Intel® LXT972M Single-Port 10/100 Mbps PHY Transceiver

Datasheet

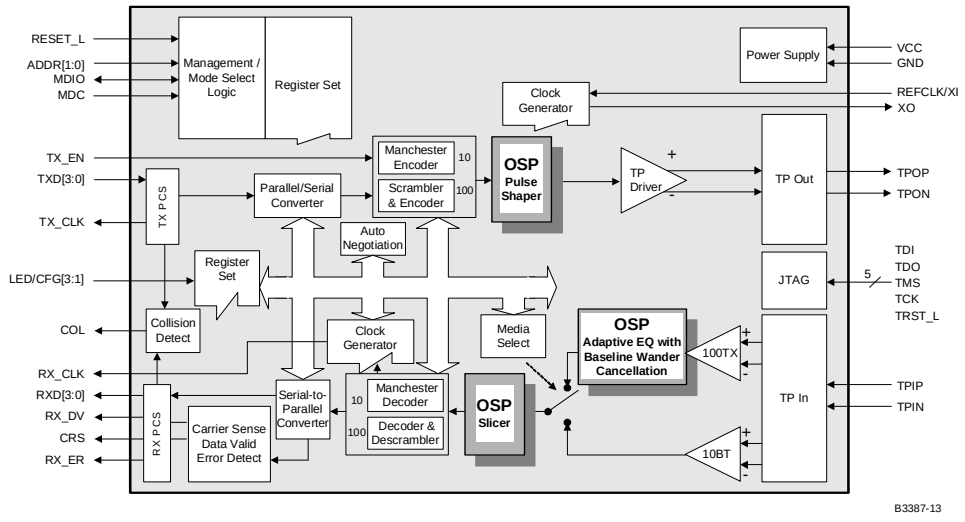
The Intel® LXT972M Single-Port 10/100 Mbps PHY Transceiver is an IEEE compliant Fast Ethernet PHY Transceiver that directly supports both 100BASE-TX and 10BASE-T applications. It provides a Media Independent Interface (MII) for easy attachment to 10/100 Media Access Controllers (MACs). Both full and half-duplex operation at 10 Mbps and 100 Mbps is supported. Operation mode can be set to auto-negotiation, parallel detection, or manual control. The device is powered from a single 3.3V power supply.

Applications

- Combination 10BASE-T/100BASE-TX Network Interface Cards (NICs)
- Wireless access points
- Network printers
- 10/100 Personal Computer Memory Card International Association (PCMCIA) cards
- Cable Modems and Set-Top Boxes

Product Features

- 3.3V Operation
- IEEE 802.3-compliant 10BASE-T or 100BASE-TX with integrated filters
- Auto-negotiation and parallel detection
- MII interface with extended register capability
- Robust baseline wander correction
- Carrier Sense Multiple Access / Collision Detection (CSMA/CD) or full-duplex operation
- JTAG boundary scan
- MDIO serial port or hardware pin configurable
- Integrated, programmable LED drivers
- 48-pin Low-profile Quad Flat Package



Document Number: 302875-005
Revision Date: 27-Oct-2005

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Revision History

Intel® LXT972M Transceiver Datasheet Revision 005 Revision Date: 27-Oct-2005	
Page	**Description**
91	Added Figure 36 “Sample LQFP Package - Intel® LXT972M Transceiver” and Figure 37 “Sample Pb-Free (RoHS-Compliant) LQFP Package - Intel® LX972M Transceiver” under Section 10.1, “Top Label Markings”.
92	Modified Table 57 “Product Ordering Information”: added RoHS information
92	Modified Figure 38 “Order Matrix for Intel® LXT972M Transceiver”.

Intel® LXT972M Transceiver Datasheet Revision 004 Revision Date: February 18, 2005	
Page	**Description**
-	Removed “Preliminary” label from document.
10	Added Table 1 “Related Documents from Intel”
92	Change to product ordering information in Chapter 11.0, “Product Ordering Information”.

Intel® LXT972M Transceiver Datasheet Revision 003 Revision Date: October 21, 2004	
Page	**Description**
1	Block diagram changed.
11	Chapter 2.0, “Block Diagram for Intel® LXT972M Transceiver”. Block diagram changed.
12	Chapter 3.0, “Pin Assignments for Intel® LXT972M Transceiver”. - Figure 2 “Pin Assignments for Intel® LXT972M Transceiver 48-Pin LQFP Package” changed. - Figure 11 “Pin Assignments for Intel® LXT972M Transceiver Pb-Free 48-Pin LQFP”. Added new figure for lead-free package. - Table 2 “Intel® LXT972M Transceiver Signal Types”. Changed old Table 2 to Table 1 and table text changed. - Table 3 “Intel® LXT972M Transceiver LQFP Numeric Pin List” changed.
15	Chapter 4.0, “Signal Descriptions for Intel® LXT972M Transceiver”. - Table 6 “Intel® LXT972M Transceiver Network Interface Signal Descriptions” changed. - Table 8 “Intel® LXT972M Transceiver Configuration and LED Driver Signal Descriptions” changed.
33	Section 5.4.4, “Hardware Configuration Settings”. - Text changed. - Table 13 “Hardware Configuration Settings for Intel® LXT972M Transceiver” changed.
35	Section 5.5.1.3, “Controlling Auto-Negotiation”. Added text.
53	Section 5.9.3, “LED Functions”. Text changed.
61	Chapter 7.0, “Electrical Specifications”. - Table 20 “Absolute Maximum Ratings for Intel® LXT972M Transceiver” changed. - Table 23 “Digital I/O Characteristics (Except for MII, XI/XO, and LED/CFG Pins)” changed. - Table 27 “100BASE-TX Transceiver Characteristics” changed.
66	Section 7.2, “Timing Diagrams”. Added timing diagrams.

Intel® LXT972M Transceiver Datasheet Revision 003 Revision Date: October 21, 2004	
Page	**Description**
75	Chapter 8.0, “Register Definitions - IEEE Base Registers” - Table 40 “Register Set for IEEE Base Registers” changed. - Table 41 “Control Register - Address 0, Hex 0” changed.
83	Chapter 9.0, “Register Definitions - Product-Specific Registers”. - Table 50 “Register Set for Product-Specific Registers” changed. - Table 54 “LED Configuration Register - Address 20, Hex 14” changed. - Table 56 “Transmit Control Register - Address 30, Hex 1E”
90	Chapter 10.0, “Intel® LXT972M Transceiver Package Specifications”. - Figure 35 “Intel® LXT972M Transceiver LQFP Package Specifications” changed.

Intel® LXT972M Transceiver Datasheet Revision 002 Revision Date: July 14, 2004	
Page	**Description**
1	Text changed.
10	Figure 1 “Intel® LXT972M Transceiver Block Diagram” - Deleted ECL Driver from figure.
21	Section 5.1, “Introduction” - Text changed.
22	Section 5.2.1.1, “Twisted-Pair Interface” - Added text on MDI crossover.
23	Section 5.2.1.2, “Fault Detection and Reporting” - Text changed.
26	Section 5.3.2.1, “External Crystal/Oscillator” - Text changed.
30	Table 12 “Hardware Configuration Settings for Intel® LXT972M Transceiver” - Bit value for 0.8 changed.
33	Section 5.5.2, “Parallel Detection” - Text changed.
36	Section 5.6.2, “Transmit Enable” - Text changed.
37	Section 5.6.4, “Carrier Sense” - Text changed.
45	Section 5.7.3.1.1, “Preamble Handling” - Text changed.
47	Section 5.7.3.2.1, “Link” - Added text.
47	Section 5.7.3.2.2, “Link Failure Override” - Added text.
47	Section 5.7.3.2.4, “Receive Data Valid” - Text changed.
48	Section 5.7.3.3.2, “Polarity Correction” - Text changed.
53	Section 5.9.4, “LED Pulse Stretching” - Text changed.
80	Table 46 “Auto-Negotiation Next Page Transmit Register - Address 7, Hex 7” - Bits 7.10:0 and 7.13 changed.
80	Table 47 “Auto-Negotiation Link Partner Next Page Receive Register - Address 8, Hex 8” - Bits 8.18 and 8.10:0 changed.
85	Table 52 “LED Configuration Register - Address 20, Hex 14” - Bit 20.0 changed.

Intel® LXT972M Transceiver Datasheet Revision 001 Revision Date: July 2, 2004	
Page	**Description**
-	Initial release of this document.

1.0 Introduction to This Document

This document includes information on the Intel® LXT972M Single-Port 10/100 Mbps PHY Transceiver (called hereafter the LXT972M Transceiver)

1.1 Document Overview

This document includes the following subjects:

- Chapter 2.0, “Block Diagram for Intel® LXT972M Transceiver”
- Chapter 3.0, “Pin Assignments for Intel® LXT972M Transceiver”
- Chapter 4.0, “Signal Descriptions for Intel® LXT972M Transceiver”
- Chapter 5.0, “Functional Description”
- Chapter 6.0, “Application Information”
- Chapter 7.0, “Electrical Specifications”
- Chapter 8.0, “Register Definitions - IEEE Base Registers”
- Chapter 9.0, “Register Definitions - Product-Specific Registers”
- Chapter 10.0, “Intel® LXT972M Transceiver Package Specifications”
- Chapter 11.0, “Product Ordering Information”

1.2 Related Documents

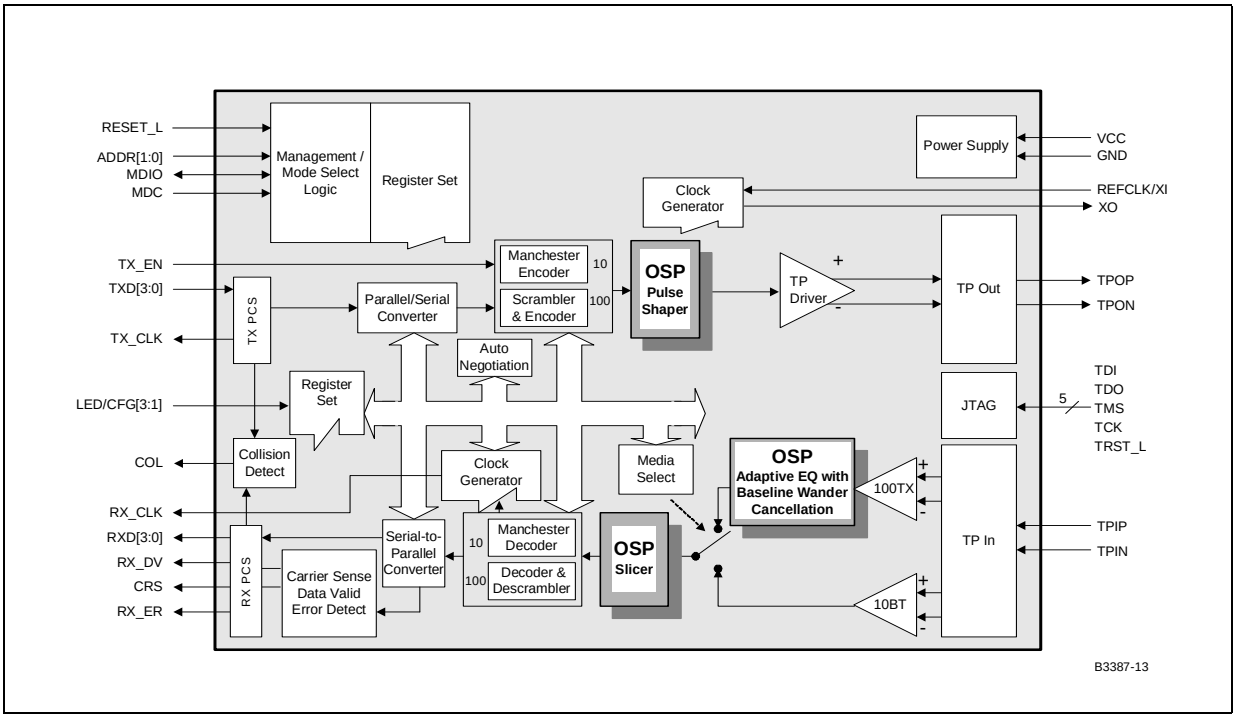
Table 1. Related Documents from Intel

Document Title	Document Number
Intel® LXT971A , LXT972A , LXT972M Single-Port 10/100 Mbps PHY Transceivers Specification Update	249354
Intel® LXT971A, LXT972A, and LXT972M 3.3V PHY Transceivers Design and Layout Guide - Application Note	249016
Magnetic Manufacturers for Networking Product Applications - Application Note	248991

2.0 Block Diagram for Intel® LXT972M Transceiver

Figure 1 is a block diagram of the LXT972M Transceiver. (This block diagram is the same as the block diagram on the first page of this document. This copy of the block diagram appears here as a convenience to the reader.)

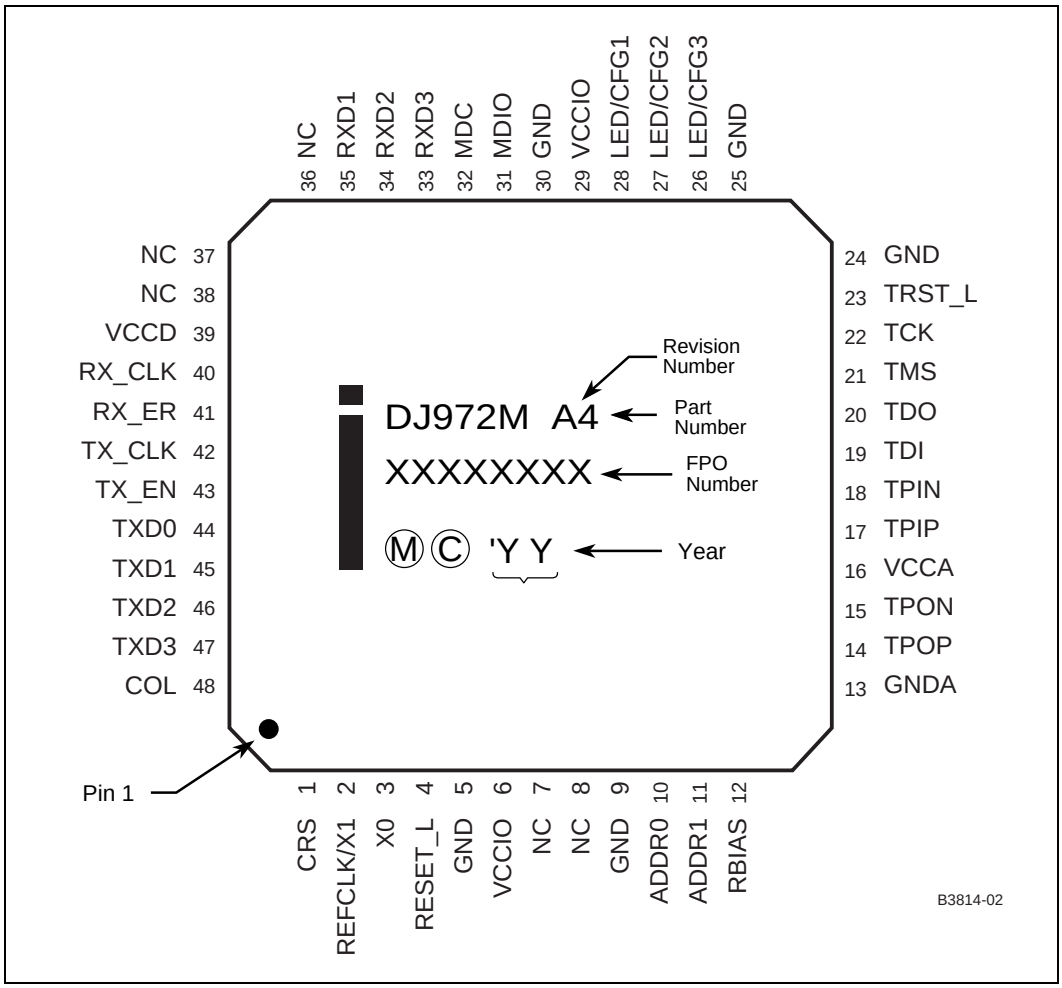
Figure 1. Intel® LXT972M Transceiver Block Diagram



3.0 Pin Assignments for Intel® LXT972M Transceiver

Figure 2 shows the pin assignments for the LXT972M Transceiver LQFP package.

Figure 2. Pin Assignments for Intel® LXT972M Transceiver 48-Pin LQFP Package



Note: For the tables in this section and the following sections, the abbreviations listed in Table 2 are used for the "Type" column.

Table 2. Intel® LXT972M Transceiver Signal Types

Abbreviation	Meaning
AI	Analog Input
AO	Analog Output
I	Input
I/O	Input/Output
O	Output
OD	Open Drain

Table 3 lists the LXT972M Transceiver LQFP pin numbers, symbols, and pin types.

Table 3. Intel® LXT972M Transceiver LQFP Numeric Pin List (Sheet 1 of 2)

Pin	Symbol	Type
1	CRS	O
2	REFCLK/XI	AI
3	XO	AO
4	RESET_L	I
5	GND	–
6	VCCIO	–
7	NC	–
8	NC	–
9	GND	–
10	ADDR0	I
11	ADDR1	I
12	RBIAS	AI
13	GNDA	–
14	TPOP	AO
15	TPON	AO
16	VCCA	–
17	TPIP	AI
18	TPIN	AI
19	TDI	I
20	TDO	O
21	TMS	I
22	TCK	I
23	TRST_L	I
24	GND	–
25	GND	–

Table 3. Intel® LXT972M Transceiver LQFP Numeric Pin List (Sheet 2 of 2)

Pin	Symbol	Type
26	LED/CFG3	I/O
27	LED/CFG2	I/O
28	LED/CFG1	I/O
29	VCCIO	–
30	GND	–
31	MDIO	I/O
32	MDC	I
33	RXD3	O
34	RXD2	O
35	RXD1	O
36	RXD0	O
37	RX_DV	O
38	GND	–
39	VCCD	–
40	RX_CLK	O
41	RX_ER	O
42	TX_CLK	O
43	TX_EN	I
44	TXD0	I
45	TXD1	I
46	TXD2	I
47	TXD3	I
48	COL	O

4.0 Signal Descriptions for Intel® LXT972M Transceiver

Intel recommends the following configurations for unused pins:

- **Unused inputs.** Configure all unused inputs and unused multi-function pins for inactive states.
- **Unused outputs.** Leave all unused outputs floating.
- **No connects.** Do not use pins designated as NC (no connect), and do not terminate them.

Note: For the tables in this section, the abbreviations listed in Table 2, “Intel® LXT972M Transceiver Signal Types” on page 13 are used for the “Type” column.

Tables in this section include the following

- Table 4, “Intel® LXT972M Transceiver MII Data Interface Signal Descriptions”
- Table 5, “Intel® LXT972M Transceiver MII Controller Interface Signal Descriptions”
- Table 6, “Intel® LXT972M Transceiver Network Interface Signal Descriptions”
- Table 7, “Intel® LXT972M Transceiver Standard Bus and Interface Signal Descriptions”
- Table 8, “Intel® LXT972M Transceiver Configuration and LED Driver Signal Descriptions”
- Table 9, “Intel® LXT972M Transceiver Power, Ground, No-Connect Signal Descriptions”
- Table 10, “Intel® LXT972M Transceiver JTAG Test Signal Descriptions”
- Table 11, “Intel® LXT972M Transceiver Pin Types and Modes”

Table 4 lists signal descriptions of the LXT972M Transceiver MII data interface pins.

Table 4. Intel® LXT972M Transceiver MII Data Interface Signal Descriptions

LQFP Pin#	Symbol	Type	Signal Description
47 46 45 44	TXD3 TXD2 TXD1 TXD0	I	**Transmit Data.** TXD is a group of parallel data signals that are driven by the MAC. TXD[3:0] transition synchronously with respect to TX_CLK. TXD[0] is the least-significant bit.
43	TX_EN	I	**Transmit Enable.** The MAC asserts this signal when it drives valid data on TXD. This signal must be synchronized to TX_CLK.
42	TX_CLK	O	**Transmit Clock.** TX_CLK is sourced by the PHY in both 10 and 100 Mbps operations. 2.5 MHz for 10 Mbps operation 25 MHz for 100 Mbps operation.
33 34 35 36	RXD3 RXD2 RXD1 RXD0	O	**Receive Data.** RXD is a group of parallel signals that transition synchronously with respect to RX_CLK. RXD[0] is the least-significant bit.
37	RX_DV	O	**Receive Data Valid.** The LXT972M Transceiver asserts this signal when it drives valid data on RXD. This output is synchronous to RX_CLK.
41	RX_ER	O	**Receive Error.** Signals a receive error condition has occurred. This output is synchronous to RX_CLK.
40	RX_CLK	O	**Receive Clock.** 25 MHz for 100 Mbps operation. 2.5 MHz for 10 Mbps operation. For details, see “Clock Requirements” on page 28 in Chapter 5.0, “Functional Description”.
48	COL	O	**Collision Detected**. The LXT972M Transceiver asserts this output when a collision is detected. This output remains High for the duration of the collision. This signal is asynchronous and is inactive during full- duplex operation.
1	CRS	O	**Carrier Sense**. During half-duplex operation (Register bit 0.8 = 0), the LXT972M Transceiver asserts this output when either transmitting or receiving data packets. During full-duplex operation (Register bit 0.8 = 1), CRS is asserted only during receive. CRS assertion is asynchronous with respect to RX_CLK. CRS is de-asserted on loss of carrier, synchronous to RX_CLK.

Table 5 lists signal descriptions of the LXT972M Transceiver MII controller interface pins.

Table 5. Intel® LXT972M Transceiver MII Controller Interface Signal Descriptions

LQFP Pin#	Symbol	Type	Signal Description
32	MDC	I	**Management Data Clock**. Clock for the MDIO serial data channel. Maximum frequency is 8 MHz.
31	MDIO	I/O	**Management Data Input/Output**. Bidirectional serial data channel for PHY/STA communication.

Table 6 lists signal descriptions of the LXT972M Transceiver network interface pins.

Table 6. Intel® LXT972M Transceiver Network Interface Signal Descriptions

LQFP Pin#	Symbol	Type	Signal Description
14 15	TPOP TPON	AO	**Twisted-Pair Outputs, Positive and Negative.** During 100BASE-TX or 10BASE-T operation, TPOP/N pins drive IEEE 802.3 compliant pulses onto the line.
17 18	TPIP TPIN	AI	**Twisted-Pair Inputs, Positive and Negative.** During 100BASE-TX or 10BASE-T operation, TPIP/N pins receive differential 100BASE-TX or 10BASE-T signals from the line.

Table 7 lists signal descriptions of the LXT972M Transceiver standard bus and interface signals.

Table 7. Intel® LXT972M Transceiver Standard Bus and Interface Signal Descriptions

LQFP Pin#	Symbol	Type	Signal Description
10 11	ADDR0 ADDR1	I	**Address**. Set device address.

Table 8 lists signal descriptions of the LXT972M Transceiver configuration and LED driver pins.

Note: Pull-up/pull-down resistors of 10k Ohms can be implemented if LEDs are not used in the design.

Table 8. Intel® LXT972M Transceiver Configuration and LED Driver Signal Descriptions

LQFP Pin#	Symbol	Type	Signal Description
4	RESET_L	I	**Reset**. This active Low input is ORed with the control register Reset bit (Register bit 0.15). The LXT972M Transceiver reset cycle is extended to 258 µs (nominal) after reset is de-asserted.
12	RBIAS	AI	**Reference Current Bias**. This pin provides bias current for the internal circuitry. Must be tied to ground through a 22.1 kΩ, 1% resistor.
2 3	REFCLK/XI XO	AI and AO	**Reference Clock Input / Crystal Input and Crystal Output**. A 25 MHz crystal oscillator circuit can be connected across XI and XO. A clock can also be used at XI. Refer to Section 5.3.2, “Clock Requirements” on page 28 in the Functional Description section.
26 27 28	LED/CFG3 LED/CFG2 LEDCFG1	I/O	**LED Drivers 1-3.** These pins drive LED indicators. Each LED can display one of several available status conditions as selected by the LED Configuration Register. (For details, see Table 54, “LED Configuration Register - Address 20, Hex 14” on page 87.) **Configuration Inputs 1-3.** These pins also provide initial configuration settings. (For details, see Table 13, “Hardware Configuration Settings for Intel® LXT972M Transceiver” on page 33.)

Table 9 lists signal descriptions of the LXT972M Transceiver power, ground, and no-connect pins.

Table 9. Intel® LXT972M Transceiver Power, Ground, No-Connect Signal Descriptions

LQFP Pin#	Symbol	Type	Signal Description
13	GNDA	–	**Analog Ground.**
5, 9, 24, 25, 30, 38	GND	–	**Ground Input/Output.** Ground return for digital I/O circuits (VCCIO).
6, 29	VCCIO	–	**MII Power.** Requires either a 3.3 V or a 2.5 V supply. Must be supplied from the same source used to power the MAC on the other side of the MII. For the LXT972M Transceiver, VCCIO is 3.3 V.
16	VCCA	–	**Analog Power.** Requires a 3.3 V power supply.
39	VCCD	–	**Digital Power.** Requires a 3.3 V power supply.
7, 8	NC	–	**No Connection**. These pins are not used and must not be terminated.

Table 10 lists signal descriptions of LXT972M Transceiver Joint Test Action Group (JTAG) pins.

Note: If a JTAG port is not used, these pins do not need to be terminated.

Table 10. Intel® LXT972M Transceiver JTAG Test Signal Descriptions

LQFP Pin#	Symbol	Type	Signal Description
19	TDI	I	**Test Data Input**. Test data sampled with respect to the rising edge of TCK.
20	TDO	O	**Test Data Output**. Test data driven with respect to the falling edge of TCK.
21	TMS	I	**Test Mode Select**.
22	TCK	I	**Test Clock**. Clock input for boundary scan.
23	TRST_L	I	**Test Reset**. This active-low test reset input is sourced by ATE.

Table 11 lists pin types and modes of the LXT972M Transceiver.

Note:

- DH = Driven High (Logic 1)
- DL = Driven Low (Logic 0)
- HZ = High Impedance
- ID = Internal Pull-Down (Weak)

Table 11. Intel® LXT972M Transceiver Pin Types and Modes

Modes	RXD3:0	RX_DV	Tx/Rx CLKS Output	RX_ER Output	COL Output	CRS Output	TXD3:0 Input	TX_EN Input
HWReset	DL	DL	DH	DL	DL	DL	ID	ID
SFTPWRDN	DL	DL	Active	DL	DL	DL	ID	ID
ISOLATE	HZ with ID	HZ with ID	HZ with ID	HZ with ID	HZ with ID	HZ with ID	ID	ID

5.0 Functional Description

This chapter has the following sections:

- Section 5.1, “Device Overview”
- Section 5.2, “Network Media / Protocol Support”
- Section 5.3, “Operating Requirements”
- Section 5.4, “Initialization”
- Section 5.5, “Establishing Link”
- Section 5.6, “MII Operation”
- Section 5.7, “100 Mbps Operation”
- Section 5.8, “10 Mbps Operation”
- Section 5.9, “Monitoring Operations”
- Section 5.10, “Boundary Scan (JTAG 1149.1) Functions”

5.1 Device Overview

The LXT972M Transceiver is a single-port Fast Ethernet 10/100 transceiver that supports 10 Mbps and 100 Mbps networks. It complies with applicable requirements of IEEE 802.3. It directly drives either a 100BASE-TX line or a 10BASE-T line.

5.1.1 Comprehensive Functionality

The LXT972M Transceiver provides a standard Media Independent Interface (MII) for 10/100 MACs. The LXT972M Transceiver performs all functions of the Physical Coding Sublayer (PCS) and Physical Media Attachment (PMA) sublayer as defined in the IEEE 802.3 100BASE-X standard. It also performs all functions of the Physical Media Dependent (PMD) sublayer for 100BASE-TX connections.

If the LXT972M Transceiver is not set for forced operation, it uses auto-negotiation/parallel detection to automatically determine line operating conditions. If the PHY device on the other side of the link supports auto-negotiation, the LXT972M Transceiver auto-negotiates with it using Fast Link Pulse (FLP) Bursts. If the PHY partner does not support auto-negotiation, the LXT972M Transceiver automatically detects the presence of either link pulses (10 Mbps PHY) or Idle symbols (100 Mbps PHY) and sets its operating conditions accordingly.

The LXT972M Transceiver provides half-duplex and full-duplex operation at 100 Mbps and 10 Mbps.

5.1.2 Optimal Signal Processing Architecture

The LXT972M Transceiver incorporates high-efficiency Optimal Signal Processing (OSP) design techniques, which combine optimal properties of digital and analog signal processing.

The receiver utilizes decision feedback equalization to increase noise and cross-talk immunity by as much as 3 dB over an ideal all-analog equalizer. Using OSP mixed-signal processing techniques in the receive equalizer avoids the quantization noise and calculation truncation errors found in traditional DSP-based receivers (typically complex DSP engines with A/D converters). This results in improved receiver noise and cross-talk performance.

The OSP signal processing scheme also requires substantially less computational logic than traditional DSP-based designs. This lowers power consumption and also reduces the logic switching noise generated by DSP engines. This logic switching noise can be a considerable source of EMI generated on the device’s power supplies.

The OSP-based LXT972M Transceiver provides improved data recovery, EMI performance, and low power consumption.

5.2 Network Media / Protocol Support

This section includes the following:

- Section 5.2.1, “10/100 Network Interface”
- Section 5.2.2, “MII Data Interface”
- Section 5.2.3, “Configuration Management Interface”

The LXT972M Transceiver supports both 10BASE-T and 100BASE-TX Ethernet over twisted-pair.

5.2.1 10/100 Network Interface

The network interface port consists of two differential signal pairs. For specific pin assignments, see Chapter 4.0, “Signal Descriptions for Intel® LXT972M Transceiver”.

The LXT972M Transceiver output drivers can generate one of the following outputs:

- 100BASE-TX
- 10BASE-T

When not transmitting data, the LXT972M Transceiver generates IEEE 802.3-compliant link pulses or idle code. Depending on the mode selected, input signals are decoded as one of the following:

When not transmitting data, the LXT972M Transceiver generates IEEE 802.3-compliant link pulses or idle code. Depending on the mode selected, input signals are decoded as one of the following:

- 100BASE-TX
- 10BASE-T

Auto-negotiation/parallel detection or manual control is used to determine the speed of this interface.

5.2.1.1 Twisted-Pair Interface

The LXT972M Transceiver supports either 100BASE-TX or 10BASE-T connections over 100 Ω, Category 5, Unshielded Twisted Pair (UTP) cable. When operating at 100 Mbps, the LXT972M Transceiver continuously transmits and receives MLT3 symbols. When not transmitting data, the LXT972M Transceiver generates “IDLE” symbols.

During 10 Mbps operation, Manchester-encoded data is exchanged. When no data is being exchanged, the line is left in an idle state. Link pulses are transmitted periodically to keep the link up.

Only a transformer, RJ-45 connector, load resistor, and bypass capacitors are required to complete this interface. On the transmit side, the LXT972M Transceiver has an active internal termination and does not require external termination resistors. Intel's patented waveshaping technology shapes the outgoing signal to help reduce the need for external EMI filters. Four slew rate settings allow the designer to match the output waveform to the magnetic characteristics. On the receive side, the internal impedance is high enough that it has no practical effect on the external termination circuit. (For the slew rate settings, see Table 56, “Transmit Control Register - Address 30, Hex 1E” on page 89.)

Note: On the LXT972M Transceiver, MDIX crossover (MDIX) is supported by board design.

5.2.1.2 Remote Fault Detection and Reporting

The LXT972M Transceiver supports the remote fault detection and reporting mechanisms. “Remote Fault” refers to a MAC-to-MAC communication function that is transparent to PHY layer devices. It is used only during auto-negotiation, and is applicable only to twisted-pair links.

Remote Fault Detection. Register bit 4.13 in the Auto-Negotiation Advertisement Register is reserved for Remote Fault indications. It is typically used when re-starting the auto-negotiation sequence to indicate to the link partner that the link is down because the advertising device detected a local fault.

When the LXT972M Transceiver receives a Remote Fault indication from its partner during auto-negotiation, the following occurs:

- Register bit 5.13 in the Link Partner Base Page Ability Register is set.
- Remote Fault Register bit 1.4 in the MII Status Register is set to pass this information to the local controller.

5.2.2 MII Data Interface

The LXT972M Transceiver supports a standard Media Independent Interface (MII). The MII consists of a data interface and a management interface. The MII Data Interface passes data between the LXT972M Transceiver and a Media Access Controller (MAC). Separate parallel buses are provided for transmit and receive. This interface operates at either 10 Mbps or 100 Mbps. The speed is set automatically, once the operating conditions of the network link have been determined. For details, see Section 5.6, “MII Operation” on page 36.

Increased MII Drive Strength. A higher Media Independent Interface (MII) drive strength may be desired in some designs to drive signals over longer PCB trace lengths, or over high-capacitive loads, through multiple vias, or through a connector. The MII drive strength in the LXT972M Transceiver can be increased by setting Register bit 26.11 through software control. Setting Register bit 26.11 = 1 through the MDC/MDIO interface sets the MII pins (RXD[3:0], RX_DV, RX_CLK, RX_ER, COL, CRS, and TX_CLK) to a higher drive strength.

5.2.3 Configuration Management Interface

The LXT972M Transceiver provides both an MDIO interface and a reduced hardware control interface for device configuration and management.

5.2.3.1 MDIO Management Interface

MDIO management interface topics include the following:

- Section 5.2.3.1.1, “MDIO Addressing for Intel® LXT972M Transceiver”
- Section 5.2.3.1.2, “MDIO Frame Structure”

The LXT972M Transceiver supports the IEEE 802.3 MII Management Interface also known as the Management Data Input/Output (MDIO) Interface. This interface allows upper-layer devices to monitor and control the state of the LXT972M Transceiver. The MDIO interface consists of a physical connection, a specific protocol that runs across the connection, and an internal set of addressable registers.

Some registers are required and their functions are defined by the IEEE 802.3 standard. The LXT972M Transceiver also supports additional registers for expanded functionality. The LXT972M Transceiver supports multiple internal registers, each of which is 16 bits wide. Specific register bits are referenced using an “X.Y” notation, where X is the register number (0-31) and Y is the bit number (0-15).

5.2.3.1.1 MDIO Addressing for Intel® LXT972M Transceiver

The MDIO addressing protocol allows a controller to communicate with multiple LXT972M Transceivers.As listed in Table 12, pins ADDR[1:0] determine the PHY device address that is selected.

Table 12. Intel® LXT972M Transceiver - PHY Device Address Selections

ADDR1 (Pin 11)	ADDR0 (Pin 10)	PHY Device Address Selected
0	0	0
0	1	1
1	0	28
1	1	29

5.2.3.1.2 MDIO Frame Structure

The physical interface consists of a data line (MDIO) and clock line (MDC). The frame structure is shown in Figure 3 and Figure 4 (Read and Write).

MDIO Interface timing is given in Chapter 7.0, “Electrical Specifications”.

Figure 3. Management Interface Read Frame Structure

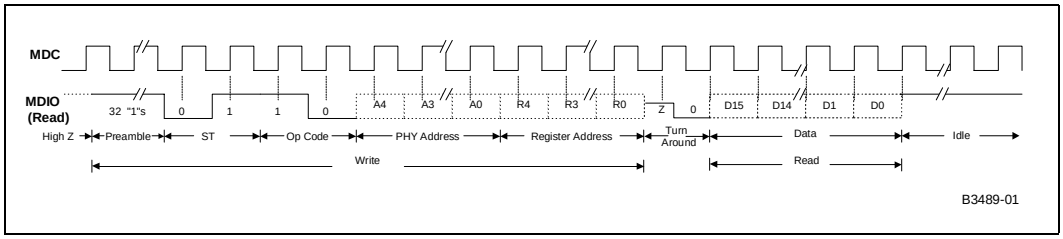
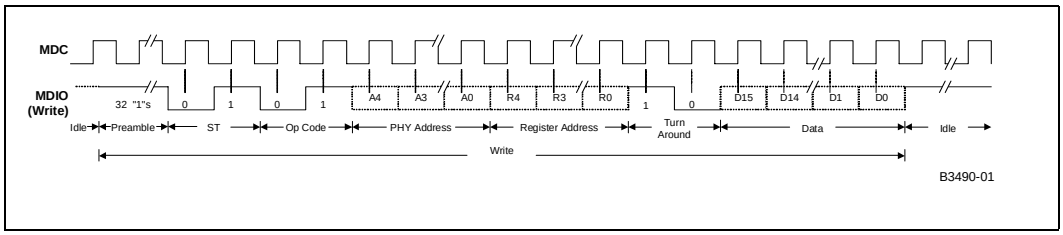


Figure 4. Management Interface Write Frame Structure



5.2.3.2 Hardware Control Interface

The LXT972M Transceiver provides a Hardware Control Interface for applications where the MDIO is not desired. The Hardware Control Interface uses the hardware configuration pins to set device configuration. For details, see Section 5.4.4, “Hardware Configuration Settings” on page 33.

5.3 Operating Requirements

5.3.1 Power Requirements

The LXT972M Transceiver requires three power supply inputs:

- VCCA
- VCCD
- VCCIO

The digital and analog circuits require 3.3 V supplies (VCCA and VCCD). These inputs may be supplied from a single source. Each supply input must be de-coupled to ground.

An additional supply may be used for the MII (VCCIO). The supply may be either +2.5 V or +3.3 V. Also, the inputs on the MII interface are tolerant to 5 V signals from the controller on the other side of the MII interface. For MII I/O characteristics, see Table 24, “Digital I/O Characteristics1 - MII Pins” on page 62.

Note: Bring up power supplies as close to the same time as possible.

Note: As a matter of good practice, keep power supplies as clean as possible.

5.3.2 Clock Requirements

5.3.2.1 External Crystal/Oscillator

The LXT972M Transceiver requires a reference clock input that is used to generate transmit signals and recover receive signals. It may be provided by either of two methods: by connecting a crystal across the oscillator pins (XI and XO) with load capacitors, or by connecting an external clock source to pin XI.

The connection of a clock source to the XI pin requires the XO pin to be left open. To minimize transmit jitter, Intel recommends a crystal-based clock instead of a derived clock (that is, a PLL-based clock).

A crystal is typically used in NIC applications. An external 25 MHz clock source, rather than a crystal, is frequently used in switch applications. For clock timing requirements, see Table 25, “I/O Characteristics - REFCLK/XI and XO Pins” on page 63.

5.3.2.2 MDIO Clock

The MII management channel (MDIO) also requires an external clock. The managed data clock (MDC) speed is a maximum of 8 MHz. For details, see Table 37, “Intel® LXT972M Transceiver MDIO Timing” on page 72.

5.4 Initialization

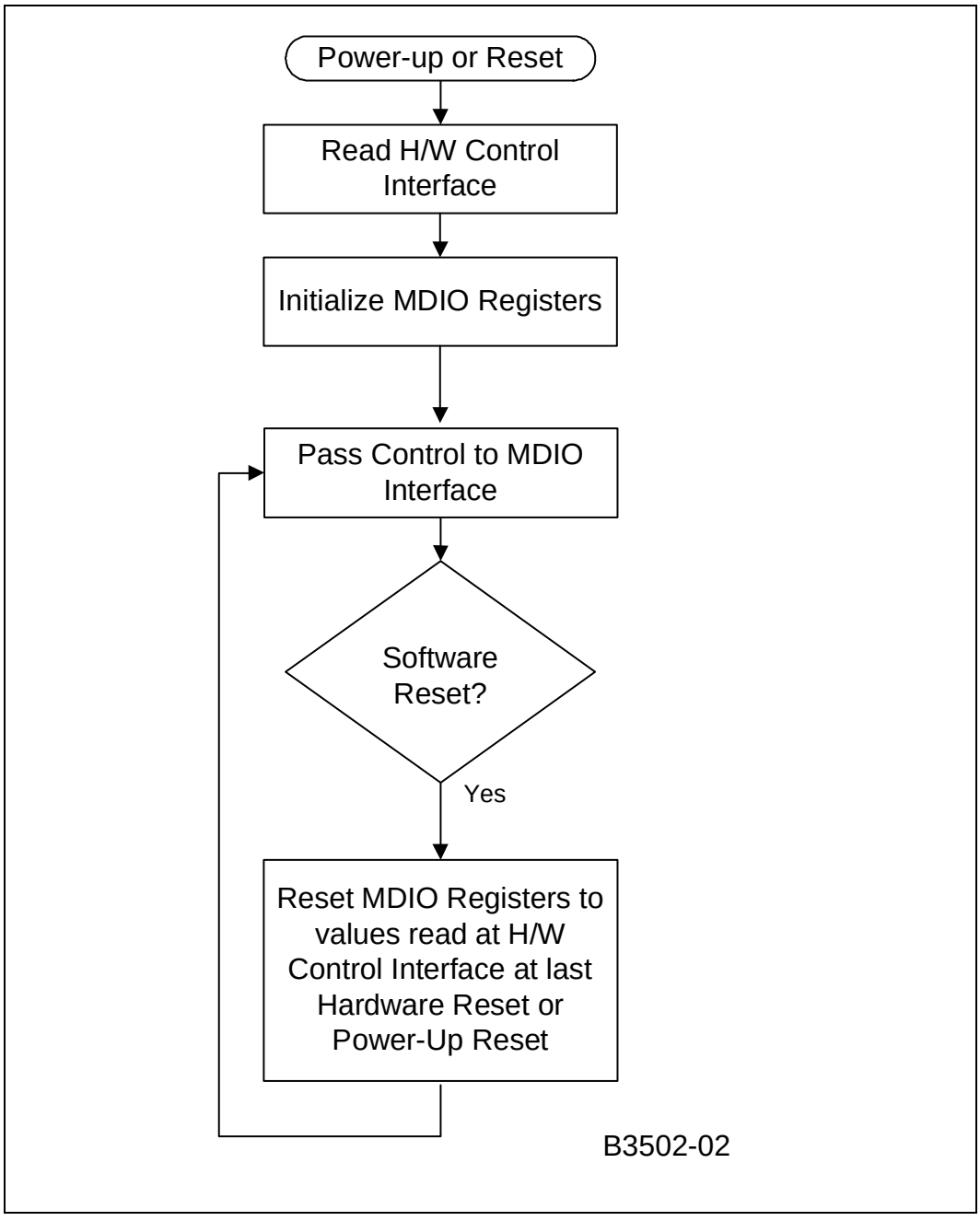
This section includes the following topics:

- Section 5.4.1, “MDIO Control Mode and Hardware Control Mode”
- Section 5.4.2, “Reduced-Power Modes”
- Section 5.4.3, “Reset for Intel® LXT972M Transceiver”
- Section 5.4.4, “Hardware Configuration Settings”

When the LXT972M Transceiver is first powered on, reset, or encounters a link failure state, it checks the MDIO register configuration bits to determine the line speed and operating conditions to use for the network link.

Figure 5 shows the initialization sequence for the LXT972M Transceiver. The configuration bits may be set by the Hardware Control or MDIO interface.

Figure 5. Initialization Sequence for Intel® LXT972M Transceiver



5.4.1 MDIO Control Mode and Hardware Control Mode

In the MDIO Control mode, the LXT972M Transceiver reads the Hardware Control Interface pins to set the initial (default) values of the MDIO registers. Once the initial values are set, bit control reverts to the MDIO interface.

The following modes are available using MDIO Control.

- Force network link operation to:
  - 100BASE-TX, Full-Duplex
  - 100BASE-TX, Half-Duplex
  - 10BASE-T, Full-Duplex
  - 10BASE-T, Half-Duplex
- Allow auto-negotiation/parallel-detection

On power-up or hardware reset, the LXT972M Transceiver reads the Hardware Control Interface pins and sets the MDIO registers accordingly.

The following modes are available using the Hardware Control:

- Auto-negotiation-enabled advertising, either:
  - 10/100 BASE-T Full/Half Duplex
  - 10/100 BASE-T Half Duplex
- LXT972M Transceiver device ID enable
- Link Hold-off

When the network link is forced to a specific configuration, the LXT972M Transceiver immediately begins operating the network interface as commanded. When auto-negotiation is enabled, the LXT972MTransceiver begins the auto-negotiation/parallel-detection operation.

5.4.2 Reduced-Power Modes

This section discusses the LXT972M Transceiver reduced-power modes.

5.4.2.1 Software Power Down

Software power-down control is provided by Register bit 0.11 in the Control Register. (See Table 41 on page 76.) During soft power-down, the following conditions are true:

- The network port is shut down.
- The MDIO registers remain accessible.

5.4.3 Reset for Intel® LXT972M Transceiver

The LXT972M Transceiver provides both hardware and software resets, each of which manage differently the configuration control of auto-negotiation, speed, and duplex-mode selection.

For a software reset, Register bit 0.15 = 1. For register bit definitions used for software reset, see Table 41, “Control Register - Address 0, Hex 0” on page 76.

- During a software reset, bit settings in Table 45, “Auto-Negotiation Advertisement Register - Address 4, Hex 4” on page 79 are not re-read from the LXT972M Transceiver configuration pins. Instead, the bit settings revert to the values that were read in during the last hardware reset. Therefore, any changes to pin values made since the last hardware reset are not detected during a software reset.
- During a software reset, registers are available for reading. To see when the LXT972M Transceiver has completed reset, the reset bit can be polled (that is, Register bit 0.15 = 0).

For pin settings used during a hardware reset, see Section 5.4.4, “Hardware Configuration Settings”. During a hardware reset, configuration settings for auto-negotiation and speed are read in from pins, and register information is unavailable for 1 ms after de-assertion of the reset.

5.4.4 Hardware Configuration Settings

The LXT972M Transceiver provides a hardware option to set the initial device configuration. As listed in Table 13, the hardware option uses the hardware configuration pins, the settings for which provide control bits.

Table 13. Hardware Configuration Settings for Intel® LXT972M Transceiver

Desired Mode			LED/CFG Pin Settings[1]			Resulting Register Bit Values						
						Control Register			Auto-Negotiation Advertisement Register			
Auto-Neg.	Speed (Mbps)	Duplex	1	2	3	Auto-Neg. 0.12	Speed 0.13	Full-Duplex 0.8	100 BASE-TX Full-Duplex 4.8	100 BASE-TX 4.7	10 BASE-T Full-Duplex 4.6	10 BASE-T 4.5
Disabled	10	Half	L	L	L	0	0	0	N/A Auto-Negotiation Advertisement			
		Full	L	L	H		0	1				
	100	Half	L	H	L		1	0				
		Full	L	H	H		1	1				
Enabled	100 Only	Half	H	L	L	1	1	0	0	1	0	0
		Full/Half	H	L	H		1	1	1	1	0	0
	10/100	Half Only	H	H	L		1	0	0	1	0	1
		Full or Half	H	H	H		1	1	1	1	1	1

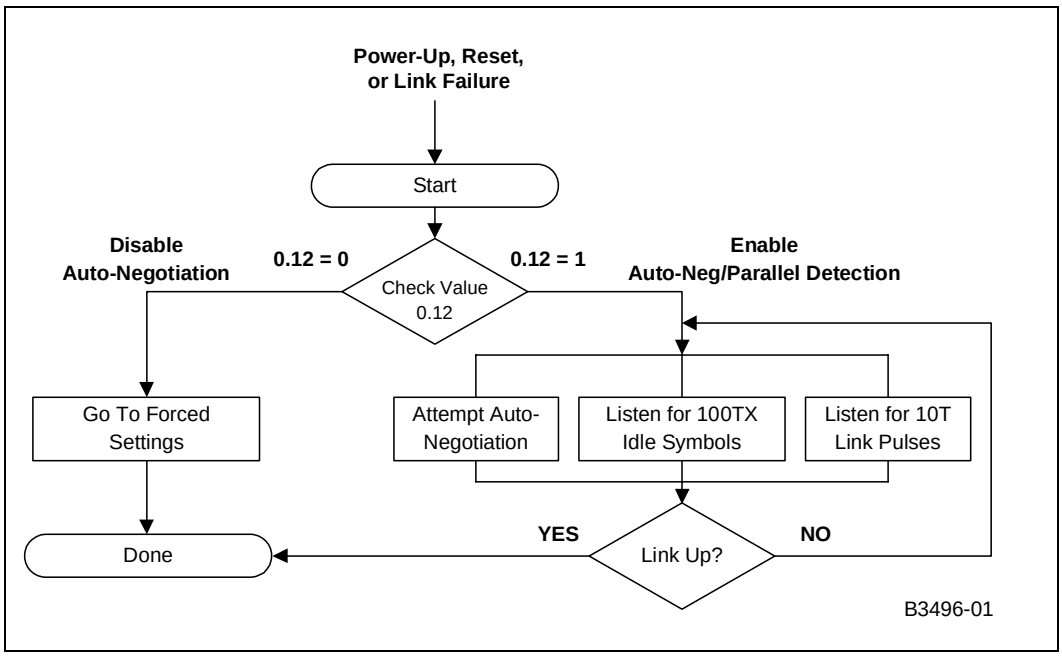
1. L = Low, and H = High. For LED/CFG pin assignments, see Chapter 3.0, “Pin Assignments for Intel® LXT972M Transceiver”.

5.5 Establishing Link

Figure 6 shows an overview of link establishment for the LXT972M Transceiver.

Note: When a link is established by parallel detection, the LXT972M Transceiver sets the duplex mode to half-duplex, as defined by the IEEE 802.3 standard.

Figure 6. Link Establishment Overview)



5.5.1 Auto-Negotiation

If not configured for forced operation, the LXT972M Transceiver attempts to auto-negotiate with its link partner by sending Fast Link Pulse (FLP) bursts. Each burst consists of up to 33 link pulses spaced 62.5 µs apart. Odd link pulses (clock pulses) are always present. Even link pulses (data pulses) may be absent or present to indicate a ‘0’ or a ‘1’. Each FLP burst exchanges 16 bits of data, which are referred to as a “link code word”. All devices that support auto-negotiation must implement the “Base Page” defined by the IEEE 802.3 standard (Registers 4 and 5).

The LXT972M Transceiver also supports the optional “Next Page” function as listed in Table 48, “Auto-Negotiation Next Page Transmit Register - Address 7, Hex 7” on page 82 and Table 49, “Auto-Negotiation Link Partner Next Page Receive Register - Address 8, Hex 8” on page 82.

5.5.1.1 Base Page Exchange

By exchanging Base Pages, the LXT972M Transceiver and its link partner communicate their capabilities to each other. Both sides must receive at least three consecutive identical base pages for negotiation to continue. Each side identifies the highest common capabilities that both sides support, and each side configures itself accordingly.

5.5.1.2 Manual Next Page Exchange

"Next Page Exchange" information is additional information that exceeds the information required by Base Page exchange and that is sent by "Next Pages". The LXT972M Transceiver fully supports the IEEE 802.3 standard method of negotiation through the Next Page exchange.

The Next Page exchange uses Register 7 to send information and Register 8 to receive it. Next Page exchange occurs only if both ends of the link partners advertise their ability to exchange Next Pages. Register bit 6.1 is used to make manual next page exchange easier for software. This register bit is cleared when a new negotiation occurs, preventing the user from reading an old value in Register 6 and assuming there is valid information in Registers 5 and 8.

5.5.1.3 Controlling Auto-Negotiation

When auto-negotiation is controlled by software, Intel recommends the following steps:

1. After power-up, power-down, or reset, the power-down recovery time (specified in Table 39, "Intel® LXT972M Transceiver RESET_L Pulse Width and Recovery Timing" on page 74) must be exhausted before proceeding.
2. Set the Auto-Negotiation Advertisement Register bits in Register 4 as desired.
3. Enable auto-negotiation. (Set MDIO Register bit 0.12 = 1.)
4. To ensure proper operation, enable or restart auto-negotiation as soon as possible after writing to Register 4.

5.5.2 Parallel Detection

In parallel with auto-negotiation, the LXT972M Transceiver also monitors for 10 Mbps Normal Link Pulses (NLP) or 100 Mbps Idle symbols. If either symbol is detected, the device automatically reverts to the corresponding speed in half-duplex mode. Parallel detection allows the LXT972M Transceiver to communicate with devices that do not support auto-negotiation.

When parallel detection resolves a link, the link must be established in half-duplex mode. According to IEEE standards, the forced link partner cannot be configured to full-duplex. If the auto-negotiation link partner does not advertise half-duplex capability at the speed of the forced link partner, link is not established. The IEEE Standard prevents full-duplex-to-half-duplex link connections.

5.6 MII Operation

This section includes the following topics:

- Section 5.6.1, “MII Clocks”
- Section 5.6.2, “Transmit Enable”
- Section 5.6.3, “Receive Data Valid”
- Section 5.6.4, “Carrier Sense”
- Section 5.6.5, “Error Signals”
- Section 5.6.6, “Collision”
- Section 5.6.7, “Loopback”

The LXT972M Transceiver implements the Media Independent Interface (MII) as defined by the IEEE 802.3 standard. Separate channels are provided for transmitting data from the MAC to the LXT972M Transceiver (TXD), and for passing data received from the line (RXD) to the MAC. Each channel has its own clock, data bus, and control signals.

The following signals are used to pass received data to the MAC:

- COL
- CRS
- RX_CLK
- RX_DV
- RX_ER
- RXD[3:0]

The following signals are used to transmit data from the MAC:

- TX_CLK
- TX_EN
- TXD[3:0]

The LXT972M Transceiver supplies both clock signals as well as separate outputs for carrier sense and collision. Data transmission across the MII is normally implemented in 4-bit-wide nibbles.

5.6.1 MII Clocks

The LXT972M Transceiver is the master clock source for data transmission, and it supplies both MII clocks (RX_CLK and TX_CLK). It automatically sets the clock speeds to match link conditions.

- When the link is operating at 100 Mbps, the clocks are set to 25 MHz.
- When the link is operating at 10 Mbps, the clocks are set to 2.5 MHz.

Figure 7 through Figure 9 show the clock cycles for each mode.

Note: The transmit data and control signals must always be synchronized to TX_CLK by the MAC. The LXT972M Transceiver samples these signals on the rising edge of TX_CLK.

Figure 7. Clocking for 10BASE-T

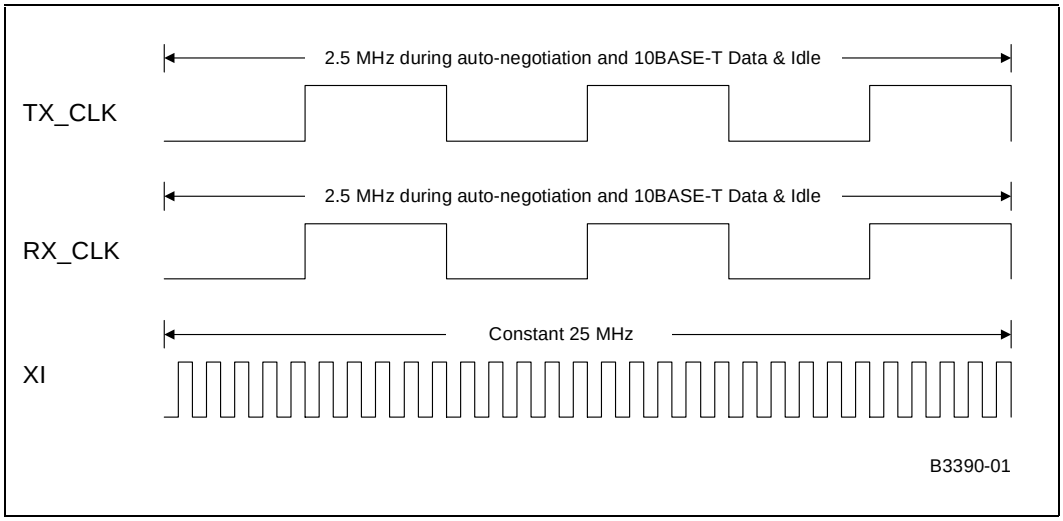


Figure 8. Clocking for 100BASE-X

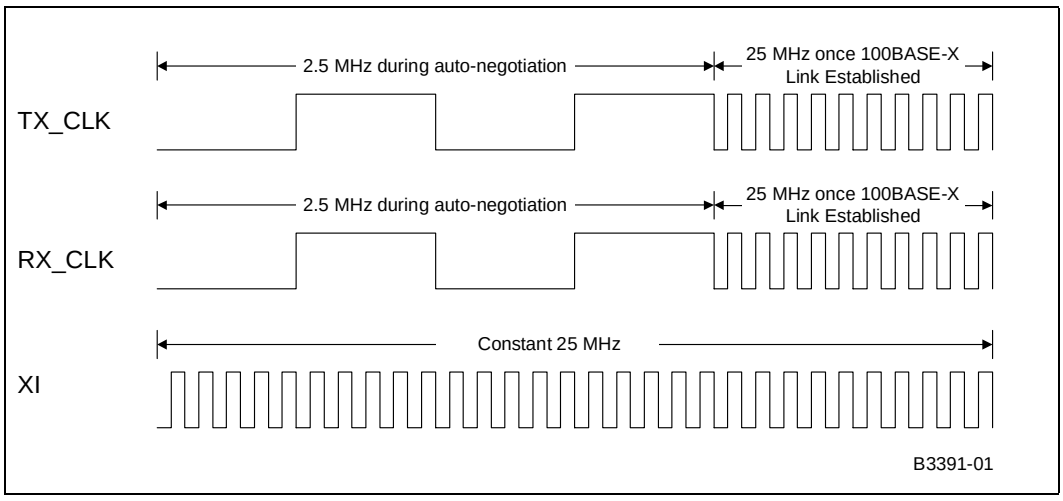
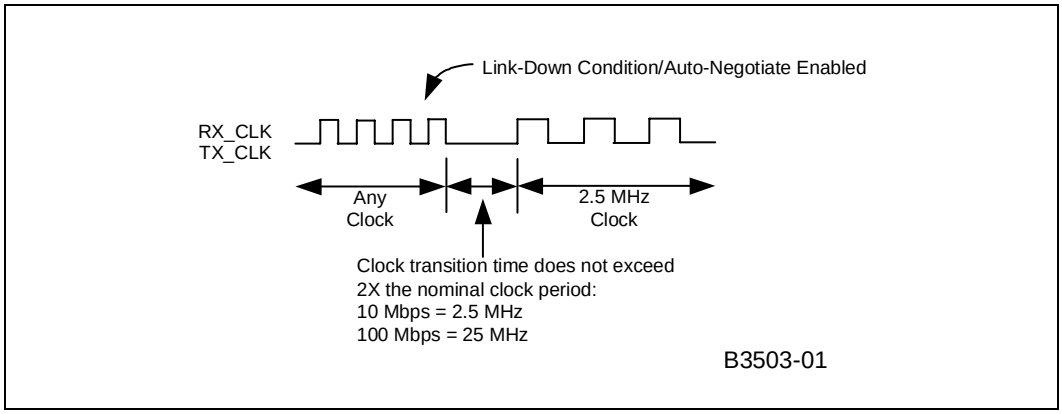


Figure 9. Clocking for Link Down Clock Transition



5.6.2 Transmit Enable

The MAC must assert TX_EN the same time as the first nibble of preamble and de-assert TX_EN after the last nibble of the packet.

5.6.3 Receive Data Valid

The LXT972M Transceiver asserts RX_DV when it receives a valid packet. Timing changes depend on line operating speed:

- For 100BASE-TX links, RX_DV is asserted from the first nibble of preamble to the last nibble of the data packet.
- For 10BASE-T links, the entire preamble is truncated. RX_DV is asserted with the first nibble of the Start of Frame Delimiter (SFD) “5D” and remains asserted until the end of the packet.

5.6.4 Carrier Sense

Carrier Sense (CRS) is an asynchronous output.

- CRS is always generated when the LXT972M Transceiver receives a packet from the line.
- CRS is also generated when the LXT972M Transceiver is in half-duplex mode when a packet is transmitted.

Table 14 summarizes the conditions for assertion of carrier sense, data loopback, and collision signals. Carrier sense is not generated when a packet is transmitted and in full-duplex mode.

Table 14. Carrier Sense, Loopback, and Collision Conditions

Speed	Duplex Condition	Carrier Sense	Test Loop-back[1, 2]	Operational Loop-back[1, 2]	Collision
100 Mbps	Full-Duplex	Receive Only	Yes	No	None
	Half-Duplex	Transmit or Receive	No	No	Transmit and Receive
10 Mbps	Full-Duplex	Receive Only	Yes	No	None
	Half-Duplex, Register bit 16.8 = 0	Transmit or Receive	Yes	Yes	Transmit and Receive
	Half-Duplex, Register bit 16.8 = 1	Transmit or Receive	No	No	Transmit and Receive

1. Test Loopback is enabled when Register bit 0.14 = 1.
2. For descriptions of Test Loopback and Operational Loopback, see Section 5.6.7, “Loopback” on page 40.

5.6.5 Error Signals

When the LXT972M Transceiver is in 100 Mbps mode and receives an invalid symbol from the network, it asserts RX_ER and drives “0101” on the RXD pins.

The TX_ER function that forces ‘H’ symbols out on the TPOP/TPON twisted pair is not implemented in the LXT972M Transceiver.

5.6.6 Collision

The LXT972M Transceiver asserts its collision signal asynchronously to any clock whenever the line state is half-duplex and the transmitter and receiver are active at the same time. Table 14 summarizes the conditions for assertion of carrier sense, data loopback, and collision signals.

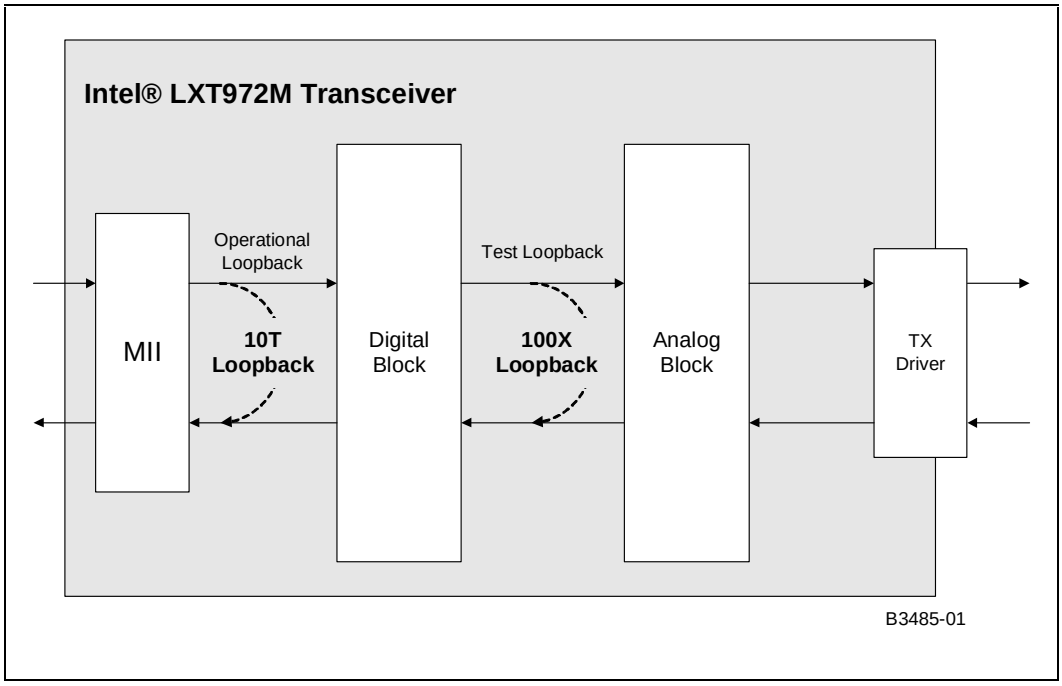
5.6.7 Loopback

The LXT972M Transceiver provides the following loopback functions:

- Section 5.6.7.1, “Operational Loopback”
- Section 5.6.7.2, “Internal Digital Loopback (Test Loopback)”

Figure 10 shows LXT972M Transceiver loopback paths.

Figure 10. Intel® LXT972M Transceiver Loopback Paths



5.6.7.1 Operational Loopback

- Operational loopback is provided for 10 Mbps half-duplex links when Register bit 16.8 = 0. Data that the MAC (TXData) transmits loops back on the receive side of the MII (RXData).
- Operational loopback is not provided for 100 Mbps links, full-duplex links, or when Register 16.8 = 1.

5.6.7.2 Internal Digital Loopback (Test Loopback)

A test loopback function is provided for diagnostic testing of the LXT972M Transceiver. During test loopback, twisted-pair and fiber interfaces are disabled. Data transmitted by the MAC is internally looped back by the LXT972M Transceiver and returned to the MAC.

Test loopback is available for both 100BASE-TX and 10BASE-T operation, and is enabled by setting the following register bits:

- Register bit 0.14 = 1 (Setting to enable loopback mode)
- Register bit 0.8 = 1 (Setting for full-duplex mode)
- Register bit 0.12 = 0. (Disable auto-negotiation.)

5.7 100 Mbps Operation

5.7.1 100BASE-X Network Operations

During 100BASE-X operation, the LXT972M Transceiver transmits and receives 5-bit symbols across the network link.

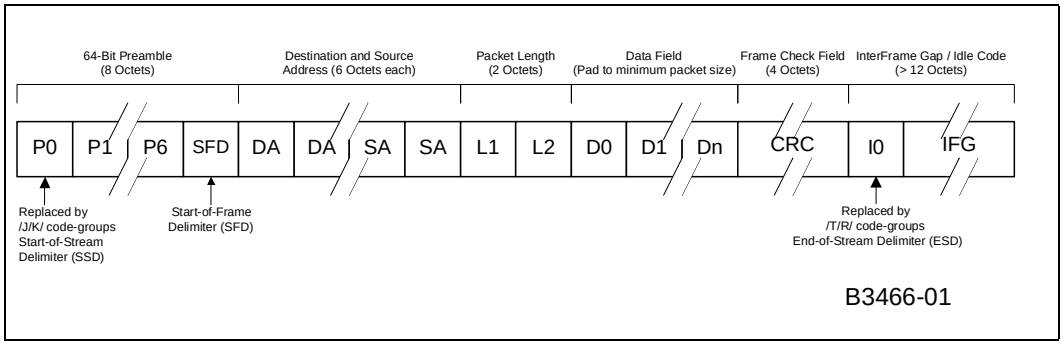
Figure 11 shows the structure of a standard frame packet in 100BASE-X mode. When the MAC is not actively transmitting data, the LXT972M Transceiver sends out Idle symbols on the line.

As Figure 11 shows, the MAC starts each transmission with a preamble pattern. As soon as the LXT972M Transceiver detects the start of preamble, it transmits a Start-of-Stream Delimiter (SSD, symbols J and K) to the network. It then encodes and transmits the rest of the packet, including the balance of the preamble, the SFD, packet data, and CRC.

Once the packet ends, the LXT972M Transceiver transmits the End-of-Stream Delimiter (ESD, symbols T and R) and then returns to transmitting Idle symbols.

For details on the symbols used, see 4B/5B coding listed in Table 15, “4B/5B Coding” on page 46.

Figure 11. 100BASE-X Frame Format



As shown in Figure 12, in 100BASE-TX mode, the LXT972M Transceiver scrambles and transmits the data to the network using MLT-3 line code. MLT-3 signals received from the network are de-scrambled, decoded, and sent across the MII to the MAC.

Figure 12. 100BASE-TX Data Path

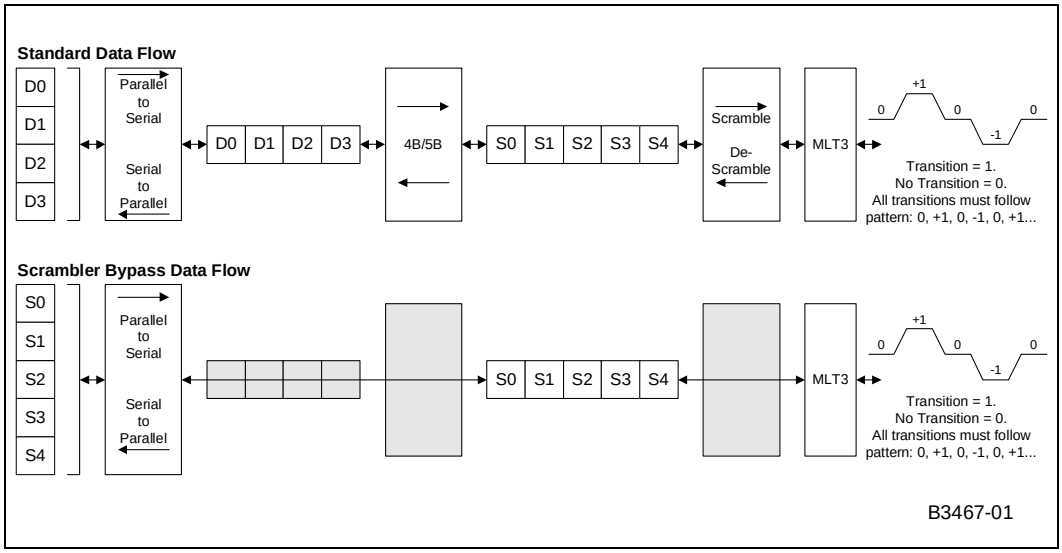
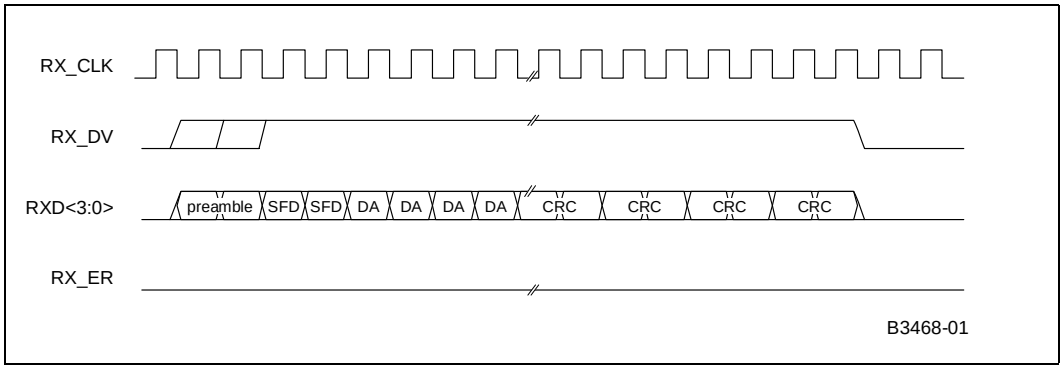


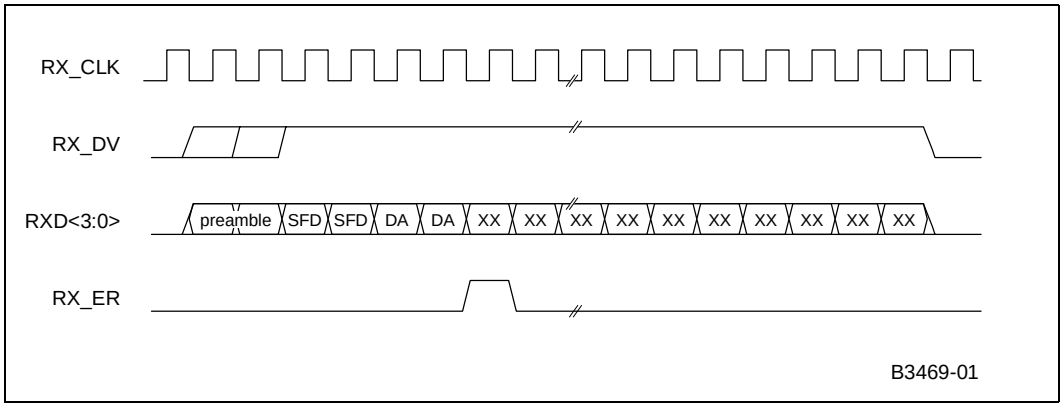
Figure 13 shows normal reception with no errors.

Figure 13. 100BASE-TX Reception with No Errors



As shown in Figure 14, when the LXT972M Transceiver receives invalid symbols from the line, it asserts RX_ER.

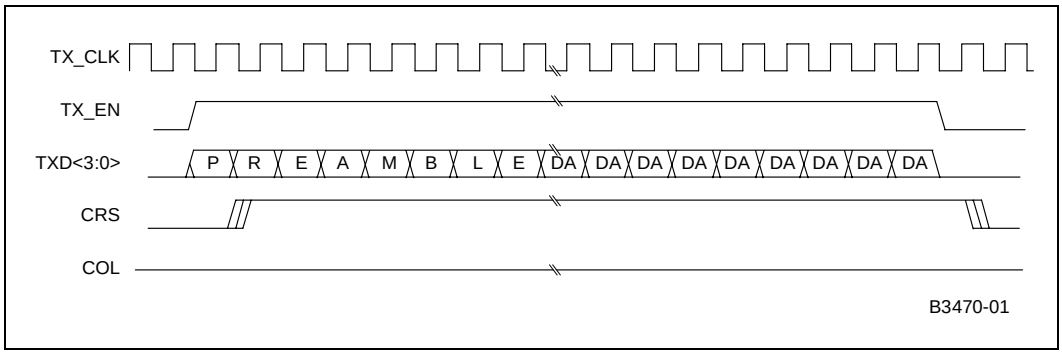
Figure 14. 100BASE-TX Reception with Invalid Symbol



5.7.2 Collision Indication

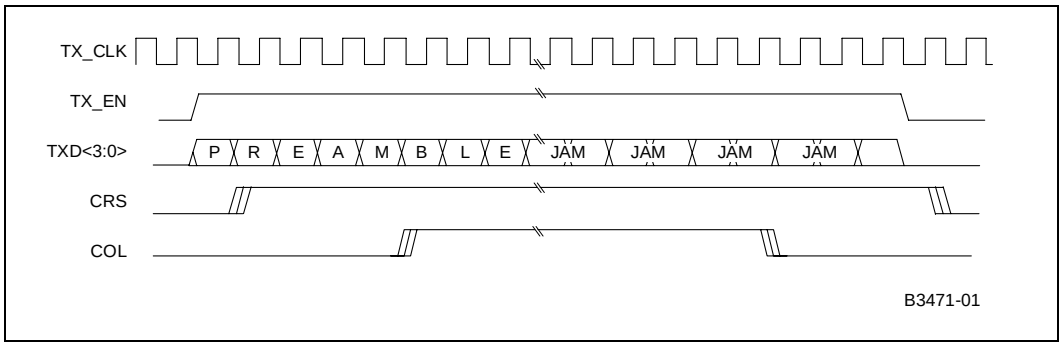
Figure 15 shows normal transmission.

Figure 15. 100BASE-TX Transmission with No Errors



Upon detection of a collision, the COL output is asserted and remains asserted for the duration of the collision as shown in Figure 16.

Figure 16. 100BASE-TX Transmission with Collision



5.7.3 100BASE-X Protocol Sublayer Operations

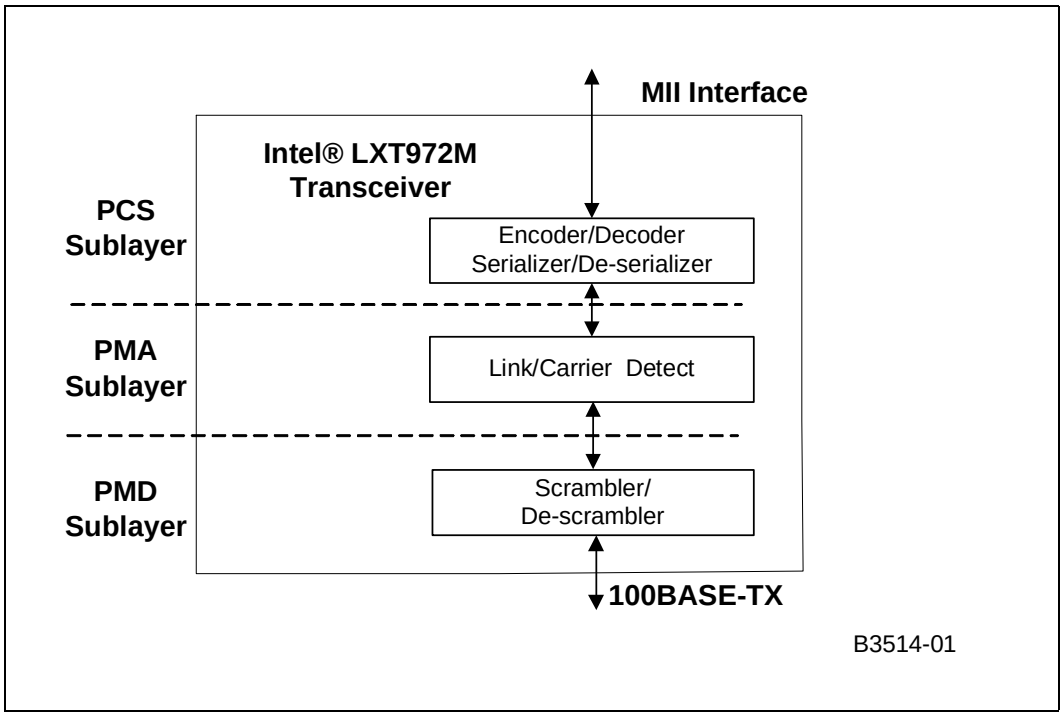
With respect to the 7-layer communications model, the LXT972M Transceiver is a Physical Layer 1 (PHY) device.

The LXT972M Transceiver implements the following sublayers of the reference model defined by the IEEE 802.3 standard, and discussed from the reference model point of view:

- Section 5.7.3.1, “Physical Coding Sublayer”
- Section 5.7.3.2, “Physical Medium Attachment Sublayer”
- Section 5.7.3.3, “Twisted-Pair Physical Medium Dependent Sublayer”

Figure 17 shows the LXT972M Transceiver protocol sublayers.

Figure 17. Intel® LXT972M Protocol Sublayers



5.7.3.1 Physical Coding Sublayer

The Physical Coding Sublayer (PCS) provides the MII interface, as well as the 4B/5B encoding/ decoding function.

For 100BASE-TX operation, the PCS layer provides IDLE symbols to the PMD-layer line driver as long as TX_EN is de-asserted.

5.7.3.1.1 Preamble Handling

When the MAC asserts TX_EN, the PCS substitutes a /J/K symbol pair, also known as the Start-of-Stream Delimiter (SSD), for the first two nibbles received across the MII. The PCS layer continues to encode the remaining MII data, following the 4B/5B coding in Table 15, until TX_EN is de-asserted. It then returns to supplying IDLE symbols to the line driver.

In the receive direction, the PCS layer performs the opposite function, substituting two preamble nibbles for the SSD. In 100 Mbps operation, preamble is always passed through the PCS layer to the MII interface.

Table 15. 4B/5B Coding (Sheet 1 of 2)

Code Type	4B Code 3 2 1 0	Name	5B Code 4 3 2 1 0	Interpretation
DATA	0 0 0 0	0	1 1 1 1 0	Data 0
	0 0 0 1	1	0 1 0 0 1	Data 1
	0 0 1 0	2	1 0 1 0 0	Data 2
	0 0 1 1	3	1 0 1 0 1	Data 3
	0 1 0 0	4	0 1 0 1 0	Data 4
	0 1 0 1	5	0 1 0 1 1	Data 5
	0 1 1 0	6	0 1 1 1 0	Data 6
	0 1 1 1	7	0 1 1 1 1	Data 7
	1 0 0 0	8	1 0 0 1 0	Data 8
	1 0 0 1	9	1 0 0 1 1	Data 9
	1 0 1 0	A	1 0 1 1 0	Data A
	1 0 1 1	B	1 0 1 1 1	Data B
	1 1 0 0	C	1 1 0 1 0	Data C
	1 1 0 1	D	1 1 0 1 1	Data D
	1 1 1 0	E	1 1 1 0 0	Data E
	1 1 1 1	F	1 1 1 0 1	Data F
IDLE	undefined	I [1]	1 1 1 11	Used as inter-stream fill code

1. The /I/ (Idle) code group is sent continuously between frames.
2. The /J/ and /K/ (SSD) code groups are always sent in pairs, and /K/ follows /J/.
3. The /T/ and /R/ (ESD) code groups are always sent in pairs, and /R/ follows /T/.
4. An /H/ (Error) code group is used to signal an error condition.

Table 15. 4B/5B Coding (Sheet 2 of 2)

Code Type	4B Code 3 2 1 0	Name	5B Code 4 3 2 1 0	Interpretation
CONTROL	0 1 0 1	J [2]	1 1 0 0 0	Start-of-Stream Delimiter (SSD), part 1 of 2
	0 1 0 1	K [2]	1 0 0 0 1	Start-of-Stream Delimiter (SSD), part 2 of 2
	Undefined	T [3]	0 1 1 0 1	End-of-Stream Delimiter (ESD), part 1 of 2
	Undefined	R [3]	0 0 1 1 1	End-of-Stream Delimiter (ESD), part 2 of 2
INVALID	Undefined	H [4]	0 0 1 0 0	Transmit Error. Used to force signaling errors
	Undefined	Invalid	0 0 0 0 0	Invalid
	Undefined	Invalid	0 0 0 0 1	Invalid
	Undefined	Invalid	0 0 0 1 0	Invalid
	Undefined	Invalid	0 0 0 1 1	Invalid
	Undefined	Invalid	0 0 1 0 1	Invalid
	Undefined	Invalid	0 0 1 1 0	Invalid
	Undefined	Invalid	0 1 0 0 0	Invalid
	Undefined	Invalid	0 1 1 0 0	Invalid
	Undefined	Invalid	1 0 0 0 0	Invalid
	Undefined	Invalid	1 1 0 0 1	Invalid

1. The /I/ (Idle) code group is sent continuously between frames.
2. The /J/ and /K/ (SSD) code groups are always sent in pairs, and /K/ follows /J/.
3. The /T/ and /R/ (ESD) code groups are always sent in pairs, and /R/ follows /T/.
4. An /H/ (Error) code group is used to signal an error condition.

5.7.3.2 Physical Medium Attachment Sublayer

5.7.3.2.1 Link

In 100 Mbps mode, link is established when the descrambler becomes locked and remains locked for approximately 50 ms. Link remains up unless the descrambler receives less than 16 consecutive idle symbols in any 2 ms period. This operation filters out small noise hits that may disrupt the link.

In 100 Mbps mode, link is established when the descrambler becomes locked and remains locked for approximately 50 ms. Link remains up unless the descrambler receives less than 16 consecutive idle symbols in any 2 ms period. This operation filters out small noise hits that may disrupt the link.

For short periods, MLT-3 idle waveforms meet all criteria for 10BASE-T start delimiters. A working 10BASE-T receive may temporarily indicate link to 100BASE-TX waveforms. However, the PHY does not bring up a permanent 10 Mbps link.

The LXT972M Transceiver reports link failure through the MII status bits (Register bits 1.2 and 17.10). Link failure causes the LXT972M Transceiver to re-negotiate if auto-negotiation is enabled.

5.7.3.2.2 Link Failure Override

The LXT972M Transceiver normally transmits data packets only if it detects the link is up. Setting Register bit 16.14 = 1 overrides this function, allowing the LXT972M Transceiver to transmit data packets even when the link is down. This feature is provided as a transmit diagnostic tool.

Note: Auto-negotiation must be disabled to transmit data packets in the absence of link. If auto-negotiation is enabled, the LXT972M Transceiver automatically transmits FLP bursts if the link is down.

Caution: During normal operation, Intel does not recommend setting Register bit 16.14 for 100 Mbps receive functions because receive errors may be generated.

5.7.3.2.3 Carrier Sense

For 100BASE-TX links, a start-of-stream delimiter (SSD) or /J/K symbol pair causes assertion of carrier sense (CRS). An end-of-stream delimiter (ESD) or /T/R symbol pair causes de-assertion of CRS. The PMA layer also de-asserts CRS if IDLE symbols are received without /T/R. However, in this case RX_ER is asserted for one clock cycle when CRS is de-asserted.

Intel does not recommend using CRS for Interframe Gap (IFG) timing for the following reasons:

- CRS de-assertion time is slightly longer than CRS assertion time. As a result, an IFG interval appears somewhat shorter to the MAC than it actually is on the wire.
- CRS de-assertion is not aligned with TX_EN de-assertion on transmit loopbacks in half-duplex mode.

5.7.3.2.4 Receive Data Valid

The LXT972M Transceiver asserts RX_DV to indicate that the received data maps to valid symbols. In 100 Mbps operation, RX_DV is active with the first nibble of preamble.

5.7.3.3 Twisted-Pair Physical Medium Dependent Sublayer

The twisted-pair Physical Medium Dependent (PMD) layer provides signal scrambling and de-scrambling functions, line coding and decoding functions (MLT-3 for 100BASE-TX, Manchester for 10BASE-T), as well as receiving, polarity correction, and baseline wander correction functions.

5.7.3.3.1 Scrambler/Descrambler

The purpose of the scrambler/descrambler is to spread the signal power spectrum and further reduce EMI using an 11-bit, data-independent polynomial. The receiver automatically decodes the polynomial whenever IDLE symbols are received.

Scrambler Seeding. Once the transmit data (or Idle symbols) are properly encoded, they are scrambled to further reduce EMI and to spread the power spectrum using an 11-bit scrambler seed. Five seed bits are determined by the PHY address, and the remaining bits are hard coded in the design.

Scrambler Bypass. The scrambler/de-scrambler can be bypassed by setting Register bit 16.12 = 1. Scrambler bypass is provided for diagnostic and test support.

5.7.3.3.2 Polarity Correction

The 100 Mbps twisted pair signaling is not polarity sensitive. As a result, the polarity status is not a valid status indicator.

5.7.3.3.3 Baseline Wander Correction

The LXT972M Transceiver provides a baseline wander correction function for when the LXT972M Transceiver is under network operating conditions. The MLT3 coding scheme used in 100BASE-TX is by definition “unbalanced”. As a result, the average value of the signal voltage can “wander” significantly over short time intervals (tenths of seconds). This wander can cause receiver errors at long-line lengths (100 meters) in less robust designs. Exact characteristics of the wander are completely data dependent.

The LXT972M Transceiver baseline wander correction characteristics allow the device to recover error-free data while receiving worst-case packets over all cable lengths.

5.7.3.3.4 Programmable Slew Rate Control

The LXT972M Transceiver device supports a programmable slew-rate mechanism whereby one of four pre-selected slew rates can be used. (For details, see Table 56, “Transmit Control Register - Address 30, Hex 1E” on page 89.) The slew-rate mechanism allows the designer to optimize the output waveform to match the characteristics of the magnetics.

5.8 10 Mbps Operation

The LXT972M Transceiver operates as a standard 10BASE-T transceiver and supports standard 10 Mbps functions. During 10BASE-T operation, the LXT972M Transceiver transmits and receives Manchester-encoded data across the network link. When the MAC is not actively transmitting data, the LXT972M Transceiver drives link pulses onto the line.

In 10BASE-T mode, the polynomial scrambler/de-scrambler is inactive. Manchester-encoded signals received from the network are decoded by the LXT972M Transceiver and sent across the MII to the MAC.

Note:

5.8.1 10BASE-T Preamble Handling

The LXT972M Transceiver offers two options for preamble handling, selected by Register bit 16.5.

- In 10BASE-T mode when Register bit 16.5 = 0, the LXT972M Transceiver strips the entire preamble off of received packets. CRS is asserted coincident with the start of the preamble. RX_DV is held Low for the duration of the preamble. When RX_DV is asserted, the very first two nibbles driven by the LXT972M Transceiver are the SFD “5D” hex followed by the body of the packet.
- In 10BASE-T mode when Register bit 16.5 = 1, the LXT972M Transceiver passes the preamble through the MII and asserts RX_DV and CRS simultaneously. (In 10BASE-T loopback, the LXT972M Transceiver loops back whatever the MAC transmits to it, including the preamble.)

5.8.2 10BASE-T Carrier Sense

For 10BASE-T links, CRS assertion is based on reception of valid preamble, and CRS de-assertion is based on reception of an end-of-frame (EOF) marker. Register bit 16.7 allows CRS de-assertion to be synchronized with RX_DV de-assertion. For details, see Table 51, “Configuration Register - Address 16, Hex 10” on page 84.

5.8.3 10BASE-T Dribble Bits

The LXT972M Transceiver handles dribble bits in all modes. If one to four dribble bits are received, the nibble is passed across the MII, padded with ones if necessary. If five to seven dribble bits are received, the second nibble is not sent to the MII bus.

5.8.4 10BASE-T Link Integrity Test

In 10BASE-T mode, the LXT972M Transceiver always transmits link pulses.

- If the Link Integrity Test function is enabled (the normal configuration), the LXT972M Transceiver monitors the connection for link pulses. Once link pulses are detected, data transmission is enabled and remains enabled as long as either the link pulses or data transmission continue. If the link pulses stop, the data transmission is disabled.
- If the Link Integrity Test function is disabled (which can be done by setting Configuration Register bit 16.14 to ‘1’), the LXT972M Transceiver transmits to the connection regardless of detected link pulses.

5.8.5 Link Failure

Link failure occurs if the Link Integrity Test is enabled and link pulses or packets stop being received. If this condition occurs, the LXT972M Transceiver returns to the auto-negotiation phase if auto-negotiation is enabled. If the Link Integrity Test function is disabled by setting Configuration Register bit 16.14 to ‘1’, the LXT972M Transceiver transmits packets, regardless of link status.

5.8.6 10BASE-T SQE (Heartbeat)

By default, the Signal Quality Error (SQE) or heartbeat function is disabled on the LXT972M Transceiver. To enable this function, set Register bit 16.9 = 1. When this function is enabled, the LXT972M Transceiver asserts its COL output for 5 to 15 bit times (BT) after each packet.

5.8.7 10BASE-T Jabber

If a transmission exceeds the jabber timer, the LXT972M Transceiver disables the transmit and loopback functions. For jabber timing parameters, see Figure 26, “Intel® LXT972M Transceiver 10BASE-T Jabber and Unjabber Timing” on page 69.

The LXT972M Transceiver automatically exits jabber mode after the unjabber time has expired. This function can be disabled by setting Register bit 16.10 = 1.

5.8.8 10BASE-T Polarity Correction

The LXT972M Transceiver automatically detects and corrects for the condition in which the receive signal (TPIP/N) is inverted. Reversed polarity is detected if eight inverted link pulses - or four inverted end-of-frame (EOF) markers - are received consecutively. If link pulses or data are not received by the maximum receive time-out period (96 to 128 ms), the polarity state is reset to a non-inverted state. When polarity reversal is detected in 10BASE-T operation, register 17.5 is set to 1. (For details, see bit 17.5 in Table 52, “Status Register #2 - Address 17, Hex 11” on page 85.)

5.9 Monitoring Operations

5.9.1 Monitoring Auto-Negotiation

Auto-negotiation can be monitored as follows:

- Register bit 17.7 is set to ‘1’ once the auto-negotiation process is completed.
- Register bits 1.2 and 17.10 are set to ‘1’ once the link is established.
- Register bits 17.14 and 17.9 can be used to determine the link operating conditions (speed and duplex).

Note: When the LXT972M Transceiver detects incorrect polarity for a 10BASE-T operation, Register bit 17.5 is set to ‘1’.

5.9.2 Monitoring Next Page Exchange

The LXT972M Transceiver offers an Alternate Next Page mode to simplify the next page exchange process. Normally, Register bit 6.1 (Page Received) remains set until read. When Alternate Next Page mode is enabled, Register bit 6.1 is automatically cleared whenever a new negotiation process takes place. This action prevents the user from reading an old value in bit 6.1 and assuming that Registers 5 and 8 (Partner Ability) contain valid information. Additionally, the LXT972M Transceiver uses Register bit 6.5 to indicate when the current received page is the base page. This information is useful for recognizing when next pages must be resent due to a new negotiation process starting. Register bits 6.1 and 6.5 are cleared when read.

5.9.3 LED Functions

The LXT972M Transceiver has these direct LED driver pins: LED/CFG1, LED/CFG2, and LED/CFG3.

On power-up, all the drivers are asserted for approximately 1 second after reset de-asserts. Each LED driver can be programmed using the LED Configuration Register (Table 54, “LED Configuration Register - Address 20, Hex 14” on page 87) to indicate one of the following conditions:

- Collision Condition
- Duplex Mode
- Link Status
- Operating Speed
- Receive Activity
- Transmit Activity

The LED drivers can also be programmed to display various combined status conditions. For example, setting Register bits 20.15:12 to ‘1101’ produces the following combination of Link and Activity indications:

- If Link is down, LED is off. If activity is detected from the MAC, the LED still blinks even if the link is down.
- If Link is up, LED is on.
- If Link is up and activity is detected, the LED blinks at the stretch interval selected by Register bits 20.3:2 and continues to blink as long as activity is present.

For the LXT972M Transceiver, the LED driver pins also provide initial configuration settings. The LED pins are sensitive to polarity and automatically pull up or pull down to configure for either open drain or open collector circuits (10 mA Max current rating) as required by the hardware configuration. For details, see the discussion of “Hardware Configuration Settings” on page 33.

5.9.4 LED Pulse Stretching

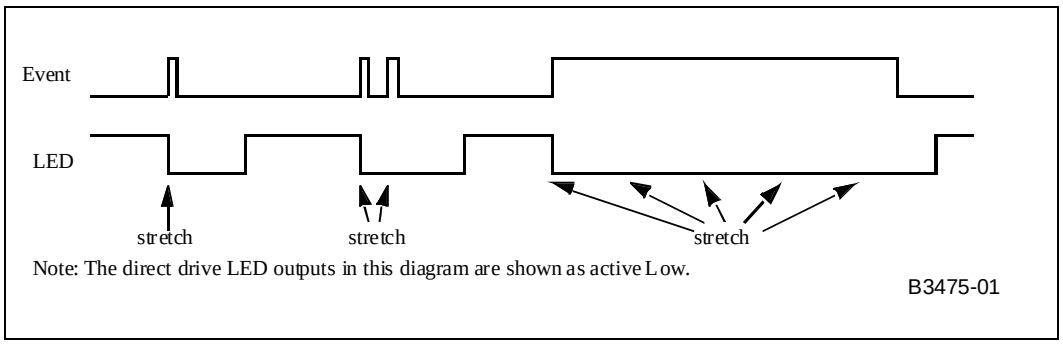
The LED Configuration Register also provides optional LED pulse stretching to 30, 60, or 100 ms. The pulse stretch time is extended further if the event occurs again during this pulse stretch period.

When an event such as receiving a packet occurs, the event is edge detected and it starts the stretch timer. The LED driver remains asserted until the stretch timer expires. If another event occurs before the stretch timer expires, then the stretch timer is reset and the stretch time is extended.

When a long event (such as duplex status) occurs, the event is edge detected and it starts the stretch timer. When the stretch timer expires, the edge detector is reset so that a long event causes another pulse to be generated from the edge detector, which resets the stretch timer and causes the LED driver to remain asserted.

Figure 18 shows how the stretch operation functions.

Figure 18. LED Pulse Stretching



5.10 Boundary Scan (JTAG 1149.1) Functions

The LXT972M Transceiver includes a IEEE 1149.1 boundary scan test port for board level testing. All digital input, output, and input/output pins are accessible.

Note: For the related BSDL file, contact your local sales office or access the Intel website (www.intel.com).

5.10.1 Boundary Scan Interface

The boundary scan interface consists of five pins (TMS, TDI, TDO, TRST_L, and TCK). It includes a state machine, data register array, and instruction register. The TMS and TDI pins are pulled up internally. TCK is pulled down internally. TDO does not have an internal pull-up or pull-down.

5.10.2 State Machine

The TAP controller is a state machine, with 16 states driven by the TCK and TMS pins. Upon reset, the TEST_LOGIC_RESET state is entered. The state machine is also reset when TMS and TDI are high for five TCK periods.

5.10.3 Instruction Register

After the state machine resets, the IDCODE instruction is always invoked. The decode logic ensures the correct data flow to the Data registers according to the current instruction.

Table 16 lists valid JTAG instructions for the LXT972M Transceiver.

Table 16. Valid JTAG Instructions

Name	Code	Description	Mode	Data Register
EXTEST	1111 1111 1110 1000	External Test	Test	BSR
IDCODE	1111 1111 1111 1110	ID Code Inspection	Normal	ID REG
SAMPLE	1111 1111 1111 1000	Sample Boundary	Normal	BSR
HIGHZ	1111 1111 1100 1111	Force Float	Normal	Bypass
CLAMP	1111 1111 1110 1111	Control Boundary to 1/0	Test	Bypass
BYPASS	1111 1111 1111 1111	Bypass Scan	Normal	Bypass

5.10.4 Boundary Scan Register

Each Boundary Scan Register (BSR) cell has two stages. A flip-flop and a latch are used for the serial shift stage and the parallel output stage. Table 17 lists the four BSR modes of operation.

Table 17. BSR Mode of Operation

Mode	Description
1	Capture
2	Shift
3	Update
4	System Function

5.10.5 Device ID Register

Table 18 lists the bits for the Device ID register. For the current version of the JEDEC continuation characters, see the specification update for the LXT972M Transceiver.

Table 18. Device ID Register for Intel® LXT972M Transceiver

Bits 31:28	Bits 27:12	Bits 11:8	Bits 7:1	Bit 0
Version	Part ID (Hex)	JEDEC Continuation Characters	JEDEC ID[1]	Reserved
XXXX	03CB	0000	111 1110	1

1. The JEDEC ID is an 8-bit identifier. The MSB is for parity and is ignored. The Intel JEDEC ID is FE (1111 1110), which becomes 111 1110.

6.0 Application Information

6.1 Magnetics Information

The LXT972M Transceiver requires a 1:1 ratio for both the receive and transmit transformers. The transformer isolation voltage should be rated at 2 kV to protect the circuitry from static voltages across the connectors and cables. For transformer/magnetics requirements, see Table 19.

Note: Before committing to a specific component, contact the manufacturer for current product specifications and validate the magnetics for the specific application.

Table 19. Magnetics Requirements

Parameter	Min	Nom	Max	Units	Test Condition
Rx turns ratio	–	1 : 1	–	–	–
Tx turns ratio	–	1 : 1	–	–	–
Insertion loss	0.0	0.6	1.1	dB	–
Primary inductance	350	–	–	µH	–
Transformer isolation	–	1.5	–	kV	–
Differential to common mode rejection	40	–	–	dB	0.1 to 60 MHz
	35	–	–	dB	60 to 100 MHz
Return Loss	-16	–	–	dB	30 MHz
	-10	–	–	dB	80 MHz

6.2 Typical Twisted-Pair Interface

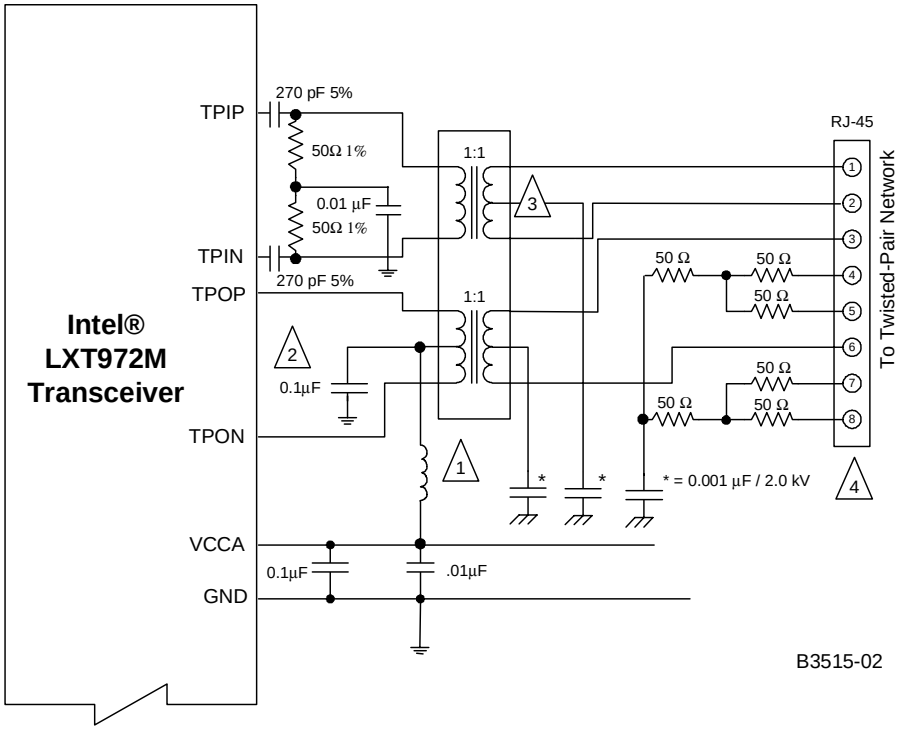
Table 20 provides a comparison of the RJ-45 connections for NIC and Switch applications in a typical twisted-pair interface setting.

Table 20. I/O Pin Comparison of NIC and Switch RJ-45 Setups

Symbol	RJ-45	
	Switch	NIC
TPIP	1	3
TPIN	2	6
TPOP	3	1
TPON	6	2

Figure 19 shows the LXT972M Transceiver in a typical twisted-pair interface, with the RJ-45 connections crossed over for a Switch configuration.

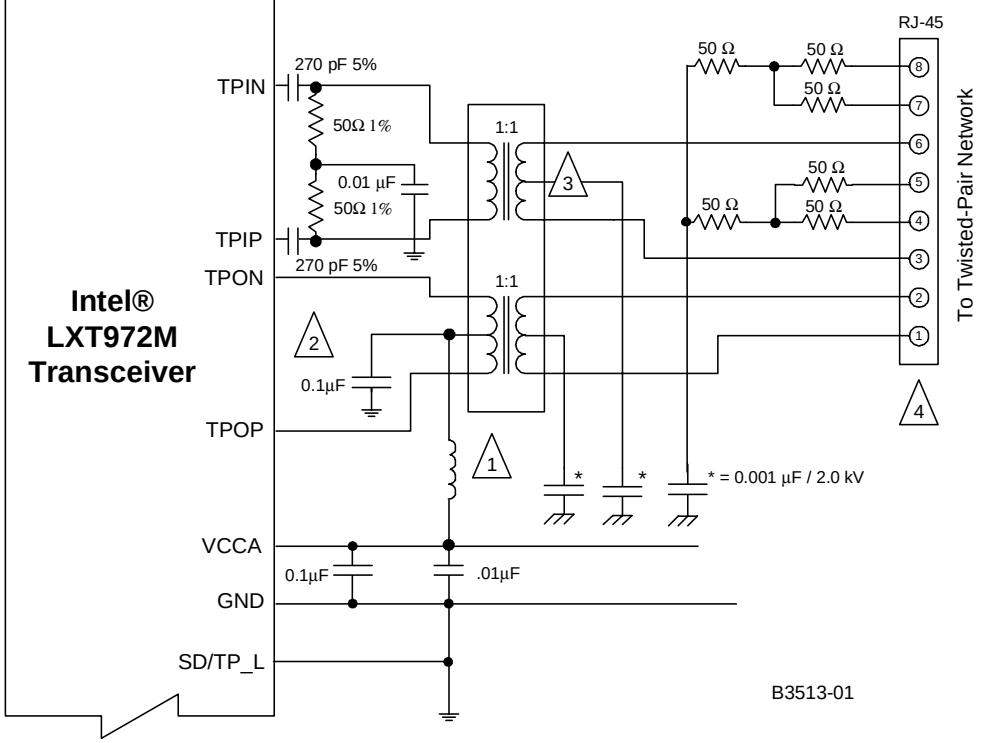
Figure 19. Intel® LXT972M Transceiver Typical Twisted-Pair Interface - Switch



1. Center tap current may be supplied from 3.3 V VCCA as shown. Additional power savings may be realized by supplying the center tap from a 2.5 V current source. A separate ferrite bead (rated at 50 mA) should be used to supply center tap current.
2. The 100 Ω transmit load termination resistor typically required is integrated in the LXT972M Transceiver.
3. Magnetics without a receive pair center-tap do not require a 2 kV termination.
4. RJ-45 connections shown are for a standard switch application. For a standard NIC RJ-45 setup, see Figure 20 on page 59.

Figure 20 shows the LXT972M Transceiver in a typical twisted-pair interface, with the RJ-45 connections configured for a NIC application.

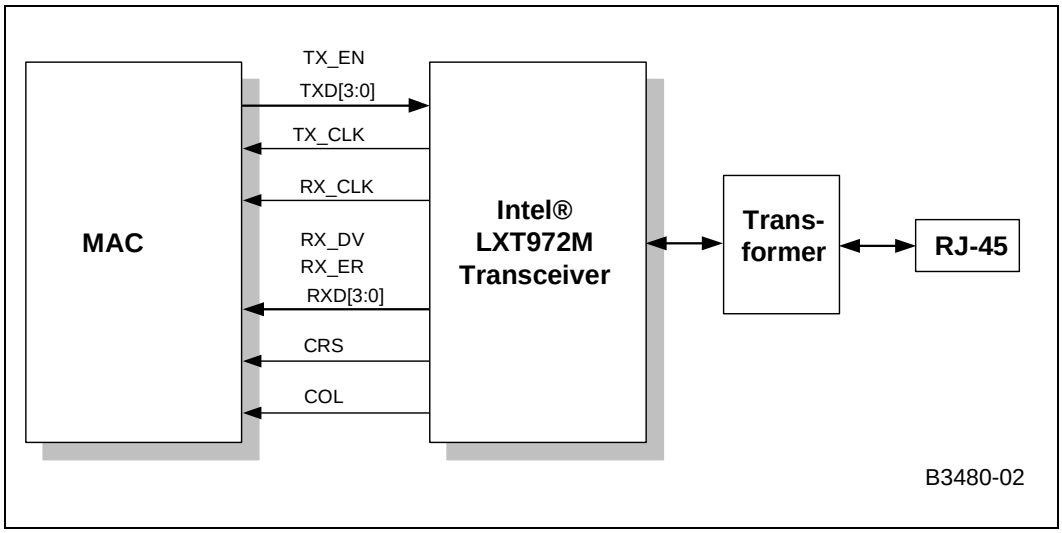
Figure 20. Intel® LXT972M Transceiver Typical Twisted-Pair Interface - NIC



1. Center tap current may be supplied from 3.3 V VCCA as shown. Additional power savings may be realized by supplying the center tap from a 2.5 V current source. A separate ferrite bead (rated at 50 mA) should be used to supply center-tap current.
2. The 100 Ω transmit load termination resistor typically required is integrated in the LXT972M Transceiver.
3. Magnetics without a receive pair center tap do not require a 2 kV termination.
4. RJ-45 connections shown for standard NIC. TX/RX crossover may be required for repeater and switch applications.

Figure 21 shows a typical media independent interface (MII) for the LXT972M Transceiver.

Figure 21. Intel® LXT972M Transceiver Typical Media Independent Interface



7.0 Electrical Specifications

This chapter includes test specifications for the LXT972M Transceiver. These specifications are guaranteed by test except where noted “by design”.

- Table 21 lists the absolute maximum ratings.
- Table 22 lists the recommended operating conditions.
- Table 23 through Table 39 list the minimum and maximum values that apply over the recommended operating conditions specified.

7.1 Electrical Parameters

Table 21 lists absolute maximum ratings for the LXT972M Transceiver.

Caution:

- Exceeding the absolute maximum rating values may cause permanent damage.
- Functional operation under these conditions is not implied.
- Exposure to maximum rating conditions for extended periods may affect device reliability.

Table 21. Absolute Maximum Ratings for Intel® LXT972M Transceiver

Parameter	Sym	Min	Max	Units
Supply Voltage	VCC	-0.3	4.0	V
Storage Temperature	TST	-65	+150	ºC

Table 22 lists the recommended operating conditions for the LXT972M Transceiver.

Table 22. Recommended Operating Conditions for Intel® LXT972M Transceiver

Parameter	Sym	Min	Typ[1]	Max	Units
Recommended operating temperature	TOPA	0	–	70	ºC
Recommended supply voltage[2] - Analog and digital	Vcca, Vccd	3.14	3.3	3.45	V
Recommended supply voltage[2] - I/O	Vccio	2.35	–	3.45	V
VCC current - 100 BASE-TX	ICC	–	92	110	mA
VCC current - 10 BASE-T	ICC	–	66	82	mA
Hard Power Down	ICC	–	–	1	mA
Soft Power Down	Icc	–	51	–	mA
Auto-Negotiation	ICC	–	90	110	mA

1. Typical values are at 25 °C and are for design aid only, not guaranteed, and not subject to production testing.
2. Voltages are with respect to ground unless otherwise specified.

Table 23 lists digital I/O characteristics for all pins except the MII, XI/XO, and LED/CFG pins.

Table 23. Digital I/O Characteristics (Except for MII, XI/XO, and LED/CFG Pins)

Parameter	Sym	Min	Typ[2]	Max	Units	Test Conditions
Input Low voltage	V_{IL}	–	–	0.8	V	–
Input High voltage	V_{IH}	2.0	–	–	V	–
Input current	I_I	-10	–	10	µA	$0.0 < V_I < V_{CC}$
Output Low voltage	V_{OL}	–	–	0.4	V	I_{OL} = 4 mA
Output High voltage	V_{OH}	2.4	–	–	V	I_{OH} = -4 mA

1. Typical values are at 25 °C and are for design aid only, not guaranteed, and not subject to production testing.

Table 24 lists digital I/O characteristics for the MII pins.

Table 24. Digital I/O Characteristics[1] - MII Pins

Parameter	Sym	Min	Typ[2]	Max	Units	Test Conditions
Input Low voltage	V_{IL}	–	–	0.8	V	–
Input High voltage	V_{IH}	2.0	–	–	V	–
Input current	I_I	-10	–	10	µA	$0.0 < V_I <$ VCCIO
Output Low voltage	V_{OL}	–	–	0.4	V	I_{OL} = 4 mA
Output High voltage	V_{OH}	2.2	–	–	V	I_{OH} = -4 mA, VCCIO = 3.3 V
	V_{OH}	2.0	–	–	V	I_{OH} = -4 mA, VCCIO = 2.5 V
Driver output resistance (Line driver output enabled)	R_O[3]	–	100	–	Ω	VCCIO = 2.5 V
	R_O[3]	–	100	–	Ω	VCCIO = 3.3 V

1. MII digital I/O pins are tolerant to 5 V inputs.
2. Typical values are at 25 °C and are for design aid only, not guaranteed, and not subject to production testing.
3. Parameter is guaranteed by design and not subject to production testing.

Table 25 lists the I/O characteristics for the REFCLK/XI and XO pins.

Table 25. I/O Characteristics - REFCLK/XI and XO Pins

Parameter	Symbol	Min	Typ[1]	Max	Units	Test Conditions
Input Low Voltage	V_{IL}	–	–	0.8	V	–
Input High Voltage	V_{IH}	2.0	–	–	V	–
Input Clock Frequency Tolerance[2]	Δf	–	–	±100	ppm	–
Input Clock Duty Cycle[2]	Tdc	35	–	65	%	–
Input Capacitance	C_{IN}	–	3.0	–	pF	–

1. Typical values are at 25 °C and are for design aid only, not guaranteed, and not subject to production testing.
2. Parameter is guaranteed by design and not subject to production testing.

Table 26 lists the I/O characteristics for the LXT972M Transceiver LED/CFG pins.

Table 26. I/O Characteristics - LED/CFG Pins

Parameter	Symbol	Min	Typ	Max	Units	Test Conditions
Input Low Voltage	V_{IL}	–	–	0.8	V	–
Input High Voltage	V_{IH}	2.0	–	–	V	–
Input Current	I_I	-10	–	10	µA	$0 < V_I < VCCIO$
Output Low Voltage	V_{OL}	–	–	0.4	V	I_{OL} = 10 mA
Output High Voltage	V_{OH}	2.0	–	–	V	I_{OH} = -10 mA

Table 27 lists the 100BASE-TX characteristics.

Table 27. 100BASE-TX Transceiver Characteristics

Parameter	Symbol	Min	Typ[1]	Max	Units	Test Conditions
Peak differential output voltage	VP	0.95	–	1.05	V	Note 2
Signal amplitude symmetry	Vss	98	–	102	%	Note 2
Signal rise/fall time	TRF	3.0	–	5.0	ns	Note 2
Rise/fall time symmetry	TRFS	–	–	0.5	ns	Note 2
Duty cycle distortion	DCD	35	50	65	%	Offset from 16 ns pulse width at 50% of pulse peak
Overshoot/Undershoot	VOS	–	–	5	%	–
Jitter (measured differentially)	–	–	–	1.4	ns	–

1. Typical values are at 25 °C and are for design aid only, not guaranteed, and not subject to production testing.
2. Measured at the line side of the transformer, line replaced by 100 Ω(+/-1%) resistor.

Table 28 lists the 10BASE-T characteristics.

Table 28. 10BASE-T Transceiver Characteristics

Parameter	Symbol	Min	Typ	Max	Units	Test Conditions
Transmitter						
Peak differential output voltage	VOP	2.2	2.5	2.8	V	With transformer, line replaced by 100 Ω resistor
Transition timing jitter added by the MAU and PLS sections	–	0	2	11	ns	After line model specified by IEEE 802.3 for 10BASE-T MAU
Receiver						
Receive Input Impedance	ZIN	–	–	22	kΩ	–
Differential Squelch Threshold	VDS	300	420	585	mV	–

Table 29 lists the 10BASE-T link integrity timing characteristics.

Table 29. 10BASE-T Link Integrity Timing Characteristics

Parameter	Symbol	Min	Typ	Max	Units	Test Conditions
Time Link Loss Receive	TLL	50	–	150	ms	–
Link Pulse	TLP	2	–	7	Link Pulses	–
Link Min Receive Timer	TLR MIN	2	–	7	ms	–
Link Max Receive Timer	TLR MAX	50	–	150	ms	–
Link Transmit Period	Tlt	8	–	24	ms	–
Link Pulse Width	Tlpw	60	–	150	ns	–

1. Typical values are at 25 °C and are for design aid only, not guaranteed, and not subject to production testing.

7.2 Timing Diagrams

Figure 22. Intel® LXT972M Transceiver 100BASE-TX Receive Timing

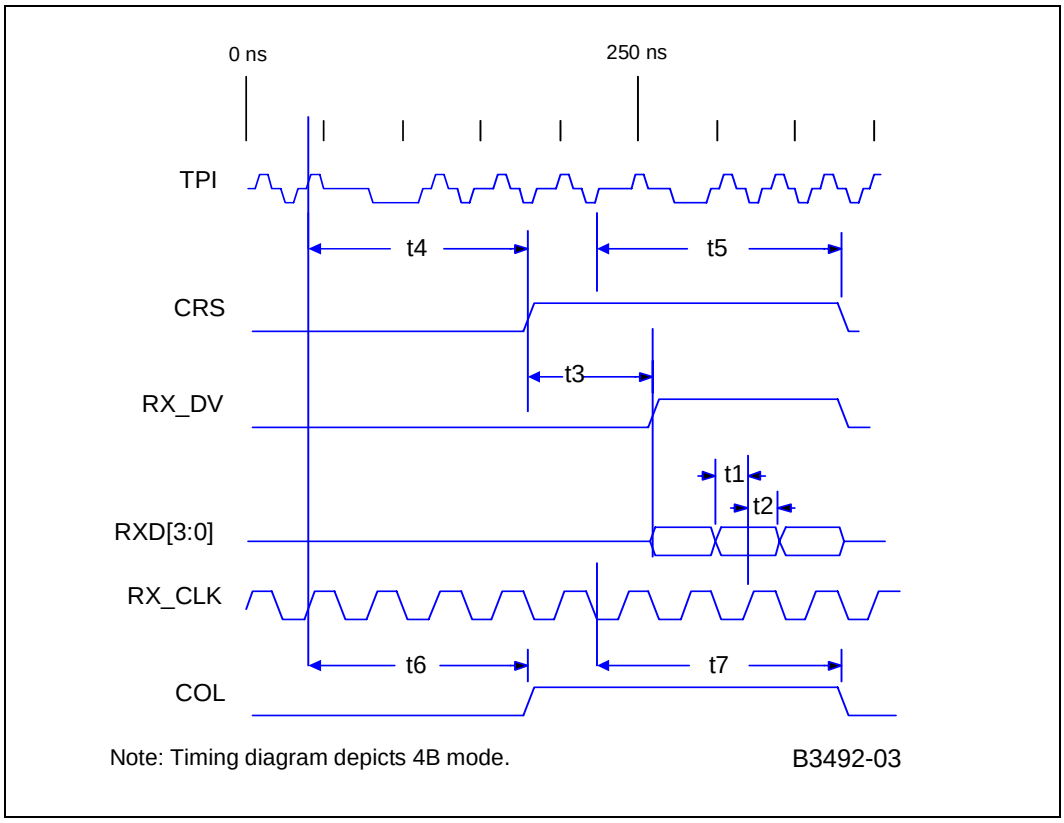


Table 30. Intel® LXT972M Transceiver 100BASE-TX Receive Timing Parameters

Parameter	Sym	Min	Typ[1]	Max	Units[2]	Test Conditions
RXD[3:0], RX_DV, RX_ER[3] setup to RX_CLK High	t1	10	–	–	ns	–
RXD[3:0], RX_DV, RX_ER hold from RX_CLK High	t2	10	–	–	ns	–
CRS asserted to RXD[3:0], RX_DV	t3	3	–	5	BT	–
Receive start of “J” to CRS asserted	t4	12	–	16	BT	–
Receive start of “T” to CRS de-asserted	t5	10	–	17	BT	–
Receive start of “J” to COL asserted	t6	16	–	22	BT	–
Receive start of “T” to COL de-asserted	t7	17	–	20	BT	–

1. Typical values are at 25 °C and are for design aid only, not guaranteed, and not subject to production testing.
2. BT (Bit Time) is the duration of one bit as transferred to and from the MAC and is the reciprocal of the bit rate. 100BASE-T bit time = 10^{-8} s or 10 ns.
3. RX_ER is not shown in the figure.

Figure 23. Intel® LXT972M Transceiver 100BASE-TX Transmit Timing

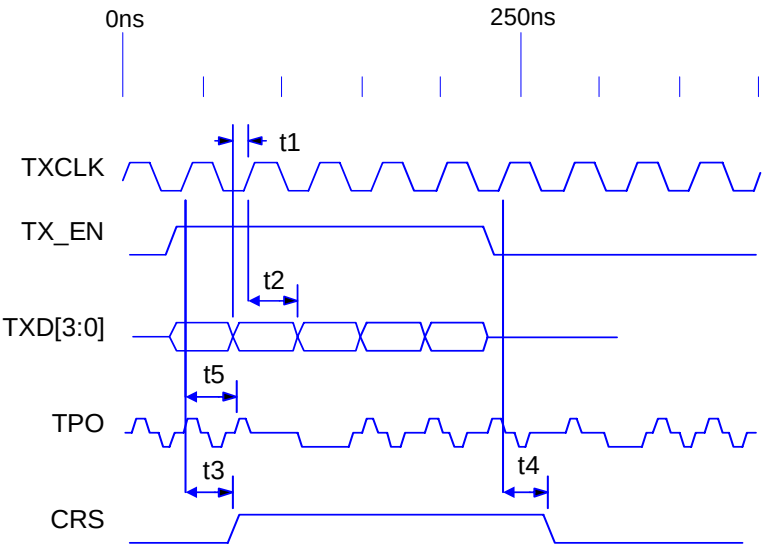


Figure 23 does not show the TX_ER signal.

Table 31. Intel® LXT972M Transceiver 100BASE-TX Transmit Timing Parameters

Parameter	Symbol	Min	Typ[1]	Max	Units[2]	Test Conditions
TXD[3:0], TX_EN setup to TX_CLK High	t1	12	–	–	ns	–
TXD[3:0], TX_EN hold from TX_CLK High	t2	0	–	–	ns	–
TX_EN sampled to CRS asserted	t3	20	–	24	BT	–
TX_EN sampled to CRS de-asserted	t4	24	–	28	BT	–
TX_EN sampled to TPO out (Tx latency)	t5	5.3	–	5.7	BT	–

1. Typical values are at 25 °C and are for design aid only, not guaranteed, and not subject to production testing.
2. BT (Bit Time) is the duration of one bit as transferred to and from the MAC and is the reciprocal of the bit rate. 100BASE-T bit time = 10^{-8} s or 10 ns.

Figure 24. Intel® LXT972M Transceiver 10BASE-T Receive Timing

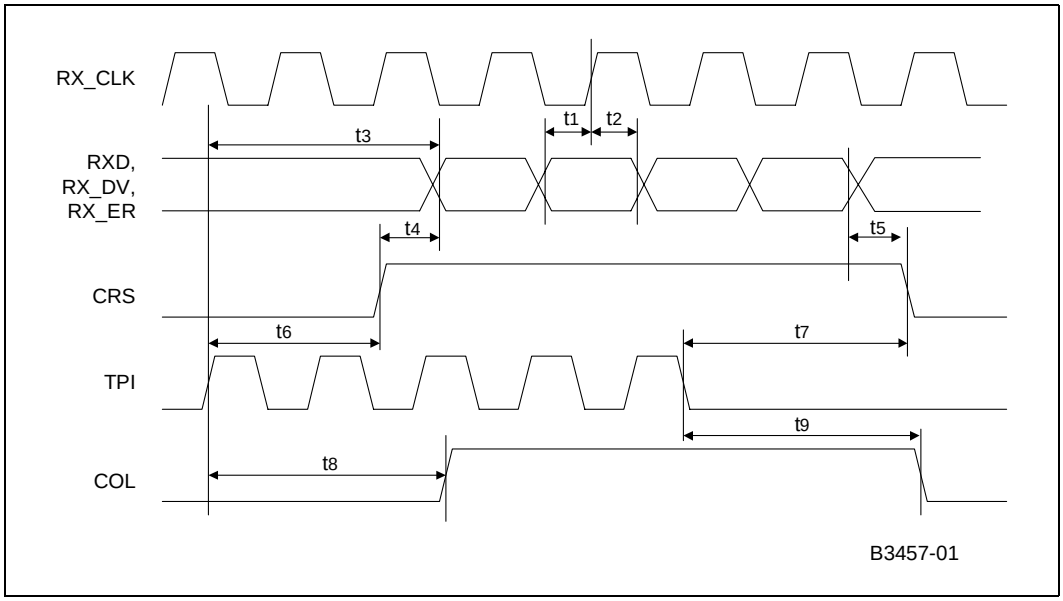


Table 32. Intel® LXT972M Transceiver 10BASE-T Receive Timing

Parameter	Sym	Min	Typ[1]	Max	Units[2]	Test Conditions
RXD, RX_DV. Setup to RX_CLK High.	t1	10	–	–	ns	–
RXD, RX_DV, RX_ER Hold from RX_CLK High	t2	10	–	–	ns	–
TPIP/N in to RXD out (Rx latency)	t3	4.2	–	6.6	BT	–
CRS asserted to RXD, RX_DV, RX_ER asserted	t4	5	–	32	BT	–
RXD, RX_DV, RX_ER de-asserted to CRS de-asserted	t5	0.3	–	0.5	BT	–
TPI in to CRS asserted	t6	2	–	28	BT	–
TPI quiet to CRS de-asserted	t7	6	–	10	BT	–
TPI in to COL asserted	t8	1	–	31	BT	–
TPI quiet to COL de-asserted	t9	5	–	10	BT	–

1. Typical values are at 25 °C and are for design aid only, not guaranteed, and not subject to production testing.
2. BT (Bit Time) is the duration of one bit as transferred to and from the MAC and is the reciprocal of the bit rate. 10BASE-T bit time = 10^{-7} s or 100 ns.

Figure 25. Intel® LXT972M Transceiver 10BASE-T Transmit Timing

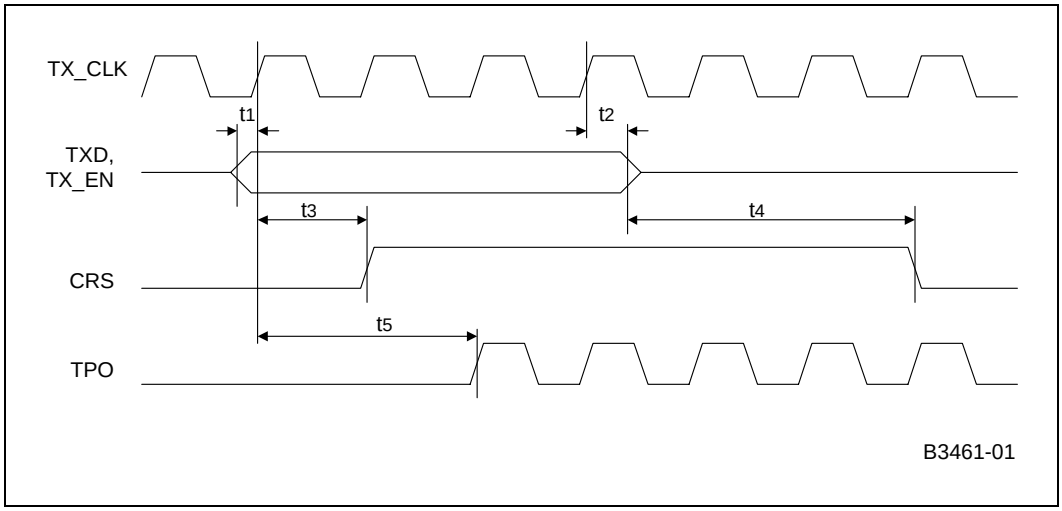


Table 33. Intel® LXT972M Transceiver 10BASE-T Transmit Timing

Parameter	Symbol	Min	Typ[1]	Max	Units[2]	Test Conditions
TXD, TX_EN, setup to TX_CLK High	t1	10	–	–	ns	–
TXD, TX_EN, hold from TX_CLK High	t2	0	–	–	ns	–
TX_EN sampled to CRS asserted	t3	–	2	–	BT	–
TX_EN sampled to CRS de-asserted	t4	–	1	–	BT	–
TX_EN sampled to TPO out (Tx latency)	t5	–	72.5	–	BT	–

1. Typical values are at 25 °C and are for design aid only, not guaranteed, and not subject to production testing.
2. BT (Bit Time) is the duration of one bit as transferred to and from the MAC and is the reciprocal of the bit rate. 10BASE-T bit time = 10^{-7} s or 100 ns.

Figure 26. Intel® LXT972M Transceiver 10BASE-T Jabber and Unjabber Timing

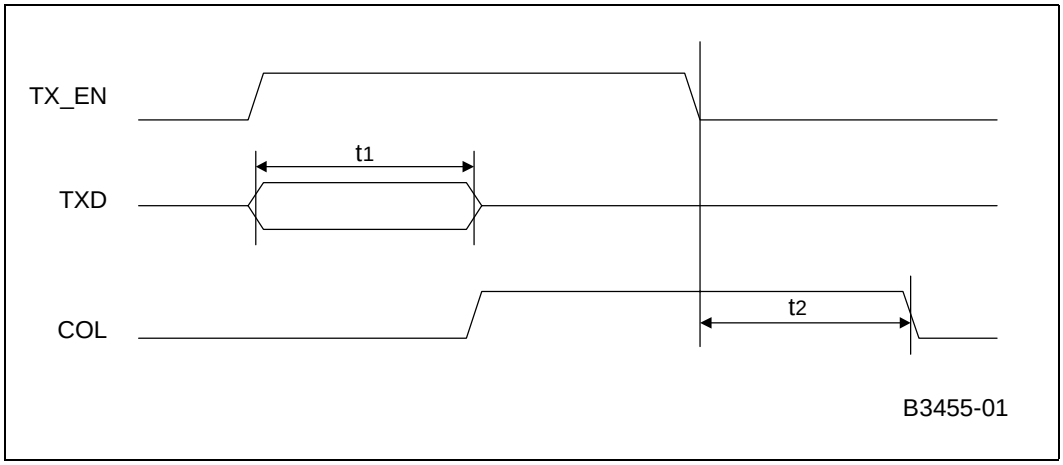


Table 34. Intel® LXT972M Transceiver 10BASE-T Jabber and Unjabber Timing

Parameter	Symbol	Min	Typ[1]	Max	Units	Test Conditions
Maximum transmit time	t1	20	–	150	ms	–
Unjabber time	t2	250	–	750	ms	–

1. Typical values are at 25 °C and are for design aid only, not guaranteed, and not subject to production testing.

Figure 27. Intel® LXT972M Transceiver 10BASE-T SQE (Heartbeat) Timing

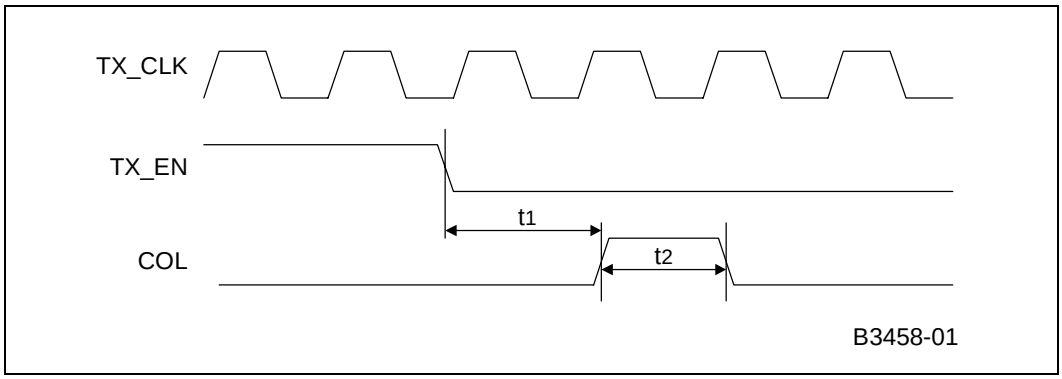


Table 35. Intel® LXT972M Transceiver 10BASE-T SQE (Heartbeat) Timing

Parameter	Symbol	Min	Typ[1]	Max	Units	Test Conditions
COL (SQE) Delay after TX_EN off	t1	0.65	–	1.6	us	–
COL (SQE) Pulse duration	t2	0.5	–	1.5	us	–

1. Typical values are at 25 °C and are for design aid only, not guaranteed, and not subject to production testing.

Figure 28. Intel® LXT972M Transceiver Auto-Negotiation and Fast Link Pulse Timing

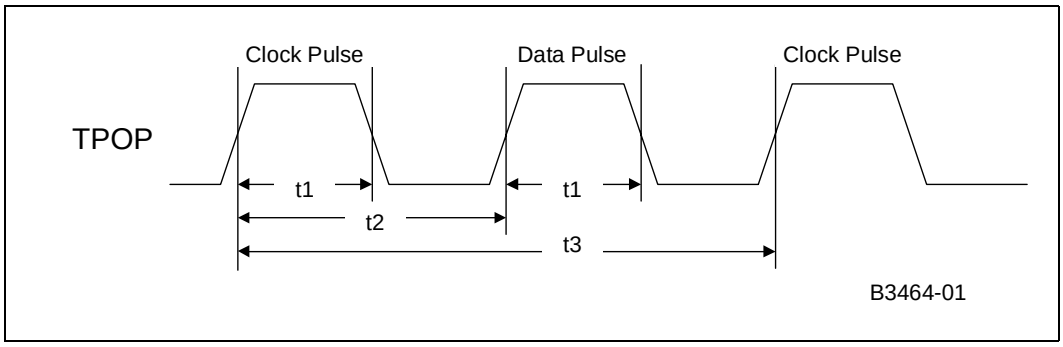


Figure 29. Intel® LXT972M Transceiver Fast Link Pulse Timing

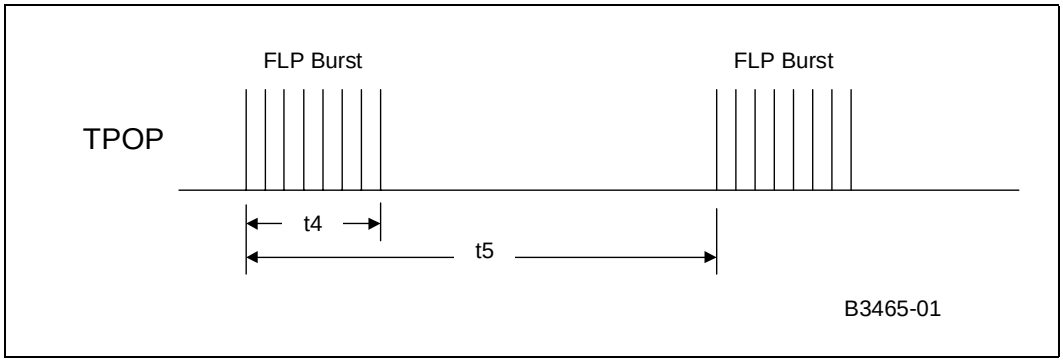


Table 36. Intel® LXT972M Transceiver Auto-Negotiation / Fast Link Pulse Timing

Parameter	Symbol	Min	Typ[1]	Max	Units	Test Conditions
Clock/Data pulse width	t1	–	100	–	ns	–
Clock pulse to Data pulse	t2	55.5	–	63.8	µs	–
Clock pulse to Clock pulse	t3	123	–	127	µs	–
FLP burst width	t4	–	2	–	ms	–
FLP burst to FLP burst	t5	8	12	24	ms	–
Clock/Data pulses per burst	–	17	–	33	Each clock pulse or data pulse	–

1. Typical values are at 25 °C and are for design aid only, not guaranteed, and not subject to production testing.

Figure 30. Intel® LXT972M Transceiver MDIO Input Timing

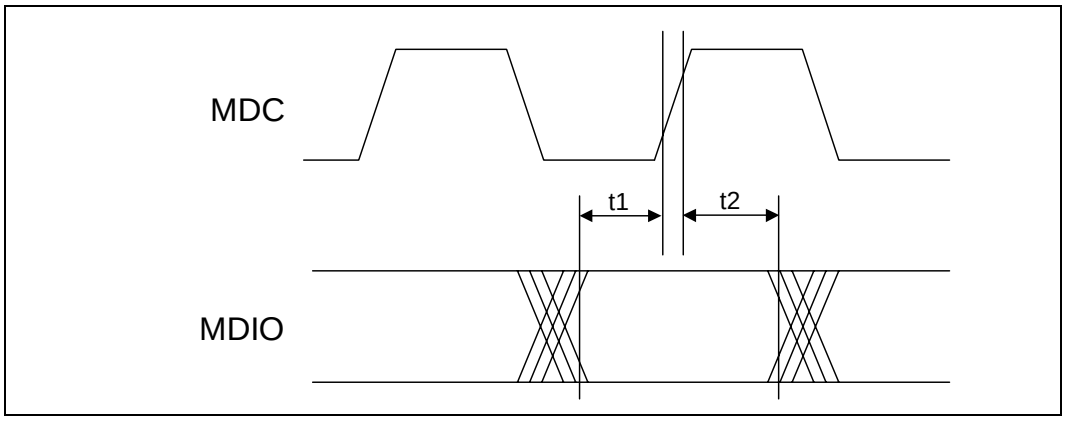


Figure 31. Intel® LXT972M Transceiver MDIO Output Timing

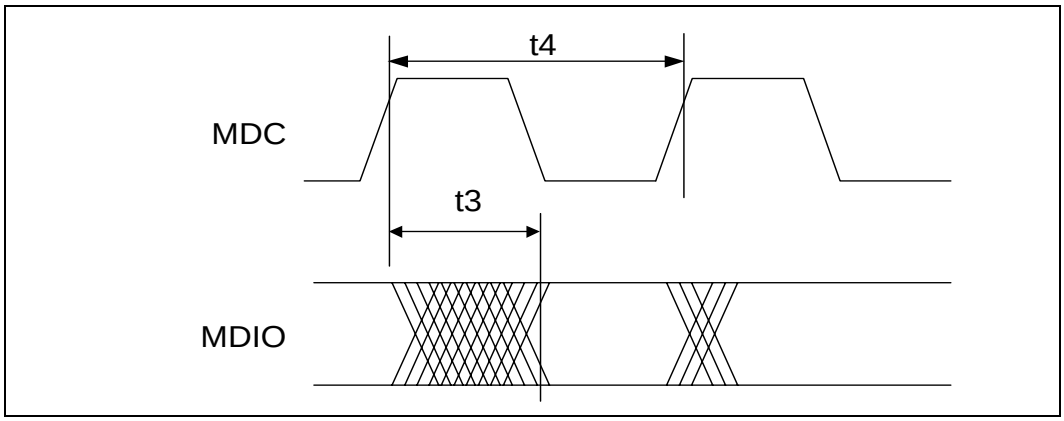


Table 37. Intel® LXT972M Transceiver MDIO Timing

Parameter	Symbol	Min	Typ[1]	Max	Units	Test Conditions
MDIO setup before MDC, sourced by STA	t1	10	–	–	ns	–
MDIO hold after MDC, sourced by STA	t2	5	–	–	ns	–
MDC to MDIO output delay, sourced by PHY	t3	–	–	150	ns	–
MDC period	t4	125	–	–	ns	MDC = 8 MHz

1. Typical values are at 25° C and are for design aid only, not guaranteed, and not subject to production testing.

Figure 32. Intel® LXT972M Transceiver Power-Up Timing

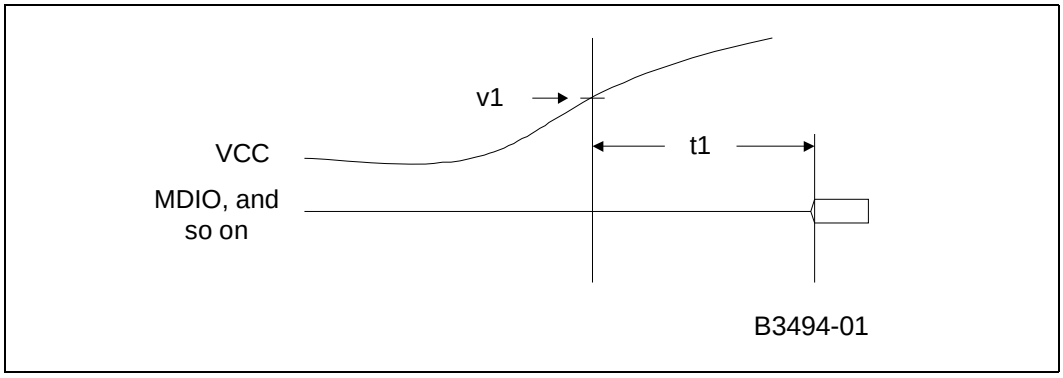


Table 38. Intel® LXT972M Transceiver Power-Up Timing

Parameter	Symbol	Min	Typ[1]	Max	Units	Test Conditions
Voltage threshold	v1	–	2.9	–	V	–
Power Up delay[2]	t1	–	–	300	µs	–

1. Typical values are at 25° C and are for design aid only, not guaranteed, and not subject to production testing.
2. Power-up delay is specified as a maximum value because it refers to the PHY guaranteed performance. The PHY comes out of reset after a delay of no more than 300 µs. System designers should consider this value as a minimum value. After threshold v1 is reached, the MAC should delay no less than 300 µs before accessing the MDIO port.

Figure 33. Intel® LXT972M Transceiver RESET_L Pulse Width and Recovery Timing

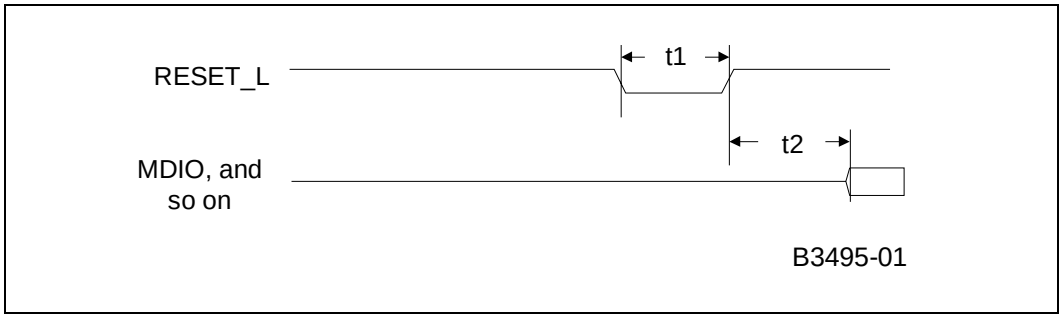


Table 39. Intel® LXT972M Transceiver RESET_L Pulse Width and Recovery Timing

Parameter	Symbol	Min	Typ[1]	Max	Units	Test Conditions
RESET_L pulse width	t1	10	–	–	ns	–
RESET_L recovery delay[2]	t2	–		300	µs	–

1. Typical values are at 25° C and are for design aid only, not guaranteed, and not subject to production testing.
2. Reset Recovery Delay is specified as a maximum value because it refers to the PHY guaranteed performance. The PHY comes out of reset after a delay of no more than 300 µs. System designers should consider this value as a minimum value. After de-asserting RESET_L, the MAC should delay no less than 300 µs before accessing the MDIO port.

8.0 Register Definitions - IEEE Base Registers

This chapter includes definitions for the IEEE base registers used by the LXT972M Transceiver. Chapter 9.0, “Register Definitions - Product-Specific Registers” includes definitions of additional product-specific LXT972M Transceiver registers, which are defined in accordance with the IEEE 802.3 standard for adding unique device functions.

The LXT972M Transceiver register set has multiple 16-bit registers.

- Table 40 is a register set listing of the IEEE base registers.
- Table 41 through Table 49 provide bit descriptions of the base registers (address 0 through 8), which are defined in accordance with the “Reconciliation Sublayer and Media Independent Interface” and “Physical Layer Link Signaling for 10/100 Mbps Auto-Negotiation” sections of the IEEE 802.3 standard.

Table 40. Register Set for IEEE Base Registers

Address	Register Name	Bit Assignments
0	Control Register	See Table 41
1	Status Register #1	See Table 42.
2	PHY Identification Register 1	See Table 43.
3	PHY Identification Register 2	See Table 44.
4	Auto-Negotiation Advertisement Register	See Table 45
5	Auto-Negotiation Link Partner Base Page Ability Register	See Table 46.
6	Auto-Negotiation Expansion Register	See Table 47.
7	Auto-Negotiation Next Page Transmit Register	See Table 48.
8	Auto-Negotiation Link Partner Next Page Receive Register	See Table 49.
9	1000BASE-T/100BASE-T2 Control Register	Not Implemented
10	1000BASE-T/100BASE-T2 Status Register	Not Implemented
11 to 14	Reserved	Not Implemented
15	Extended Status Register	Not Implemented

Table 41 lists control register bits.

Table 41. Control Register - Address 0, Hex 0

Bit	Name	Description	Type [1]	Default
0.15	Reset	0 = Normal operation 1 = PHY reset	R/W SC	0
0.14	Loopback	0 = Disable loopback mode 1 = Enable loopback mode	R/W	0
0.13	Speed Selection	0.6 / 0.13 / Speed Selected 0 / 0 / 10 Mbps 0 / 1 / 100 Mbps 1 / 0 / 1000 Mbps (not supported) 1 / 1 / Reserved	R/W	Note 2
0.12	Auto-Negotiation Enable	0 = Disable auto-negotiation process 1 = Enable auto-negotiation process	R/W	Note 2
0.11	Power-Down	0 = Normal operation 1 = Power-down	R/W	0
0.10	Isolate	0 = Normal operation 1 = Electrically isolate PHY from MII	R/W	0
0.9	Restart Auto-Negotiation	0 = Normal operation 1 = Restart auto-negotiation process	R/W SC	0
0.8	Duplex Mode	0 = Half-duplex 1 = Full-duplex	R/W	Note 2
0.7	Collision Test	0 = Disable COL signal test 1 = Enable COL signal test	R/W	0
0.6	Speed Selection	X - 0.6 / 0.13 / Speed Selected 0 / 0 / 10 Mbps 0 / 1 / 100 Mbps 1 / 0 / 1000 Mbps (not supported) 1 / 1 / Reserved	R/W	0
0.5:0	Reserved	Write as ‘0’. Ignore on Read.	R/W	00000

1. R/W = Read/Write
   SC = Self Clearing
2. Some bits have their default values determined at reset by hardware configuration pins. For default details for these bits, see Section 5.4.4, “Hardware Configuration Settings”.

Table 42 lists MII status register bits.

Table 42. MII Status Register #1 - Address 1, Hex 1

Bit	Name	Description	Type [1]	Default
1.15	100BASE-T4 Not Supported	0 = PHY not able to perform 100BASE-T4 1 = PHY able to perform 100BASE-T4	RO	0
1.14	100BASE-X Full-Duplex	0 = PHY not able to perform full-duplex 100BASE-X 1 = PHY able to perform full-duplex 100BASE-X	RO	1
1.13	100BASE-X Half-Duplex	0 = PHY not able to perform half-duplex 100BASE-X 1 = PHY able to perform half-duplex 100BASE-X	RO	1
1.12	10 Mbps Full-Duplex	0 = PHY not able to operate at 10 Mbps full-duplex mode 1 = PHY able to operate at 10 Mbps in full-duplex mode	RO	1
1.11	10 Mbps Half-Duplex	0 = PHY not able to operate at 10 Mbps in half-duplex 1 = PHY able to operate at 10 Mbps in half-duplex mode	RO	1
1.10	100BASE-T2 Full-Duplex Not Supported	0 = PHY not able to perform full-duplex 100BASE-T2 1 = PHY able to perform full-duplex 100BASE-T2	RO	0
1.9	100BASE-T2 Half-Duplex Not Supported	0 = PHY not able to perform half-duplex 100BASE-T2 1 = PHY able to perform half-duplex 100BASE-T2	RO	0
1.8	Extended Status	0 = No extended status information in register 15 1 = Extended status information in register 15	RO	0
1.7	Reserved	Ignore when read.	RO	0
1.6	MF Preamble Suppression	0 = PHY cannot accept management frames with preamble suppressed 1 = PHY accepts management frames with preamble suppressed	RO	0
1.5	Auto-Negotiation complete	0 = Auto-negotiation not complete 1 = Auto-negotiation complete	RO	0
1.4	Remote Fault	0 = No remote fault condition detected 1 = Remote fault condition detected	RO/LH	0
1.3	Auto-Negotiation Ability	0 = PHY is not able to perform auto-negotiation 1 = PHY is able to perform auto-negotiation	RO	1
1.2	Link Status	0 = Link is down 1 = Link is up	RO/LL	0
1.1	Jabber Detect	0 = Jabber condition not detected 1 = Jabber condition detected	RO/LH	0
1.0	Extended Capability	0 = Basic register capabilities 1 = Extended register capabilities	RO	1

1. RO = Read Only
   LL = Latching Low
   LH = Latching High

For Table 43 and Table 44, see Figure 34.

Table 43. PHY Identification Register 1 - Address 2, Hex 2

Bit	Name	Description	Type [1]	Default
2.15:0	PHY ID Number	The PHY identifier is composed of bits 3 through 18 of the Organizationally Unique Identifier (OUI).	RO	0013 hex
1. RO = Read Only				

Table 44. PHY Identification Register 2 - Address 3, Hex 3

Bit	Name	Description	Type [1]	Default
3.15:10	PHY ID number	The PHY identifier is composed of bits 19 through 24 of the OUI.	RO	011110
3.9:4	Manufacturer's model number	6 bits containing manufacturer's part number.	RO	001110
3.3:0	Manufacturer's revision number	4 bits containing manufacturer's revision number.	RO	For current revision ID information, see the Specification Update.
1. RO = Read Only				

Figure 34. PHY Identifier Bit Mapping

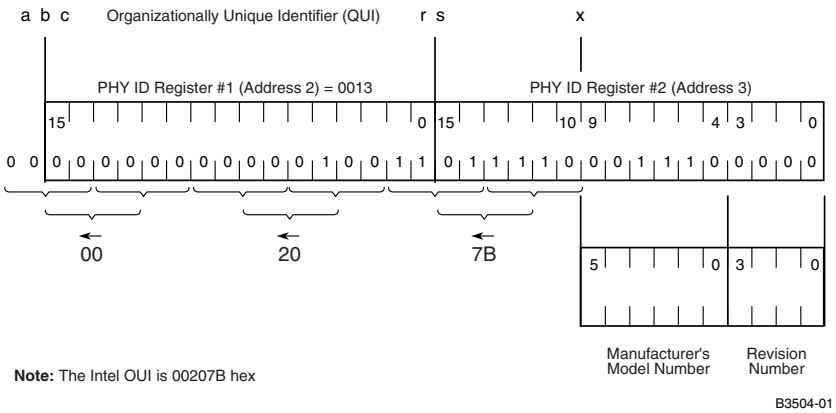


Table 45 lists auto-negotiation advertisement bits.

Table 45. Auto-Negotiation Advertisement Register - Address 4, Hex 4

Bit	Name	Description	Type [1]	Default
4.15	Next Page	0 = Port has no ability to send multiple pages. 1 = Port has ability to send multiple pages.	R/W	0
4.14	Reserved	Ignore when read.	RO	0
4.13	Remote Fault	0 = No remote fault. 1 = Remote fault.	R/W	0
4.12	Reserved	Write as '0'. Ignore on Read.	R/W	0
4.11	Asymmetric Pause	Pause operation defined in IEEE 802.3 Standard, Clause 40 and 27	R/W	0
4.10	Pause	0 = Pause operation disabled. 1 = Pause operation enabled for full-duplex links	R/W	0
4.9	100BASE-T4	0 = 100BASE-T4 capability is not available. 1 = 100BASE-T4 capability is available. **NOTE:** The LXT972M Transceiver does not support 100BASE-T4 but allows this bit to be set to advertise in the auto-negotiation sequence for 100BASE-T4 operation. An external 100BASE-T4 transceiver can be switched in if this capability is desired.	R/W	0
4.8	100BASE-TX full-duplex	0 = Port is not 100BASE-TX full-duplex capable. 1 = Port is 100BASE-TX full-duplex capable.	R/W	Note 2
4.7	100BASE-TX	0 = Port is not 100BASE-TX capable. 1 = Port is 100BASE-TX capable.	R/W	Note 2
4.6	10BASE-T full-duplex	0 = Port is not 10BASE-T full-duplex capable. 1 = Port is 10BASE-T full-duplex capable.	R/W	Note 2
4.5	10BASE-T	0 = Port is not 10BASE-T capable. 1 = Port is 10BASE-T capable.	R/W	Note 2
4.4:0	Selector Field, S<4:0>	<00001> = IEEE 802.3. <00010> = IEEE 802.9 ISLAN-16T. <00000> = Reserved for future auto-negotiation development. <11111> = Reserved for future auto-negotiation development. **NOTE:** Unspecified or reserved combinations must not be transmitted.	R/W	00001

1. R/W = Read/Write
   RO = Read Only
2. Some bits have their default values determined at reset by hardware configuration pins. For default details for these bits, see Section 5.4.4, "Hardware Configuration Settings".

Table 46 lists auto-negotiation link partner base page ability bits.

Table 46. Auto-Negotiation Link Partner Base Page Ability Register - Address 5, Hex 5

Bit	Name	Description	Type [1]	Default
5.15	Next Page	0 = Link Partner has no ability to send multiple pages. 1 = Link Partner has ability to send multiple pages.	RO	0
5.14	Acknowledge	0 = Link Partner has not received Link Code Word from the LXT972M Transceiver. 1 = Link Partner has received Link Code Word from the LXT972M Transceiver.	RO	0
5.13	Remote Fault	0 = No remote fault. 1 = Remote fault.	RO	0
5.12	Reserved	Ignore when read.	RO	0
5.11	Asymmetric Pause	Pause operation defined in IEEE 802.3 Standard, Clause 40 and 27. 0 = Link Partner is not Pause capable. 1 = Link Partner is Pause capable.	RO	0
5.10	Pause	0 = Link Partner is not Pause capable. 1 = Link Partner is Pause capable.	RO	0
5.9	100BASE-T4	0 = Link Partner is not 100BASE-T4 capable. 1 = Link Partner is 100BASE-T4 capable.	RO	0
5.8	100BASE-TX Full-Duplex	0 = Link Partner is not 100BASE-TX full-duplex capable. 1 = Link Partner is 100BASE-TX full-duplex capable.	RO	0
5.7	100BASE-TX	0 = Link Partner is not 100BASE-TX capable. 1 = Link Partner is 100BASE-TX capable.	RO	0
5.6	10BASE-T Full-Duplex	0 = Link Partner is not 10BASE-T full-duplex capable. 1 = Link Partner is 10BASE-T full-duplex capable.	RO	0
5.5	10BASE-T	0 = Link Partner is not 10BASE-T capable. 1 = Link Partner is 10BASE-T capable.	RO	0
5.4:0	Selector Field S<4:0>	<00001> = IEEE 802.3. <00010> = IEEE 802.9 ISLAN-16T. <00000> = Reserved for future auto-negotiation development. <11111> = Reserved for future auto-negotiation development. Unspecified or reserved combinations must not be transmitted.	RO	0

1. RO = Read Only

Table 47 lists auto-negotiation expansion bits.

Table 47. Auto-Negotiation Expansion - Address 6, Hex 6

Bit	Name	Description	Type [1]	Default
6.15:6	Reserved	Ignore when read.	RO	0
6.5	Base Page	This bit indicates the status of the auto-negotiation variable base page. It flags synchronization with the auto-negotiation state diagram, allowing detection of interrupted links. This bit is used only if Register bit 16.1 (that is, Alternate NP feature) is set. 0 = Base page = False (base page not received) 1 = Base page = True (base page received)	RO/LH	0
6.4	Parallel Detection Fault	0 = Parallel detection fault has not occurred. 1 = Parallel detection fault has occurred.	RO/LH	0
6.3	Link Partner Next Page Able	0 = Link partner is not next page able. 1 = Link partner is next page able.	RO	0
6.2	Next Page Able	0 = Local device is not next page able. 1 = Local device is next page able.	RO	1
6.1	Page Received	This bit is cleared on Read. If Register bit 16.1 is set, the Page Received bit is also cleared when either mr_page_rx = false or transmit_disable = true. 1 = Indicates a new page is received and the received code word is loaded into Register 5 (Base Pages) or Register 8 (Next Pages) as specified in Clause 28 of IEEE 802.3.	RO/LH	0
6.0	Link Partner A/N Able	0 = Link partner is not auto-negotiation able. 1 = Link partner is auto-negotiation able.	RO	0

1. RO = Read Only LH = Latching High

Table 48 lists auto-negotiation next page transmit bits.

Table 48. Auto-Negotiation Next Page Transmit Register - Address 7, Hex 7

Bit	Name	Description	Type [1]	Default
7.15	Next Page (NP)	0 = Last page 1 = Additional next pages follow	R/W	0
7.14	Reserved	Ignore when read.	RO	0
7.13	Message Page (MP)	0 = Register bits 7.10:0 are user defined. 1 = Register bits 7.10.0 follow IEEE message page format.	R/W	1
7.12	Acknowledge 2 (ACK2)	0 = Cannot comply with message 1 = Complies with message	R/W	0
7.11	Toggle (T)	0 = Previous value of the transmitted Link Code Word equalled logic one 1 = Previous value of the transmitted Link Code Word equalled logic zero	R/W	0
7.10:0	Message/ Unformatted Code Field	If Register bits 7.13 = 0, Register bits 7.10:0 are user-defined. If Register bits 7.13 = 1, Register bits 7.10:0 follow IEEE message page format.	R/W	00000000 001
1. RO = Read Only. R/W = Read/Write				

Table 49 lists auto-negotiation link partner next page receive bits.

Table 49. Auto-Negotiation Link Partner Next Page Receive Register - Address 8, Hex 8

Bit	Name	Description	Type [1]	Default
8.15	Next Page (NP)	0 = Link Partner has no additional next pages to send 1 = Link Partner has additional next pages to send	RO	0
8.14	Acknowledge (ACK)	0 = Link Partner has not received Link Code Word from LXT972M Transceiver. 1 = Link Partner has received Link Code Word from LXT972M Transceiver.	RO	0
8.13	Message Page (MP)	0 = Register bits 8.10:0 are user defined. 1 = Register bits 8.10:0 follow IEEE message page format.	RO	0
8.12	Acknowledge 2 (ACK2)	0 = Link Partner cannot comply with the message 1 = Link Partner complies with the message	RO	0
8.11	Toggle (T)	0 = Previous value of transmitted Link Code Word equal to logic one 1 = Previous value of transmitted Link Code Word equal to logic zero	RO	0
8.10:0	Message/Unformatted Code Field	If Register bit 8.13 = 0, Register bits 18.10:0 are user defined. If Register bit 8.13 = 1, Register bits 18.10:0 follow IEEE message page format.	RO	000000 0000
1. RO = Read Only.				

9.0 Register Definitions - Product-Specific Registers

This chapter includes definitions of product-specific LXT972M Transceiver registers that are defined in accordance with the IEEE 802.3 standard for adding unique device functions. (For definitions of the IEEE base registers used by the LXT972M Transceiver, see Chapter 8.0, "Register Definitions - IEEE Base Registers".)

- Table 50 lists the register set of the product-specific registers.
- Table 51 through Table 56 provide bit descriptions of the product-specific registers (address 17 through 30).

Table 50. Register Set for Product-Specific Registers

Address	Register Name	Bit Assignments
16	Port Configuration Register	See Table 51
17	Status Register #2	See Table 52
18	Reserved	
19	Status Change Register	See Table 53
20	LED Configuration Register	See Table 54
21	Reserved	
22-25	Reserved	
26	Digital Configuration Register	See Table 55
27	Reserved	
28	Reserved	
29	Reserved	
30	Transmit Control Register	See Table 56
31	Reserved	

Table 51 lists configuration bits.

Table 51. Configuration Register - Address 16, Hex 10

Bit	Name	Description	Type [1]	Default
16.15	Reserved	Write as '0'. Ignore on Read.	R/W	0
16.14	Force Link Pass	0 = Normal operation 1 = Force Link pass	R/W	0
16.13	Transmit Disable	0 = Normal operation 1 = Disable Twisted Pair transmitter	R/W	0
16.12	Bypass Scrambler (100BASE-TX)	0 = Normal operation 1 = Bypass Scrambler and Descrambler	R/W	0
16.11	Reserved	Write as '0'. Ignore on Read.	R/W	0
16.10	Jabber (10BASE-T)	0 = Normal operation 1 = Disable Jabber Correction	R/W	0
16.9	SQE (10BASE-T)	0 = Disable Heart Beat 1 = Enable Heart Beat	R/W	0
16.8	TP Loopback (10BASE-T)	0 = Normal operation 1 = Disable TP loopback during half-duplex operation	R/W	0
16.7	CRS Select (10BASE-T)	0 = Normal Operation 1 = CRS deassert extends to RX_DV deassert	R/W	1
16.6	Reserved	Write as '0'. Ignore on Read.	R/W	0
16.5	PRE_EN	Preamble Enable. 0 = Set RX_DV high coincident with SFD. 1 = Set RX_DV high and RXD = preamble when CRS is asserted. **NOTE:** Preamble is always enabled in 100 Mbps operation.	R/W	0
16.4:3	Reserved	Write as '0'. Ignore on Read.	R/W	00
16.2	Reserved	Write as '0'. Ignore on Read.	R/W	0
16.1	Alternate NP feature	0 = Disable alternate auto negotiate next page feature. 1 = Enable alternate auto negotiate next page feature. This bit enables or disables the register bit 6.5 capability.	R/W	0
16.0	Reserved	Write as '0'. Ignore on Read.	R/W	0
1. R/W = Read /Write				

Table 52 lists register #2 status bits.

Table 52. Status Register #2 - Address 17, Hex 11

Bit	Name	Description	Type [1]	Default
17.15	Reserved	Always 0.	RO	0
17.14	10/100 Mode	0 = LXT972M Transceiver is not operating 100BASE-TX mode. 1 = LXT972M Transceiver is operating in 100BASE-TX mode.	RO	0
17.13	Transmit Status	0 = LXT972M Transceiver is not transmitting a packet. 1 = LXT972M Transceiver is transmitting a packet.	RO	0
17.12	Receive Status	0 = LXT972M Transceiver is not receiving a packet. 1 = LXT972M Transceiver is receiving a packet.	RO	0
17.11	Collision Status	0 = No collision. 1 = Collision is occurring.	RO	0
17.10	Link	0 = Link is down. 1 = Link is up.	RO	0
17.9	Duplex Mode	0 = Half-duplex. 1 = Full-duplex.	RO	0
17.8	Auto-Negotiation	0 = LXT972M Transceiver is in manual mode. 1 = LXT972M Transceiver is in auto-negotiation mode.	RO	0
17.7	Auto-Negotiation Complete	0 = Auto-negotiation process not completed. 1 = Auto-negotiation process completed. This bit is valid only when auto negotiate is enabled. The value is equivalent to the value of Register bit 1.5.	RO	0
17.6	Reserved	Always 0.	RO	0
17.5	Polarity	0 = Polarity is not reversed. 1 = Polarity is reversed. **NOTE:** Polarity is not a valid status in 100 Mbps mode.	RO	0
17.4	Pause	0 = The LXT972M Transceiver is not Pause capable. 1 = The LXT972M Transceiver is Pause capable.	R	0
17:3	Error	0 = No error occurred 1 = Error occurred (Remote Fault, jabber, parallel detect fault) **NOTE:** The register bit is cleared when the registers that generate the error condition are read.	RO	0
17:2	Reserved	Always 0.	RO	0
17:1	Reserved	Always 0.	RO	0
17.0	Reserved	Always 0.	RO	0

1. RO = Read Only. R/W = Read/Write

Table 53 lists status change bits.

Table 53. Status Change Register - Address 19, Hex 13

Bit	Name	Description	Type [1]	Default
19.15:9	Reserved	Ignore on Read.	RO	N/A
19.8	Reserved	Ignore on Read.	RO	0
19.7	ANDONE	Auto-negotiation Status 0 = Auto-negotiation has not completed. 1 = Auto-negotiation has completed.	RO/ SC	N/A
19.6	SPEEDCHG	Speed Change Status 0 = A Speed Change has not occurred since last reading this register. 1 = A Speed Change has occurred since last reading this register.	RO/ SC	0
19.5	DUPLEXCHG	Duplex Change Status 0 = A Duplex Change has not occurred since last reading this register. 1 = A Duplex Change has occurred since last reading this register.	RO/ SC	0
19.4	LINKCHG	Link Status Change Status 0 = A Link Change has not occurred since last reading this register. 1 = A Link Change has occurred since last reading this register.	RO/ SC	0
19.3	Reserved	Ignore on Read.	RO	0
19.2	Reserved	Ignore on Read.	RO	0
19.1	Reserved	Ignore on Read.	RO	0
19.0	Reserved	Ignore on Read.	RO	0
1. R/W = Read/Write, RO = Read Only, SC = Self Clearing.				

Table 54 lists LED configuration bits.

Table 54. LED Configuration Register - Address 20, Hex 14 (Sheet 1 of 2)

Bit	Name	Description	Type [1]	Default
20.15:12	LED1 Programming bits	0000 = Display Speed Status (Continuous, Default) 0001 = Display Transmit Status (Stretched) 0010 = Display Receive Status (Stretched) 0011 = Display Collision Status (Stretched) 0100 = Display Link Status (Continuous) 0101 = Display Duplex Status (Continuous) 0110 = Unused 0111 = Display Receive or Transmit Activity (Stretched) 1000 = Test mode - turn LED on (Continuous) 1001 = Test mode - turn LED off (Continuous) 1010 = Test mode - blink LED fast (Continuous) 1011 = Test mode - blink LED slow (Continuous) 1100 = Display Link and Receive Status combined [2] (Stretched)[3] 1101 = Display Link and Activity Status combined [2] (Stretched)[3] 1110 = Display Duplex and Collision Status combined [4] (Stretched)[3] 1111 = Unused	R/W	0000
20.11:8	LED2 Programming bits	0000 = Display Speed Status 0001 = Display Transmit Status 0010 = Display Receive Status 0011 = Display Collision Status 0100 = Display Link Status (Default) 0101 = Display Duplex Status 0110 = Unused 0111 = Display Receive or Transmit Activity 1000 = Test mode - turn LED on 1001 = Test mode - turn LED off 1010 = Test mode - blink LED fast 1011 = Test mode - blink LED slow 1100 = Display Link and Receive Status combined [2] (Stretched)[3] 1101 = Display Link and Activity Status combined [2] (Stretched)[3] 1110 = Display Duplex and Collision Status combined [4] (Stretched)[3] 1111 = Unused	R/W	0100

1. R/W = Read /Write. RO = Read Only. LH = Latching High
2. Link status is the primary LED driver. The LED is asserted (solid ON) when the link is up. The secondary LED driver (Receive or Activity) causes the LED to change state (blink). Activity causes the LED to blink, regardless of the link status.
3. Combined event LED settings are not affected by Pulse Stretch Register bit 20.1. These display settings are stretched regardless of the value of 20.1.
4. Duplex status is the primary LED driver. The LED is asserted (solid ON) when the link is full-duplex. Collision status is the secondary LED driver. The LED changes state (blinks) when a collision occurs.
5. Values are approximations. Not guaranteed or production tested.

Table 54. LED Configuration Register - Address 20, Hex 14 (Sheet 2 of 2)

Bit	Name	Description	Type [1]	Default
20.7:4	LED3 Programming bits	0000 = Display Speed Status 0001 = Display Transmit Status 0010 = Display Receive Status (Default) 0011 = Display Collision Status 0100 = Display Link Status 0101 = Display Duplex Status 0110 = Unused 0111 = Display Receive or Transmit Activity 1000 = Test mode- turn LED on 1001 = Test mode- turn LED off 1010 = Test mode- blink LED fast 1011 = Test mode- blink LED slow 1100 = Display Link and Receive Status combined [2] (Stretched)[3] 1101 = Display Link and Activity Status combined [2] (Stretched)[3] 1110 = Display Duplex and Collision Status combined [4] (Stretched)[3] 1111 = Unused	R/W	0010
20.3:2	LEDFREQ[5]	00 = Stretch LED events to 30 ms. 01 = Stretch LED events to 60 ms. 10 = Stretch LED events to 100 ms. 11 = Reserved.	R/W	00
20.1	PULSE-STRETCH	0 = Disable pulse stretching of all LEDs. 1 = Enable pulse stretching of all LEDs.	R/W	1
20.0	Reserved	Write as ‘0’. Ignore on Read.	R/W	0

1. R/W = Read /Write. RO = Read Only. LH = Latching High
2. Link status is the primary LED driver. The LED is asserted (solid ON) when the link is up. The secondary LED driver (Receive or Activity) causes the LED to change state (blink). Activity causes the LED to blink, regardless of the link status.
3. Combined event LED settings are not affected by Pulse Stretch Register bit 20.1. These display settings are stretched regardless of the value of 20.1.
4. Duplex status is the primary LED driver. The LED is asserted (solid ON) when the link is full-duplex. Collision status is the secondary LED driver. The LED changes state (blinks) when a collision occurs.
5. Values are approximations. Not guaranteed or production tested.

Table 55 lists digital configuration bits for the LXT972M Transceiver.

Table 55. Digital Configuration Register - Address 26, Hex 1A

Bit	Name	Description	Type [1]	Default
26.15:12	Reserved	Write as ‘0’. Ignore on Read.	R/W	0000
26.11	MII Drive Strength	MII Drive Strength 0 = Normal MII drive strength 1 = Increase MII drive strength	R/W	0
26.10	Reserved	Write as ‘0’. Ignore on Read.	R/W	0
26.9	Show Symbol Error	Show Symbol Error 0 = Normal MII_RXER 1 = 100BASE-X Error Signal to MII_RxER	R/W	0
26.8:0	Reserved	Write as ‘0’. Ignore on Read.	RO	000000000

1. R/W = Read /Write, RO = Read Only

Table 56 lists transmit control bits.

Table 56. Transmit Control Register - Address 30, Hex 1E

Bit	Name	Description	Type[2]	Default
30.15:13	Reserved	Write as '0'. Ignore on Read.	R/W	000
30.12	Transmit Low Power	Transmit Low Power 0 = Normal transmission. 1 = Forces the transmitter into low power mode. Also forces a zero-differential transmission.	R/W	0
30.11:10	Port Rise Time Control[1]	Port Rise Time Control 00 = 3.0 ns (Default) 01 = 3.4 ns 10 = 3.9 ns 11 = 4.4 ns	R/W	00
30.9:0	Reserved	Ignore on Read.	R/W	0000000000

1. Values are approximations and may vary outside indicated values based upon implementation loading conditions. Not guaranteed.
2. R/W = Read/Write
3. Latch State during Reset is based on the state of hardware configuration pins at RESET_L.

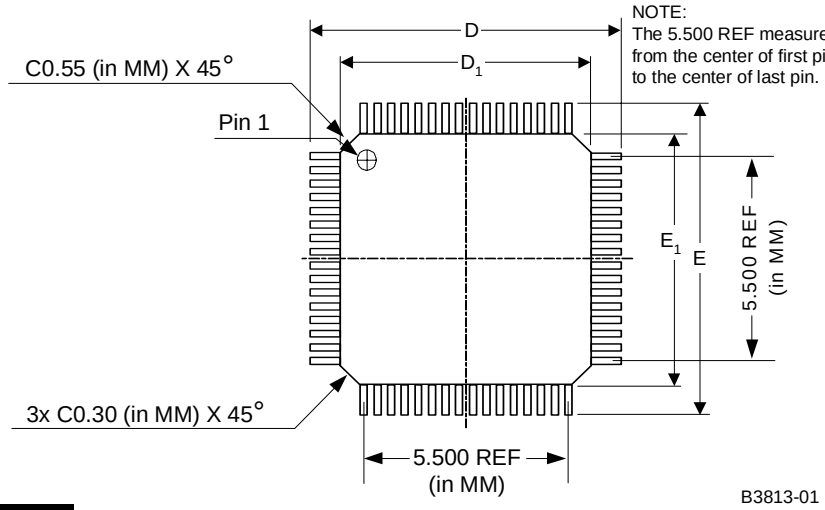
10.0 Intel® LXT972M Transceiver Package Specifications

Figure 35. Intel® LXT972M Transceiver LQFP Package Specifications

48-Pin Low-Profile Quad Flat Pack

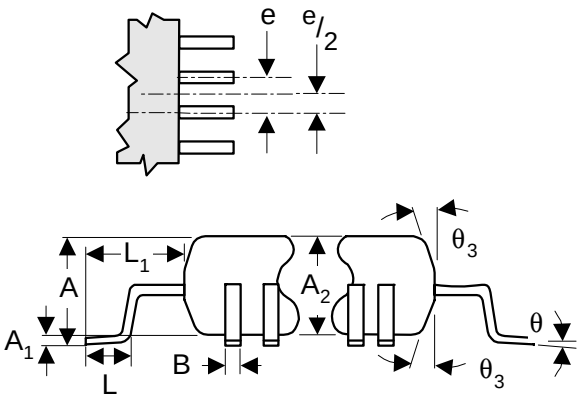
Part Number LXT972M - Temperature Range (0ºC to +70ºC)

NOTE: The package figure is generic and used only to demonstrate package dimensions.



Dim	Millimeters	
	Min	Max
A	–	1.60
A_1	0.05	0.15
A_2	1.35	1.45
B	0.17	0.27
D	8.80	9.20
D_1	6.90	7.10
E	8.80	9.20
E_1	6.90	7.10
e	0.50 BSC[1]	
L	0.45	0.75
L_1	1.00 REF	
θ_3	11°	13°
θ	0°	7°

1. Basic Spacing between Centers



10.1 Top Label Markings

Figure 36 shows a sample LQFP package for the LXT972M Transceiver.

Note: In contrast to the Pb-Free (RoHS-compliant) LQFP package, the non-RoHS-compliant package does not have the “e3” symbol in the last line of the package label.

Figure 36. Sample LQFP Package - Intel® LXT972M Transceiver

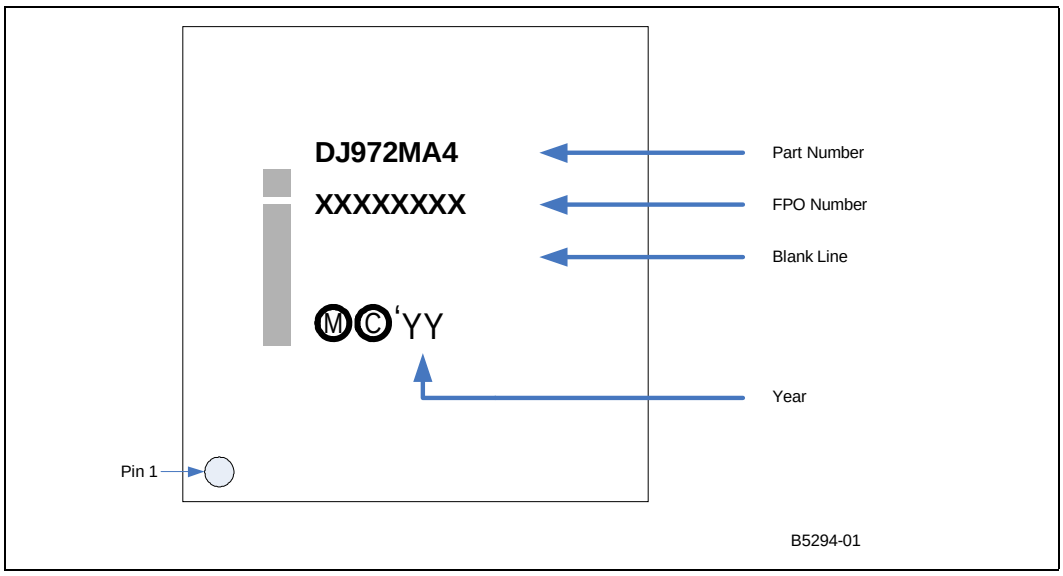
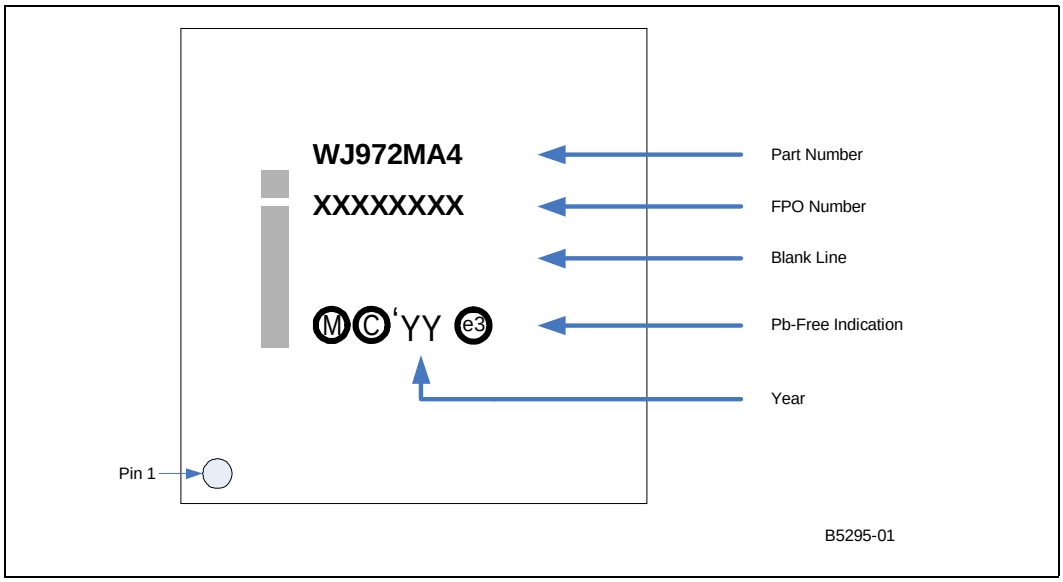


Figure 37 shows a sample Pb-Free (RoHS-compliant) LQFP package for the LXT972M Transceiver.

Figure 37. Sample Pb-Free (RoHS-Compliant) LQFP Package - Intel® LX972M Transceiver



11.0 Product Ordering Information

Table 57 lists product ordering information for the LXT972M Transceiver.

Table 57. Product Ordering Information

Number	Revision	Package Type	Pin Count	RoHS Compliant
DJLXT972MLC.A4	A4	LQFP	48	No
WJLXT972MLC.A4	A4	LQFP	48	Yes

Figure 38 shows an order matrix with sample information for ordering an LXT972M Transceiver.

Figure 38. Order Matrix for Intel® LXT972M Transceiver