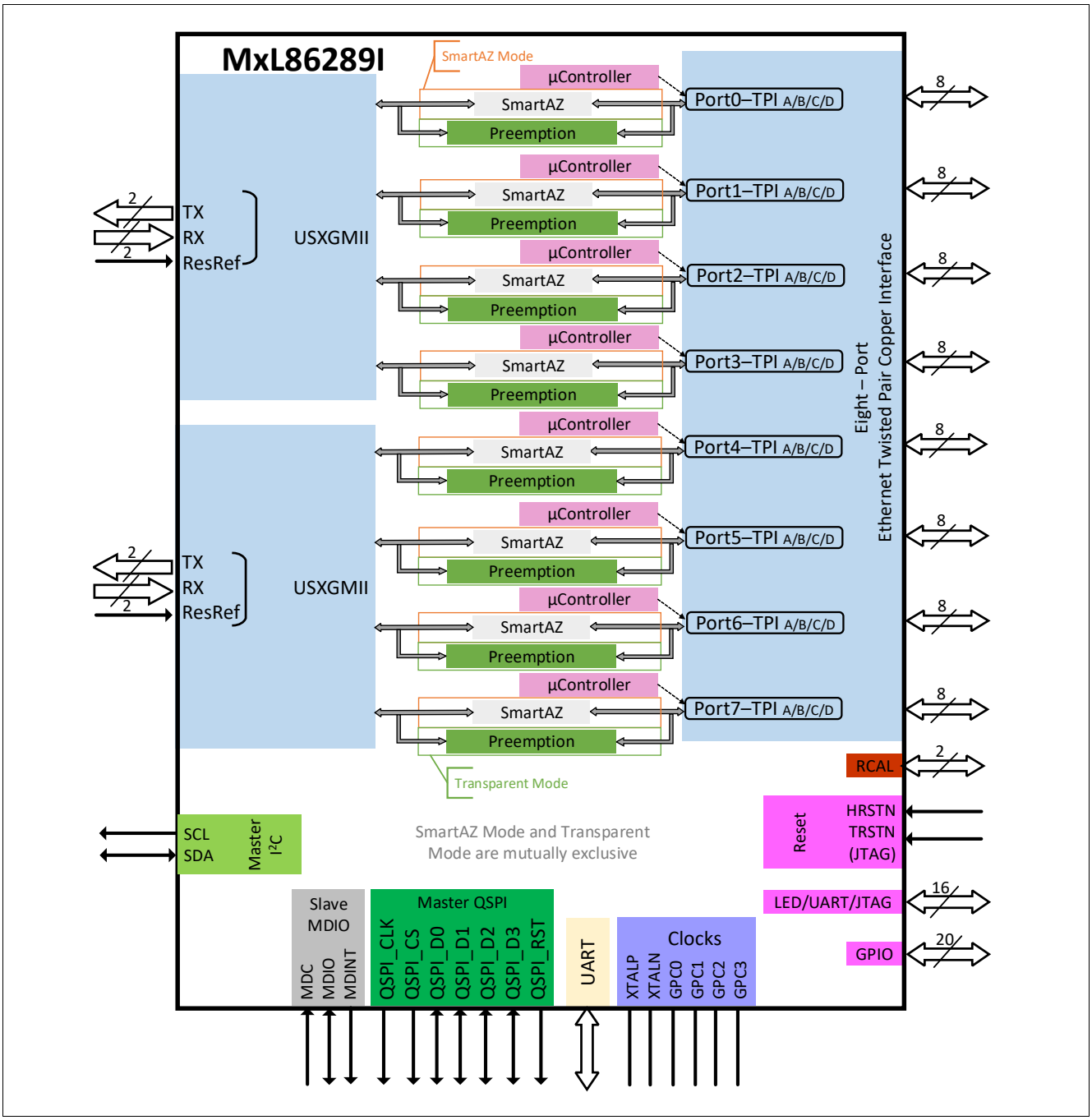


Figure 1 MxL86289I Block Diagram

2 External Signals

This chapter describes the signal mapping to the package.

2.1 Logic Symbol

Figure 2 gives an overview of the device's external interfaces.

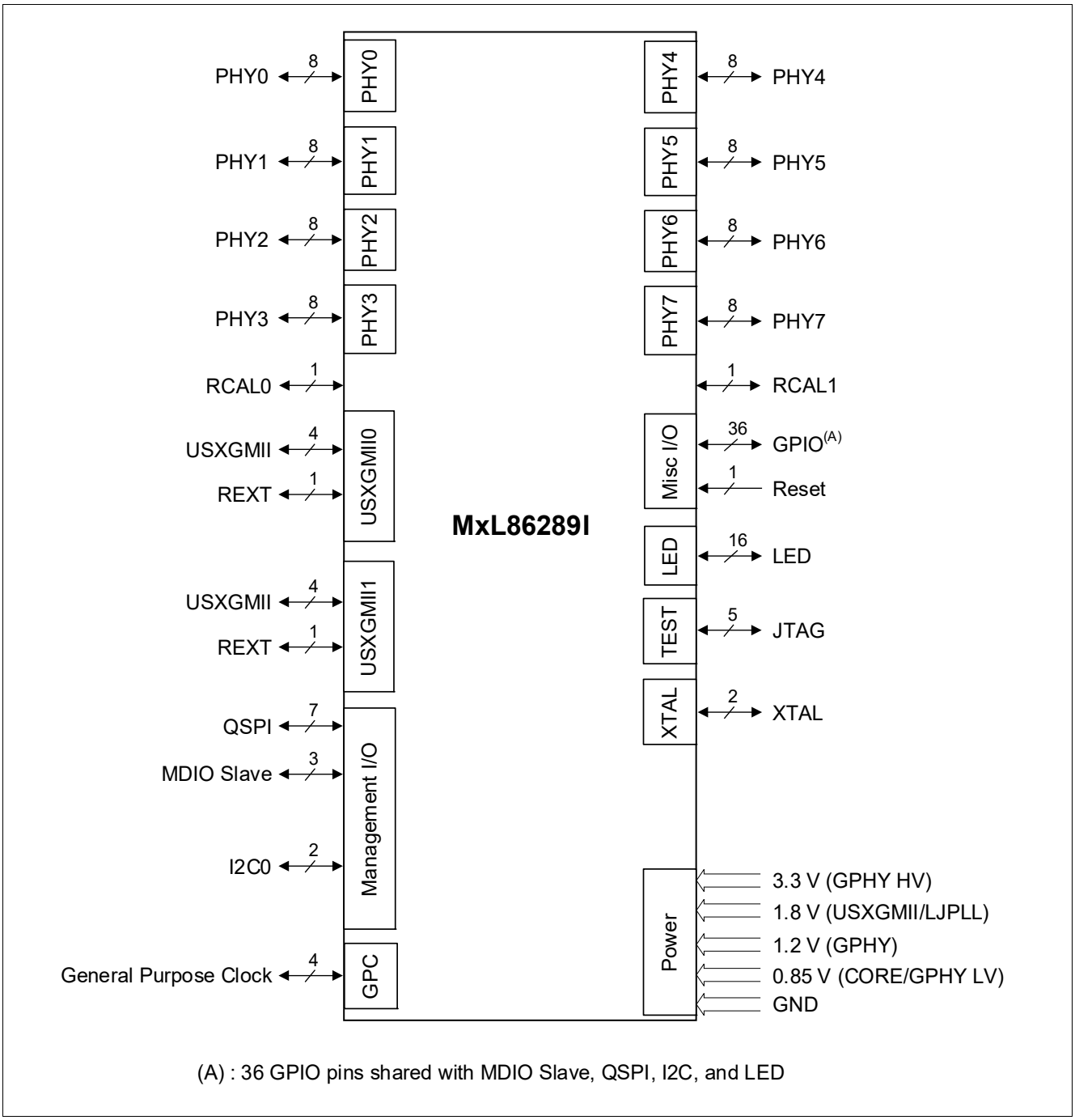


Figure 2 MxL86289I External Signal Overview

2.2 External Signal Description

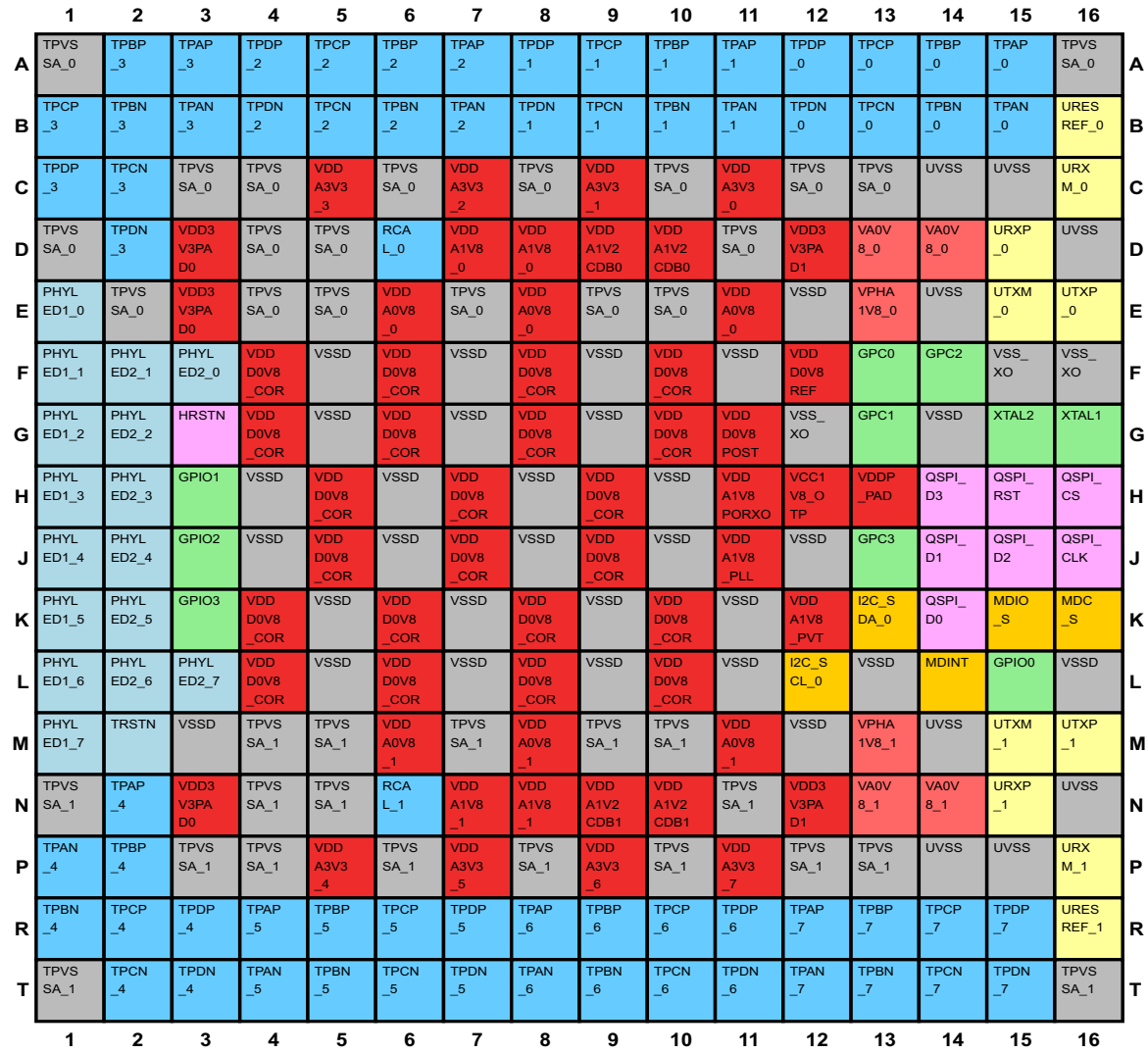
This section provides the ball diagram, abbreviations for pin types and buffer types, and the table of input and output signals.

2.2.1 Ball Diagram

Figure 3 shows the ball diagram. **Table 1** lists the ball diagram color codes.

Table 1 Ball Diagram Color Codes

Color	Description
Red	Power
Light Red	USXGMII Power
Orange	MDIO, I^2C Signals
Grey	Ground
Blue	TPI-related Signals
Pink	QSPI, Reset Signals
Yellow	USXGMI Signals
Light Green	Clock, GPIO Signals
Light Blue	LED, JTAG Signals



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
A	TPVSSA_0	TPBP_3	TPAP_3	TPDP_2	TPCP_2	TPBP_2	TPAP_2	TPDP_1	TPCP_1	TPBP_1	TPAP_1	TPDP_0	TPCP_0	TPBP_0	TPAP_0	TPVSSA_0	A
B	TPCP_3	TPBN_3	TPAN_3	TPDN_2	TPCN_2	TPBN_2	TPAN_2	TPDN_1	TPCN_1	TPBN_1	TPAN_1	TPDN_0	TPCN_0	TPBN_0	TPAN_0	URESREF_0	B
C	TPDP_3	TPCN_3	TPVSSA_0	TPVSSA_0	VDDA3V3_3	TPVSSA_0	VDDA3V3_2	TPVSSA_0	VDDA3V3_1	TPVSSA_0	VDDA3V3_0	TPVSSA_0	TPVSSA_0	UVSS	UVSS	URXM_0	C
D	TPVSSA_0	TPDN_3	VDD3V3PAD0	TPVSSA_0	TPVSSA_0	RCAL_0	VDDA1V8_0	VDDA1V8_0	VDDA1V2CDB0	VDDA1V2CDB0	TPVSSA_0	VDD3V3PAD1	VA0V8_0	VA0V8_0	URXP_0	UVSS	D
E	PHYLED1_0	TPVSSA_0	VDD3V3PAD0	TPVSSA_0	TPVSSA_0	VDDA0V8_0	TPVSSA_0	VDDA0V8_0	TPVSSA_0	TPVSSA_0	VDDA0V8_0	VSSD	VPHA1V8_0	UVSS	UTXM_0	UTXP_0	E
F	PHYLED1_1	PHYLED2_1	PHYLED2_0	VDDD0V8_COR	VSSD	VDDD0V8_COR	VSSD	VDDD0V8_COR	VSSD	VDDD0V8_COR	VSSD	VDDD0V8REF	GPC0	GPC2	VSS_XO	VSS_XO	F
G	PHYLED1_2	PHYLED2_2	HRSTN	VDDD0V8_COR	VSSD	VDDD0V8_COR	VSSD	VDDD0V8_COR	VSSD	VDDD0V8_COR	VDDD0V8POST	VSS_XO	GPC1	VSSD	XTAL2	XTAL1	G
H	PHYLED1_3	PHYLED2_3	GPIO1	VSSD	VDDD0V8_COR	VSSD	VDDD0V8_COR	VSSD	VDDD0V8_COR	VSSD	VDDA1V8PORXO	VCC1V8_OTP	VDDP_PAD	QSPI_D3	QSPI_RST	QSPI_CS	H
J	PHYLED1_4	PHYLED2_4	GPIO2	VSSD	VDDD0V8_COR	VSSD	VDDD0V8_COR	VSSD	VDDD0V8_COR	VSSD	VDDA1V8_PLL	VSSD	GPC3	QSPI_D1	QSPI_D2	QSPI_CLK	J
K	PHYLED1_5	PHYLED2_5	GPIO3	VDDD0V8_COR	VSSD	VDDD0V8_COR	VSSD	VDDD0V8_COR	VSSD	VDDD0V8_COR	VSSD	VDDA1V8_PVT	I2C_SDA_0	QSPI_D0	MDIO_S	MDC_S	K
L	PHYLED1_6	PHYLED2_6	PHYLED2_7	VDDD0V8_COR	VSSD	VDDD0V8_COR	VSSD	VDDD0V8_COR	VSSD	VDDD0V8_COR	VSSD	I2C_SCL_0	VSSD	MDINT	GPIO0	VSSD	L
M	PHYLED1_7	TRSTN	VSSD	TPVSSA_1	TPVSSA_1	VDDA0V8_1	TPVSSA_1	VDDA0V8_1	TPVSSA_1	TPVSSA_1	VDDA0V8_1	VSSD	VPHA1V8_1	UVSS	UTXM_1	UTXP_1	M
N	TPVSSA_1	TPAP_4	VDD3V3PAD0	TPVSSA_1	TPVSSA_1	RCAL_1	VDDA1V8_1	VDDA1V8_1	VDDA1V2CDB1	VDDA1V2CDB1	TPVSSA_1	VDD3V3PAD1	VA0V8_1	VA0V8_1	URXP_1	UVSS	N
P	TPANP_4	TPBP_4	TPVSSA_1	TPVSSA_1	VDDA3V3_4	TPVSSA_1	VDDA3V3_5	TPVSSA_1	VDDA3V3_6	TPVSSA_1	VDDA3V3_7	TPVSSA_1	TPVSSA_1	UVSS	UVSS	URXM_1	P
R	TPBN_4	TPCP_4	TPDP_4	TPAP_5	TPBP_5	TPCP_5	TPDP_5	TPAP_6	TPBP_6	TPCP_6	TPDP_6	TPAP_7	TPBP_7	TPCP_7	TPDP_7	URESREF_1	R
T	TPVSSA_1	TPCN_4	TPDN_4	TPAN_5	TPBN_5	TPCN_5	TPDN_5	TPAN_6	TPBN_6	TPCN_6	TPDN_6	TPAN_7	TPBN_7	TPCN_7	TPDN_7	TPVSSA_1	T
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	

Figure 3 Ball Diagram for PG-FCLBGA-256 (Top View)

2.2.2 Abbreviations

Table 2 and Table 3 summarize the abbreviations used in the signal tables.

Table 2 Abbreviations for Pin Type

Abbreviations	Description
I	Input-only, digital levels
O	Output-only, digital levels
I/O	Bidirectional input/output signal, digital levels
Prg	Bidirectional pin, programmable to operate either as input or output, digital levels
AI	Input-only, analog levels
AO	Output-only, analog levels
AI/AO	Bidirectional, analog levels
PWR	Power
GND	Ground

Table 3 Abbreviations for Buffer Type

Abbreviations	Description
A	Analog characteristics, see the AC/DC specification for more information.
Prg	Programmable (open-drain/push-pull, pull-up/pull-down characteristic are programmable)
PU	Pull up (internal, weak)

2.2.3 Input/Output Signals

Table 4 to Table 15 provide a detailed description of all the pins.

2.2.3.1 Ethernet Twisted Pair Interface

Unused TPI signals must be unconnected.

Table 4 Ethernet Twisted Pair Interface Signals

Ball No.	Name	Pin Type	Buffer Type	Function
Ethernet Port Twisted Pair Interface				
A15	**TPAP_0**	AI/AO	A	**Port 0 Transmit/Receive Positive/Negative**
B15	**TPAN_0**	AI/AO	A	
A14	**TPBP_0**	AI/AO	A	
B14	**TPBN_0**	AI/AO	A	
A13	**TPCP_0**	AI/AO	A	
B13	**TPCN_0**	AI/AO	A	
A12	**TPDP_0**	AI/AO	A	
B12	**TPDN_0**	AI/AO	A	
A11	**TPAP_1**	AI/AO	A	**Port 1 Transmit/Receive Positive/Negative**
B11	**TPAN_1**	AI/AO	A	
A10	**TPBP_1**	AI/AO	A	
B10	**TPBN_1**	AI/AO	A	
A9	**TPCP_1**	AI/AO	A	
B9	**TPCN_1**	AI/AO	A	
A8	**TPDP_1**	AI/AO	A	
B8	**TPDN_1**	AI/AO	A	
A7	**TPAP_2**	AI/AO	A	**Port 2 Transmit/Receive Positive/Negative**
B7	**TPAN_2**	AI/AO	A	
A6	**TPBP_2**	AI/AO	A	
B6	**TPBN_2**	AI/AO	A	
A5	**TPCP_2**	AI/AO	A	
B5	**TPCN_2**	AI/AO	A	
A4	**TPDP_2**	AI/AO	A	
B4	**TPDN_2**	AI/AO	A	
A3	**TPAP_3**	AI/AO	A	**Port 3 Transmit/Receive Positive/Negative**
B3	**TPAN_3**	AI/AO	A	
A2	**TPBP_3**	AI/AO	A	
B2	**TPBN_3**	AI/AO	A	
B1	**TPCP_3**	AI/AO	A	
C2	**TPCN_3**	AI/AO	A	
C1	**TPDP_3**	AI/AO	A	

Table 4 Ethernet Twisted Pair Interface Signals (cont'd)

Ball No.	Name	Pin Type	Buffer Type	Function
D2	**TPDN_3**	AI/AO	A	
N2	**TPAP_4**	AI/AO	A	**Port 4 Transmit/Receive Positive/Negative**
P1	**TPAN_4**	AI/AO	A	
P2	**TPBP_4**	AI/AO	A	
R1	**TPBN_4**	AI/AO	A	
R2	**TPCP_4**	AI/AO	A	
T2	**TPCN_4**	AI/AO	A	
R3	**TPDP_4**	AI/AO	A	
T3	**TPDN_4**	AI/AO	A	
R4	**TPAP_5**	AI/AO	A	**Port 5 Transmit/Receive Positive/Negative**
T4	**TPAN_5**	AI/AO	A	
R5	**TPBP_5**	AI/AO	A	
T5	**TPBN_5**	AI/AO	A	
R6	**TPCP_5**	AI/AO	A	
T6	**TPCN_5**	AI/AO	A	
R7	**TPDP_5**	AI/AO	A	
T7	**TPDN_5**	AI/AO	A	
R8	**TPAP_6**	AI/AO	A	**Port 6 Transmit/Receive Positive/Negative**
T8	**TPAN_6**	AI/AO	A	
R9	**TPBP_6**	AI/AO	A	
T9	**TPBN_6**	AI/AO	A	
R10	**TPCP_6**	AI/AO	A	
T10	**TPCN_6**	AI/AO	A	
R11	**TPDP_6**	AI/AO	A	
T11	**TPDN_6**	AI/AO	A	
R12	**TPAP_7**	AI/AO	A	**Port 7 Transmit/Receive Positive/Negative**
T12	**TPAN_7**	AI/AO	A	
R13	**TPBP_7**	AI/AO	A	
T13	**TPBN_7**	AI/AO	A	
R14	**TPCP_7**	AI/AO	A	
T14	**TPCN_7**	AI/AO	A	
R15	**TPDP_7**	AI/AO	A	
T15	**TPDN_7**	AI/AO	A	
Ethernet Port Test Point				
D6	**RCAL_0**	AI/AO	A	**Test Point for GPHY Ethernet Ports 0 to 3** Test point, do not connect.
N6	**RCAL_1**	AI/AO	A	**Test Point for GPHY Ethernet Ports 4 to 7** Test point, do not connect.

2.2.3.2 USXGMII Interface

Table 5 USXGMII Interface Signals

Ball No.	Name	Pin Type	Buffer Type	Function
D15	**URXP_0**	AI	A	**Differential USXGMII 0 Data Input Pair** These are the negative and positive signals of the differential input pair of the USXGMII SerDes interface. Due to the integrated CDR, no external transmission peer source-synchronous clock is required for USXGMII. These pins must be AC-coupled.
C16	**URXM_0**	AI	A	
E16	**UTXP_0**	AO	A	**Differential USXGMII 0 Data Output Pair** These are the negative and positive signals of the differential output pair of the USXGMII SerDes interface. Due to the integrated CDR, no external transmission peer source-synchronous clock is required for USXGMII. These pins must be AC-coupled.
E15	**UTXM_0**	AO	A	
B16	**URESREF_0**	AI/AO	A	**External USXGMII Tuning Resistor 0** Attach a 200 Ω (±1%) resistor-to-ground on the board.
N15	**URXP_1**	AI	A	**Differential USXGMII 1 Data Input Pair** These are the negative and positive signals of the differential input pair of the USXGMII SerDes interface. Due to the integrated CDR, no external transmission peer source-synchronous clock is required for USXGMII. These pins must be AC-coupled.
P16	**URXM_1**	AI	A	
M16	**UTXP_1**	AO	A	**Differential USXGMII 1 Data Output Pair** These are the negative and positive signals of the differential output pair of the USXGMII SerDes interface. Due to the integrated CDR, no external transmission peer source-synchronous clock is required for USXGMII. These pins must be AC-coupled.
M15	**UTXM_1**	AO	A	
R16	**URESREF_1**	AI/AO	A	**External USXGMII Tuning Resistor 1** Attach a 200 Ω (±1%) resistor-to-ground on the board.

2.2.3.3 MDIO Interface

Table 6 MDIO Management Interface Signals

Ball No.	Name	Pin Type	Buffer Type	Function
MDIO Slave Interface				
L14	**MDINT**	O		**MDIO Interrupt from Any GPHY** The interrupt interrupts an external block such as a higher-level management entity or a device controller of an SoC, on detection of certain events and states inside the GPHY device. Voltage Domain: 1.8 V / 3.3 V
	GPIO4	Prg	Prg	**General Purpose IO 4** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 1.8 V / 3.3 V
K16	**MDC_S**	I		**MDIO Slave Clock** The external controller provides the serial clock of up to 25 MHz on this input. Voltage Domain: 1.8 V / 3.3 V
	GPIO5	Prg	Prg	**General Purpose IO 5** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 1.8 V / 3.3 V
K15	**MDIO_S**	I/O		**MDIO Slave Data Input/Output** The external controller uses this signal to address internal registers and to transfer data to and from the internal registers. Voltage Domain: 1.8 V / 3.3 V
	GPIO6	Prg	Prg	**General Purpose IO 6** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 1.8 V / 3.3 V

2.2.3.4 QSPI Interface

Table 7 QSPI Management Interface Signals

Ball No.	Name	Pin Type	Buffer Type	Function
K14	**QSPI_D0**	I/O		**QSPI Data 0** QSPI interface data 0 Voltage Domain: 3.3 V
	GPIO9	Prg	Prg	**General Purpose IO 9** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
J14	**QSPI_D1**	I/O		**QSPI Data 1** QSPI interface data 1 Voltage Domain: 3.3 V
	GPIO10	Prg	Prg	**General Purpose IO 10** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
J15	**QSPI_D2**	I/O		**QSPI Data 2** QSPI interface data 2 Voltage Domain: 3.3 V
	GPIO11	Prg	Prg	**General Purpose IO 11** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
H14	**QSPI_D3**	I/O		**QSPI Data 3** QSPI interface data 3 Voltage Domain: 3.3 V
	GPIO12	Prg	Prg	**General Purpose IO 12** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
J16	**QSPI_CLK**	O		**QSPI Clock** QSPI interface clock output Voltage Domain: 3.3 V
	GPIO13	Prg	Prg	**General Purpose IO 13** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V

Table 7 QSPI Management Interface Signals (cont'd)

Ball No.	Name	Pin Type	Buffer Type	Function
H16	**QSPI_CS**	O		**QSPI Chip Select** QSPI interface chip select Voltage Domain: 3.3 V
	GPIO14	Prg	Prg	**General Purpose IO 14** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
H15	**QSPI_RST**	O		**QSPI Reset** QSPI Reset Voltage Domain: 3.3 V
	GPIO15	Prg	Prg	**General Purpose IO 15** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V

2.2.3.5 I²C Interface

Table 8 I²C Management Interface Signals

Ball No.	Name	Pin Type	Buffer Type	Function
L12	**I2C_SCL_0**	O		**I²C 0 Clock Output** I²C 0 interface clock output Voltage Domain: 3.3 V
	GPIO16	Prg	Prg	**General Purpose IO 16** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
K13	**I2C_SDA_0**	I/O		**I²C 0 Data** I²C 0 interface data Voltage Domain: 3.3 V
	GPIO17	Prg	Prg	**General Purpose IO 17** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V

2.2.3.6 Reset Interface

Table 9 Reset Signals

Ball No.	Name	Pin Type	Buffer Type	Function
G3	**HRSTN**	I	PU	**Hardware Reset** Asynchronous active low device reset Voltage Domain: 3.3 V

2.2.3.7 LED/UART/JTAG Interface

Table 10 LED and Debug Interface Signals

Ball No.	Name	Pin Type	Buffer Type	Function
LED Signals				
E1	**PHYLED1_0**	I/O		**GPHY LED1 for Port 0** LED control output, drives single-color or dual color LEDs. Voltage Domain: 3.3 V
	GPIO20	Prg	Prg	**General Purpose IO 20** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
	FW_UTXD	O		**Firmware UART Data Output** Firmware UART interface data output Voltage Domain: 3.3 V
F3	**PHYLED2_0**	I/O		**GPHY LED2 for Port 0** LED control output, drives single-color or dual color LEDs. Voltage Domain: 3.3 V
	GPIO21	Prg	Prg	**General Purpose IO 21** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
	FW_URXD	I		**Firmware UART Data Input** Firmware UART interface data input Voltage Domain: 3.3 V
F1	**PHYLED1_1**	I/O		**GPHY LED1 for Port 1** LED control output, drives single-color or dual color LEDs. Voltage Domain: 3.3 V
	GPIO23	Prg	Prg	**General Purpose IO 23** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
	FW_UTXD	O		**Firmware UART Data Output** Firmware UART interface data output Voltage Domain: 3.3 V
F2	**PHYLED2_1**	I/O		**GPHY LED2 for Port 1** LED control output, drives single-color or dual color LEDs. Voltage Domain: 3.3 V
	GPIO24	Prg	Prg	**General Purpose IO 24** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V

Table 10 LED and Debug Interface Signals (cont'd)

Ball No.	Name	Pin Type	Buffer Type	Function
G1	**PHYLED1_2**	I/O		**GPHY LED1 for Port 2** LED control output, drives single-color or dual color LEDs. Voltage Domain: 3.3 V
	GPIO26	Prg	Prg	**General Purpose IO 26** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
	TDI	I		**JTAG Serial Test Data Input** Voltage Domain: 3.3 V *Note: No external pull-up required.*
	FW_UTXD	O		**Firmware UART Data Output** Firmware UART interface data output Voltage Domain: 3.3 V
G2	**PHYLED2_2**	I/O		**GPHY LED2 for Port 2** LED control output, drives single-color or dual color LEDs. Voltage Domain: 3.3 V
	GPIO27	Prg	Prg	**General Purpose IO 27** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
	TMS	I		**JTAG Test Mode Select** Voltage Domain: 3.3 V *Note: No external pull-up required.*
H1	**PHYLED1_3**	I/O		**GPHY LED1 for Port 3** LED control output, drives single-color or dual color LEDs. Voltage Domain: 3.3 V
	GPIO29	Prg	Prg	**General Purpose IO 29** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
	TCK	I		**JTAG Test Clock** The signals TDI, TDO and TMS are synchronous subject to this JTAG test clock. Voltage Domain: 3.3 V
	FW_UTXD	O		**Firmware UART Data Output** Firmware UART interface data output Voltage Domain: 3.3 V

Table 10 LED and Debug Interface Signals (cont'd)

Ball No.	Name	Pin Type	Buffer Type	Function
H2	**PHYLED2_3**	I/O		**GPHY LED2 for Port 3** LED control output, drives single-color or dual color LEDs. Voltage Domain: 3.3 V
	GPIO30	Prg	Prg	**General Purpose IO 30** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
	TDO	I/O		**JTAG Serial Test Data Output** JTAG test data output. Voltage Domain: 3.3 V *Note: No external pull-up required.*
J1	**PHYLED1_4**	I/O		**GPHY LED1 for Port 4** LED control output, drives single-color or dual color LEDs. Voltage Domain: 3.3 V
	GPIO32	Prg	Prg	**General Purpose IO 32** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
	FW_UTXD	O		**Firmware UART Data Output** Firmware UART interface data output Voltage Domain: 3.3 V
J2	**PHYLED2_4**	I/O		**GPHY LED2 for Port 4** LED control output, drives single-color or dual color LEDs. Voltage Domain: 3.3 V
	GPIO33	Prg	Prg	**General Purpose IO 33** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
K1	**PHYLED1_5**	I/O		**GPHY LED1 for Port 5** LED control output, drives single-color or dual color LEDs. Voltage Domain: 3.3 V
	GPIO35	Prg	Prg	**General Purpose IO 35** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
	FW_UTXD	O		**Firmware UART Data Output** Firmware UART interface data output Voltage Domain: 3.3 V

Table 10 LED and Debug Interface Signals (cont'd)

Ball No.	Name	Pin Type	Buffer Type	Function
K2	**PHYLED2_5**	I/O		**GPHY LED2 for Port 5** LED control output, drives single-color or dual color LEDs. Voltage Domain: 3.3 V
	GPIO36	Prg	Prg	**General Purpose IO 36** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
L1	**PHYLED1_6**	I/O		**GPHY LED1 for Port 6** LED control output, drives single-color or dual color LEDs. Voltage Domain: 3.3 V
	GPIO38	Prg	Prg	**General Purpose IO 38** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
	FW_UTXD	O		**Firmware UART Data Output** Firmware UART interface data output Voltage Domain: 3.3 V
L2	**PHYLED2_6**	I/O		**GPHY LED2 for Port 6** LED control output, drives single-color or dual color LEDs. Voltage Domain: 3.3 V
	GPIO39	Prg	Prg	**General Purpose IO 39** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
M1	**PHYLED1_7**	I/O		**GPHY LED1 for Port 7** LED control output, drives single-color or dual color LEDs. Voltage Domain: 3.3 V
	GPIO41	Prg	Prg	**General Purpose IO 41** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
	FW_UTXD	O		**Firmware UART Data Output** Firmware UART interface data output Voltage Domain: 3.3 V

Table 10 LED and Debug Interface Signals (cont'd)

Ball No.	Name	Pin Type	Buffer Type	Function
L3	**PHYLED2_7**	I/O		**GPHY LED2 for Port 7** LED control output, drives single-color or dual color LEDs. Voltage Domain: 3.3 V
	GPIO42	Prg	Prg	**General Purpose IO 42** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
M2	**TRSTN**	I		**JTAG Test Enabling** At logic HIGH: the GPIO pins are used as JTAG interface (TCK, TDI, TDO, and TMS) At logic LOW: the GPIO pins their normal application mode Voltage Domain: 3.3 V

2.2.3.8 Miscellaneous Signals

Table 11 Miscellaneous Signals

Ball No.	Name	Pin Type	Buffer Type	Function
Reset and Clocking				
G16	**XTAL1**	AI	A	**Crystal: Oscillator Input** A crystal must be connected between XTAL1 and XTAL2. Additional load capacitances must tie both pins to GND.
	CLK	AI	A	**Crystal Oscillator: Clock Input** A clock of 25, 50, or 156.25 MHz must be connected to CLK. See **Section 7.7.2** for the clock details. XTAL2 must not be connected.
G15	**XTAL2**	AO	A	**Crystal: Oscillator Output** A crystal must be connected between XTAL1 and XTAL2. Additional load capacitances must tie both pins to GND.
F13	**GPC0**	Prg		**General Purpose Clock 0** General purpose clock for SyncE or external devices. Either input or output mode. Voltage Domain: 3.3 V
	GPIO44	Prg	Prg	**General Purpose IO 44** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
G13	**GPC1**	Prg		**General Purpose Clock 1** General purpose clock for SyncE or external devices. Either input or output mode. Voltage Domain: 3.3 V
	GPIO45	Prg	Prg	**General Purpose IO 45** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
F14	**GPC2**	Prg		**General Purpose Clock 2** General purpose clock for SyncE or external devices. Either input or output mode. Voltage Domain: 3.3 V
	GPIO46	Prg	Prg	**General Purpose IO 46** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V

Table 11 Miscellaneous Signals (cont'd)

Ball No.	Name	Pin Type	Buffer Type	Function
J13	**GPC3**	Prg		**General Purpose Clock 3** General purpose clock for SyncE or external devices. Either input or output mode. Voltage Domain: 3.3 V
	GPIO47	Prg	Prg	**General Purpose IO 47** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
L15	**GPIO0**	Prg	Prg	**General Purpose IO 0** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 1.8 V / 3.3 V
	EXTINT0	Prg	Prg	**External Interrupt 0** Voltage Domain: 1.8 V / 3.3 V
H3	**GPIO1**	Prg	Prg	**General Purpose IO 1** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
	EXTINT1	Prg	Prg	**External Interrupt 1** Voltage Domain: 3.3 V
J3	**GPIO2**	Prg	Prg	**General Purpose IO 2** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V
K3	**GPIO3**	Prg	Prg	**General Purpose IO 3** Either input or output mode. The output characteristic is either open drain or push-pull. Voltage Domain: 3.3 V

2.2.3.9 Power Supply for GPHY

Table 12 Power Supply Pins for GPHY

Ball No.	Name	Pin Type	Buffer Type	Function
C11	**VDDA3V3_0**	PWR		**GPHY 0, 3.3 V Voltage Domain Supply** This is the PHY 0 AFE 3.3 V supply.
C9	**VDDA3V3_1**	PWR		**GPHY 1, 3.3 V Voltage Domain Supply** This is the PHY 1 AFE 3.3 V supply.
C7	**VDDA3V3_2**	PWR		**GPHY 2, 3.3 V Voltage Domain Supply** This is the PHY 2 AFE 3.3 V supply.
C5	**VDDA3V3_3**	PWR		**GPHY 3, 3.3 V Voltage Domain Supply** This is the PHY 3 AFE 3.3 V supply.
P5	**VDDA3V3_4**	PWR		**GPHY 4, 3.3 V Voltage Domain Supply** This is the PHY 4 AFE 3.3 V supply.
P7	**VDDA3V3_5**	PWR		**GPHY 5, 3.3 V Voltage Domain Supply** This is the PHY 5 AFE 3.3 V supply.
P9	**VDDA3V3_6**	PWR		**GPHY 6, 3.3 V Voltage Domain Supply** This is the PHY 6 AFE 3.3 V supply.
P11	**VDDA3V3_7**	PWR		**GPHY 7, 3.3 V Voltage Domain Supply** This is the PHY 7 AFE 3.3 V supply.
D7, D8	**VDDA1V8_0**	PWR		**GPHY 0, 1, 2, 3, 1.8 V Voltage Domain Supply** This is the 1.8 V supply for PHY 0 to PHY 3 AFE voltage domain. It supplies mixed signal blocks in the AFE.
N7, N8	**VDDA1V8_1**	PWR		**GPHY 4, 5, 6, 7, 1.8 V Voltage Domain Supply** This is the 1.8 V supply for PHY 4 to PHY 7 AFE voltage domain. It supplies mixed signal blocks in the AFE.
E6, E8, E11	**VDDA0V8_0**	PWR		**GPHY 0, 1, 2, 3, 0.85 V Voltage Domain Supply** This is the supply for PHY 0 to PHY 3 low voltage domain. It supplies mixed signal blocks in the AFE.
M6, M8, M11	**VDDA0V8_1**	PWR		**GPHY 4, 5, 6, 7, 0.85 V Voltage Domain Supply** This is the supply for PHY 4 to PHY 7 low voltage domain. It supplies mixed signal blocks in the AFE.
D3, E3, N3	**VDD3V3PAD0**	PWR		**Power Supply Digital Domain 3.3 V** 3.3 V Voltage Digital Power Supply
D12, N12	**VDD3V3PAD1**	PWR		**Power Supply Digital Domain 3.3 V** 3.3 V Voltage Digital Power Supply
H13	**VDDP_PAD**	PWR		**Power Supply Digital Domain 1.8V / 3.3 V** 3.3 V or 1.8 V Pad Voltage Digital Power Supply based on pin strapping.

Table 12 Power Supply Pins for GPHY (cont'd)

Ball No.	Name	Pin Type	Buffer Type	Function
F4, G4, F6, G6, F8, G8, F10, G10, H5, J5, H7, J7, H9, J9, K4, L4, K6, L6, K8, L8, K10, L10	**VDDD0V8_COR**	PWR		**Power Supply Digital Domain 0.85 V** 0.85 V Core Voltage Digital Power Supply
H11	**VDDA1V8PORXO**	PWR		**Power Supply Domain 1.8 V**
D9, D10	**VDDA1V2CDB0**	PWR		**Power Supply Domain 1.2 V**
N9, N10	**VDDA1V2CDB1**	PWR		**Power Supply Domain 1.2 V**
J11	**VDDA1V8_PLL**	PWR		**Power Supply Domain 1.8 V**
F12	**VDDD0V8REF**	PWR		**Power Supply Digital Domain 0.85 V**
G11	**VDDD0V8POST**	PWR		**Power Supply Digital Domain 0.85 V**
K12	**VDDA1V8_PVT**	PWR		**Power Supply Domain 1.8 V**
H12	**VCC1V8_OTP**	PWR		**Power Supply Domain 1.8 V**

2.2.3.10 Power Supply for USXGMII

Table 13 Power Supply Pins for USXGMII

Ball No.	Name	Pin Type	Buffer Type	Function
D13, D14	**VA0V8_0**	PWR		**USXGMII 0 - 0.85 V Analog Domain Supply**
E13	**VPHA1V8_0**	PWR		**USXGMII 0 - 1.8 V Domain Supply**
N13, N14	**VA0V8_1**	PWR		**USXGMII 1 - 0.85 V Analog Domain Supply**
M13	**VPHA1V8_1**	PWR		**USXGMII 1 - 1.8 V Domain Supply**

2.2.3.11 Power Supply for TPI (AFE)

Table 14 Power Supply Pins for TPI (AFE)

Ball No.	Name	Pin Type	Buffer Type	Function
A1, A16, C3, C4, C6, C8, C10, C12, C13, D1, D4, D5, D11, E2, E4, E5, E7, E9, E10	**TPVSSA_0**	GND		**Analog Ground**
M4, M5, M7, M9, M10, N1, N4, N5, N11, P3, P4, P6, P8, P10, P12, P13, T1, T16	**TPVSSA_1**	GND		**Analog Ground**

2.2.3.12 Ground

Table 15 Ground Pins

Ball No.	Name	Pin Type	Buffer Type	Function
E12, F5, G5, F7, G7, F9, G9, F11, G14, H4, J4, H6, J6, H8, J8, H10, J10, J12, K5, L5, K7, L7, K9, L9, K11, L11, L13, L16, M3, M12	**VSSD**	GND		**Digital Ground**
C14, C15, D16, E14, M14, N16, P14, P15	**UVSS**	GND		**USXGMII Ground**
F15, F16, G12	**VSS_XO**	GND		**XO Device Ground** XO ground

3 Functional Description

3.1 Power Supply, Clock, and Reset

This section provides the information required to power up the MxL86289I.

3.1.1 Power Supply

These four power supply rails are required: 3.3 V, 0.85 V, 1.8 V, and 1.2 V. **Section 7.7.1** contains the power-up sequence.

3.1.2 Clock

An internal PLL circuit generates the required internal clocks, based on an external reference clock.

The available options are:

- An external 25 MHz crystal connected to the MxL86289I. **Section 7.7.9** documents the required crystal specification.
- 25 MHz direct from an external oscillator
- An external CML/LVPECL reference clock operating at 50 MHz
- An external LVPECL reference clock operating at 156.25 MHz

3.1.3 Reset Generation

The external hardware reset input (HRSTN pin) resets all the hardware modules including the pin strapping information during boot:

- Driving the HRSTN pin low causes an asynchronous reset of the MxL86289I system.
- Releasing the HRSTN pin high triggers the power-on sequence.

The HRSTN pin is internally connected to a weak internal pull-up resistor.

3.1.4 Power-On Sequence

The MxL86289I powers on when the power is applied and the HRSTN pin is high. See **Figure 18**.

The steps executed at power on are:

1. Lock the internal PLL.
2. Read the pin strap information, see **Section 3.1.5** for more information.
3. Boot the microprocessor from the internal ROM.
4. In flashless mode, wait for the firmware to download into on-chip memory.
5. Authenticate the firmware image in the flash memory device or on-chip memory.
6. Auto-negotiate the link speeds for the Ethernet TPI and USXGMII interfaces.
7. Train and link up each interface in accordance with the IEEE 802.3 **[2]** standards.

3.1.5 Configuration by Pin Strapping

The MxL86289I is configurable by means of pin strapping on a number of the GPIO pins. The pin strapping configurations are captured during the chip power-on sequence until the reset initialization is complete.

The pin strap values are set to logical high or low by connecting the corresponding pin via an external 1 kΩ resistor to either ground or the pin supply voltage.

Table 16 and **Table 17** describe the pin strap mapping.

Table 16 Pin Names Used for Pin Strapping

Ball Name	Ball Number	Configuration Item Description
GPC1	G13	PS_PHY_MADDR(4)
GPC2	F14	PS_PHY_MADDR(3)
GPC3	J13	PS_CLK_SEL
GPIO1	H3	PS_CLK_SEL1
GPIO2	J3	PS_RJ45_TAB
MDINT	L14	PS_MDINT_POLARITY
GPIO3	K3	PS_MDIO_VOLTAGE
GPC0	F13	PS_SUPER_ISOLATE
QSPI_CS	H16	PS_FLASHLESS

Table 17 Pin Strapping Configuration Description

Pin Strapping Signals	Description
PS_PHY_MADDR(4:3)	**MDIO PHY Address** Specifies the most significant two bits of the MDIO address. The lowest three bits are hard-coded to 0, 1, 2, 3, 4, 5, 6, and 7 for each BASE-T port of the MxL86289I.
PS_MDINT_POLARITY	**MDIO Interrupt Polarity** Specifies the polarity of the MDIO interrupt. 0_B **HIGH** MDIO interrupt is active high. 1_B **LOW** MDIO interrupt is active low.
PS_RJ45_TAB	**RJ45 Tab Configuration** Specifies the tab-up or tab-down configuration of the RJ45. Each BASE-T port has the same configuration. 1_B **DOWN** Tab-down 0_B **UP** Tab-up
PS_MDIO_VOLTAGE	**MDIO Voltage** Specifies whether the maximum voltage level used by the MDIO signals is 3.3 V or 1.8 V. 0_H **LOW** MDIO_S, MDC_S, MDINT, and GPIO0 signal pins are supplied with 1.8 V. In this configuration, V_{DDP} must be supplied with 1.8 V. 1_H **NORMAL** MDIO_S, MDC_S, MDINT, and GPIO0 signal pins are supplied with 3.3 V. In this configuration, V_{DDP} must be supplied with 3.3 V.

Table 17 Pin Strapping Configuration Description (cont'd)

Pin Strapping Signals	Description
PS_CLK_SEL PS_CLK_SEL1	**Input Clock Selection** Specifies the input clock frequency used. MSB is PS_CLK_SEL1. LSB is PS_CLK_SEL. 11_B **25** 25 MHz 10_B **50** 50 MHz 01_B **156** 156.25 MHz 00_B **RES** Reserved
PS_SUPER_ISOLATE	**Super Isolate** Specifies whether the PHY is immediately active after a reset or is halted until it is manually activated. 0_H **HALT** The PHYs are inactive after reset. 1_H **NORMAL** The PHYs are active after reset.
PS_FLASHLESS	**Flashless** Specifies whether the device operates with or without an external flash memory device. 0_H **FLASHLESS** A flash memory device is not attached. 1_H **NORMAL** A flash memory device is attached.

Alternative ways to configure the MxL86289I after the boot process are to use the MDIO interface **[1]** and write into various control registers, as detailed in **Section 3.3**, or to use the FCA **[1]**.

3.2 MDIO Slave Interface

The SMDIO module and the Ethernet PHY (GPHY) port 0 to 7 are directly attached to the MDIO slave interface as shown in the **Figure 4**. Each GPHY port supports both IEEE 802.3 clause 22 and clause 45 protocol. It allows direct access to the PHY using the correct MDIO PHY address. The MDIO address used for this access is configurable through pin-strapping, as described in **Section 3.1.5**.

The SMDIO module provides access to the external flash memory device via the QSPI interface and the internal SRAM. The MxL86289I supports downloading of firmware to the flash memory device or the internal SRAM via the SMDIO module attached to the MDIO bus. In the flash mode, whereby the firmware is downloaded to the external flash memory device, the MDIO address used for this access is the same MDIO address as GPHY port 0 defined by the pin strapping. In the flashless mode, whereby the firmware is downloaded to the internal SRAM, the MDIO address used for this access is $1F_H$. The MxL86289I user guide **[1]** describing the driver software executed on the external processor must be followed to execute this feature. The SMDIO module supports only IEEE 802.3 clause 22 protocol.

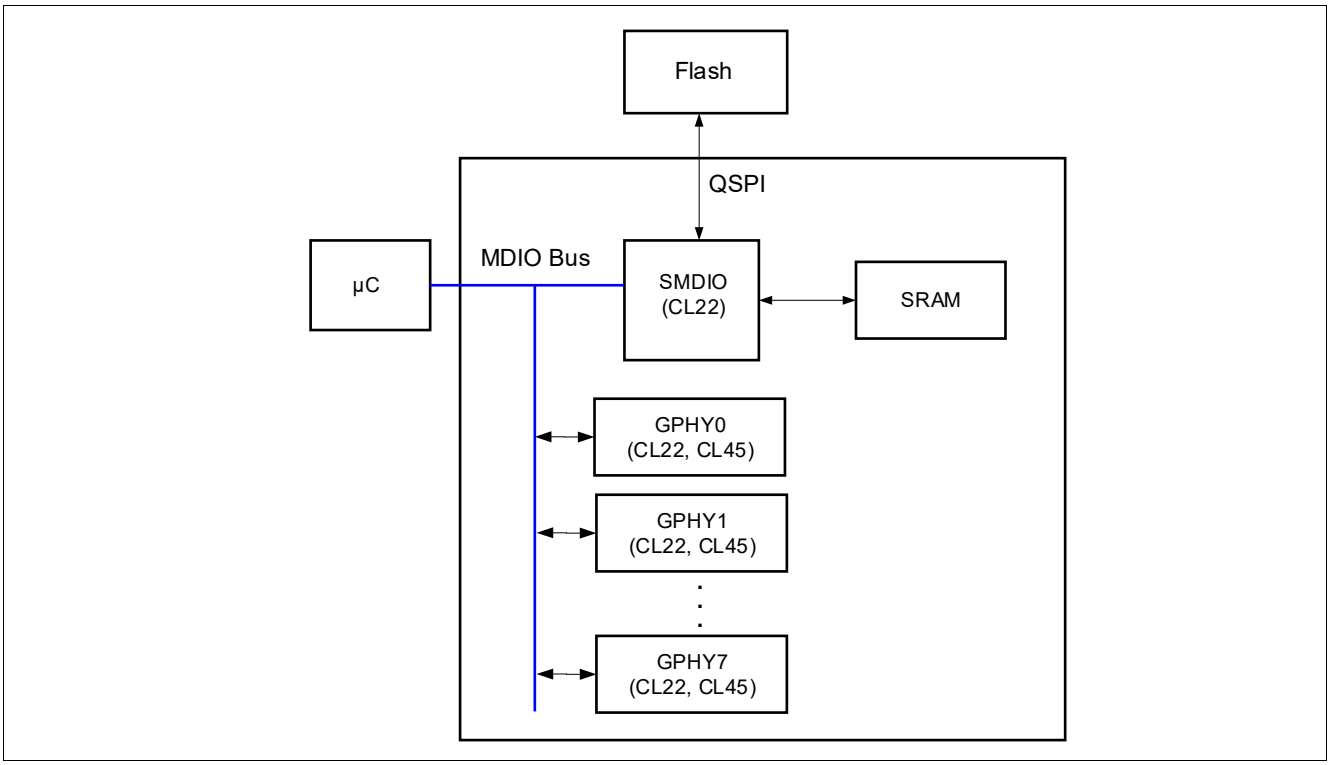


Figure 4 MDIO Slave

When other devices in the system need to be configured through MDIO, they must be connected to the MDIO slave interface and configured such that no addressing conflict arises.

The standard MDIO protocol requires a 32-bit preamble at the beginning of each read or write access. To speed up the data exchange, reduce the preamble down to 1 bit for the second and subsequent accesses.

The standard MDIO protocol uses a clock rate of 2.5 MHz on MDC. To speed up the data exchange, increase the clock applied on MDC_S to the maximum 25 MHz. **Section 7.7.4** contains more details on AC characteristics.

3.3 Configuration via MDIO Management Interface

It is possible to connect an external controller's STA to the chip's slave MDIO interface. This allows access to the MDIO and MMD registers standardized in IEEE 802.3, enabling the STA to control the chip configuration and retrieve status information. The MDIO transactions are any of the three types described in IEEE 802.3 Clause 22, Clause 22 Extended, and Clause 45 [2].

Figure 5 and Table 18 show the minimum time required for the MDIO to be available for access.

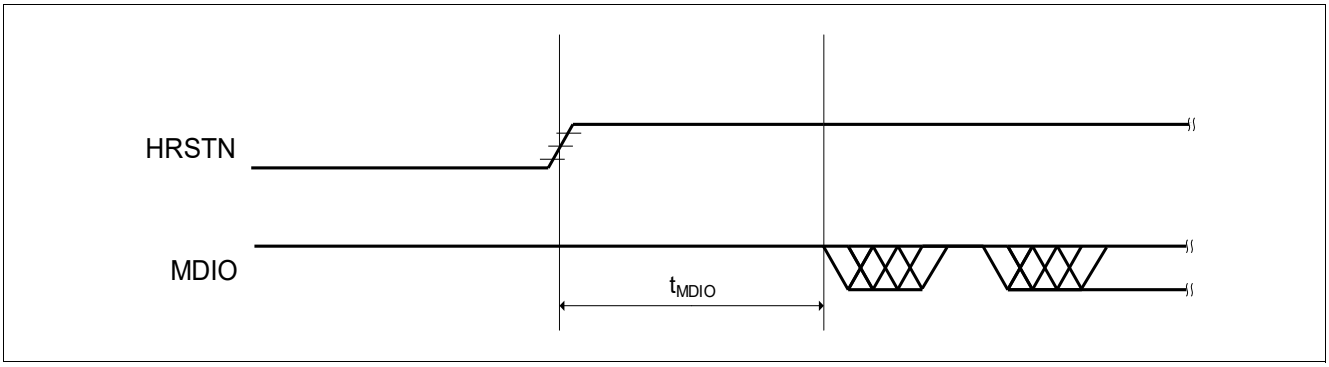


Figure 5 MDIO Access Timing

Table 18 MDIO Ready Timing

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
MDIO Ready Time with Flash Device Attached	T_{MDIO}	750	–	–	ms	**Flash Memory Mode** This is the minimum amount of time the MDIO interface is unavailable while the MxL86289I boots and the firmware is downloaded from an external flash device using the QSPI interface.
MDIO Ready Time without Flash Device Attached	T_{MDIO}	50	–	–	ms	**Flashless Mode** This is the minimum amount of time the MDIO interface requires before a firmware download can be initiated from a host MAC SoC using the MDIO interface. MDIO and MMD register access is only available after the firmware download has completed and successfully authenticated.

3.4 I²C Master Interface

The MxL86289I has one chip-integrated I²C master controller. The Inter-IC (I²C) Bus was developed by Philips Semiconductors (now NXP Semiconductors). This specification is compliant with **[9]**.

The I²C is a simple, bi-directional half-duplex bus with data transfers of up to 100 Kbps in standard mode, up to 400 Kbps in fast mode, up to 1000 Kbps in fast mode plus, and up to 3.4 Mbps in high-speed (hs) mode.

I²C provides a protocol allowing devices to communicate directly with each other via two wires. One line is responsible for the clock synchronization (SCL), the other is responsible for the data transfer (SDA). The number of devices connected to the I²C bus is limited only by a maximum bus capacity of 400 pF. Each device is recognized by a unique address.

The two bi-directional bus lines, a Serial Data (SDA) line and a Serial Clock (SCL) line, are connected to a positive supply voltage via pull-up resistors. The output stages of devices must have an open drain to perform the required wired-AND function. One line is pulled low when one of the open-drain transistors is selected. Otherwise, no signal is asserted to the line. The external pull-up resistors lift the level to HIGH.

The I²C specification defines a master/slave relationship where each device works either as a transmitter or a receiver depending on the device function. This functionality is set in the initialization procedure of each module.

Features

- One I²C controller
- Master-mode supported
- Compatible to the I²C specification version 6.0, April 2014[1)]
- Data transfer in standard- (0 to 100 kBaud), fast- (0 to 400 kBaud), fast mode plus (0 to 1 Mbps) and high-speed mode (0 to 3.4 Mbps)

1) For deviations of timing values compared to the Philips Semiconductors (now NXP Semiconductors*) specifications, see **Chapter 7 Electrical Characteristics**.

3.5 Quad Serial Peripheral Interface

A Quad Serial Peripheral Interface (QSPI) is equipped to provide access to external Quad-SPI flash memory devices. The MxL86289I requires an external Quad-SPI flash memory to operate in flash mode. Flashless mode allows the firmware to be downloaded via the slave MDIO. The mode is selectable by pin strapping.

Use of an additional QSPI flash memory device depends upon the device operation mode:

- In flash mode, the firmware for the MxL86289I is stored in an external QSPI flash memory device and transferred over the QSPI interface. In flash mode, an external QSPI flash memory device is required.
- In flashless mode, the firmware for the MxL86289I is stored on a host SoC and transferred over the slave MDIO interface. In flashless mode, an external QPSI flash memory device is not required.

The QSPI supports:

- Up to 101.5625 MHz for single/double data rate
- eXecution In Place (XIP), fully memory mapped access for CPU
- Addressing up to 512 MB range

3.5.1 Supported Flash Memory Devices

Table 19 lists the qualified flash memory devices. However, it is possible for the user to select a device not present in the list after consideration of command compatibility and timing compatibility as listed in Table 20. The flash memory device must support 101.5625 MHz single data rate.

Table 19 Supported Flash Memory Devices

Vendor	Model
Macronix	MX25L6433F
Winbond	W25Q64JV-DTR

Table 20 Flash Command and Timing

Instruction	Abbreviation	Command	Command Cycles	Address Cycles	Dummy Cycles	Data Cycles
Write Enable	WREN	06_H	8	0	0	0
Write Disable	WRDI	04_H	8	0	0	0
Read ID	RDID	$9F_H$	8	0	0	24
Read Status Register	RDSR	05_H	8	0	0	8
Write Status Register	WRSR	01_H	8	0	0	8
Read Configuration Register	RDCR	15_H	8	0	0	8
Read Data Bytes	READ	03_H	8	24	0	8
Fast Read	FREAD	$0B_H$	8	24	8	8
Quad Read	4READ	EB_H	8	6	10	2
XIP	XIP	EB_H	8	6	10	2 x n[1)]
Chip Erase	CE	$C7_H$	8	0	0	0
Block Erase	BE	$D8_H$	8	24	0	0
Sector Erase	SE	20_H	8	24	0	0
Page Program	PP	02_H	8	24	0	8 x n[1)]
Reset Enable	RSTEN	66_H	8	0	0	0
Reset	RST	99_H	8	0	0	0

1) n is the number of bytes

3.6 GPIO Mapping

Other than the GPIO functionality, the GPIO pins are also shared with other alternative functions. The GPIO pins are configurable to alternative functions, which are based on the pinmux settings as shown in **Table 21**.

Table 21 GPIO Mapping

Pinmux Mode 0 (Default)	Pinmux Mode 1	Pinmux Mode 2	Pinmux Mode 3
GPIO0	GPIO0	EXTINT0	—
GPIO1	GPIO1	EXTINT1	—
GPIO2	GPIO2	—	—
GPIO3	GPIO3	—	—
MDINT	GPIO4	—	—
MDC_S	GPIO5	—	—
MDIO_S	GPIO6	—	—
QSPI_D0	GPIO9	—	—
QSPI_D1	GPIO10	—	—
QSPI_D2	GPIO11	—	—
QSPI_D3	GPIO12	—	—
QSPI_CLK	GPIO13	—	—
QSPI_CS	GPIO14	—	—
QSPI_RST	GPIO15	—	—
I2C_SCL_0	GPIO16	—	—
I2C_SDA_0	GPIO17	—	—
PHYLED1_0	GPIO20	—	FW_UTXD
PHYLED2_0	GPIO21	—	FW_URXD
PHYLED1_1	GPIO23	—	—
PHYLED2_1	GPIO24	—	—
PHYLED1_2	GPIO26	—	TDI
PHYLED2_2	GPIO27	—	TMS
PHYLED1_3	GPIO29	—	TCK
PHYLED2_3	GPIO30	—	TDO
PHYLED1_4	GPIO32	—	—
PHYLED2_4	GPIO33	—	—
PHYLED1_5	GPIO35	—	—
PHYLED2_5	GPIO36	—	—
PHYLED1_6	GPIO38	—	—
PHYLED2_6	GPIO39	—	—
PHYLED1_7	GPIO41	—	—
PHYLED2_7	GPIO42	—	—
GPC0	GPIO44	—	—
GPC1	GPIO45	—	—

Table 21 GPIO Mapping (cont'd)

Pinmux Mode 0 (Default)	Pinmux Mode 1	Pinmux Mode 2	Pinmux Mode 3
GPC2	GPIO46	—	—
GPC3	GPIO47	—	—

3.7 Ethernet PHY Interface

The Ethernet PHY implements the physical layer of the Ethernet standard. It supports Digital Signal Processing (DSP) and Analog Signal Processing (ASP) functions in transmitting data over the twisted pair cable.

3.7.1 Twisted Pair Interface

The Twisted Pair Interface (TPI) of the MxL86289I is fully compliant with IEEE 802.3. The MxL86289I integrates series resistors required to terminate the TPI links with a 100 Ω nominal impedance to facilitate a low-power implementation and reduce PCB costs. As a consequence, it is possible to connect the TPI pins directly via a transformer to the RJ45 connector. Additional external circuitry is required for common-mode termination and rejection as described in **Section 7.8.1**.

Figure 6 shows a schematic of the TPI circuitry taking these components into account.

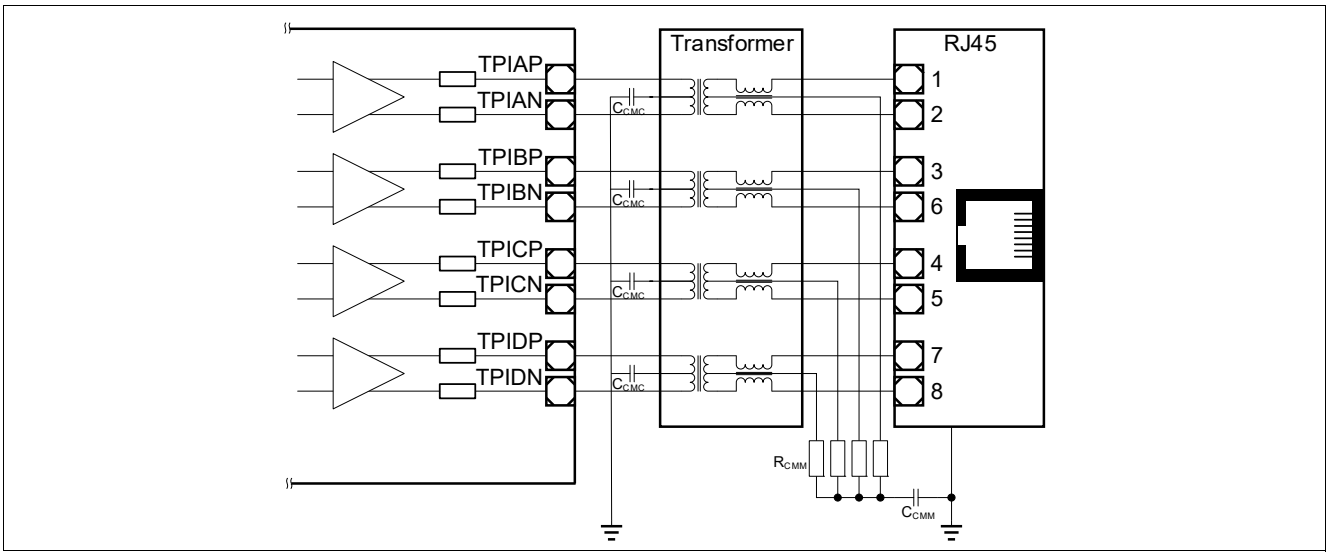


Figure 6 Twisted-Pair Interface of MxL86289I Including Transformer and RJ45 Plug

3.7.2 Transformerless Ethernet

Transformerless Ethernet (TLE) is required for backplane applications where the use of a transformer is not always required to fulfill the galvanic decoupling requirements of the isolation specifications. In such applications, removing the transformer reduces both the external bill of material and the space requirements on the PCB.
As the MxL86289I incorporates a voltage-mode line driver, the only stringent requirement is to use AC coupling, which is achievable using simple SMD type series capacitors. The value of the capacitors is selected such that the high-pass characteristics correspond to an equivalent standard transformer based application. The recommended value is $C_{coupling}$ = 100 nF. **Figure 7** shows the external circuitry for TLE.

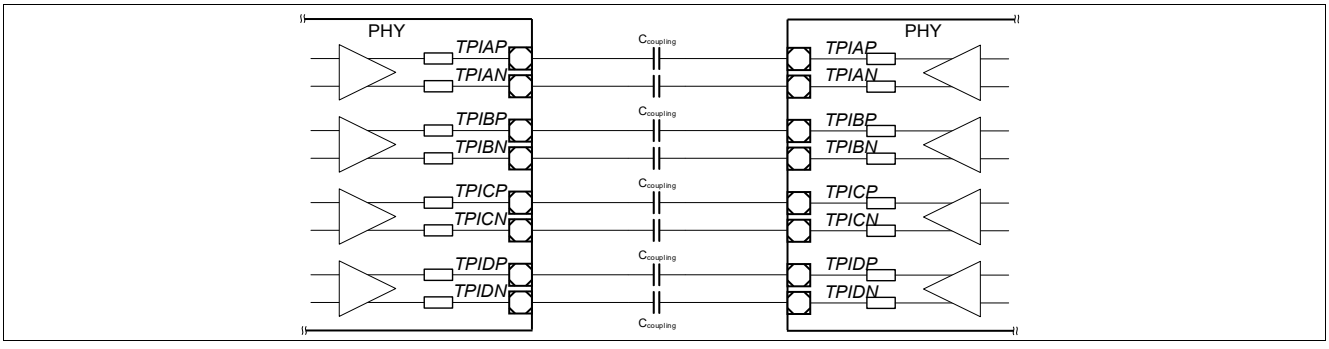


Figure 7 External Circuitry for the Transformerless Ethernet Application

3.7.3 Auto-Negotiation

The MxL86289I supports auto-negotiation (ANEG) as part of the startup procedure to exchange capability information with the link partner. ANEG is enabled at the MxL86289I initialization and its 2.5 Gbps speed capability is advertised. The ANEG procedure is executed according to IEEE 802.3 Clause 28, Clause 40, and IEEE 802.3 Clause 126 [2]. When the link partner does not support ANEG, the MxL86289I determines the link speed configuration using parallel detection as described in Clause 28.

With MDIO commands, it is possible to disable ANEG and change the advertised link rates. The STA is also able to disable ANEG. In this situation, the system configuration must ensure compatibility between link partners to allow link up in a compatible mode.

Attention: STD_CTRL.DPLX only takes effect when the ANEG process is disabled and the GPHY TPI is not operating in loopback mode, that is, bits STD_CTRL.ANEN and STD_CTRL.LB are set to zero. Forced half-duplex mode (STD_CTRL.DPLX = 0b0) is only supported in 10BASE-T and 100BASE-TX speed modes.
This field is ignored for higher speeds. This field is also ignored for transparent mode because half-duplex is not supported in this mode.

3.7.4 Auto-Downspeed

The auto-downspeed (ADS) feature implements a process to renegotiate the link with a lower speed when the link quality is insufficient. The feature ensures maximum interoperability even in harsh, or inadequate, cable infrastructure environments. In particular, ADS is applied during the 2.5GBASE-T/1000BASE-T training phase. ADS is also required when the quality or characteristics of the cable in use cannot support the advertised speed.

For example, it is possible to advertise 2.5GBASE-T/1000BASE-T during ANEG when both link partners are connected via a cable that does not support the 4-pair Gigabit Ethernet mode. The MxL86289I detects such a configuration to avoid repeating link up failures and clears the 2.5GBASE-T/1000BASE-T capability in the ANEG advertisement registers. After the resulting link down, the next ANEG procedure no longer advertises 1000BASE-T/2.5GBASE-T. The next link up is done at the next advertised speed below 1000 Mbps.

The MxL86289I also executes an ADS procedure when the signal quality is not suited to a 1000BASE-T/2.5GBASE-T link up due to increased alien noise or a loop length that significantly exceeds the standard specification.

When the MxL86289I is configured not to advertise a speed capability below 1000 Mbps, the ADS feature is automatically disabled.

3.7.5 Polarity Reversal Correction

For each of the 4 pairs, the MxL86289I automatically detects and corrects any inversion of the signal polarity on the P and N signals. The detection is done during the auto-negotiation phase. The detected polarity is frozen when the link is established, and remains unchanged until the link is dropped.

The polarity corrections applied are indicated in the register: `PMA_MGBT_POLARITY` (register 1.130); and are valid after auto-negotiation is complete.

3.7.6 Auto-Crossover Correction

To maximize interoperability, even in inadequate wiring environments, the MxL86289I automatically performs cable crossover (MDI-X) correction. **Table 22** lists the supported pair-mappings detectable and correctable by the device.

The MxL86289I automatically detects and corrects crossed cable configuration, where the transmit-receive pairing between partners does not match. The auto-crossover function is fully compliant with IEEE 802.3, Clause 40.4.4 [2], in 1000BASE-T and 2.5GBASE-T mode.

The corrections applied are indicated in the register: PMA_MGBT_POLARITY (register 1.130) and are valid when auto-negotiation is complete.

Table 22 Supported Twisted Pair Mappings on a Cat 5 or Better Cable

Crossover Modes on RJ45[1)]		RJ45 Pinning							
Mode	**Description**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
11	Straight cable, standard compliant	TPIAP **(A+)**	TPIAN **(A-)**	TPIBP **(B+)**	TPICP **(C+)**	TPICN **(C-)**	TPIBN **(B-)**	TPIDP **(D+)**	TPIDN **(D-)**
00	Full Gigabit Ethernet MDI-X This is standard-compliant MDI-X with pair A/B swapped and pair C/D swapped.	TPIBP **(B+)**	TPIBN **(B-)**	TPIAP **(A+)**	TPIDP **(D+)**	TPIDN **(D-)**	TPIAN **(A-)**	TPICP **(C+)**	TPICN **(C-)**

1) This pin assignment is according to TIA/EIA-568-A/B.

3.7.7 RJ45 Tab Up or Tab Down Configuration

Figure 8 shows that the RJ45 plug on the system PCB is solderable with the tab either up or down.

The difference between tab up and tab down is a swap in position between A and D, and a swap in position between B and C. The pin strap PS_RJ45_TAB allows the system designer to perform this configuration. As a result, a PCB layout does not need to be modified when a RJ45 tab up or down socket needs to be mounted. The single pin strap is applicable to all ports, which are either all tab down or all tab up.

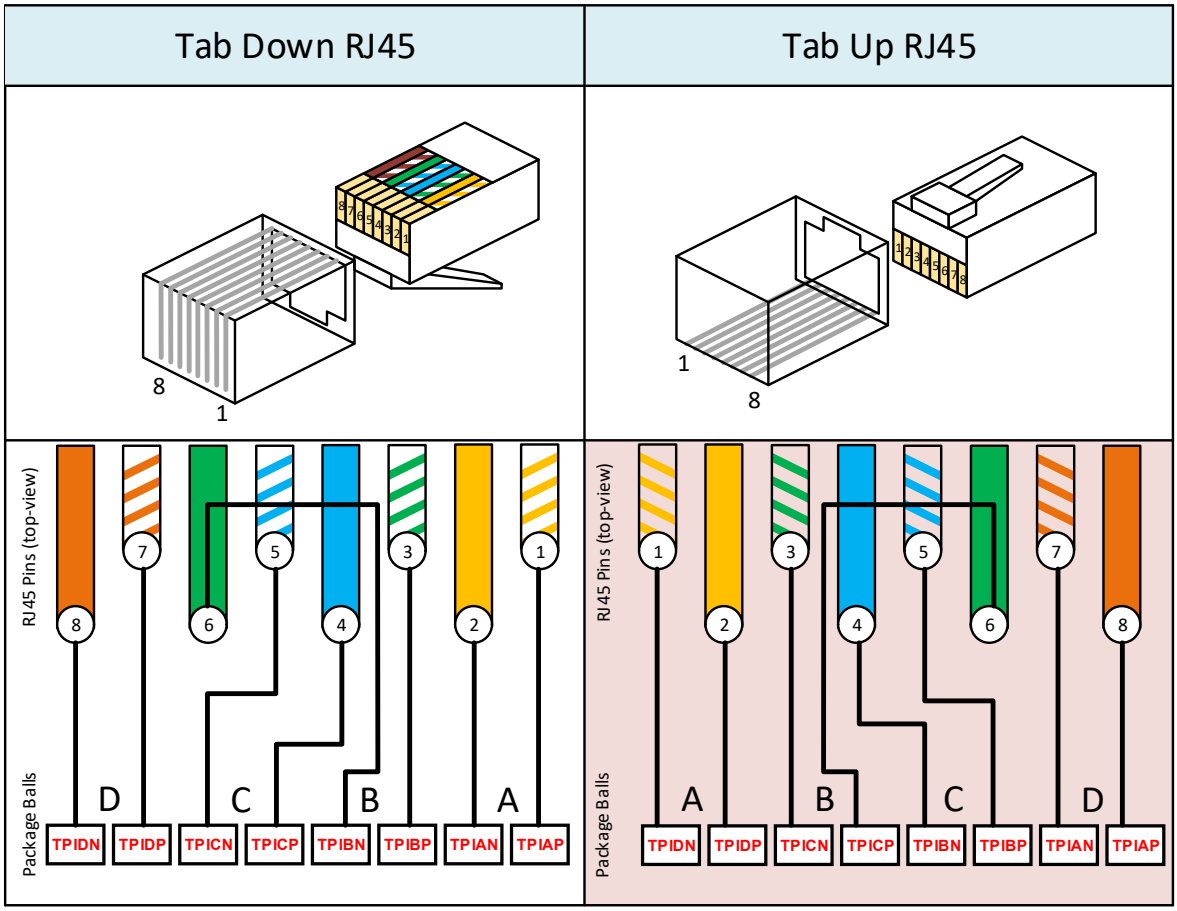


Figure 8 RJ45 Tab Up or Tab Down Configuration

3.7.8 Wake-on-LAN

The MxL86289I supports WoL. The MxL86289I generates an interrupt to an external controller when it detects special WoL Ethernet packets. This allows the controller to enter sleep mode when there is no Ethernet traffic to process, and be woken up when traffic starts. WoL packets are detected at all link speeds. **Figure 9** shows the scenario when connected to an external device.

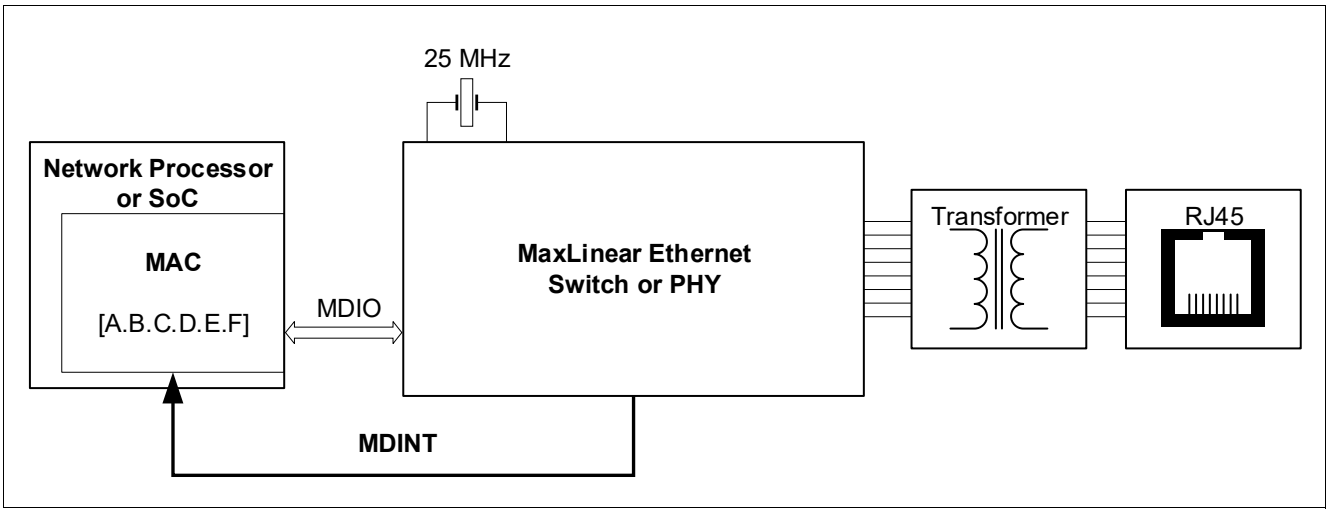


Figure 9 WoL Application Block Diagram

The most commonly used WoL packet is called a magic packet, which contains the MAC address of the device to be woken up, and an optional password called SecureON. The MAC address and the optional SecureON password relevant for the WoL logic inside the MxL86289I are configurable in the WoL MDIO registers in the Vendor Specific 2, VSPEC2 MMD, device described in **Chapter 4**. When such a configured magic packet is received, an MDINT interrupt is issued.

Table 23 gives an example programming sequence for these configuration registers.

Table 23 Programming Sequence for the Wake-on-LAN Functionality

Step	Register Access	Remark
1	`MDIO.MMD.WOLAD01` = $EEFF_H$	Programs the fifth and sixth MAC address bytes.
2	`MDIO.MMD.WOLAD23` = $CCDD_H$	Programs the third and fourth MAC address bytes.
3	`MDIO.MMD.WOLAD45` = $AABB_H$	Programs the first and second MAC address bytes.
4	`MDIO.MMD.WOLPW01` = 4455_H	Programs the fifth and sixth SecureON password bytes.
5	`MDIO.MMD.WOLPW23` = 2233_H	Programs the third and fourth SecureON password bytes.
6	`MDIO.MMD.WOLPW45` = 0011_H	Programs the first and second SecureON password bytes.
7	`MDIO.PHY.IMASK.WOL` = 1_B	Enables the wake-on-LAN interrupt mask.
8	`MDIO.MMD.WOLCTRL.WOL.EN` = 1_B	Enables wake-on-LAN functionality.

3.8 Ethernet SerDes Interface

The MxL86289I implements two Ethernet serial data interfaces. **Table 24** lists the data rates supported by the USXGMII interface.

The external PHY is able to initiate clause 37 auto-negotiation to change speed and new link up. In USXGMII mode, the interface supports the Packet Control Header (PCH) over preamble to transport control or timestamp indications between the MAC and the PHY.

Table 24 Ethernet SerDes Interface Feature List

Modes	Baudrate	Coding	Link Speed	IEEE Clause	Auto-Negotiation Clause
10G-QXGMII	10.3125 GT/s	64b/66b	2.5 Gbps, 1 Gbps, 100 Mbps, and 10 Mbps	49	37

3.8.1 Ethernet SerDes Interface Configuration at Power On

The MxL86289I USXGMII interface is configured to operate automatically after reset. It is not necessary for the STA to change the VSPEC1_PM_CTRL.USXGMII_REACH register to operate in this default mode.

These are the steps in the default process:

1. USXGMII auto-negotiation is enabled by default.
2. The TPI configuration after link up defines the corresponding USXGMII PHY-side port configuration. The MAC-side SoC must configure its USXGMII MAC-side interface to match the MxL86289I PHY-side configuration.
3. The MxL86289I API describes the procedure to update the Rx/Tx equalization parameters. The MxL86289I automatically updates the Rx/Tx equalization parameters for standard trace lengths based on the trace length programmed in VSPEC1_PM.USXGMII_REACH. For custom trace lengths, the Rx/Tx equalization parameters are configured using the API. Contact MaxLinear for access to the API documentation.

3.9 LED Interface

This section describes the LED interface.

3.9.1 LED

The MxL86289I allows 16 synchronized LEDs to be used for visual status indication. Each LED pin drives either a single color LED or dual color LED.

3.9.2 LED Configuration

The MxL86289I API describing the driver software executed on the Host SoC must be followed to configure this interface.

Figure 10 shows the external LED connected to either ground or the power rail in single color mode.

Figure 11 and **Figure 12** show the connection of single and dual color LEDs when the pin is also used for pin strapping.

Note: These figures do not show the full recommended circuits with all the necessary components. Refer to the relevant HDK/EVK PCB design documentation for more details.

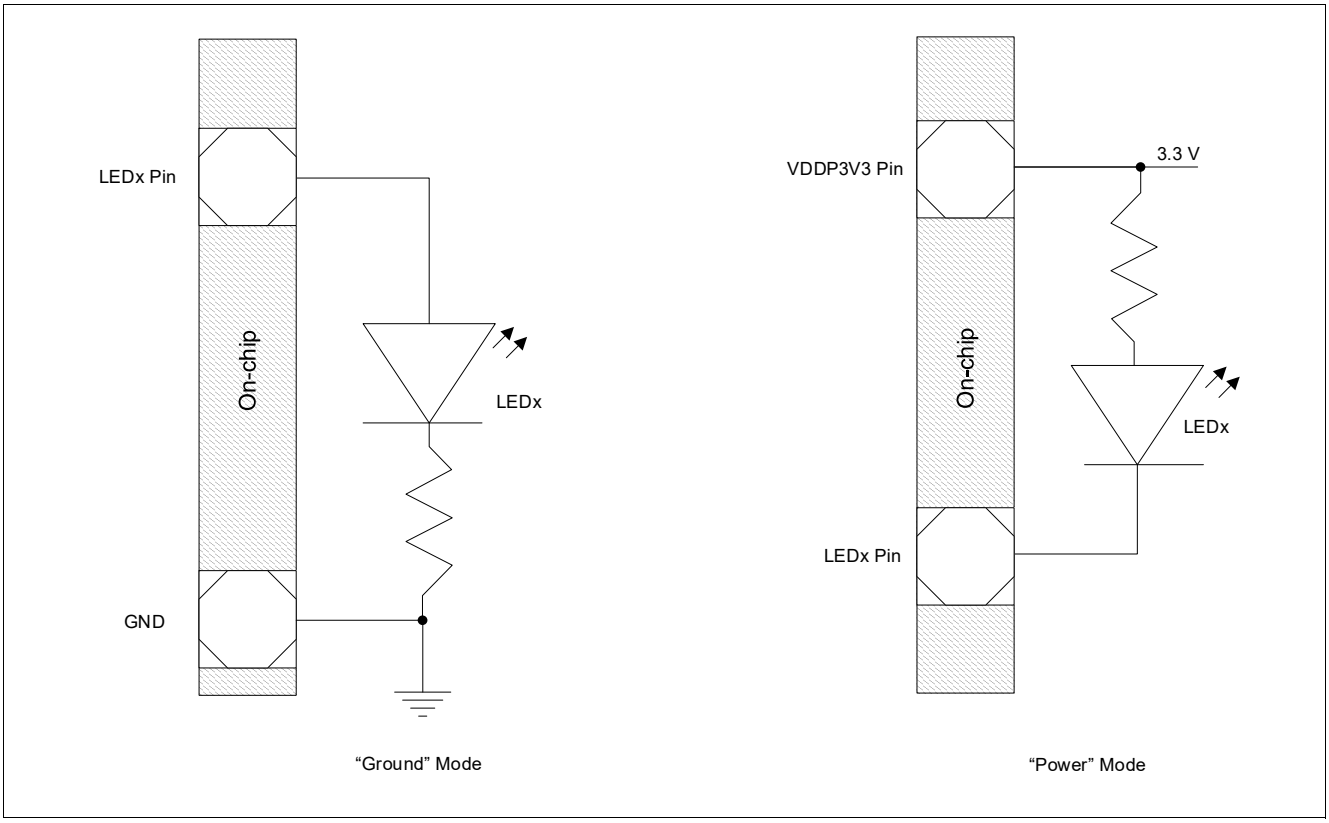


Figure 10 LED Connection Options to Ground or Power Supply

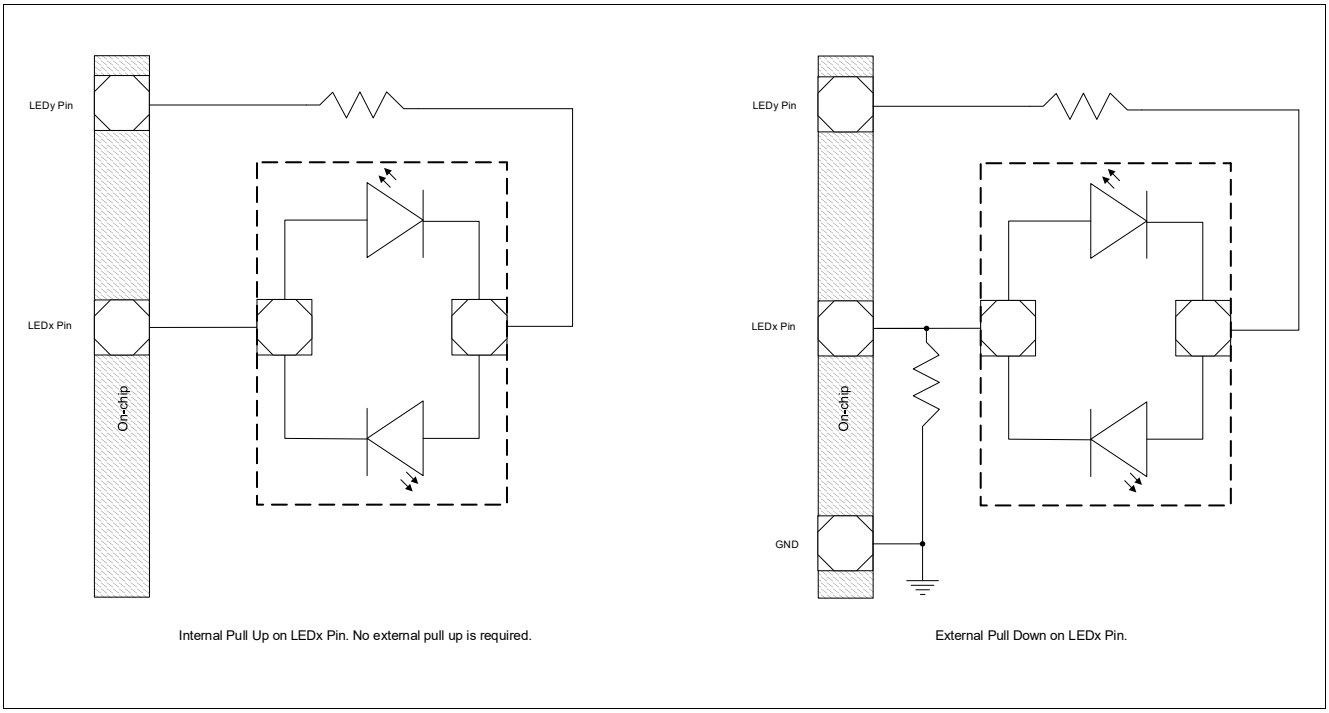


Figure 11 Connection of a Dual Color LED and Configuring Pin Strap Value

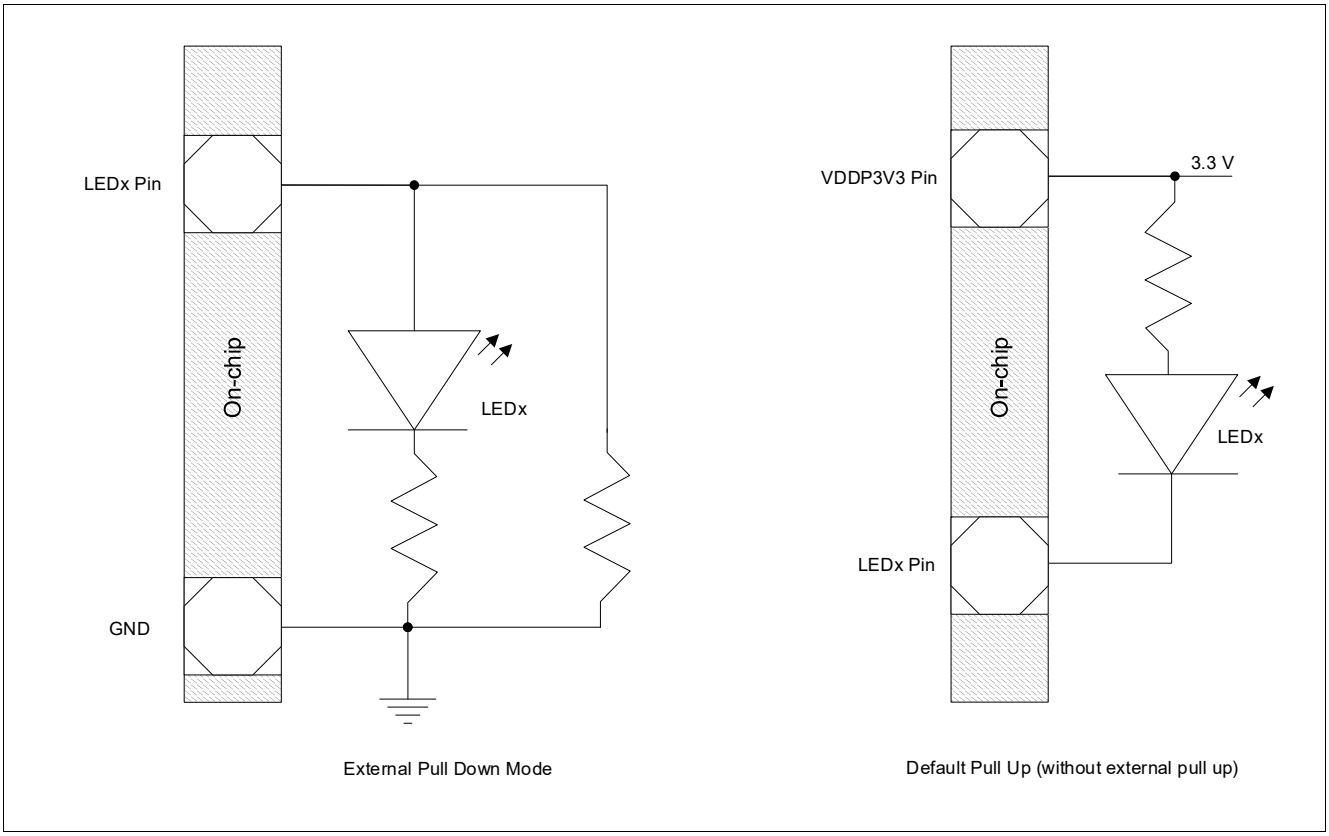


Figure 12 Connection of a Single Color LED and Configuring Pin Strap Value

3.9.3 LED Brightness Control

There are two LED brightness modes configurable by the API, based on the system requirement.

- LED Brightness Level Maximum Mode
  Fixed level signal (no pulses) for maximum brightness, also available as a control signal for other purposes.
- LED Brightness Level Control Mode (Constant Mode)
  Allows the configuration of 16 levels of LED brightness. See **Brightness Control**.

Brightness Control

This block controls the brightness of the LED by controlling the time duration for which the LED is on/off. The persistence characteristic of the eye causes it to perceive this as LED brightness. When LED is off, the output is disabled. When the LED is on, the output is enabled. The brightness control affects the LED output enable directly.

Figure 13 shows the brightness control frequency is 81.25 Hz, where each period is divided into 64 slots.

In the LED brightness level maximum mode, the LED is enabled in all 64 slots, as shown in brightness level 0 which is the maximum brightness.

In the LED brightness level control mode, the LED is enabled for n consecutive slots, where n is determined by the configured brightness level. **Figure 13** shows the brightness level in active low mode, whereby brightness level 15 is the minimum brightness.

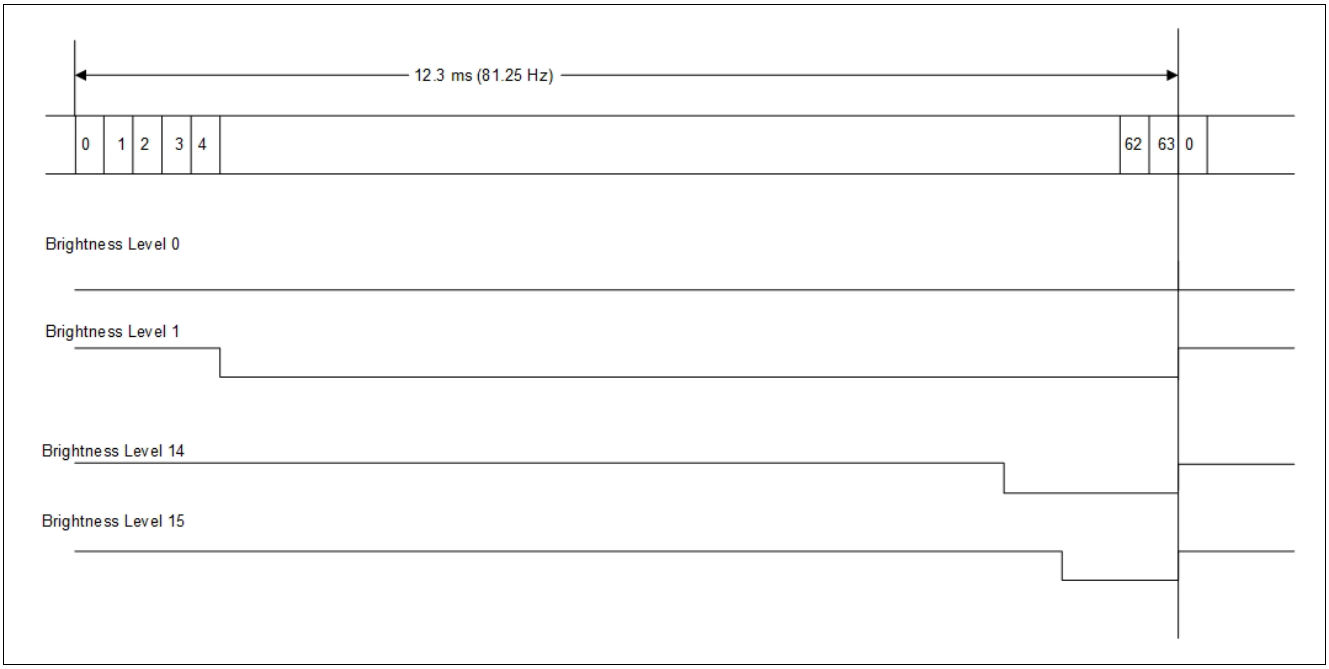


Figure 13 LED Brightness Control by Controlling LED Output Enable/Disable

3.10 Precision Time Protocol

The MxL86289I provides support for the Precision Time Protocol (PTP) feature, which is used to precisely synchronize clocks at the system level. PTP is used to synchronize the time of day (ToD) of slave clocks to a master clock over Ethernet networks. It is standardized in IEEE 1588-2002, and in IEEE 1588-2008 as a second revision (1588v2). The MxL86289I has built-in hardware support to provide high precision and easy to use PTP clock synchronization.

The MxL86289I supports PTP with these features:

- Implementation of a 64-bit counter, which counts with a granularity of 2 ns.
- Two 16 entry deep FIFOs with overflow and underflow support, one FIFO to store the timestamps and CRCs of outgoing packets, and one FIFO to store the timestamps and CRCs of incoming packets.
- Timestamps are captured with high precision in transmitted and received PTP packets when the start of frame delimiter of a packet is detected.
- Timestamps can be triggered by the edge of an input signal to allow synchronous latching of the timestamp of the on-chip counter, and the counter of an external master or slave clock to calculate counter differences. It is possible to select GPC0, GPC1, GPC2, or GPC3 as the input for the trigger signal.
- A recurring pulse signal can be generated either at the GPC0, GPC1, GPC2, or GPC3. The signal can be a Pulse Per Second (PPS) signal or a signal with another configurable frequency.
- **2-step Time Stamping**
  This scheme uses a Follow_Up message to carry the time stamp of the corresponding sync message. The time stamp is not inserted in the sync message on the fly while the packet is being transmitted, but later in the next PTP message. This scheme allows the MxL86289I to perform hardware-assisted precise time stamping capture, using the PHY layer to precisely indicate when the packet Start-of-Frame Delimiter (SFD) symbol is sent out or received on the physical layer. The time stamp, together with the corresponding packet CRC, is stored in a memory area on the MxL86289I.
- **1-step Time Stamping**
  This scheme is used to reduce the number of PTP messages. In this scheme, the MxL86289I MAC inserts the time stamp in the sync message on the fly when it passes through the MxL86289I MAC layer. The MxL86289I inserts the time stamp in the PTP sync message on the fly.

Attention: 1-step Time Stamping is not supported in transparent mode

3.10.1 PTP Configuration

The MxL86289I API describing the driver software executed on the external processor SoC must be followed to configure this feature.

3.11 Pulse Per Second

The MxL86289I provides support for Pulse Per Second (PPS) signal generation, which is used at the PCB level to synchronize various devices. The general purpose clock pins GPC0, GPC1, GPC2, or GPC3 are configured for this purpose.

3.11.1 PPS Configuration

The MxL86289I API describing the driver software executed on the external processor SoC must be followed to configure this feature.

3.12 Synchronous Ethernet

The MxL86289I allows a Synchronous Ethernet (SyncE) interface to support transportation of a source clock from a clock master to clock clients. When the TPI is a clock slave, the MxL86289I receives the synchronization clock from the Ethernet cable, and provides it to the system on pin GPC0, GPC1, GPC2, or GPC3. When the TPI is a clock master, the MxL86289I receives the clock from the system on pin GPC0, GPC1, GPC2, or GPC3 and sends it over the Ethernet cable as a clock master.

It is configurable to synchronize to one of these clock sources:

- Recovered received clock by SerDes
- Recovered received clock by 2.5G BASE-T PHY
- Input clock via GPC0, GPC1, GPC2, or GPC3

These functions are clocked from the synchronized clock:

- SerDes
- 2.5GBASE-T PHY
- 1588/PTP timers
- Output clock via GPC0, GPC1, GPC2, or GPC3

Loss of signal detection is integrated on chip and all the modules are supplied seamlessly with clocks generated from the local source when the external master clock signal is not available.

3.12.1 SyncE Configuration

The MxL86289I API describing the driver software executed on the external processor SoC must be followed to configure this feature.

3.13 Smart-AZ

The Smart-AZ feature is relevant when the 8-Port 2.5 Gigabit Ethernet PHY is connected to a MAC SoC that does not implement the EEE feature in its MAC layer. In this case, the MAC SoC is not able to initiate a transition to the low-power idle state.

To alleviate the limitation of such a MAC SoC, the MxL86289I detects the conditions that may lead to low-power idle and generates the control messages to enter EEE mode in accordance with the IEEE 802.3az standard.

The Smart-AZ feature is not enabled by default and is not supported in transparent mode.

3.14 Preemption

The IEEE 802.3br [2] and IEEE 802.1Qbu standards [11] introduced a one-level Ethernet frame preemption paradigm. In this approach, frames transmitted through a switch output port are classified as express frames or preemptable frames, depending on their priority levels. Express frames are able to preempt preemptable frames. Two frames belonging to the same class are not able to preempt each other. This allows the transmission of non-critical frames to be interrupted by critical frames, hence avoiding critical frames being blocked for long periods of time.

The MxL86289I does not preempt any Ethernet frames or change the order of the Ethernet frames. However, it is preemption-aware and able to identify the various preemption classes. The PCH transports preemption information over the USXGMII interface, consequently the MxL86289I also supports this feature in the PCH.

This feature is relevant in a Time Sensitive Network.

Attention: Preemption is only supported in transparent mode when the MxL86289I is not operating in 10BASE-T. Preemptable frames are dropped in SmartAZ mode.

3.15 Power Management

This section describes the power management functions of the MxL86289I integrated Ethernet PHY.

3.15.1 Power States

Figure 14 illustrates the power states and transitions of each integrated Ethernet PHY.

In this state diagram, the (0.11) syntax corresponds to the value of bit 11 from register 0 in device 0, which is `STD_CTRL.PD`. This is the Power Down (PD) bit in `MDIO STD_CTRL`, described in **Chapter 4**. The STA is able to use this `STD_CTRL.PD` field to bring the physical interface into the **POWER DOWN State**.

The other states are automatically entered by the MxL86289I depending on the context, and following the EEE protocol. This is done without any intervention from the STA.

The Normal Link Pulse (NLP) and Fast Link Pulse (FLP) are received on the TPI from a link partner and used to wake up the MxL86289I and enter auto-negotiation.

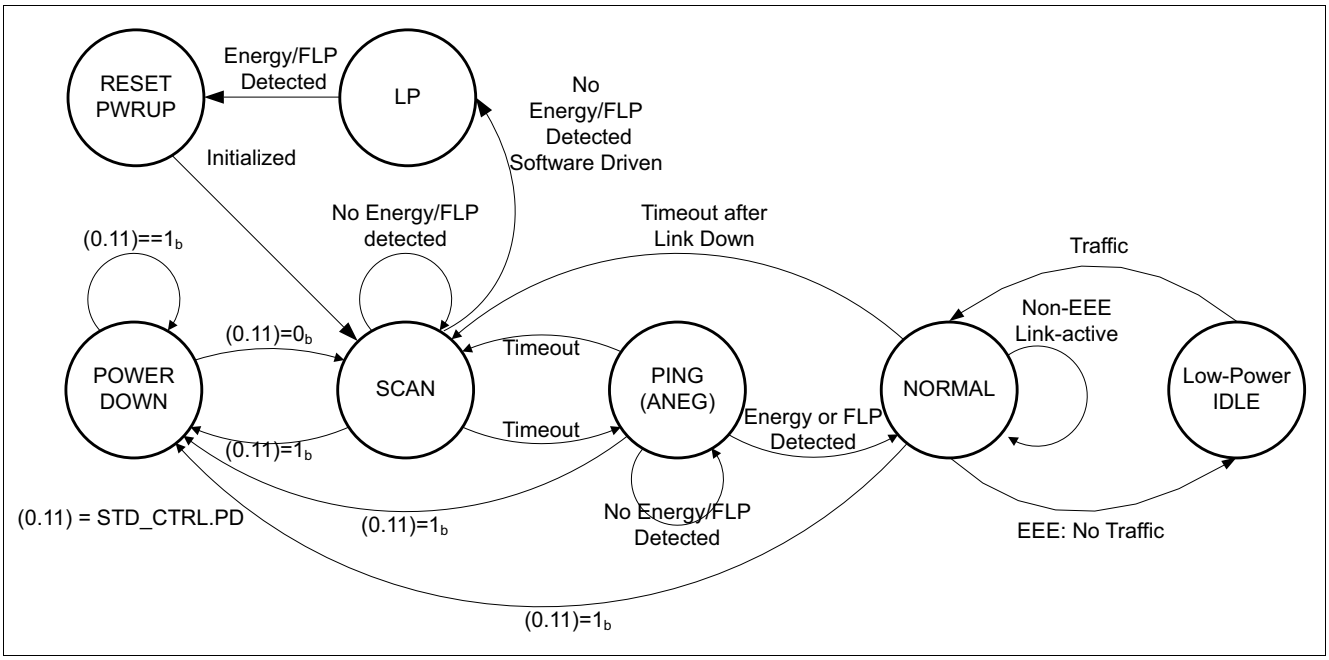


Figure 14 State Diagram for Power Down State Management

3.15.2 RESET PWRUP

The MxL86289I starts up in the RESET Power Up (PWRUP) state after either a hardware reset or power up.

After initialization, the PHYs always transition to the **SCAN (ANEG) State**.

3.15.3 POWER DOWN State

The **POWER DOWN State** is entered by setting the PD bit (0.11) of the MDIO standard register `STD_CTRL` to 1, regardless of the current state of the device. The **POWER DOWN State** corresponds to power down as specified in IEEE 802.3, Clause 22.2.4.1.5. Some signal processing blocks are stopped to save energy, but the MxL86289I still responds to MDIO messages.

Exiting the **POWER DOWN State** is triggered by setting the PD bit (0.11) of `STD_CTRL` to 0, which initiates a transition to the **SCAN (ANEG) State**.

3.15.4 SCAN (ANEG) State

The SCAN state differs from the **POWER DOWN State** in that the receiver periodically scans for signal energy or FLP bursts on the TPI. There is no transmission in this state. When an FLP burst is received, the MxL86289I enters the auto-negotiation protocol to exchange capabilities with the link partner and establish a data link in the **NORMAL State**.

3.15.5 PING (ANEG) State

The PING state is similar to the **SCAN (ANEG) State** except that the transceiver transmits an FLP burst onto the TPI for a programmable amount of time. This is used to wake potential link partners from the **POWER DOWN State**. This state corresponds to the state of ANEG described in Clause 28 of the IEEE standard **[2]**.

3.15.6 Low-Power State

The MxL86289I's Low-Power (LP) state is enabled by configuring the MDIO register `PHY_CTL2.LP`. The LP state is entered automatically when there is no Ethernet cable connected to the MxL86289I. The MxL86289I firmware detects this condition when no energy or Link Pulse is present on the TPI and enters the LP state. It is intended to set the MxL86289I into its maximum power saving state. In this state, most digital domains are in reset. Only a minimal amount of circuitry (analog/digital) operates to detect signal energy on the receiver of a TPI and trigger a wake-up.

When the port is in the LP state, the STAs do not have access to the corresponding MDIO/MMD registers.

The LP state is exited upon detection of signal energy on the twisted pair (either NLP or FLP). The port transitions to the **RESET PWRUP** state automatically. The STA host is also able to trigger an LP state exit by applying an API to wake up the specific port that entered the LP state.

It is possible for the STA host to be informed of the LP entry condition. By setting the `PHY_IMASK.LP` bit to ACTIVE, the STA requests the MDINT interrupt from the port when the entry conditions are met. **Figure 15** shows all the LP related control bits and communication mechanism between the STA and the MxL86289I.

It is possible for the STA host to be informed of the LP exit condition. By setting the `VSPEC1_IMASK.CDET` bit to ACTIVE, the STA requests the MDINT interrupt from the port when energy on the link is detected during auto-negotiation. Even when none of the ports are in the LP state, this interrupt is triggered whenever energy is first detected on the link. When the STA triggers the LP state exit via a wake-up request, and there is no energy on the link after the LP state exit, no interrupt is asserted.

Attention: An active-high MDINT in push-pull mode (default is tristate mode) is not supported in the LP mode.

Attention: VSPEC1_IMASK.CDET is not supported in forced speed 10BASE-T/100BASE-TX mode. Auto-negotiation is required to support this feature.

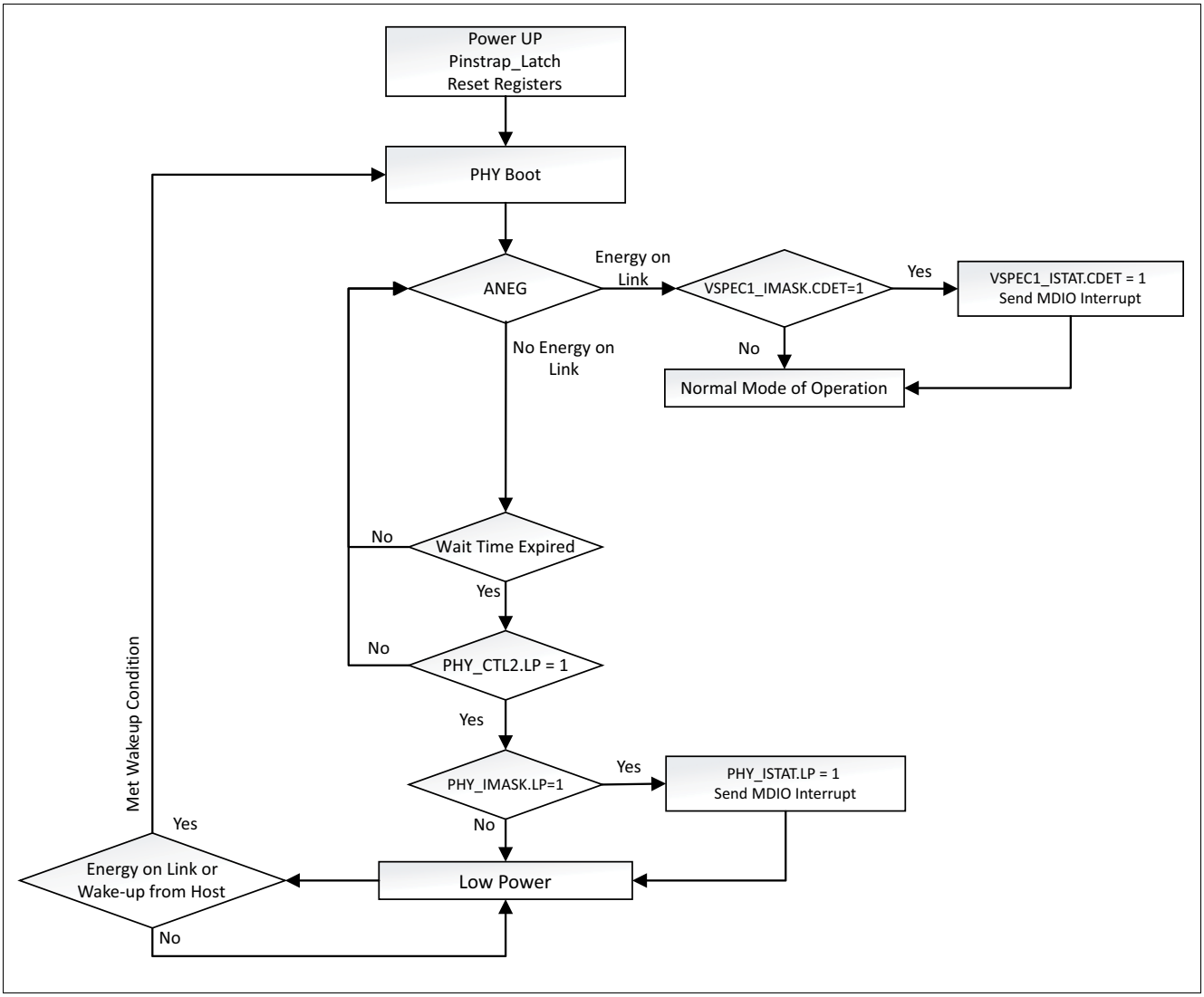


Figure 15 Low Power Sequence

Table 25 Low Power State Entry and Exit Sequence

Step	State	Remark
1	ACTIVE The LP feature is enabled by setting `PHY_CTL2.LP` = 1	Use the MDIO register PHY_CTL2.LP to enable or disable the LP feature.
2	ANEG, Ability Detect	The firmware detects no energy on the cable when no FLP is received for a long period of time. When the LP feature is not enabled, this time is fixed to between 6.4 and 9.6 seconds. When the LP feature is enabled, this time is configured using the `VSPEC1_LOW_POWER_ENTRY_TIME.LPE_TIM` register. Time in seconds = 4 x value programmed. Default time is 4 seconds. (`VSPEC1_LOW_POWER_ENTRY_TIME.LPE_TIM` = 1). There is an initial time of between 2.4 and 5.6 seconds, which adds on to the programmed time.
3	LP Entry Timer	This time is configured with the `VSPEC1_LOW_POWER_ENTRY_TIME.LPE_TIM` register. The value is set in steps of 4 seconds. The default time is 4 seconds.
4	LP Entry	The MxL86289I saves MDIO LP persistent registers. An interrupt is sent to indicate entry into the LP state.
5	LP State	Power consumption is saved in this state. The MxL86289I listens to energy pulses from the link partner ANEG as a condition to trigger an exit from the LP state. Only a minimal amount of circuitry operates to detect signal energy on TPI and trigger a wake-up. The port LEDs and MDIO interface are disabled.
6	LP Exit (Option 1) Based on energy detected on the cable	The MxL86289I restores the configurations in the MDIO registers. An interrupt is sent to indicate an exit from the LP state.
7	LP Exit (Option 2) Based on a wake-up request from the STA	The STA is able to request an LP exit by using a provided API. The MxL86289I restores the configurations in the MDIO registers. No interrupt is sent to notify LP exit. Since MDIO/MMD register access is unavailable for ports in the low power state, this option is only available if there is at least one port not in the low power state.
8	ANEG, LINK-UP, and ACTIVE	The MxL86289I operates in normal power modes.

These are persistent MDIO registers saved and restored during LP entry-exit.

1. STD_CTRL.SSM
2. STD_CTRL.DPLX
3. STD_CTRL.ANEN
4. STD_CTRL.SSL
5. STD_AN_ADV.TAF
6. STD_AN_ADV.XNP
7. STD_GCTRL.MBTHD
8. STD_GCTRL.MBTFD
9. STD_GCTRL.MSPT
10. STD_GCTRL.MS
11. STD_GCTRL.MSEN
12. PHY_IMASK
13. PHY_CTL1.AMDIX
14. PHY_CTL1.MDIAB
15. PHY_CTL1.MDICD
16. PHY_CTL1.POLA
17. PHY_CTL1.POLB
18. PHY_CTL1.POLC
19. PHY_CTL1.POLD
20. PHY_CTL2.LPI
21. PHY_CTL2.ANPD
22. PHY_CTL2.PSCL
23. PHY_CTL2.LP
24. PHY_CTL2.STICKY
25. PHY_CTL2.SDETP
26. PHY_LED
27. ANEG_CTRL.ANEG_ENAB
28. ANEG_MGBT_AN_CTRL.LDL
29. ANEG_MGBT_AN_CTRL.FR
30. ANEG_MGBT_AN_CTRL.FR2G5BT
31. ANEG_MGBT_AN_CTRL.AB2G5BT
32. ANEG_MGBT_AN_CTRL.PT
33. ANEG_MGBT_AN_CTRL.MS_MAN_EN
34. ANEG_MGBT_AN_CTRL.MSCV
35. ANEG_EEE_AN_ADV1.EEE_100BTX
36. ANEG_EEE_AN_ADV1.EEE_1000BT
37. ANEG_EEE_AN_ADV2.EEE2G5
38. ANEG_MGBT_AN_CTRL2.THPBYP2G5
39. VSPEC1_NBT_DS_CTRL.NO_NRG_RST
40. VSPEC1_NBT_DS_CTRL.DOWNSHIFTEN
41. VSPEC1_NBT_DS_CTRL.DOWNSHIFT_THR
42. VSPEC1_NBT_DS_CTRL.NRG_RST_CNT
43. VSPEC1_NBT_DS_CTRL.FORCE_RST
44. VSPEC1_LED0
45. VSPEC1_LED1
46. VSPEC1_PM_CTRL
47. VSPEC1_LOW_POWER_ENTRY_TIME.LPE_TIM
48. VSPEC1_IMASK
49. VSPEC1_FRCTL.CAP_EXT
50. VSPEC1_FRCTL.CAP_TXDIS

51. VSPEC1_FRCTL.CAP_THPBYP
52. VSPEC1_FRCTL.CAP_CISCO
53. VSPEC1_FRCTL.CAP_IEEE
54. VSPEC1_FRCTL.MAX_FR_RETRY
55. VSPEC2_WOL_CTRL
56. VPSPEC2_WOL_AD01
57. VPSPEC2_WOL_AD23
58. VPSPEC2_WOL_AD45
59. VPSPEC2_WOL_PW01
60. VPSPEC2_WOL_PW23
61. VPSPEC2_WOL_PW45

3.15.7 NORMAL State

The NORMAL state is used to establish and maintain a link connection. When a connection is dropped, the MxL86289I moves back into the **SCAN (ANEG) State**.

3.15.8 Low Power IDLE State - Energy-Efficient Ethernet

The IEEE 802.3 standard [2] describes the EEE operation supported by the MxL86289I in the various speeds of 100BASE-TX, 1000BASE-T, and 2.5GBASE-T. The general idea of EEE is to save power during periods of low link utilization. Instead of sending active idle data, the transmitters are switched off for a short period of time. This is called the quiet period. The link is kept active by means of a frequent refresh cycle initiated by the PHY itself while in the low power state. This sequence is repeated until a wake request is generated by one of the link partner MACs. The MxL86289I follows the IEEE 802.3 standard regarding EEE. Figure 16 illustrates the principle. This state is entered automatically when the low power idle conditions are met.

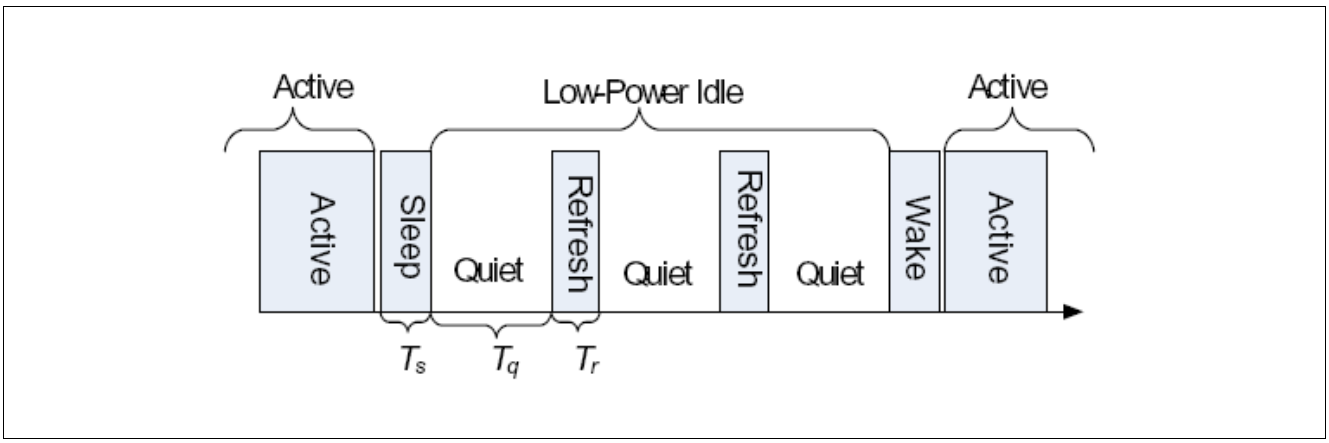


Figure 16 EEE Low Power Idle Sequence

3.16 Firmware Upgrade

The MxL86289I provides a Firmware Upgrade feature that allows feature and functional enhancements of the MxL86289I in the field.
It is possible to download a new firmware image via the MxL86289I's **MDIO Slave Interface** to a serial flash memory device connected to the MxL86289I's QSPI. The MxL86289I is then able to fetch the upgraded firmware from the flash memory after a reboot.

For Security Development Lifecycle (SDL) **[12]** reasons, the MxL86289I only accepts firmware images electronically signed by MaxLinear. When authentication of the flash image by the MxL86289I fails, or the download of the image is aborted or fails, the MxL86289I resets and wait for a new image to be downloaded.

In flashless mode, the host MAC SoC must transfer the MxL86289I's firmware image into the MxL86289I's on-chip memory at the MxL86289I's boot-up time. MaxLinear will provide the procedure to facilitate the firmware transfer. To upgrade the MxL86289I's firmware image, the device must be put into the reset state and restarted. This allows the usual **Power-On Sequence** to occur with the newly upgraded firmware image to be downloaded over the MDIO slave interface using a dedicated MDIO address. Once the firmware image has been transferred to the MxL86289I's on-chip memory, it is authenticated. After successfully authenticating the image, the MxL86289I continues with normal boot process. If authentication fails, or the image download fails or is aborted, the MxL86289I resets and waits for the host MAC SoC to restart the process.

The supported options for upgrading the firmware image are:

- The firmware is upgradeable over the MDIO slave interface to the flash memory device.
- Firmware download over the MDIO slave interface with MDIO address 0x1F to on-chip memory in flashless mode.
- In addition firmware download into "empty" flash is supported over MDIO slave interface.

Attention: The MDIO slave interface for firmware download or upgrade supports IEEE 802.3 Clause 22 only.

Attention: The MDIO address for firmware download or upgrade to flash is defined by the pin strapping in Table 17 with the lowest three bits equal to 0.

Attention: After the firmware upgrade to the flash memory is completed, the MxL86289I must be rebooted such that the new image is authenticated. The same requirement also applies to flash memory devices that are programmed directly by customers, which do not use the firmware upgrade procedure provided in this section.

The procedure to download firmware over the MDIO slave interface is documented in **[1]**. It provides information on the update/download process and which actions are required in the MAC SoC application.

Security feature to prevent flash memory wear-out due to frequent updates (flash anti-wear out) is not supported within the MxL86289I. When the system to which the MxL86289I is attached mandates such features, they must be supported by the system itself. Flash memory components typically support a minimum of 100,000 erase/program cycles, so flash wear-out is unlikely. However, ensuring a minimum interval between flash updates decreases the likelihood of wear-out. An interval of one hour sets the minimum time before wear-out to longer than 11 years. The system is also expected to ensures that the firmware is only installed when a new firmware is available and does not attempt to install a new firmware after every reboot in flash mode.

Security feature to prevent rollback of the image to a previous version (anti-rollback) is supported within the MxL86289I. The MxL86289I verifies that the new firmware has a higher or same security version number (SVN) than the previously installed firmware before executing it. If this step fails due to the firmware SVN being a lower version, the MxL86289I resets itself and waits for the host SoC to download a new image to the flash memory over the MDIO slave interface. In flashless mode, the MxL86289I resets itself and waits for the host MAC SoC to restart the firmware transfer process. If the system does not desire to have this anti-rollback feature, MaxLinear will deliver firmware images with fixed SVN, such that the security check will always pass.

4 MDIO and MMD Register Interface Description

This chapter describes the MDIO and MMD registers available to support the MxL86289I feature set. These registers are accessible by an external management entity (called STA in IEEE) to control, configure, or read the status of the MxL86289I. After power-on, the MxL86289I resets the MDIO and MMD registers to default values sufficient to operate without specific programing.

All the register definitions, behaviors, and fields are strictly compliant with IEEE 802.3. Refer to IEEE 802.3 [2] for more information about the registers. The only registers not referenced in IEEE 802.3 are two register groups that are vendor-specific: VSPEC1 and VSPEC2. These allow custom functions related to MxL86289I.

In the register descriptions, the section or table references refer to the IEEE 802.3 [2].

4.1 MDIO-specific Terminology

This list describes how the common IEEE 802.3 terms relate to MDIO and MMD register concepts discussed in this chapter.

- **STA**: Station Management. A host connected to the MDIO interface. STAs are generally Media Access Controllers (MACs). The STA drives the MDIO bus as a clock master and the MxL86289I is an MDIO slave.
- **Host**: Used as a synonym of STA in this document.
- **PHY**: Physical Layer. In the MxL86289I, this encompasses Analog Signal Processing, Digital Signal Processing, and Physical Coding Sublayer (PCS). The PHY contains several sublayers that are individually manageable entities known as MDIO manageable devices (MMDs).
- **MMD**: MDIO Manageable Device. The list of MMDs available in the MxL86289I is in **Section 4.3**.
- **Device**: In the context of the MDIO/MMD registers, a device is a register bank grouped by logical sublayers of the PHY layer.
- **Clause**: Refers to a particular section of the IEEE 802.3 standard [2]. In particular, Clause 22 describes MDIO device 0 and Clause 45 describes the other MMDs.
- **MII**: Media Independent Interface. This encompasses the MDIO and the (G)MII as described in Clause 22. STD registers in device 0 are also called MII registers.

4.2 Register Naming and Numbering

The register numbering convention in this document is similar to that of IEEE 802.3.

The numbering syntax uses three numbers, a.b.c, as specified in IEEE 802.3, paragraph 45.1 [2], and the notation is generalized to Clause 22 registers in device 0 STD. The alphanumeric syntax also uses the same structure and uses the names of the MMD devices, registers, and register fields separated by underscores and dots.

4.2.1 Register Numbering

The syntax is as follows, with a, b, and c written as decimal numbers:

a.b.c = <DEVICE_NUMBER>.<REGISTER_NUMBER>.<FIELD_NUMBER>

When the last indicator (c) is omitted, the register numbering refers to the full register.

When a field is more than a single bit, the bit range is indicated using a colon (for example, 1:3 is the field of bits 1 to 3). In an MDIO register, the least significant bit is bit 0 and most significant bit is bit 15. All MDIO registers are 16-bit wide.

4.2.2 Register Naming

The syntax is as follows, with AA, BB, and CC written as alphanumeric strings:

AA_BB.CC = <DEVICE_NAME>_<REGISTER_NAME>.<FIELD_NAME>

When the last indicator (CC) is omitted, the register naming refers to the full register.

The fields named RES, RES1, and RES2 refer to reserved fields as per IEEE 802.3.

4.2.3 Examples

`STD_STAT.ANOK` is the name of the field 0.1.5, which indicates that auto-negotiation is complete.

`ANEG_CTRL.ANEG_RESTART` is the name of the field 7.0.9, which allows the STA to restart the Ethernet ANEG procedure.

`ANEG_PHYID1` is the complete 16-bit register number 7.2, for the PHY identifier 1 number.

`VSPEC1_LED1.BLINKS` is the 4-bit wide field number 30.2.15:12, which contains LED1 slow blinking configuration.

4.3 MMD Devices Present in MxL86289I

The MMD devices implement groups of standardized registers under the management of the STA.

Table 26 MDIO/MMD Devices Present in MxL86289I

MDIO/MMD Name	Device Number (decimal)	Description
STD	0	MDIO Standard Device as described in Clause 22. This also contains a number of MxL86289I-specific PHY registers.
PMAPMD	1	Control and status registers related to the PMA/PMD signal processing modules
PCS	3	Control and status registers related to the PCS encoding/decoding device
ANEG	7	Control and status registers related to the auto-negotiation device
VSPEC1	30	MxL86289I-specific LED control and other MxL86289I-specific control
VSPEC2	31	MxL86289I-specific WoL control

4.4 Responsibilities of the STA

The MxL86289I responds to all published register addresses for the device and returns a value of zero for undefined and unsupported registers.

In accordance with IEEE 802.3 guidelines, it is the responsibility of the STA entity to ensure that mutually acceptable speeds are applied consistently across all the MMDs of the MxL86289I.

The MxL86289I ignores writes to the PMA/PMD speed selection bits that select speeds not advertised in the PMA/PMD speed ability register. The PMA/PMD speed selection defaults to a supported ability.

4.5 MDIO Access Protocols to Read / Write Registers

All the MDIO/MMD registers are accessible from an external chip connected to the MDIO bus on the MDIO_S and MDC_S pins. The MxL86289I supports several MDIO frame protocols:

- Clause 22: To access Device 0
- Clause 22 Extended: To access other devices using the indirection scheme specified by IEEE 802.3
  Dev 1: PMAPMD
  Dev 3: PCS
  Dev 7: ANEG
  Dev 30: VSPEC1
  Dev 31: VSPEC2
- Clause 45: to access all devices

Both Clause 22 Extended and Clause 45 are used to access MMD devices. However, the mechanism implemented in the MxL86289I provides faster speeds using Clause 45. It creates differences in latencies in the MDIO reply:

- The Clause 22 Extended protocol involves an indirect mechanism.
- The Clause 45 protocol provides faster replies.

The Clause 22 registers are accessed using the Clause 45 electrical interface and the Clause 22 management frame structure. Refer to IEEE 802.3 section 45 **[2]**.

5 MDIO Registers Detailed Description

Table 27 Register Access Type

Mode	Symbol
Read-Only Register (Status or Ability Register)	RO
Read-Write Register (MDIO Register)	RW
Read-Write Self-Clearing Register (bit cleared after read from MDIO)	RWSC
Read-Only Self-Clearing Register (bit cleared after read from MDIO)	ROSC
Read-Only Latching Low Register	ROLL
Read-Only Latching High Register	ROLH

5.1 Standard Management Registers

This section describes the IEEE 802.3 standard management registers corresponding to Clause 22.

Table 28 Registers Overview- Standard Management Registers

Register Short Name	Register Long Name	Reset Value
STD_CTRL	STD Control (Register 0.0)	3040_H
STD_STAT	Status Register (Register 0.1)	7949_H
STD_PHYID1	PHY Identifier 1 (Register 0.2)	$C133_H$
STD_PHYID2	PHY Identifier 2 (Register 0.3)	5400_H 1)
STD_AN_ADV	Auto-Negotiation Advertisement (Register 0.4)	$9DE1_H$
STD_AN_LPA	Auto-Negotiation Link Partner Ability (Register 0.5)	$1DE0_H$
STD_AN_EXP	Auto-Negotiation Expansion (Register 0.6)	0064_H
STD_AN_NPTX	Auto-Negotiation Next Page Transmit Register (Register 0.7)	2001_H
STD_AN_NPRX	Auto-Negotiation Link Partner Received Next Page Register (Register 0.8)	0000_H
STD_GCTRL	Gigabit Control Register (Register 0.9)	0200_H
STD_GSTAT	Gigabit Status Register (Register 0.10)	0000_H
STD_MMDCTRL	MMD Access Control Register (Register 0.13)	0000_H
STD_MMDDATA	MMD Access Data Register (Register 0.14)	0000_H
STD_XSTAT	Extended Status Register (Register 0.15)	2000_H

1) For the device specific reset value, see the Product and Package Naming table in the **Product Ordering Information** chapter.

5.1.1 Standard Management Register Descriptions

This section describes all the STD registers in detail.

STD Control (Register 0.0)

This register controls the main functions of the PHY.

IEEE Standard Register=0.0

STD_CTRL **Reset Value**

STD Control (Register 0.0) **3040_H**

15	14	13	12	11	10	9	8	7	6	5	0
RST	**LB**	**SSL**	**ANEN**	**PD**	**ISOL**	**ANRS**	**DPLX**	**COL**	**SSM**	**RES**	
rwsc	rw	rw	rw	rw	rw	rwsc	rw	rw	rw	ro	

Field	Bits	Type	Description
RST	15	RWSC	**Reset** Resets the PHY to its default state. Active links are terminated. This is a self-clearing bit, which is set to zero by the hardware after a reset is performed. 0_B **NORMAL** Normal operational mode 1_B **RESET** Resets the device.
LB	14	RW	**Loopback on GMII** This mode enables looping back of MII data from the transmit to the receive direction. No data is transmitted to the Ethernet PHY. The device operates at the selected speed. The collision signal remains de-asserted unless otherwise forced by the collision test. 0_B **NORMAL** Normal operational mode 1_B **ENABLE** Closes the loopback from Tx to Rx at xMII.
SSL	13	RW	**Forced Speed Selection LSB** This bit only takes effect when bit ANEN is set to zero, which disables the auto-negotiation process. This is the lower bit (LSB) of the forced speed selection and is used in conjunction with the higher bit (MSB). The standard procedure to force 2500 Mbps operation (when ANEG is disabled) is to program PMA_CTRL with 1.0.6 = 1.0.13 = 1 and 1.0.5:2 = [0 1 1 0]. The GPHY mirrors 1.0.6, 1.0.13 and 0.0.6, 0.0.13. This is the MSB LSB bit value encoding: 00_B 10 Mbps 01_B 100 Mbps 10_B 1000 Mbps 11_B Reserved, defaults to 2500 Mbps operation when the PMA_CTRL register 1.0.5:2 equals [0 1 1 0].

Field	Bits	Type	Description (cont'd)
ANEN	12	RW	**Auto-Negotiation Enable** Allows enabling and disabling of the auto-negotiation process capability of the PHY. When enabled, the force bits for duplex mode (CTRL.DPLX) and the speed selection (CTRL.SSM, CTRL.SSL) become inactive; otherwise, the force bits define the PHY operation. 0_B **DISABLE** Disables the auto-negotiation protocol. 1_B **ENABLE** Enables the auto-negotiation protocol.
PD	11	RW	**Power Down** Forces the device into a power down state (SLEEP) in which power consumption is the bare minimum required to still maintain the MII management interface communication. When activating the power down functionality, the PHY terminates active data links. The MII interface is also stopped in power down mode. 0_B **NORMAL** Normal operational mode 1_B **POWERDOWN** Forces the device into power down mode.
ISOL	10	RW	**Isolate** The isolation mode isolates the PHY from the MAC. The MAC interface inputs are ignored, whereas the MAC interface outputs are set to tristate (high-impedance). 0_B **NORMAL** Normal operational mode 1_B **ISOLATE** Isolates the PHY from the MAC.
ANRS	9	RWSC	**Restart Auto-Negotiation** Restarts the auto-negotiation process on the MDI. This bit does not have any effect when auto-negotiation is disabled using CTRL.ANEN. This bit is self-clearing after the auto-negotiation process is initiated. 0_B **NORMAL** Stays in current mode. 1_B **RESTART** Restarts auto-negotiation.
DPLX	8	RW	**Forced Duplex Mode** This bit only takes effect when bit CTRL.ANEN is set to zero, which disables the auto-negotiation process. This bit controls the forced duplex mode. It allows forcing of the PHY into full-duplex or half-duplex mode. This bit does not take effect in loopback mode, when bit CTRL.LB is set to 1_B. It is only possible to force the duplex mode to half-duplex in 10BASE-T and 100BASE-TX speed modes. This field is ignored for higher speeds. 0_B **HD** Half-duplex 1_B **FD** Full-duplex
COL	7	RW	**Collision Test** Allows testing of the COL signal at the xMII interface. When the collision test is enabled, the state of the TX_EN signal is looped back to the COL signal within a minimum latency. 0_B **DISABLE** Normal operational mode 1_B **ENABLE** Activates the collision test.

Field	Bits	Type	**Description** (cont'd)
SSM	6	RW	**Forced Speed Selection MSB** This bit only takes effect when bit ANEN is set to zero, which disables the auto-negotiation process. This is the higher bit (MSB) of the forced speed selection and is used in conjunction with the lower bit (LSB). The preferred way to force 2500 Mbps operation (when ANEG is disabled) is to program PMA_CTRL with 1.0.6 = 1.0.13 = 1 and 1.0.5:2 = [0 1 1 0]. The GPHY mirrors 1.0.6, 1.0.13 and 0.0.6, 0.0.13. This is the MSB LSB bit value encoding: 00_B 10 Mbps 01_B 100 Mbps 10_B 1000 Mbps 11_B Reserved, defaults to 2500 Mbps operation when the PMA_CTRL register 1.0.5:2 equals [0 1 1 0].
RES	5:0	RO	**Reserved** Write as zero, ignore on read.

Status Register (Register 0.1)

This register contains status and capability information about the device. All the bits are read-only. A write access by the MAC does not have any effect. Refer to IEEE 802.3 22.2.4.2.

IEEE Standard Register=0.1

STD_STAT **Reset Value**

Status Register (Register 0.1) **7949_H**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CBT4	**CBTXF**	**CBTXH**	**XBTF**	**XBTH**	**CBT2F**	**CBT2H**	**EXT**	**RES**	**MFPS**	**ANOK**	**RF**	**ANAB**	**LS**	**JD**	**XCAP**
ro	ro	ro	ro	ro	ro	ro	ro	ro	ro	ro	rolh	ro	roll	rolh	ro

Field	Bits	Type	Description
CBT4	15	RO	**IEEE 100BASE-T4** Specifies the 100BASE-T4 ability. 0_B **DISABLED** PHY does not support this mode. 1_B **ENABLED** PHY supports this mode.
CBTXF	14	RO	**IEEE 100BASE-TX Full Duplex** Specifies the 100BASE-TX full duplex capability. 0_B **DISABLED** PHY does not support this mode. 1_B **ENABLED** PHY supports this mode.
CBTXH	13	RO	**IEEE 100BASE-TX Half-Duplex** Specifies the 100BASE-TX half-duplex capability. 0_B **DISABLED** PHY does not support this mode. 1_B **ENABLED** PHY supports this mode.
XBTF	12	RO	**IEEE 10BASE-T Full-Duplex** Specifies the 10BASE-T full-duplex capability. 0_B **DISABLED** PHY does not support this mode. 1_B **ENABLED** PHY supports this mode.
XBTH	11	RO	**IEEE 10BASE-T Half-Duplex** Specifies the 10BASE-T half-duplex capability. 0_B **DISABLED** PHY does not support this mode. 1_B **ENABLED** PHY supports this mode.
CBT2F	10	RO	**IEEE 100BASE-T2 Full-Duplex** Specifies the 100BASE-T2 full-duplex capability. 0_B **DISABLED** PHY does not support this mode. 1_B **ENABLED** PHY supports this mode.
CBT2H	9	RO	**IEEE 100BASE-T2 Half-Duplex** Specifies the 100BASE-T2 half-duplex capability. 0_B **DISABLED** PHY does not support this mode. 1_B **ENABLED** PHY supports this mode.

Field	Bits	Type	Description (cont'd)
EXT	8	RO	**Extended Status** The extended status registers are used to specify 1000 Mbps speed capabilities in the register XSTAT. 0_B **DISABLED** No extended status information available in register 15 1_B **ENABLED** Extended status information available in register 15
RES	7	RO	**Reserved** Ignore when read.
MFPS	6	RO	**Management Preamble Suppression** Specifies the Management Frame (MF) preamble suppression ability. 0_B **DISABLED** PHY requires management frames with preamble. 1_B **ENABLED** PHY accepts management frames without preamble.
ANOK	5	RO	**Auto-Negotiation Completed** Indicates whether the auto-negotiation process is completed or in progress. 0_B **RUNNING** Auto-negotiation process is in progress. 1_B **COMPLETED** Auto-negotiation process is completed.
RF	4	ROLH	**Remote Fault** Indicates the detection of a remote fault event. GPHY does not indicate RF. 0_B **INACTIVE** No remote fault condition detected 1_B **ACTIVE** Remote fault condition detected
ANAB	3	RO	**Auto-Negotiation Ability** Specifies the auto-negotiation ability. 0_B **DISABLED** PHY is not able to perform auto-negotiation. 1_B **ENABLED** PHY is able to perform auto-negotiation.
LS	2	ROLL	**Link Status** Indicates the link status of the PHY to the link partner. 0_B **INACTIVE** The link is down. No communication with link partner possible. 1_B **ACTIVE** The link is up. Data communication with link partner is possible.
JD	1	ROLH	**Jabber Detect** Indicates that a jabber event was detected. 0_B **NONE** No jabber condition detected 1_B **DETECTED** Jabber condition detected
XCAP	0	RO	**Extended Capability** Indicates the availability and support of extended capability registers. 0_B **DISABLED** Only base registers are supported. 1_B **ENABLED** Extended capability registers are supported.

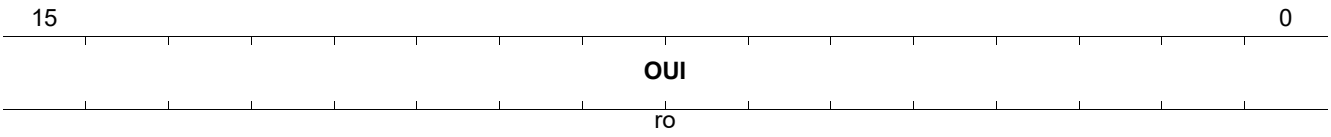
PHY Identifier 1 (Register 0.2)

This code specifies the Organizationally Unique Identifier (OUI), and the vendor's model and revision number.

IEEE Standard Register=0.2

STD_PHYID1 **Reset Value**

PHY Identifier 1 (Register 0.2) **$C133_H$**



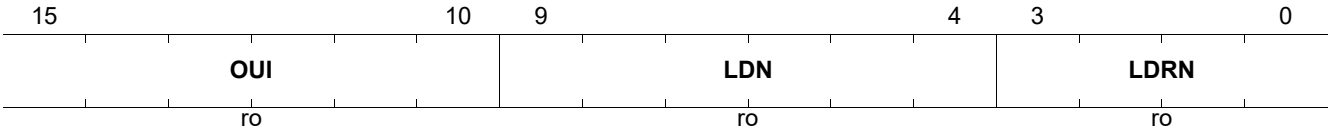
Field	Bits	Type	Description
OUI	15:0	RO	**Organizationally Unique Identifier Bits 3:18**

PHY Identifier 2 (Register 0.3)

IEEE Standard Register=0.3

STD_PHYID2 **Reset Value**

PHY Identifier 2 (Register 0.3) **5400_H**



Field	Bits	Type	Description
OUI	15:10	RO	**Organizationally Unique Identifier Bits 19:24**
LDN	9:4	RO	**Device Number** Specifies the device number[1)] to distinguish between several different products.
LDRN	3:0	RO	**Device Revision Number** Specifies the device revision number[1)] to distinguish between several versions of this device.

1) For the device specific reset value, see the Product and Package Naming table in the **Product Ordering Information** chapter.

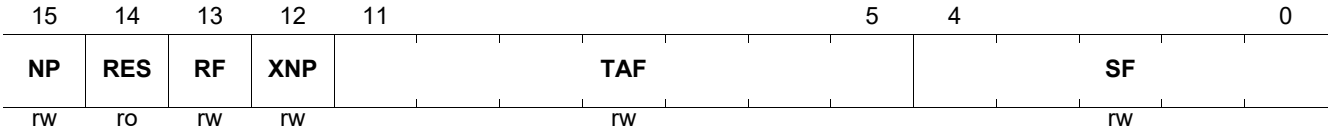
Auto-Negotiation Advertisement (Register 0.4)

This register contains the advertised abilities of the PHY during auto-negotiation.

IEEE Standard Register=0.4

STD_AN_ADV **Reset Value**

Auto-Negotiation Advertisement (Register 0.4) **$9DE1_H$**



Field	Bits	Type	Description
NP	15	RW	**Next Page** The next page indication is encoded in bit AN_ADV.NP regardless of the selector field value or link code word encoding. The PHY always advertises NP when a 1000BASE-T mode is advertised during auto-negotiation. 0_B **INACTIVE** No next page to follow 1_B **ACTIVE** Additional next page(s) to follow
RES	14	RO	**Reserved** Write as zero, ignore on read.
RF	13	RW	**Remote Fault** This bit allows indication of a fault to the link partner. 0_B **NONE** No remote fault is indicated. 1_B **FAULT** A remote fault is indicated.
XNP	12	RW	**Extended Next Page** Indicates the GPHY supports transmission of extended next pages (XNP). 0_B **UNABLE** GPHY is XNP unable. 1_B **ABLE** GPHY is XNP able.
TAF	11:5	RW	**Technology Ability Field** This is an 8-bit wide field containing information indicating supported technologies. The GPHY supports half-duplex and full-duplex 10BASE-T and 100BASE-TX and also both symmetric and asymmetric PAUSE. 40_H **PS_ASYM** Advertises asymmetric pause 20_H **PS_SYM** Advertises symmetric pause 10_H **DBT4** Advertises 100BASE-T4 08_H **DBT_FDX** Advertises 100BASE-TX full-duplex 04_H **DBT_HDX** Advertises 100BASE-TX half-duplex 02_H **XBT_FDX** Advertises 10BASE-T full-duplex 01_H **XBT_HDX** Advertises 10BASE-T half-duplex

Field	Bits	Type	Description (cont'd)
SF	4:0	RW	**Selector Field** This field is a 5-bit wide field for encoding 32 possible messages. The encodings are defined in IEEE 802.3-2008 Annex 28A. Unspecified combinations are reserved for future use. Reserved combinations of this field are not to be transmitted. 00001_B**IEEE802DOT3** Selects the IEEE 802.3 technology.

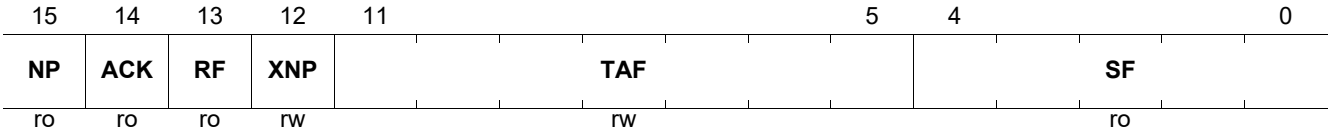
Auto-Negotiation Link Partner Ability (Register 0.5)

IEEE Standard Register=0.5

When the auto-negotiation is complete, this register contains the advertised ability of the link partner. The bit definitions are a direct representation of the received link code word.

STD_AN_LPA **Reset Value**

Auto-Negotiation Link Partner Ability (Register 0.5) **$1DE0_H$**



Field	Bits	Type	Description
NP	15	RO	**Next Page** Next page request indication from the link partner. 0_B **INACTIVE** No next page to follow 1_B **ACTIVE** Additional next pages to follow
ACK	14	RO	**Acknowledge** Acknowledgment indication from the link partner's link code word. 0_B **INACTIVE** The device did not receive its link partner's link code word. 1_B **ACTIVE** The device received its link partner's link code word.
RF	13	RO	**Remote Fault** Remote fault indication from the link partner. 0_B **NONE** Remote fault is not indicated by the link partner. 1_B **FAULT** Remote fault is indicated by the link partner.
XNP	12	RW	**Extended Next Page** Indicates the GPHY supports transmission of extended next pages (XNP). 0_B **UNABLE** Link partner is XNP unable. 1_B **ABLE** Link partner is XNP able.
TAF	11:5	RW	**Technology Ability Field** 40_H **PS_ASYM** Advertises asymmetric pause 20_H **PS_SYM** Advertises symmetric pause 10_H **DBT4** Advertises 100BASE-T4 08_H **DBT_FDX** Advertises 100BASE-TX full-duplex 04_H **DBT_HDX** Advertises 100BASE-TX half-duplex 02_H **XBT_FDX** Advertises 10BASE-T full-duplex 01_H **XBT_HDX** Advertises 10BASE-T half-duplex
SF	4:0	RO	**Selector Field** 00001_B**IEEE802DOT3** Selects the IEEE 802.3 technology

Auto-Negotiation Expansion (Register 0.6)

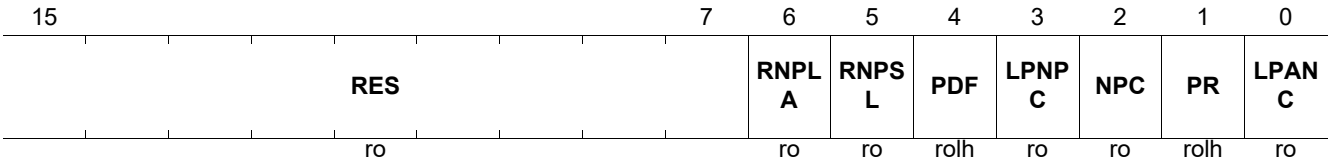
This is the auto-negotiation expansion register indicating the status of the link partner's auto-negotiation. This register is valid only after the auto-negotiation is completed.

Refer to IEEE 802.3 28.2.4.1.5.

IEEE Standard Register=0.6

STD_AN_EXP **Reset Value**

Auto-Negotiation Expansion (Register 0.6) **0064_H**



Field	Bits	Type	Description
RES	15:7	RO	**Reserved** Write as zero, ignore on read.
RNPLA	6	RO	**Receive Next Page Location Able** According to 802.3-2015, indicates the Rx NP location is indicated by field RNPSL. 0_B **UNABLE** Received Next Page Storage Location is not specified by bit (6.5). 1_B **ABLE** Received Next Page Storage Location is specified by bit (6.5).
RNPSL	5	RO	**Receive Next Page Storage Location** According to 802.3-2015, indicates the Rx NP is in register 0.8 for the GPHY. 0_B **FIVE** Link partner next pages are stored in register 5. 1_B **EIGHT** Link partner next pages are stored in register 8.
PDF	4	ROLH	**Parallel Detection Fault** 0_B **NONE** A fault was not detected via the parallel detection function. 1_B **FAULT** A fault was detected via the parallel detection function.
LPNPC	3	RO	**Link Partner Next Page Capable** 0_B **UNABLE** Link partner is unable to exchange next pages. 1_B **CAPABLE** Link partner is capable of exchanging next pages.
NPC	2	RO	**Next Page Capable** 0_B **UNABLE** GPHY is unable to exchange next pages. 1_B **CAPABLE** GPHY is capable of exchanging next pages.
PR	1	ROLH	**Page Received** 0_B **NONE** A new page was not received. 1_B **RECEIVED** A new page was received.
LPANC	0	RO	**Link Partner Auto-Negotiation Capable** 0_B **UNABLE** Link partner is unable to auto-negotiate. 1_B **CAPABLE** Link partner is auto-negotiation capable.

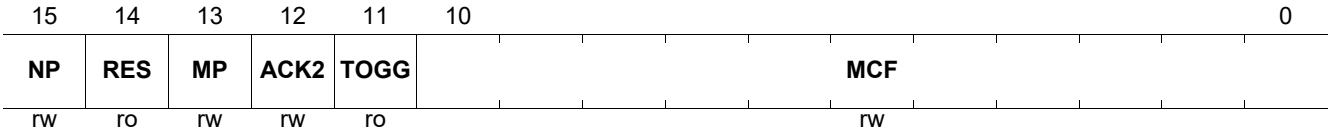
Auto-Negotiation Next Page Transmit Register (Register 0.7)

The auto-negotiation next page transmit register contains the next page link code word to be transmitted when next page ability is supported. Refer to IEEE 802.3 28.2.4.1.6.

IEEE Standard Register=0.7

STD_AN_NPTX **Reset Value**

Auto-Negotiation Next Page Transmit Register (Register 0.7) **2001_H**



Field	Bits	Type	Description
NP	15	RW	**Next Page** 0_B **INACTIVE** Last page 1_B **ACTIVE** Additional next page(s) to follow
RES	14	RO	**Reserved** Write as zeros, ignore on read.
MP	13	RW	**Message Page** Indicates the content of MCF is either an unformatted page or a formatted message. 0_B **UNFOR** Unformatted page 1_B **MESSG** Message page
ACK2	12	RW	**Acknowledge 2. GPHY Does Not Comply** 0_B **INACTIVE** Device is not able to comply with message. 1_B **ACTIVE** Device complies with message.
TOGG	11	RO	**Toggle** This bit always takes the opposite value of the Toggle bit in the previously exchanged link code word. 0_B **ZERO** Previous value of the transmitted link code word was 1_B. 1_B **ONE** Previous value of the transmitted link code word was 0_B.

Field	Bits	Type	Description (cont'd)
MCF	10:0	RW	**Message or Unformatted Code Field** When the Message Page bit is set to 1_B (0.7.13), this field is the Message Code Field of a message page used in next page exchange. The message codes are described in IEEE 802.3 Appendix 28C. It is used to indicate the type of message in UCF1 and UCF2. 00_H Reserved 01_H Null message 02_H One Unformatted Page (UP) with TAF follows 03_H Two UPs with TAF follows 04_H Remote fault details message 05_H OUI message 06_H PHY ID message 07_H 100BASE-T2 message 08_H 1000BASE-T message 09_H MULTIGBASE-T message $0A_H$ EEE technology capability follows in next UP $0B_H$ OUI XNP

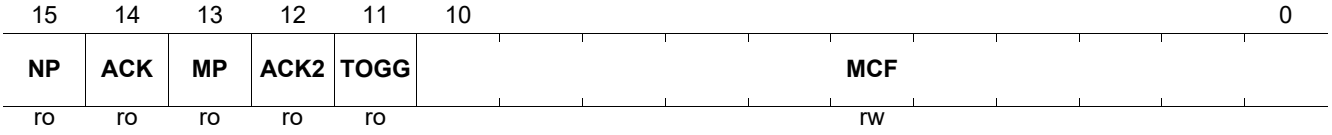
Auto-Negotiation Link Partner Received Next Page Register (Register 0.8)

This register contains the next page link code word received from the link partner. Refer to IEEE 802.3-2008 28.2.4.1.7.

IEEE Standard Register=0.8

STD_AN_NPRX
Auto-Negotiation Link Partner Received Next Page Register (Register 0.8)

Reset Value
0000_H



Field	Bits	Type	Description
NP	15	RO	**Next Page** 0_B **INACTIVE** No next pages to follow 1_B **ACTIVE** Additional next page(s) to follow
ACK	14	RO	**Acknowledge** 0_B **INACTIVE** The device did not receive its link partner's link code word. 1_B **ACTIVE** The device received its link partner's link code word.
MP	13	RO	**Message Page** Indicates the content of MCF is either an unformatted page or a formatted message. 0_B **UNFOR** Unformatted page 1_B **MESSG** Message page
ACK2	12	RO	**Acknowledge 2** 0_B **INACTIVE** Device is not able to comply with the message. 1_B **ACTIVE** Device complies with the message.
TOGG	11	RO	**Toggle** This bit always takes the opposite value of the Toggle bit in the previously exchanged link code word. 0_B **ZERO** Previous value of the transmitted link code word was 1_B. 1_B **ONE** Previous value of the transmitted link code word was 0_B.

Field	Bits	Type	Description (cont'd)
MCF	10:0	RW	**Message or Unformatted Code Field** This field is the Message Code Field of a message page used in next page exchange. The message codes are described in IEEE 802.3 Appendix 28C. It is used to indicate the type of message in UCF1 and UCF2. 00_H Reserved 01_H Null message 02_H One Unformatted Page (UP) with TAF follows 03_H Two UPs with TAF follows 04_H Remote fault details message 05_H OUI message 06_H PHY ID message 07_H 100BASE-T2 message 08_H 1000BASE-T message 09_H MULTIGBASE-T message $0A_H$ EEE technology capability follows in next UP $0B_H$ OUI XNP

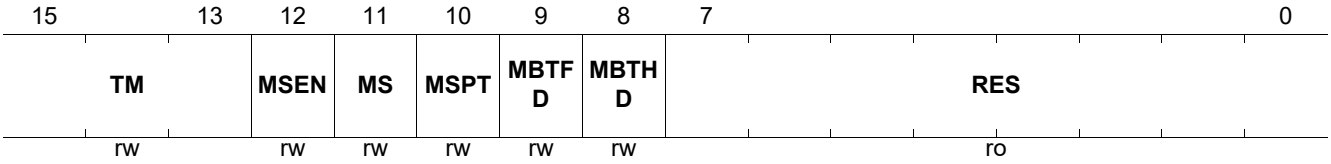
Gigabit Control Register (Register 0.9)

This is the control register to configure the Gigabit Ethernet behavior of the PHY. Refer to IEEE 802.3-2008 40.5.1.1.

IEEE Standard Register=0.9

STD_GCTRL **Reset Value**

Gigabit Control Register (Register 0.9) **0200_H**



Field	Bits	Type	Description
TM	15:13	RW	**Transmitter Test Mode** This register field allows enabling of the standard transmitter test modes. 000_B **NOP** Normal operation 001_B **WAV** Test mode 1 transmit waveform test 010_B **JITM** Test mode 2 transmit jitter test in master mode 011_B **JITS** Test mode 3 transmit jitter test in slave mode 100_B **DIST** Test mode 4 transmitter distortion test
MSEN	12	RW	**Master/Slave Manual Configuration Enable** 0_B **DISABLED** Disables master/slave manual configuration value. 1_B **ENABLED** Enables master/slave manual configuration value.
MS	11	RW	**Master/Slave Configuration Value** Allows forcing of master or slave mode manually when AN_GCTRL.MSEN is set to 1_B. 0_B **SLAVE** Configures PHY as slave during master/slave negotiation. 1_B **MASTER** Configures PHY as master during master/slave negotiation.
MSPT	10	RW	**Master/Slave Port Type** Defines whether the PHY advertises itself as a multi- or single-port device, which in turn impacts the master/slave resolution function. 0_B **SPD** Single-port device 1_B **MPD** Multi-port device
MBTFD	9	RW	**1000BASE-T Full-Duplex** Advertises the 1000BASE-T full-duplex capability; always forced to 1 in converter mode. 0_B **DISABLED** Advertises PHY as not 1000BASE-T full-duplex capable 1_B **ENABLED** Advertises PHY as 1000BASE-T full-duplex capable

Field	Bits	Type	Description (cont'd)
MBTHD	8	RW	**1000BASE-T Half-Duplex** Always advertises the 1000BASE-T half-duplex capability as disabled. The GPHY does not support 1000BASE-T half-duplex capability. 0_B **DISABLED** Advertises PHY as not 1000BASE-T half-duplex capable 1_B **ENABLED** Advertises PHY as 1000BASE-T half-duplex capable
RES	7:0	RO	**Reserved** Write as zero, ignore on read.

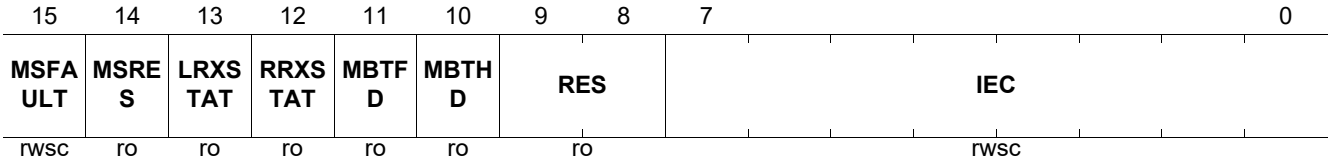
Gigabit Status Register (Register 0.10)

This is the status register used to reflect the Gigabit Ethernet status of the PHY. Refer to IEEE 802.3-2022 40.5.1.1.

IEEE Standard Register=0.10

STD_GSTAT **Reset Value**

Gigabit Status Register (Register 0.10) **0000_H**



Field	Bits	Type	Description
MSFAULT	15	RWSC	**Master/Slave Manual Configuration Fault** This bit is set when the number of failed master-slave resolutions reaches 7. It is cleared upon each read of GSTAT. This bit self clears on auto-negotiation enable or auto-negotiation complete. 0_B **OK** Master/slave manual configuration resolved successfully 1_B **NOK** Master/slave manual configuration resolved with a fault
MSRES	14	RO	**Master/Slave Configuration Resolution** 0_B **SLAVE** Local PHY configuration resolved to SLAVE 1_B **MASTER** Local PHY configuration resolved to MASTER
LRXSTAT	13	RO	**Local Receiver Status** Indicates the status of the local receiver. 0_B **NOK** Local receiver not OK 1_B **OK** Local receiver OK
RRXSTAT	12	RO	**Remote Receiver Status** Indicates the status of the remote receiver. 0_B **NOK** Remote receiver not OK 1_B **OK** Remote receiver OK
MBTFD	11	RO	**Link Partner Capable of Operating 1000BASE-T Full-Duplex** 0_B **DISABLED** Link partner is not capable of operating 1000BASE-T full-duplex 1_B **ENABLED** Link partner is capable of operating 1000BASE-T full-duplex
MBTHD	10	RO	**Link Partner Capable of Operating 1000BASE-T Half-Duplex** 0_B **DISABLED** Link partner is not capable of operating 1000BASE-T half-duplex 1_B **ENABLED** Link partner is capable of operating 1000BASE-T half-duplex
RES	9:8	RO	**Reserved** Write as zero, ignore on read.

Field	Bits	Type	**Description** (cont'd)
IEC	7:0	RWSC	**Idle Error Count** Indicates the idle error count. This field contains a cumulative count of the errors detected when the receiver receives idles.

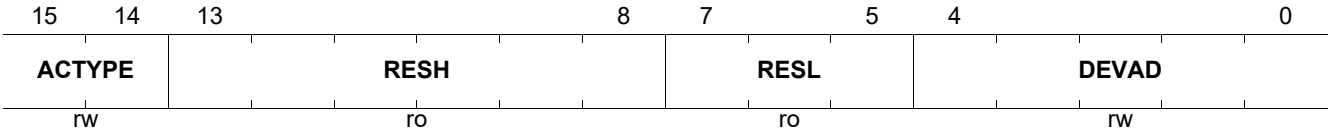
MMD Access Control Register (Register 0.13)

The MMD access control register is used in conjunction with the MMDDATA register to access the MMD register space. This uses address directing as specified in IEEE 802.3 Clause 22 Extended.

IEEE Standard Register=0.13

STD_MMDCTRL **Reset Value**

MMD Access Control Register (Register 0.13) **0000_H**



Field	Bits	Type	Description
ACTYPE	15:14	RW	**Access Type Function** When the MMDDATA register is accessed via an address access (ACTYPE=0), the access is directed to the address register within the MMD associated with the value in the DEVAD field. Otherwise, both the DEVAD field and the MMD address register direct the MMDDATA register data accesses to the appropriate registers within that MMD. 00_B **ADDRESS** Accesses to the MMDDATA register access the MMD individual address register. 01_B **DATA** Accesses to the MMDDATA register access the register within the MMD selected. 10_B **DATA_PI** Accesses to the MMDDATA register access the register within the MMD selected. 11_B **DATA_PIWR** Accesses to the MMDDATA register access the register within the MMD selected.
RESH	13:8	RO	**Reserved** Write as zero, ignored on read.
RESL	7:5	RO	**Reserved** Write as zero, ignored on read.
DEVAD	4:0	RW	**Device Address** The DEVAD field directs any accesses of register MMDDATA to the appropriate MMD as described in IEEE 802.3-2008 Clause 45.2.

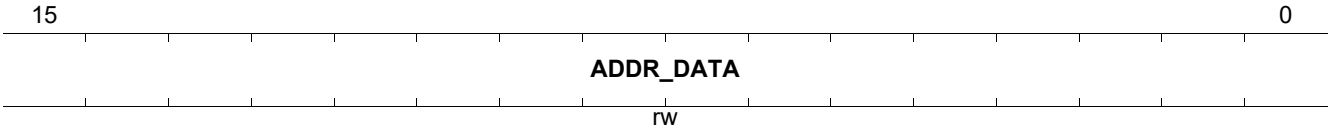
MMD Access Data Register (Register 0.14)

The MMD access data register is used in conjunction with the MMD access control (MMDCTRL) register to access the MMD register space. For more information on MMD access, refer to IEEE 802.3-2008 Clause 22.2.4.3.12, Clause 45.2, and Annex 22D.

IEEE Standard Register=0.14

STD_MMDDATA **Reset Value**

MMD Access Data Register (Register 0.14) **0000_H**



Field	Bits	Type	Description
ADDR_DATA	15:0	RW	**Address or Data Register** This register accesses either a specific MMD address register or the data content of the MMD register to which this address register points. The MMDCTRL register defines which function is currently valid.

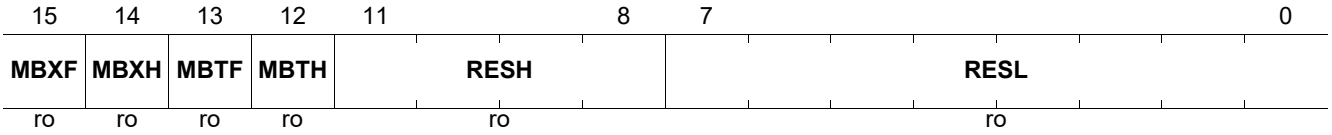
Extended Status Register (Register 0.15)

This register contains extended status and capability information about the PHY. All the bits are read-only. A write access does not have any effect.

IEEE Standard Register=0.15

STD_XSTAT **Reset Value**

Extended Status Register (Register 0.15) **2000_H**



Field	Bits	Type	Description
MBXF	15	RO	**1000BASE-X Full-Duplex Capability** Specifies whether the PHY is capable of operating 1000BASE-X full-duplex. 0_B **DISABLED** PHY does not support this mode. 1_B **ENABLED** PHY supports this mode.
MBXH	14	RO	**1000BASE-X Half-Duplex Capability** Specifies whether the PHY is capable of operating 1000BASE-X half-duplex. 0_B **DISABLED** PHY does not support this mode. 1_B **ENABLED** PHY supports this mode.
MBTF	13	RO	**1000BASE-T Full-Duplex Capability** Specifies whether the PHY is capable of operating 1000BASE-T full-duplex. 0_B **DISABLED** PHY does not support this mode. 1_B **ENABLED** PHY supports this mode.
MBTH	12	RO	**1000BASE-T Half-Duplex Capability** GPHY do not support 1000BASE-T half-duplex capability. 0_B **DISABLED** PHY does not support this mode. 1_B **ENABLED** PHY supports this mode.
RESH	11:8	RO	**Reserved** Ignore when read.
RESL	7:0	RO	**Reserved** Ignore when read.

5.2 PHY-specific Management Registers

This section describes the PHY-specific management registers in device 0.

Table 29 Registers Overview- PHY-specific Management Registers

Register Short Name	Register Long Name	Reset Value
PHY_STAT1	Physical Layer Status 1 (Register 0.17)	$000C_H$
PHY_CTL1	Physical Layer Control 1 (Register 0.19)	0001_H
PHY_CTL2	Physical Layer Control 2 (Register 0.20)	0006_H
PHY_ERRCNT	Error Counter (Register 0.21)	0000_H
PHY_MIISTAT	Media-Independent Interface Status (Register 0.24)	0000_H
PHY_IMASK	Interrupt Mask Register (Register 0.25)	0000_H
PHY_ISTAT	Interrupt Status Register (Register 0.26)	0000_H
PHY_LED	LED Control Register (Register 0.27)	$FF00_H$
PHY_TPGCTRL	Test-Packet Generator Control (Register 0.28)	0000_H
PHY_TPGDATA	Test-Packet Generator Data (Register 0.29)	$00AA_H$
PHY_FWV	Firmware Version Register (Register 0.30)	0000_H

5.2.1 PHY-specific Management Register Descriptions

This section describes all the PHY registers in detail.

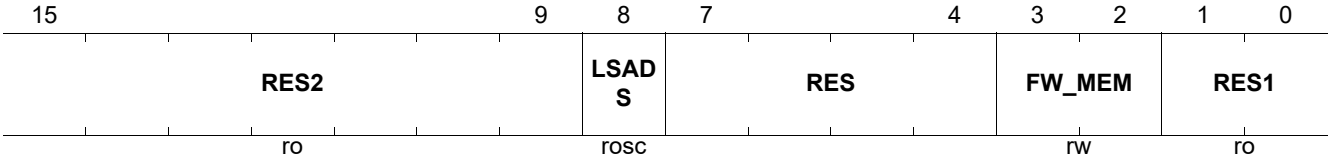
Physical Layer Status 1 (Register 0.17)

This register reports PHY link information, for example link-up, polarity reversals, and port mapping. The content of this register is only valid when the link is up.

IEEE Standard Register=0.17

PHY_STAT1 **Reset Value**

Physical Layer Status 1 (Register 0.17) **$000C_H$**



Field	Bits	Type	Description
RES2	15:9	RO	**Reserved** Write as zero, ignored on read.
LSADS	8	ROSC	**Link Speed Auto-Downspeed Status** Monitors the status of the Auto-Downspeed (ADS). 0_B **NORMAL** Did not perform any link speed ADS. 1_B **DETECTED** Detected an ADS.
FW_MEM	3:2	RW	**Firmware Memory Location** Indicates memory target used for firmware execution. 11_B **RAM** Firmware is executed from SRAM. Others: Reserved.
RES1	1:0	RO	**Reserved** Write as zero, ignored on read.

Physical Layer Control 1 (Register 0.19)

This register controls the PHY functions.

IEEE Standard Register=0.19

PHY_CTL1 **Reset Value**

Physical Layer Control 1 (Register 0.19) **0001_H**

15	13	12	11	8	7	6	5	4	3	2	1	0
TLOOP		TXOFF	TXADJ		POLD	POLC	POLB	POLA	MDICD	MDIAB	RES	AMDIX
rw		rw	rw		rw	rw	rw	rw	rw	rw	ro	rw

Field	Bits	Type	Description
TLOOP	15:13	RW	**Test Loop** Configures predefined test loops. 000_B **OFF** Test loops are switched off - normal operation. 001_B **NETL** Near-end test loop 010_B **FETL** Far-end test loop. 100_B **RJTL** RJ45 connector test loop. 101_B **FETL S** Standalone far-end test loop. No dependency on GMII_TX_CLK and GMII_RX_CLK. Others: Reserved.
TXOFF	12	RW	**Transmitter Off** This register bit turns the transmitter off. This feature is used for return loss measurements. 0_B **ON** Transmitter is on. 1_B **OFF** Transmitter is off.
TXADJ	11:8	RW	**Transmit Level Adjustment** Reserved.
POLD	7	RW	**Polarity Inversion Control on Port D** 0_B **NORMAL** Polarity normal 1_B **INVERTED** Polarity inversion
POLC	6	RW	**Polarity Inversion Control on Port C** 0_B **NORMAL** Polarity normal 1_B **INVERTED** Polarity inversion
POLB	5	RW	**Polarity Inversion Control on Port B** 0_B **NORMAL** Polarity normal 1_B **INVERTED** Polarity inversion
POLA	4	RW	**Polarity Inversion Control on Port A** 0_B **NORMAL** Polarity normal 1_B **INVERTED** Polarity inversion
MDICD	3	RW	**Mapping of MDI Ports C and D** Used when Auto-MDIX is OFF to force the MDIX cable crossover configuration. 0_B **MDI** Normal MDI mode 1_B **MDIX** Crossover MDI-X mode

Field	Bits	Type	Description (cont'd)
MDIAB	2	RW	**Mapping of MDI Ports A and B** Used when Auto-MDIX is OFF to force the MDIX cable crossover configuration. 0_B **MDI** Normal MDI mode 1_B **MDIX** Crossover MDI-X mode
RES	1	RO	**Reserved**
AMDIX	0	RW	**PHY Performs Auto-MDI/MDI-X or Uses Manual MDI/MDI-X** 0_B **MANUAL** PHY uses manual MDI/MDI-X. 1_B **AUTO** PHY performs Auto-MDI/MDI-X.

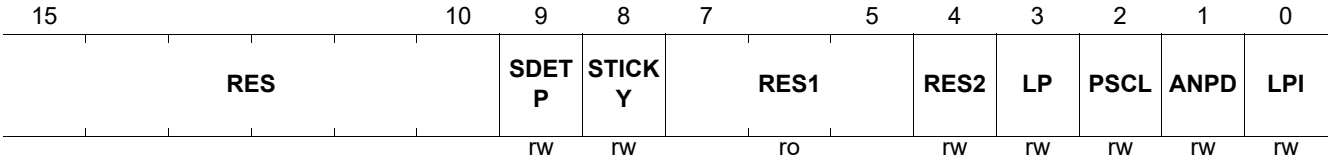
Physical Layer Control 2 (Register 0.20)

This register controls the PHY functions.

IEEE Standard Register=0.20

PHY_CTL2 **Reset Value**

Physical Layer Control 2 (Register 0.20) **0006_H**



Field	Bits	Type	Description
SDETP	9	RW	**Signal Detection Polarity for the 1000BASE-X PHY** This field is reserved because 1000BASE-X is not supported on this PHY port.
STICKY	8	RW	**Sticky-Bit Handling** Setting this bit to 1_B ensures that all the vendor specific registers (of type RW) in the PHY (device 0), VSPEC1 (device 30), and VSPEC2 (device 31) are not changed during a MDIO reset or software reset of the GPHY. This allows the STA to keep the configurations chosen before reset. 0_B **OFF** Sticky-bit handling is disabled. 1_B **ON** Sticky-bit handling is enabled.
RES1	7:5	RO	**Reserved** Write as zero, ignored on read.
RES2	4	RW	**Reserved**
LP	3	RW	**Low Power Mode** Low Power Mode (LP) allows the GPHY to save energy by disabling most of the digital logic to reduce power consumption to its lowest level. The entry to LP is triggered when the PHY does not sense any energy on the cable and no link pulses (NLP, FLP, Beacons) are received. After spending VSPEC1_NBT_DS_CTRL.NRG_RST_CNT without energy in the ABILITY_DETECT state defined by IEEE 802.3 Clause 28, and after the timer defined VSPEC1_LOW_POWER_ENTRY_TIME.LPE_TIM expired, the PHY enters LP. 0_B **OFF** LP is disabled. The GPHY does not enter LP. 1_B **ON** LP is enabled. The GPHY enters LP when no energy is sensed.
PSCL	2	RW	**Power Consumption Scaling Depending on Link Quality** Allows enabling/disabling of the power consumption scaling depending on the link quality. 0_B **OFF** PSCL is disabled. 1_B **ON** PSCL is enabled.

Field	Bits	Type	Description (cont'd)
ANPD	1	RW	**Auto-Negotiation Power Down** Allows enabling/disabling of the power down modes during auto-negotiation looking for a link partner. 0_B **OFF** ANPD is disabled. 1_B **ON** ANPD is enabled.
LPI	0	RW	**Assert LPI via MDIO** Controls assertion/de-assertion of the LPI by the MDIO instead of following the (X)GMII LPI. Used to force the EEE on the TPI (ignoring the LPI indication from MAC). 0_B **DE-ASSERT** LPI is de-asserted on TPI. 1_B **ASSERT** LPI is asserted on TPI.

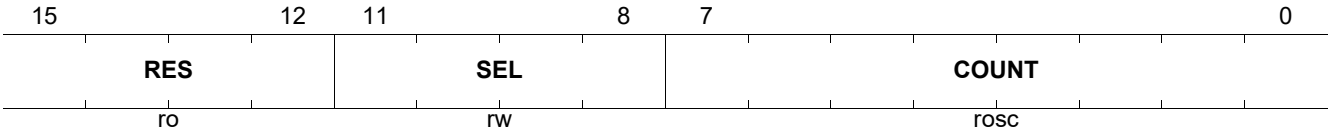
Error Counter (Register 0.21)

This register controls the error counter. It allows the number of errors detected in the PHY to be counted for monitoring purposes.

IEEE Standard Register=0.21

PHY_ERRCNT **Reset Value**

Error Counter (Register 0.21) **0000_H**



Field	Bits	Type	Description
RES	15:12	RO	**Reserved** Write as zero, ignored on read.
SEL	11:8	RW	**Select Error Event** Configures which error type the error counter counts: 0000_B**RXERR** Receive errors are counted. 0001_B**RXACT** Receive frames are counted. 0010_B**ESDERR** ESD errors are counted. 0011_B**SSDERR** SSD errors are counted. 0100_B**TXERR** Transmit errors are counted. 0101_B**TXACT** Transmit frames events are counted. 0110_B**COL** Collision events are counted. 1000_B**NLD** Number of Link Down events are counted. 1001_B**NDS** Number of ADS events are counted. 1010_B**RES** Reserved 1011_B**RES** Reserved
COUNT	7:0	ROSC	**Counter Value** This counter value is updated each time the selected error event is detected. The counter value is reset every time a read operation on this register is performed or the error event is changed. The counter saturates at value FF_H.

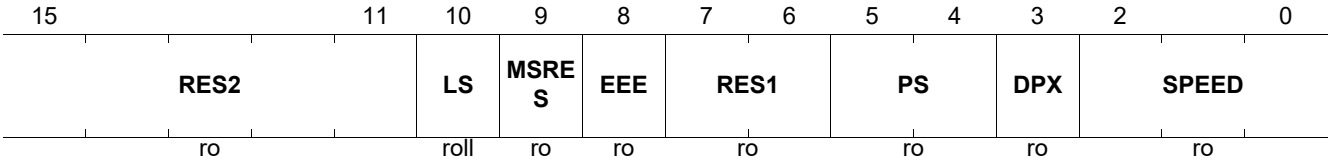
Media-Independent Interface Status (Register 0.24)

This register contains status information on the Ethernet link, concatenated in a single register to allow concise status read by the STA in a single register.

IEEE Standard Register=0.24

PHY_MIISTAT **Reset Value**

Media-Independent Interface Status (Register 0.24) **0000_H**



Field	Bits	Type	Description
RES2	15:11	RO	**Reserved** Write as zero, ignored on read.
LS	10	ROLL	**Link Status of GPHY Ethernet PHY Operation** Indicates the link status of the PHY. 0_B **INACTIVE** The link is down. No communication with link partner possible. 1_B **ACTIVE** The link is up. Data communication with link partner is possible.
MSRES	9	RO	**Master/Slave Configuration** Indicates the master/slave configuration 0_B **SLAVE** Local PHY configuration is SLAVE after ANEG. 1_B **MASTER** Local PHY configuration is MASTER after ANEG.
EEE	8	RO	**Energy-Efficient Ethernet Mode** 0_B **OFF** EEE is disabled after ANEG resolution. 1_B **ON** EEE is enabled after ANEG resolution.
RES1	7:6	RO	**Reserved**
PS	5:4	RO	**Pause Status for Flow Control** 00_B **NONE** No PAUSE 01_B **TX** Transmit PAUSE 10_B **RX** Receive PAUSE 11_B **TXRX** Both transmit and receive PAUSE
DPX	3	RO	**GPHY Ethernet PHY Duplex Mode** 0_B **HDX** Half-duplex 1_B **FDX** Full-duplex
SPEED	2:0	RO	**GPHY Ethernet PHY Speed** 000_B **TEN** 10 Mbps 001_B **FAST** 100 Mbps 010_B **GIGA** 1000 Mbps 011_B **ANEG** Auto-negotiation mode 100_B **BZ2G5** 2.5 Gbps

Interrupt Mask Register (Register 0.25)

This register defines the mask for the Interrupt Status Register (ISTAT), which contains the event source for the MDINT interrupt sent from the GPHY to an external chip.

The information about the interrupt source is indicated in the ISTAT register.

IEEE Standard Register=0.25

PHY_IMASK **Reset Value**

Interrupt Mask Register (Register 0.25) **0000_H**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
WOL	**MSRE**	**NPRX**	**NPTX**	**ANE**	**ANC**	**RES**	**LOR**	**LP**	**TEMP**	**ADSC**	**MDIPC**	**MDIXC**	**DXMC**	**LSPC**	**LSTC**
rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw	rw

Field	Bits	Type	Description
WOL	15	RW	**Wake-on-LAN Event Mask** When active and masked in IMASK, the MDINT is activated upon detection of a valid WoL event. 0_B **INACTIVE** Interrupt is masked out. 1_B **ACTIVE** Interrupt is activated.
MSRE	14	RW	**Master/Slave Resolution Error Mask** When active, MDINT is activated upon detection of a master/slave resolution error (MSRE) during a 1000BASE-T ANEG. 0_B **INACTIVE** Interrupt is masked out. 1_B **ACTIVE** Interrupt is activated.
NPRX	13	RW	**Next Page Received Mask** When active, MDINT is activated upon reception of a next page in STD_AN_NPRX. 0_B **INACTIVE** Interrupt is masked out. 1_B **ACTIVE** Interrupt is activated.
NPTX	12	RW	**Next Page Transmitted Mask** When active, MDINT is activated upon transmission of the currently stored next page in STD_AN_NPTX. 0_B **INACTIVE** Interrupt is masked out. 1_B **ACTIVE** Interrupt is activated.
ANE	11	RW	**Auto-Negotiation Error Mask** When active, MDINT is activated upon detection of an ANEG error. 0_B **INACTIVE** Interrupt is masked out. 1_B **ACTIVE** Interrupt is activated.
ANC	10	RW	**Auto-Negotiation Complete Mask** When active, MDINT is activated upon completion of the ANEG process. 0_B **INACTIVE** Interrupt is masked out. 1_B **ACTIVE** Interrupt is activated.

Field	Bits	Type	Description (cont'd)
LOR	8	RW	**SyncE Loss Of Reference** When active, MDINT is activated upon loss of SyncE reference clock. 0_B **INACTIVE** Interrupt is masked out. 1_B **ACTIVE** Interrupt is activated.
LP	7	RW	**LP Entry Indication Mask** 0_B **INACTIVE** Interrupt is masked out. The STA does not need to be informed of the event. 1_B **ACTIVE** Interrupt is activated. The STA receives MDINT when the PHY is about to enter LP.
TEMP	6	RW	**TEMP** 0_B **INACTIVE** Interrupt is masked out. The STA does not need to be informed of the event. 1_B **ACTIVE** Interrupt is activated. The interrupt is triggered when the temperature goes beyond the normal operating range.
ADSC	5	RW	**Link Speed Auto-Downspeed Detect Mask** When active, MDINT is activated upon detection of a link speed ADS event. 0_B **INACTIVE** Interrupt is masked out. 1_B **ACTIVE** Interrupt is activated.
MDIPC	4	RW	**MDI Polarity Change Detect Mask** When active, MDINT is activated upon detection of an MDI polarity change event. 0_B **INACTIVE** Interrupt is masked out. 1_B **ACTIVE** Interrupt is activated.
MDIXC	3	RW	**MDIX Change Detect Mask** When active, MDINT is activated upon detection of an MDI/MDIX cross-over change event. 0_B **INACTIVE** Interrupt is masked out. 1_B **ACTIVE** Interrupt is activated.
DXMC	2	RW	**Duplex Mode Change Mask** When active, MDINT is activated upon detection of full or half-duplex change. 0_B **INACTIVE** Interrupt is masked out. 1_B **ACTIVE** Interrupt is activated.
LSPC	1	RW	**Link Speed Change Mask** When active, MDINT is activated upon detection of link speed change. 0_B **INACTIVE** Interrupt is masked out. 1_B **ACTIVE** Interrupt is activated.
LSTC	0	RW	**Link State Change Mask** When active, MDINT is activated upon detection of link status change. 0_B **INACTIVE** Interrupt is masked out. 1_B **ACTIVE** Interrupt is activated.

Interrupt Status Register (Register 0.26)

This register defines the event source for the MDINT interrupt sent from the GPHY to an external chip.

PHY_ISTAT is a cleared on read by the STA.

IEEE Standard Register=0.26

PHY_ISTAT **Reset Value**

Interrupt Status Register (Register 0.26) **0000_H**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
WOL	**MSRE**	**NPRX**	**NPTX**	**ANE**	**ANC**	**RES**	**LOR**	**LP**	**TEMP**	**ADSC**	**MDIPC**	**MDIXC**	**DXMC**	**LSPC**	**LSTC**
rosc	rosc	rosc	rosc	rosc	rosc	rosc	rosc	rosc	rosc	rosc	rosc	rosc	rosc	rosc	rosc

Field	Bits	Type	Description
WOL	15	ROSC	**Wake-on-LAN Interrupt Status** When this bit is set, the MDINT is activated upon detection of a valid WoL event. 0_B **INACTIVE** This event is not the interrupt source. 1_B **ACTIVE** The WoL event is the source of the interrupt.
MSRE	14	ROSC	**Master/Slave Resolution Error Interrupt Status** When this bit is set, the MDINT is activated upon detection of a MSRE during a 1000BASE-T ANEG. 0_B **INACTIVE** This event is not the interrupt source. 1_B **ACTIVE** The MSRE event is the source of the interrupt.
NPRX	13	ROSC	**Next Page Received Interrupt Status** When this bit is set, the MDINT is activated upon reception of a next page in STD_AN_NPRX. 0_B **INACTIVE** This event is not the interrupt source. 1_B **ACTIVE** The NPRX event is the source of the interrupt.
NPTX	12	ROSC	**Next Page Transmitted Interrupt Status** When this bit is set, the MDINT is activated upon transmission of the currently stored next page in STD_AN_NPTX. 0_B **INACTIVE** This event is not the interrupt source. 1_B **ACTIVE** The NPTX event is the source of the interrupt.
ANE	11	ROSC	**Auto-Negotiation Error Interrupt Status** When this bit is set, the MDINT is activated upon detection of an ANEG error. 0_B **INACTIVE** This event is not the interrupt source. 1_B **ACTIVE** The ANEG error event is the source of the interrupt.
ANC	10	ROSC	**Auto-Negotiation Complete Interrupt Status** When this bit is set, the MDINT is activated upon completion of the ANEG process. 0_B **INACTIVE** This event is not the interrupt source. 1_B **ACTIVE** The ANEG complete event is the source of the interrupt.

Field	Bits	Type	Description (cont'd)
LOR	8	ROSC	**SyncE Loss Of Reference** When this bit is set, MDINT is activated upon loss of SyncE reference clock. 0_B **INACTIVE** This event is not the interrupt source. 1_B **ACTIVE** The LOR change event is the source of the interrupt.
LP	7	ROSC	**LP Entry Indication** 0_B **INACTIVE** No indication of LP entry 1_B **ACTIVE** Indication of LP entry.
TEMP	6	ROSC	**TEMP** Indicates that thermal mitigation action must be taken when the temperature goes beyond the normal operating range. The GPHY implements ADS by default when this happens, but it is possible to disable ADS. When the SoC disables ADS, it is recommended that the SoC initiates a link down and changes the speed capability to cool the device back to the normal temperature range. When the temperature reaches the maximum absolute rating, the device resets for safety purposes. Thermal mitigation must ensure that the maximum absolute temperature limits are never reached. 0_B **INACTIVE** This event is not the interrupt source. 1_B **ACTIVE** The TEMP change event is the source of the interrupt.
ADSC	5	ROSC	**Link Speed Auto-Downspeed Detect Interrupt Status** When this bit is set, the MDINT is activated upon detection of a link speed ADS event. 0_B **INACTIVE** This event is not the interrupt source. 1_B **ACTIVE** The ADSC change event is the source of the interrupt.
MDIPC	4	ROSC	**MDI Polarity Change Detect Interrupt Status** When this bit is set, the MDINT is activated upon detection of an MDI polarity change event. 0_B **INACTIVE** This event is not the interrupt source. 1_B **ACTIVE** The MDIPC change event is the source of the interrupt.
MDIXC	3	ROSC	**MDIX Change Detect Interrupt Status** When this bit is set, the MDINT is activated upon detection of an MDI/MDIX cross-over change event. 0_B **INACTIVE** This event is not the interrupt source. 1_B **ACTIVE** The MDIX change event is the source of the interrupt.
DXMC	2	ROSC	**Duplex Mode Change Interrupt Status** When this bit is set, the MDINT is activated upon detection of a full or half-duplex change. 0_B **INACTIVE** This event is not the interrupt source. 1_B **ACTIVE** The DXMC change event is the source of the interrupt.
LSPC	1	ROSC	**Link Speed Change Interrupt Status** When this bit is set, the MDINT is activated upon detection of link speed change. 0_B **INACTIVE** This event is not the interrupt source. 1_B **ACTIVE** The LSPC change event is the source of the interrupt.

Field	Bits	Type	Description (cont'd)
LSTC	0	ROSC	**Link State Change Interrupt Status** When this bit is set, the MDINT is activated upon detection of link status change. 0_B **INACTIVE** This event is not the interrupt source. 1_B **ACTIVE** The LSTC change event is the source of the interrupt.

LED Control Register (Register 0.27)

This register contains the control bits for direct access to the LEDs by setting the on/off LEDxDA bits (where x is from 0 to 1).

To directly control the LED, the integrated LED functions must be disabled by the LEDxEN bit in this register.

The integrated LED functions are specified in the more sophisticated LED control registers in the MMD device VSPEC1.

IEEE Standard Register=0.27

PHY_LED **Reset Value**

LED Control Register (Register 0.27) **$FF00_H$**

15	12	11	10	9	8	7	4	3	2	1	0
RES		RES	RES	LED1EN	LED0EN	RES1		RES	RES	LED1DA	LED0DA
rw		rw	rw	rw	rw	ro		rw	rw	rw	rw

Field	Bits	Type	Description
RES	15:12	RW	**Reserved** The default value must not be changed.
LED1EN	9	RW	**Enable Integrated Function of LED1** Write a 0 to this bit to disable the pre-configured integrated function for this LED. The LED remains off unless directly accessed via LED1DA. 0_B **DISABLE** Disables the integrated LED function. 1_B **ENABLE** Enables the integrated LED function.
LED0EN	8	RW	**Enable Integrated Function of LED0** Write a 0 to this bit to disable the pre-configured integrated function for this LED. The LED remains off unless directly accessed via LED0DA. 0_B **DISABLE** Disables the integrated LED function. 1_B **ENABLE** Enables the integrated LED function.
RES1	7:4	RO	**Reserved** Write as zero, ignored on read.
LED1DA	1	RW	**Direct Access to LED1** Write a 1 to this bit to illuminate the LED. LED1EN must be set to zero. 0_B **OFF** Switch off the LED. 1_B **ON** Switch on the LED.
LED0DA	0	RW	**Direct Access to LED0** Write a 1 to this bit to illuminate the LED. LED0EN must be set to zero. 0_B **OFF** Switch off the LED. 1_B **ON** Switch on the LED.

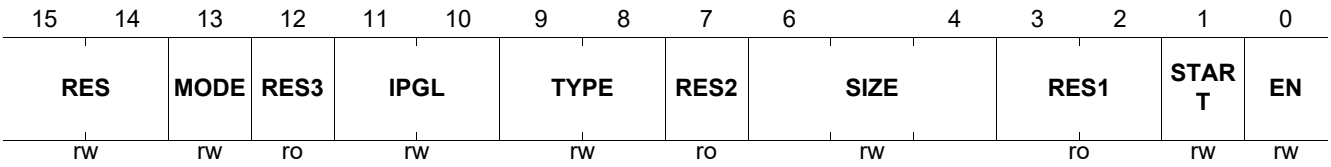
Test-Packet Generator Control (Register 0.28)

This register controls the operation of the integrated Test-Packet Generator (TPG). This module is only used for testing purposes.

IEEE Standard Register=0.28

PHY_TPGCTRL **Reset Value**

Test-Packet Generator Control (Register 0.28) **0000_H**



Field	Bits	Type	Description
RES	15:14	RW	**Reserved** Write as zero, ignore on read.
MODE	13	RW	**TPG Mode** Configures the packet generation mode. 0_B **CONTINUOUS** Sends packets continuously. 1_B **SINGLE** Sends a single packet.
RES3	12	RO	**Reserved** Write as zero, ignore on read.
IPGL	11:10	RW	**Inter-Packet Gap Length** Configures the length of the inter-packet gap in bit times. 00_B **RES** Reserved 01_B **BT96** Length is 96 bit times 10_B **BT960** Length is 960 bit times 11_B **BT9600** Length is 9600 bit times
TYPE	9:8	RW	**Packet Data Type** Configures the packet data type to be either predefined, byte increment, or random. When predefined, the content of the register TPGDATA is used. 00_B **RANDOM** Uses random data as the packet content. 01_B **BYTEINC** Uses byte increment as the packet content. 10_B **PREDEF** Uses predefined content of the register TPGDATA. 11_B **RES** Reserved.
RES2	7	RO	**Reserved.** Write as zero, ignore on read.

Field	Bits	Type	Description (cont'd)
SIZE	6:4	RW	**Packet Size** Configures the size of the generated Ethernet packets in bytes. The size includes DA, SA, length/type, payload, and FCS. 000_B **B64** Packet length is 64 bytes 001_B **B2048** Packet length is 2048 bytes 010_B **B256** Packet length is 256 bytes 011_B **B4096** Packet length is 4096 bytes 100_B **B1024** Packet length is 1024 bytes 101_B **B1518** Packet length is 1518 bytes 110_B **B9000** Packet length is 9000 bytes
RES1	3:2	RO	**Reserved** Write as zero, ignore on read.
START	1	RW	**Start or Stop TPG Data Generation.** Starts the TPG data generation. Depending on the MODE, the TPG sends only one packet or chunks of 10000 packets until stopped. 0_B **STOP** Stops the TPG data generation. 1_B **START** Starts the TPG data generation.
EN	0	RW	**Enable the TPG** Enables the TPG for data generation. 0_B **DISABLE** Disables the TPG 1_B **ENABLE** Enables the TPG

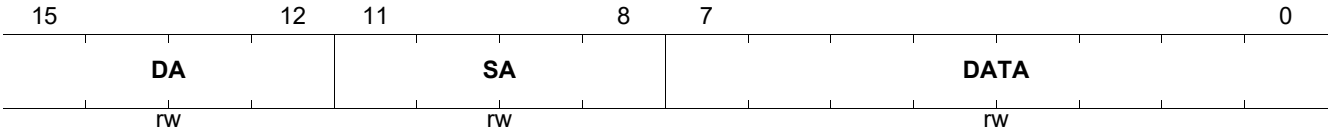
Test-Packet Generator Data (Register 0.29)

Specifies the payload data to be used when sending a non-random data packet. All payload data bytes are sent with this value.

IEEE Standard Register=0.29

PHY_TPGDATA **Reset Value**

Test-Packet Generator Data (Register 0.29) **$00AA_H$**



Field	Bits	Type	Description
DA	15:12	RW	**Destination Address** Configures the destination address nibble. The destination address builds up to 00-03-19-FF-FF-F[DA].
SA	11:8	RW	**Source Address** Configures the source address nibble. The source address builds up to 00-03-19-FF-FF-F[SA].
DATA	7:0	RW	**Data Byte to be Transmitted** This is the content of the payload bytes in the frame to send constant data. The bit masks are shown here. For configuration details, refer to the corresponding chapter. 80_H **PREC** Selects whether to take full precision (1) or reduced precision (0) at bit 7 60_H **PREC2** For reduced precision, selects the options with bits [6:5] 10_H **RESERVED** Reserved

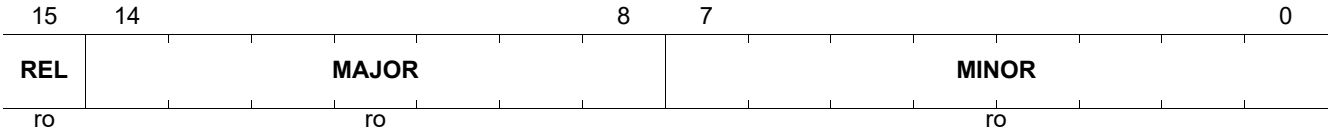
Firmware Version Register (Register 0.30)

This register contains the version of the PHY firmware. The firmware initializes the version number at boot time with its current software version. This register is read-only by the external STA.

IEEE Standard Register=0.30

PHY_FWV **Reset Value**

Firmware Version Register (Register 0.30) **0000_H**



Field	Bits	Type	Description
REL	15	RO	**Release Indication** This parameter indicates either a test or a release version. 0_B **TEST** Indicates a test version. 1_B **RELEASE** Indicates a released version.
MAJOR	14:8	RO	**Major Version Number** Specifies the main version release number of the firmware.
MINOR	7:0	RO	**Minor Version Number** Specifies the sub-version release number of the firmware.

6 MMD Registers Detailed Description

Table 30 Register Access Type

Mode	Symbol
Status Register (Status or Ability Register)	RO
Read-Write Register (MDIO Register)	RW
Read-Write Self-Clearing Register (bit is cleared after read from MDIO)	RWSC
Read-Only Self-Clearing Register (bit is cleared after read from MDIO)	ROSC

6.1 Standard PMAPMD Registers for MMD=0x01

Table 31 Registers Overview- Standard PMAPMD Registers

Register Short Name	Register Long Name	Reset Value
PMA_CTRL1	PMA/PMD Control 1 (Register 1.0)	2058_H
PMA_STAT1	PMA/PMD Status 1 (Register 1.1)	0000_H
PMA_DEVID1	PHY Identifier 1 (Register 1.2)	$C133_H$
PMA_DEVID2	PHY Identifier 2 (Register 1.3)	5400_H 1)
PMA_SPEED_ABILITY	PMA/PMD Speed Ability (Register 1.4)	2070_H
PMA_DIP1	Devices in Package 1 (Register 1.5)	$008B_H$
PMA_DIP2	Devices in Package 2 (Register 1.6)	$C000_H$
PMA_CTL2	PMA/PMD Control 2 (Register 1.7)	0030_H
PMA_STAT2	PMA/PMD Status 2 (Register 1.8)	8200_H
PMA_EXT_ABILITY	PMA/PMD Extended Ability (Register 1.11)	$41A0_H$
PMA_PACKID1	AN Package Identifier (Register 1.14)	$C133_H$
PMA_PACKID2	AN Package Identifier (Register 1.15)	5400_H 1)
PMA_MGBT_EXTAB	PMAPMD Extended Ability (Register 1.21)	0001_H
PMA_MGBT_STAT	MULTIGBASE-T Status (Register 1.129)	0000_H
PMA_MGBT_POLARITY	MULTIGBASE-T Pair Swap and Polarity (Register 1.130)	0003_H
PMA_MGBT_TX_PBO	MULTIGBASE-T Tx Power Backoff and PHY Short Reach Setting (Register 1.131)	0000_H
PMA_MGBT_TEST_MODE	MULTIGBASE-T Test Mode (Register 1.132)	0000_H
PMA_MGBT_SNR_OPMARGIN_A	MULTIGBASE-T SNR Margin Channel A (Register 1.133)	0000_H
PMA_MGBT_SNR_OPMARGIN_B	MULTIGBASE-T SNR Margin Channel B (Register 1.134)	0000_H
PMA_MGBT_SNR_OPMARGIN_C	MULTIGBASE-T SNR Margin Channel C (Register 1.135)	0000_H
PMA_MGBT_SNR_OPMARGIN_D	MULTIGBASE-T SNR Margin Channel D (Register 1.136)	0000_H
PMA_MGBT_MINMARGIN_A	MULTIGBASE-T SNR Minimum Margin Channel A (Register 1.137)	0000_H
PMA_MGBT_MINMARGIN_B	MULTIGBASE-T SNR Minimum Margin Channel B (Register 1.138)	0000_H
PMA_MGBT_MINMARGIN_C	MULTIGBASE-T SNR Minimum Margin Chan C (Register 1.139)	0000_H
PMA_MGBT_MINMARGIN_D	MULTIGBASE-T SNR Minimum Margin Chan D (Register 1.140)	0000_H
PMA_MGBT_POWER_A	MULTIGBASE-T Rx Power Channel A (Register 1.141)	0000_H
PMA_MGBT_POWER_B	MULTIGBASE-T Rx Power Channel B (Register 1.142)	0000_H
PMA_MGBT_POWER_C	MULTIGBASE-T Rx Power Chan C (Register 1.143)	0000_H
PMA_MGBT_POWER_D	MULTIGBASE-T Rx Power Chan D (Register 1.144)	0000_H
PMA_MGBT_SKEW_DELAY_0	MULTIGBASE-T Skew Delay 0 (Register 1.145)	0000_H
PMA_MGBT_SKEW_DELAY_1	MULTIGBASE-T Skew Delay 1 (Register 1.146)	0000_H

Table 31 Registers Overview- Standard PMAPMD Registers (cont'd)

Register Short Name	Register Long Name	Reset Value
PMA_MGBT_FAST_RETRAIN_STA_CTRL	MULTIGBASE-T Skew Delay 2 (Register 1.147)	0010_H
PMA_TIMESYNC_CAP	PMA TimeSync Capability Indication (Register 1.1800)	0000_H

1) For the device specific reset value, see the Product and Package Naming table in the **Product Ordering Information** chapter.

6.1.1 PMAPMD Register Descriptions

This section describes all the PMAPMD registers in detail.

PMA/PMD Control 1 (Register 1.0)

IEEE Standard Register=1.0

PMA_CTRL1 **Reset Value**

PMA/PMD Control 1 (Register 1.0) **2058_H**

15	14	13	12	11	10 ... 7	6	5 ... 2	1	0
RST	**RES**	**SSL**	**RES**	**LOW_POW***	**RES**	**SSM**	**SPEED_SEL**	**NS1**	**NS2**
rw		rw		rw		rw	rw	ro	ro

Field	Bits	Type	Description
RST	15	RW	**Reset** 0_B Normal operation 1_B PMA/PMD reset
SSL	13	RW	**Speed Selection (LSB)** Used in conjunction with field SPEED_SEL_MSB. MSB LSB: 00_B 10 Mbps 01_B 100 Mbps 10_B 1000 Mbps 11_B Bits [5:2] select the speed (SPEED_SEL field)
LOW_POWER	11	RW	**Low Power** 0_B Normal operation 1_B Enters low power mode.
SSM	6	RW	**Speed Selection (MSB)** Used in conjunction with field SPEED_SEL_LSB. MSB LSB: 00_B 10 Mbps 01_B 100 Mbps 10_B 1000 Mbps 11_B Bits [5:2] select the speed (SPEED_SEL field)
SPEED_SEL	5:2	RW	**Speed Selection** Bit usage (from bit 5 to bit 2): 0 0 0 0_B Not supported. The speed defaults to 2.5 Gbps. 0 0 0 1_B Not supported. The speed defaults to 2.5 Gbps. 0 0 1 0_B Not supported. The speed defaults to 2.5 Gbps. 0 0 1 1_B Not supported. The speed defaults to 2.5 Gbps. 0 1 0 0_B Not supported. The speed defaults to 2.5 Gbps. 0 1 0 1_B Not supported. The speed defaults to 2.5 Gbps. 0 1 1 0_B 2.5 Gbps 0 1 1 1_B Not supported 1 x x x_B Reserved

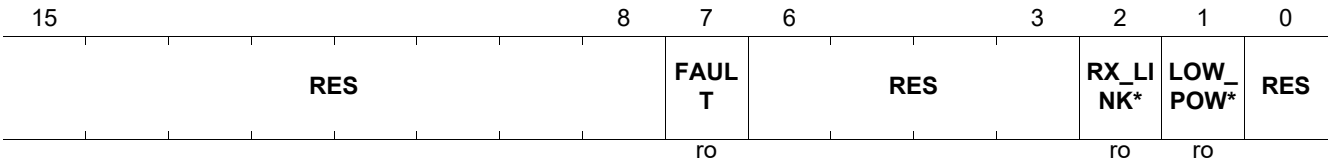
Field	Bits	Type	**Description** (cont'd)
NS1	1	RO	**Not Supported** PMA remote loopback mode is not supported by the GPHY.
NS2	0	RO	**Not Supported** PMA local loopback mode is not supported by the GPHY.

PMA/PMD Status 1 (Register 1.1)

IEEE Standard Register=1.1

PMA_STAT1 **Reset Value**

PMA/PMD Status 1 (Register 1.1) **0000_H**



Field	Bits	Type	Description
FAULT	7	RO	**Fault** 0_B Fault condition not detected 1_B Fault condition detected
RX_LINK_STATUS	2	RO	**Receive Link Status** 0_B PMA/PMD receive link down 1_B PMA/PMD receive link up
LOW_POWER_ABILITY	1	RO	**Low Power Ability** 0_B PMA/PMD does not support low power mode. 1_B PMA/PMD supports low power mode.

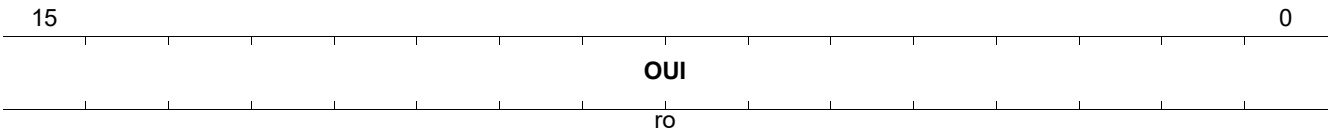
PHY Identifier 1 (Register 1.2)

IEEE Standard Register=1.2

Bits 31 - 16 of device ID

PMA_DEVID1 **Reset Value**

PHY Identifier 1 (Register 1.2) **$C133_H$**



Field	Bits	Type	Description
OUI	15:0	RO	**Organizationally Unique Identifier** Organizationally Unique Identifier Bits 3:18

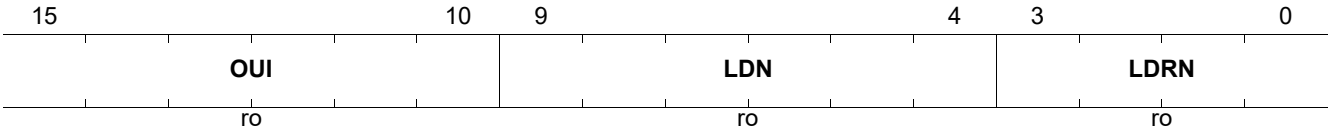
PHY Identifier 2 (Register 1.3)

IEEE Standard Register=1.3

Bits 15 - 0 of device ID

PMA_DEVID2 **Reset Value**

PHY Identifier 2 (Register 1.3) **5400_H**



Field	Bits	Type	Description
OUI	15:10	RO	**Organizationally Unique Identifier Bits 19:24**
LDN	9:4	RO	**Device Number** Specifies the device number[1)] to distinguish between several different products.
LDRN	3:0	RO	**Device Revision Number** Specifies the device revision number[1)] to distinguish between several versions of this device.

1) For the device specific reset value, see the Product and Package Naming table in the **Product Ordering Information** chapter.

PMA/PMD Speed Ability (Register 1.4)

IEEE Standard Register=1.4

PMA_SPEED_ABILITY **Reset Value**

PMA/PMD Speed Ability (Register 1.4) **2070_H**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
RES	**CAP_5G**	**CAP_2G5**	**RES2**	**RES**		**CAP_100G**	**CAP_40G**	**CAP_10_***	**CAP_10M**	**CAP_100M**	**CAP_100***	**RES**	**R10PASS***	**CAP_2BA***	**CAP_10G***
	ro	ro	ro			ro	ro	ro	ro	ro	ro		ro	ro	ro

Field	Bits	Type	Description
CAP_5G	14	RO	**Not Supported** 0_B PMA/PMD is not capable of operating as 5 Gbps. 1_B PMA/PMD is capable of operating at 5 Gbps.
CAP_2G5	13	RO	**2.5 G capable** 0_B PMA/PMD is not capable of operating as 2.5 Gbps. 1_B PMA/PMD is capable of operating at 2.5 Gbps.
RES2	12	RO	**Reserved** Value always 0
CAP_100G	9	RO	**Not Supported** 0_B PMA/PMD is not capable of operating as 100 Gbps. 1_B PMA/PMD is capable of operating at 100 Gbps.
CAP_40G	8	RO	**Not Supported** 0_B PMA/PMD is not capable of operating as 40 Gbps. 1_B PMA/PMD is capable of operating at 40 Gbps.
CAP_10_1G	7	RO	**Not Supported** 0_B PMA/PMD is not capable of operating at 10 Gbps downstream and 1 Gbps upstream. 1_B PMA/PMD is capable of operating at 10 Gbps downstream and 1 Gbps upstream.
CAP_10M	6	RO	**10M capable** 0_B PMA/PMD is not capable of operating as 10 Mbps. 1_B PMA/PMD is capable of operating at 10 Mbps.
CAP_100M	5	RO	**100M capable** 0_B PMA/PMD is not capable of operating as 100 Mbps. 1_B PMA/PMD is capable of operating at 100 Mbps.
CAP_1000M	4	RO	**1000M capable** 0_B PMA/PMD is not capable of operating as 1000 Mbps. 1_B PMA/PMD is capable of operating at 1000 Mbps.
R10PASS_TS_CAPABLE	2	RO	**Not Supported** 0_B PMA/PMD is not capable of operating as 10PASS-TS. 1_B PMA/PMD is capable of operating as 10PASS-TS.

Field	Bits	Type	Description (cont'd)
CAP_2BASE_TL	1	RO	**Not Supported** 0_B PMA/PMD is not capable of operating as 2BASE-TL. 1_B PMA/PMD is capable of operating as 2BASE-TL.
CAP_10G_CAP	0	RO	**Not Supported** 0_B PMA/PMD is not capable of operating at 10 Gbps. 1_B PMA/PMD is capable of operating at 10 Gbps.

Devices in Package 1 (Register 1.5)

IEEE Standard Register=1.5

PMA_DIP1 **Reset Value**

Devices in Package 1 (Register 1.5) **$008B_H$**

15	12	11	10	9	8	7	6	5	4	3	2	1	0
RES		SEP_PMA*	SEP_PMA*	SEP_PMA*	SEP_PMA*	ANEG	TC	DTE_XS	PHY_XS	PCS	WIS	PMD_PMA	CLAUSE_*
ro		ro	ro	ro	ro	ro	ro	ro	ro	ro	ro	ro	ro

Field	Bits	Type	Description
RES	15:12	RO	**Reserved** Ignore on read
SEP_PMA_4	11	RO	**Separate PMA (4)** 0_B Separate PMA (4) not present in package 1_B Separate PMA (4) present in package
SEP_PMA_3	10	RO	**Separate PMA (3)** 0_B Separate PMA (3) not present in package 1_B Separate PMA (3) present in package
SEP_PMA_2	9	RO	**Separate PMA (2)** 0_B Separate PMA (2) not present in package 1_B Separate PMA (2) present in package
SEP_PMA_1	8	RO	**Separate PMA (1)** 0_B Separate PMA (1) not present in package 1_B Separate PMA (1) present in package
ANEG	7	RO	**Auto-Negotiation Present** This bit is always set to 1_B in the GPHY. 0_B ANEG not present in package 1_B ANEG present in package
TC	6	RO	**TC Present** 0_B TC not present in package 1_B TC present in package
DTE_XS	5	RO	**DTE XS Present** 0_B DTE XS not present in package 1_B DTE XS present in package
PHY_XS	4	RO	**PHY XS Present** 0_B PHY XS not present in package 1_B PHY XS present in package
PCS	3	RO	**PCS Present** This bit is always set to 1_B in the GPHY. 0_B PCS not present in package 1_B PCS present in package

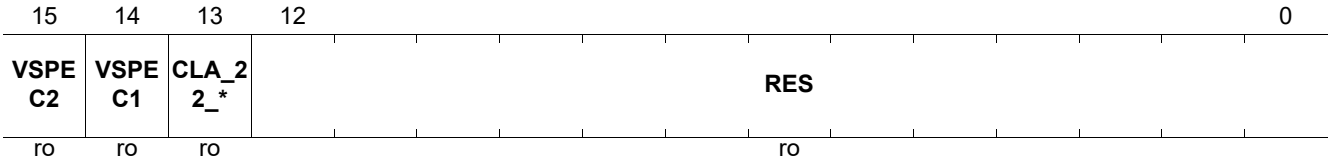
Field	Bits	Type	Description (cont'd)
WIS	2	RO	**WIS Present** 0_B WIS not present in package 1_B WIS present in package
PMD_PMA	1	RO	**PMD/PMA Present** This bit is always set to 1_B in the GPHY. 0_B PMA/PMD not present in package 1_B PMA/PMD present in package
CLAUSE_22	0	RO	**Clause 22 Registers Present** This bit is always set to 1_B in the GPHY. 0_B Clause 22 registers not present in package 1_B Clause 22 registers present in package

Devices in Package 2 (Register 1.6)

IEEE Standard Register=1.6

PMA_DIP2 **Reset Value**

Devices in Package 2 (Register 1.6) **$C000_H$**



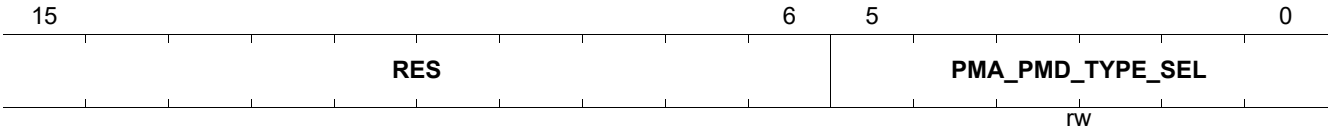
Field	Bits	Type	Description
VSPEC2	15	RO	**Vendor-specific Device 2** This bit is always set to 1_B in the GPHY. 0_B Vendor-specific device 2 not present in package 1_B Vendor-specific device 2 present in package
VSPEC1	14	RO	**Vendor-specific Device 1** This bit is always set to 1_B in the GPHY. 0_B Vendor-specific device 1 not present in package 1_B Vendor-specific device 1 present in package
CLA_22_EXT	13	RO	**Clause 22 Extension** 0_B Clause 22 extension not present in package 1_B Clause 22 extension present in package
RES	12:0	RO	**Reserved** Ignore on read.

PMA/PMD Control 2 (Register 1.7)

IEEE Standard Register=1.7

PMA_CTL2 **Reset Value**

PMA/PMD Control 2 (Register 1.7) **0030_H**



Field	Bits	Type	Description
PMA_PMD_TYPE_SEL	5:0	RW	**PMA/PMD Type Selection** 5 4 3 2 1 0 Others = Reserved 1 1 0 0 0 1_B Unsupported, defaults to 2.5GBASE-T PMA 1 1 0 0 0 0_B 2.5GBASE-T PMA 1 0 1 1 x x_B Unsupported, defaults to 2.5GBASE-T PMA 1 0 1 0 1 1_B Unsupported, defaults to 2.5GBASE-T PMA 1 0 1 0 1 0_B Unsupported, defaults to 2.5GBASE-T PMA 1 0 1 0 0 1_B Unsupported, defaults to 2.5GBASE-T PMA 1 0 1 0 0 0_B Unsupported, defaults to 2.5GBASE-T PMA 1 0 0 1 1 x_B Unsupported, defaults to 2.5GBASE-T PMA 1 0 0 1 0 1_B Unsupported, defaults to 2.5GBASE-T PMA 1 0 0 1 0 0_B Unsupported, defaults to 2.5GBASE-T PMA 1 0 0 0 1 1_B Unsupported, defaults to 2.5GBASE-T PMA 1 0 0 0 1 0_B Unsupported, defaults to 2.5GBASE-T PMA 1 0 0 0 0 1_B Unsupported, defaults to 2.5GBASE-T PMA 1 0 0 0 0 0_B Unsupported, defaults to 2.5GBASE-T PMA 0 1 1 1 x x_B Unsupported, defaults to 2.5GBASE-T PMA 0 1 1 0 1 1_B Unsupported, defaults to 2.5GBASE-T PMA 0 1 1 0 1 0_B Unsupported, defaults to 2.5GBASE-T PMA 0 1 1 0 0 1_B Unsupported, defaults to 2.5GBASE-T PMA 0 1 1 0 0 0_B Unsupported, defaults to 2.5GBASE-T PMA 0 1 0 1 1 1_B Unsupported, defaults to 2.5GBASE-T PMA 0 1 0 1 1 0_B Unsupported, defaults to 2.5GBASE-T PMA 0 1 0 1 0 1_B Unsupported, defaults to 2.5GBASE-T PMA 0 1 0 1 0 0_B Unsupported, defaults to 2.5GBASE-T PMA 0 1 0 0 1 1_B Unsupported, defaults to 2.5GBASE-T PMA 0 1 0 0 1 0_B Unsupported, defaults to 2.5GBASE-T PMA 0 1 0 0 0 1_B Unsupported, defaults to 2.5GBASE-T PMA 0 1 0 0 0 0_B Unsupported, defaults to 2.5GBASE-T PMA

Field	Bits	Type	**Description** (cont'd)
PMA_PMD_TYPE_SEL	5:0	RW	**PMA/PMD Type Selection (cont'd)** $0\ 0\ 1\ 1\ 1\ 1_B$ 10BASE-T PMA/PMD $0\ 0\ 1\ 1\ 1\ 0_B$ 100BASE-TX PMA/PMD $0\ 0\ 1\ 1\ 0\ 1_B$ Unsupported, defaults to 2.5GBASE-T PMA $0\ 0\ 1\ 1\ 0\ 0_B$ 1000BASE-T PMA/PMD $0\ 0\ 1\ 0\ 1\ 1_B$ Unsupported, defaults to 2.5GBASE-T PMA $0\ 0\ 1\ 0\ 1\ 0_B$ Unsupported, defaults to 2.5GBASE-T PMA $0\ 0\ 1\ 0\ 0\ 1_B$ Unsupported, defaults to 2.5GBASE-T PMA $0\ 0\ 1\ 0\ 0\ 0_B$ Unsupported, defaults to 2.5GBASE-T PMA $0\ 0\ 0\ 1\ 1\ 1_B$ Unsupported, defaults to 2.5GBASE-T PMA $0\ 0\ 0\ 1\ 1\ 0_B$ Unsupported, defaults to 2.5GBASE-T PMA $0\ 0\ 0\ 1\ 0\ 1_B$ Unsupported, defaults to 2.5GBASE-T PMA $0\ 0\ 0\ 1\ 0\ 0_B$ Unsupported, defaults to 2.5GBASE-T PMA $0\ 0\ 0\ 0\ 1\ 1_B$ Unsupported, defaults to 2.5GBASE-T PMA $0\ 0\ 0\ 0\ 1\ 0_B$ Unsupported, defaults to 2.5GBASE-T PMA $0\ 0\ 0\ 0\ 0\ 1_B$ Unsupported, defaults to 2.5GBASE-T PMA $0\ 0\ 0\ 0\ 0\ 0_B$ Unsupported, defaults to 2.5GBASE-T PMA

PMA/PMD Status 2 (Register 1.8)

IEEE Standard Register=1.8

PMA_STAT2 **Reset Value**

PMA/PMD Status 2 (Register 1.8) **8200_H**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DEVICE_PRESENT		TX_FAUL*	RX_FAUL*	TX_FAULT	RX_FAULT	EXT_ABI*	PMD_TX_*	RMGBT_S*	RMGBT_L*	RMGBT_E*	RMGBT_L*	RMGBT_S*	RMGBT_L*	RMGBT_E*	PMA_LOC*
ro		ro	ro	ro	ro	ro	ro	ro	ro	ro	ro	ro	ro	ro	ro

Field	Bits	Type	Description
DEVICE_PRESENT	15:14	RO	**Device Present** 00_B No device responding at this address 01_B No device responding at this address 10_B Device responding at this address 11_B No device responding at this address
TX_FAULT_ABILITY	13	RO	**Transmit Fault Ability** 0_B PMA/PMD is not able to detect a fault condition on the transmit path. 1_B PMA/PMD is able to detect a fault condition on the transmit path.
RX_FAULT_ABILITY	12	RO	**Receive Fault Ability** 0_B PMA/PMD is not able to detect a fault condition on the receive path. 1_B PMA/PMD is able to detect a fault condition on the receive path.
TX_FAULT	11	RO	**Transmit Fault** 0_B No fault condition on transmit path 1_B Fault condition on transmit path
RX_FAULT	10	RO	**Receive Fault** 0_B No fault condition on receive path 1_B Fault condition on receive path
EXT_ABILITIES	9	RO	**Extended Abilities** 0_B PMA/PMD does not have extended abilities. 1_B PMA/PMD has extended abilities listed in register 1.11.
PMD_TX_DISABLE	8	RO	**PMD Transmit Disable** 0_B PMD is not able to disable the transmit path. 1_B PMD is able to disable the transmit path.
RMGBT_SR_ABILITY	7	RO	**MULTIGBASE-SR Ability** 0_B PMA/PMD is not able to perform MULTIGBASE-SR. 1_B PMA/PMD is able to perform MULTIGBASE-SR.
RMGBT_LR_ABILITY	6	RO	**MULTIGBASE-LR Ability** 0_B PMA/PMD is not able to perform MULTIGBASE-LR. 1_B PMA/PMD is able to perform MULTIGBASE-LR.
RMGBT_ER_ABILITY	5	RO	**MULTIGBASE-ER Ability** 0_B PMA/PMD is not able to perform MULTIGBASE-ER. 1_B PMA/PMD is able to perform MULTIGBASE-ER.

Field	Bits	Type	Description (cont'd)
RMGBT_LX4_ ABILITY	4	RO	**MULTIGBASE-LX4 Ability** 0_B PMA/PMD is not able to perform MULTIGBASE-LX4. 1_B PMA/PMD is able to perform MULTIGBASE-LX4.
RMGBT_SW_ ABILITY	3	RO	**MULTIGBASE-SW Ability** 0_B PMA/PMD is not able to perform MULTIGBASE-SW. 1_B PMA/PMD is able to perform MULTIGBASE-SW.
RMGBT_LW_ ABILITY	2	RO	**MULTIGBASE-LW Ability** 0_B PMA/PMD is not able to perform MULTIGBASE-LW. 1_B PMA/PMD is able to perform MULTIGBASE-LW.
RMGBT_EW_ ABILITY	1	RO	**MULTIGBASE-EW Ability** 0_B PMA/PMD is not able to perform MULTIGBASE-EW. 1_B PMA/PMD is able to perform MULTIGBASE-EW.
PMA_LOCAL_ LOOPBACK	0	RO	**PMA Local Loopback** 0_B PMA is not able to perform a local loopback function. 1_B PMA is able to perform a local loopback function.

PMA/PMD Extended Ability (Register 1.11)

IEEE Standard Register=1.11

PMA_EXT_ABILITY **Reset Value**

PMA/PMD Extended Ability (Register 1.11) **$41A0_H$**

15	14	13	11	10	9	8	7	6	5	4	3	2	1	0
RES	**R2G5_EX***	**RES**		**R40G_10***	**P2MP_AB***	**R10BASE***	**R100BAS***	**R1000BA***	**R1000BA***	**RMGBT_K***	**RMGBT_K***	**RMGBT_A***	**RMGBT_L***	**RMGBT_C***
	ro			ro	ro	ro	ro	ro	ro	ro	ro	ro	ro	ro

Field	Bits	Type	Description
R2G5_EXT_ABILITIES	14	RO	**2.5G/5G Extended Abilities** 0_B PMA/PMD does not have 2.5G/5G extended abilities. 1_B PMA/PMD has 2.5G/5G extended abilities listed in register 1.21.
R40G_100G_EXT_ABILITIES	10	RO	**40G/100G Extended Abilities** 0_B PMA/PMD does not have 40G/100G extended abilities. 1_B PMA/PMD has 40G/100G extended abilities listed in register 1.13.
P2MP_ABILITY	9	RO	**P2MP Ability** 0_B PMA/PMD does not have P2MP extended abilities. 1_B PMA/PMD has P2MP abilities listed in register 1.12.
R10BASE_T_ABILITY	8	RO	**10BASE-T Ability** 0_B PMA/PMD is not able to perform 10BASE-T. 1_B PMA/PMD is able to perform 10BASE-T.
R100BASE_TX_ABILITY	7	RO	**100BASE-TX Ability** 0_B PMA/PMD is not able to perform 100BASE-TX. 1_B PMA/PMD is able to perform 100BASE-TX.
R1000BASE_KX_ABILITY	6	RO	**1000BASE-KX Ability** 0_B PMA/PMD is not able to perform 1000BASE-KX. 1_B PMA/PMD is able to perform 1000BASE-KX.
R1000BASE_T_ABILITY	5	RO	**1000BASE-T Ability** 0_B PMA/PMD is not able to perform 1000BASE-T. 1_B PMA/PMD is able to perform 1000BASE-T.
RMGBT_KR_ABILITY	4	RO	**MULTIGBASE-KR Ability** 0_B PMA/PMD is not able to perform MULTIGBASE-KR. 1_B PMA/PMD is able to perform MULTIGBASE-KR.
RMGBT_KX4_ABILITY	3	RO	**MULTIGBASE-KX4 Ability** 0_B PMA/PMD is not able to perform MULTIGBASE-KX4. 1_B PMA/PMD is able to perform MULTIGBASE-KX4.
RMGBT_ABILITY	2	RO	**10GBASE-T Ability** 0_B PMA/PMD is not able to perform MULTIGBASE-T. 1_B PMA/PMD is able to perform MULTIGBASE-T.
RMGBT_LRM_ABILITY	1	RO	**MULTIGBASE-LRM Ability** 0_B PMA/PMD is not able to perform MULTIGBASE-LRM. 1_B PMA/PMD is able to perform MULTIGBASE-LRM.

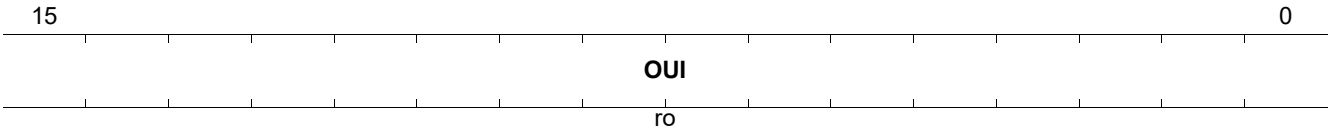
Field	Bits	Type	Description (cont'd)
RMGBT_CX4_ ABILITY	0	RO	**MULTIGBASE-CX4 Ability** 0_B PMA/PMD is not able to perform MULTIGBASE-CX4. 1_B PMA/PMD is able to perform MULTIGBASE-CX4.

AN Package Identifier (Register 1.14)

IEEE Standard Register=1.14

PMA_PACKID1 **Reset Value**

AN Package Identifier (Register 1.14) **C133$_H$**



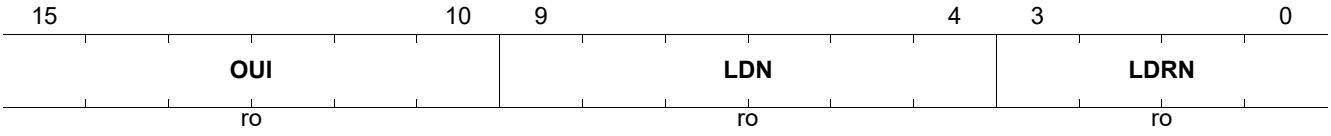
Field	Bits	Type	Description
OUI	15:0	RO	**Organizationally Unique Identifier** Organizationally Unique Identifier Bits 3:18

AN Package Identifier (Register 1.15)

IEEE Standard Register=1.15

PMA_PACKID2 **Reset Value**

AN Package Identifier (Register 1.15) **5400_H**



Field	Bits	Type	Description
OUI	15:10	RO	**Organizationally Unique Identifier Bits 19:24**
LDN	9:4	RO	**Device Number** Specifies the device number[1)] to distinguish between several different products.
LDRN	3:0	RO	**Device Revision Number** Specifies the device revision number[1)] to distinguish between several versions of this device.

1) For the device specific reset value, see the Product and Package Naming table in the **Product Ordering Information** chapter.

PMAPMD Extended Ability (Register 1.21)

Read only. Write from the STA has no effect.

IEEE Standard Register=1.21

PMA_MGBT_EXTAB **Reset Value**

PMAPMD Extended Ability (Register 1.21) **0001_H**

Field	Bits	Type	Description
RES	15:2	RO	**Reserved** Value always 0
AB5G	1	RO	**PMA Ability to Perform 5GBASE-T** 0_B **UNABLE** PMA is not able to perform 5GBASE-T. 1_B **ABLE** PMA is able to perform 5GBASE-T.
AB2G5	0	RO	**PMA Ability to Perform 2.5GBASE-T** 0_B **UNABLE** PMA is not able to perform 2.5GBASE-T. 1_B **ABLE** PMA is able to perform 2.5GBASE-T.

MULTIGBASE-T Status (Register 1.129)

IEEE Standard Register=1.129

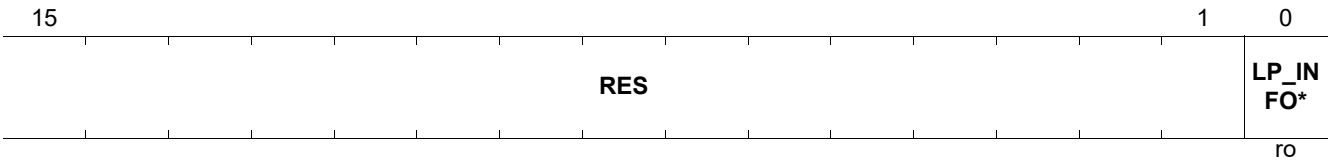
Indicates startup for 2.5G was completed.

When read as a 1, indicates that the startup protocol (for 2.5G/5GBASE-T) was completed (link_status = OK, pcs_status = OK), and that the contents of bits 1.130.11:0 (Polarity), 1.131.15:10 (PBO), 1.145.14:8 (Skew), 1.146.14:8, and 1.146.6:0 (Skew), established during the startup protocol, are valid.

When read as a 0, indicates that the startup process was not completed, and that the contents of bit 1.129.0, established during the startup protocol, are invalid. A PMA must return a value of 0 in bit 1.129.1 when the PMA link_status = FAIL.

PMA_MGBT_STAT **Reset Value**

MULTIGBASE-T Status (Register 1.129) **0000_H**



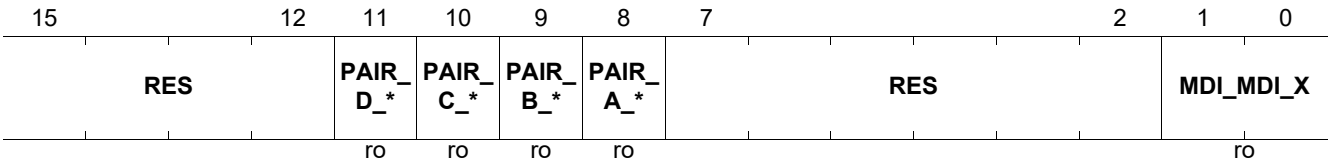
Field	Bits	Type	Description
LP_INFORMATION_VALID	0	RO	**LP Information Valid** When set, this bit indicates the startup protocol (126.4.2.5) was completed. 0_B Link partner information is invalid 1_B Link partner information is valid

MULTIGBASE-T Pair Swap and Polarity (Register 1.130)

IEEE Standard Register=1.130

PMA_MGBT_POLARITY **Reset Value**

MULTIGBASE-T Pair Swap and Polarity (Register 1.130) **0003_H**



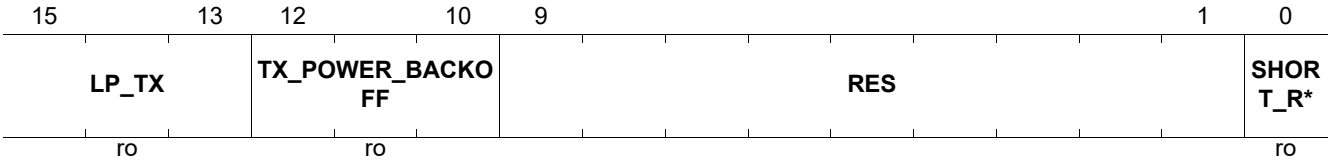
Field	Bits	Type	Description
PAIR_D_POLARITY	11	RO	**Pair D Polarity** 0_B Polarity of pair D is not reversed. 1_B Polarity of pair D is reversed.
PAIR_C_POLARITY	10	RO	**Pair C Polarity** 0_B Polarity of pair C is not reversed. 1_B Polarity of pair C is reversed.
PAIR_B_POLARITY	9	RO	**Pair B Polarity** 0_B Polarity of pair B is not reversed. 1_B Polarity of pair B is reversed.
PAIR_A_POLARITY	8	RO	**Pair A Polarity** 0_B Polarity of pair A is not reversed. 1_B Polarity of pair A is reversed.
MDI_MDI_X	1:0	RO	**MDI/MDI-X** Indicates the status of pair swaps at the MDI / MD-X. 00_B **ABCD CROSS** Pair AB and Pair CD crossover 01_B **CD CROSS** Pair CD crossover only 10_B **AB CROSS** Pair AB crossover only 11_B **NORMAL** No crossover

MULTIGBASE-T Tx Power Backoff and PHY Short Reach Setting (Register 1.131)

IEEE Standard Register=1.131

PMA_MGBT_TX_PBO **Reset Value**

MULTIGBASE-T TX Power Backoff and PHY Short Reach Setting (Register 1.131) **0000_H**



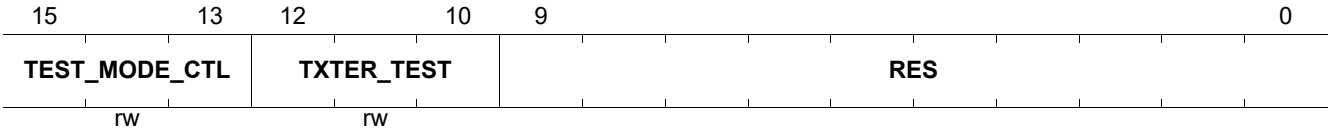
Field	Bits	Type	Description
LP_TX	15:13	RO	**Link Partner Tx** The power backoff setting of the link partner. The bit number assignment order is: 15 14 13 000_B 0 dB 001_B 2 dB 010_B 4 dB 011_B 6 dB 100_B 8 dB 101_B 10 dB 110_B 12 dB 111_B 14 dB
TX_POWER_BACKOFF	12:10	RO	**Tx Power Backoff** The power backoff of PHY211 PMA. The bit number assignment order is: 12 11 10 000_B 0 dB 001_B 2 dB 010_B 4 dB 011_B 6 dB 100_B 8 dB 101_B 10 dB 110_B 12 dB 111_B 14 dB
SHORT_REACH_MODE	0	RO	**Short Reach Mode** 0_B PHY is not operating in short reach mode 1_B PHY is operating in short reach mode (not supported)

MULTIGBASE-T Test Mode (Register 1.132)

IEEE Standard Register=1.132

PMA_MGBT_TEST_MODE **Reset Value**

MULTIGBASE-T Test Mode (Register 1.132) **0000_H**



Field	Bits	Type	Description
TEST_MODE_CTL	15:13	RW	**Test Mode Control** 000_B Normal operation 001_B Test mode 1 010_B Test mode 2 011_B Test mode 3 100_B Test mode 4 101_B Test mode 5 110_B Test mode 6 111_B Test mode 7
TXTER_TEST	12:10	RW	**Transmitter Test** Frequencies for tones used in Test Mode 4. 000_B Reserved 001_B Dual tone 1 010_B Dual tone 2 011_B Reserved 100_B Dual tone 3 101_B Dual tone 4 110_B Dual tone 5 111_B Reserved

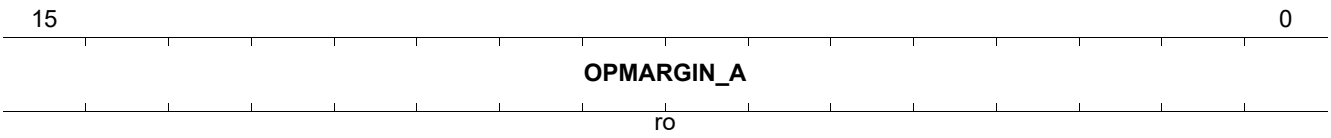
MULTIGBASE-T SNR Margin Channel A (Register 1.133)

Register 1.133 contains the current SNR operating margin measured at the slicer input for channel A for the MULTIGBASE-T PMA.

IEEE Standard Register=1.133

PMA_MGBT_SNR_OPMARGIN_A **Reset Value**

MULTIGBASE-T SNR Margin Channel A (Register 1.133) **0000_H**



Field	Bits	Type	Description
OPMARGIN_A	15:0	RO	**OPMARGIN_A** SNR operating margin measured at the slicer input for channel A

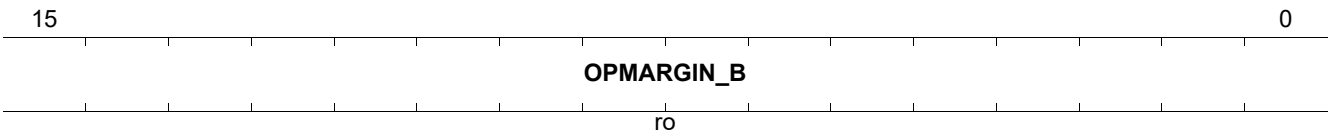
MULTIGBASE-T SNR Margin Channel B (Register 1.134)

Register 1.134 contains the current SNR operating margin measured at the slicer input for channel B for the MULTIGBASE-T PMA.

IEEE Standard Register=1.134

PMA_MGBT_SNR_OPMARGIN_B **Reset Value**

MULTIGBASE-T SNR Margin Channel B (Register 1.134) **0000_H**



Field	Bits	Type	Description
OPMARGIN_B	15:0	RO	**OPMARGIN_B** SNR operating margin measured at the slicer input for channel B

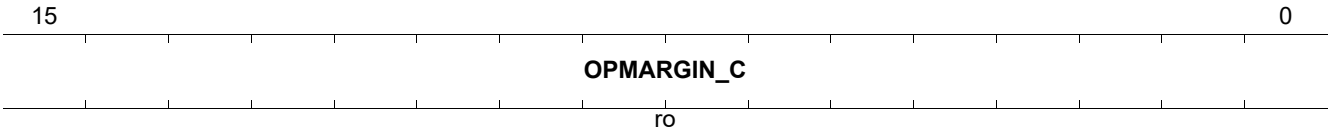
MULTIGBASE-T SNR Margin Channel C (Register 1.135)

Register 1.135 contains the current SNR operating margin measured at the slicer input for channel C for the MULTIGBASE-T PMA.

IEEE Standard Register=1.135

PMA_MGBT_SNR_OPMARGIN_C **Reset Value**

MULTIGBASE-T SNR Margin Channel C (Register 1.135) **0000_H**



Field	Bits	Type	Description
OPMARGIN_C	15:0	RO	**OPMARGIN_C** SNR operating margin measured at the slicer input for channel C

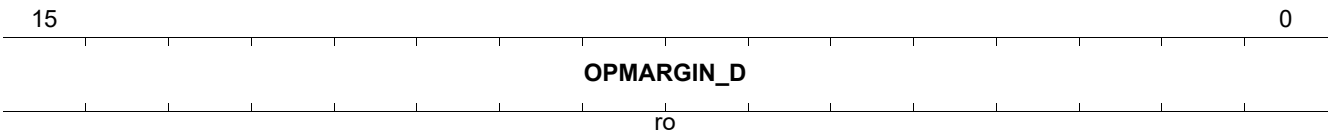
MULTIGBASE-T SNR Margin Channel D (Register 1.136)

Register 1.136 contains the current SNR operating margin measured at the slicer input for channel D for the MULTIGBASE-T PMA.

IEEE Standard Register=1.136

PMA_MGBT_SNR_OPMARGIN_D **Reset Value**

MULTIGBASE-T SNR Margin Channel D (Register 1.136) **0000_H**



Field	Bits	Type	Description
OPMARGIN_D	15:0	RO	**OPMARGIN_D** SNR operating margin measured at the slicer input for channel D

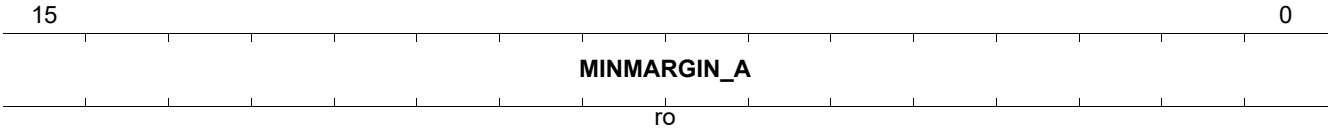
MULTIGBASE-T SNR Minimum Margin Channel A (Register 1.137)

The minimum margin channel A register contains a latched copy of the lowest value observed in the SNR operating margin channel A register (1.133) since the last read.

IEEE Standard Register=1.137

PMA_MGBT_MINMARGIN_A **Reset Value**

MULTIGBASE-T SNR Minimum Margin Channel A (Register 1.137) **0000_H**



Field	Bits	Type	Description
MINMARGIN_A	15:0	RO	**MINMARGIN_A** Lowest value observed in the SNR operating margin channel A register (1.133) since the last read

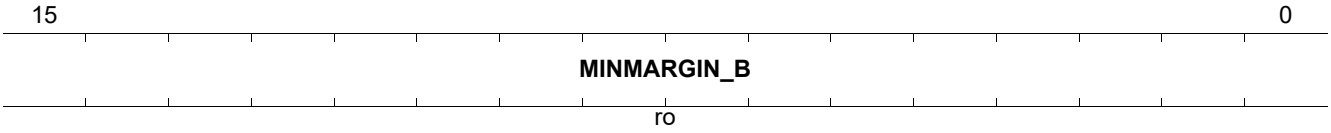
MULTIGBASE-T SNR Minimum Margin Channel B (Register 1.138)

The minimum margin channel A register contains a latched copy of the lowest value observed in the SNR operating margin channel B register (1.134) since the last read.

IEEE Standard Register=1.138

PMA_MGBT_MINMARGIN_B **Reset Value**

MULTIGBASE-T SNR Minimum Margin Channel B (Register 1.138) **0000_H**



Field	Bits	Type	Description
MINMARGIN_B	15:0	RO	**MINMARGIN_B** Lowest value observed in the SNR operating margin channel B register (1.134) since the last read

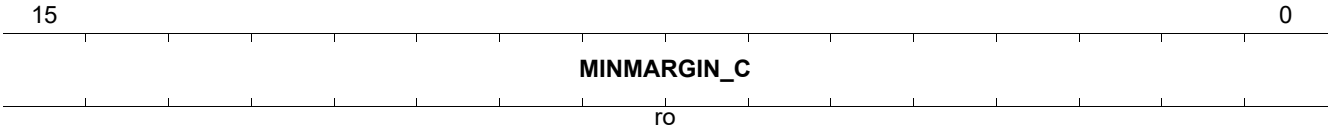
MULTIGBASE-T SNR Minimum Margin Chan C (Register 1.139)

The minimum margin channel C register contains a latched copy of the lowest value observed in the SNR operating margin channel C register (1.135) since the last read.

IEEE Standard Register=1.139

PMA_MGBT_MINMARGIN_C **Reset Value**

MULTIGBASE-T SNR Minimum Margin Chan C (Register 1.139) **0000_H**



Field	Bits	Type	Description
MINMARGIN_C	15:0	RO	**MINMARGIN_C** Lowest value observed in the SNR operating margin channel C register (1.135) since the last read

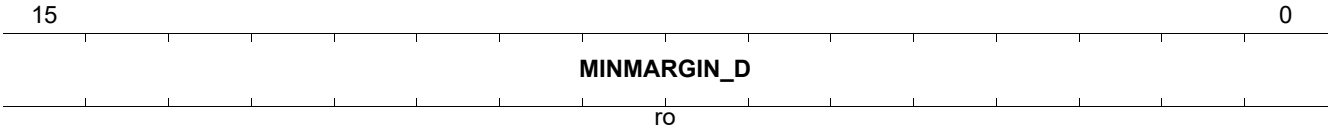
MULTIGBASE-T SNR Minimum Margin Chan D (Register 1.140)

The Minimum margin channel D register contains a latched copy of the lowest value observed in the SNR operating margin channel D register (1.136) since the last read.

IEEE Standard Register=1.140

PMA_MGBT_MINMARGIN_D **Reset Value**

MULTIGBASE-T SNR Minimum Margin Chan D (Register 1.140) **0000_H**



Field	Bits	Type	Description
MINMARGIN_D	15:0	RO	**MINMARGIN_D** Lowest value observed in the SNR operating margin channel D register (1.136) since the last read

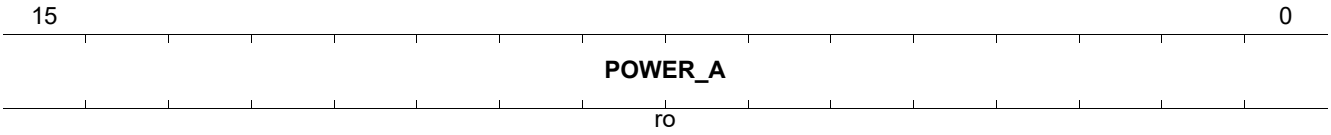
MULTIGBASE-T Rx Power Channel A (Register 1.141)

The Rx signal power channel A register is read only and contains the receive signal power measured at the MDI during training as described in 55.4.3.1.

IEEE Standard Register=1.141

PMA_MGBT_POWER_A **Reset Value**

MULTIGBASE-T Rx Power Channel A (Register 1.141) **0000_H**



Field	Bits	Type	Description
POWER_A	15:0	RO	**POWER_A** Receive signal power measured at the MDI during training

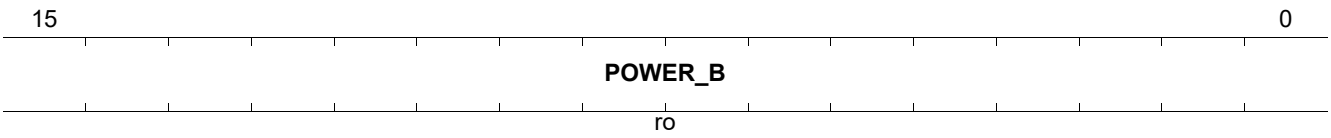
MULTIGBASE-T Rx Power Channel B (Register 1.142)

The Rx signal power channel B register is read only and contains the receive signal power measured at the MDI during training as described in 55.4.3.1.

IEEE Standard Register=1.142

PMA_MGBT_POWER_B **Reset Value**

MULTIGBASE-T Rx Power Channel B (Register 1.142) **0000_H**



Field	Bits	Type	Description
POWER_B	15:0	RO	**POWER_B** Receive signal power measured at the MDI during training

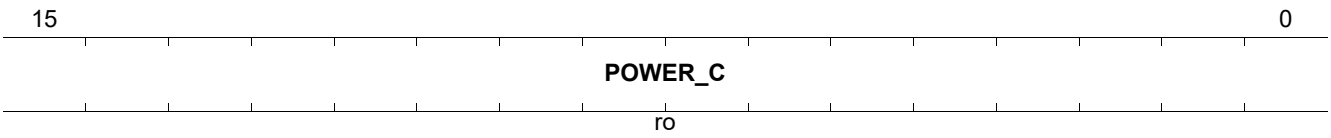
MULTIGBASE-T Rx Power Chan C (Register 1.143)

The Rx signal power channel C register is read only and contains the receive signal power measured at the MDI during training as described in 55.4.3.1.

IEEE Standard Register=1.143

PMA_MGBT_POWER_C **Reset Value**

MULTIGBASE-T Rx Power Chan C (Register 1.143) **0000_H**



Field	Bits	Type	Description
POWER_C	15:0	RO	**POWER_C** Receive signal power measured at the MDI during training

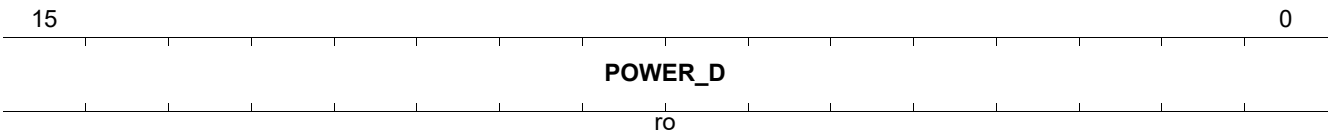
MULTIGBASE-T Rx Power Chan D (Register 1.144)

The Rx signal power channel D register is read only and contains the receive signal power measured at the MDI during training as described in 55.4.3.1.

IEEE Standard Register=1.144

PMA_MGBT_POWER_D **Reset Value**

MULTIGBASE-T Rx Power Chan D (Register 1.144) **0000_H**



Field	Bits	Type	Description
POWER_D	15:0	RO	**POWER_D** Receive signal power measured at the MDI during training

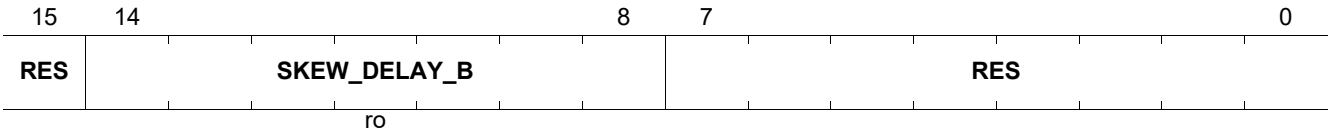
MULTIGBASE-T Skew Delay 0 (Register 1.145)

IEEE Standard Register=1.145

The skew delay reports the current skew delay on each of the pairs with respect to physical pair A. It is reported with 1.25 ns resolution to an accuracy of 2.5 ns. The number is in two's complement notation with positive values representing delay and negative values representing advance with respect to physical pair A. When the delay exceeds the maximum amount represented by the range -80 ns to +78.75 ns, the field displays the maximum value.

PMA_MGBT_SKEW_DELAY_0 **Reset Value**

MULTIGBASE-T Skew Delay 0 (Register 1.145) **0000_H**



Field	Bits	Type	Description
SKEW_DELAY_B	14:8	RO	**Skew Delay B** Skew delay for pair B

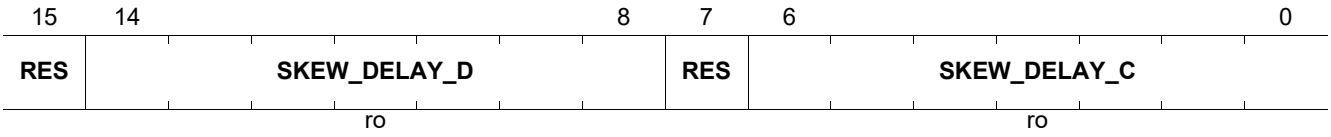
MULTIGBASE-T Skew Delay 1 (Register 1.146)

IEEE Standard Register=1.146

The skew delay reports the current skew delay on each of the pairs with respect to physical pair A. It is reported with 1.25 ns resolution to an accuracy of 2.5 ns. The number is in two's complement notation with positive values representing delay and negative values representing advance with respect to physical pair A. When the delay exceeds the maximum amount represented by the range -80 ns to +78.75 ns, the field displays the maximum value.

PMA_MGBT_SKEW_DELAY_1 **Reset Value**

MULTIGBASE-T Skew Delay 1 (Register 1.146) **0000_H**



Field	Bits	Type	Description
SKEW_DELAY_D	14:8	RO	**Skew Delay D** Skew delay for pair D
SKEW_DELAY_C	6:0	RO	**Skew Delay C** Skew delay for pair C

MULTIGBASE-T Skew Delay 2 (Register 1.147)

IEEE Standard Register=1.147

PMA_MGBT_FAST_RETRAIN_STA_CTRL **Reset Value**

MULTIGBASE-T Skew Delay 2 (Register 1.147) **0010_H**

Field	Bits	Type	Description
LP_FAST_RETRAIN_COUNT	15:11	RO	**LP Fast Retrain Count** Counts the number of fast retrains requested by the link partner.
LD_FAST_RETRAIN_COUNT	10:6	RO	**LD Fast Retrain Count** Counts the number of fast retrains requested by the local device.
FAST_RETRAIN_ABILITY	4	RO	**Fast Retrain Ability** 0_B Fast retrain capability is not supported. 1_B Fast retrain capability is supported.
FAST_RETRAIN_NEGOTIATED	3	RO	**Fast Retrain Negotiated** 0_B Fast retrain capability was not negotiated. 1_B Fast retrain capability was negotiated.
FAST_RETRAIN_SIG_TYPE	2:1	RW	**Fast Retrain Signal Type** 00_B PHY signals IDLE during fast retrain 01_B PHY signals local fault during fast retrain 10_B PHY signals link interruption during fast retrain 11_B Reserved
FAST_RETRAIN_ENABLE	0	RW	**Fast Retrain Enable** 0_B Fast retrain capability is disabled. 1_B Fast retrain capability is enabled.

PMA TimeSync Capability Indication (Register 1.1800)

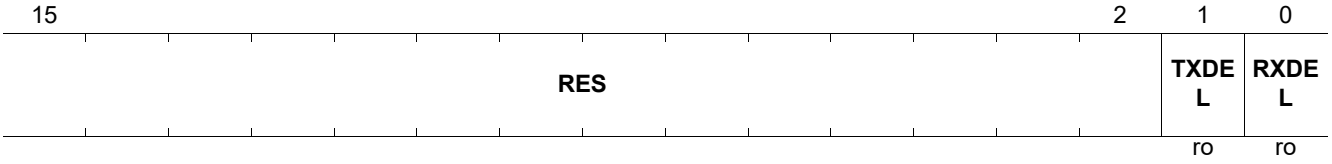
PMA TimeSync Capability indication register.

GPHY does not support providing data path delay information.

IEEE Standard Register=1.1800

PMA_TIMESYNC_CAP **Reset Value**

PMA TimeSync Capability Indication (Register 1.1800) **0000_H**



Field	Bits	Type	Description
TXDEL	1	RO	**Transmit Data Path Delay Information** Not supported by the GPHY. 0_B **NONE** PHYs do not have this capability. 1_B **CAPABLE** Minimum and maximum Tx data path delay available
RXDEL	0	RO	**Receive Data Path Delay Information** Not supported by the GPHY. 0_B **NONE** PHYs do not have this capability. 1_B **CAPABLE** Minimum and maximum Rx data path delay available

6.2 Standard PCS Registers

This section describes the PCS registers for MMD device 0x03.

Table 32 Registers Overview- Standard PCS Registers

Register Short Name	Register Long Name	Reset Value
PCS_CTRL1	PCS Control 1 (Register 3.0)	$205C_H$
PCS_STAT1	PCS Status 1 (Register 3.1)	0000_H
PCS_DEVID1	PHY Identifier 1 (Register 3.2)	$C133_H$
PCS_DEVID2	PHY Identifier 2 (Register 3.3)	5400_H 1)
PCS_SPEED_ABILITY	PCS Speed Ability (Register 3.4)	0040_H
PCS_DIP1	PCS Devices in Package 1 (Register 3.5)	$008B_H$
PCS_DIP2	PCS Devices in Package 2 (Register 3.6)	$C000_H$
PCS_CTRL2	PCS Control 2 (Register 3.7)	$000A_H$
PCS_STAT2	PCS Status 2 (Register 3.8)	9000_H
PCS_PACKID1	PCS Package Identifier 1 (Register 3.14)	$C133_H$
PCS_PACKID2	PCS Package Identifier 2 (Register 3.15)	5400_H 1)
PCS_EEE_CAP	PCS EEE Capability (Register 3.20)	0006_H
PCS_EEE_CAP2	EEE Control and Capability 2 (Register 3.21)	0001_H
PCS_EEE_WAKERR	PCS EEE Status Register 1 (Register 3.22)	0000_H
PCS_2G5_STAT1	BASE-R and 10GBASE-T PCS Status 1 (Register 3.32)	0000_H
PCS_2G5_STAT2	MULTIGBASE-T PCS Status 2 (Register 3.33)	0000_H
PCS_TIMESYNC_CAP	PCS TimeSync Capability Register (Register 3.1800)	0000_H

1) For the device specific reset value, see the Product and Package Naming table in the **Product Ordering Information** chapter.

6.2.1 PCS Register Descriptions

This section describes all the PCS registers in detail.

PCS Control 1 (Register 3.0)

IEEE Standard Register=3.0

PCS_CTRL1 **Reset Value**

PCS Control 1 (Register 3.0) **$205C_H$**

15	14	13	12	11	10	9 … 7	6	5 … 2	1	0
RST	**LOOP BACK**	**SSL**	**RES**	**LOW_ POW***	**RXCK ST**	**RES**	**SSM**	**SPEED_SEL**	**RES**	
rw	rw	rw		rw	rw		rw	rw		

Field	Bits	Type	Description
RST	15	RW	**Reset** 0_B Normal operation 1_B PCS reset - Self-clearing
LOOPBACK	14	RW	**Loopback** 0_B Disable loopback mode 1_B Enable loopback mode
SSL	13	RW	**Forced Speed Selection (LSB)** This bit is used in conjunction with SPEED_SEL_LSB. The bit assignment order is: MSB LSB 00_B 10 Mbps 01_B 100 Mbps 10_B 1000 Mbps 11_B Bits [5:2] select the speed
LOW_POWER	11	RW	**Low Power** 0_B Normal operation 1_B Low-power mode
RXCKST	10	RW	**Clock Stop Enable** The MAC sets this bit to active to allow the GPHY to stop the clocking during the LPI_MODE. 0_B The clock is not stoppable. 1_B The GPHY stops the (X)GMII clock during LPI.
SSM	6	RW	**Forced Speed Selection (MSB)** This bit is used in conjunction with SPEED_SEL_MSB. The bit assignment order is: MSB LSB 00_B 10 Mbps 01_B 100 Mbps 10_B 1000 Mbps 11_B Bits [5:2] select the speed

Field	Bits	Type	**Description** (cont'd)
SPEED_SEL	5:2	RW	**Forced Speed Selection Values** $0\ 0\ 0\ 0_B$ Unsupported, defaults to 2.5 Gbps $0\ 0\ 0\ 1_B$ Unsupported, defaults to 2.5 Gbps $0\ 0\ 1\ 0_B$ Unsupported, defaults to 2.5 Gbps $0\ 0\ 1\ 1_B$ Unsupported, defaults to 2.5 Gbps $0\ 1\ 0\ 0_B$ Unsupported, defaults to 2.5 Gbps $0\ 1\ 0\ 1_B$ Reserved $0\ 1\ 1\ 1_B$ 2.5 Gbps $1\ 1\ x\ x_B$ Reserved

PCS Status 1 (Register 3.1)

IEEE Standard Register=3.1

PCS_STAT1 **Reset Value**

PCS Status 1 (Register 3.1) **0000_H**

15	12	11	10	9	8	7	6	5	3	2	1	0
RES		TX_LPI_*	RX_LPI_*	TX_LPI_*	RX_LPI_*	FAULT	TXCKST	RES		PCS_RX_*	LOW_POW*	RES
		ro	ro	ro	ro	ro	ro			ro	ro	

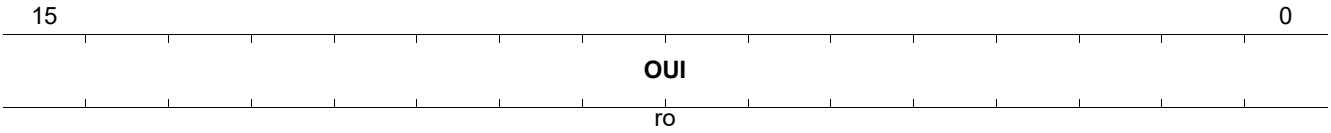
Field	Bits	Type	Description
TX_LPI_RXD	11	RO	**Tx LPI Received** 0_B LPI not received 1_B Tx PCS received LPI
RX_LPI_RXD	10	RO	**Rx LPI Received** 0_B LPI not received 1_B Rx PCS received LPI
TX_LPI_INDICATION	9	RO	**Tx LPI Indication** 0_B PCS is not currently receiving LPI. 1_B Tx PCS is currently receiving LPI.
RX_LPI_INDICATION	8	RO	**Rx LPI Indication** 0_B PCS is not currently receiving LPI. 1_B Rx PCS is currently receiving LPI.
FAULT	7	RO	**Fault** 0_B No fault condition detected 1_B Fault condition detected
TXCKST	6	RO	**Clock Stop Capable** 0_B The clock is not stoppable. 1_B The MAC is allowed to stop the clock during LPI.
PCS_RX_LINK_STATUS	2	RO	**PCS Receive Link Status** 0_B PCS receive link down 1_B PCS receive link up
LOW_POWER_ABILITY	1	RO	**Low Power Ability** 0_B PCS does not support low power mode. 1_B PCS supports low power mode.

PHY Identifier 1 (Register 3.2)

IEEE Standard Register=3.2

PCS_DEVID1 **Reset Value**

PHY Identifier 1 (Register 3.2) **$C133_H$**



Field	Bits	Type	Description
OUI	15:0	RO	**Organizationally Unique Identifier Bits 3:18**

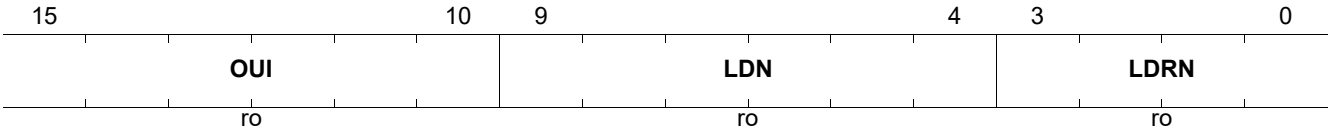
PHY Identifier 2 (Register 3.3)

Organizationally Unique Identifier Bits 19:24

IEEE Standard Register=3.3

PCS_DEVID2 **Reset Value**

PHY Identifier 2 (Register 3.3) **5400_H**



Field	Bits	Type	Description
OUI	15:10	RO	**Organizationally Unique Identifier Bits 19:24**
LDN	9:4	RO	**Device Number** Specifies the device number[1)] to distinguish between several different products.
LDRN	3:0	RO	**Device Revision Number** Specifies the device revision number[1)] to distinguish between several versions of this device.

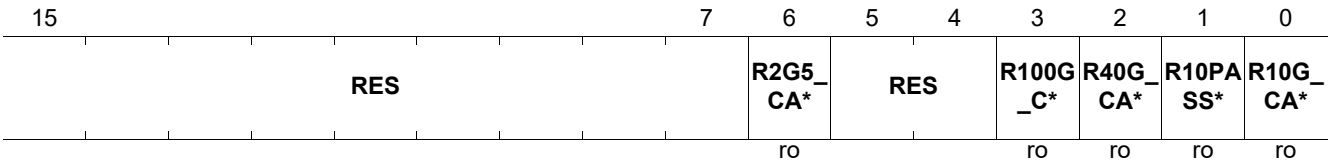
1) For the device specific reset value, see the Product and Package Naming table in the **Product Ordering Information** chapter.

PCS Speed Ability (Register 3.4)

IEEE Standard Register=3.4

PCS_SPEED_ABILITY **Reset Value**

PCS Speed Ability (Register 3.4) **0040_H**



Field	Bits	Type	Description
R2G5_CAPABLE	6	RO	**2G5 Capable** This bit is always set to 1_B because the PCS is capable of operating at 2.5 Gbps.
R100G_CAPABLE	3	RO	**100G Capable** 0_B PCS is not capable of operating at 100 Gbps. 1_B PCS is capable of operating at 100 Gbps.
R40G_CAPABLE	2	RO	**40G Capable** 0_B PCS is not capable of operating at 40 Gbps. 1_B PCS is capable of operating at 40 Gbps.
R10PASS_TS_2BASE_TL	1	RO	**10PASS-TS/2BASE-TL Capable** 0_B PCS is not capable of operating as the 10P/2B PCS. 1_B PCS is capable of operating as the 10P/2B PCS.
R10G_CAPABLE	0	RO	**10G Capable** 0_B PCS is not capable of operating at 10 Gbps. 1_B PCS is capable of operating at 10 Gbps.

PCS Devices in Package 1 (Register 3.5)

IEEE Standard Register=3.5

PCS_DIP1 **Reset Value**

PCS Devices in Package 1 (Register 3.5) **$008B_H$**

15	12	11	10	9	8	7	6	5	4	3	2	1	0
RES		SEPARAT*	SEP_PMA*	SEPARAT*	SEPARAT*	ANEG	TC	DTE_XS	PHY_XS	PCS	WIS_PRE*	PMD_PMA	CL22
ro		ro	ro	ro	ro	ro	ro	ro	ro	ro	ro	ro	ro

Field	Bits	Type	Description
RES	15:12	RO	**Reserved** Ignore on read
SEPARATED_PMA_4	11	RO	**Separate PMA (4)** 0_B Separate PMA (4) not present in package 1_B Separate PMA (4) present in package
SEP_PMA_3	10	RO	**Separate PMA (3)** 0_B Separate PMA (3) not present in package 1_B Separate PMA (3) present in package
SEPARATED_PMA_2	9	RO	**Separate PMA (2)** 0_B Separate PMA (2) not present in package 1_B Separate PMA (2) present in package
SEPARATED_PMA_1	8	RO	**Separate PMA (1)** 0_B Separate PMA (1) not present in package 1_B Separate PMA (1) present in package
ANEG	7	RO	**Auto-Negotiation Present** 0_B Auto-negotiation not present in package 1_B Auto-negotiation present in package
TC	6	RO	**TC Present** 0_B TC not present in package 1_B TC present in package
DTE_XS	5	RO	**DTE XS Present** 0_B DTE XS not present in package 1_B DTE XS present in package
PHY_XS	4	RO	**PHY XS Present** 0_B PHY XS not present in package 1_B PHY XS present in package
PCS	3	RO	**PCS Present** 0_B PCS not present in package 1_B PCS present in package
WIS_PRESENT	2	RO	**WIS Present** 0_B WIS not present in package 1_B WIS present in package

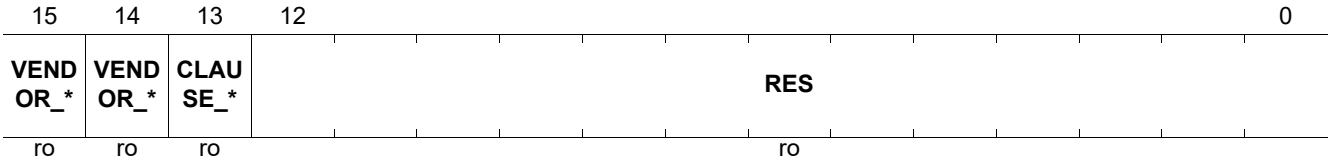
Field	Bits	Type	Description (cont'd)
PMD_PMA	1	RO	**PMD/PMA Present** 0_B PMA/PMD not present in package 1_B PMA/PMD present in package
CL22	0	RO	**Clause 22 Registers Present** 0_B Clause 22 registers not present in package 1_B Clause 22 registers present in package

PCS Devices in Package 2 (Register 3.6)

IEEE Standard Register=3.6

PCS_DIP2 **Reset Value**

PCS Devices in Package 2 (Register 3.6) **$C000_H$**



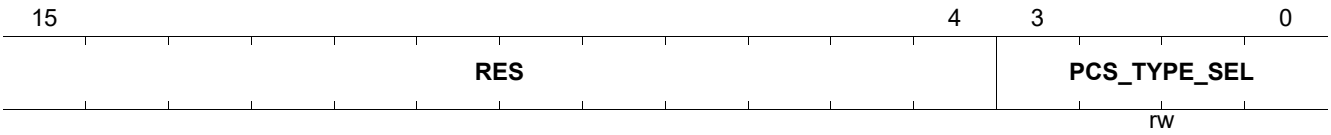
Field	Bits	Type	Description
VENDOR_SPECIFIC_DEVICE_2	15	RO	**Vendor-specific Device 2** 0_B Vendor-specific device 2 not present in package 1_B Vendor-specific device 2 present in package
VENDOR_SPECIFIC_DEVICE_1	14	RO	**Vendor-specific Device 1** 0_B Vendor-specific device 1 not present in package 1_B Vendor-specific device 1 present in package
CLAUSE_22_EXTENSION	13	RO	**Clause 22 Extension** 0_B Clause 22 extension not present in package 1_B Clause 22 extension present in package
RES	12:0	RO	**Reserved** Ignore on read.

PCS Control 2 (Register 3.7)

IEEE Standard Register=3.7

PCS_CTRL2 **Reset Value**

PCS Control 2 (Register 3.7) **$000A_H$**



Field	Bits	Type	Description
PCS_TYPE_SEL	3:0	RW	**PCS Type Selection** 0000_B Not supported, defaults to 2.5 Gbps 0001_B Not supported, defaults to 2.5 Gbps 0010_B Not supported, defaults to 2.5 Gbps 0011_B Not supported, defaults to 2.5 Gbps 0100_B Not supported, defaults to 2.5 Gbps 0101_B Not supported, defaults to 2.5 Gbps 0110_B Not supported, defaults to 2.5 Gbps 0111_B Not supported, defaults to 2.5 Gbps 1000_B Reserved 1001_B Not supported, defaults to 2.5 Gbps 1010_B Select 2.5 Gbps PCS type (Default) 1011_B Not supported, defaults to 2.5 Gbps 1100_B Not supported, defaults to 2.5 Gbps 1101_B Not supported, defaults to 2.5 Gbps 1110_B Reserved 1111_B Reserved

PCS Status 2 (Register 3.8)

IEEE Standard Register=3.8

PCS_STAT2 **Reset Value**

PCS Status 2 (Register 3.8) **9000_H**

15	14	13	12	11	10	9	6	5	4	3	2	1	0
DEVICE_PRESENT		RES	R2G5_CA*	TX_FAULT	RX_FAULT	RES		R100GBA*	R40GBAS*	R10GBAS*	R10GBAS*	R10GBAS*	R10GBAS*
ro			ro	ro	ro			ro	ro	ro	ro	ro	ro

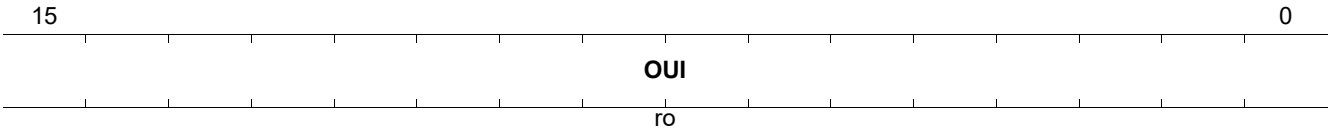
Field	Bits	Type	Description
DEVICE_PRESENT	15:14	RO	**Device Present** 00_B No device responding at this address 01_B No device responding at this address 10_B Device responding at this address 11_B No device responding at this address
R2G5_CAPABLE	12	RO	**2G5BASE-T Capable** 0_B PCS is not able to support 2.5GBASE-T PCS type. 1_B PCS is able to support 2.5GBASE-T PCS type.
TX_FAULT	11	RO	**Transmit Fault** 0_B No fault condition on transmit path 1_B Fault condition on transmit path
RX_FAULT	10	RO	**Receive Fault** 0_B No fault condition on receive path 1_B Fault condition on receive path
R100GBASE_R_CAPABLE	5	RO	**100GBASE-R Capable** 0_B PCS is not able to support 100GBASE-R PCS type. 1_B PCS is able to support 100GBASE-R PCS type.
R40GBASE_R_CAPABLE	4	RO	**40GBASE-R Capable** 0_B PCS is not able to support 40GBASE-R PCS type. 1_B PCS is able to support 40GBASE-R PCS type.
R10GBASE_T_CAPABLE	3	RO	**10GBASE-T Capable** 0_B PCS is not able to support 10GBASE-T PCS type. 1_B PCS is able to support 10GBASE-T PCS type.
R10GBASE_W_CAPABLE	2	RO	**10GBASE-W Capable** 0_B PCS is not able to support 10GBASE-W PCS type. 1_B PCS is able to support 10GBASE-W PCS type.
R10GBASE_X_CAPABLE	1	RO	**10GBASE-X Capable** 0_B PCS is not able to support 10GBASE-X PCS type. 1_B PCS is able to support 10GBASE-X PCS type.
R10GBASE_R_CAPABLE	0	RO	**10GBASE-R Capable** 0_B PCS is not able to support 10GBASE-R PCS types. 1_B PCS is able to support 10GBASE-R PCS types.

PCS Package Identifier 1 (Register 3.14)

IEEE Standard Register=3.14

PCS_PACKID1 **Reset Value**

PCS Package Identifier 1 (Register 3.14) **C133$_H$**



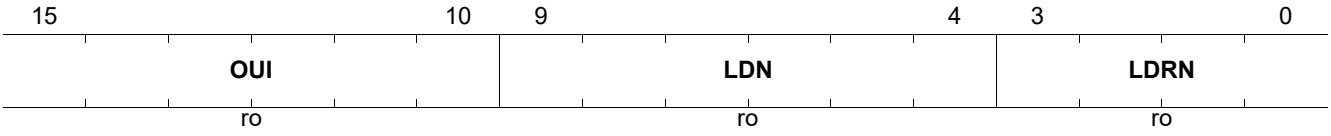
Field	Bits	Type	Description
OUI	15:0	RO	**Organizationally Unique Identifier Bits 3:18**

PCS Package Identifier 2 (Register 3.15)

IEEE Standard Register=3.15

PCS_PACKID2 **Reset Value**

PCS Package Identifier 2 (Register 3.15) **5400_H**



Field	Bits	Type	Description
OUI	15:10	RO	**Organizationally Unique Identifier Bits 19:24**
LDN	9:4	RO	**Device Number** Specifies the device number[1)] to distinguish between several different products.
LDRN	3:0	RO	**Device Revision Number** Specifies the device revision number to distinguish between several versions of this device.

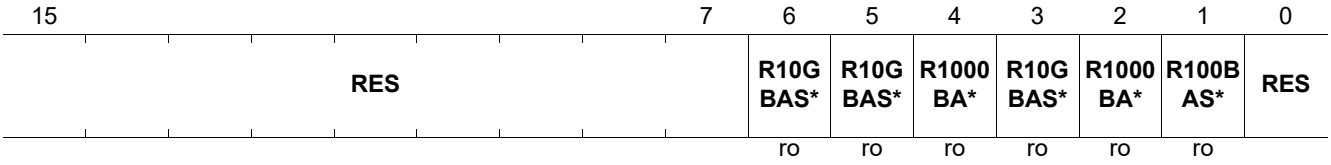
1) For the device specific reset value, see the Product and Package Naming table in the **Product Ordering Information** chapter.

PCS EEE Capability (Register 3.20)

IEEE Standard Register=3.20

PCS_EEE_CAP **Reset Value**

PCS EEE Capability (Register 3.20) **0006_H**



Field	Bits	Type	Description
R10GBASE_KR_EEE	6	RO	**10GBASE-KR EEE** 0_B EEE is not supported for 10GBASE-KR. 1_B EEE is supported for 10GBASE-KR.
R10GBASE_KX4_EEE	5	RO	**10GBASE-KX4 EEE** 0_B EEE is not supported for 10GBASE-KX4. 1_B EEE is supported for 10GBASE-KX4.
R1000BASE_KX_EEE	4	RO	**1000BASE-KX EEE** 0_B EEE is not supported for 1000BASE-KX. 1_B EEE is supported for 1000BASE-KX.
R10GBASE_T_EEE	3	RO	**10GBASE-T EEE** 0_B EEE is not supported for 10GBASE-T. 1_B EEE is supported for 10GBASE-T.
R1000BASE_T_EEE	2	RO	**1000BASE-T EEE** 0_B EEE is not supported for 1000BASE-T. 1_B EEE is supported for 1000BASE-T.
R100BASE_TX_EEE	1	RO	**100BASE-TX EEE** 0_B EEE is not supported for 100BASE-TX. 1_B EEE is supported for 100BASE-TX.

EEE Control and Capability 2 (Register 3.21)

Read only. Write from the STA has no effect.

IEEE Standard Register=3.21

PCS_EEE_CAP2 **Reset Value**

EEE Control and Capability 2 (Register 3.21) **0001_H**

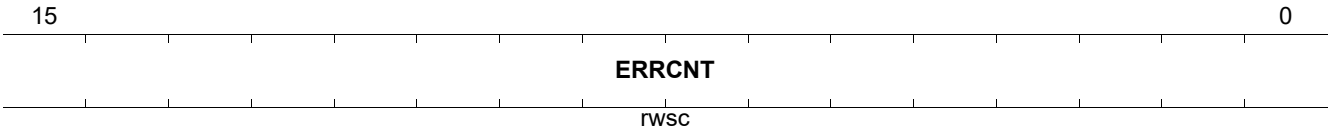
Field	Bits	Type	Description
RES	15:2	RO	**Reserved** Value always 0.
AB5GEEE	1	RO	**EEE Supported for 5GBASE-T** 0_B **UNABLE** EEE is not supported for 5GBASE-T. 1_B **ABLE** EEE is supported for 5GBASE-T.
AB2G5EEE	0	RO	**EEE Supported for 2.5GBASE-T** 0_B **UNABLE** EEE is not supported for 2.5GBASE-T. 1_B **ABLE** EEE is supported for 2.5GBASE-T.

PCS EEE Status Register 1 (Register 3.22)

IEEE Standard Register=3.22

PCS_EEE_WAKERR **Reset Value**

PCS EEE Status Register 1 (Register 3.22) **0000_H**



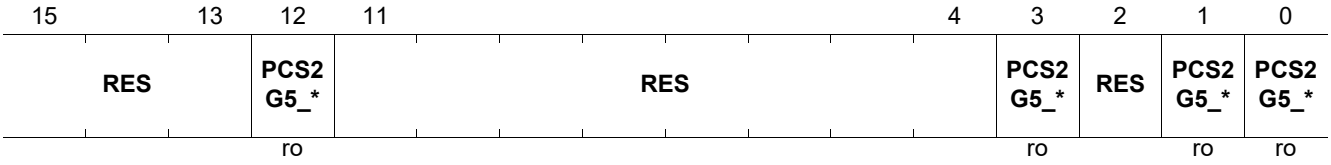
Field	Bits	Type	Description
ERRCNT	15:0	RWSC	**EEE Wake Error Counter** This is a 16-bit saturating counter indicating the number of times the GPHY PHY fails to wake up within the EEE time. This counter is cleared upon read from the STA.

BASE-R and 10GBASE-T PCS Status 1 (Register 3.32)

IEEE Standard Register=3.32

PCS_2G5_STAT1 **Reset Value**

BASE-R and 10GBASE-T PCS Status 1 (Register 3.32) **0000_H**

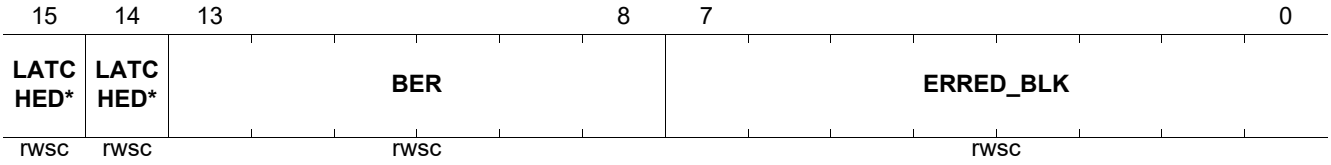


Field	Bits	Type	Description
PCS2G5_LINK_STATUS	12	RO	**BASE-R and 10GBase-T Rx Link Status** 0_B 2G5 PCS receive link down 1_B 2G5 PCS receive link up
PCS2G5_PAT_TEST_AB	3	RO	**PRBS9 Pattern Testing Ability** 0_B PCS is not able to support PRBS9 pattern testing. 1_B PCS is able to support PRBS9 pattern testing.
PCS2G5_HI_BER	1	RO	**PCS 2G5 High BER** This bit is a direct reflection of the state of the hi_lfer variable in 126.3.6.2.2 for 2.5GBASE-T. A latch high view of this status is reflected in MDIO register 3.33.14. 0_B The 64B/65B receiver detects a BER below 10^-4. 1_B The 64B/65B receiver detects a BER above or equal to 10^-4.
PCS2G5_BLO_LOCK	0	RO	**PCS 2G5 Block Lock** 0_B 64B/65B receiver does not have block lock. 1_B 64B/65B receiver has block lock.

MULTIGBASE-T PCS Status 2 (Register 3.33)

PCS_2G5_STAT2 **Reset Value**

MULTIGBASE-T PCS Status 2 (Register 3.33) **0000_H**



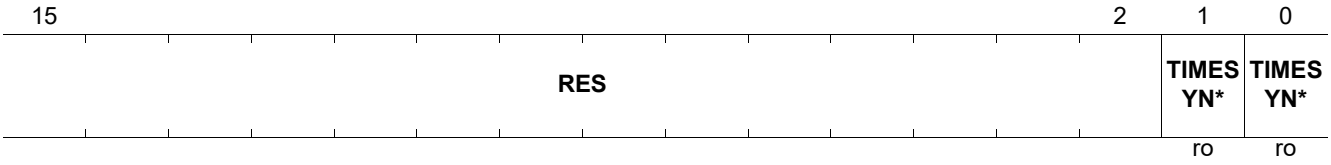
Field	Bits	Type	Description
LATCHED_BLOCK_LOCK	15	RWSC	**Latched Block Lock** 0_B PCS 2G5 does not have block lock. 1_B PCS 2G5 has block lock.
LATCHED_HIGH_BER	14	RWSC	**Latched High BER** 0_B PCS 2G5 did not report a high BER. 1_B PCS 2G5 reported a high BER.
BER	13:8	RWSC	**BER** BER counter
ERRED_BLK	7:0	RWSC	**Errored Blocks** Errored blocks counter

PCS TimeSync Capability Register (Register 3.1800)

IEEE Standard Register=3.1800

PCS_TIMESYNC_CAP **Reset Value**

PCS TimeSync Capability Register (Register 3.1800) **0000_H**



Field	Bits	Type	Description
TIMESYNC_TX_PATH_DATA_DELAY	1	RO	**TimeSync Transmit Path Data Delay** 0_B PCS does not provide information on transmit path data delay. For the GPHY, the value is always 0. 1_B PCS provides information on transmit path data delay in registers 3.1801 through 3.1804.
TIMESYNC_RX_PATH_DATA_DELAY	0	RO	**TimeSync Receive Path Data Delay** 0_B PCS does not provide information on receive path data delay. For the GPHY, the value is always 0. 1_B PCS provides information on receive path data delay in registers 3.1805 through 3.1808.

6.3 Standard Auto-Negotiation Registers for MMD=0x07

This register file contains the auto-negotiation registers for MMD device 0x07.

Table 33 Registers Overview- Standard Auto-Negotiation Registers

Register Short Name	Register Long Name	Reset Value
ANEG_CTRL	Auto-Negotiation Control (Register 7.0)	3000_H
ANEG_STAT	Auto-Negotiation Status (Register 7.1)	0008_H
ANEG_DEVID1	PHY Identifier 1 (Register 7.2)	$C133_H$
ANEG_DEVID2	PHY Identifier 2 (Register 7.3)	5400_H 1)
ANEG_DIP1	Device in Package 1 (Register 7.5)	$008B_H$
ANEG_DIP2	Device in Package 2 (Register 7.6)	$C000_H$
ANEG_PACKID1	AN Package Identifier (Register 7.14)	$C133_H$
ANEG_PACKID2	AN Package Identifier (Register 7.15)	5400_H 1)
ANEG_ADV	ANEG Adv. for GPHY (Register 7.16)	$9DE1_H$
ANEG_LP_BP_AB	AN Link Partner Base Page Ability (Register 7.19)	$0DE0_H$
ANEG_XNP_TX1	ANEG Local Dev XNP TX1 (Register 7.22)	0001_H
ANEG_XNP_TX2	ANEG Local Dev XNP TX2 (Register 7.23)	0000_H
ANEG_XNP_TX3	ANEG Local Dev XNP TX3 (Register 7.24)	0000_H
ANEG_LP_XNP_AB1	ANEG Link Partner XNP RX (Register 7.25)	0000_H
ANEG_LP_XNP_AB2	ANEG Link Partner XNP RX (Register 7.26)	0000_H
ANEG_LP_XNP_AB3	ANEG Link Partner XNP RX (Register 7.27)	0000_H
ANEG_MGBT_AN_CTRL	MULTI GBT AN Control (Register 7.32)	0082_H
ANEG_MGBT_AN_STA	MultiGBASE-T AN Status (Register 7.33)	0000_H
ANEG_EEE_AN_ADV1	EEE Advertisement 1 (Register 7.60)	0006_H
ANEG_EEE_AN_LPAB1	EEE Link Partner Ability 1 (Register 7.61)	0000_H
ANEG_EEE_AN_ADV2	EEE Advertisement 2 (Register 7.62)	0001_H
ANEG_EEE_LP_AB2	EEE Link Partner Ability 2 (Register 7.63)	0001_H
ANEG_MGBT_AN_CTRL2	MGBT ANEG Control 2 (Register 7.64)	0008_H

1) For the device specific reset value, see the Product and Package Naming table in the **Product Ordering Information** chapter.

6.3.1 ANEG Register Descriptions

This section describes all the ANEG registers in detail.

Auto-Negotiation Control (Register 7.0)

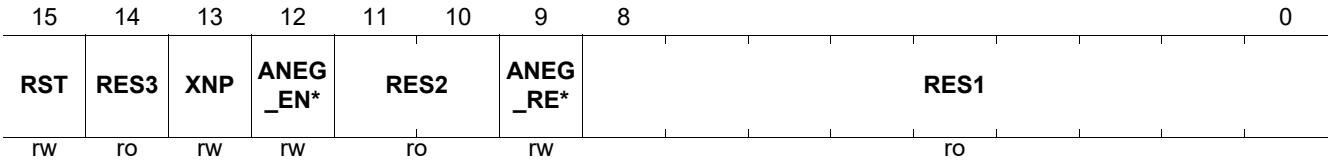
The register controls the main function of auto-negotiation as defined in Clause 45. Refer to IEEE 802.3 45.2.7.1.

This register mirrors register STD_CTRL from Clause 22.

IEEE Standard Register=7.0

ANEG_CTRL **Reset Value**

Auto-Negotiation Control (Register 7.0) **3000_H**



Field	Bits	Type	Description
RST	15	RW	**Reset** This bit resets the entire PHY to its default state. Active links are terminated. This is a self-clearing bit. The GPHY firmware sets the bit to 0 via the hardware when the reset is completed. 0_B **NORMAL** Normal GPHY operation 1_B **RESET** GPHY reset
RES3	14	RO	**Reserved** Value always 0, writes ignored.
XNP	13	RW	**Extended Next Page Control** 0_B **ZERO** Extended next page is disabled. 1_B **ONE** Extended next page is enabled.
ANEG_ENAB	12	RW	**Auto-Negotiation Enable** This bit enables the ANEG process to determine the link configuration. Bit 7.0.12 is a copy of bit 0.12 in register 0 (STD_CTRL). 0_B **ZERO** ANEG process is disabled. 1_B **ONE** ANEG process is enabled.
RES2	11:10	RO	**Reserved** Value always zero, writes ignored.
ANEG_RESTART	9	RW	**Restart Auto-Negotiation** The ANEG process is restarted by setting bit 7.0.9 to 1.Bit 7.0.9 is a mirror of bit 0.9 in register 0 (STD_CTRL). Completion of ANEG is indicated in bit 0.1.5 and 7.1.5. 0_B **ZERO** Normal operation 1_B **RESTART** Restarts ANEG process.
RES1	8:0	RO	**Reserved** Value always 0, writes ignored.

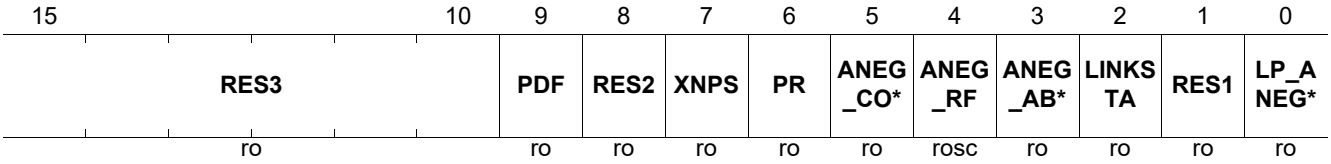
Auto-Negotiation Status (Register 7.1)

All the bits in the ANEG_STA status register are read only and correspond to the outcome or current status of the auto-negotiation process.

IEEE Standard Register=7.1

ANEG_STAT **Reset Value**

Auto-Negotiation Status (Register 7.1) **0008_H**



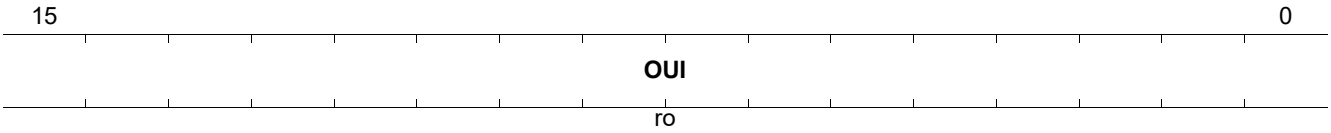
Field	Bits	Type	Description
RES3	15:10	RO	**Reserved** Value always zero, writes ignored.
PDF	9	RO	**Parallel Detection Fault** 0_B **NOFAULT** No fault detected 1_B **FAULT** Fault detected via the parallel mechanism
RES2	8	RO	**Reserved** Value always 0, writes ignored.
XNPS	7	RO	**Extended Next Page Status** When set to 1_B, bit 7.1.7 indicates that both the GPHY and the link partner confirmed support for extended next page. When set to 0_B, bit 7.1.7 indicates that the extended next page feature is not used. 0_B **ZERO** Extended next page is not allowed. 1_B **ONE** Extended next page format is used.
PR	6	RO	**Page Received** The Page Received bit (7.1.6) is set to 1_B to indicate that a new link codeword was received and stored in the AN LP Base Page ability registers 7.19 or AN LP XNP ability registers 7.25 to 7.27. 0_B **ZERO** No page received 1_B **ONE** Page received
ANEG_COMPLETE	5	RO	**Auto-Negotiation Complete** When read as a 1, bit 7.1.5 indicates that the ANEG process was completed and that the contents of the ANEG registers 7.16 and 7.19 are valid. When read as a 0, bit 7.1.5 indicates that the ANEG process was not completed and that the contents of the 7.19, 7.22 through 7.27, and 7.33 registers are as defined by the current state of the ANEG protocol, or as written by manual configuration. 0_B **ZERO** ANEG process not completed 1_B **ONE** ANEG process completed

Field	Bits	Type	Description (cont'd)
ANEG_RF	4	ROSC	**Remote Fault** When read as 1, bit 7.1.4 indicates that a remote fault condition was detected. Bit 7.1.4 is a copy of bit 1.4 in register 1, device 0. 0_B **NORMAL** No remote fault condition detected 1_B **FAULT** Remote fault condition detected
ANEG_ABLE	3	RO	**Auto-Negotiation Ability** Bit 7.1.3 is a copy of bit 1.3 in register 1. This is the ANEG ability of the GPHY. 0_B **UNABLE** PHY is not able to perform ANEG. 1_B **ABLE** PHY is able to perform ANEG.
LINKSTA	2	RO	**Link Status** When read as 1_B, bit 7.1.2 indicates that the PMA/PMD determined that a valid link is established. This bit is a duplicate of the PMA/PMD link status bit in 1.1.2. This bit latches low so it does not represent the current status, but is used to indicate link drop since the last read from the management interface. Reading this bit from the MDIO resets the bit to the current value of the link. 0_B **DOWN** Link is down. 1_B **UP** Link is up.
RES1	1	RO	**Reserved** Value always 0, write ignored.
LP_ANEG_ABLE	0	RO	**Link Partner Auto-Negotiation Ability** 0_B **UNABLE** Link partner is not capable of ANEG. 1_B **ABLE** Link partner is capable of ANEG.

PHY Identifier 1 (Register 7.2)

ANEG_DEVID1 **Reset Value**

PHY Identifier 1 (Register 7.2) **C133$_H$**



Field	Bits	Type	Description
OUI	15:0	RO	**Organizationally Unique Identifier**

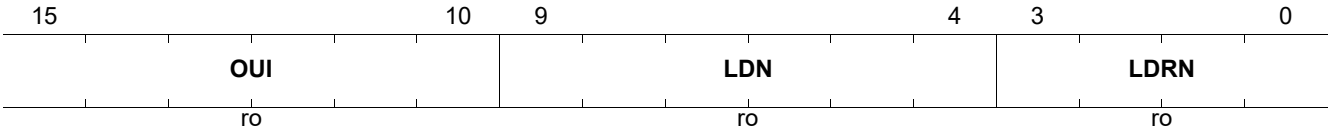
PHY Identifier 2 (Register 7.3)

Organizationally Unique Identifier

IEEE Standard Register=7.3

ANEG_DEVID2 **Reset Value**

PHY Identifier 2 (Register 7.3) **5400_H**



Field	Bits	Type	Description
OUI	15:10	RO	**Organizationally Unique Identifier**
LDN	9:4	RO	**Device Number** Specifies the device number[1)] to distinguish between several different products.
LDRN	3:0	RO	**Device Revision Number** Specifies the device revision number[1)] to distinguish between several versions of this device.

1) For the device specific reset value, see the Product and Package Naming table in the **Product Ordering Information** chapter.

Device in Package 1 (Register 7.5)

IEEE Standard Register=7.5

ANEG_DIP1 **Reset Value**

Device in Package 1 (Register 7.5) **$008B_H$**

15	12	11	10	9	8	7	6	5	4	3	2	1	0
RES		**PMA4**	**PMA3**	**PMA2**	**PMA1**	**ANEG**	**TC**	**DTEXS**	**PHYXS**	**PCS**	**WIS**	**PMAPMD**	**CL22**
ro		ro	ro	ro	ro	ro	ro	ro	ro	ro	ro	ro	ro

Field	Bits	Type	Description
RES	15:12	RO	**Reserved** Ignore on read.
PMA4	11	RO	**Separate PMA4 Present in Package** 0_B **ABSENT** Separate PMA4 not present in package 1_B **PRESENT** Separate PMA4 present in package
PMA3	10	RO	**Separate PMA3 Present in Package** 0_B **ABSENT** Separate PMA3 not present in package 1_B **PRESENT** Separate PMA3 present in package
PMA2	9	RO	**Separate PMA2 Present in Package** 0_B **ABSENT** Separate PMA2 not present in package 1_B **PRESENT** Separate PMA2 present in package
PMA1	8	RO	**Separate PMA1 Present in Package** 0_B **ABSENT** Separate PMA1 not present in package 1_B **PRESENT** Separate PMA1 present in package
ANEG	7	RO	**Auto-Negotiation Present in Package** 0_B **ABSENT** ANEG not present in package 1_B **PRESENT** ANEG present in package
TC	6	RO	**TC Present in Package** 0_B **ABSENT** TC registers not present in package 1_B **PRESENT** TC registers present in package
DTEXS	5	RO	**DTE XS Present in Package** 0_B **ABSENT** DTE XS registers not present in package 1_B **PRESENT** DTE XS registers present in package
PHYXS	4	RO	**PHYXS Present in Package** 0_B **ABSENT** PHYXS registers not present in package 1_B **PRESENT** PHYXS registers present in package
PCS	3	RO	**PCS Present in Package** 0_B **ABSENT** PCS registers not present in package 1_B **PRESENT** PCS registers present in package
WIS	2	RO	**WIS Present in Package** 0_B **ABSENT** WIS registers present in package 1_B **PRESENT** WIS registers present in package

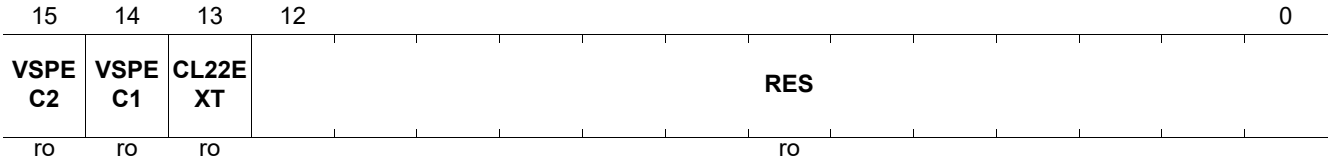
Field	Bits	Type	Description (cont'd)
PMAPMD	1	RO	**PMA PMD Present in Package** 0_B **ABSENT** PMA PMD registers not present in package 1_B **PRESENT** PMA PMD registers present in package
CL22	0	RO	**Clause 22 Register Present in Package** 0_B **ABSENT** Clause 22 registers no present in package 1_B **PRESENT** Clause 22 registers present in package

Device in Package 2 (Register 7.6)

IEEE Standard Register=7.6

ANEG_DIP2 **Reset Value**

Device in Package 2 (Register 7.6) **$C000_H$**



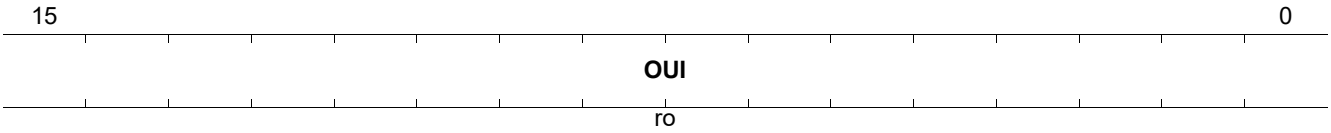
Field	Bits	Type	Description
VSPEC2	15	RO	**Vendor Specific Device 2 Present in Package** 0_B **ABSENT** Vendor Specific Device 2 not present in package 1_B **PRESENT** Vendor Specific Device 2 present in package
VSPEC1	14	RO	**Vendor Specific Device 1 Present in Package** 0_B **ABSENT** Vendor Specific Device 1 not present in package 1_B **PRESENT** Vendor Specific Device 1 present in package
CL22EXT	13	RO	**Clause 22 Extension Present in Package** 0_B **ABSENT** Clause 22 extension not present in package 1_B **PRESENT** Clause 22 extension present in package
RES	12:0	RO	**Reserved** Ignore on read.

AN Package Identifier (Register 7.14)

IEEE Standard Register=7.14

ANEG_PACKID1 **Reset Value**

AN Package Identifier (Register 7.14) **$C133_H$**



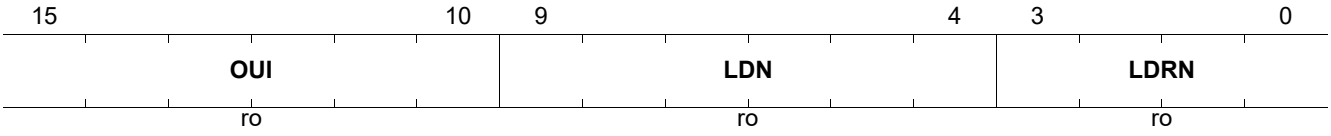
Field	Bits	Type	Description
OUI	15:0	RO	**Organizationally Unique Identifier Bits 3:18**

AN Package Identifier (Register 7.15)

IEEE Standard Register=7.15

ANEG_PACKID2 **Reset Value**

AN Package Identifier (Register 7.15) **5400_H**



Field	Bits	Type	Description
OUI	15:10	RO	**Organizationally Unique Identifier Bits 19:24**
LDN	9:4	RO	**Device Number** Specifies the device number[1)] to distinguish between several different products.
LDRN	3:0	RO	**Device Revision Number** Specifies the device revision number[1)] to distinguish between several versions of this device.

1) For the device specific reset value, see the Product and Package Naming table in the **Product Ordering Information** chapter.

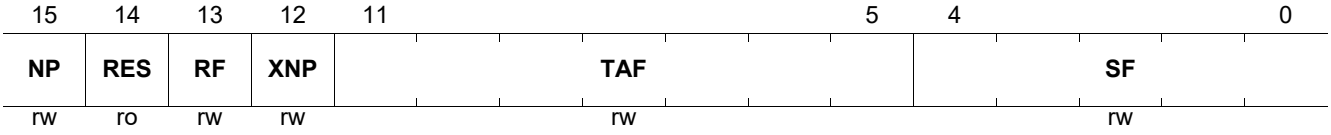
ANEG Adv. for GPHY (Register 7.16)

This register is a copy of the ANEG advertisement register (Register 4). A read to the AN advertisement register (7.16) reports the value of the ANEG advertisement register (Register 4). Writes to the AN advertisement register (7.16) cause a write to occur to the ANEG advertisement register (Register 4).

IEEE Standard Register=7.16

ANEG_ADV **Reset Value**

ANEG Adv. for GPHY (Register 7.16) **$9DE1_H$**



Field	Bits	Type	Description
NP	15	RW	**Next Page Able** 0_B **INACTIVE** No next page allowed. 1_B **ACTIVE** Additional next page(s) to follow.
RES	14	RO	**Reserved** Write as zero, ignore on read.
RF	13	RW	**Remote Fault** The remote fault bit allows indication of a fault to the link partner. Refer to IEEE 802.3 28.2.1.2.4.
XNP	12	RW	**Transmission of Extended Next Pages** Indicates that the GPHY is able to transmit extended next pages. 0_B **UNABLE** GPHY is XNP unable. 1_B **ABLE** GPHY is XNP able.
TAF	11:5	RW	**Technology Ability Field** The technology ability field is an 8-bit wide field containing information indicating supported technologies. The GPHY supports 10BASE-T (half- and full-duplex), 100BASE-TX (half- and full-duplex), and both symmetric and asymmetric PAUSE. 40_H **PS_ASYM** Advertises asymmetric pause 20_H **PS_SYM** Advertises symmetric pause 10_H **DBT4** Advertises 100BASE-T4 08_H **DBT_FDX** Advertises 100BASE-TX full-duplex 04_H **DBT_HDX** Advertises 100BASE-TX half-duplex 02_H **XBT_FDX** Advertises 10BASE-T full-duplex 01_H **XBT_HDX** Advertises 10BASE-T half-duplex
SF	4:0	RW	**Selector Field** This field is always set to 00001_B because the GPHY only supports the 802.3 Ethernet standard. 00001_B**IEEE8023** IEEE 802.3 technology.

AN Link Partner Base Page Ability (Register 7.19)

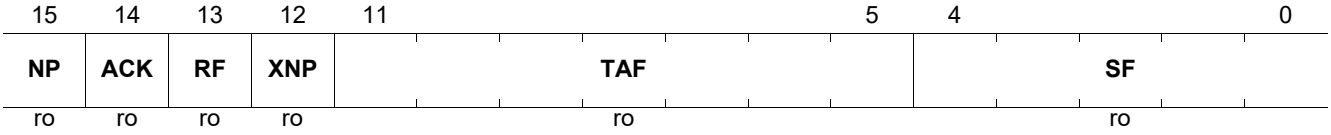
Register 7.19 is a copy of register 5 from Clause 28. It contains the Base Page received from the link partner.

All of the bits in the AN LP Base Page Ability register are read only.

IEEE Standard Register=7.19

ANEG_LP_BP_AB **Reset Value**

AN Link Partner Base Page Ability (Register 7.19) **$0DE0_H$**



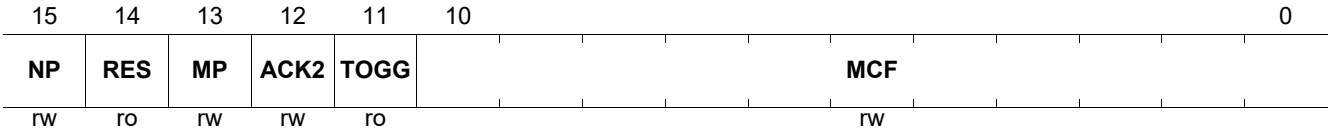
Field	Bits	Type	Description
NP	15	RO	**Link Partner Next Page** Next page request indication from the link partner. 0_B **INACTIVE** No next page to follow 1_B **ACTIVE** Additional next page to follow
ACK	14	RO	**Link Partner Acknowledge** Acknowledgment indication from the link partner's link code word. 0_B **INACTIVE** Device did not successfully receive its link partner's link code word. 1_B **ACTIVE** Device successfully received its link partner's link code word.
RF	13	RO	**Link Partner Remote Fault** Remote fault indication from the link partner. 0_B **NONE** Remote fault is not indicated by the link partner. 1_B **FAULT** Remote fault is indicated by the link partner.
XNP	12	RO	**Link Partner XNP Ability** 0_B **UNABLE** Link partner is not XNP able. 1_B **ABLE** Link partner is XNP able.
TAF	11:5	RO	**Technology Ability Field** These bits indicate the link partner's supported technologies received in the Base Page. 40_H **PS_ASYM** Advertises asymmetric pause 20_H **PS_SYM** Advertises symmetric pause 10_H **DBT4** Advertises 100BASE-T4 08_H **DBT_FDX** Advertises 100BASE-TX full-duplex 04_H **DBT_HDX** Advertises 100BASE-TX half-duplex 02_H **XBT_FDX** Advertises 10BASE-T full-duplex 01_H **XBT_HDX** Advertises 10BASE-T half-duplex

Field	Bits	Type	Description (cont'd)
SF	4:0	RO	**Link Partner Selector Field** This selector field represents one of the 32 possible messages with encoding definitions defined in IEEE 802.3 Annex 28A. 00_H Reserved 01_H IEEE 802.3 02_H IEEE 802.9 ISLAN-16T 03_H IEEE 802.5 04_H IEEE 1394 05_H Reserved ... $1F_H$ Reserved

ANEG Local Dev XNP TX1 (Register 7.22)

ANEG_XNP_TX1 **Reset Value**

ANEG Local Dev XNP TX1 (Register 7.22) **0001_H**



Field	Bits	Type	Description
NP	15	RW	**Next Page** When the NP bit is set, the GPHY requests to transmit one additional page. The next page transmission ends when both ends of a link segment set their next page bits to logic 0, indicating that neither has anything additional to transmit. 0_B **INACTIVE** No next page to follow. 1_B **ACTIVE** Additional next page(s) to follow.
RES	14	RO	**Reserved** Write as 0, ignore on read.
MP	13	RW	**Message Page** Message Page (MP) is used by the next page function to differentiate a MP from an UP. Only MPs are used by the GPHY. 0_B **UNFOR** Unformatted Page 1_B **MESSG** Message Page
ACK2	12	RW	**Acknowledge 2** Not used during GPHY ANEG. 0_B **INACTIVE** Device does not comply with message. 1_B **ACTIVE** Device complies with message.
TOGG	11	RO	**Toggle** The Toggle bit is used to ensure proper synchronization between the GPHY and the link partner. 0_B **ZERO** Previous value of the Tx LCW was 1_B. 1_B **ONE** Previous value of the Tx LCW was 0_B.

Field	Bits	Type	Description (cont'd)
MCF	10:0	RW	**Message Code Field** When the Message Page bit is set to 1_B (7.16.1), this field is the Message Code Field of a message page used in a next page exchange. The message codes are described in IEEE 802.3 Appendix 28C. This is used to indicate the type of message in UCF1 and UCF2. 00_H Reserved 01_H Null message 02_H One Unformatted Page (UP) with TAF follows 03_H Two UPs with TAF follows 04_H Remote fault details message 05_H OUI message 06_H PHY ID message 07_H 100BASE-T2 message 08_H 1000BASE-T message 09_H MULTIGBASE-T message $0A_H$ EEE technology capability follows in next UP $0B_H$ OUI XNP

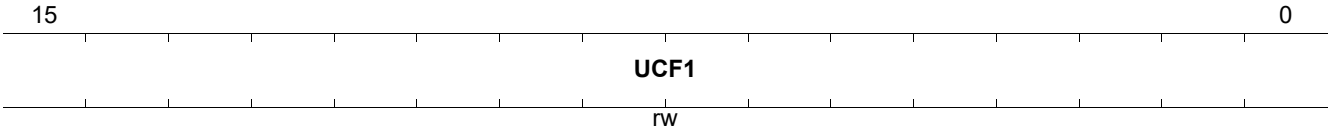
ANEG Local Dev XNP TX2 (Register 7.23)

Unformatted code field 1 contains seed information and advertises support of 1 GBT full-duplex and half-duplex. Refer to 28.2.3.4.

IEEE Standard Register=7.23

ANEG_XNP_TX2 **Reset Value**

ANEG Local Dev XNP TX2 (Register 7.23) **0000_H**



Field	Bits	Type	Description
UCF1	15:0	RW	**Unformatted Code Field 1** Transmits the master-slave seed bit to facilitate ANEG resolution, port type, and duplex capability.

ANEG Local Dev XNP TX3 (Register 7.24)

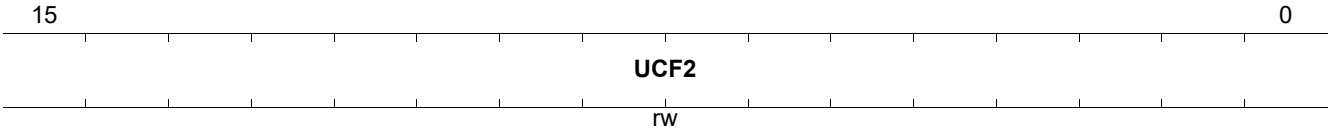
Unformatted code field 2 - Register 7.24

Refer to 28.2.3.4.

IEEE Standard Register=7.24

ANEG_XNP_TX3 **Reset Value**

ANEG Local Dev XNP TX3 (Register 7.24) **0000_H**



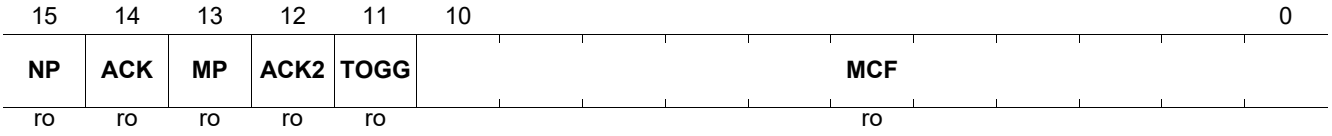
Field	Bits	Type	Description
UCF2	15:0	RW	**Unformatted Code Field 2** 2.5 GBASE-T ability is advertised by default.

ANEG Link Partner XNP RX (Register 7.25)

IEEE Standard Register=7.25

ANEG_LP_XNP_AB1 **Reset Value**

ANEG Link Partner XNP RX (Register 7.25) **0000_H**



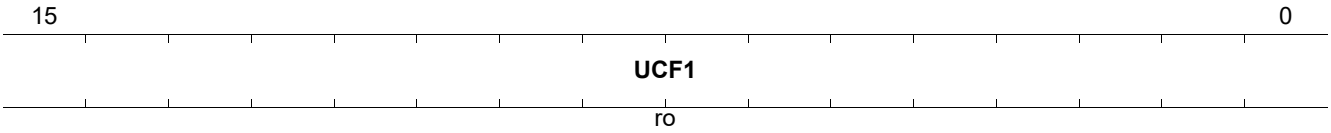
Field	Bits	Type	Description
NP	15	RO	**Link Partner Next Page** Refer to 28.2.3.4.3. The NP bit is used by the next page function to indicate whether or not this is the last next page to be transmitted. 0_B **INACTIVE** Last page 1_B **ACTIVE** Additional next page(s) to follow
ACK	14	RO	**Link Partner Acknowledge** As defined in 28.2.1.2.5. The Acknowledge (Ack) bit is used by the ANEG function to indicate that the GPHY successfully received its link partner's link codeword.
MP	13	RO	**Link Partner Message Page** Indicates that the content of MCF is either an unformatted page or a formatted message. 0_B **UNFOR** Unformatted page 1_B **MESSG** Message page
ACK2	12	RO	**Link Partner Acknowledge 2** 0_B **INACTIVE** Device is unable to comply with message. 1_B **ACTIVE** Device complies with message.
TOGG	11	RO	**Link Partner Toggle** This bit is set to the opposite of the TOGG bit in the previous page. 0_B **ZERO** Previous value of the TX LCW was 1_B. 1_B **ONE** Previous value of the TX LCW was 0_B.
MCF	10:0	RO	**Link Partner Message Code Field** This field indicates the type of Message Code. 009_H **MC_2G5BT** Message code for 2.5GBASE-T

ANEG Link Partner XNP RX (Register 7.26)

IEEE Standard Register=7.26

ANEG_LP_XNP_AB2 **Reset Value**

ANEG Link Partner XNP RX (Register 7.26) **0000_H**



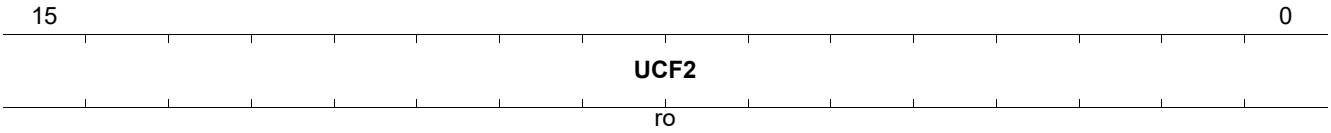
Field	Bits	Type	Description
UCF1	15:0	RO	**Unformatted Code Field 1** Refer to 28.2.3.4.

ANEG Link Partner XNP RX (Register 7.27)

IEEE Standard Register=7.27

ANEG_LP_XNP_AB3 **Reset Value**

ANEG Link Partner XNP RX (Register 7.27) **0000_H**



Field	Bits	Type	Description
UCF2	15:0	RO	**Unformatted Code Field 2** Refer to 28.2.3.4.

MULTI GBT AN Control Register (Register 7.32)

This register advertises the GPHY capabilities.

IEEE Standard Register=7.32

ANEG_MGBT_AN_CTRL **Reset Value**

MULTI GBT AN Control Register (Register 7.32) **0082_H**

15	14	13	12	11 9	8	7	6	5	4 3	2	1	0
MS_MAN_*	**MSCV**	**PT**	**AB_10GBT**	**RES2**	**AB_5GBT**	**AB_2G5BT**	**FR_5GBT**	**FR_2G5BT**	**RES1**	**LDPMA**	**FR**	**LDL**
rw	rw	rw	ro	ro	ro	rw	ro	rw	ro	rw	rw	rw

Field	Bits	Type	Description
MS_MAN_EN	15	RW	**Master Slave Manual Config Enable** 0_B **ANEG** ANEG is used to determine the master-slave selection. 1_B **MAN** Manual configuration. The MSCV bit determines the master-slave selection.
MSCV	14	RW	**Master Slave Config Value** 0_B **SLAVE** Manual set to SLAVE 1_B **MASTER** Manual set to MASTER
PT	13	RW	**Port Type** 0_B **MASTER** Preference as Master - single port device 1_B **SLAVE** Preference as Slave - multi-port device
AB_10GBT	12	RO	**10GBASE-T Ability** Not supported. Value always 0.
RES2	11:9	RO	**Reserved** Value always 0, writes ignored.
AB_5GBT	8	RO	**5GBASE-T Ability** Not supported by the GPHY. 0_B **UNABLE** Do not advertise PHY as 5GBASE-T capable. 1_B **ABLE** Advertises PHY as 5GBASE-T capable. Not supported.
AB_2G5BT	7	RW	**2.5GBASE-T Ability** 0_B **UNABLE** Do not advertise PHY as 2.5GBASE-T capable. 1_B **ABLE** Advertises PHY as 2.5GBASE-T capable.
FR_5GBT	6	RO	**5GBASE-T Fast Retrain Ability** Not supported by GPHY. 0_B **UNABLE** Do not advertise PHY as 5GBASE-T fast retrain able. 1_B **ABLE** Advertises PHY as 5GBASE-T fast retrain capable. Not supported.
FR_2G5BT	5	RW	**2.5GBASE-T Fast Retrain Ability** 0_B **UNABLE** Do not advertise PHY as 2.5G fast retrain able. 1_B **ABLE** Advertises PHY as 2.5G fast retrain able.
RES1	4:3	RO	**Reserved** Value always 0, writes ignored.

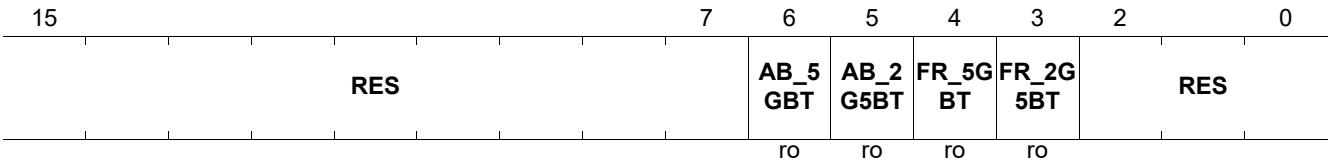
Field	Bits	Type	**Description** (cont'd)
LDPMA	2	RW	**GPHY PMA Training Reset Request** When this bit is set to 1_B, the GPHY expects the link partner to reset the PMA training PRBS for every PMA training frame. When this bit is set to 0_B, the GPHY expects the link partner to run the PMA training PRBS continuously through every PMA training frame.
FR	1	RW	**Fast Retrain Ability**
LDL	0	RW	**GPHY Loop Timing Ability**

MultiGBASE-T AN Status Register (Register 7.33)

IEEE Standard Register=7.33

ANEG_MGBT_AN_STA **Reset Value**

MultiGBASE-T AN Status register (Register 7.33) **0000_H**



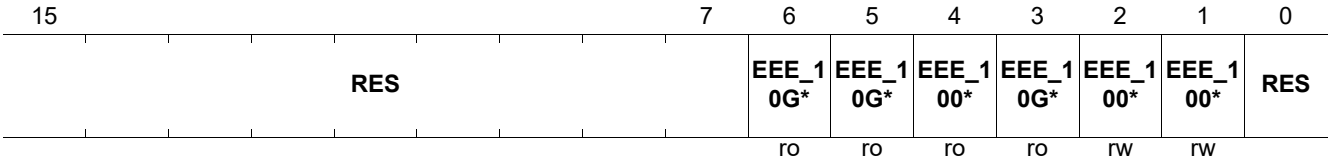
Field	Bits	Type	Description
AB_5GBT	6	RO	**5GBASE-T Ability of Link Partner** This bit is only valid when the link is established and ANEG completed. 0_B **UNABLE** Link partner is not capable of 5GBASE-T. 1_B **ABLE** Link partner is capable of 5GBASE-T.
AB_2G5BT	5	RO	**2.5GBASE-T Ability of Link Partner** This bit is only valid when the link is established and ANEG completed (bit 7.1.5 is set to 1_B). 0_B **UNABLE** Link partner is not capable of 2.5GBASE-T. 1_B **ABLE** Link partner is capable of 2.5GBASE-T.
FR_5GBT	4	RO	**5GBASE-T Fast Retrain Ability of Link Partner** This bit is only valid when the link is established and ANEG completed. 0_B **UNABLE** Link partner is not capable of 5GBASE-T fast retrain. 1_B **ABLE** Link partner is capable of 5GBASE-T fast retrain
FR_2G5BT	3	RO	**2.5GBASE-T Fast Retrain Ability of Link Partner** This bit is only valid when the link is established and ANEG completed (bit 7.1.5 is set to 1_B). 0_B **UNABLE** Link partner is not capable of 2.5GBASE-T fast retrain. 1_B **ABLE** Link partner is capable of 2.5GBASE-T fast retrain.

EEE Advertisement 1 (Register 7.60)

IEEE Standard Register=7.60

ANEG_EEE_AN_ADV1 **Reset Value**

EEE Advertisement 1 (Register 7.60) **0006_H**



Field	Bits	Type	Description
EEE_10GBKR	6	RO	**Support of 10GBASE-KR EEE** 0_B **DISABLED** This PHY mode is not supported for EEE. 1_B **ENABLE** This PHY mode is supported for EEE.
EEE_10GBKX4	5	RO	**Support of 10GBASE-KX4 EEE** 0_B **DISABLED** This PHY mode is not supported for EEE. 1_B **ENABLE** This PHY mode is supported for EEE.
EEE_1000BKX	4	RO	**Support of 1000BASE-KX EEE** 0_B **DISABLED** This PHY mode is not supported for EEE. 1_B **ENABLE** This PHY mode is supported for EEE.
EEE_10GBT	3	RO	**Support of 10GBASE-T EEE** 0_B **DISABLED** This PHY mode is not supported for EEE. 1_B **ENABLE** This PHY mode is supported for EEE.
EEE_1000BT	2	RW	**Support of 1000BASE-T EEE** 0_B **DISABLED** This PHY mode is not supported for EEE. 1_B **ENABLE** This PHY mode is supported for EEE.
EEE_100BTX	1	RW	**Support of 100BASE-TX EEE** 0_B **DISABLED** This PHY mode is not supported for EEE. 1_B **ENABLE** This PHY mode is supported for EEE.

EEE Link Partner Ability 1 (Register 7.61)

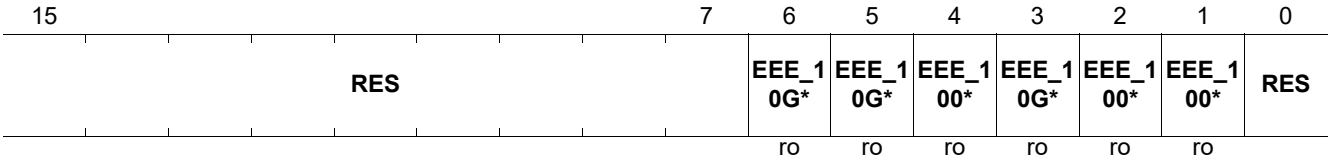
After the AN process is completed, this register reflects the contents of the link partner's EEE advertisement register. The definitions are the same as for the EEE AN advertisement 1 register.

IEEE Standard Register=7.61

All of the bits in the EEE LP ability 1 register are read only. A write operation to the EEE LP advertisement register has no effect.

ANEG_EEE_AN_LPAB1 **Reset Value**

EEE Link Partner Ability 1 (Register 7.61) **0000_H**



Field	Bits	Type	Description
EEE_10GBKR	6	RO	**Support of 10GBASE-KR EEE** 0_B **DISABLED** This PHY mode is not supported for EEE. 1_B **ENABLE** This PHY mode is supported for EEE.
EEE_10GBKX4	5	RO	**Support of 10GBASE-KX4 EEE** 0_B **DISABLED** This PHY mode is not supported for EEE. 1_B **ENABLE** This PHY mode is supported for EEE.
EEE_1000BKX	4	RO	**Support of 1000BASE-KX EEE** 0_B **DISABLED** This PHY mode is not supported for EEE. 1_B **ENABLE** This PHY mode is supported for EEE.
EEE_10GBT	3	RO	**Support of 10GBASE-T EEE** 0_B **DISABLED** This PHY mode is not supported for EEE. 1_B **ENABLE** This PHY mode is supported for EEE.
EEE_1000BT	2	RO	**Support of 1000BASE-T EEE** 0_B **DISABLED** This PHY mode is not supported for EEE. 1_B **ENABLE** This PHY mode is supported for EEE.
EEE_100BTX	1	RO	**Support of 100BASE-TX EEE** 0_B **DISABLED** This PHY mode is not supported for EEE. 1_B **ENABLE** This PHY mode is supported for EEE.

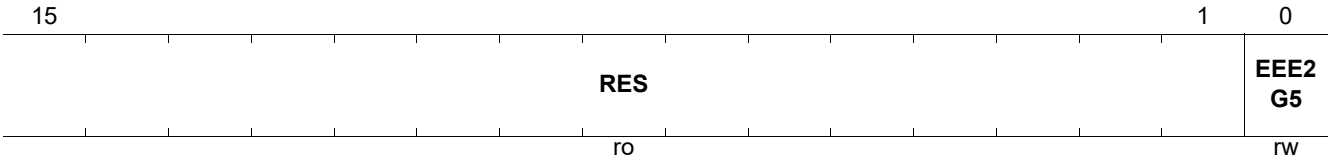
EEE Advertisement 2 (Register 7.62)

EEE advertisement 2 register is a continuation of EEE advertisement 1 register.

IEEE Standard Register=7.62

ANEG_EEE_AN_ADV2 **Reset Value**

EEE Advertisement 2 (Register 7.62) **0001_H**



Field	Bits	Type	Description
RES	15:1	RO	**Reserved**
EEE2G5	0	RW	**Advertise 2.5GBASE-T EEE Capability** 0_B **DISABLED** This PHY mode does not advertise 2.5GBASE-T EEE. 1_B **ENABLE** This PHY mode advertises 2.5GBASE-T EEE.

EEE Link Partner Ability 2 (Register 7.63)

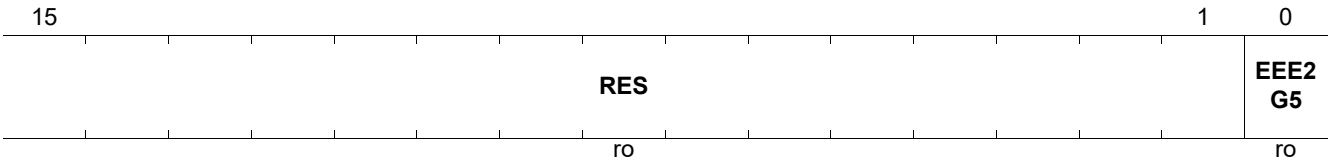
When the AN and training processes are complete, this register reflects the contents of the link partner's EEE advertisement 2 register.

IEEE Standard Register=7.63

All the bits in the EEE LP Ability 2 register are read-only. A write to the EEE LP Ability 2 register has no effect.

ANEG_EEE_LP_AB2 **Reset Value**

EEE Link Partner Ability 2 (Register 7.63) **0001_H**



Field	Bits	Type	Description
RES	15:1	RO	**Reserved**
EEE2G5	0	RO	**Link Partner Advertised 2.5GBASE-T EEE Capability** 0_B **DISABLED** LP is not 2.5GBASE-T EEE capable. 1_B **ENABLE** LP is 2.5GBASE-T EEE capable.

MGBT ANEG Control 2 (Register 7.64)

This register is an extension of the ANEG Control Register for Multi GBT. It is used for 2.5 G ANEG configuration.

IEEE Standard Register=7.64

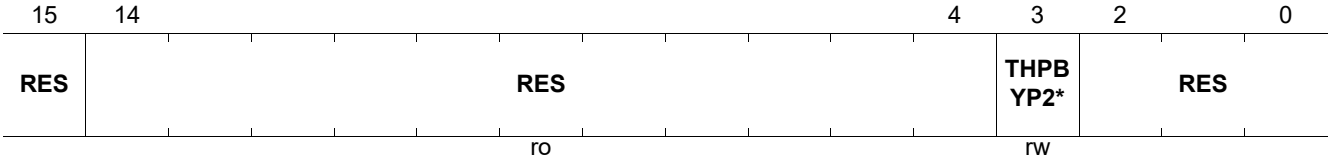
Bit 7.64.3 is valid only when 7.32.5 is set to 1_B advertising fast retrain ability, and is used to request the link partner whether to initially reset the THP during fast retrain. THP Bypass Request is exchanged during link training, refer to 126.4.2.5.10.

When bit 7.64.3 is set to 0_B, the GPHY requests the link partner not to reset THP during fast retrain.

When bit 7.64.3 is set to 1_B, the GPHY requests the link partner to initially reset THP during fast retrain.

ANEG_MGBT_AN_CTRL2 **Reset Value**

MGBT ANEG Control 2 (Register 7.64) **0008_H**



Field	Bits	Type	Description
RES	14:4	RO	**Reserved**
THPBYP2G5	3	RW	**THP Bypass During Fast Retrain** The GPHY requests a THP bypass during fast retrain. 0_B **NORST** GPHY requests the link partner NOT to initially reset THP during fast retrain. 1_B **RST** GPHY requests the link partner to initially reset THP during fast retrain.

6.4 Vendor Specific 1 Device Registers

This register file contains GPHY-specific registers for MMD=30 (decimal).

Table 34 Registers Overview- Vendor Specific 1 Device Registers

Register Short Name	Register Long Name	Reset Value
VSPEC1_LED0	Configuration for LED Pin 0 (Register 30.1)	0310_H
VSPEC1_LED1	Configuration for LED Pin 1 (Register 30.2)	0320_H
VSPEC1_TXS_SCL_OFFSET	PHY Transmit Amplitude Control Register (Register 30.8)	0000_H
VSPEC1_NBT_DS_CTRL	NBASE-T Downshift Control Register (Register 30.10)	0400_H
VSPEC1_NBT_DS_STA	NBASE-T Downshift Status Register (Register 30.11)	0000_H
VSPEC1_PM_CTRL	Packet Manager Control (Register 30.12)	3000_H
VSPEC1_TEMP_STA	Temperature Code (Register 30.14)	0000_H
VSPEC1_IMASK	VSPEC1 Interrupt Mask Register (Register 30.17)	0000_H
VSPEC1_ISTAT	VSPEC1 Interrupt Mask Register (Register 30.18)	0000_H
VSPEC1_USXGMII_STAT	USXGMII Status Register (Register 30.19)	0000_H
VSPEC1_LANE_ASP_MAP	ASP Mapping to Physical Lanes (Register 30.20)	$00E4_H$
VSPEC1_LOW_POWER_ENTRY_TIME	Time to Enter Low Power (Register 30.21)	0001_H
VSPEC1_FRCTL	Fast Retrain Control and Status (Register 30.22)	0000_H

6.4.1 VSPEC1 Register Descriptions

This section describes all the VSPEC1 registers in detail.

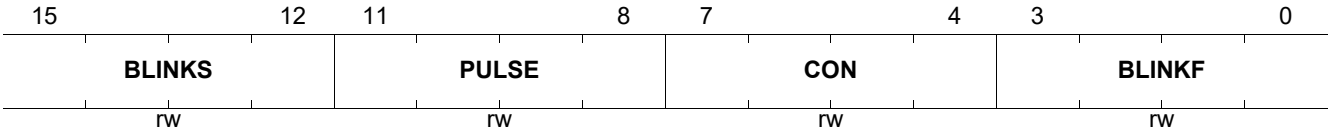
Configuration for LED Pin 0 (Register 30.1)

This register configures the behavior of the LED0 pin depending on predefined states or events the PHY entered into or raised. Since more than one event/state may be active at the same time, more than one function may apply at the same time. The priority from highest to lowest is given by the order: PULSE, BLINKS, BLINKF, and CON. The LED PULSE for the selected activity is only displayed for the link speed selected in CON. When CON is selected as NONE, no PULSE is displayed on the LED for any activity. To avoid the LED being constantly on when it is configured for pulsing alone, set the NO_CON bit in the PULSE field (bit 11).

IEEE Standard Register=30.1

VSPEC1_LED0 **Reset Value**

Configuration for LED Pin 0 (Register 30.1) **0310_H**



Field	Bits	Type	Description
BLINKS	15:12	RW	**Slow Blinking Configuration** The BLINKS field selects the PHY states where the LED blinks with the predefined slow frequency. Each bit mask indicates a link speed. Combinations of these bit masks are used to provide a combination of link speed states to enable the behavior. 0000_B**NONE** Not active 0001_B**LINK10** Blink when link is 10 Mbps. 0010_B**LINK100** Blink when link is 100 Mbps. 0100_B**LINK1000** Blink when link is 1000 Mbps. 1000_B**LINK2500** Blink when link is 2500 Mbps.
PULSE	11:8	RW	**Pulsing Configuration** The PULSE field is a mask field that combines certain events, such as TXACT|RXACT, to generate a pulse on the LED when such an event is detected. 0000_B**NONE** No pulsing 0001_B**TXACT** Transmit activity 0010_B**RXACT** Receive activity 0100_B**COL** Collision 1000_B**NO_CON** Constant on behavior is switched off.

Field	Bits	Type	Description (cont'd)
CON	7:4	RW	**Constant On Configuration** The CON field selects the PHY states where the LED is constantly on. Each bit mask indicates a link speed. Combinations of these bit masks are used to provide a combination of link speed states to enable the behavior. 0000_B**NONE** Not active 0001_B**LINK10** On when link is 10 Mbps. 0010_B**LINK100** On when link is 100 Mbps. 0100_B**LINK1000** On when link is 1000 Mbps. 1000_B**LINK2500** On when link is 2500 Mbps.
BLINKF	3:0	RW	**Fast Blinking Configuration** The BLINKF field selects the PHY states where the LED blinks with the predefined fast frequency. Each bit mask indicates a link speed. Combinations of these bit masks are used to provide a combination of link speed states to enable the behavior. 0000_B**NONE** No active 0001_B**LINK10** Blink when Link is 10 Mbps. 0010_B**LINK100** Blink when Link is 100 Mbps. 0100_B**LINK1000** Blink when Link is 1000 Mbps. 1000_B**LINK2500** Blink when Link is 2500 Mbps.

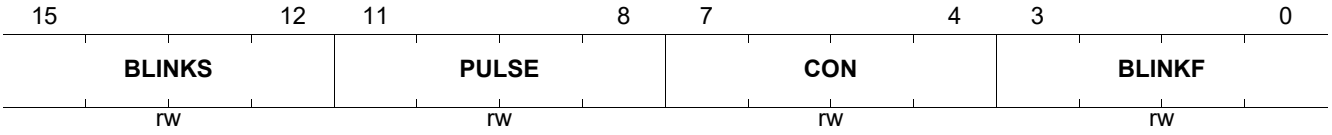
Configuration for LED Pin 1 (Register 30.2)

Configuration register for LED pin 1

IEEE Standard Register=30.2

VSPEC1_LED1 **Reset Value**

Configuration for LED Pin 1 (Register 30.2) **0320_H**



Field	Bits	Type	Description
BLINKS	15:12	RW	**Slow Blinking Configuration** The BLINKS field selects the PHY states where the LED blinks with the predefined slow frequency. Each bit mask indicates a link speed. Combinations of these bit masks are used to provide a combination of link speed states to enable the behavior. 0000_B**NONE** Not active 0001_B**LINK10** Blink when link is 10 Mbps. 0010_B**LINK100** Blink when link is 100 Mbps. 0100_B**LINK1000** Blink when link is 1000 Mbps. 1000_B**LINK2500** Blink when link is 2500 Mbps.
PULSE	11:8	RW	**Pulsing Configuration** The PULSE field is a mask field that combines certain events, such as TXACT|RXACT, to generate a pulse on the LED when such an event is detected. 0000_B**NONE** No pulsing 0001_B**TXACT** Transmit activity 0010_B**RXACT** Receive activity 0100_B**COL** Collision 1000_B**NO_CON** Constant on behavior is switched off.
CON	7:4	RW	**Constant On Configuration** The CON field selects the PHY states where the LED is constantly on. Each bit mask indicates a link speed. Combinations of these bit masks are used to provide a combination of link speed states to enable the behavior. 0000_B**NONE** Not active 0001_B**LINK10** On when link is 10 Mbps. 0010_B**LINK100** On when link is 100 Mbps. 0100_B**LINK1000** On when link is 1000 Mbps. 1000_B**LINK2500** On when link is 2500 Mbps.

Field	Bits	Type	Description (cont'd)
BLINKF	3:0	RW	**Fast Blinking Configuration** The BLINKF field selects the PHY states where the LED blinks with the predefined fast frequency. Each bit mask indicates a link speed. Combinations of these bit masks are used to provide a combination of link speed states to enable the behavior. 0000_B**NONE** Not active 0001_B**LINK10** Blink when link is 10 Mbps. 0010_B**LINK100** Blink when link is 100 Mbps. 0100_B**LINK1000** Blink when link is 1000 Mbps. 1000_B**LINK2500** Blink when link is 2500 Mbps.

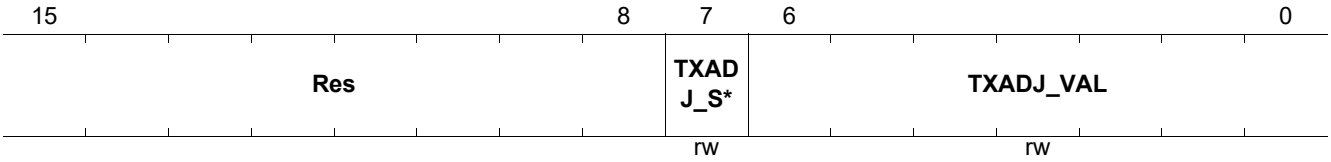
PHY Transmit Amplitude Control Register (Register 30.8)

This register adjusts the transmit amplitude of the PHY.

IEEE Standard Register=30.8

VSPEC1_TXS_SCL_OFFSET **Reset Value**

PHY Transmit Amplitude Control Register (Register 30.8) **0000_H**



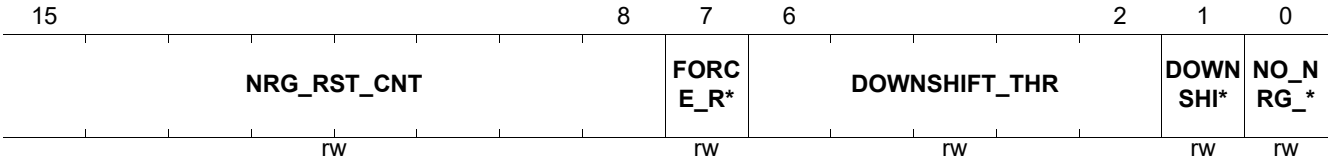
Field	Bits	Type	Description
TXADJ_SGN	7	RW	**Transmit Amplitude Adjustment Sign** 0_B **INC** Increase transmit amplitude 1_B **DEC** Decrease transmit amplitude
TXADJ_VAL	6:0	RW	**Transmit Amplitude Adjustment Value** Multiply the transmit amplitude by the following factor. (1 + (1-TXADJ_SGN*2)*TXADJ_VAL/128) The amplitude adjustment takes effect on the next link up.

NBASE-T Downshift Control Register (Register 30.10)

IEEE Standard Register=30.10

VSPEC1_NBT_DS_CTRL **Reset Value**

NBASE-T Downshift Control Register (Register 30.10) **0400_H**



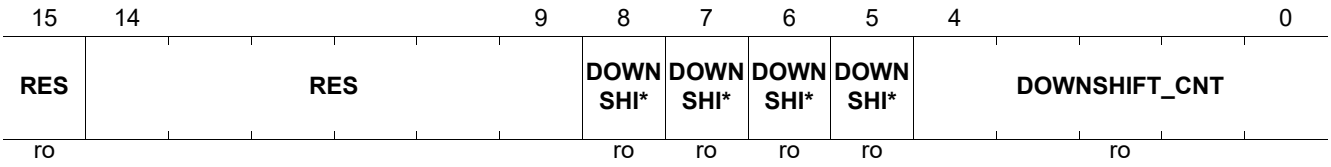
Field	Bits	Type	Description
NRG_RST_CNT	15:8	RW	**Timer to Reset the Downshift Process** When the energy is zero for a duration equal to NRG_RST_CNT seconds, the ANEG advertised capabilities are reset to the maximum GPHY capabilities. When NRG_RST_CNT is lower than 2, the ADS feature cannot be enabled. Default is 4 seconds. *Note: This timer only takes effect when NO_NRG_RST is set.*
FORCE_RST	7	RW	**Force Reset of Downwshift Process** Setting this bit to 1 immediately resets the ANEG advertised capabilities to the maximum GPHY capabilities.
DOWNSHIFT_THR	6:2	RW	**NBASE-T Downshift Training Counter Threshold** dsh_thr variable in NBASE-T specification This is a 4-bit counter from 0 to 15 used to control the number of training cycles allowed for linkup, otherwise downshift.
DOWNSHIFT_EN	1	RW	**NBASE-T Downshift Enable** dsh_en variable in NBASE-T specification 0_B **DISABLE** Disables NBT downshift. 1_B **ENABLE** Enables NBT downshift.
NO_NRG_RST	0	RW	**Advertise All Speeds if No Energy Detected** When no energy is detected, this resets to advertise all speeds. Energy variable in NBASE-T specification 0_B **DISABLE** Do not reset speeds advertised when no energy is detected. 1_B **ENABLE** Reset speeds advertised when no energy is detected.

NBASE-T Downshift Status Register (Register 30.11)

IEEE Standard Register=30.11

VSPEC1_NBT_DS_STA **Reset Value**

NBASE-T Downshift Status Register (Register 30.11) **0000_H**



Field	Bits	Type	Description
DOWNSHIFT_1G	8	RO	**Downshift from 1G to Lower Speed**
DOWNSHIFT_2G5	7	RO	**Downshift from 2.5 G to Lower Speed**
DOWNSHIFT_5G	6	RO	**Downshift 5G to Lower Speed** Not supported by the GPHY
DOWNSHIFT_10G	5	RO	**Downshift 10G to Lower Speed** Not supported by the GPHY
DOWNSHIFT_CNT	4:0	RO	**Training Attempt Counter** Counts training attempts to select the operating speed. dsh_cnt state variable in NBASE-T specification

Packet Manager Control (Register 30.12)

IEEE Standard Register=30.12

Control the Packet Manager Configuration

VSPEC1_PM_CTRL **Reset Value**

Packet Manager Control (Register 30.12) **3000_H**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
USXGMII*	**USXGMII_REACH**			**MDINT_M***	**RES**	**RES**	**PTP_EN**	**RES**	**SYNCE_CLK**		**SYNCE_EN**	**PRE_EMP_EN**	**PCH_EN**	**SI**	**PM_EN**
rw	rw			rw	rw	rw	rw	rw	rw		rw	rw	rw	rw	rw

Field	Bits	Type	Description
USXGMII_FIXED2G5	15	RW	**Force USXGMII Interface to Remain in 2.5G Speed or TPI Link Speed** Irrespective of the TPI link speed, the USXGMII operates at 2.5G speed when this bit is enabled. The GPHY packet manager performs the rate adaptation, and flow control is used to backpressure the MAC SoC when required. 0_B **NO_FORCE** The USXGMII speed is reconfigured by the GPHY based on the TPI link speed. 1_B **FORCE** The USXGMII speed is forced to the 2.5G speed.
USXGMII_REACH	14:12	RW	**USXGMII Tx and Rx Configuration** Based on the loop length between the GPHY and STA connected through USXGMII interface. No action taken if USXGMII interface is not available. 000_B **SHORT** Short reach configuration of USXGMII Tx and Rx equalization by firmware 001_B **MEDIUM** Medium reach configuration of USXGMII Tx and Rx equalization by firmware 010_B **LONG** Long reach configuration of USXGMII Tx and Rx equalization by firmware 011_B **CUSTOM** Custom Configuration At start-up default settings available after boot. If custom configuration of USXGMII Tx and Rx equalization required then the parameters can be set with custom values using GPHY API Others: Reserved.
MDINT_MODE	11	RW	**MDIO Interrupt Mode** Sets the mode of the MDIO interrupt signal. 0_B **TRI** Tristate mode The MDIO interrupt signal is tristate when the interrupt is inactive. It is driven only when the interrupt is active. 1_B **PP** Push-pull mode The MDIO interrupt signal is constantly driven.
PTP_EN	8	rw	**1588 PTP Enable** Enable 1588 PTP feature 0_B **DISABLE** Disable 1_B **ENABLE** Enable

Field	Bits	Type	Description
SYNCE_CLK	6:5	RW	**Configure the SyncE Clock Frequency Class** MaxLinear recommends using the API to configure SyncE. 00_B **PSTN** The SyncE clock frequency is PSTN class: 8 kHz. 01_B **EEC1** The SyncE clock frequency is EEC-1 class: 2.048 MHz. 10_B **EEC2** The SyncE clock frequency is EEC-2 class: 1.544 MHz. 11_B **RES** Reserved
SYNCE_EN	4	RW	**Enable SyncE Feature** SyncE is disabled by default. MaxLinear recommends using the API to enable SyncE. 0_B **DISABLE** Disable SyncE 1_B **ENABLE** Enable SyncE
PRE_EMP_EN	3	RW	**Enable pre-emption support** Not applicable if PM_EN=1 0_B **DISABLE** Disable 1_B **ENABLE** Enable
PCH_EN	2	RW	**Enable PCH** Enable PCH preamble 0_B **DISABLE** Disable 1_B **ENABLE** Enable
SI	1	RW	**Super Isolate** Use in Super Isolate mode. Forces the device into a power down state by pin strapping (SLEEP) in which power consumption is the bare minimum required to still maintain the MII management interface communication. When activating the power down functionality, the PHY terminates active data links. The MII interface is also stopped in power down mode. See also IEEE 802.3-2008 22.2.4.1.5. The SI bit is only used to release the device from Super Isolate mode. Entering Super Isolate mode can only be activated by pin strapping at power up. 0_B **NORMAL** Normal operational mode 1_B **SUPER_ISOLATE** Super Isolate mode
PM_EN	0	RW	**Enable Packet Manager** This field enables LPI generation within the GPHY. The Packet Manager on the GPHY supports the Smart AZ features. This bit is only applicable for port 0, once this bit in port 0 is set, it will apply to all GPHY ports. Reseting this bit back from 1 to 0 is not supported. 0_B **DISABLE** PM is bypassed, transparent mode 1_B **ENABLE** SmartAZ mode

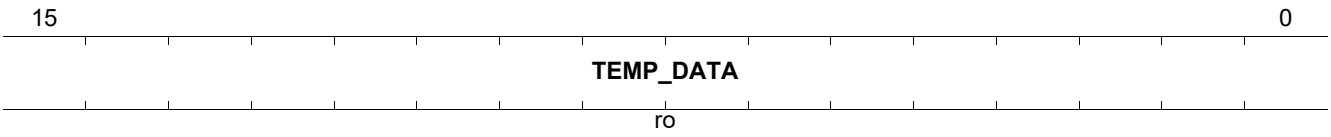
Temperature Code (Register 30.14)

Junction temperature is presented in degrees Celsius

IEEE Standard Register=30.14

VSPEC1_TEMP_STA **Reset Value**

Temperature Code (Register 30.14) **0000_H**



Field	Bits	Type	Description
TEMP_DATA	15:0	RO	**Junction Temperature** The temperature is represented as a two's complement binary fixed point number, of which the 7 LSBs are fractional. The STA must take the thermal mitigation measures when the junction temperature exceeds the normal operating range if ADS is disabled. TEMP_DATA is invalid when the value is 0000_H. Example Tj Values (Decimal): • For Tj = -40 degC, TEMP_DATA = $EC00_H$ • For Tj= +125 degC, TEMP_DATA = $3E80_H$

VSPEC1 Interrupt Mask Register (Register 30.17)

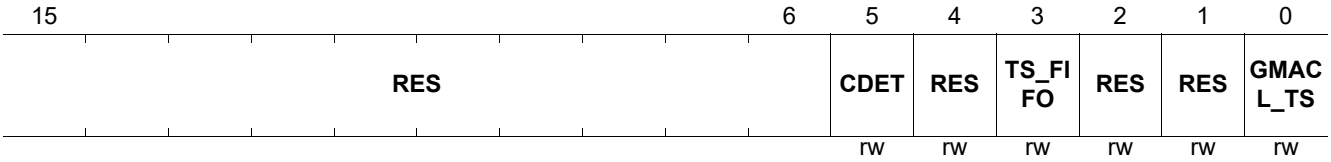
This register defines the mask for the Interrupt Status Register (ISTAT), which contains the event source for the MDINT interrupt sent from the GPHY to an external chip. The mask is cleared whenever the corresponding interrupt is serviced.

The information about the interrupt source is indicated in the VSPEC1_ISTAT register.

IEEE Standard Register=30.17

VSPEC1_IMASK **Reset Value**

VSPEC1 Interrupt Mask Register (Register 30.17) **0000_H**



Field	Bits	Type	Description
CDET	5	RW	**Cable Detect Interrupt** When active, MDINT is activated upon interrupt from detection of energy on the link. 0_B **INACTIVE** Interrupt is masked out. 1_B **ACTIVE** Interrupt is activated.
TS_FIFO	3	RW	**Time Stamp FIFO Interrupt** When active, MDINT is activated upon interrupt from either Tx or Rx Time stamp FIFO. 0_B **INACTIVE** Interrupt is masked out. 1_B **ACTIVE** Interrupt is activated.
GMACL_TS	0	RW	**Status of Interrupt Request GMACL TS** When active, MDINT is activated upon GMACL time stamp valid interrupt 0_B **INACTIVE** Interrupt is masked out. 1_B **ACTIVE** Interrupt is activated.

VSPEC1 Interrupt Status Register (Register 30.18)

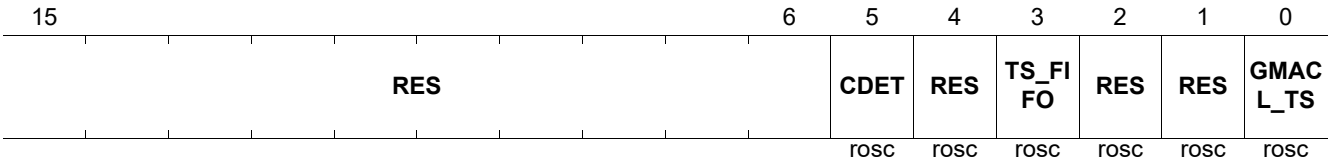
This register defines the event source for the MDINT interrupt sent from the GPHY to an external chip based on the mask settings in the VSPEC1_IMASK register.

VSPEC1_ISTAT is a cleared on read by the STA.

IEEE Standard Register=30.18

VSPEC1_ISTAT **Reset Value**

VSPEC1 Interrupt Status Register (Register 30.18) **0000_H**



Field	Bits	Type	Description
CDET	5	ROSC	**Cable Detect Interrupt** When this bit is set, MDINT is activated upon interrupt from detection of energy on the link. 0_B **INACTIVE** This event is not the interrupt source. 1_B **ACTIVE** The cable detect interrupt is the source of the interrupt.
TS_FIFO	3	ROSC	**Time Stamp FIFO Interrupt** When this bit is set, MDINT is activated upon interrupt from either Tx or Rx time stamp FIFO. 0_B **INACTIVE** This event is not the interrupt source. 1_B **ACTIVE** The time stamp FIFO interrupt is the source of the interrupt.
GMACL_TS	0	ROSC	**Status of Interrupt Request GMACL TS** When this bit is set, MDINT is activated upon interrupt from GMACL time stamp valid interrupt. 0_B **INACTIVE** This event is not the interrupt source. 1_B **ACTIVE** The GMACL time stamp is the source of the interrupt.

USXGMII Status Register (Register 30.19)

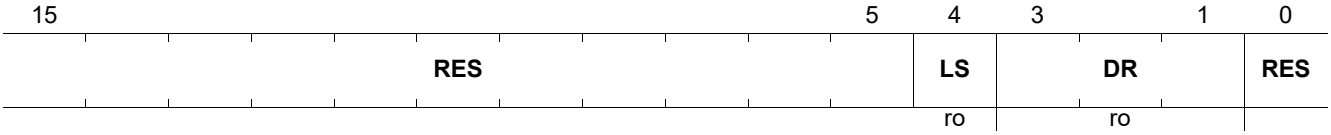
This is the USXGMII status register.

All the bits in this status register are read only. A write has no effect.

IEEE Standard Register=30.19

VSPEC1_USXGMII_STAT **Reset Value**

USXGMII Status Register (Register 30.19) **0000_H**



Field	Bits	Type	Description
LS	4	RO	**USXGMII Link Status** Indicates the link status of the USXGMII. 0_B **INACTIVE** The link is down. No communication with link partner is possible. 1_B **ACTIVE** The link is up. Data communication with link partner is possible.
DR	3:1	RO	**USXGMII Data Rate** This field indicates the operating data rate of USXGMII when the link is up. 000_B **DR_10** USXGMII link rate is 10 Mbps. 001_B **DR_100** USXGMII link rate is 100 Mbps. 010_B **DR_1G** USXGMII link rate is 1000 Mbps. 011_B **DR_ANEG** USXGMII is in auto-negotiation. 100_B **DR_2G5** USXGMII link rate is 2500 Mbps.

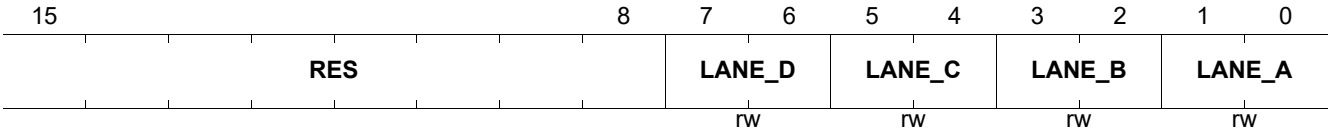
ASP Mapping to Physical Lanes (Register 30.20)

This register offers a programmable option to map physical lanes A, B, C, and D of the TPI to the ASPs. Each ASP must be mapped to each lane.

IEEE Standard Register=30.20

VSPEC1_LANE_ASP_MAP **Reset Value**

ASP Mapping to Physical Lanes (Register 30.20) **$00E4_H$**



Field	Bits	Type	Description
LANE_D	7:6	RW	**Map Physical Lane-D to the ASP** 00_B **ASPA** Map Physical Lane-D to the ASP-A 01_B **ASPB** Map Physical Lane-D to the ASP-B 10_B **ASPC** Map Physical Lane-D to the ASP-C 11_B **ASPD** Map Physical Lane-D to the ASP-D
LANE_C	5:4	RW	**Map Physical Lane-C to the ASP** 00_B **ASPA** Map Physical Lane-C to the ASP-A 01_B **ASPB** Map Physical Lane-C to the ASP-B 10_B **ASPC** Map Physical Lane-C to the ASP-C 11_B **ASPD** Map Physical Lane-C to the ASP-D
LANE_B	3:2	RW	**Map Physical Lane-B to the ASP** 00_B **ASPA** Map Physical Lane-B to the ASP-A 01_B **ASPB** Map Physical Lane-B to the ASP-B 10_B **ASPC** Map Physical Lane-B to the ASP-C 11_B **ASPD** Map Physical Lane-B to the ASP-D
LANE_A	1:0	RW	**Map Physical Lane-A to the ASP** 00_B **ASPA** Map Physical Lane-A to the ASP-A 01_B **ASPB** Map Physical Lane-A to the ASP-B 10_B **ASPC** Map Physical Lane-A to the ASP-C 11_B **ASPD** Map Physical Lane-A to the ASP-D

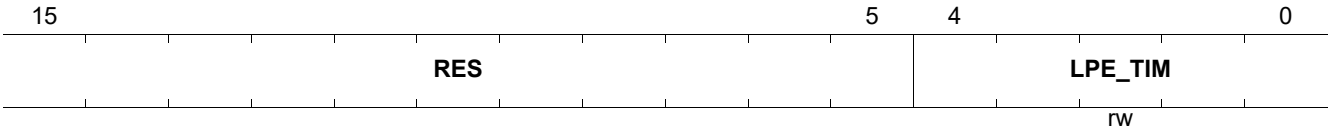
Time to Enter Low Power (Register 30.21)

Programmable option to delay the time taken to enter low power mode.

IEEE Standard Register=30.21

VSPEC1_LOW_POWER_ENTRY_TIME **Reset Value**

Time to Enter Low Power (Register 30.21) **0001_H**



Field	Bits	Type	Description
LPE_TIM	4:0	RW	**Low Power Entry Time** This is the time taken from detection of no activity on the line to the low power completion. The granularity is 4 seconds and adds 2.4 seconds to 5.6 seconds on to the initial time.

Fast Retrain Control and Status (Register 30.22)

This register supports fast retrain (FR) as follows:

1. Configures the FR capability (IEEE, CISCO(THPBYP,TXDIS,EXT) [10]).
2. Records the link partner FR capability.
3. Reports the FW resolution of the FR capability.
4. Defines the maximum allowed number of times to try FR before performing a full link down.

IEEE Standard Register=30.22

VSPEC1_FRCTL **Reset Value**

Fast Retrain Control and Status (Register 30.22) **0000_H**

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MAX_FR_*	**STAT_IE***	**STAT_CI***	**STAT_TH***	**STAT_TX***	**STAT_EXT**	**LP_IEEE**	**LP_CISCO**	**LP_THPB***	**LP_TXDIS**	**LP_EXT**	**CAP_IEEE**	**CAP_CIS***	**CAP_THP***	**CAP_TXD***	**CAP_EXT**
rw	ro	ro	ro	ro	ro	ro	ro	ro	ro	ro	rw	rw	rw	rw	rw

Field	Bits	Type	Description
MAX_FR_RETRY	15	RW	**Maximum Number of FR Retries Before Taking Linking Down** 0_B **DISABLE** Maximum number of retries limited to 4. 1_B **ENABLE** Maximum number of retries limited to 8.
STAT_IEEE	14	RO	**Resolved for IEEE FR** 0_B **DISABLE** Resolved to no IEEE FR. 1_B **ENABLE** Resolved to IEEE FR.
STAT_CISCO	13	RO	**Resolved for CISCO FR** 0_B **DISABLE** Resolved to no CISCO FR 1_B **ENABLE** Resolved to CISCO FR
STAT_THPBYP	12	RO	**Resolved Status THP BYP during COEF_EXCH for Either CISCO FR or IEEE FR** 0_B **DISABLE** Resolved that THP is not BYP for either CISCO FR or IEEE FR 1_B **ENABLE** Resolved that THP is BYP during COEF EXCH for either CISCO FR or IEEE FR
STAT_TXDIS	11	RO	**Resolved Status for CISCO FR with TX DISABLE** 0_B **DISABLE** Resolved that CISCO FR is not followed by TX DISABLE after link fail signaling 1_B **ENABLE** Resolved that CISCO FR is followed by TX DISABLE after link fail signaling
STAT_EXT	10	RO	**Resolved Status for CISCO Extended FR Timing** 0_B **DISABLE** Resolved for no CISCO FR with extended timing 1_B **ENABLE** Resolved for CISCO FR with extended timing
LP_IEEE	9	RO	**LP Request for IEEE FR** 0_B **DISABLE** No advertise for IEEE FR 1_B **ENABLE** Advertise capable of doing IEEE FR

Field	Bits	Type	Description (cont'd)
LP_CISCO	8	RO	**LP Request for CISCO FR** 0_B **DISABLE** No advertise for CISCO FR 1_B **ENABLE** Advertise capable of doing CISCO FR
LP_THPBYP	7	RO	**LP Request for THP BYP During COEF_EXCH for Either CISCO FR or IEEE FR** 0_B **DISABLE** No request for THP BYP for either CISCO FR or IEEE FR 1_B **ENABLE** Request for THP BYP during COEF EXCH for either CISCO FR or IEEE FR
LP_TXDIS	6	RO	**LP Request for CISCO FR with TX DISABLE** 0_B **DISABLE** No request that CISCO FR is followed by TX DISABLE after link fail signaling 1_B **ENABLE** Request that CISCO FR is followed by TX DISABLE after link fail signaling
LP_EXT	5	RO	**LP Request for CISCO Extended FR Timing** 0_B **DISABLE** No request for CISCO FR with extended timing 1_B **ENABLE** Request for CISCO FR with extended timing
CAP_IEEE	4	RW	**Request for IEEE FR** 0_B **DISABLE** No advertise for IEEE FR 1_B **ENABLE** Advertise capable of doing IEEE FR
CAP_CISCO	3	RW	**Capable of Advertising CISCO FR** 0_B **DISABLE** No advertise for CISCO FR 1_B **ENABLE** Advertise capable of doing CISCO FR
CAP_THPBYP	2	RW	**Request LP for THP BYP during COEF_EXCH for Both CISCO FR and IEEE FR** 0_B **DISABLE** No request to LP for THP BYP for either CISCO FR or IEEE FR 1_B **ENABLE** Request LP for THP BYP during COEF EXCH for either CISCO FR or IEEE FR
CAP_TXDIS	1	RW	**Request for CISCO FR with TX DISABLE** 0_B **DISABLE** No request for CISCO FR with TX DISABLE after link fail signaling 1_B **ENABLE** Advertise request that CISCO FR is followed by TX DISABLE after link fail signaling
CAP_EXT	0	RW	**Request for CISCO Extended FR Timing** 0_B **DISABLE** No request for CISCO FR with extended timing 1_B **ENABLE** Advertise request for CISCO FR with extended timing

6.5 Vendor Specific 2 Device Registers

This register file contains the GPHY-specific registers for MMD=31 (decimal).

Table 35 Registers Overview- Vendor Specific 2 Device Registers

Register Short Name	Register Long Name	Reset Value
VPSPEC2_WOL_CTL	WoL Control Register (Register 31.3590)	0000_H
VPSPEC2_WOL_AD01	WoL Address Byte 0 and 1 (Register 31.3592)	0000_H
VPSPEC2_WOL_AD23	WoL Address Byte 2 and 3 (Register 31.3593)	0000_H
VPSPEC2_WOL_AD45	WoL Address Byte 4 and 5 (Register 31.3594)	0000_H
VPSPEC2_WOL_PW01	WoL SecureON Password Byte 0 (Register 31.3595)	0000_H
VPSPEC2_WOL_PW23	WoL SecureON Password Byte 2 and 3 (Register 31.3596)	0000_H
VPSPEC2_WOL_PW45	WoL SecureON Password Byte 4 and 5 (Register 31.3597)	0000_H

6.5.1 VSPEC2 Register Descriptions

This section describes all the VSPEC2 registers in detail.

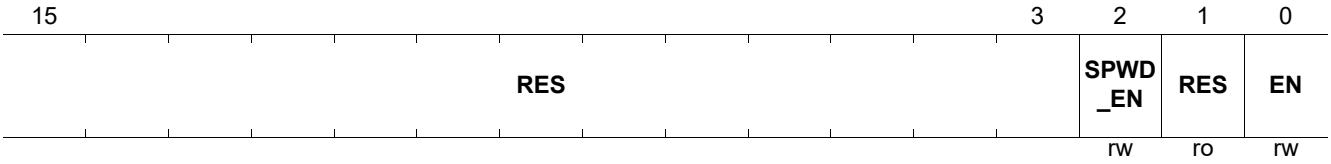
Wake-on-LAN Control Register (Register 31.3590)

This is the Wake-on-LAN control register. Redirected to PCS_PDI_WOL_CTL.

IEEE Standard Register=31.3590

VPSPEC2_WOL_CTL **Reset Value**

Wake-on-LAN Control Register (Register 31.3590) **0000_H**



Field	Bits	Type	Description
SPWD_EN	2	RW	**Secure-ON Password Enable** When this bit is set to enabled, the SecureON password is checked after 16 MAC address repetitions. 0_B **DISABLED** Disables the SecureON password check 1_B **ENABLED** Enables the SecureON password check
RES	1	RO	**Reserved** Must always be written to 0.
EN	0	RW	**Enables the Wake-on-LAN Functionality** When WoL is enabled, the PHY scans for the configured magic packet and indicates its reception via the register bit ISTAT. WoL and optionally also via interrupt. 0_B **DISABLED** Disables the WoL functionality 1_B **ENABLED** Enables the WoL functionality

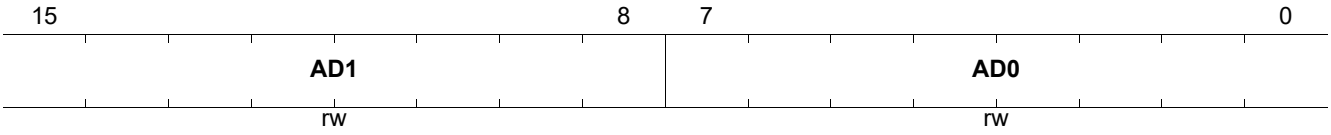
Wake-on-LAN Address Byte 0 and 1 (Register 31.3592)

Wake-on-LAN Address Byte 0 and 1. Redirected to PCS_PDI_WOL_AD01.

IEEE Standard Register=31.3592

VPSPEC2_WOL_AD01 **Reset Value**

Wake-on-LAN Address Byte 0 and 1 (Register 31.3592) **0000_H**



Field	Bits	Type	Description
AD1	15:8	RW	**Address Byte 1** Defines byte 1 of the WoL-designated MAC address to which the PHY is sensitive.
AD0	7:0	RW	**Address Byte 0** Defines byte 0 of the WoL-designated MAC address to which the PHY is sensitive.

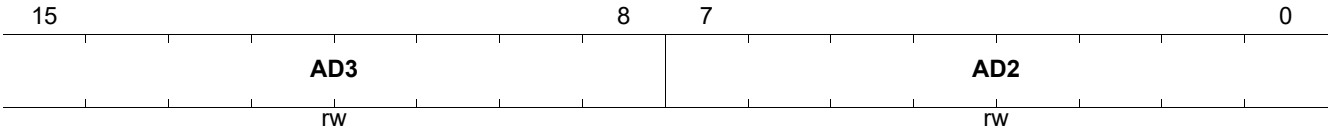
Wake-on-LAN Address Byte 2 and 3 (Register 31.3593)

Wake-on-LAN Address Byte 2 and 3. Redirected to PCS_PDI_WOL_AD23.

IEEE Standard Register=31.3593

VPSPEC2_WOL_AD23 **Reset Value**

Wake-on-LAN Address Byte 2 and 3 (Register 31.3593) **0000_H**



Field	Bits	Type	Description
AD3	15:8	RW	**Address Byte 3** Defines byte 3 of the WoL-designated MAC address to which the PHY is sensitive.
AD2	7:0	RW	**Address Byte 2** Defines byte 2 of the WoL-designated MAC address to which the PHY is sensitive.

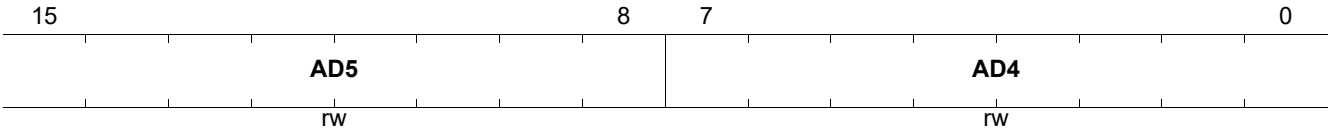
Wake-on-LAN Address Byte 4 and 5 (Register 31.3594)

Wake-on-LAN Address Byte 4 and 5. Redirected to PCS_PDI_WOL_AD45.

IEEE Standard Register=31.3594

VPSPEC2_WOL_AD45 **Reset Value**

Wake-on-LAN Address Byte 4 and 5 (Register 31.3594) **0000_H**



Field	Bits	Type	Description
AD5	15:8	RW	**Address Byte 5** Defines byte 5 of the WoL-designated MAC address to which the PHY is sensitive.
AD4	7:0	RW	**Address Byte 4** Defines byte 4 of the WoL-designated MAC address to which the PHY is sensitive.

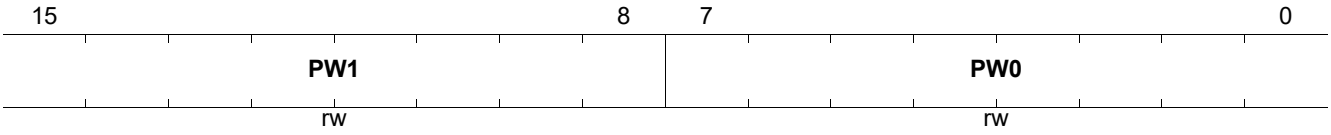
Wake-on-LAN SecureON Password Byte 0 (Register 31.3595)

Wake-on-LAN SecureON Password Byte 0. Redirected to PCS_PDI_WOL_PWD01.

IEEE Standard Register=31.3595

VPSPEC2_WOL_PW01 **Reset Value**

Wake-on-LAN SecureON Password Byte 0 (Register 31.3595) **0000_H**



Field	Bits	Type	Description
PW1	15:8	RW	**SecureON Password Byte 1** Defines byte 1 of the WoL-designated SecureON password to which the PHY is sensitive.
PW0	7:0	RW	**SecureON Password Byte 0** Defines byte 0 of the WoL-designated SecureON password to which the PHY is sensitive.

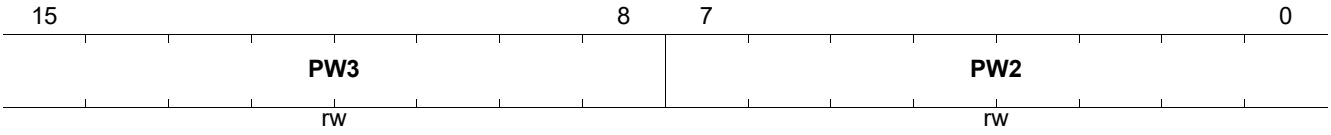
Wake-on-LAN SecureON Password Byte 2 and 3 (Register 31.3596)

Wake-on-LAN SecureON Password Byte 2 and 3. Redirected to PCS_PDI_WOL_PWD23.

IEEE Standard Register=31.3596

VPSPEC2_WOL_PW23 **Reset Value**

Wake-on-LAN SecureON Password Byte 2 and 3 (Register 31.3596) **0000_H**



Field	Bits	Type	Description
PW3	15:8	RW	**SecureON Password Byte 3** Defines byte 3 of the WoL-designated SecureON password to which the PHY is sensitive.
PW2	7:0	RW	**SecureON Password Byte 2** Defines byte 2 of the WoL-designated SecureON password to which the PHY is sensitive.

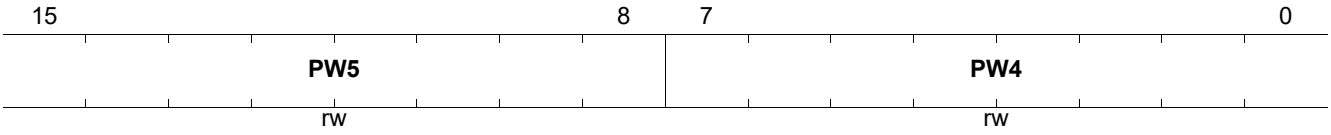
Wake-on-LAN SecureON Password Byte 4 and 5 (Register 31.3597)

Wake-on-LAN SecureON Password Byte 4 and 5. Redirected to PCS_PDI_WOL_PWD45.

IEEE Standard Register=31.3597

VPSPEC2_WOL_PW45 **Reset Value**

Wake-on-LAN SecureON Password Byte 4 and 5 (Register 31.3597) **0000_H**



Field	Bits	Type	Description
PW5	15:8	RW	**SecureON Password Byte 5** Defines byte 5 of the WoL-designated SecureON password to which the PHY is sensitive.
PW4	7:0	RW	**SecureON Password Byte 4** Defines byte 4 of the WoL-designated SecureON password to which the PHY is sensitive.

7 Electrical Characteristics

This chapter provides the electrical characteristics for the MxL86289I.

7.1 Absolute Maximum Ratings

Table 36 shows the absolute maximum ratings for the MxL86289I.

Table 36 Absolute Maximum Ratings

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Storage Temperature Limits	T_{STG}	-55.0	–	125.0	°C	–
Soldering Temperature	T_{SOL}	–	–	260.0	°C	Compliance with lead free re-flow soldering profile as J-STD-020D
Moisture Level 3 Temperature Limits	T_{ML3}	–	–	260.0	°C	According to IPS J-STD 020
Absolute Junction Temperature	T_{JABS}	-40.0		125	°C	The thermal solution must ensure that T_J never exceeds T_{JABS} maximum. The chip resets the device when T_J > T_{JABS} maximum to prevent any damage to occur.
DC Voltage Limits on VDD3V3PAD1, VDD3V3PAD2 Pins	V_{DDP3V3}	-0.5	–	+3.63	V	Generic ball V_{HIGH} supply
DC Voltage Limits on VDDP_PAD Pins when Ball K3 Pin Strap PS_MDIO_VOLTAGE is HIGH	V_{DDP}	-0.5	–	+3.63	V	Multi voltage ball V_{HIGH} supply
DC Voltage Limits on VDDP_PAD Pins when Ball K3 Pin Strap PS_MDIO_VOLTAGE is LOW	V_{DDP}	-0.5	–	+1.98	V	Multi voltage ball supply. 1.8 V supply dedicated to MDIO pins in lower mode
DC Voltage Limits on VDDA3V3_0, VDDA3V3_1, VDDA3V3_2, VDDA3V3_3, VDDA3V3_4, VDDA3V3_5, VDDA3V3_6, and VDDA3V3_7 Pins	V_{DDA3V3}	-0.5	–	+3.63	V	Chip analog V_{HIGH} supply
DC Voltage Limits on VDDA1V8_0, VDDA1V8_1 Pins	V_{DDA1V8}	-0.5	–	+1.98	V	Chip analog supply

Table 36 Absolute Maximum Ratings (cont'd)

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
DC Voltage Limits on VDDA1V8PORXO, VDDA1V8_PVT, VCC1V8_OTP Pins	$V_{DDA1V8PORXO}$ $V_{DDA1V8PVT}$ $V_{CC1V8OTP}$	-0.5	–	+1.98	V	Chip clocking supply
DC Voltage Limits on VPHA1V8_0, VPHA1V8_1, and VDDA1V8_PLL Pins	V_{PH} $V_{DDA1V8PLL}$	-0.5	–	+1.98	V	USXGMII, LJ PLL V_{HIGH} supply
DC Voltage Limits on VDDA1V2CDB0, VDDA1V2CDB1 Pins	$V_{DDA1V2CDB}$	-0.5	–	+1.32	V	Chip analog supply
DC Voltage Limits on VDDA0V8_0, VDDA0V8_1, VDDD0V8REF, VDDD0V8POST Pins	V_{DDA0V8} $V_{DDD0V8PLL}$	-0.5	–	+0.89	V	Chip analog V_{LOW} supply, LJ PLL V_{LOW} supply
DC Voltage Limits on VDDD0V8_COR Pins	V_{DD}	-0.5	–	+0.89	V	Chip core supply
DC Voltage Limits on VA0V8_0, VA0V8_1 Pins	V_P	-0.5	–	+0.89	V	USXGMII V_{LOW} supply
DC Voltage Limits on Any Other Pins[1] with Respect to Ground	V_{DC}	-0.5	–	V_{DDP3V3}+ 0.5	V	Unless specified otherwise
XTAL1 Input Voltage	V_{XTAL1}	-0.30	–	2.0	V	–
ESD HBM Robustness	$V_{ESD,HBM}$	–	–	1000.0	V	According to ANSI/ESDA/JEDEC JS-001-2014
ESD CDM Robustness	$V_{ESD,CDM}$	–	–	250.0	V	According to ANSI/ESDA/JEDEC JS-002-2014

1) Any pin that is not a supply pin out of one of the domains: V_{DDP}, V_{PH}, V_P, V_{DDA3V3}, $V_{DDA1V8PORXO}$, $V_{DDA1V2CDB}$, V_{DDA0V8}, V_{DD}, and V_{DDA1V8}.

Attention: Stresses above the maximum values listed in this table may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Maximum ratings are absolute ratings; exceeding only one of these values may cause irreversible damage to the device.

7.2 Operating Range

Table 37 defines the limit values of voltages and temperature which may be applied to guarantee proper operation of the MxL86289I.

Table 37 Operating Range

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Ambient Temperature under Bias	T_A	-40.0	–	85.0	°C	The thermal design must ensure that the maximum junction temperature is not exceeded. The use of a heat sink may be suitable.
Junction Temperature	T_j	–	–	110.0	°C	Thermal solution must ensure that T_j remains within operating range and never exceeds maximum absolute ratings (T_{JABS}).
Generic Pin Supply Voltage	V_{DDP3V3}	3.14	3.30	3.46	V	Generic pin V_{HIGH} supply
Multi Voltage Pin Supply Voltage for MDIO Signals when Ball K3 Pin Strap PS_MDIO_VOLTAGE is HIGH	V_{DDP}	3.14	3.30	3.46	V	Multi voltage pin V_{HIGH} supply
Multi Voltage Pin Supply Voltage for MDIO Signals when Ball K3 Pin Strap PS_MDIO_VOLTAGE is LOW	V_{DDP}	1.71	1.80	1.89	V	Multi voltage pin supply. 1.8 V supply dedicated to MDIO pins in lower mode
Analog High Supply Voltage	V_{DDA3V3}	3.14	3.30	3.46	V	Chip analog V_{HIGH} supply
XO Supply Voltage	$V_{DDA1V8PORXO}$	1.71	1.80	1.89	V	Chip clocking V_{HIGH} supply
Analog Medium Supply Voltage	V_{DDA1V8}	1.71	1.80	1.89	V	Chip analog V_{MED} supply
CDB Supply Voltage	$V_{DDA1V2CDB}$	1.14	1.20	1.26	V	Chip analog supply
USXGMII High Supply Voltage	V_{PH}	1.71	1.80	1.89	V	USXGMII V_{HIGH} supply
LJ PLL High Supply Voltage	$V_{DDA1V8PLL}$	1.71	1.80	1.89	V	LJ PLL V_{HIGH} supply
Analog Low Supply Voltage	V_{DDA0V8}	0.81	0.85	0.89	V	Chip analog V_{LOW} supply
LJ PLL Low Supply Voltage	$V_{DDD0V8PLL}$	0.81	0.85	0.89	V	LJ PLL V_{LOW} supply
Chip Core Supply Voltage	V_{DD}	0.81	0.85	0.89	V	Chip core supply
USXGMII Low Supply Voltage	V_P	0.81	0.85	0.89	V	USXGMII V_{LOW} supply
Ground	V_{SS}	0.00	0.00	0.00	V	–

Attention: Operations above the maximum values listed here for extended periods may adversely affect long-term reliability of the device.

7.3 Typical Power Consumption

Table 38 lists the typical power consumption for different modes. Typical power is the power consumed by a nominal process device, nominal supply voltages, at 25°C ambient temperature and a CAT5e link segment.

The conditions for Link-up are full speed and bidirectional, full duplex traffic on all 8 ports. There are 10G links on both SerDes interfaces.

Table 38 Typical Power Consumption

	3.3 V V_{HIGH} Domain Current	1.8 V Domain Current	1.2 V Domain Current	0.85 V V_{LOW} Domain Current	0.85 V V_P Domain Current	Chip Power
Unit	**mA**	**mA**	**mA**	**mA**	**mA**	**W**
2500BASE-T Link-up, 100 m Cable	393	138	470	3453	128	5.2
2500BASE-T Link-up, 30 m Cable	372	136	450	2930	127	4.6
2500BASE-T EEE	313	124	138	1592	124	2.9
1000BASE-T Link-up, 100 m Cable	306	136	435	1489	124	3.1
1000BASE-T EEE	47	126	123	895	126	1.4
100BASE-TX Link-up, 100 m Cable	91	124	111	694	122	1.4
100BASE-TX EEE	60	148	120	646	124	1.1
10BASE-Te Link-up, 100 m Cable	89	127	66	616	117	1.2
Cable Unplugged - ANEG	40	127	66	635	123	1.1
Cable Unplugged - Low Power	23	121	4	338	123	0.7
Reset	3	25	0	64	3	0.1

7.4 Maximum Thermal Design Power

Table 39 lists the maximum Thermal Design Power (TDP). The TDP is the power consumption for a full traffic load and worst-case process, supply voltage, cable, and temperature conditions. This value is relevant to design the thermal solution.

Table 39 Maximum Power Consumption

Condition	Maximum Power (W)
Maximum Chip Power at Maximum Operating Range	7.3

Note: With a properly designed thermal solution (heat sink), it is unlikely that Tj exceeds the maximum operating junction temperature. An excess is reported in the MDIO register VSPEC1_TEMP_STA and the STA can initiate a renegotiation to a lower link rate to get Tj back into the operating temperature range if ADS is disabled.

7.5 Maximum Current

Table 40 provides the maximum current to dimension the power supply. It is the maximum current consumption per rail for a full traffic load and worst-case process, supply voltage and temperature conditions that may occur in any operating state of the device. The maximum current can be higher than the steady state current, for instance in training phases of the internal filters.

Table 40 Maximum Current Per Rail

3.3 V Domain Current	1.8 V Domain Current	1.2 V Domain Current	0.85 V V_{LOW} Domain Current	0.85 V V_P Domain Current
mA	**mA**	**mA**	**mA**	**mA**
477	154	587	6000	203

7.6 DC Characteristics

These sections document the DC characteristics of the MxL86289I external interfaces.

7.6.1 Digital Interfaces

This section defines the DC characteristics of the GPIO interface as follows:

- General Purpose IO
- MDIO
- QSPI
- UART
- I^2C
- Interrupts
- Clock Input and Outputs
- LED
- JTAG
- HRSTN

Table 41 summarizes the DC characteristics for V_{DDP} = 3.3 V.

Table 41 DC Characteristics of the GPIO Interfaces (VDDP = 3.3 V)

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Input High Voltage	V_{IH}	0.7*V_{DDP}	–	V_{DDP}+0.3	V	–
Input Low Voltage	V_{IL}	–0.3	–	0.3*V_{DDP}	V	–
Output High Voltage	V_{OH}	V_{DDP}-0.4	–	–	V	I_{OH} = 2, 4, 8, 12 mA
Output Low Voltage	V_{OL}	–	–	0.4	V	I_{OL} = 2, 4, 8, 12 mA

Table 42 summarizes the DC characteristics for V_{DDP} = 1.8 V.

Table 42 DC Characteristics of the GPIO Interfaces (VDDP = 1.8 V[1])

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Input High Voltage	V_{IH}	0.65*V_{DDP}	–	V_{DDP}+0.3	V	–
Input Low Voltage	V_{IL}	–0.3	–	0.35*V_{DDP}	V	–
Output High Voltage	V_{OH}	V_{DDP}-0.4	–	–	V	I_{OH} = 2, 4, 8, 12 mA
Output Low Voltage	V_{OL}	–	–	0.4	V	I_{OL} = 2, 4, 8, 12 mA

1) 1.8V is only applicable to the pins specified in **PS_MDIO_VOLTAGE** of **Table 17**.

7.6.2 Twisted Pair Interface

The TPI conforms to the specifications of 10BASE-Te (Clause 14), 100BASE-TX (Clause 25), 1000BASE-T (Clause 40), and 2.5GBASE-T (Clause 126) given in IEEE802.3, and ANSI X3.263-1995.

7.6.3 Built-in Temperature Sensor

Table 43 provides the parameters of the integrated temperature sensor.

Table 43 Temperature Sensor Characteristics

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Temperature Range	T_{range}	-40		125	°C	The thermal mitigation measures must ensure that T_j remains within the operating range. When T_j exceeds the maximum ratings, the device performs a self-reset to prevent damage.
Resolution		–	12	–	bits	–
Accuracy		-3	–	+3	°C	Without calibration

7.7 AC Characteristics

The AC characteristics of the external interfaces are specified under these operating conditions:

T_A = -40 to 85°C

V_{DDP} = 3.3 V ± 5%

V_{SS} = 0 V

The timing measurements are made at minimum V_{IH} for a logical 1 and at maximum V_{IL} for a logical 0. See **Table 41** and **Table 42** for more details.

Figure 17 shows the AC testing input/output waveforms. The load capacitors are according to the specific interface standard. All non-specified interfaces use 30 pF as assumed loading.

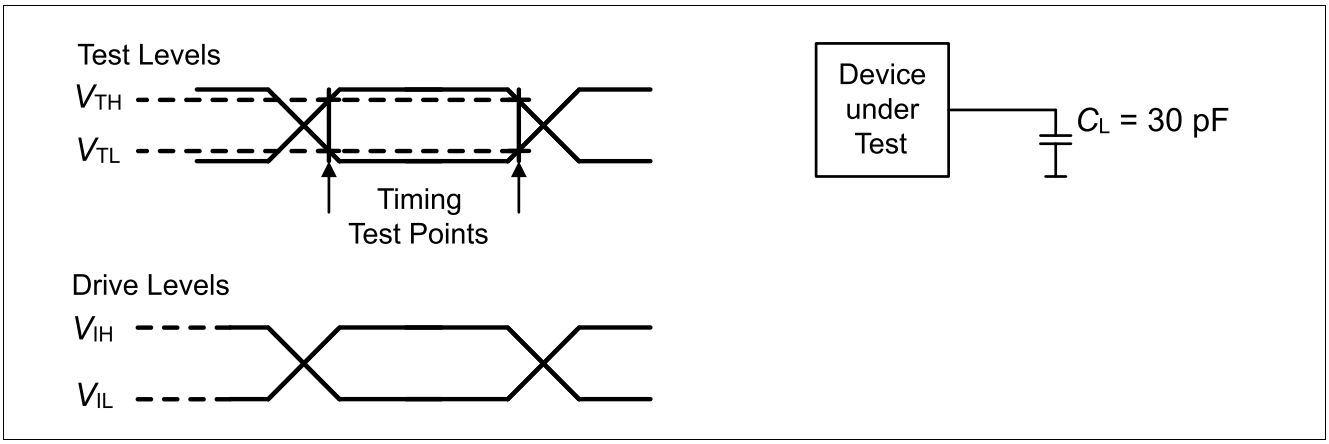


Figure 17 Input/Output Waveform for AC Tests

7.7.1 Power Up Sequence

All V_{HIGH}, V_{PH}, V_{DDA}, V_P, and V_{LOW} are supplied externally.

In this section, for the sake of simplicity:

- All 3.3 V supplies are represented as V_{HIGH}.
- All 1.8 V supplies are represented as V_{PH}.
- All 1.2 V supplies are represented as V_{DDA}.
- The 0.85 V analog supply of SerDes is represented as V_P.
- The rest of the 0.85 V supplies are represented as V_{LOW}.

All the supply domains V_{HIGH}, V_{PH}, V_{DDA}, V_P, and V_{LOW}, and the input reference clock must be stabilized before releasing the reset HRSTN.

There is no known voltage rail power up sequence except that V_{HIGH} must be ramped up and stable before V_{PH} is ramped up, V_{LOW} must be ramped up and stable before V_P is ramped up, and V_{LOW} must be ramped up and stable before V_{PH} is ramped up. MaxLinear recommends implementing the power-up sequence defined in the reference board. Refer to the relevant hardware documentation available at **https://maxlinear.com/myMxL** for more information on the power circuitry.

The MxL86289I supports an asynchronous hardware reset HRSTN. **Table 44** lists the timing requirements of the power supply pins. The timings refer to the signal sequence waveforms depicted in **Figure 18**.

When PS_MDIO_VOLTAGE is low, V_{DDP} is treated as V_{PH}.

When PS_MDIO_VOLTAGE is high, V_{DDP} is treated as V_{HIGH}.

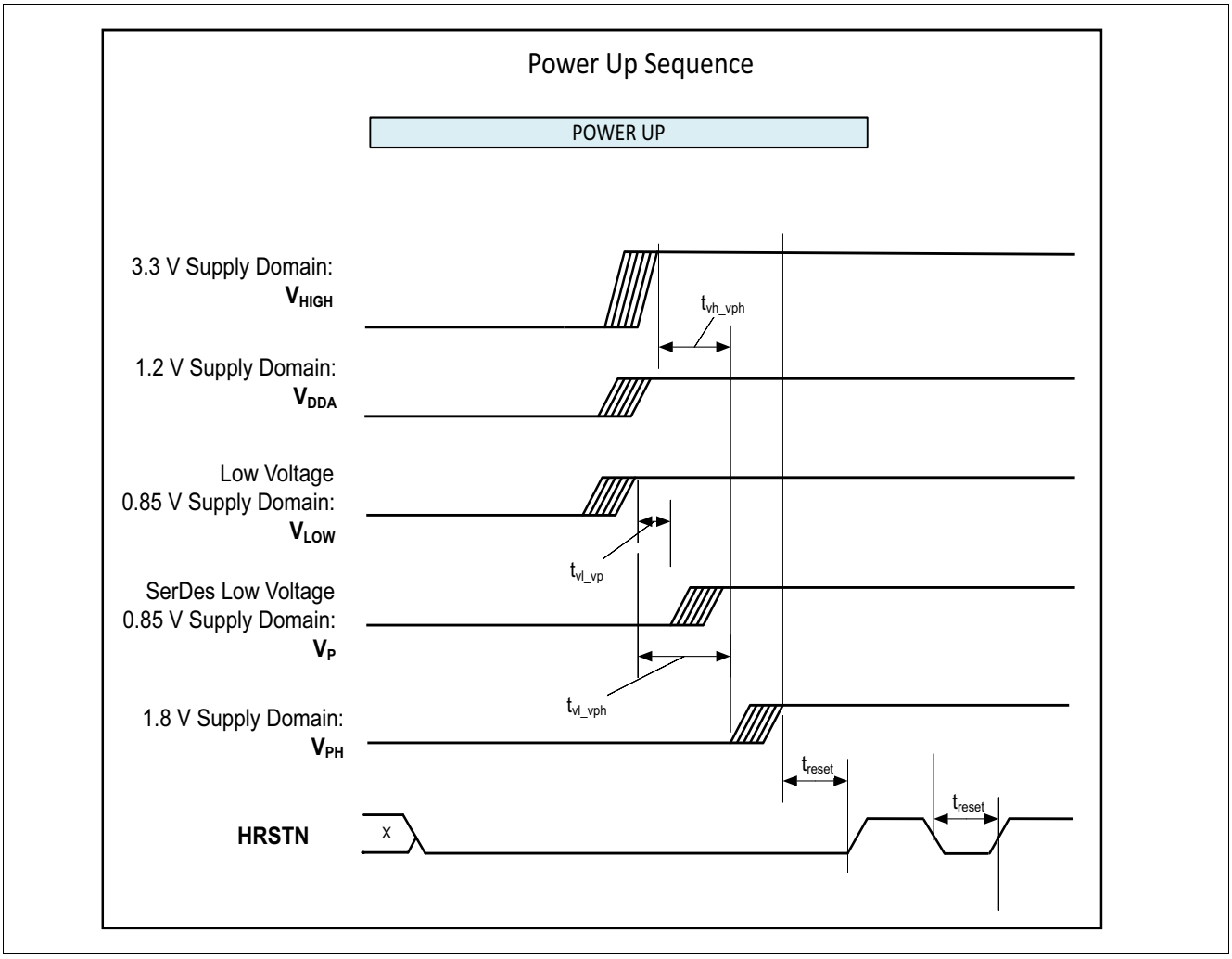


Figure 18 Timing Diagram for the Reset Sequence

Table 44 Power Supply Timings

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Delay between V_{HIGH} and V_{PH} Domains Voltage Ramp Up	t_{vh_vph}	50	-	-	µs	The V_{PH} voltage must never be higher than V_{HIGH} voltage
Delay between V_{LOW} and V_P Domains Voltage Ramp Up	t_{vl_vp}	1	-	-	µs	The V_P voltage must never power up before V_{LOW} voltage.
Delay between V_{LOW} and V_{PH} Domains Voltage Ramp Up	t_{vl_vph}	50	-	-	µs	The V_{PH} voltage must never power up before V_{LOW} voltage.
Reset Time after all Voltage Domains are Stabilized	t_{reset}	100	–	–	ns	HRSTN must be released after the power supplies stabilized.

7.7.2 Input Clock

Table 45 lists the input clock requirements when not using a crystal, for example when an external reference clock is injected into the XTAL1 pin of the MxL86289I, such as nominal frequency, frequency deviation, duty cycle, and signal characteristics. When a crystal is applied to generate the reference clock using the integrated XO, the clock requirements stated here are explicitly met as long as the specification for the crystal is satisfied.

Table 45 AC Characteristics of Input Clock on XTAL1 Pin

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Frequency with 25 MHz Input	f_{clk25}	–	25.0	–	MHz	–
Frequency with 50 MHz Input	f_{clk50}	–	50.0	–	MHz	–
Frequency with 156.25 MHz Input	f_{clk156}	–	156.25	–	MHz	–
Frequency Deviation[1)]		-50.0	–	+50.0	ppm	–
Duty Cycle		40.0	50.0	60.0	%	–
Rise/Fall Times with 25 MHz Input		–	–	10.0	ns	25 MHz
Rise/Fall Times with 50 MHz Input		–	–	5.0	ns	50 MHz
Rise/Fall Times with 156.25 MHz Input		–	–	1.0	ns	156.25 MHz
Input Long Term Jitter (Jrms)		–	–	2.0	ps	1 kHz to 10 MHz
Input Voltage Swing		300.0	–	–	mV	Peak to Peak value
Input Voltage		0	–	1.8	V	–

1) Including the frequency stability tolerance due to temperature, and aging effects over the product lifetime.

7.7.3 Power Supply Rail Requirements

Table 46 lists the required characteristics of the power supplies. The definitions of the power supply rails are the same as that described in Section 7.7.1.

Table 46 AC Characteristics of the Power Supply

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Power Supply Ripple on V_P	R_{VP}	–	–	40.0	mV	Peak to Peak value See Figure 19.
Power Supply Ripple on V_{LOW}	R_{VLOW}	–	–	40.0	mV	Peak to Peak value
Power Supply Ripple on V_{DDA}	R_{VDDA}	–	–	50.0	mV	Peak to Peak value
Power Supply Ripple on V_{HIGH}	R_{VHIGH}	–	–	50.0	mV	Peak to Peak value
Power Supply Ripple on V_{PH}	R_{VPH}	–	–	50.0	mV	Peak to Peak value Max. 18 mV peak to peak for any noise in 200 kHz to 100 MHz range. See Figure 20.

7.7.3.1 V_P AC and DC Power Supply Recommendations

This section contains the V_P supply power requirements.

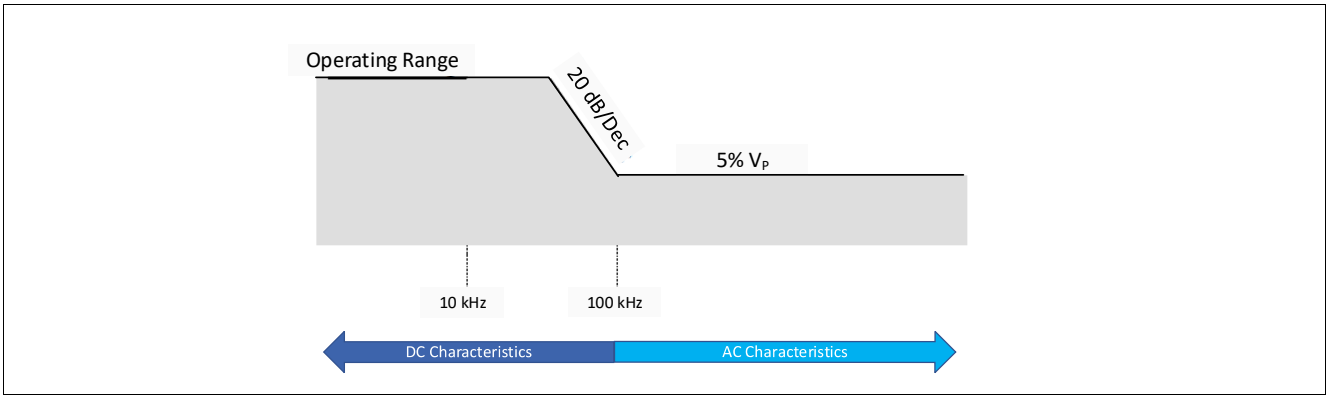


Figure 19 DC and AC Characteristics for V_P Supply

DC Characteristics

- Operating range: See the range of V_P in **Table 37**
- Frequency range: 0 to 100 kHz
- Recommendations:
  - The overshoot or undershoot of the low-frequency supply caused by the board filter network should be lower than 100 kHz.
  - The overall DC budget should account for the low frequency overshoot/undershoot in addition to the board plus package IR drop.
  - There is a transition zone between 10 kHz and 100 kHz in which it is possible for the supply noise to increase as the frequency decreases at a rate of 20 dB/Dec up to the maximum of the operating range.

AC Characteristics

- Max 5% (peak-to-peak) of the DC level for all noise greater than 100 kHz
- Recommendations:
  - A switching supply can be used until the overall noise limits (including, the self noise) are met.

7.7.3.2 V_{PH} AC and DC Power Supply Recommendations

This section contains the V_{PH} supply power requirements.

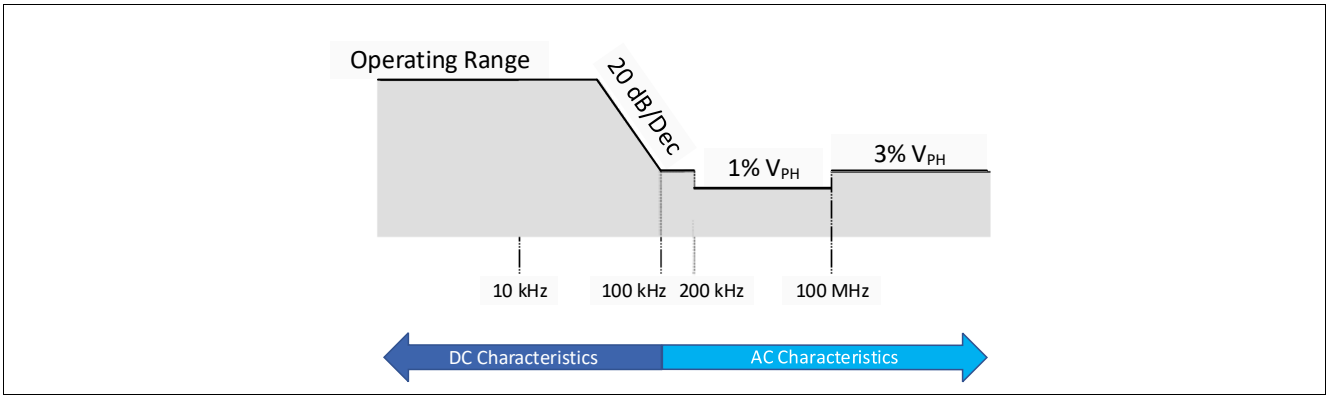


Figure 20 DC and AC Characteristics for V_{PH} Supply

DC Characteristics

- Operating range: See the range of V_{PH} in **Table 37**
- Frequency range: 0 to 100 kHz
- Recommendations:
  - The overshoot or undershoot of the low-frequency supply caused by the board filter network should be lower than 100 kHz.
  - The overall DC budget should account for the low frequency overshoot/undershoot in addition to the board plus package IR drop.
  - There is a transition zone between 10 kHz and 100 kHz in which it is possible for the supply noise to increase as the frequency decreases at a rate of 20 dB/Dec up to the maximum of the operating range.

AC Characteristics

- 100 kHz to 200 kHz: A maximum value of 3% ripple (peak-to-peak) of the DC level is allowed for all noise in this region.
- 200 kHz to 100 MHz: A maximum value of 1% ripple (peak-to-peak) of the DC level is allowed in this region.
- 100 MHz and above: A maximum value of 3% ripple (peak-to-peak) of the DC level is allowed for all noise in this region.
- Recommendations:
  - Use an LDO as a switching supply.
  - When using a switching power supply for V_{PH}, ensure that the 200 kHz to 100 MHz ripple requirements are met. Switching power supplies' tone and harmonics typically occur in this region.
  - Do not share this power rail directly with any other noisy circuitry.
  - Follow the relevant hardware documentation available at **https://maxlinear.com/myMxL** on the power circuitry.

7.7.4 MDIO Slave Interface

Figure 21 shows a timing diagram of the MDIO slave interface for a clock cycle in the read, write, and turnaround mode, respectively. The timing measures are annotated. Table 47 summarizes the defined absolute values.

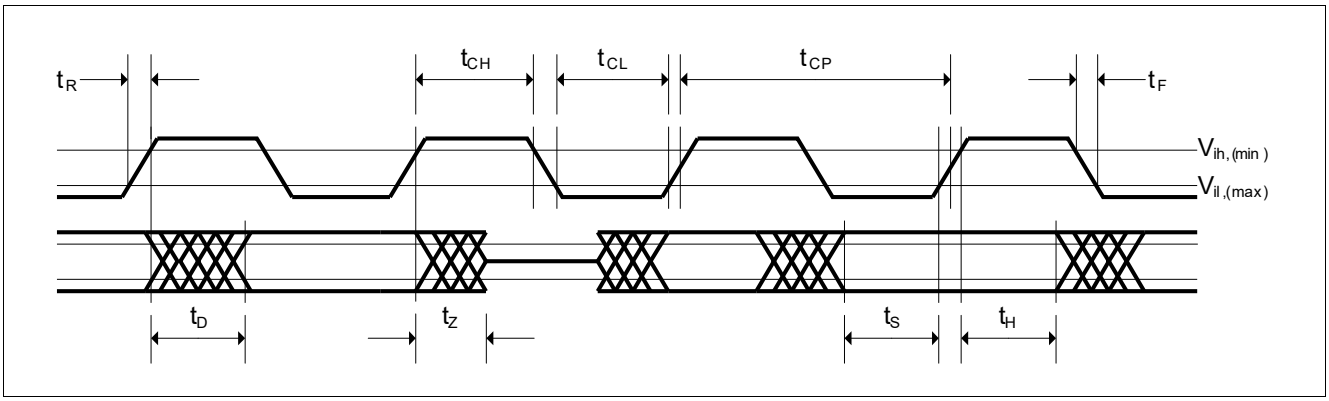


Figure 21 Timing Diagram for the MDIO Slave Interface

Table 47 Timing Characteristics of the MDIO Slave Interface

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
MDC High Time	t_{CH}	10.0	–	–	ns	The MDC signal must conform to the specified MDC timings when measured at the MxL86289I's MDC_S pin.
MDC Low Time	t_{CL}	10.0	–	–	ns	
MDC Clock Period	t_{CP}	40.0	400.0	–	ns	
MDC Clock Frequency[1)]	t_{CP}	–	2.5	25.0	MHz	
MDC Rise Time	t_R	–	–	5.0	ns	
MDC Fall Time	t_F	–	–	5.0	ns	
MDIO Input Setup Time Subject to ↑ MDC	t_S	10.0	–	–	ns	MxL86289I Receive
MDIO Input Hold Time Subject to ↑ MDC	t_H	10.0	–	–	ns	MxL86289I Receive
MDIO Output Delay Time Subject to ↑ MDC	t_D	0.0	–	10	ns	MxL86289I Transmit
Standard at 2.5 MHz						
MDIO Output Delay Subject to ↑ MDC	t_D	0.0	–	300.0	ns	PHY Transmit

1) The MDC clock supports a range of frequencies up to 25 MHz. The default/typical frequency is 2.5 MHz.

7.7.5 Quad Serial Peripheral Interface (QSPI)

Figure 22 shows the QSPI master timing.

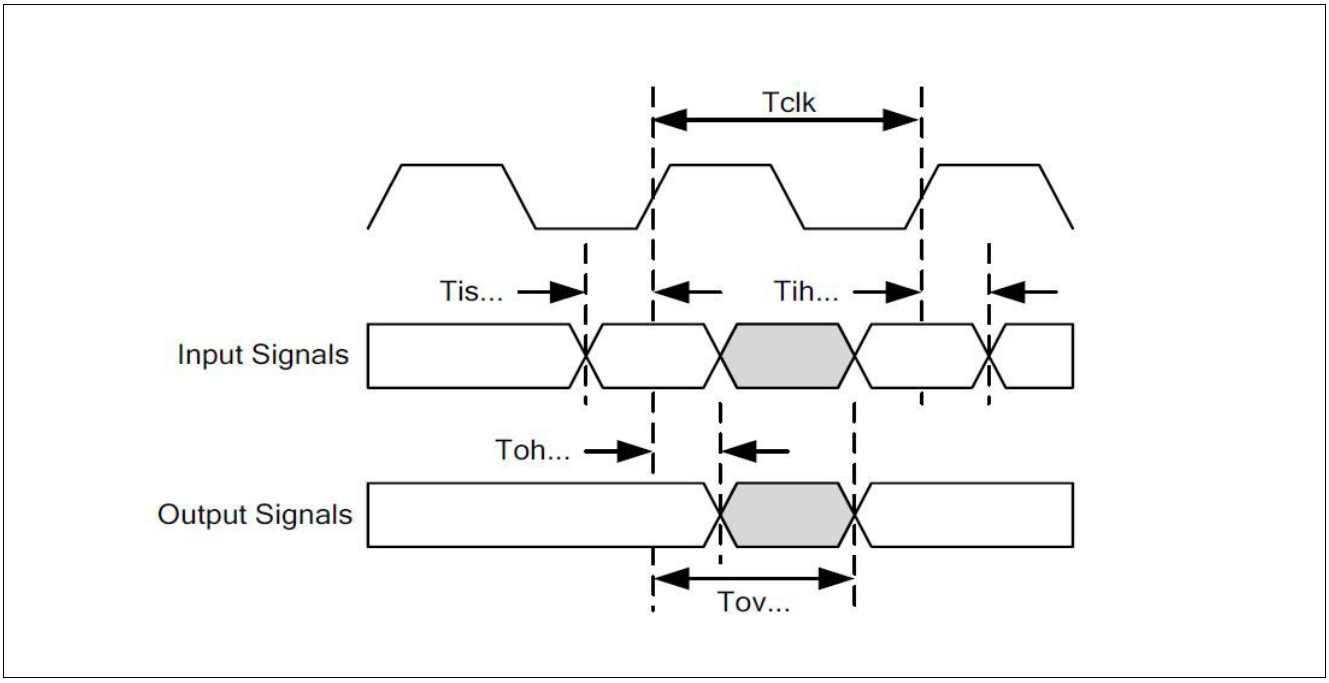


Figure 22 QSPI Master Interface Timing

Table 48 QSPI Interface Timing Parameters

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Master Mode						
TX Data Output Hold	*Toh*	5%	–	–	Tclk	For Tclk = 20 ns
Tx Data Output Delay	*Tov*	0	–	50%	Tclk	For Tclk = 20 ns
Rx Data Input Setup time	*Tis*	35%	–	–	Tclk	For Tclk = 20 ns
Rx Data Hold Time	*Tih*	5%	–	–	Tclk	For Tclk = 20 ns
SPI Clock Period (Master Mode)	*Tclk*	9.846	–	–	ns	Maximum 101.5625 MHz
SPI Clock Rising	S_7	0.1	–	–	V/ns	–
SPI Clock Falling	S_6	0.1	–	–	V/ns	–

7.7.6 I²C Interface

Figure 23 shows the I²C interface timing.

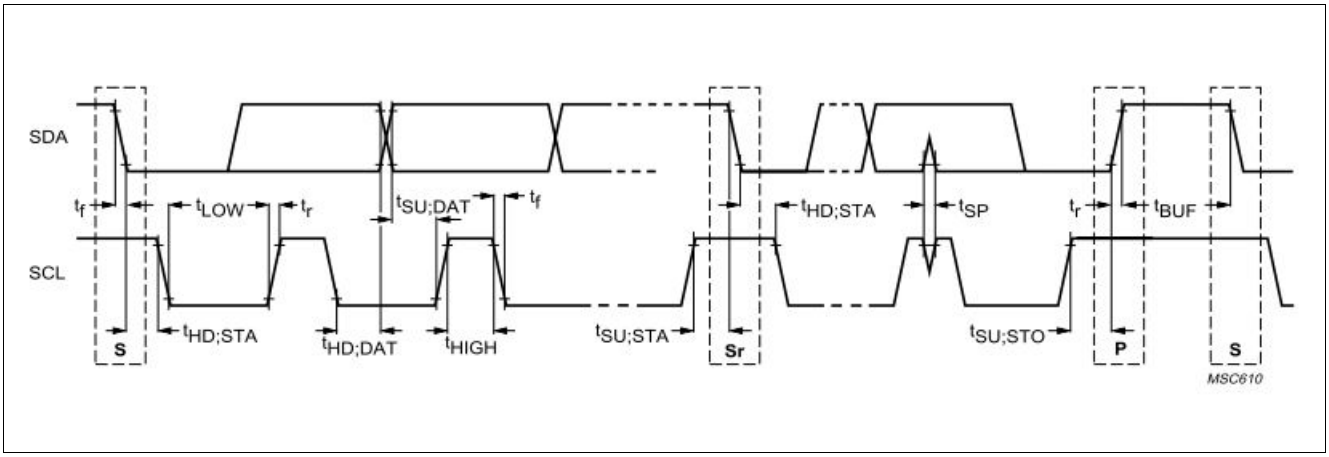


Figure 23 I²C Timing

Table 49 describes the timing values.

Table 49 I²C Timing

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
SCL Frequency	f_{SCL}	0	–	100	kHz	–
Setup Time Data to Shift Clock	$t_{SU,DAT}$	250	–	–	ns	–
Hold Time Data to Shift Clock	$t_{HD,DAT}$	0	–	3.45	µs	–
Setup Time START to Shift Clock	$t_{SU,STA}$	4700	–	–	ns	–
Hold Time START, STOP to Shift Clock	$t_{HD,STA/STO}$	4.0	–	-	µs	–
Low Time	t_{LOW}	4700	–	–	ns	–
High Time	t_{HIGH}	4000	–	–	ns	–
Rising Time	t_r	–	–	1000	ns	–
Falling Time	t_f	–	–	300	ns	–
Bus Free Time	t_{BUF}	4700	–	–	ns	–

7.7.7 JTAG Interface

The JTAG test interface is used for debugging the CPU and boundary scan.

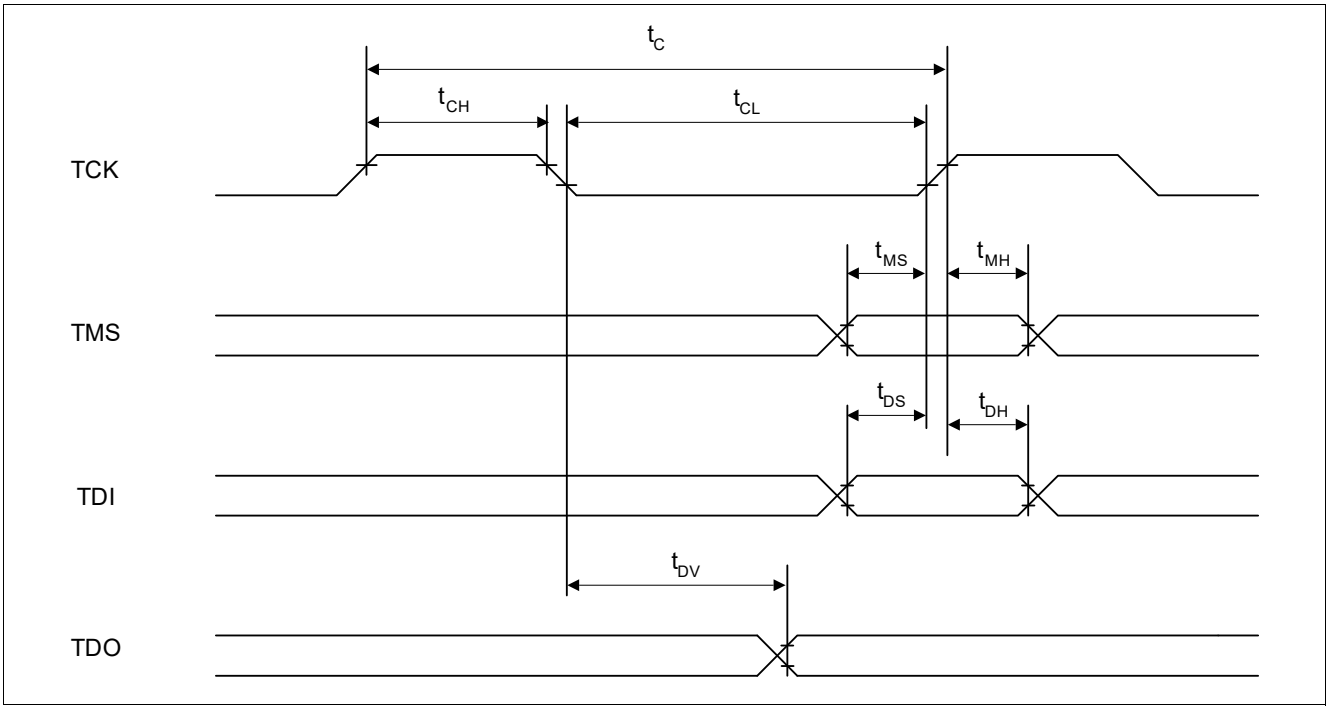


Figure 24 Test Interface Timing

Table 50 and Table 51 describe the timing values for the test interface.

Table 50 Test Interface Clock

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
TCK Clock Period	t_C	100	–	–	ns	–
TCK High Time	t_{CH}	40	–	–	ns	–
TCK Low Time	t_{CL}	40	–	–	ns	–

Table 51 JTAG Timing

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
TMS Setup Time	t_{MS}	40	–	–	ns	–
TMS Hold Time	t_{MH}	40	–	–	ns	–
TDI Setup Time	t_{DS}	40	–	–	ns	–
TDI Hold Time	t_{DH}	40	–	–	ns	–
Hold: TRSTN After TCK	t_{HD}	10	–	–	ns	–
TDO Valid Delay	t_{DV}	–	–	60	ns	–

7.7.8 USXGMII Interface Characteristics

This section describes the AC characteristics of the USXGMII interface on the MxL86289I.

The USXGMII interface characteristics are described in:

- USXGMII transmit characteristics (**Section 7.7.8.1**)
- USXGMII receive characteristics (**Section 7.7.8.2**)

7.7.8.1 USXGMII Transmit Characteristics

Table 52 shows the requirements of the USXGMII interface on the MxL86289I.

Table 52 Transmit Characteristics of the USXGMII

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Reference Differential Impedance	Z_d	–	100	–	Ω	–
Termination Mismatch	R_M	–	–	5	%	–
DC Common Mode Voltage	V_{cm}	0	–	3.6	V	–
Output Rise and Fall Time	t_{RH}, t_{FH}	24	–	–	ps	20%→80%
Output AC Common Mode Voltage	–	–	–	15	mV	mV (RMS)
Differential Output Return Loss[1]	SDD22	20	–	–	dB	0.05-0.1 GHz
		10	–	–	dB	0.1-7.5 GHz
		–	–	–		7.5-15 GHz
Common Mode Output Return Loss[2]	SCC22	6	–	–	dB	0.1-15 GHz

1) Return loss given by equation SDD22(dB) = 10 - 16.6 Log10(f/7.5), with f in GHz.
2) Common mode reference impedance is 25 Ω common mode return loss helps absorb reflections and noise for EMI.

7.7.8.2 USXGMII Receive Characteristics

Table 53 shows the requirements of the USXGMII interface on the MxL86289I.

Table 53 Receive Characteristics of the USXGMII

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Reference Differential Impedance	Z_d	–	100	–	Ω	–
Termination Mismatch	Z_M	–	–	5	%	–
AC Common Mode Voltage	–	–	–	25	mV	mV (RMS)
Differential Output Return Loss[1]	SDD11	20	–	–	dB	0.05-0.1 GHz
		10	–	–	dB	0.1-7.5 GHz
		–	–	–		7.5-15 GHz
Common Mode Input Return Loss[2]	SCC11	6	–	–	dB	0.1-15 GHz
Differential to Common Mode Input Conversion[2]	SCD11	12	–	–	dB	0.1-15 GHz

1) Return loss given by equation SDD11(dB) = 10 - 16.6 Log10(f/7.5), with f in GHz.
2) Common mode reference impedance is 25 Ω. SCD11 relates to conversion of differential to common mode and the associated generation of EMI.

7.7.9 Crystal Specification

The 25 MHz crystal must follow the specification given in Table 54.

Table 54 Specification of the Crystal

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Frequency with 25 MHz Input	f_{clk25}	–	25.0	–	MHz	–
Total Frequency Stability	–	-50	–	+50	ppm	Refers to the sum of all effects: such as general tolerance, aging, and temperature dependency
Series Resonant Resistance	–	–	–	40	Ω	–
Drive Level	–	–	0.1	0.2	mW	–
Load Capacitance	C_L	16	–	26	pF	–
Shunt Capacitance	C_0	–	–	7	pF	–

7.8 External Circuitry

This section specifies the component characteristics of the external circuitry connected to the TPIs of the MxL86289I.

7.8.1 Twisted-Pair Common-Mode Rejection and Termination Circuitry

Figure 25 shows the external circuitry necessary to properly terminate the common mode of the TPI.

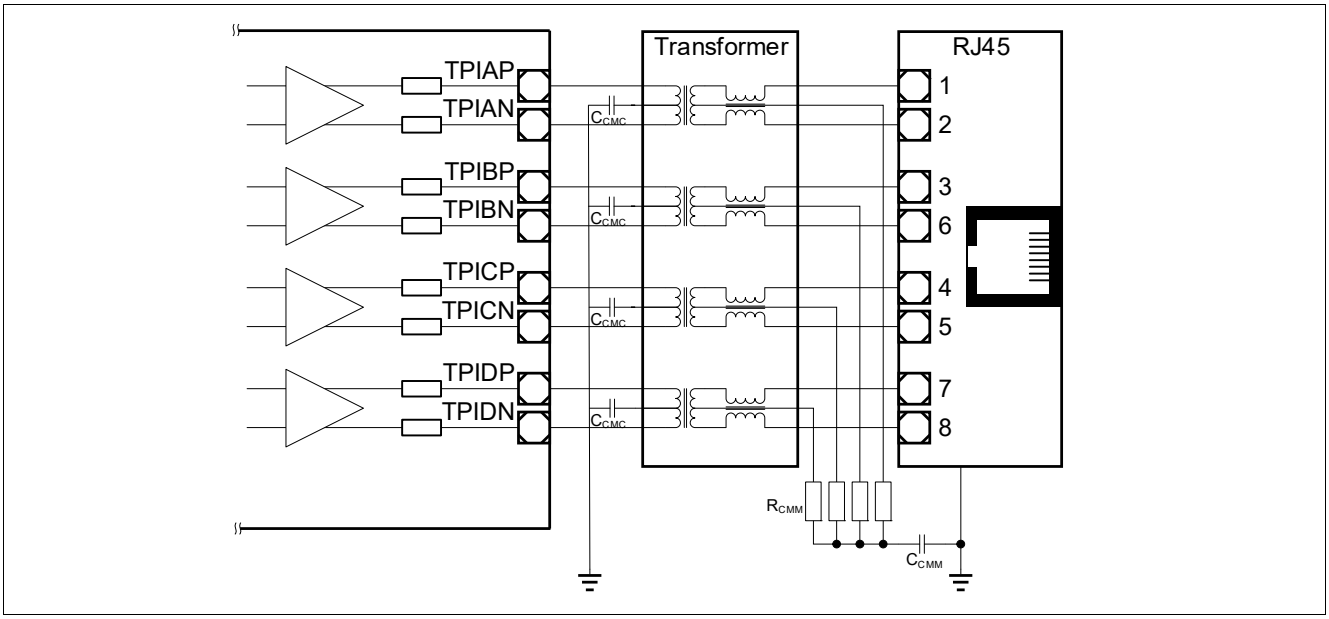


Figure 25 Twisted Pair Common-Mode Rejection and Termination Circuitry

Table 55 defines the component values and their supported tolerances.

Table 55 Electrical Characteristics for Common-Mode Rejection and Termination Circuitry

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Common-Mode Decoupling Capacitance (Media End)	C_{CMM}	800	1000	1200	pF	±15%, 3 kV
Common-Mode Decoupling Capacitance (Chip End)	C_{CMC}	80	100	120	nF	±15%, 25 V
Common-Mode Termination Resistance (Media End)	R_{CMM}	67.5	75	82.5	Ω	±5%

7.8.2 Transformer (Magnetics)

This section specifies the required electrical characteristics of the transformer[1)] devices that are supported. The specifications listed here guarantee proper operation according to IEEE 802.3 [2].

Figure 26 depicts a typical Gigabit Ethernet capable transformer device.

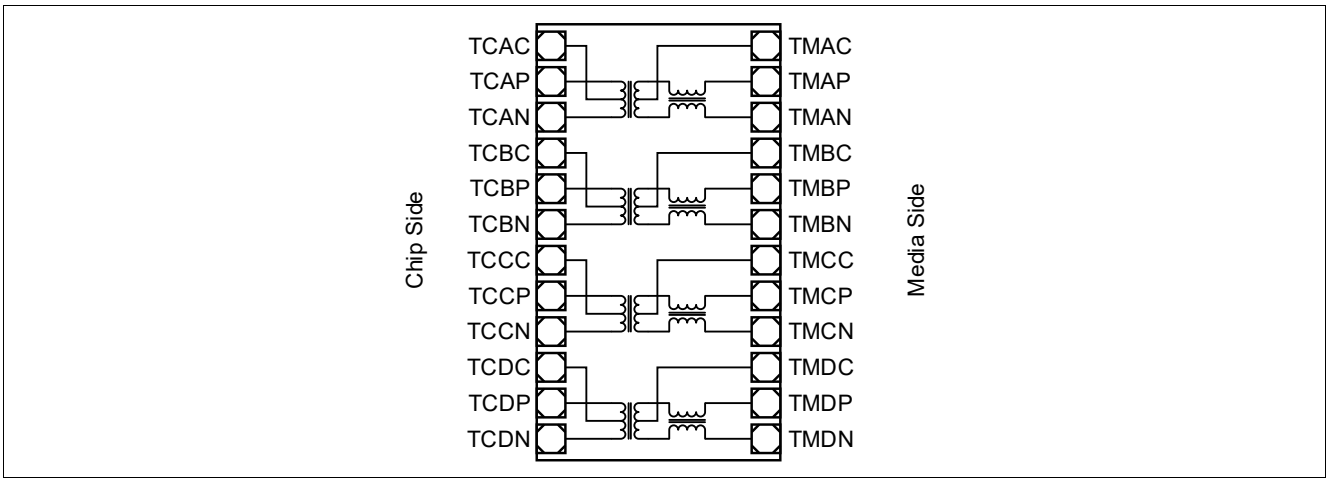


Figure 26 Schematic of an Ethernet Transformer Device

Table 56 lists the characteristics of the supported transformer devices. These characteristics represent the minimum values for achieving standard performance. Since the transformer significantly impacts the link performance, it is possible to increase the loop reach by selecting transformers with improved parameters.

Table 56 Electrical Characteristics for Supported Transformers (Magnetics)

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Turns Ratio	1:tr	0.95	1.00	1.05		±5%
Differential-to-Common-mode Rejection	DCMR	40	–	–	dB	30 MHz
		35	–	–	dB	60 MHz
		30	–	–	dB	100 MHz
Crosstalk Attenuation	CTA	45	–	–	dB	30 MHz
		40	–	–	dB	60 MHz
		35	–	–	dB	100 MHz
Insertion Loss	IL	–	–	1	dB	1 MHz ≤ f ≤ 250 MHz
Return Loss	RL	16	–	–	dB	1 MHz ≤ f ≤ 40 MHz
Return Loss	RL	16-10*log10(f/40)	–	–	dB	40 MHz ≤ f ≤ 250 MHz

1) Also often referred to as magnetics.

7.8.3 RJ45 Plug

Table 57 describes the electrical characteristics of the RJ45 plug to be used in conjunction with MxL86289I.

Table 57 Electrical Characteristics for Supported RJ45 Plugs

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Crosstalk Attenuation	CTA	45	–	–	dB	30 MHz
		40	–	–	dB	60 MHz
		35	–	–	dB	100 MHz
Insertion Loss	IL	–	–	1	dB	1 MHz ≤ f ≤ 250 MHz
Return Loss	RL	16	–	–	dB	1 MHz ≤ f ≤ 40 MHz
Return Loss	RL	16-10*log10(f/40)	–	–	dB	40 MHz ≤ f ≤ 250 MHz

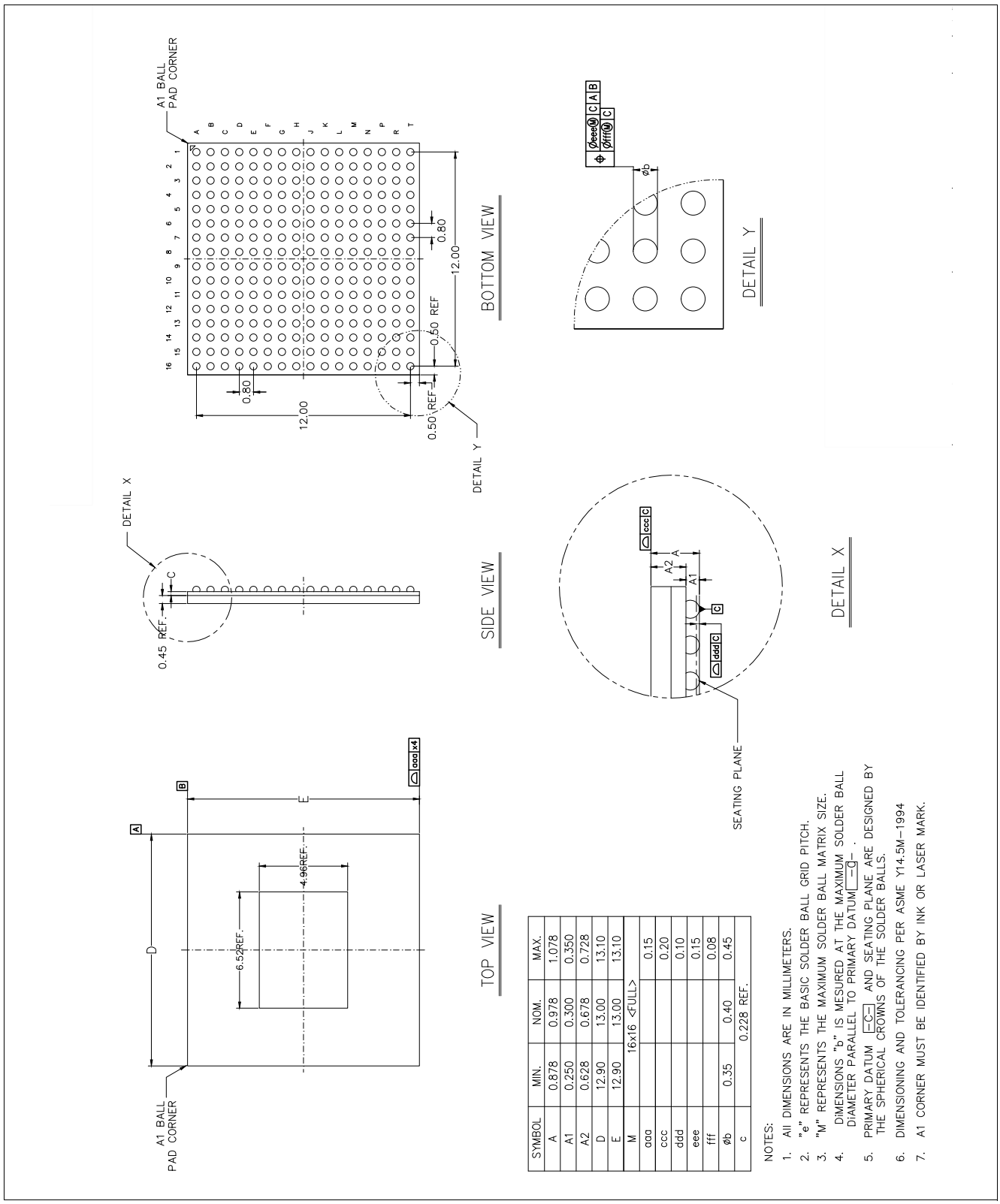
8 Package Outline

The product is assembled in a PG-FCLBGA-256 package, which complies with regulations requiring lead free material. **Table 58** lists the parameters generated in accordance with JEDEC JESD51 standards **[5]**.

Table 58 JEDEC Thermal Resistance Package Parameter - Compact 2-R Model Network

Item	Name/Value
Thermal Resistance - Junction to Case Top	$R_{th,\ JCtop}$ = 0.084 K/W
Minimum Thermal Resistance - Junction to 0 mm from package edge on PCB	$R_{th,\ JB}$ = 3.70 K/W

Figure 27 shows the mechanical drawings for this package. The dimensions are in millimeters.



SYMBOL	MIN.	NOM.	MAX.
A	0.878	0.978	1.078
A1	0.250	0.300	0.350
A2	0.628	0.678	0.728
D	12.90	13.00	13.10
E	12.90	13.00	13.10
M	16x16 <FULL>		
aaa			0.15
ccc			0.20
ddd			0.10
eee			0.15
fff			0.08
øb	0.35	0.40	0.45
c		0.228 REF.	

NOTES:
1. All DIMENSIONS ARE IN MILLIMETERS.
2. "e" REPRESENTS THE BASIC SOLDER BALL GRID PITCH.
3. "M" REPRESENTS THE MAXIMUM SOLDER BALL MATRIX SIZE.
4. DIMENSIONS "b" IS MESURED AT THE MAXIMUM SOLDER BALL DIAMETER PARALLEL TO PRIMARY DATUM —G— .
5. PRIMARY DATUM —C— AND SEATING PLANE ARE DESIGNED BY THE SPHERICAL CROWNS OF THE SOLDER BALLS.
6. DIMENSIONING AND TOLERANCING PER ASME Y14.5M–1994
7. A1 CORNER MUST BE IDENTIFIED BY INK OR LASER MARK.

Figure 27 PG-FCLBGA-256 13 mm x 13 mm Package Outline

9 Product Ordering Information

Table 59 provides the product ordering information.

Table 59 Product and Package Naming

Marketing Part Number	Ordering Part Number	Shipping Format	Package	Device Number[1)]	Device Revision Number[2)]	PHY Identifier[3)]
MxL86289I	MXL86289I-ABE-T	Tray	PG-FCLBGA-256	0x14	0xC	0x554C

1) LDN field in CL22 and CL45 registers.
2) LDRN field in CL22 and CL45 registers.
3) PHY Identifier 2 register 16-bit value.

Note: For more information about part numbers, as well as the most up-to-date information and additional information on environmental rating, go to https://www.maxlinear.com/products/interface/ethernet.

Literature References

[1] Ethernet PHY MxL862xx Configuration User Guide Rev. 1.0 (in preparation)

Attention: Refer to the latest revisions of the documents.

Standards References

[2] IEEE 802.3-2022: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications, IEEE Computer Society, May 2022
https://standards.ieee.org/ieee/802.3/10422/

[3] SyncE Jitter and Wander specification ITU-T G.8262: Timing characteristics of synchronous Ethernet equipment slave clock, Edition 4.0, November 2018
https://www.itu.int/rec/T-REC-G.8262-201811-I/en

[4] IEEE 1588-2008: IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems, July 2008
https://standards.ieee.org/ieee/1588/6825/

[5] JEDEC standard, JESD 51: Methodology for the Thermal Measurement of Component Packages (Single Semiconductor Device), December 1995
https://www.jedec.org/standards-documents/docs/jesd-51

[6] Universal SXGMII Interface for a Single MultiGigabit Copper Network Port, Revision 2.4, Cisco Systems, July 30th 2019

[7] Cisco USXGMII Multiport Copper PHY Specification, EDCS-1517762, Version 2.15, May 11th, 2017

[8] Cisco USXGMII Single-port Copper PHY Specification, EDCS-1150953, Version 2.4, May 23rd 2016

[9] The I2C-Bus Specification Version 2.1, January 2000

[10] Negotiated Fast Retrain, Revision 2.0, Cisco Systems, June 10th, 2011

[11] IEEE 802.1Qbu: Frame Preemption, IEEE 802.1 working group, October 7th 2015

[12] Microsoft Security Development Lifecycle
https://www.microsoft.com/en-us/securityengineering/sdl/practices

Terminology

A

ADS	Auto-Downspeed
AFE	Analog Front End
ANEG	Auto-Negotiation
ANSI	American National Standards Institute
ASP	Analog Signal Processing

B

BW	Bandwidth

C

Cat 5	Category 5 Cabling
CDB	Clock Distribution Block
CDR	Clock and Data Recovery
CML	Current Mode Logic

D

DSP	Digital Signal Processing
DWRR	Deficit Weighted Round Robin

E

EEE	Energy-Efficient Ethernet
EEPROM	Electrically Erasable Programmable ROM
EMI	Electromagnetic Interference
ESD	Electrostatic Discharge

F

FCA	Flash Configuration Area
FLP	Fast Link Pulse

G

GMII	Gigabit Media-Independent Interface
GPIO	General Purpose Input/Output

H

HBM	Human Body Model

I

I^2C	Internally Integrated Circuit Interface (also I2C)
IC	Integrated Circuit
IEEE	Institute of Electrical and Electronics Engineers

J

JTAG	Joined Test Action Group

L

LAN	Local Area Network
LED	Light Emitting Diode

LJPLL	Low Jitter Phase-Locked Loop
LPI	Low Power Idle
LSB	Least Significant Bit
M	
MAC	Media Access Controller
MDI	Media-Dependent Interface
MDIO	Management Data Input/Output
MDIX	Media-Dependent Interface Crossover
MMD	MDIO Manageable Device
MSB	Most Significant Bit
N	
NLP	Normal Link Pulse
O	
OSI	Open Systems Interconnection
OUI	Organizationally Unique Identifier
P	
PCB	Printed Circuit Board
PCS	Physical Coding Sublayer
PD	Power Down
PHY	Physical Layer (device)
PLL	Phase-Locked Loop
PMA	Physical Media Attachment
PPS	Pulse Per Second
PTP	Precision Time Protocol
PTS	Precision Time Stamping
Q	
QSPI	Quad Serial Peripheral Interface
R	
Rx	Receive
S	
SerDes	Serializer-Deserializer
SFP	Small Form-Factor Pluggable
SMD	Surface Mounted Device
SoC	System on Chip
STA	Station Management Entity (MAC SoC)
SVN	Security Version Number
T	
TLE	Transformerless Ethernet
TPG	Test Packet Generator
TPI	Twisted Pair Interface

Tx	Transmit
U	
USXGMII	Universal Serial Multi(x) Gigabit Media Independent Interface
W	
WoL	Wake-on-LAN
X	
XO	Crystal Oscillator