

# **TECHNICAL MANUAL**

## **L80600 10/100/1000 Mbits/s Ethernet PHY**

**March 2001**

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This document describes the LSI Logic Corporation L80600 10/100/1000 Mb/s Ethernet PHY and will remain the official reference source for all revisions/releases of this product until rescinded by an update.

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# Preface

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This book is the primary reference and Technical Manual for the L80600 10/100/1000 Mbps/s Ethernet PHY. It contains a complete functional description for the product and includes complete physical and electrical specifications.

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## Audience

This document was prepared for logic designers and applications engineers and is intended to provide an overview of the L80600.

This document assumes that you have some familiarity with Ethernet LANs and related support devices. The people who benefit from this book are:

- Engineers and managers who are evaluating the L80600 for possible use in a system
  - Engineers who are designing the L80600 into a system
- 

## Organization

This document has the following chapters:

- [Chapter 1, Introduction](#)
- [Chapter 2, Functional Description](#)
- [Chapter 3, Signals](#)
- [Chapter 4, Registers](#)
- [Chapter 5, Configuration Options](#)
- [Chapter 6, Applications](#)
- [Chapter 7, Test Conditions](#)

- [Chapter 8, Specifications](#)
- [Chapter 9, L80600 Frequently Asked Questions](#)

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## Related Publications

- IEEE 802.3z “MAC Parameters, Physical Layer, Repeater and Management Parameters for 1000 Mbit/s Operation.”
- IEEE 802.3ab “Physical layer specification for 1000 Mbit/s operation on four pairs of category 5 or better balanced twisted-pair cable (1000BASE-T).”
- IEEE 802.3 and 802.3u (For 10/100 Mbit/s operation.)

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## Conventions Used in This Manual

The first time a word or phrase is defined in this manual, it is *italicized*.

The word *assert* means to drive a signal true or active. The word *deassert* means to drive a signal false or inactive. Signals that are active LOW end in an “n.”

Hexadecimal numbers are indicated by the prefix “0x” —for example, 0x32CF. Binary numbers are indicated by the prefix “0b” —for example, 0b0011.0010.1100.1111.

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# Chapter 1

## Introduction

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### 1.1 General Description

The L80600 is a full-featured Physical Layer (PHY) transceiver with integrated Physical Media Dependent (PMD) sublayers to support 10BASE-T, 100BASE-TX and 1000BASE-T Ethernet protocols.

The L80600 is designed for easy implementation of 10/100/1000 Mb/s Ethernet LANs. It interfaces directly to twisted-pair media by means of an external transformer. This device interfaces directly to the Media Access Control (MAC) layer through the IEEE 802.3u Standard Media Independent Interface (MII) or the IEEE 802.3z Gigabit Media Independent Interface (GMII).

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### 1.2 Applications

The L80600 fits applications in:

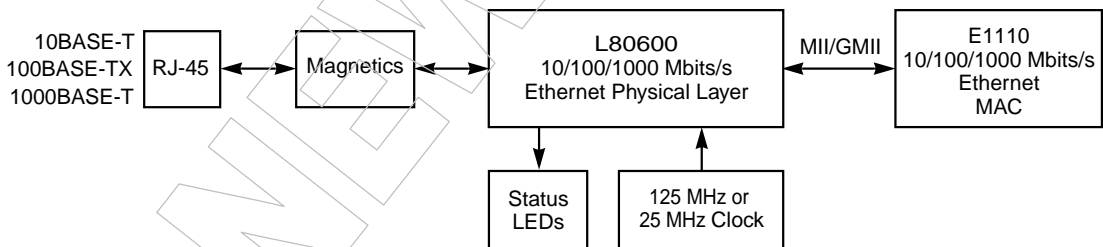
- 10/100/1000 Mb/s capable node cards
  - Switches with 10/100/1000 Mb/s capable ports
  - High speed uplink ports (backbone)
- 

### 1.3 Features

- 100BASE-TX and 1000BASE-T compliant
- Fully compliant to IEEE 802.3u 100BASE-TX and IEEE 802.3z/ab 1000BASE-T specifications. Fully integrated and fully compliant ANSI X3.T12 PMD physical sublayer that includes adaptive equalization and Baseline Wander compensation.
- 10BASE-T compatible

- IEEE 802.3u AutoNegotiation and Parallel Detection
- Fully AutoNegotiates between 1000 Mb/s, 100 Mb/s, and 10 Mb/s full-duplex and half-duplex devices
- Interoperates with first generation 1000BASE-T Physical layer transceivers
- 3.3 V MAC interfaces:  
IEEE 802.3u MII  
IEEE 802.3z GMII
- LED support: Link, Speed, Activity, Collision, TX and RX
- Supports 125-MHz or 25-MHz reference clock
- Requires only one 1.8 V and one 3.3 V supply
- Supports MDIX at 10, 100, and 1000 Mb/s
- Supports JTAG (IEEE1149.1)
- Dissipates 1 watt in 10/100 Mb/s mode
- Programmable Interrupts
- 208-pin PQFP package

**Figure 1.1 System Diagram**



# Chapter 2

## Functional Description

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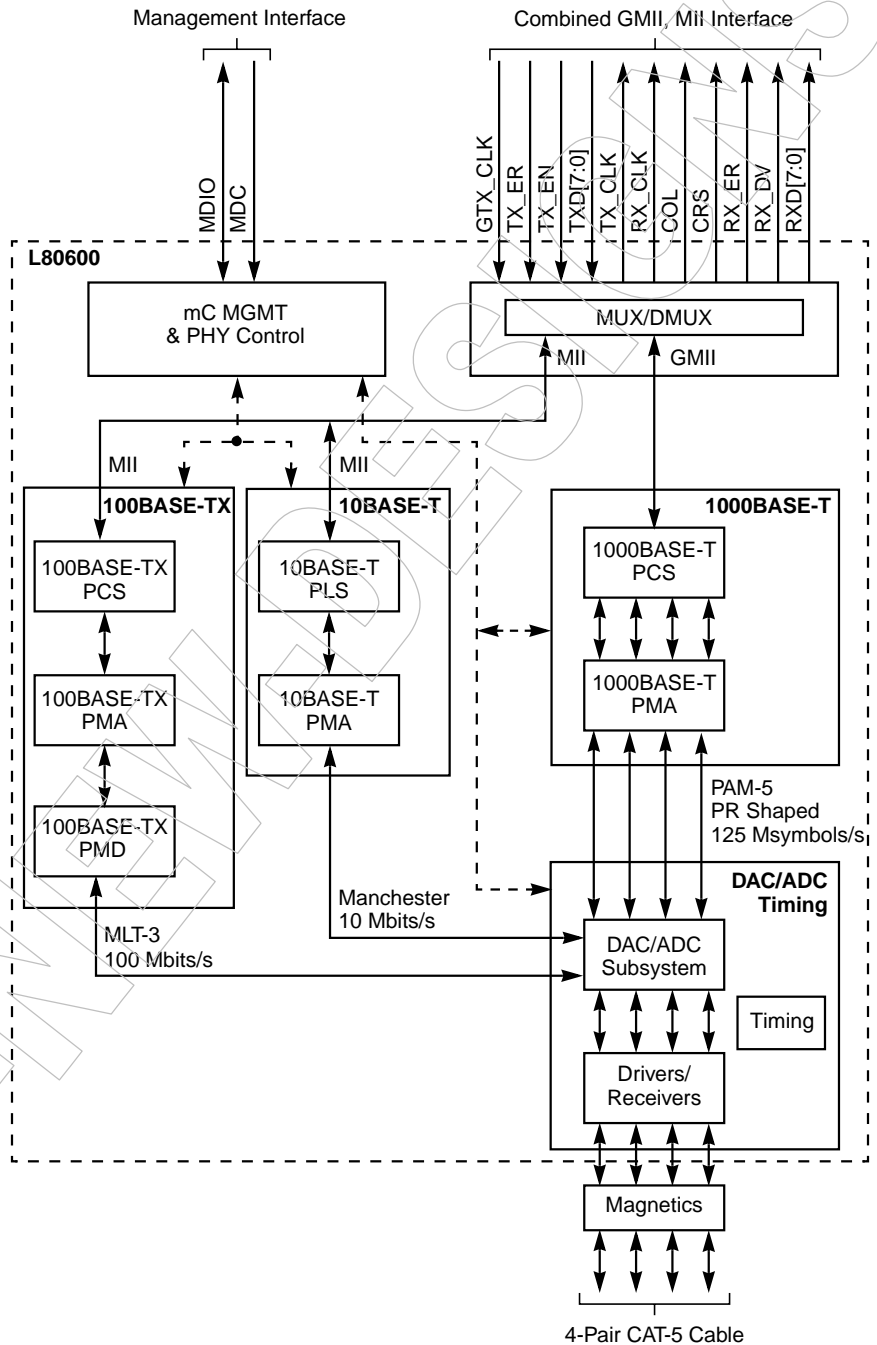
This chapter describes the functional blocks and operation of the L80600. The chapter contains the following sections:

- [Section 2.1, “Introduction”](#)
  - [Section 2.2, “100BASE-T Functional Description”](#)
  - [Section 2.3, “Gigabit MII \(GMII\)”](#)
  - [Section 2.4, “ADC/DAC/Timing Subsystem”](#)
  - [Section 2.5, “10BASE-T and 100BASE-TX Transmitter”](#)
  - [Section 2.6, “100BASE-TX Receiver”](#)
  - [Section 2.7, “Clock Recovery Module”](#)
  - [Section 2.8, “10BASE-T Functional Description”](#)
  - [Section 2.9, “ENDEC Module”](#)
  - [Section 2.10, “802.3u MII”](#)
  - [Section 2.11, “Status Information”](#)
- 

### 2.1 Introduction

The L80600 is a full featured 10/100/1000 Mb/s Ethernet Physical Layer (PHY) device, consisting of digital 10/100/1000 Mb/s core integrated into a single chip with a common twisted-pair interface, combined MII/GMII controller interface, and management interface (see [Figure 2.1](#)).

**Figure 2.1 L80600 Block Diagram**

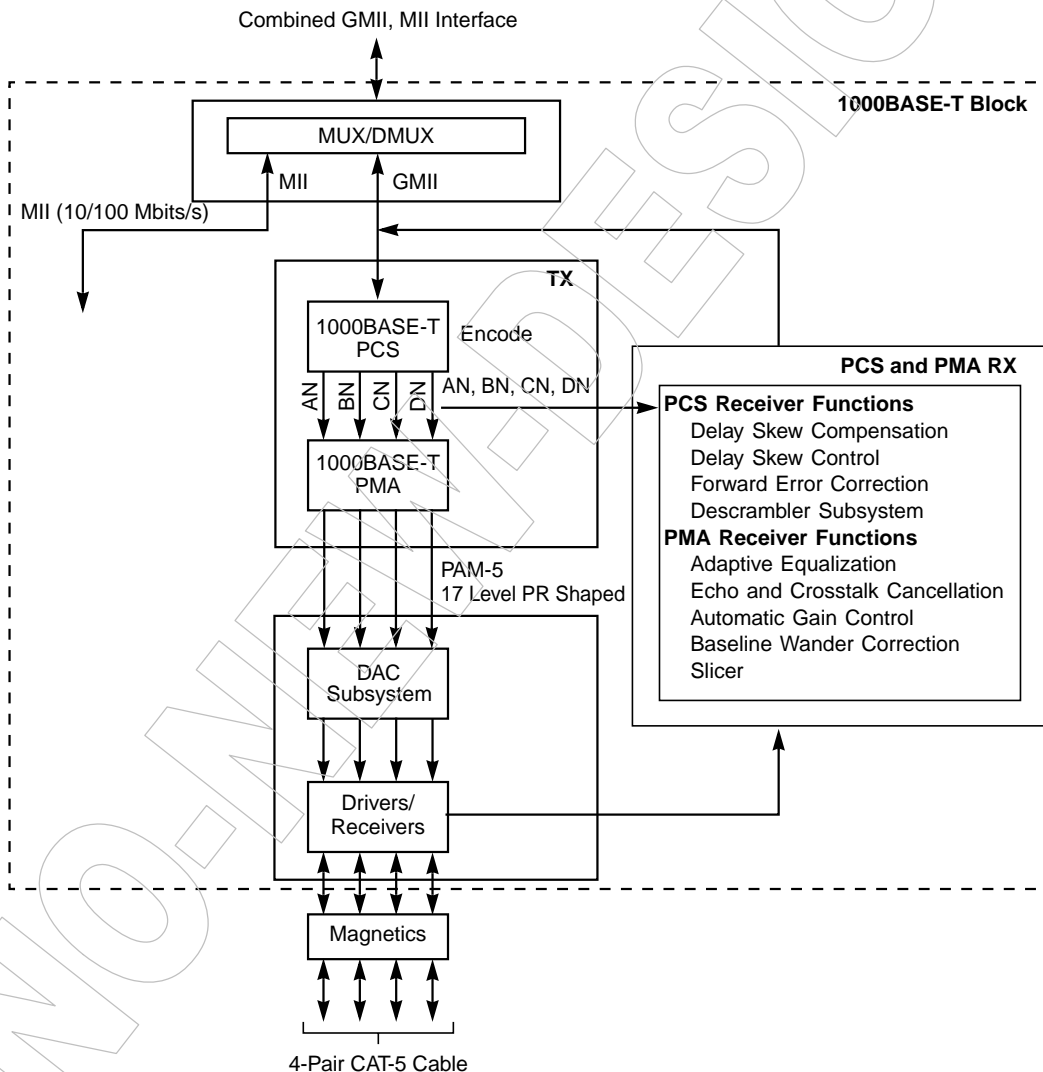




## 2.2 1000BASE-T Functional Description

The 1000BASE-T transceiver, shown in Figure 2.2, consists of a PCS Transmitter, Physical Medium Attachment (PMA) Transmitter, PMA Receiver, and a Physical Coding Sublayer (PCS) Receiver.

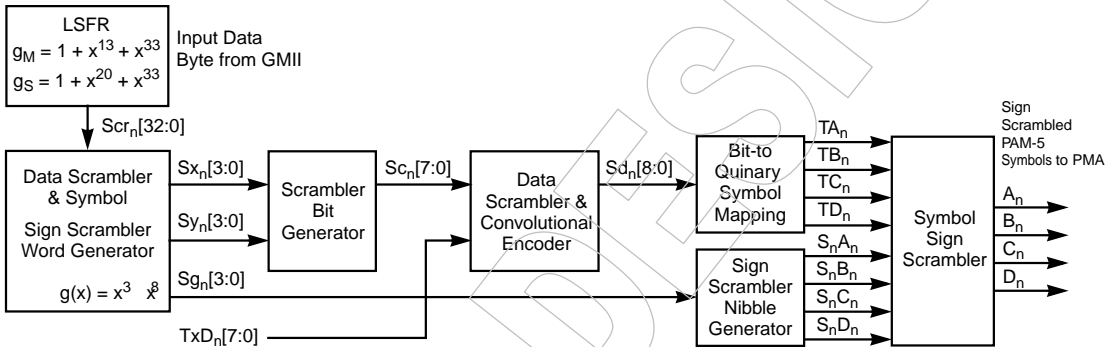
**Figure 2.2 1000BASE-T Functional Block Diagram**



## 2.2.1 1000BASE-T PCS Transmitter Block

The PCS transmitter consists of several functional blocks that convert the 8-bit  $\text{TXD}_n$  data from the GMII to PAM-5 symbols to be passed onto the PMA function. The block diagram of the PCS transmitter data path functions in Figure 2.3 provides an overview of each of the functional blocks within the PCS transmitter.

**Figure 2.3 PCS TX Functional Block Diagram**



The transmitter consists of eight functional blocks:

- LFSR (Linear Feedback Shift Register)
- Data Scrambler and Symbol Sign Scrambler Word Generator
- Scrambler Bit Generator
- Data Scrambler
- Convolutional Encoder
- Bit-to-Symbol Quinary Symbol Mapping
- Sign Scrambler Nibble Generator
- Symbol Sign Scrambler

The requirements for the PCS transmit functionality are also defined in the IEEE 802.3ab specification section 40.3.1.3 “PCS Transmit Function”.

### 2.2.1.1 Linear Feedback Shift Register (LFSR)

The side-stream scrambler function uses a LFSR implementing one of two equations, based on the mode of operation (master or slave). For master operation, the equation is as follows:

$$g_M(x) = 1 + x^{13} + x^{33}$$

For slave operation, use the following equation:

$$g_S(x) = 1 + x^{20} + x^{33}$$

The 33-bit data output,  $SCR_n[32:0]$ , of this block is then fed into the data scrambler and symbol sign scrambler word generator.

### 2.2.1.2 Data and Symbol Sign Scrambler Word Generator

The word generator uses the  $SCR_n[32:0]$  to generate further scrambled values. The following signals are generated:  $SX_n[3:0]$ ,  $Sy_n[3:0]$ , and  $Sg_n[3:0]$ .

The 4-bit  $SX_n[3:0]$  and  $Sy_n[3:0]$  values are then fed into the scrambler bit generator. The 4-bit  $Sg_n[3:0]$  sign values are fed into the sign scrambler nibble generator.

### 2.2.1.3 Scrambler Bit Generator

This function uses the  $SX_n$  and  $Sy_n$  signals along with the  $TX\_MODE$  and  $TX\_ENABLE$  signals to generate the  $SC_n[7:0]$ , which is further scrambled based on the condition of the  $TX\_MODE$  and  $TX\_ENABLE$  signal. The  $TX\_MODE$  signal can indicate the sending of idles ( $SEND\_I$ ), zeros ( $SEND\_Z$ ) or idles and data ( $SEND\_N$ ). The  $TX\_MODE$  signal is generated by the microcontroller function. The  $TX\_ENABLE$  signal is either asserted to indicate data transmission is occurring or not asserted for no data transmission. The PCS Data Transmission Enable state machine generates the  $TX\_ENABLE$  signal.

The 8-bit  $SC_n[7:0]$  signals are then fed into the data scrambler functional block.

#### 2.2.1.4 Data Scrambler

This function generates scrambled data by accepting the  $TxD_n[7:0]$  data from the GMII and scrambling it based on various inputs.

The data scrambler generates the 8-bit  $SD_n[7:0]$  value, which scrambles the  $TxD_n$  data based primarily on the  $SC_n$  values and the accompanying control signals.

All 8-bits of  $SD_n[7:0]$  are passed into the bit-to-quinary symbol mapping block, while 2 bits,  $SD_n[7:6]$ , are fed into the convolutional encoder.

#### 2.2.1.5 Convolutional Encoder

The encoder uses  $SD_n[7:6]$  bits and  $TX\_ENABLE$  to generate an additional data bit, which is called  $SD_n[8]$ .

The one clock delayed versions  $CS_{n-1}[1:0]$  are passed into the data scrambler functional block. This  $SD_n[8]$  bit is then passed into the bit-to-symbol quinary symbol mapping function.

#### 2.2.1.6 Bit-to-Symbol Quinary Symbol Mapping

This function implements Table 40-1 and 40-2 Bit-to-Symbol Mapping for even and odd subsets, located in the IEEE 802.3ab specification. It takes the 9-bit  $SD_n[8:0]$  data and converts it to the appropriate quinary symbols as defined by the tables.

The output of this functional block generates the  $TA_n$ ,  $TB_n$ ,  $TC_n$ , and  $TD_n$  symbols, which are then passed into the symbol sign scrambler.

Before describing the symbol sign scrambler, the sign scrambler nibble generator is described, since this also feeds the symbol sign scrambler.

#### 2.2.1.7 Sign Scrambler Nibble Generator

This function performs some further scrambling of the sign values,  $Sg_n[3:0]$ , generated by the data scrambler and symbol sign scrambler word generator. This sign scrambling is dependent on the  $TX\_ENABLE$  signal.

The  $S_nA_n$ ,  $S_nB_n$ ,  $S_nC_n$ , and  $S_nD_n$  outputs are then fed into the symbol sign scrambler function.

### 2.2.1.8 Symbol Sign Scrambler

This function scrambles the sign of the  $TA_n$ ,  $TB_n$ ,  $TC_n$ , and  $TD_n$  input values from the bit-to-symbol quinary symbol mapping function, by either inverting or not inverting the signs. This is done as follows:

$$A_n = TA_n \times S_n A_n$$

$$B_n = TB_n \times S_n B_n$$

$$C_n = TC_n \times S_n C_n$$

$$D_n = TD_n \times S_n D_n$$

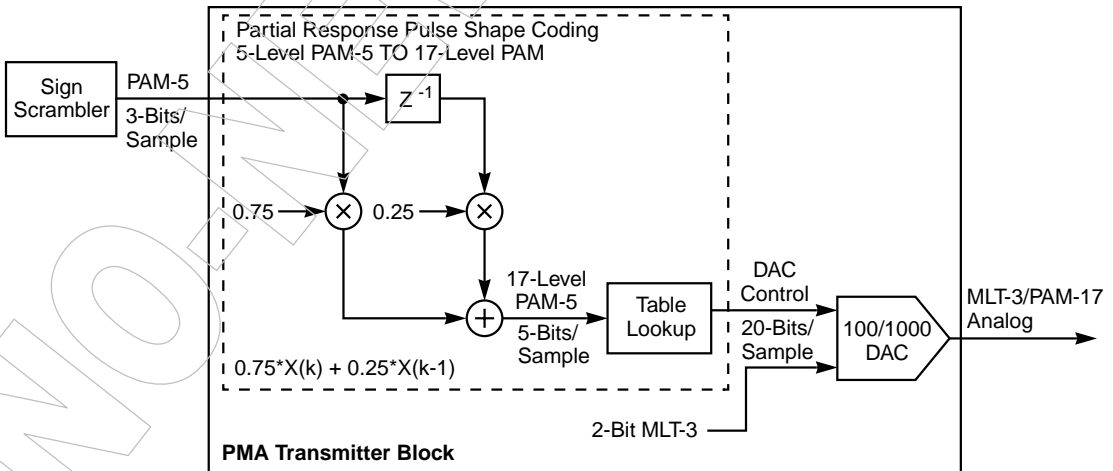
The outputs of this functional block ( $A_n$ ,  $B_n$ ,  $C_n$ , and  $D_n$ ) are the sign scrambled PAM-5 symbols. They are then passed onto the PMA for further processing.

### 2.2.2 1000BASE-T PMA Transmitter Block

The PMA transmit block shown in [Figure 2.4](#) contains the following blocks:

- Partial Response Encoder
- 100/1000 DAC Line Driver

**Figure 2.4 PMA Transmitter Block**



### 2.2.2.1 Partial Response Encoder

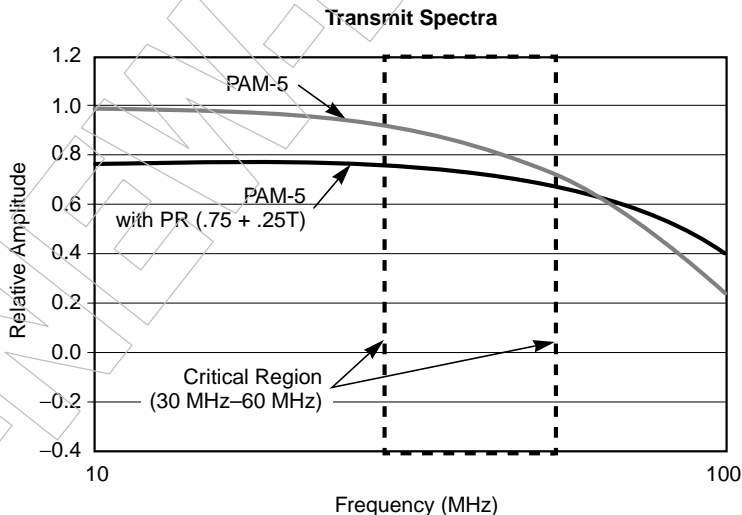
Partial Response (PR) coding (shaping) is used on the PAM-5 coded signals to spectrally shape the transmitted PAM-5 signal in order to reduce emissions in the critical frequency band ranging from 30 MHz to 60 MHz. The PR Z-transform implemented is:

$$0.75 + 0.25 Z^{-1}$$

The result of the PR coding on the PAM-5 signal results in 17-level PAM-5 or PAM-17 signal that is used to drive a common 100/1000 DAC and line driver. Without the PR coding, each signal can have five levels, given by 1, 0.5 and 0 V. If all combinations of the five levels are used for the present and previous outputs, then a simple table shows that there are 17 unique output levels when PR coding is used.

Figure 2.4 shows the PMA Transmitter and the embedded PR encoder block with its inputs and outputs. Figure 2.5 shows the effect on the spectrum of PAM-5 after PR shaping.

**Figure 2.5 Effect on Spectrum of PR-Shaped PAM-5 Coding**



### 2.2.2.2 10/100/1000 DAC Line Driver

The PAM-17 information from the PR encoder is used to drive a common 10/100/1000 DAC and line driver that converts digital data to suitable analog line voltages.

## 2.2.3 1000BASE-T PMA Receiver Block

The PMA Receiver consists of several functional blocks that process the four digitized voltage waveforms representing the received quartet of quinary PAM-5 symbols. The DSP processing implemented in the receiver extracts a best estimate of the quartet of quinary symbols originated by the transmitter at the far end of the CAT-5 cable and delivers them to the PCS RX block for further processing. There are four separate receivers, one for each twisted-pair.

The main processing blocks include:

- Adaptive Equalizer
- Echo and Crosstalk Cancellers
- Automatic Gain Control (AGC)
- Baseline Wander (BLW) Correction
- Slicer

### 2.2.3.1 Adaptive Equalizer

The Adaptive Equalizer compensates for the cable's nonideal (nonflat) frequency versus attenuation characteristics, which results in signal distortion. The cable attenuates the higher frequencies more than the lower frequencies, and this attenuation difference must be equalized. The Adaptive Equalizer is a digital filter with tap coefficients continually adapted to minimize the Mean Square Error (MSE) value of the slicer's error signal output. Continuous adaptation of the equalizer coefficients means that the optimum set of coefficients are always achieved for any given length or quality of cable.

### 2.2.3.2 Echo and Crosstalk Cancellers

The Echo and Crosstalk Cancellers cancel the echo and crosstalk produced while transmitting and receiving simultaneously. Echo is produced when the transmitted signal interferes with the received signal on the same wire. Crosstalk is caused by the transmitted signal on each of the other three wire pairs interfering with the receive signal of the fourth wire pair. An Echo and Crosstalk Canceller is needed for each of the wire pairs.

### 2.2.3.3 Automatic Gain Control (AGC)

The Automatic Gain Control acts upon the output of the Echo and Crosstalk Cancellers to adjust the receiver gain. Different AGC methods are available within the chip and the optimum one is selected based on the operational state of the chip (master, slave, start-up, and so on).

### 2.2.3.4 Baseline Wander (BLW) Correction

BLW is the slow variation of the DC level of the incoming signal due to the nonideal electrical characteristics of the magnetics and the inherent DC component of the transmitted waveform. The BLW correction circuit utilizes the slicer error signal to estimate and then correct for BLW.

### 2.2.3.5 Slicer

The Slicer selects the PAM-5 symbol value (+2, +1, 0, -1, -2) closest to the voltage input value after the signal has been corrected for line Intersymbol Interference (ISI), attenuation, echo, crosstalk and BLW.

The slicer produces an error output and symbol value decision output. The error output is the difference between the actual voltage input and the ideal voltage level representing the symbol value. The error output is fed back to the BLW, AGC, Crosstalk Canceller and Echo Canceller blocks to be used in their respective algorithms.

## 2.2.4 1000BASE-T PCS Receiver Block

The PCS receiver consists of several functional blocks that convert the incoming quartet of quinary symbols (PAM-5) data from the PMA RX A, B, C, and D to 8-bit receive data (RXD[7:0]), data valid (RX\_DV), and receive error (RX\_ER) signals on the GMII. The block diagram of the 1000BASE-T Functional Block in [Figure 2.2](#) provides an overview of the 1000BASE-T transceiver and shows the functionality of the PCS receiver.

The major functional blocks of the PCS Receiver include:

- Delay Skew Compensation
- Delay Skew Control
- Forward Error Correction (FEC)
- Descrambler Subsystem
- Receive State Machine



The requirements for the PCS receive functionality are also defined in the IEEE 802.3ab specification in section 40.3.1.4 “PCS Receive Function.”

#### **2.2.4.1 Delay Skew Compensation**

This function is used to align the received data from the four PMA receivers and to determine the correct spatial ordering of the four incoming twisted-pairs (which twisted-pair carries  $A_n$ , which one carries  $B_n$ , and so on). The deskewed and ordered symbols are then presented to the FEC Decoder. The differential time or time delay skew is due to the differences in length of each of the four pairs of twisted wire in the CAT-5 cable, manufacturing variation of the insulation of the wire pairs, and in some cases, differences in insulation materials used in the wire pairs. Correct symbol order to the FEC is required, since the receiver does not have prior knowledge of the order of the incoming twisted-pairs within the CAT-5 cable.

#### **2.2.4.2 Delay Skew Control**

This function controls the delay skew compensation function by providing the necessary controls and selects to allow for compensation in two dimensions (time and position). The time factor is the delay skew between the four incoming data streams from the PMA RX A, B, C, and D. This delay skew originates back at the input to the ADC/DAC/Timing subsystem. Since the receiver initially does not know the ordering of the twisted-pairs, correct ordering must be determined automatically by the receiver during start-up. Delay skew compensation and twisted-pair ordering is part of the training function performed during start-up.

#### **2.2.4.3 Forward Error Correction (FEC) Decoder**

This function decodes the quartet of quinary symbols from the PMA receivers and generates the  $SD_n$  binary values. The FEC decoder uses a standard 8-state Trellis code operation.

The FEC decoder decodes the quartet of quinary (PAM-5) symbols and generates the corresponding  $SD_n$  binary words. Initially,  $SD_n[3:0]$  may not have the proper bit ordering, however, correct ordering is established by the reordering algorithm at start-up.

#### 2.2.4.4 Descrambler Subsystem

The descrambler block performs the reverse scrambling function that was implemented in the transmit section. This function works in conjunction with the delay skew control. It provides the receiver generated  $SD_n[3:0]$  bits for comparison in the delay skew control function.

#### 2.2.4.5 Receive State Machine

This state machine operation is defined in IEEE 802.3ab section 40.3.1.4. In summary, it provides the necessary receive control signals of RX\_DV and RX\_ER to the GMII. In specific conditions, as defined in the IEEE 802.3ab specification, it generates RXD[7:0] data.

---

### 2.3 Gigabit MII (GMII)

The Gigabit Media Independent Interface (GMII) is intended for use between Ethernet PHYs and Station Management (STA) entities and is selected by either hardware or software configuration. The purpose of this interface is to differentiate between the various media that are transparent to the MAC layer.

The GMII Interface accepts either GMII or MII data, control and status signals and routes them either to the 1000BASE-T, 100BASE-TX, or 10BASE-T modules, respectively.

The mapping between GMII and MII is illustrated in [Table 2.1](#).

**Table 2.1 GMII/MII Mapping**

GMII	MII
RXD[3:0]	RXD[3:0]
RXD[4:7]	
RX_DV	RX_DV
RX_ER	RX_ER
RX_CLK	RX_CLK
	TX_CLK

**Table 2.1 GMII/MII Mapping (Cont.)**

GMII	MII
TXD[3:0]	TXD[3:0]
TXD[4:7]	
TX_EN	TX_EN
TX_ER	TX_ER
GTX_CLK	
COL	COL
CRS	CRS

The GMII interface has the following characteristics:

- Supports 10/100/1000 Mbit/s operation
- Data and delimiters are synchronous to clock references
- Provides independent 8-bit wide transmit and receive data paths
- Provides a simple management interface
- Uses signal levels that are compatible with common CMOS digital ASIC processes and some bipolar processes
- Provides for both Full-Duplex and Half-Duplex operation

The GMII interface is defined in the IEEE 802.3z document Clause 35. In each direction of data transfer, there are data (an eight-bit bundle), delimiter, error, and clock signals. GMII signals are defined such that an implementation may multiplex most GMII signals with the similar PCS service interface defined in IEEE 802.3u Clause 22.

Two media status signals are provided. One indicates the presence of carrier (CRS), and the other indicates the occurrence of a collision (COL). The GMII uses the MII management interface consisting of two signals (MDC and MDIO), which provide access to management parameters and services as specified in IEEE 802.3u Clause 22.

The MII signal names have been retained and the functions of most signals are the same, but additional valid combinations of signals have been defined for 1000 Mbit/s operation.

The Reconciliation sublayer maps the signal set provided at the GMII to the PLS service primitives provided to the MAC.

---

## 2.4 ADC/DAC/Timing Subsystem

The 1000BASE-T receive section consists of four channels, each receiving IEEE 802.3ab compliant PAM-5 coded data including Partial Response (PR) shaping at 125 MBaud over a maximum of a 100 m of CAT-5 cable. The four pairs of receive input pins are AC coupled through the magnetics to the CAT-5 cable. Each receive pin pair is differentially terminated with an external 100  $\Omega$  resistor to match the cable impedance. Each receive channel consists of a high-precision Analog to Digital data converter (ADC) that quantizes the incoming data into a digital word at the rate of 125 Mbits/s. The ADC is sampled with a clock of 125 MHz recovered from the incoming data stream.

The 1000BASE-T transmit section consists of four channels, each transmitting IEEE 802.3ab compliant 17-level PAM-5 data at 125 Msymbols/s. The four pairs of transmit output pins are AC coupled through the magnetics to the CAT-5 cable. Each transmit pin pair is differentially terminated with an external 100  $\Omega$  resistor to match the cable impedance. Each transmit channel consists of a Digital to Analog Converter (DAC) and line driver capable of producing 17 discrete levels corresponding to the PR shaping of a PAM-5 coded data stream. Each DAC is clocked with a 125-MHz clock, which is the X1/Ref clock in the Master mode of operation, and the recovered receive clock in the Slave mode of operation.

The L80600 incorporates a sophisticated Clock Generation Module (CGM) that supports 10/100/1000 modes of operation with an external 125 MHz clock reference ( $\pm 50$  ppm). The Clock Generation module internally generates multiple phases of clocks at various frequencies to support high-precision and low-jitter Clock Recovery Modules (CRM) for robust data recovery, and to support accurate low jitter transmission of data symbols in the Master and Slave mode of operation.

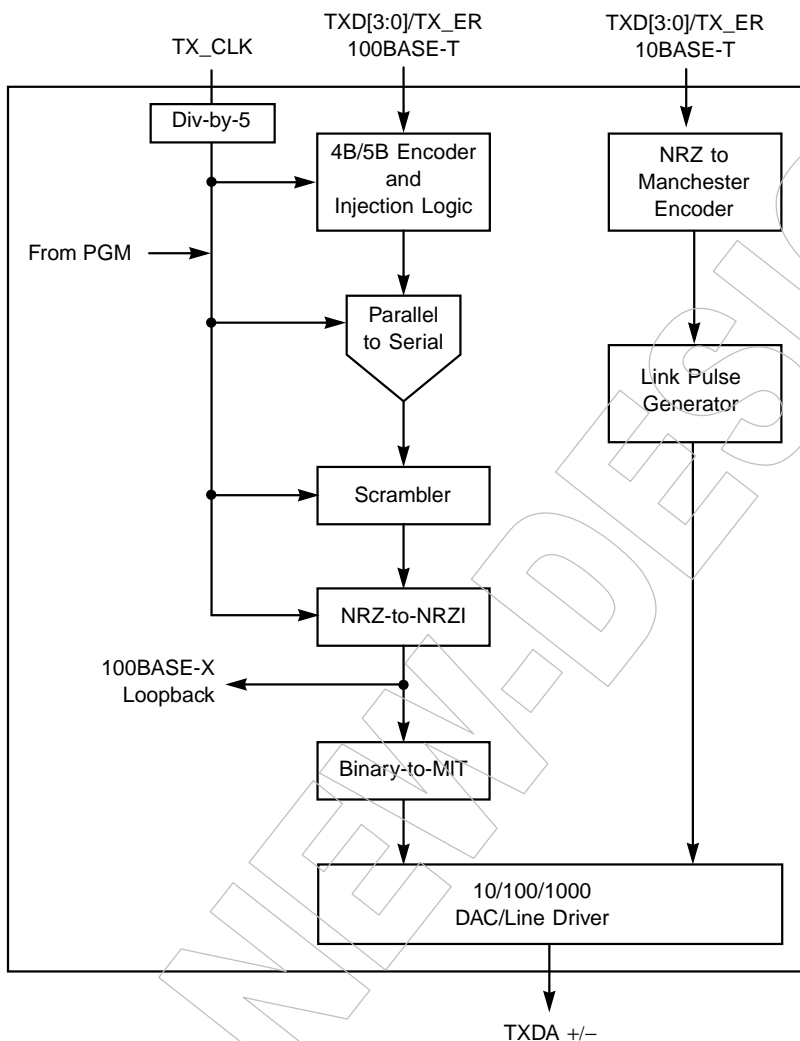
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## 2.5 10BASE-T and 100BASE-TX Transmitter

The 10BASE-T and 100BASE-TX transmitter consists of several functional blocks that convert synchronous 4-bit nibble data, as provided by the MII, to a 10 Mbit/s MLT signal for 10BASE-T operation or scrambled MLT-3 125 Mbit/s serial data stream for 100BASE-TX operation. Since the 10BASE-T and 100BASE-TX transmitters are integrated with the 1000BASE-T transmitter, the differential output pins, TD+/- are routed to channel A of the AC coupling magnetics.

The block diagram in [Figure 2.6](#) provides an overview of each functional block within the 10BASE-T and 100BASE-TX transmit section.

**Figure 2.6 100BASE-TX Transmit Block Diagram**



The Transmitter section consists of the following functional blocks:

#### **10BASE-T BLOCK**

- NRZ to Manchester Encoder
- Link Pulse Generator
- DAC/Line Driver

## 100BASE-TX BLOCK

- 4B/5B Code-Group Encoder and Injection block
- Parallel-to-Serial block
- Scrambler block
- NRZ to NRZI Encoder block
- Binary to MLT-3 Converter/DAC/Line Driver

In 10BASE-T mode, the transmitter does not meet the IEEE 802.3 specification Clause 14. This specification requires that the 10 Mbits/s output levels are within the following limits:

VOD = 2.2 to 2.8 V peak-differential when terminated by a 100  $\Omega$  resistor directly at the RJ45 outputs. The L80600 10 Mbits/s output levels are typically 1.58 V peak differential. In 10 Mbit/s operation the L80600 is able to transmit and receive up to 187 meters of CAT-5 cable and up to 150 meters using CAT-3 cable. No impact was seen on the receive ability of the link partner due to the reduced levels of VOD.

The L80600 implements the 100BASE-X transmit state machine diagram as specified in the IEEE 802.3u Standard, Clause 24.

### 2.5.1 Code-Group Encoding and Injection

The code-group encoder converts 4-bit (4B) nibble data generated by the MAC into 5-bit (5B) code-groups for transmission. This conversion is required to allow control data to be combined with packet data code-groups. Refer to [Table 2.2](#) for 4B to 5B code-group mapping details.

The code-group encoder substitutes the first 8-bits of the MAC preamble with a J/K code-group pair (0b11000 0b10001) upon transmission. The code-group encoder continues to replace subsequent 4B preamble and data nibbles with corresponding 5B code-groups. At the end of the transmit packet, upon the deassertion of Transmit Enable signal from the MAC, the code-group encoder injects the T/R code-group pair (0b01101 0b00111) indicating the end of frame.

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

**Table 2.2 4B5B Code-Group Encoding/Decoding**

Name	PCS 5B Code-Group	MII 4B Nibble Code
Data Codes		
0	11110	0000
1	01001	0001
2	10100	0010
3	10101	0011
4	01010	0100
5	01011	0101
6	01110	0110
7	01111	0111
8	10010	1000
9	10011	1001
A	10110	1010
B	10111	1011
C	11010	1100
D	11011	1101
E	11100	1110
F	11101	1111
Idle And Control Codes		
H	00100	HALT Code-Group - Error code
I	11111	Interpacket IDLE - 0000 <sup>1</sup>
J	11000	First Start of Packet - 0101 <sup>1</sup>
K	10001	Second Start of Packet - 0101 <sup>1</sup>
T	01101	First End of Packet - 0000 <sup>1</sup>
R	00111	Second End of Packet - 0000 <sup>1</sup>



**Table 2.2 4B5B Code-Group Encoding/Decoding (Cont.)**

Name	PCS 5B Code-Group	MII 4B Nibble Code
Invalid Codes		
V	00000	0110 or 0101 <sup>2</sup>
V	00001	0110 or 0101 <sup>2</sup>
V	00010	0110 or 0101 <sup>2</sup>
V	00011	0110 or 0101 <sup>2</sup>
V	00101	0110 or 0101 <sup>2</sup>
V	00110	0110 or 0101 <sup>2</sup>
V	01000	0110 or 0101 <sup>2</sup>
V	01100	0110 or 0101 <sup>2</sup>
V	10000	0110 or 0101 <sup>2</sup>
V	11001	0110 or 0101 <sup>2</sup>

1. Control code-groups I, J, K, T and R in data fields are mapped as invalid codes, together with RX\_ER asserted.
2. Normally, invalid codes (V) are mapped to 0x6 on RXD[3:0] with RX\_ER asserted.

## 2.5.2 Parallel-to-Serial Converter

After the code-group coding and injection process, the 5-bit (5B) code-groups are then converted to a serial data stream at 125 MHz.

## 2.5.3 Scrambler

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

The scrambler is configured as a closed loop linear feedback shift register (LFSR) with an 11-bit polynomial. The output of the closed loop LFSR is X-OR'ed with the serial NRZ data from the serializer block. The

result is a scrambled data stream with sufficient randomization to decrease radiated emissions at certain frequencies by as much as 20 dB. The L80600 uses the PHY\_ID (pins PHYAD [4:0]) to set a unique seed value for the scramblers. The resulting energy generated by each channel is out of phase with respect to each channel, thus reducing the overall electromagnetic radiation.

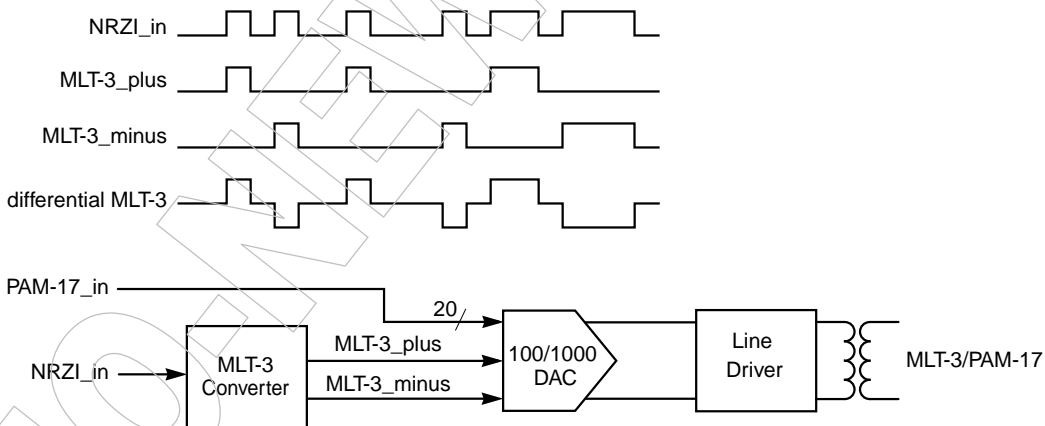
## 2.5.4 NRZ to NRZI Encoder

After the transmit data stream has been serialized and scrambled, the data is NRZI encoded to comply with the TP-PMD standard for 100BASE-TX transmission over Category-5 unshielded twisted-pair cable. There is no ability to bypass this block within the L80600.

## 2.5.5 MLT-3 Converter/DAC/Line Driver

Binary to MLT-3 conversion is accomplished by converting the serial NRZI data stream output from the NRZI encoder into two binary data streams with alternately phased logic one events. These two binary data streams are then passed to a 100/1000 DAC and line driver that converts the pulses to suitable analog line voltages. Refer to [Figure 2.7](#).

**Figure 2.7 NRZI to MLT-3 Conversion**



The 100BASE-TX MLT-3 signal sourced by the TXDA+/- line driver output pins is slew rate controlled. This should be considered when selecting AC coupling magnetics to ensure TP-PMD Standard compliant transition times ( $3 \text{ ns} < t_r < 5 \text{ ns}$ ).

The 100BASE-TX transmit TP-PMD function within the L80600 is capable of sourcing only MLT-3 encoded data. Binary output from the TXDA+/- outputs is not possible in 100 Mbit/s mode.

### 2.5.6 TX\_ER

Assertion of the TX\_ER input while the TX\_EN input is also asserted causes the L80600 to substitute HALT code-groups for the 5B data present at TXD[3:0]. However, the Start-of-Stream Delimiter (SSD) /J/K/ and End-of-Stream Delimiter (ESD) /T/R/ are not substituted with HALT code-groups. As a result, the assertion of TX\_ER while TX\_EN is asserted results in a frame properly encapsulated with the /J/K/ and /T/R/ delimiters, which contain HALT code-groups in place of the data code-groups.

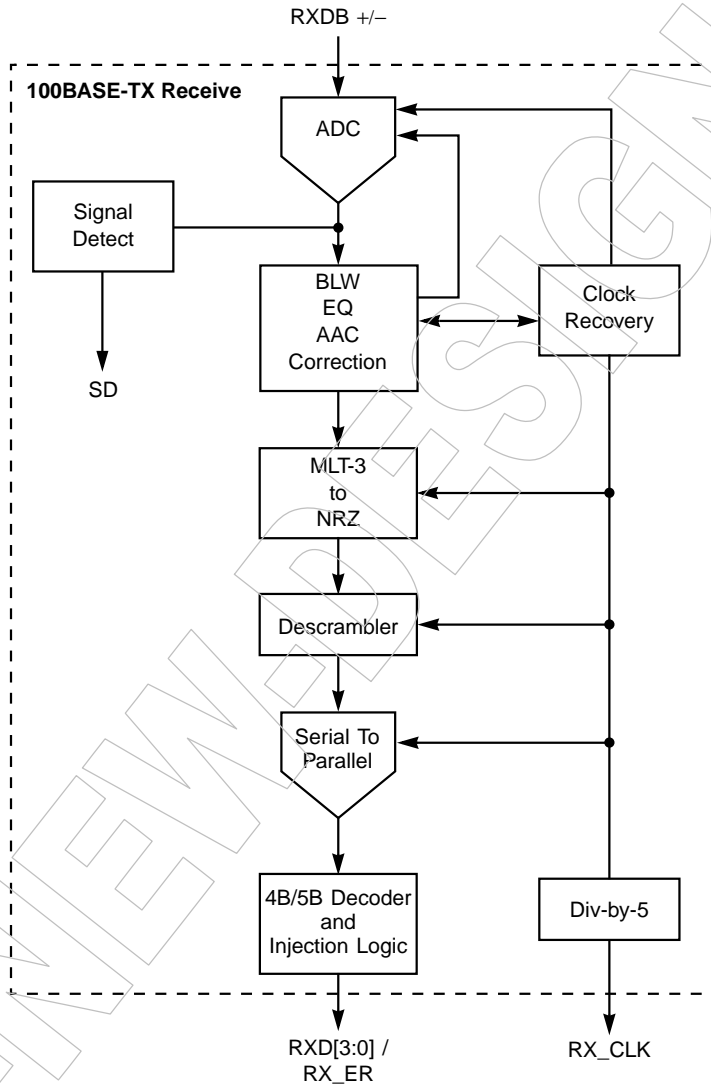
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## 2.6 100BASE-TX Receiver

The 100BASE-TX receiver consists of several functional blocks that convert the scrambled MLT-3 125 Mbits/s serial data stream to synchronous 4-bit nibble data that is provided to the MII. Because the 100BASE-TX TP-PMD is integrated with the 1000BASE-T, the differential input data RXDB+/- is routed from channel B of the AC coupling magnetics.

See [Figure 2.8](#) for a block diagram of the 100BASE-TX receive function. This provides an overview of each functional block within the 100BASE-TX receive section.

**Figure 2.8 100BASE-TX Receive Block Diagram**



The Receive section consists of the following functional blocks:

- ADC Block
- Signal Detect
- BLW/EQ/AAC Correction
- Clock Recovery Module

- MLT-3 to NRZ Decoder
- Descrambler (bypass option)
- Serial to Parallel
- 5B/4B Decoder (bypass option)
- Code Group Alignment
- 4B/5B Decoder
- Link Integrity Monitor
- Bad SSD Detection

### 2.6.1 ADC Block

The L80600 requires no external attenuation circuitry at its receive inputs, RXDB+/- . It accepts TP-PMD compliant waveforms directly, which requires only a 100  $\Omega$  termination and a simple 1:1 transformer. The analog MLT-3 signal (with noise and system impairments) is received and converted to the digital domain using an Analog to Digital Converter (ADC) to allow digital signal processing (DSP) to take place on the received signal.

### 2.6.2 Signal Detect

The signal detect function of the L80600 is incorporated to meet the specifications mandated by the ANSI FDDI TP-PMD Standard as well as the IEEE 802.3u 100BASE-TX standard for both voltage thresholds and timing parameters.

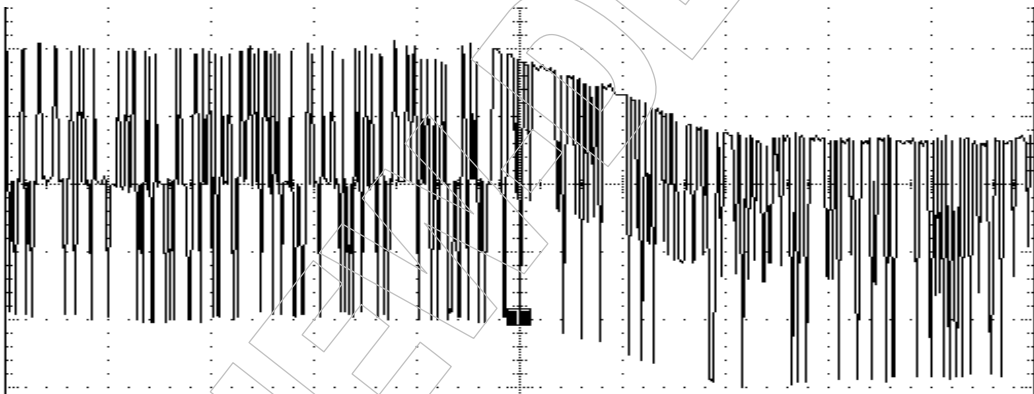
Note: The reception of fast link pulses per IEEE 802.3u AutoNegotiation by the 100BASE-X receiver does not cause the L80600 to assert signal detect.

### 2.6.3 BLW/EQ/AAC Correction

The digital data from the ADC block flows into the DSP Block (BLW/EQ/AAC Correction) for processing. The DSP block applies proprietary processing algorithms to the received signals. The algorithms are all part of an integrated DSP receiver. The primary DSP functions applied are:

- **Baseline Wander (BLW).** This can generally be defined as the change in the average DC content, over time, of an AC coupled digital transmission over a given transmission medium (copper wire). BLW results from the interaction between the low frequency components of a transmitted bitstream and the frequency response of the AC coupling component(s) within the transmission system. If the low frequency content of the digital bitstream goes below the low frequency pole of the AC coupling transformer, the droop characteristics of the transformer dominate, resulting in potentially serious BLW. The digital oscilloscope plot provided in [Figure 2.9](#) illustrates the severity of the BLW event that can theoretically be generated during 100BASE-TX packet transmission. This event consists of approximately 800 mV of DC offset for a period of 120  $\mu$ s. Left uncompensated, events such as this can cause packet loss.

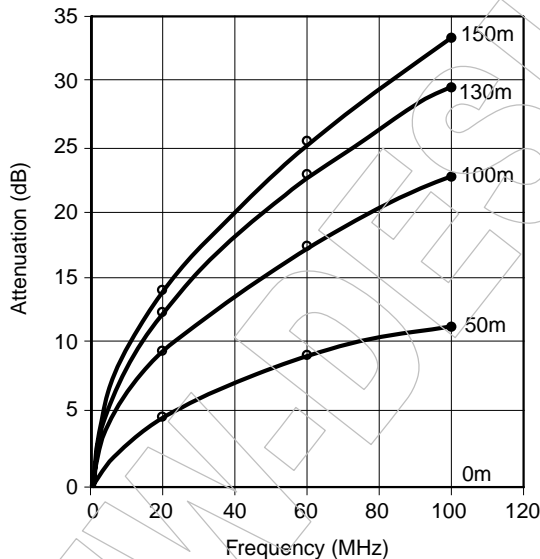
**Figure 2.9 100BASE-TX BLW Event**



- **Signal Equalization.** In high-speed twisted-pair signalling, the frequency content of the transmitted signal can vary greatly during normal operation based primarily on the randomness of the scrambled data stream and is thus susceptible to frequency dependent attenuation (see [Figure 2.10](#)). This variation in signal attenuation caused by frequency variations must be compensated for to ensure the integrity of the transmission. To ensure quality transmission when using MLT-3 encoding, the compensation must be able to adapt to various cable lengths and cable types depending on the installed environment. The selection of long cable lengths for a given implementation requires significant compensation, which over-compensates for shorter, less attenuating lengths. Conversely,

the selection of short or intermediate cable lengths requiring less compensation causes serious under-compensation for longer length cables. Therefore, the compensation or equalization must be adaptive to ensure proper conditioning of the received signal, independent of the cable length.

**Figure 2.10 EIA/TIA Attenuation vs. Frequency for 0, 50, 100, 130 and 150 Meters of CAT-5 Cable**



- Automatic Attenuation Control (AAC). This allows the DSP block to fit the resultant output signal to match the limit characteristic of its internal decision block to ensure error free sampling.

---

## 2.7 Clock Recovery Module

The Clock Recovery Module (CRM) uses the output information from the DSP Block to generate a phase corrected 125 MHz clock for the 100BASE-T receiver.

The CRM is implemented using an advanced digital Phase-Locked Loop (PLL) architecture that replaces sensitive analog circuitry. Using digital PLL circuitry allows the L80600 to be manufactured and specified to tighter tolerances.

## 2.7.1 MLT-3 to NRZ Decoder

The L80600 decodes the MLT-3 information from the DSP block to binary NRZI form and finally to NRZ data.

## 2.7.2 Descrambler

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

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

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

Synchronization of the descrambler to the original scrambling sequence (N) is achieved based on the knowledge that the incoming scrambled data stream consists of scrambled IDLE data. After the descrambler has recognized 12 consecutive IDLE code-groups, where an unscrambled IDLE code-group in 5B NRZ is equal to five consecutive ones (0b11111), it synchronizes to the receive data stream and generates unscrambled data in the form of unaligned 5B code-groups.

To maintain synchronization, the descrambler must continuously monitor the validity of the unscrambled data that it generates. To ensure this, a line state monitor and a hold timer are used to constantly monitor the synchronization status. Upon synchronization of the descrambler, the hold timer starts a 722  $\mu$ s countdown. Upon detection of sufficient IDLE code-groups (16 idle symbols) within the 722  $\mu$ s period, the hold timer resets and begins a new countdown. This monitoring operation continues indefinitely given a properly operating network connection with good signal integrity. If the line state monitor does not recognize sufficient unscrambled IDLE code-groups within the 722  $\mu$ s period, the entire descrambler is forced out of the current state of synchronization and reset in order to reacquire synchronization.

## 2.7.3 Serial to Parallel Converter

The 100BASE-X receiver includes a Serial to Parallel converter. The converter also provides code-group alignment, and operates on unaligned serial data from the descrambler (or, if the descrambler is bypassed, directly from the MLT-3 to NRZ decoder) and converts it into



5B code-group data (5 bits). Code-group alignment occurs after the J/K code-group pair is detected. Once the J/K code-group pair (0b11000 10001) is detected, subsequent data is aligned on a fixed boundary.

#### **2.7.4 4B/5B Decoder**

The code-group decoder functions as a lookup table that translates incoming 5B code-groups into 4B nibbles. The code-group decoder first detects the J/K code-group pair preceded by IDLE code-groups and replaces the J/K with MAC preamble. Specifically, the J/K 10-bit code-group pair is replaced by the nibble pair (0b0101 0b0101). All subsequent 5B code-groups are converted to the corresponding 4B nibbles for the duration of the entire packet. This conversion ceases upon the detection of the T/R code-group pair denoting the End of Stream Delimiter (ESD) or with the reception of a minimum of two IDLE code-groups.

#### **2.7.5 100BASE-X Link Integrity Monitor**

The 100BASE-X Link monitor ensures that a valid and stable link is established before enabling both the Transmit and Receive PCS layer. Signal Detect must be valid for at least 500  $\mu$ s to allow the link monitor to enter the “Link Up” state, and enable transmit and receive functions.

Signal detect can be forced active by setting Bit 4 of the ECTRL1 register 0x10. Additionally, Signal Detect can be AND’ed with the descrambler locked indication by setting Bit 3 of the EXTRL1 register. With bit 3 set, the descrambler “Locked” is required to enter the Link Up state, but only Signal Detect is required to maintain the link in the Link Up state.

#### **2.7.6 Bad SSD Detection**

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

If this condition is detected, the L80600 asserts RX\_ER and presents RXD[3:0] = 0b1110 to the MII for the cycles that correspond to received 5B code-groups until at least two IDLE code groups are detected.

Once at least two IDLE code groups are detected, RX\_ER and CRS become deasserted.

---

## 2.8 10BASE-T Functional Description

This section describes the main functions of the 10BASE-T block.

### 2.8.1 Carrier Sense

Carrier Sense (CRS) may be asserted due to receive activity after valid data is detected through the Smart Squelch function.

For 10 Mbits/s Half-Duplex operation, CRS is asserted during either packet transmission or reception.

For 10 Mbits/s Full-Duplex operation, CRS is asserted only due to receive activity.

CRS is deasserted following an end of packet.

### 2.8.2 Collision Detect and Heartbeat

A collision is detected on the twisted-pair cable when the receive and transmit channels are active simultaneously while in Half-Duplex mode.

Also after each transmission, the 10 Mbit/s block generates a Heartbeat signal by applying a 1  $\mu$ s pulse on the COL lines that go into the MAC. This signal is called the Signal Quality Error (SQE) and its function as defined by IEEE 802.3 is to assure the continued functionality of the collision circuitry.

### 2.8.3 Link Detector/Generator

The link generator is a timer circuit that generates a link pulse, as defined by the 10BASE-T specification, and sent by the transmitter. The pulse, which is 100 ns wide, is transmitted on the transmit output every 16 ms in the absence of transmit data. The pulse is used to check the integrity of the connection to the remote MAU.

The link detection circuit checks for valid pulses from the remote MAU. If valid link pulses are not received, the link detector disables the twisted-pair transmitter, receiver, and collision detection functions.

## 2.8.4 Jabber

The Jabber function disables the transmitter if the transmitter attempts to transmit a longer than legal-sized packet. The jabber timer monitors the transmitter and disables the transmission if the transmitter is active for greater than 20–30 ms. The transmitter is then disabled for the entire time that the ENDEC module's internal transmit is asserted. The transmitter signal has to be deasserted for approximately 400–600 ms (the unjab time) before the Jabber function re-enables the transmit outputs.

There is also a jabber disable bit in the 10TOPR register (bit 5), which when activated, disables the jabber function.

## 2.8.5 Transmit Driver

The 10 Mbit/s transmit driver in the L80600 uses the 100/1000 Mbits/s common driver.

---

## 2.9 ENDEC Module

The ENDEC consists of two major blocks:

- The Manchester Encoder. It accepts NRZ data from the controller, Manchester encodes it, and transmits it differentially to the transceiver through the differential transmit driver.
- The Manchester Decoder. It receives Manchester data from the transceiver, converts it to NRZ data, and recovers clock pulses and sends them to the controller.

### 2.9.1 Manchester Encoder and Differential Driver

The Manchester encoder begins operation when the Transmit Enable input (TX\_EN) goes HIGH. The encoder then converts the clock and NRZ data to Manchester data for the transceiver. As long as TX\_EN is HIGH, the Transmit Data (TXD) is encoded for the transmit-driver pair

(TX ).TXD must be valid on the rising edge of the Transmit Clock (TX\_CLK). Transmission ends when TX\_EN goes LOW. The last transition is always positive; it occurs at the center of the bit cell if the last bit is a one, or at the end of the bit cell if the last bit is a zero.

## 2.9.2 Manchester Decoder

The Manchester decoder consists of a differential receiver and a PLL to separate the Manchester encoded data stream into internal clock signals and data. Once the input exceeds the squelch requirements, Carrier Sense (CRS) is asserted off the first edge presented to the decoder. Once the decoder has locked onto the incoming data stream, it provides data (RXD) and clock (RX\_CLK) to the MAC.

The decoder detects the end of a frame when no more midbit transitions are detected. Typically, within one and a half bit times after the last bit, carrier sense (CRS) is deasserted. Receive clock stays active for at least five more bit times after CRS goes LOW, to guarantee the receive timing of the controller.

---

## 2.10 802.3u MII

The L80600 incorporates the Media Independent Interface (MII) as specified in Clause 22 of the IEEE 802.3u standard. This interface may be used to connect PHY devices to a MAC in 10/100 Mbit/s mode. This section describes both the serial MII management interface as well as the nibble wide MII data interface.

The serial management interface of the MII allows for the configuration and control of multiple PHY devices, gathering of status and error information, and the determination of the type and capabilities of the attached PHY(s).

The nibble wide MII data interface consists of a receive bus and a transmit bus, each with control signals to facilitate data transfer between the PHY and the upper layer (MAC).

### 2.10.1 Serial Management Register Access

The serial management MII specification defines a set of thirty-two 16-bit status and control registers that are accessible through the management

interface pins MDC and MDIO for 10/100/1000 Mbit/s operation. The L80600 implements all the required MII registers as well as several optional registers. These registers are fully described in [Chapter 4, “Registers.”](#) A description of the serial management access protocol follows.

## 2.10.2 Serial Management Access Protocol

The serial control interface consists of two pins, Management Data Clock (MDC) and Management Data Input/Output (MDIO). MDC has a maximum clock rate of 2.5 MHz and no minimum rate. The MDIO line is bidirectional and may be shared by up to 32 devices. The MDIO frame format is shown below in [Table 2.3](#).

**Table 2.3 Typical MDIO Frame Format**

MI Management Serial Protocol	<idle><start><op code><device addr><reg addr><turnaround><data><idle>
Read Operation	<idle><01><10><AAAA><RRRR><Z0><xxxx xxxx xxxx xxxx><idle>
Write Operation	<idle><01><01><AAAA><RRRR><10><xxxx xxxx xxxx xxxx><idle>

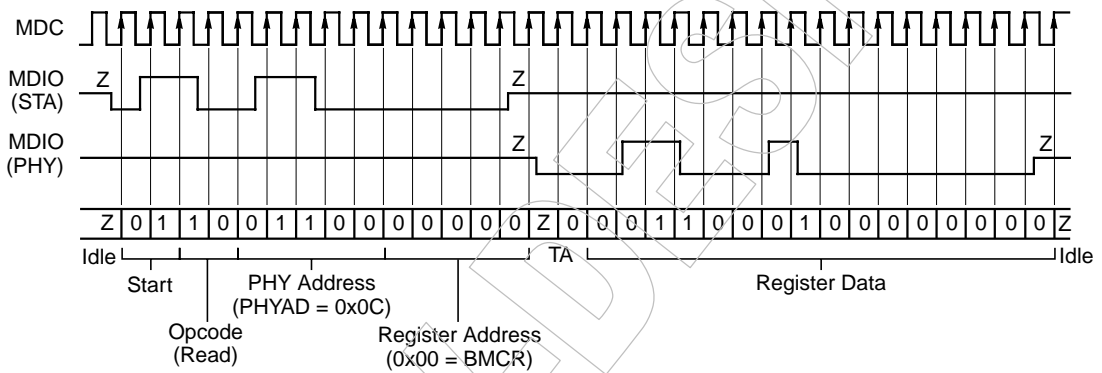
The MDIO pin requires a pull-up resistor (1.5 k $\Omega$ ) which, during IDLE and turnaround, pulls MDIO HIGH. To initialize the MDIO interface, the station management entity sends a sequence of 32 contiguous logic ones on MDIO to provide the L80600 with a sequence that can be used to establish synchronization. This preamble may be generated either by driving MDIO HIGH for 32 consecutive MDC clock cycles, or by simply allowing the MDIO pull-up resistor to pull the MDIO pin HIGH during which time 32 MDC clock cycles are provided. In addition, 32 MDC clock cycles should be used to resynchronize the device if an invalid start, opcode, or turnaround bit is detected.

The L80600 waits until it has received this preamble sequence before responding to any other transaction. Once the L80600 serial management port has been initialized, no further preamble sequencing is required until after a power-on/reset, invalid start, invalid opcode, or invalid turnaround bit has occurred.

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

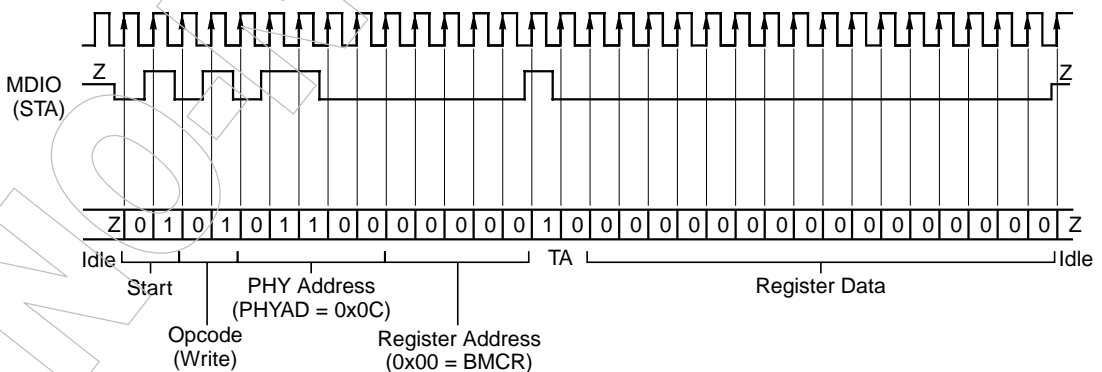
Turnaround is defined as an idle bit time inserted between the Register Address field and the Data field. To avoid contention during a read transaction, no device is allowed to actively drive the MDIO signal during the first bit of turnaround. The addressed L80600 drives the MDIO with a zero for the second bit of turnaround and follows this with the required data. [Figure 2.11](#) shows the timing relationship between MDC and the MDIO as driven/received by the Station (STA) and the L80600 (PHY) for a typical register read access.

**Figure 2.11 Typical MDC/MDIO Read Operation**



For write transactions, the station management entity writes data to the addressed L80600, eliminating the requirement for MDIO Turnaround. The turnaround time is filled by the management entity by inserting <10>. [Figure 2.12](#) shows the timing relationship for a typical MII register write access.

**Figure 2.12 Typical MDC/MDIO Write Operation**



### 2.10.3 Serial Management Preamble Suppression

The L80600 supports a Preamble Suppression mode as indicated by a one in bit 6 of the Basic Mode Status Register (BMSR, address 0x01). If the station management entity (MAC or other management controller) determines that all PHYs in the system support Preamble Suppression by returning a one in this bit, then the station management entity need not generate preamble for each management transaction.

The L80600 requires a single initialization sequence of 32 bits of preamble following power-up/hardware reset. This requirement is generally met by the mandatory pull-up resistor on MDIO in conjunction with a continuous MDC, or the management access made to determine whether Preamble Suppression is supported.

While the L80600 requires an initial preamble sequence of 32 bits for management initialization, it does not require a full 32-bit sequence between each subsequent transaction. A minimum of one idle bit between management transactions is required as specified in IEEE 802.3u.

### 2.10.4 PHY Address Sensing

The L80600 provides five PHY address pins. The information from these pins is latched into the ECTLR1 register (address 0x10, bits [10:6]) at device power-up or reset. The L80600 supports PHY Address strapping values 0 (<00000>) through 31 (<11111>). PHY Address 0 puts the device into Isolate Mode.

### 2.10.5 Nibble-Wide MII Data Interface

Clause 22 of the IEEE 802.3u specification defines the Media Independent Interface (MII). This interface includes a dedicated receive bus and a dedicated transmit bus. These two data buses, along with various control and indicate signals, allow for the simultaneous exchange of data between the L80600 and the upper layer agent (MAC).

The receive interface consists of a nibble wide data bus RXD[3:0], a receive error signal RX\_ER, a receive data valid flag RX\_DV, and a receive clock RX\_CLK for synchronous transfer of the data. The receive clock operates at 25 MHz to support 100 Mbit/s operation.

The transmit interface consists of a nibble wide data bus TXD[3:0], a transmit error flag TX\_ER, a transmit enable control signal TX\_EN, and a transmit clock TX\_CLK operating at 25 MHz.

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

### **2.10.6 Collision Detect**

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

### **2.10.7 Carrier Sense**

Carrier Sense (CRS) may be asserted during 10/100 Mbit/s operation when a valid link (SD) and two noncontiguous zeros are detected on the line.

For 10/100 Mbit/s Half-Duplex operation, CRS is asserted during either packet transmission or reception.

For 10/100 Mbit/s Full-Duplex operation, CRS is asserted only due to receive activity.

CRS is deasserted following an end of packet.

### **2.10.8 MII Isolate Mode**

The L80600 can be set to Isolate Mode by setting bit 10 in the Basic Mode Control Register (0x00) to 1.

With bit 10 in the BMCR set to one, the L80600 does not respond to packet data present at TXD[3:0], TX\_EN, and TX\_ER inputs and presents a high impedance on the TX\_CLK, RX\_CLK, RX\_DV, RX\_ER, RXD[3:0], COL, and CRS outputs. The L80600 continues to respond to all serial management transactions over the MDIO/MDC lines.



While in Isolate mode, the TXD+/- outputs are dependent on the current state of AutoNegotiation. The L80600 can AutoNegotiate or parallel detect to a specific technology depending on the receive signal at the RXD+/- inputs. A valid link can be established for RXD even when the L80600 is in Isolate mode.

The user should have a basic understanding of Clause 22 of the IEEE 802.3u standard.

---

## 2.11 Status Information

There are 9 pins available to convey status information to the user through LEDs. The 9 pins indicate link status, collision status, duplex status, activity, device speed indication, and separate indications for receive (RX) and transmit (TX) for the device. The pin functions are shown in [Table 2.4](#).

**Table 2.4      Status Pins**

Pin	Description
LED_LNK	Indicates Good Link Status for 100BASE-TX and 1000BASE-T.
LED_COL	Indicates that the PHY has detected a collision condition (simultaneous transmit and receive activity while in Half-Duplex mode).
LED_DUPLEX	Indicates that the L80600 is in Full-Duplex mode of operation.
LED_ACT	Indicates Receive or Transmit activity.
LED_10	Indicates that the PHY is in 10BASE-T mode.
LED_100	Indicate that s the PHY is in 100BASE-TX mode.
LED_1000	Indicates that the PHY is in 1000BASE-T mode.
LED_TX	Indicates that the PHY is transmitting.
LED_RX	Indicates that the PHY is receiving.

### 2.11.1 Link Establishment

For 10BASE-T, a link is established if Normal Link Pulses are detected that are separated by 16 ms or by packet data received.

For 100BASE-T, a link is established as a result of an input receive amplitude compliant with TP-PMD specifications that result in internal generation of Signal Detect. LED\_LNK is asserted after the internal Signal Detect has remained asserted for a minimum of 500  $\mu$ s. LED\_LNK is deasserted immediately following the deassertion of the internal Signal Detect.

For 1000BASE-T, a link is established as a result of training, AutoNegotiation completed, and reliable reception of signals transmitted from a remote PHY.

# Chapter 3

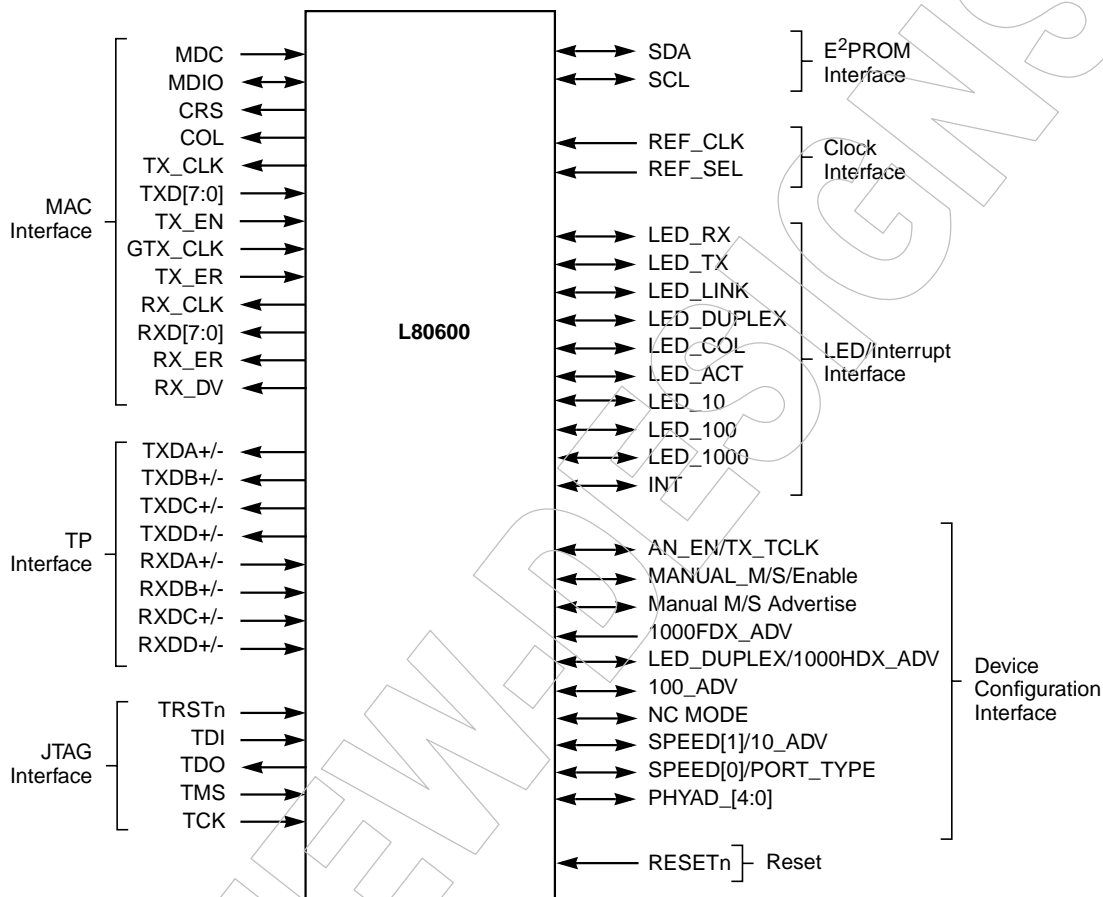
## Signals

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This chapter contains detailed descriptions of each of the L80600 signals. The chapter contains the following sections:

- [Section 3.1, “Signal Notation”](#)
- [Section 3.2, “MAC Interface”](#)
- [Section 3.3, “Twisted-Pair \(TP\) Interface”](#)
- [Section 3.4, “JTAG Interface”](#)
- [Section 3.5, “EEPROM Interface”](#)
- [Section 3.6, “Clock Interface”](#)
- [Section 3.7, “LED/Interrupt Interface”](#)
- [Section 3.8, “Device Configuration Interface”](#)
- [Section 3.9, “Reset”](#)
- [Section 3.10, “Power And Ground Pins”](#)
- [Section 3.11, “Special Connect Pins”](#)

**Figure 3.1 L80600 System Interfaces**



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## 3.1 Signal Notation

The notation convention for each of the signal descriptions given in this chapter is given in [Table 3.1](#).

**Table 3.1 Signal Notation**

Notation	Meaning
I	Input
O	Output
I/O	Bidirectional
Z	3-State
O_Z	3-State Output
I/O_Z	3-State Input/Output
S	Strapping Pin
PU	Pull-Up
PD	Pull-Down
S	Strap Option (the pin may be strapped HIGH or LOW for power-up or reset configuration options)

In addition to the notations listed in [Table 3.1](#), the pin number associated with each signal is listed in each description.

---

## 3.2 MAC Interface

The following signals allow the device to communicate with a MAC.

**MDC**

**Management Data Clock**

**I 151**

Synchronous clock to the MDIO management data input/output serial interface that may be asynchronous to the transmit and receive clocks. The maximum clock rate is 2.5 MHz. There is no minimum clock rate.

<b>MDIO</b>	<b>Management Data I/O</b>	<b>O 150</b>
	Bidirectional management instruction/data signal that may be sourced by the station management entity or the PHY. This pin requires a 1.5 kΩ pullup resistor.	
<b>CRS</b>	<b>Carrier Sense</b>	<b>O 111</b>
	Asserted HIGH to indicate the presence of carrier due to receive or transmit activity in Half-Duplex mode. This signal is not defined and is LOW for 1000BASE-T Full-Duplex mode. For 100BASE-TX Full-Duplex operation, CRS is asserted only for receive activity.	
<b>COL</b>	<b>Collision Detect</b>	<b>O 110</b>
	Asserted HIGH to indicate detection of a collision condition (simultaneous transmit and receive activity) in Half-Duplex modes. This signal is not synchronous to either MII clock (GTX_CLK, TX_CLK or RX_CLK). This signal is not defined and is LOW for Full-Duplex mode.	
<b>TX_CLK</b>	<b>Transmit Clock (100 Mbits/s)</b>	<b>O 130</b>
	Continuous clock signal generated from REF_CLK and driven by the PHY during 100 Mbit/s operation. It is used on the MII to clock all MII Transmit (TXD[7:0], TX_ER), signals into the PHY.	
	The Transmit Clock frequency is constant and the frequency is 25% of the nominal MII transmit data bit rate for parallel transfers (25 MHz) for 100BASE-TX.	
	TX_CLK should not be confused with the TX_TCLK signal.	
<b>TXD[7:0]</b>	<b>Transmit Data</b>	<b>I [135, 138:141, 144:146]</b>
	These signals carry 4B data nibbles (TXD[3:0]) during 100 Mbit/s MII mode and 8-bit data (TXD[7:0]) in 1000 Mbit/s GMII mode. They are synchronous to the Transmit Clocks (TX_CLK, GTX_CLK). TX_EN, when asserted, enables transmit data for all modes, all sourced by the controller.	
<b>TX_EN</b>	<b>Transmit Enable</b>	<b>I 134</b>
	Active HIGH input driven by the MAC when it requests transmission of the data present on the TXD lines (nibble data for 100 Mbit/s mode and 8-bit data for 1000 Mbit/s GMII mode.)	

<b>GTX_CLK</b>	<b>GMII Transmit Clock</b> <span style="float: right;"><b>I 147</b></span> This continuous clock signal is sourced from the upper level MAC to the PHY. The nominal frequency is 125 MHz, which is derived in the MAC from its 125 MHz reference clock. In most applications, it is the same referenced clock the PHY uses.
<b>TX_ER</b>	<b>Transmit Error</b> <span style="float: right;"><b>I 133</b></span> Active HIGH input during 100 Mbit/s nibble mode and 1000 Mbit/s GMII mode and forces the PHY to transmit invalid symbols. The TX_ER signal must be synchronous to the Transmit Clocks (TX_CLK and GTX_CLK).  In 4B nibble mode, assertion of Transmit Error by the controller causes the PHY to issue invalid symbols followed by HALT (H) symbols until TX_ER is deasserted.  In 1000 Mbit/s GMII mode, assertion causes the PHY to emit one or more code-groups that are not valid data or delimiter set in the transmitted frame.
<b>RX_CLK</b>	<b>Receive Clock</b> <span style="float: right;"><b>O 126</b></span> Provides the recovered following receive clocks for different modes of operation:  25 MHz nibble clock in 100 Mbit/s nibble mode. 125 MHz byte clock in 1000 Mbit/s GMII mode.
<b>RXD[7:0]</b>	<b>Receive Data</b> <span style="float: right;"><b>O [114:115, 118:121, 124:125]</b></span> These signals carry 4-bit data nibbles (RXD[3:0]) during 100 Mbit/s MII mode and 8-bit data bytes (RXD[7:0]) in 1000 Mbit/s GMII mode. They are synchronous to the Receive Clock (RX_CLK). Receive data is driven by the PHY to the controller, and is strobed by Receive Data Valid (RX_DV), which is also sourced by the PHY.
<b>RX_ER</b>	<b>Receive Error</b> <span style="float: right;"><b>O 112</b></span> In 100 Mbit/s nibble mode and 1000 Mbit/s GMII mode, this active-HIGH output indicates that the PHY has detected a Receive Error. The RX_ER signal must be synchronous with the Receive Clock (RX_CLK).
<b>RX_DV</b>	<b>Receive Data Valid</b> <span style="float: right;"><b>O 113</b></span> Asserted HIGH to indicate that valid data is present on the corresponding RXD[3:0] for 100 Mbit/s nibble mode and RXD[7:0] in 1000 Mbit/s GMII mode.

---

### 3.3 Twisted-Pair (TP) Interface

The following signals provide the means for the L80600 to communicate to the media.

**TXD[A:D]+/-    Transmit Data    O [9:10, 13:14, 39:40, 43:44]**

The TP Interface connects the L80600 to the CAT-5 cable through a single common magnetics transformer. The Transmit (TXD) and Receive (RXD) twisted-pair pins carry bit-serial data at a 125 MHz baud rate. These differential outputs are configurable to either 100BASE-TX or 1000BASE-T signalling as follows:

100BASE-TX: Transmission of 3-level MLT-3 data.

1000BASE-T: Transmission of 17-level PAM-5 with PR-shaping data.

The L80600 automatically configures the common driver outputs for the proper signal type as a result of either forced configuration or AutoNegotiation.

Note: During 10/100 Mbit/s operation, only TXDA+ and TXDA- are active

**RXD[A:D]+/-    Receive Data    I [4:5, 18:19, 34:35, 48:49]**

Differential receive signals.

Note: During 10/100 Mbit/s operation, only RXDB+ and RXDB- are active.

---

### 3.4 JTAG Interface

This section describes the JTAG signals used for device testing.

**TRSTn    Test Reset    I 156**

IEEE 1149.1 Test Reset pin. This pin is an active-LOW reset and provides for asynchronous reset of the Tap Controller. This reset has no effect on the device registers.

This pin should be tied LOW during regular chip operation.



<b>TDI</b>	<b>Test Data Input</b> <b>I 157</b> IEEE 1149.1 Test Data Input pin. This pin is the test data scanned into the device through TDI. This pin should be tied LOW during regular chip operation.
<b>TDO</b>	<b>Test Data Output</b> <b>O 158</b> IEEE 1149.1 Test Data Output pin. The most recent test results are scanned out of the device through TDO. This pin can be left floating if not used.
<b>TMS</b>	<b>Test Mode Select</b> <b>I 159</b> IEEE 1149.1 Test Mode Select pin. This pin sequences the Tap Controller (16-state FSM) to select the desired test instruction. This pin should be tied LOW during regular chip operation.
<b>TCK</b>	<b>Test Clock</b> <b>I 163</b> IEEE 1149.1 Test Clock input. This pin is the primary clock source for all test logic input and output controlled by the testing entity. This pin should be tied LOW during regular chip operation.

---

## 3.5 EEPROM Interface

The EEPROM signals are given in this section.

<b>SDA</b>	<b>Serial Data</b> <b>I/O PU 189</b> This pin is used for EEPROM data. It should be left floating if the EEPROM interface is not used.
<b>SCL</b>	<b>Serial Clock</b> <b>I/O PD 190</b> This pin is used for EEPROM clock. It should be left floating if the EEPROM interface is not used.

---

## 3.6 Clock Interface

This section describes the clock and clock select signals.

<b>REF_CLK</b>	<b>Clock Input</b>	<b>I 153</b>
	125 MHz or 25 MHz (both require $\pm 50$ ppm tolerance and less than 200 ps of jitter).	
<b>REF_SEL</b>	<b>Clock Select</b>	<b>I 154</b>
	This pin enables the use of a 125 MHz clock source to REF_CLK when left floating and enables a 25 MHz clock source when pulled LOW.	

---

## 3.7 LED/Interrupt Interface

This section describes the LED and interrupt signals. See [Section 6.5, “LED/Strapping Options”](#) for more information regarding how to use these signals and their active states.

<b>LED_RX</b>	<b>Receive Activity LED</b>	<b>I/O, S, PD 207</b>
	The Receive LED output indicates that the PHY is receiving.	
<b>LED_TX</b>	<b>Transmit Activity LED</b>	<b>I/O, S, PD 205</b>
	The Transmit LED output indicates that the PHY is transmitting.	
<b>LED_LNK</b>	<b>Good Link LED Status</b>	<b>I/O, S, PD 204</b>
	Indicates status for Good Link. The criteria for good link are:  10BASE-T: Link is established by detecting Normal Link Pulses separated by 16 ms or by packet data received.  100BASE-T: Link is established as a result of an input receive amplitude compliant with TP-PMD specifications that results in internal generation of Signal Detect. LED_LNK is asserted after the internal Signal Detect has remained asserted for a minimum of 500 $\mu$ s. LED_LNK is deasserted immediately following the deassertion of the internal Signal Detect.	

1000BASE-T: Link is established as a result of training, AutoNegotiation completed, valid 1000BASE-T link established and reliable reception of signals transmitted from a remote PHY is established.

## **LED\_DUPLEX**

### **Duplex LED Status** **I/O, S, PD 185**

If LED\_DUPLEX is asserted, it indicates the Full-Duplex mode of operation is active. If it is deasserted, it indicates that the device is in Half-Duplex mode.

## **LED\_COL**

### **Collision LED Status** **I/O, S, PD 201**

Indicates that the PHY has detected a collision condition (simultaneous transmit and receive activity while in Half-Duplex mode).

## **LED\_ACT**

### **TX/RX Activity LED Status** **I/O, S, PU 200**

Indicates either transmit or receive activity.

## **LED\_10**

### **10 Mbit/s Speed LED** **I/O, S, PD 180**

If LED\_10 is asserted, the current speed of operation is 10 Mbits/s.<sup>1</sup>

## **LED\_100**

### **100 Mbit/s Speed LED** **I/O, S, PU 181**

If LED\_100 is asserted, the current speed of operation is 100 Mbits/s.<sup>1</sup>

## **LED\_1000**

### **1000 Mbit/s Speed LED** **I/O, S, PU 184**

If LED\_1000 is asserted, the current speed of operation is 1000 Mbits/s.<sup>1</sup>

## **INT**

### **Interrupt** **I/O, S, PD 208**

Generates a interrupt upon PHY status changes. The interrupt function is enabled in the extended register sets.

See [Section 5.10, "Firmware Interrupt."](#)

---

1. Each of the Speed LED signals (LED\_10, LED\_100, LED\_1000) is AND'ed with the LED\_LNK signal. The signals are asserted only if the PHY has established a good link at the speed indicated.

---

## 3.8 Device Configuration Interface

This section describes the strap signals that are used to configure the device.

### AN\_EN/TX\_TCLK

#### AutoNegotiation Enable

I/O, S, PU 192

This input sets the value of the AutoNegotiation Enable bit (register 0 bit-12).

HIGH = enable AutoNegotiation

LOW = disable AutoNegotiation

#### TX\_TCLK

This is an output used to measure jitter during Test Mode 3 as described by IEEE 802.3ab specification. TX\_TCLK should not be confused with the TX\_CLK signal.

### MANUAL\_M/S\_ENABLE

#### Manual Master/Slave Enable

I/O, S, PD 195

This input sets the value of manual the Master/Slave Configuration Enable bit ([1000BASE-T Control Register \(1KTCR\) Address 0x09](#) bit-12).

HIGH = enable manual Master/Slave Configuration

LOW = disable manual Master/Slave Configuration

### MANUAL\_M/S\_ADVERTISE

#### Manual Master/Slave Config Value

I/O, S, PD 191

This input sets the value of the Master/Slave Advertise bit ([1000BASE-T Control Register \(1KTCR\) Address 0x09](#) bit-11).

HIGH = configure PHY to Master during Master/Slave negotiation

LOW = configure PHY to Slave during Master/Slave negotiation.

This bit is only used if the MANUAL\_M/S\_ENABLE pin is HIGH.

### **1000FDX\_ADV**

#### **AUTO\_Negotiation 1000 FDX Advertise I, S, PU 184**

The value strapped during power-on reset determines the mode of operation advertised during AutoNegotiation.

HIGH = advertise 1000 Mbits/s Full-Duplex capability

LOW = do not advertise 1000 Mbits/s Full-Duplex capability

### **LED\_DUPLEX/1000HDX\_ADV**

**I/O, S, PD 185**

#### **Duplex Mode Select/1000 Mbits/s Half-Duplex Advertise**

This strap option has two functions, depending on whether AutoNegotiation is enabled or not:

If AutoNegotiation is disabled:

HIGH = Full-Duplex mode of operation

LOW = Half-Duplex mode of operation.

If AutoNegotiation is enabled:

HIGH = advertise 1000 Mbit/s HDX capability

LOW = do not advertise 1000 Mbit/s HDX capability.

### **100\_ADV**

#### **100 Mbit/s Full/Half-Duplex Advertise I/O, S, PU 181**

This strap option pin determines if 100 Mbit/s Full/Half-Duplex capability is advertised during AutoNegotiation.

HIGH = advertise both Full and Half-Duplex capability

LOW = advertise neither 100 Mbit/s capability

### **NC\_MODE**

#### **Noncompliant Mode**

**I/O, S, PD 196**

This mode allows interoperability with certain Non-IEEE compliant 1000BASE-T transceivers.

HIGH = Enables Noncompliant mode

LOW = Disables Noncompliant mode

### **SPEED[1]/10\_ADV**

**I/O, S, PD 180**

### **SPEED[0]/PORT\_TYPE**

#### **SPEED SELECT**

**I/O, S, PD 208**

These two strap option pins have two different functions depending on whether AutoNegotiation is enabled or not.

AutoNegotiation disabled (forced speed mode):

<b>SPEED[1:0]</b>	<b>Mode</b>
00	10BASE-T
01	100BASE-TX
10	1000BASE-T
11	Reserved

AutoNegotiation Enabled (advertised capability)

SPEED[1]/10\_ADV = HIGH: advertise 10 Mbit/s capability (both Full-Duplex and Half-Duplex.)

SPEED[1]/10\_ADV = LOW: do not advertise 10 Mbit/s capability (neither Full-Duplex nor Half-Duplex is advertised.)

SPEED[0]/PORT\_TYPE = HIGH: advertise MultiNode (Repeater or Switch).

SPEED[0]/PORT\_TYPE = LOW: advertise Single-Node mode (NIC).

**PHYAD\_0**

**I/O, S, PU 200**

**PHYAD\_1:4**

**PHY ADDRESS [4:0]**

**I/O, S, PD 201, 204, 205, 207**

The L80600 provides five PHY address-sensing pins for multiple applications. The five PHYAD[4:0] are registered as inputs at reset with PHYAD\_4 being the MSB of the 5-bit PHY address.

---

## 3.9 Reset

RESETn	Reset	I 164
	The active LOW RESETn input allows for hard-reset, soft-reset, and 3-state output reset combinations. The RESETn input must be LOW for a minimum of 140 $\mu$ s.	

---

## 3.10 Power And Ground Pins

### 3.10.1 TTL/CMOS Input/Output Supply

IO_VDD	3.3 V I/O Supply	58, 64, 73, 79, 87, 93, 102, 109, 117, 123, 132, 143, 149, 167, 178, 187, 193, 202
IO_VSS	I/O Ground	57, 63, 72, 78, 86, 92, 101, 108, 116, 122, 131, 142, 148, 168, 179, 188, 194, 203

### 3.10.2 Transmit/Receive Supply

CD#_AVDD	3.3 V Common Driver Supply	8, 15, 38, 45
CD#_AGND	Common Driver Ground	11, 12, 41, 42
R#_AVDD#	3.3 V Receiver Analog Supply	2, 6, 17, 21, 32, 36, 47, 51
R#_AGND#	Receiver Analog Ground	3, 7, 16, 20, 33, 37, 46, 50
R#_ASUB	Receiver Substrate Ground	1, 22, 31, 52

### 3.10.3 Internal Supply Pairs

CORE_VDD	1.8 V Digital Supply	69, 83, 98, 129, 137, 160, 171, 182, 197
CORE_VSS	Digital Ground	68, 82, 97, 128, 136, 161, 172, 183, 198
CORE_SUB	Substrate Ground	67, 96, 127, 162, 173, 199

<b>PGM_AVDD</b>	<b>3.3 V PGM/CGM Supply</b>	<b>27</b>
	It is recommended that a low pass RC filter (18–22 $\Omega$ resistor and a 22 $\mu$ F capacitor) be connected to this pin.	
<b>PGM_AGND</b>	<b>PGM/CGM Ground</b>	<b>28</b>
<b>BG_SUB</b>	<b>BG Substrate Ground</b>	<b>26</b>
<b>BG_AVDD</b>	<b>3.3 V BG Supply</b>	<b>23</b>
<b>BG_AGND</b>	<b>BG Ground</b>	<b>25</b>
<b>SHR_VDD</b>	<b>3.3 V Share Logic Supply</b>	<b>29</b>
<b>SHR_GND</b>	<b>Share Logic Ground</b>	<b>30</b>
<b>OSC_VDD</b>	<b>3.3 V Oscillator Supply</b>	<b>155</b>
<b>OSC_VSS</b>	<b>Oscillator Ground</b>	<b>152</b>

### 3.11 Special Connect Pins

<b>BG_REF</b>	<b>Internal Reference Bias</b>	<b>24</b>
	Requires connection to ground using a 9.31 k $\Omega$ resistor.	
<b>TEST</b>		<b>186, 206</b>
	These pins should be tied to 3.3 V.	
<b>SI, SO</b>		<b>104,105</b>
	These two pins should be left floating.	
<b>RESERVE_FLOAT</b>	<b>53-56, 59-62, 65, 66, 70, 71, 74-77, 80, 81, 84, 85, 88-91, 94, 95, 99, 100, 103,106, 107</b>	
	These pins are reserved and are to be left floating.	
<u>Note:</u>	Please also see next signal. There are two sets of reserved pins: one set needs to be pulled-down to GND, while the other set needs to be left floating).	
<b>RESERVE_GND</b>	<b>165, 166, 169, 170,174,175, 176,177</b>	
	These pins are reserved and need to be tied to GND.	
<b>RESERVE_FLOAT</b>	<b>59, 60, 61, 62, 65, 66, 70, 71, 74, 75, 76, 77, 80, 81, 84, 85, 88, 89, 90, 91, 94, 95, 99, 100, 103, 106, 107</b>	
	These pins are reserved and need to be left floating.	



# Chapter 4

## Registers

This chapter describes the registers in the L80600. It contains the following sections:

- [Section 4.1, “Register Notation”](#)
- [Section 4.2, “Standard Registers”](#)
- [Section 4.3, “Extended Registers”](#)

### 4.1 Register Notation

In addition to the bit default value, the notations shown in [Table 4.1](#) appear in each register bit description as appropriate.

**Table 4.1 Register Notation**

Notation	Meaning
<b>RW</b>	Read Write access
<b>RO</b>	Read Only access
<b>L(H)</b>	Latched and held until read, based upon the occurrence of the corresponding event
<b>SC</b>	Register sets on event occurrence and self-clears when event ends
<b>P</b>	Register bit is permanently set to a default value
<b>COR</b>	Clear on read
<b>Strap[x]</b>	Default value read from strapped value at device pin at reset, where x may take the following values: [0] internal pull-down [1] internal pull-up [Z] no internal pull-up or pull-down (floating)

## 4.2 Standard Registers

The standard registers are summarized in [Table 4.2](#). Detailed descriptions of each register follow the table.

**Table 4.2 L80600 Standard Register Map**

Offset		Access	Abbreviation	Description
Hex	Decimal			
0x00	0	RW	BMCR	Basic Mode Control Register
0x01	1	RO	BMSR	Basic Mode Status Register
0x02	2	RO	PHYIDR1	PHY Identifier Register #1
0x03	3	RO	PHYIDR2	PHY Identifier Register #2
0x04	4	RW	ANAR	AutoNegotiation Advertisement Register
0x05	5	RW	ANLPAR	AutoNegotiation Link Partner Ability Register
0x06	6	RW	ANER	AutoNegotiation Expansion Register
0x07	7	RW	ANNPTR	AutoNegotiation Next Page TX
0x08	8	RW	ANNPRR	AutoNegotiation Next Page RX
0x09	9	RW	1KTCR	1000BASE-T Control Register
0x0A	10	RO	1KSTSR	1000BASE-T Status Register
0x0B–0x0E	11–14	RO	Reserved	Reserved
0x0F	15	RO	1KSCR	1000BASE-T Extended Status Register
0x10	16	RW	STRAP_REG	Strap Options Register
0x11	17	RO	PHY_SUP	PHY Support
0x12–0x14	18–20	RO	Reserved	Reserved

**Table 4.2 L80600 Standard Register Map (Cont.)**

Offset		Access	Abbreviation	Description
Hex	Decimal			
0x15	21	RW	MDIX_SEL	MDIX Select
0x16	22	RW	EXPAND_MEM	Expanded Memory Access
0x17–0x1C	23–28	RO	Reserved	Reserved
0x1D	29	RW	EXP_MEM_DAT	Expanded Memory Data
0x1E	30	RW	EXP_MEM_ADD	Expanded Memory Address
0x1F	31	RO	Reserved	Reserved

### 4.2.1 Basic Mode Register (BMCR) Address 0x00

15	14	13	12	11	10	9	8
Reset	Loopback	Speed[0]	AN_ENable	Power_Down	Isolate	Restart_AN	Duplex
7	6	5	0				
Collision Test	Speed[1]	Reserved					

**Reset** **0, RW/SC 15**

1 = Initiate software reset or indicates reset in process.  
 0 = Normal operation.

This bit sets the status and control registers of the PHY to their default states. The bit is self-clearing and returns a value of 1 until the reset process is complete (approximately 1.2 ms for reset duration). Reset is finished once the AutoNegotiation process has begun or the device has entered its forced mode.

**Loopback** **0, RW 14**

1 = Loopback enabled.  
 0 = Normal operation.

The loopback function enables MII/GMII transmit data to be routed to the MII/GMII receive data path.

Setting this bit may cause the descrambler to lose synchronization and produce a 500  $\mu$ s “dead time” before any valid data appears at the MII receive outputs in 100 Mbits/s mode.

**Speed[0]** **Strap Pin 208 0, RW 13**

**Speed Select**

When AutoNegotiation is disabled, bits 6 (Speed[1]) and 13 (Speed[0]) select device speed selection according to the table below:

Speed[1:0]	Speed Mode
0b11	Reserved
0b10	1000 Mbits/s
0b01	100 Mbits/s
0b00	10 Mbits/s

The default value of this bit is the strap value of pin 208 during reset/power-on (provided the AN\_EN pin is LOW).

<b>AN_Enable</b>	<b>AutoNegotiation Enable</b>	<b>Strap [1], RW 12</b>
	1 = AutoNegotiation Enabled. Bits 6, 8, and 13 of this register are ignored when this bit is set.	
	0 = AutoNegotiation Disabled. Bits 6, 8, and 13 determine the link speed and mode.	
<b>Power_Down</b>	<b>Power Down</b>	<b>0, RW 11</b>
	1 = Power down (only the Management Interface and logic are active).	
	0 = Normal operation.	
<b>Isolate</b>	<b>Isolate</b>	<b>0, RW 10</b>
	1 = Isolates the Port from the MII with the exception of the serial management. When this bit is asserted, the L80600 does not respond to TXD[3:0], TX_EN, or TX_ER inputs, and it presents a high-impedance on the TX_CLK, RX_CLK, RX_DV, RX_ER, RXD[3:0], COL, and CRS outputs.	
	0 = Normal operation.	
<b>Restart_AN</b>	<b>Restart AutoNegotiation</b>	<b>0, RW, SC 9</b>
	1 = Restart AutoNegotiation. Reinitiates the AutoNegotiation process. If AutoNegotiation is disabled (bit 12 = 0), this bit is ignored. This bit is self-clearing and returns a value of 1 until AutoNegotiation is initiated, whereupon it self-clears. Operation of the AutoNegotiation process is not affected when the management entity clears this bit.	
	0 = Normal operation.	
<b>Duplex</b>	<b>Duplex Mode</b>	<b>Strap [1], RW 8</b>
	1 = Full-Duplex operation. Duplex selection is allowed <u>only</u> when AutoNegotiation is disabled (bit 12 = 0).	
	0 = Half-Duplex operation.	

**Collision Test Collision Test****0, RW 7**

1 = Collision test enabled.

When set, this bit causes the COL signal to be asserted in response to the assertion of TX\_EN within 512 bit times. The COL signal is deasserted within 4 bit times in response to the deassertion of TX\_EN.

0 = Normal operation.

**Speed[1]****Speed Select****Strap Pin 180 0, RW 6**

See the description for bit 13.

The default value of this bit is the strap value during reset/power-on (provided the AN\_EN pin is LOW).

**Reserved****0, RO [5:0]**

Reserved by IEEE: Write ignored, read as 0.

**4.2.2 Basic Mode Status Register (BMSR) Address 0x01**

15	14	13	12	11	10	9	8
100BASE-T4	100BASE-TX Full-Duplex	100BASE-TX Half-Duplex	10BASE-T Full-Duplex	10BASE-T Half-Duplex	100BASE-T2 Full-Duplex	100BASE-T2 Half-Duplex	100BASE-T Extended Status
7	6	5	4	3	2	1	0
Reserved	Preamble Suppression	AutoNegotiation Complete	Remote Fault	AutoNegotiation Ability	Link Status	Jabber Detect	Extended Capability

**100BASE-T4 100BASE-T4 Capable****0, RO 15**

1 = Device able to operate in 100BASE-T4 mode.

0 = Device not able to operate in 100BASE-T4 mode.

The L80600 does not support 100BASE-T4 mode. This bit should always be read back as 0.

**100BASE-TX Full-Duplex****100BASE-TX Full-Duplex Capable****1, RO 14**

1 = Device able to operate in 100BASE-TX Full-Duplex mode.

0 = Device unable to operate in 100BASE-TX Full-Duplex mode.

### **100BASE-TX Half-Duplex**

#### **100BASE-TX Half-Duplex Capable**

**1, RO 13**

1 = Device able to operate in 100BASE-TX Half-Duplex mode.

0 = Device unable to operate in 100BASE-TX Half-Duplex mode.

### **10BASE-T Full-Duplex**

#### **10BASE-T Full-Duplex Capable**

**0, RO 12**

1 = Device able to operate in 10BASE-T Full-Duplex mode.

0 = Device unable to operate in 10BASE-T Full-Duplex mode.

### **10BASE-T Half-Duplex**

#### **10BASE-T Half-Duplex Capable**

**0, RO 11**

1 = Device able to operate in 10BASE-T Half-Duplex mode.

0 = Device unable to operate in 10BASE-T Half-Duplex mode.

### **100BASE-T2 Full-Duplex**

#### **100BASE-T2 Full-Duplex Capable**

**0, RO 10**

1 = Device able to operate in 100BASE-T2 Full-Duplex mode.

0 = Device unable to operate in 100BASE-T2 Full-Duplex mode.

The L80600 does not support 100BASE-T2 mode. This bit should always be read back as 0.

### **100BASE-T2 Half-Duplex**

#### **100BASE-T2 Half-Duplex Capable**

**0, RO 9**

1 = Device able to operate in 100BASE-T2 Half-Duplex mode.

0 = Device unable to operate in 100BASE-T2 Half-Duplex mode.

The L80600 does not support 100BASE-T2 mode. This bit should always be read back as 0.

## **1000BASE-T Extended Status**

### **1000BASE-T Extended Status Register** **1, RO 8**

1 = Device supports Extended Status Register 0x0F (15).

0 = Device does not support Extended Status Register 0x0F (15).

### **Reserved**

**0, RO 7**

Reserved by IEEE: Write ignored, read as 0.

## **Preamble Suppression**

### **Preamble Suppression Capable** **1, RO 6**

1 = Device able to perform management transaction with preamble suppressed (32-bits of preamble needed only once after reset, invalid opcode, or invalid turnaround).

## **AutoNegotiation Complete**

**0, RO 5**

1 = AutoNegotiation process complete and contents of registers 5, 6, 7, and 8 are valid.

0 = AutoNegotiation process not complete.

## **Remote Fault**

**0, RO 4**

1 = Remote Fault condition detected (cleared on read or by reset). Fault criteria: Far End Fault Indication or notification from Link Partner of Remote Fault.

0 = No remote fault condition detected.

## **AutoNegotiation Ability**

### **Auto Configuration Ability** **1, RO 3**

1 = Device is able to perform AutoNegotiation.

0 = Device is not able to perform AutoNegotiation.

## **Link Status**

### **Link Lost Since Last Read Status** **0, RO 2**

1 = Link was good since last read of this register. (10/100/1000 Mb/s operation).

0 = Link was lost since last read of this register.

The occurrence of a link failure condition causes the Link Status bit to clear. Once cleared, this bit may only be set by establishing a good link condition and a read using the management interface.

This bit does not indicate the link status, but rather if the link was lost since it was last read. For actual link status, either this register should be read twice, or the **PHY**



Support Register (PHY\_SUP) Address 0x11 (17) bit 2 should be read.

**Jabber Detect**

**0, RO 1**

Set to 1 if 10BASE-T Jabber detected locally.

1 = Jabber condition detected.

0 = No Jabber.

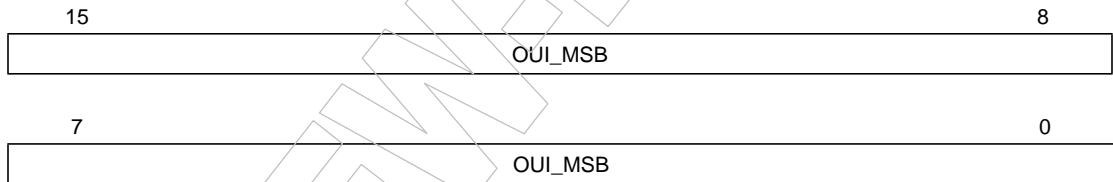
**Extended Capability**

**1, RO 0**

1 = Extended register capable.

### 4.2.3 PHY Identifier Register #1 (PHYIDR1) Address 0x02

PHY Identifier Register #1 (PHYIDR1) Address 0x02 and PHY Identifier Register #2 (PHYIDR2) Address 0x03 together form a unique identifier for the L80600. The Identifier consists of a concatenation of the Organizationally Unique Identifier (OUI), the vendor's model number and the model revision number. A PHY may return a value of zero in each of the 32 bits of the PHY Identifier if desired. The PHY Identifier is intended to support network management. The assigned OUI is 0x080017.

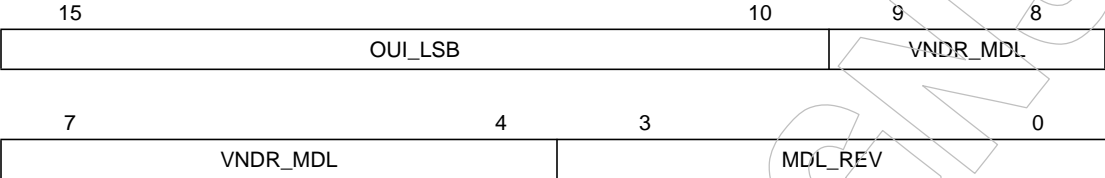


**OUI\_MSB**

**OUI Most Significant Bits <0010\_0000\_0000\_0000>, RO [15:0]**

Bits 3 to 18 of the OUI (0x080017) are stored in bits 15 to 0, respectively, of this register. The most significant two bits of the OUI are ignored (the IEEE standard refers to these as bits 1 and 2).

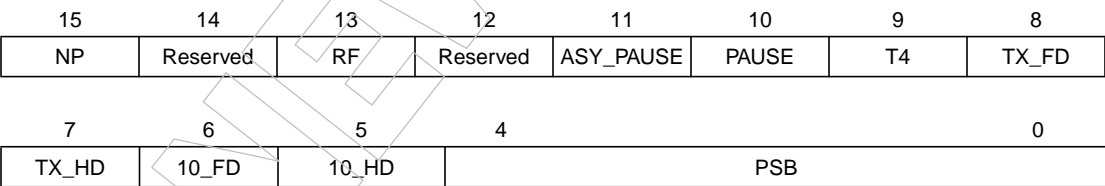
#### 4.2.4 PHY Identifier Resister #2 (PHYIDR2) Address 0x03



- OUI\_LSB**      **OUI Least Significant Bits**      **<01\_0111>, RO [15:10]**  
 Bits 19 to 24 of the OUI (0x080017) are mapped to bits 15 to 10, respectively, of this register.
- VNDR\_MDL**      **Vendor Model Number**      **<0b00\_0110>, RO [9:4]**  
 The six bits of vendor model number are mapped to bits 9 to 4 (most significant bit to bit 9).
- MDL\_REV**      **Model Revision Number**      **<0b0001>, RO [3:0]**  
 Four bits of the vendor model revision number are mapped to bits 3 to 0 (most significant bit to bit 3). This field is incremented for all major device changes.

#### 4.2.5 AutoNegotiation Advertisement Register (ANAR) Address 0x04

This register contains the advertised abilities of the device as they will be transmitted to the device's link partner during AutoNegotiation.



- NP**      **Next Page Indication**      **0, RO 15**  
 1 = Next Page Transfer desired.  
 0 = Next Page Transfer not desired.  
 See [Section 6.9.3, "Next Page," page 6-16.](#)
- Reserved**      **0, RO 14**  
 Reserved by IEEE. Writes are ignored, read as 0.

<b>RF</b>	<b>Remote Fault</b>	<b>0, RO 13</b>
	1 = Advertises that this device has detected a Remote Fault.	
	0 = No Remote Fault detected.	
<b>Reserved</b>		<b>0, RO 12</b>
	Reserved for Future IEEE use. Write as 0, read as 0.	
<b>ASY_PAUSE</b>	<b>Asymmetrical Pause</b>	<b>0, RO 11</b>
	1 = MAC/Controller supports Asymmetrical Pause direction.	
	0 = MAC/Controller does not support Asymmetrical Pause direction.	
	See <a href="#">Section 6.9.2, “Asymmetrical Pause,”</a> page 6-15.	
<b>PAUSE</b>		<b>0, RW 10</b>
	1 = MAC/Controller supports Pause frames.	
	0 = MAC/Controller does not support Pause frames.	
<b>T4</b>	<b>100BASE-T4 Support</b>	<b>0, RO 9</b>
	0 = No support for 100BASE-T4.	
	The L80600 does not support 100BASE-T4 mode. This bit should always be read back as 0.	
<b>TX_FD</b>	<b>100BASE-TX Full-Duplex Support</b>	<b>Strap Pin 181 1, RW 8</b>
	1 = 100BASE-TX Full-Duplex is supported by the local device.	
	0 = 100BASE-TX Full-Duplex not supported.	
	The default value of this bit is the strap value during reset/power-on (provided the AN_EN pin is HIGH).	
<b>TX_HD</b>	<b>100BASE-TX Support</b>	<b>Strap Pin 181 1, RW 7</b>
	1 = 100BASE-TX is supported by the local device.	
	0 = 100BASE-TX not supported.	
	The default value of this bit is the strap value during reset/power-on (provided the AN_EN pin is HIGH).	
<b>10_FD</b>	<b>10BASE-T Full-Duplex Support</b>	<b>Strap Pin 180 0, RW 6</b>
	1 = 10BASE-T Full-Duplex is supported.	
	0 = 10BASE-T Full-Duplex is not supported.	

The default value of this bit is the strap value of pin 180 during reset/power-on (provided the AN\_EN pin is HIGH).

**10\_HD**      **10BASE-T Support**      **Strap Pin 180 0, RW 5**  
 1 = 10BASE-T is supported.

0 = 10BASE-T is not supported.

**PSB**      **Protocol Selection Bits**      **<0b00001>, RO [4:0]**  
 These bits contain the binary encoded protocol selector supported by this port. <0b00001> indicates that this device supports IEEE 802.3u.

## 4.2.6 AutoNegotiation Link Partner Ability Register (ANLPAR) Address 0x05

This register contains the advertised abilities of the Link Partner as received during AutoNegotiation.

15	14	13	12	11	10	9	8
NP	ACK	RF	Reserved	ASY_PAUSE	PAUSE	T4	TX_FD
7	6	5	4	PSB			
TX	10_FD	10					0

**NP**      **Next Page Indication**      **0, RO 15**  
 0 = Link Partner does not desire Next Page Transfer.  
 1 = Link Partner desires Next Page Transfer.

**ACK**      **Acknowledge**      **0, RO 14**  
 1 = Link Partner acknowledges reception of the ability data word.  
 0 = Not acknowledged.

The device's AutoNegotiation state machine automatically controls this bit based on the incoming FLP bursts. Software should not attempt to write to this bit.

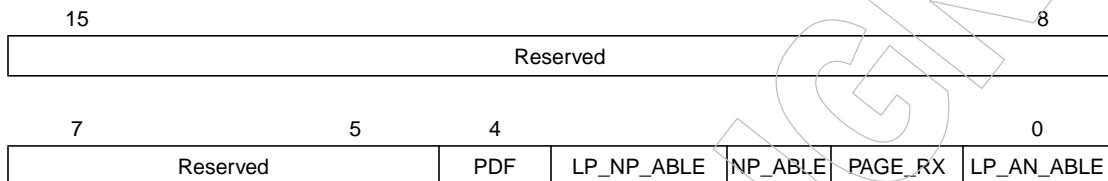
**RF**      **Remote Fault**      **0, RO 13**  
 1 = Remote Fault indicated by Link Partner.  
 0 = No Remote Fault indicated by Link Partner.

**Reserved**      **0, RO 12**  
 Reserved for Future IEEE use. Write as 0, read as 0.

<b>ASY_PAUSE</b>	<b>Asymmetrical Pause</b>	<b>0, RO 11</b>
	1 = Link Partner supports Asymmetrical Pause direction.	
	0 = Link Partner does not support Asymmetrical Pause direction.	
<b>PAUSE</b>		<b>0, RO 10</b>
	1 = Link Partner supports Pause frames.	
	0 = Link Partner does not support Pause frames.	
<b>T4</b>	<b>100BASE-T4 Support</b>	<b>0, RO 9</b>
	1 = 100BASE-T4 is supported by the Link Partner.	
	0 = 100BASE-T4 not supported by the Link Partner.	
<b>TX_FD</b>	<b>100BASE-TX Full-Duplex Support</b>	<b>0, RO 8</b>
	1 = 100BASE-TX Full-Duplex is supported by the Link Partner.	
	0 = 100BASE-TX Full-Duplex not supported by the Link Partner.	
<b>TX</b>	<b>100BASE-TX Support</b>	<b>0, RO 7</b>
	1 = 100BASE-TX is supported by the Link Partner.	
	0 = 100BASE-TX not supported by the Link Partner.	
<b>10_FD</b>	<b>10BASE-T Full-Duplex Support</b>	<b>0, RO 6</b>
	1 = 10BASE-T Full-Duplex is supported by the Link Partner.	
	0 = 10BASE-T Full-Duplex not supported by the Link Partner.	
<b>10</b>	<b>10BASE-T Half-Duplex Support</b>	<b>0, RO 5</b>
	1 = 10BASE-T Half-Duplex is supported by the Link Partner.	
	0 = 10BASE-T Half-Duplex not supported by the Link Partner.	
<b>PSB</b>	<b>Protocol Selection Bits</b>	<b>&lt;0b00000&gt;, RO [4:0]</b>
	Link Partners's binary encoded protocol selector.	

## 4.2.7 AutoNegotiate Expansion Register (ANER) Address 0x06

This register contains additional Local Device and Link Partner status information.



**Reserved** **0, RO [15:5]**

Reserved by IEEE. Writes ignored, read as 0.

**PDF** **Parallel Detection Fault** **0, RO 4**

1 = A fault has been detected through the Parallel Detection function.

0 = A fault has not been detected through the Parallel Detection function.

**LP\_NP\_ABLE** **Link Partner Next Page Able** **0, RO 3**

1 = Link Partner supports Next Page negotiation.

0 = Link Partner does not support Next Page negotiation.

**NP\_ABLE** **Next Page Able** **1, RO 2**

1 = local device is able to send additional "Next Pages".

0 = local device is not able to send additional "Next Pages".

**PAGE\_RX** **Link Code Word Page Received** **0, RO 1**

1 = Link Code Word has been received. The bit is cleared when this register is read.

0 = Link Code Word has not been received.

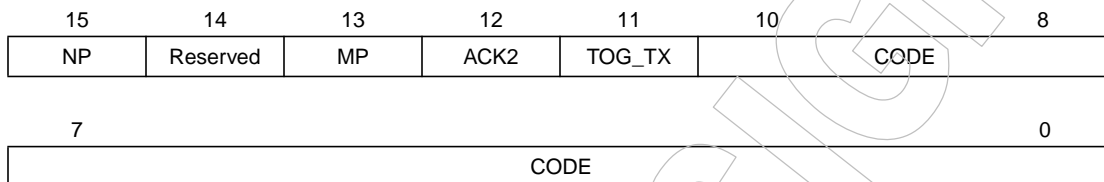
**LP\_AN\_ABLE** **Link Partner AutoNegotiation Able** **0, RO 0**

1 = Indicates that the Link Partner supports AutoNegotiation.

0 = Indicates that the Link Partner does not support AutoNegotiation.

## 4.2.8 AutoNegotiation Next Page Transmit Register (ANNPTR) Address 0x07

This register contains the Next Page information sent by this device to its Link Partner during AutoNegotiation.



**NP** **Next Page Indication** **1, RW 15**

1 = Another Next Page desired.

0 = No other Next Page Transfer desired.

Does not conform to IEEE specifications. See [Section 6.9.3, "Next Page," page 6-16](#) for more information.

**Reserved** **0, RO 14**

Reserved by IEEE. Writes ignored, read as 0.

**MP** **Message Page** **1, RO 13**

1 = Message Page.

0 = Unformatted Page.

**ACK2** **Acknowledge2** **0, RO 12**

1 = Will comply with message.

0 = Cannot comply with message.

ACK2 is used by the next page function to indicate that the Local Device has the ability to comply with the message received.

**TOG\_TX** **Toggle** **0, RO 11**

1 = Value of toggle bit in previously transmitted Link Code Word was logic 0.

0 = Value of toggle bit in previously transmitted Link Code Word was logic 1.

Toggle is used by the Arbitration function within AutoNegotiation to ensure synchronization with the Link Partner during Next Page exchange. This bit must always

take the opposite value of the Toggle bit in the previously exchanged Link Code Word.

## CODE

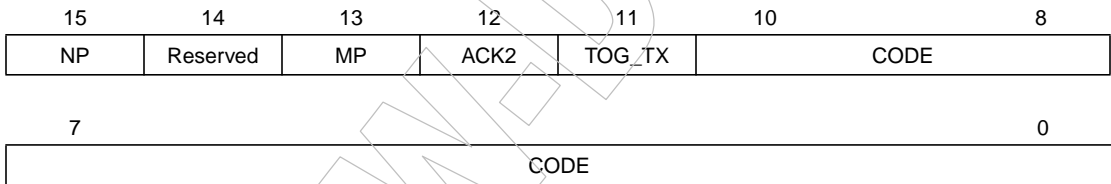
**Code Field** <0b000\_0000\_1000>, RO [10:0]

This field represents the code field of the next page transmission. If the MP bit is set (bit 13 of this register), the code is interpreted as a “Message Page”, as defined in annex 28C of IEEE 802.3u. Otherwise, the code is interpreted as an “Unformatted Page”, and the interpretation is application specific.

The default value of CODE represents a Null Page as defined in Annex 28C of IEEE 802.3u.

### 4.2.9 AutoNegotiation Next Page Receive Register (ANNPRR) Address 0x08

This register contains the Next Page information sent by this device to its Link Partner during AutoNegotiation.



**NP** **Next Page Indication** **0, RO 15**

1 = Another Next Page desired.

0 = No other Next Page Transfer desired.

**Reserved** **0, RO 14**

Reserved by IEEE. Writes ignored, read as 0.

**MP** **Message Page** **0, RO 13**

1 = Message Page.

0 = Unformatted Page.

**ACK3** **Acknowledge3** **0, RO 12**

1 = Will comply with message.

0 = Cannot comply with message.

ACK3 is used by the next page function to indicate that the Local Device has the ability to comply with the message received.



**TOG\_TX**

**Toggle**

**0, RO 11**

1 = Value of the toggle bit in previously transmitted Link Code Word was logic 0.

0 = Value of the toggle bit in previously transmitted Link Code Word was logic 1.

Toggle is used by the Arbitration function within AutoNegotiation to ensure synchronization with the Link Partner during Next Page exchange. This bit always takes the opposite value of the Toggle bit in the previously exchanged Link Code Word.

**CODE**

**Code Field**

**<0b0000 0000 000>, RO [10:0]**

This field represents the code field of the next page transmission. If the MP bit is set (bit 13 of this register), the code is interpreted as a “Message Page”, as defined in annex 28C of IEEE 802.3u. Otherwise, the code is interpreted as an “Unformatted Page”, and the interpretation is application specific.

The default value of CODE represents a Reserved for future use as defined in Annex 28C of IEEE 802.3u.

#### 4.2.10 1000BASE-T Control Register (1KTCR) Address 0x09

15	14	13	12	11	10	9	8
Test Mode			Manual Master/Slave Enable	Manual Master/Slave Advertise	Port_Type	1000BASE-T Full-Duplex	1000BASE-T Half-Duplex
7	Reserved						0

**Test Mode**

**0 RW [15:13]**

The test mode is selected according to the table.

**Test Mode [15:13] Test Mode Selected**

0b100	Test Mode 4
0b011	Test Mode 3
0b010	Test Mode 2
0b001	Test Mode 1
0b000	Normal Operation

See IEEE 802.3ab section 40.6.1.1.2 “Test Modes” for more information. The output for TX\_TCLK when the device is in test mode is on pin 192.

**Manual Master/Slave Enable** **Strap Pin 195 0,RW 12**

**Enable Manual Master/Slave Configuration**

1 = Enable Manual Master/Slave Configuration control.

0 = Disable Manual Master/Slave Configuration control.

The default value of this bit is the strap value during reset/power-on.

**Manual Master/Slave Advertise** **Strap Pin 191 0,RW 11**

**Advertise Master/Slave Configuration Value**

1 = Advertise PHY as MASTER when register 0x09 bit 12 is 1.

0 = Advertise PHY as SLAVE when register 0x09 bit 12 is 1.

The default value of this bit is the strap value during reset/power-on.

**Port\_Type** **Strap Pin 208 0, RO 10**

**Port Type: Multiport or Single Port**

1 = Repeater or Switch (L80600 does not support Repeater mode).

0 = DTE(NIC).

The default value of this bit is the strap value during reset/power-on (provided the AN\_EN pin is HIGH).

**1000BASE-T Full-Duplex** **Strap Pin 184 1, RW 9**

**Advertise 1000BASE-T Full-Duplex Capable**

1 = Advertise DTE as 1000BASE-T Full-Duplex Capable.

0 = Advertise DTE as not 1000BASE-T Full-Duplex Capable.

The default value of this bit is the strap value during reset/power-on (provided the AN\_EN pin is HIGH).

**1000BASE-T Half-Duplex** **Strap Pin 185 1, RW 8**

**Advertise 1000BASE-T Half-Duplex Capable**

1 = Advertise DTE as 1000BASE-T Half-Duplex Capable.

0 = Advertise DTE as not 1000BASE-T Half-Duplex Capable.

The default value of this bit is the strap value during reset/power-on (provided the AN\_EN pin is HIGH).

**Reserved**

**0, RW [7:0]**

Reserved by IEEE: Writes ignored, Read as 0.

#### 4.2.11 1000BASE-T Status Register (1KSTSR) Address 0x0A (10)

This register provides status for the 1000BASE-T link.

15	14	13	12	11	10	9	8
Master-Slave Manual Config Fault	MS_Config_ Results	Local Receiver Status	Remote Receiver Status	LP_1000T_ FD	LP_1000T_ HD	LP_ASM_ DIR	Reserved
7	IDLE Error Count (MSB)						0

**Master-Slave Manual Config Fault** **0, RO 15**

**Master/Slave Manual Configuration Fault Detected**

1 = Master/Slave manual configuration fault detected.

0 = No Master/Slave manual configuration fault detected.

**MS\_Config\_Results**

**Master Slave Configuration Results** **0, RO 14**

1 = Configuration resolved to Master.

0 = Configuration resolved to Slave.

**Local Receiver Status**

**0, RO 13**

1 = OK.

0 = Not OK.

**Remote Receiver Status**

**0, RO 12**

1 = OK.

0 = Not OK.

**LP\_1000T\_FD Link Partner 1000T Full-Duplex**

**0, RO 11**

1 = Link Partner capable of 1000BASE-T Full-Duplex.

0 = Link Partner not capable of 1000BASE-T Full-Duplex.

**LP\_1000T\_HD Link Partner 1000T Half-Duplex**

**0, RO 10**

1 = Link Partner capable of 1000BASE-T Half-Duplex.

0 = Link Partner not capable of 1000BASE-T Half-Duplex.

**LP\_ASM\_DIR Link Partner ASM\_DIR Capable** **0, RO 9**  
 1 = Link Partner Asymmetric Pause Direction capable.  
 0 = Link Partner not Asymmetric Pause Direction capable.

**Reserved** **0, RO 8**  
 Reserved by IEEE. Write ignored, read as 0.

**IDLE Error Count (MSB)** **0, RO [7:0]**

#### 4.2.12 Registers 0x0B–0x0E

The IEEE has reserved the registers in this range.

#### 4.2.13 1000BASE-T Extended Status Register (1KSCR) Address 0x0F (15)

15	14	13	12	11	10	9	8
1000BASE-X _FD	1000BASE-X _DH	1000BASE-T _FD	1000BASE-T _HD	Reserved			
7	Reserved						0

**1000BASE-X\_FD**  
**1000BASE-X Full-Duplex Support** **0, RO 15**  
 1 = 1000BASE-X is supported by the local device.  
 0 = 1000BASE-X is not supported.  
 L80600 does not support 1000BASE-X. This bit should always be read back as 0.

**1000BASE-X\_DH**  
**1000BASE-X Half-Duplex Support** **0, RO 14**  
 1 = 1000BASE-X is supported by the local device.  
 0 = 1000BASE-X is not supported.  
 L80600 does not support 1000BASE-X. This bit should always be read back as 0.

**1000BASE-T\_FD**  
**1000BASE-T Full-Duplex Support** **1, RO 13**  
 1 = 1000BASE-T is supported by the local device.  
 0 = 1000BASE-T is not supported.

## 1000BASE-T\_HD

### 1000BASE-T Half-Duplex Support

**1, RO 12**

1 = 1000BASE-T is supported by the local device.

0 = 1000BASE-T is not supported.

### Reserved

**0, RO [11:0]**

Reserved by IEEE. Write ignored, read as 0.

## 4.2.14 Strap Option Register (STRAP\_REG) Address 0x10 (16)

The register below summarizes all the strap options.

15				11		10		9		8					
PHY_Address[4:0]						NC_MODE Value		Manual Master/ Slave Enable		AN Enable					
7		6		5		4		3		2		1		0	
Master/Slave Value		Reserved				1000HDX_ADV Value		1000FDX_ADV Value		100FDX/HDX_AD V		Sel_Speed[1:0]			

### PHY\_Address[4:0]

**0b00001, RO [15:11]**

Strap option pins 200, 201, 204, 205, 207. Changeable only through restrapping and resetting the device.

### NC\_MODE Value

#### Noncompliant Mode

**Strap [0], RW 10**

Strap option NC\_MODE (pin 196).

1 = AutoNegotiates with certain early revisions on the L80600 and IEEE 802.3ab compliant PHYs.

0 = AutoNegotiates with IEEE 802.3ab compliant PHYs only.

### Manual\_M/S\_Enable

**Strap [0], RO 9**

#### Manual Master/Slave Configuration Enable

Strap option MANUAL\_M/S\_ENABLE (pin 195). This value can be overwritten by changing bit 12 of the [1000BASE-T Control Register \(1KTCR\) Address 0x09](#).

### AN Enable

#### AutoNegotiation Enable

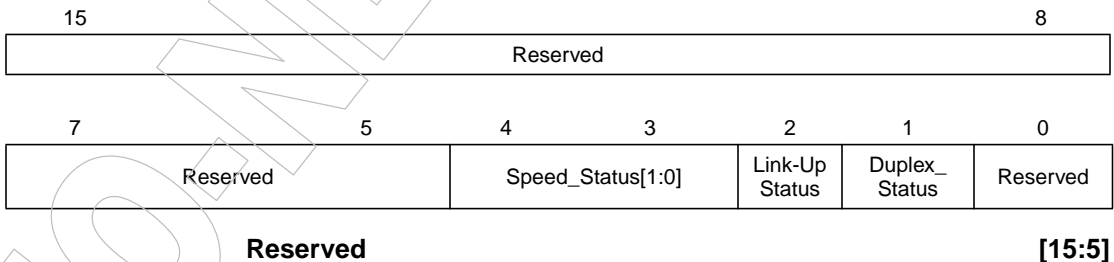
**Strap [1], RO 8**

Strap option AN\_EN (pin 192). This value can be overwritten by changing bit 12 of the [Basic Mode Register \(BMCR\) Address 0x00](#). However, this bit retains

the original strapped value, regardless of changes to bit 12 of the [Basic Mode Register \(BMCR\) Address 0x00](#).

<b>Master/Slave Value</b>	<b>Strap [0], RO 7</b>
Strap option MAS_SLAVE (pin 191). This value can be overwritten by changing bit 11 of the <a href="#">1000BASE-T Control Register (1KTCR) Address 0x09</a> .	
<b>Reserved</b>	<b>Strap [0], RO 6</b>
<b>Reserved</b>	<b>Strap [1], RO 5</b>
<b>1000HDX_ADV Value</b>	<b>Strap [1], RO 4</b>
<b>1000 HDX Advertisement</b> Strap option 1000_HDX_ADV (pin 185).	
<b>1000FDX_ADV Value</b>	<b>Strap [1], RO 3</b>
<b>1000 FDX Advertisement</b> Strap option 1000_FDX_ADV (pin 184).	
<b>100FDX/HDX_ADV</b>	<b>Strap [1], RO 2</b>
<b>100 FDX and HDX Advertisement</b> Strap option 100_ADV (pin 181).	
<b>Sel_Speed[1:0]</b>	<b>Strap [00], RO [1:0]</b>
<b>Speed Select</b> Strap option pins 180 and 208 respectively. This value can be overwritten by changing bits 6 and 13 of the <a href="#">Basic Mode Register (BMCR) Address 0x00</a> .	

#### 4.2.15 PHY Support Register (PHY\_SUP) Address 0x11 (17)



**Speed\_Status[1:0]** Strap or AN determined value, RW [4:3]

**Speed Resolved**

These two bits indicate the speed of operation as determined by AutoNegotiation or as set by manual configuration.

Speed_Status[1:0]	Speed of operation
10	1000 Mbits/s
01	100 Mbits/s
00	10 Mbits/s

**Link-up\_Status**

**Link Status**

**0, RW 2**

1 = a good link is established

0 = no link is established

**Duplex\_Status**

**0, RW 1**

1 = the current mode of operation is Full-Duplex.

0 = the current mode of operation is Half-Duplex.

**Reserved**

**0**

## 4.2.16 MDIX\_SEL Address 0x15 (21)



**Reserved**

**[15:1]**

**MDIX\_Sel**

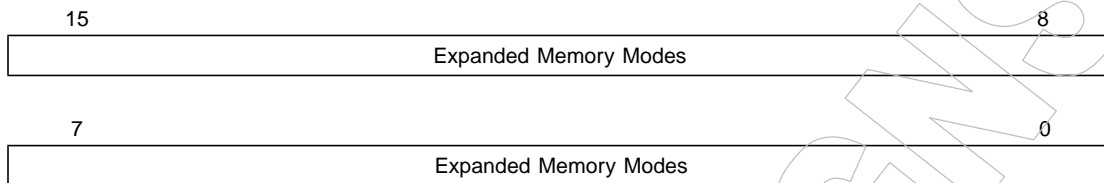
**0 0**

If Automatic MDIX selection is disabled, this bit can be used to select either crossover or straight cable operation:

1 = Crossover channels A and B (the cable is straight).

0 = Don't crossover channels A and B (the cable is crossover).

#### 4.2.17 EXPAND\_MEM\_MODE Address 0x16 (22)

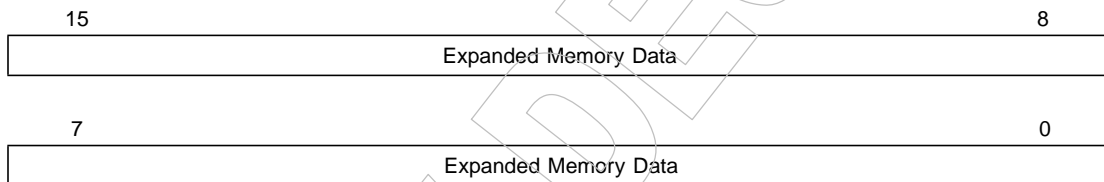


##### Expanded Memory Modes

RW [15:0]

Allows access to expanded memory and sets the mode of access. Also see [EXP\\_MEM\\_DATA Address 0x1D \(29\)](#) and [EXP\\_MEM\\_ADDR Address 0x1E \(30\)](#) and [Chapter 9, “L80600 Frequently Asked Questions.”](#)

#### 4.2.18 EXP\_MEM\_DATA Address 0x1D (29)



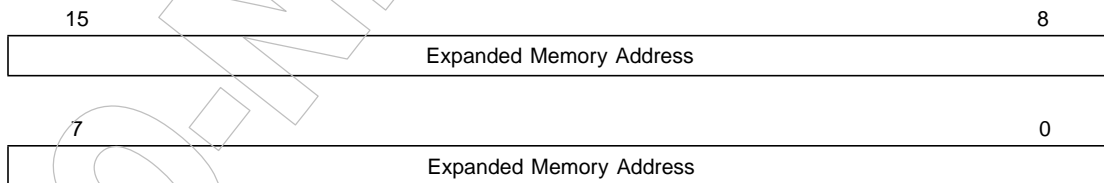
##### Expanded Memory Data

RW [15:0]

Data to be written to or read from expanded memory. Note that in 8-bit mode, the data resides at the LSB octet of this register.

See an example in [Chapter 9, “L80600 Frequently Asked Questions.”](#)

#### 4.2.19 EXP\_MEM\_ADDR Address 0x1E (30)



##### Expanded Memory Address

RW [15:0]

Pointer to the address in expanded memory. The pointer is 16-bits wide.

See an example in [Chapter 9, “L80600 Frequently Asked Questions.”](#)



## 4.3 Extended Registers

This section describes the extended registers. They are located in expanded memory that contain extended register sets to access interrupt status and control functions. These registers are 8-bits wide and accessed through EXP\_MEM\_MODE, EXP\_MEM\_DATA and EXP\_MEM\_ADDR registers

Table 4.3 is a summary of the registers. Detailed register descriptions follow the table.

**Table 4.3 Extended Register Map**

Offset	Access	Abbreviation	Description
Hex			
0x810D	RO	ISR0	Interrupt Status Register 0
0x810E	RO	ISR1	Interrupt Status Register 1
0x810F	RO	IRR0	Interrupt Reason Register 0
0x8110	RO	IRR1	Interrupt Reason Register 1
0x8111	RO	RRR0	Interrupt Raw Reason Register 0
0x8112	RO	RRR1	Interrupt Raw Reason Register 1
0x8113	RW	IER0	Interrupt Enable Register 0
0x8114	RW	IER1	Interrupt Enable Register 1
0x8115	RW	ICLR0	Interrupt Clear Register 0
0x8116	RW	ICLR1	Interrupt Clear Register 1
0x8117	RW	ICTR	Interrupt Control Register
0x8118	RW	AN_THRESH	An_Threshold Value Register
0x8119	RW	LINK_THRESH	Link_Threshold Value Register
0x811A	RW	IEC_THRESH	IEC_Threshold Value Register

### 4.3.1 Interrupt\_Status ISR0 Address 0x810D

7	6	5	4	3	2	1	0
ISR_AN_COMP_THRESH	ISR_AN_COMP	ISR_AN_REMOTE_FAULT	ISR_SPEED	ISR_LINK_THRESH	ISR_LINK	ISR_DUPLEX	ISR_JABBER

#### ISR\_AN\_COMP\_THRESH

##### **AN Counter Reached Threshold 0, RO 7**

The AutoNegotiation Counter counts the number of times AN occurs. This bit determines if the counter has reached a preset threshold value.

1 = COUNTER\_AUTONEG > AN\_COMP\_THRESH.

0 = Cleared when corresponding ICLR0 bit 7 is set

#### ISR\_AN\_COMP

##### **0, RO 6**

1 = When BMSR 0x01 bit 5 AN\_COMPLETE changes.

0 = Cleared when corresponding ICLR0 bit 6 is set

#### ISR\_AN\_REMOTE\_FAULT

##### **0, RO 5**

1 = When BMSR 0x01 bit 4 AN\_REMOTE\_FAULT changes.

0 = Cleared when corresponding ICLR0 bit 5 is set

#### ISR\_SPEED

##### **0, RO 4**

1 = When PHY\_Sup 0x11 bit 3 and 4

RESOLVED\_SPEED change state qualified by link up.

0 = Cleared when corresponding ICLR0 bit 4 is set.

#### ISR\_LINK\_THRESH

##### **Link Counter Reached Threshold 0, RO 3**

The Link Counter counts the number of link sessions. This bit determines if the Link Counter has reached a preset threshold value.

1 = When (COUNTER\_LINK\_10 + COUNTER\_LINK\_100 + COUNTER\_LINK\_1000) > LINK\_THRESH.

0 = Cleared when corresponding ICLR0 bit 3 is set.

#### ISR\_LINK

##### **0, RO 2**

1 = When PHY\_Sup 0x11 bit 2 RESOLVED\_LINK changes state.

0 = Cleared when corresponding ICLR0 bit 2 is set.

**ISR\_DUPLEX****0, RO 1**

1 = When PHY\_Sup 0x11 bit 1 RESOLVED\_DUPLEX changes state qualified by link up.

0 = Cleared when corresponding ICLR0 bit 1 is set.

**ISR\_JABBER****0, RO 0**

1 = When BMSR 0x01 bit 1 jabber changes state.

0 = Cleared when corresponding ICLR0 bit 0 is set.

**4.3.2 Interrupt\_Status ISR1 Address 0x810E**

7	6	5	4	3	2	1	0
ISR_CONFIG_FAULT	ISR_CONFIG	ISR_LOC_RCVR_STATUS	ISR_REM_RCVR_STATUS	ISR_IEC_THRESH	ISR_FW_ROM	ISR_FW_RAM	ISR_RESET

**ISR\_CONFIG\_FAULT****0, RO 7**

1 = When 1KSTSR 0x0A bit 15 CONFIG\_FAULT changes state.

0 = Cleared when corresponding ICLR1 bit is set.

**ISR\_CONFIG****0, RO 6**

1 = When 1KSTSR 0x0A bit 14

CONFIG\_RESOLVED\_TO\_MASTER changes state qualified by link up.

0 = When corresponding ICLR1 bit 6 is set.

**ISR\_LOC\_RCVR\_STATUS****0, RO 5**

1 = When 1KSTSR 0x0A bit 13 1000BT

LOC\_RCVR\_STATUS changes state.

0 = When corresponding ICLR1 bit 5 is set.

**ISR\_REM\_RCVR\_STATUS****0, RO 4**

1 = When 1KSTSR 0x0A bit 12 1000BT

REM\_RCVR\_STATUS changes state.

0 = When corresponding ICLR1 bit 4 is set.

**ISR\_IEC\_THRESH Idle****Error Counter Reached Threshold****0, RO 3**

The Idle Error Counter counts the number of idle errors.

This bit determines if the IEC has reached a preset threshold value.

1 = When 1KSTSR 0x0A bits 0 to 7

IDLE\_ERROR\_COUNT > IEC\_THRESH.

0 = When corresponding ICLR1 bit 3 is set.

**ISR\_FW\_ROM** **0, RO 2**  
 1 = Firmware is detected to be running from ROM.  
 0 = Firmware is detected to be running from RAM.

**ISR\_FW\_RAM** **0, RO 1**  
 1 = Firmware is detected to be running from RAM.  
 0 = Firmware is detected to be running from ROM.

**ISR\_RESET** **1, RO 0**  
 1 = Firmware cycles through the reset sequence.  
 0 = Corresponding bit in ICLR1 bit 0 is set.

### 4.3.3 Interrupt\_Reason IRR0 Address 0x810F

7	6	5	4	3	2	1	0
Reserved	IRR_AN_COMP	IRR_AN_REMOTE_FAULT	IRR_SPEED[1:0]	IRR_LINK	IRR_DUPLEX	IRR_JABBER	

**Reserved** **0 7**

**IRR\_AN\_COMP** **0, RO 6**  
 Copy of BMSR 0x01 bit 5 AN\_COMPLETE at the time interrupt is asserted.

**IRR\_AN\_REMOTE\_FAULT** **0, RO 5**  
 Copy of BMSR 0x01 bit 4 AN\_REMOTE\_FAULT at the time interrupt is asserted.

**IRR\_SPEED[1:0]** **0, RO [4:3]**  
 Copy of PHY\_SUP 0x11 bits 3 and 4 SPEED\_RES at the time interrupt is asserted if link is up.

**IRR\_LINK** **0, RO 2**  
 Copy of PHY\_SUP 0x11 bit 2 LINK\_RES at the time interrupt is asserted.

**IRR\_DUPLEX** **0, RO 1**  
 Copy of PHY\_SUP 0x11 bit 1 DUPLEX\_RES at the time interrupt is asserted if link is up.

**IRR\_JABBER** **0, RO 0**  
 COPY of BMSR 0x01 bit 1 JABBER at the time interrupt is asserted.

#### 4.3.4 Interrupt\_Reason IRR1 Address 0x8110

7	6	5	4	3	2	1	0
IRR_CONFIG_FAULT	IRR_CONFIG	IRR_LOC_RCVR_STATUS	IRR_REM_RCVR_STATUS	Reserved			

**IRR\_CONFIG\_FAULT** **0, RO 7**  
Copy of 1KSTSR 0x0A bit 15 CONFIG\_FAULT at the time interrupt is asserted.

**IRR\_CONFIG** **0, RO 6**  
Copy of 1KSTSR 0x0A bit 14 AN\_REMOTE\_FAULT at the time interrupt is asserted if link is up.

**IRR\_LOC\_RCVR\_STATUS** **0, RO 5**  
Copy of 1KSTSR 0x0A bit 13 LOC\_RCVR\_STATUS at the time interrupt is asserted.

**IRR\_REM\_RCVR\_STATUS** **0, RO 4**  
Copy of 1KSTSR 0x0A bit 12 REM\_RCVR\_STATUS at the time interrupt is asserted.

**Reserved** **0, RO [3:0]**

#### 4.3.5 Interrupt\_Raw\_Reason RRR0 Address 0x8111

7	6	5	4	3	2	1	0
Reserved	IRW_AN_COMP	IRW_AN_REMOTE_FAULT	IRW_SPEED[1:0]	IRW_LINK	IRW_DUPLEX	IRW_JABBER	

**Reserved** **0, RO 7**

**IRW\_AN\_COMP** **0, RO 6**  
Current value of BMSR 0x01 bit 5 AN\_COMPLETE.

**IRW\_AN\_REMOTE\_FAULT** **0, RO 5**  
Current value of BMSR 0x01 bit 4 AN\_REMOTE\_FAULT.

**IRW\_SPEED[1:0]** **0, RO [4:3]**  
Current value of PHY\_SUP 0x11 bits 3 and 4  
SPEED\_RES when link is up; otherwise, last value of bits 3 and 4 when link was up.

**IRW\_LINK** **0, RO 2**  
Current value of PHY\_SUP 0x11 bit 2 LINK\_RES.

**IRW\_DUPLEX****0, RO 1**

Current value of PHY\_SUP 0x11 bit 1 DUPLEX\_RES if link is up; otherwise, the last value of duplex last time link was up.

**IRW\_JABBER****0, RO 0**

Current value of BMSR 0x01 bit 1 jabber.

**4.3.6 Interrupt\_Raw\_Reason RRR1 Address 0x8112**

7	6	5	4	3	2	1	0
IRW_CONFIG_FAULT	IRW_CONFIG	IRW_LOC_RCVR_STATUS	IWR_REM_RCVR_STATUS	Reserved			

**IRW\_CONFIG\_FAULT****0, RO 7**

Current value of 1KSTSR 0x0A bit 15 CONFIG\_FAULT at the time interrupt is asserted.

**IRW\_CONFIG****0, RO 6**

Current value of 1KSTSR 0x0A bit 14 AN\_REMOTE\_FAULT at the time interrupt is asserted if link is up.

**IRW\_LOC\_RCVR\_STATUS****0, RO 5**

Current value of 1KSTSR 0x0A bit 13 LOC\_RCVR\_STATUS at the time interrupt is asserted.

**IRW\_REM\_RCVR\_STATUS****0, RO 4**

Current value of 1KSTSR 0x0A bit 12 REM\_RCVR\_STATUS at the time interrupt is asserted.

**Reserved****0, RO [3:0]****4.3.7 Interrupt\_Enable IER0 Address 0x811**

7	6	5	4	3	2	1	0
IER_AN_COMP_THRESH	IER_AN_COMP	IER_AN_REMOTE_FAULT	IER_SPEED	IER_LINK_THRESH	IER_LINK	IER_DUPLEX	IER_JABBER

**IER\_AN\_COMP\_THRESH****0, RW 7**

1 = Enable IER\_AN\_COMP\_THRESH interrupt.  
0 = Disable IER\_AN\_COMP\_THRESH interrupt.

**IER\_AN\_COMP** **0, RW 6**  
 1 = Enable IER\_AN\_COMP interrupt.  
 0 = Disable IER\_AN\_COMP interrupt.

**IER\_AN\_REMOTE\_FAULT** **0, RW 5**  
 1 = Enable IER\_AN\_REM\_FAULT interrupt.  
 0 = Disable IER\_AN\_REM\_FAULT interrupt.

**IER\_SPEED** **0, RW 4**  
 1 = Enable IER\_SPEED interrupt.  
 0 = Disable IER\_SPEED interrupt.

**IER\_LINK\_THRESH** **0, RW 3**  
 1 = Enable IER\_LINK\_THRESH interrupt.  
 0 = Disable IER\_LINK\_THRESH interrupt.

**IER\_LINK** **0, RW 2**  
 1 = Enable IER\_LINK interrupt.  
 0 = Disable IER\_LINK interrupt.

**IER\_DUPLEX** **0, RW 1**  
 1 = Enable IER\_DUPLEX interrupt.  
 0 = Disable IER\_DUPLEX interrupt.

**IER\_JABBER** **0, RW 0**  
 1 = Enable IER\_JABBER interrupt.  
 0 = Disable IER\_JABBER interrupt.

#### 4.3.8 Interrupt\_Enable IER1 Address 0x8114

7	6	5	4	3	2	1	0
Reserved	IER_CONFIG	IER_LOC_RCVR_STATUS	IER_REM_RCVR_STATUS	IER_IEC_THRESH	IER_FW_ROM	IER_FW_RAM	IER_RESET

**Reserved** **0, RO 7**

**IER\_CONFIG** **0, RW 6**  
 1 = Enable IER\_CONFIG interrupt.  
 0 = Disable IER\_CONFIG interrupt.

**IER\_LOC\_RCVR\_STATUS** **0, RW 5**  
 1 = Enable IER\_LOC\_RCVR\_STATUS interrupt.  
 0 = Disable IER\_LOC\_RCVR\_STATUS interrupt.

**IER\_REM\_REVR\_STATUS** **0, RW 4**  
 1 = Enable IER\_REM\_REVR\_STATUS interrupt.  
 0 = Disable IER\_REM\_REVR\_STATUS interrupt.

**IER\_IEC\_THRESH** **0, RW 3**  
 1 = Enable IER\_IEC\_THRESH interrupt.  
 0 = Disable IER\_IEC\_THRESH interrupt.

**IER\_FW\_ROM** **0, RW 2**  
 1 = Enable IER\_FW\_ROM interrupt.  
 0 = Disable IER\_FW\_ROM interrupt.

**IER\_FW\_RAM** **0, RW 1**  
 1 = Enable IER\_FW\_RAM interrupt.  
 0 = Disable IER\_FW\_RAM interrupt.

**IER\_RESET** **0, RW 0**  
 1 = Enable IER\_RESET interrupt.  
 0 = Disable IER\_RESET interrupt.

#### 4.3.9 Interrupt\_Clear ICLR0 Address 0x8115

7	6	5	4	3	2	1	0
ICR_AN_COMP_THRESH	ICR_AN_COMP	ICR_AN_REMOTE_FAULT	ICR_SPEED	ICR_LINK_THRESH	ICR_LINK	ICR_DUPLEX	ICR_JABBER

**ICR\_AN\_COMP\_THRESH** **0, RW 7**  
 1 = Clear ICR\_AN\_COMP\_THRESH interrupt and clear COUNTER\_AUTONEG.  
 0 = No action.

**ICR\_AN\_COMP** **0, RW 6**  
 1 = Clear ICR\_AN\_COMP interrupt.  
 0 = No action.

**ICR\_AN\_REMOTE\_FAULT** **0, RW 5**  
 1 = Clear ICR\_AN\_REMOTE\_FAULT interrupt.  
 0 = No action.

**ICR\_SPEED** **0, RW 4**  
 1 = Clear ICR\_SPEED interrupt.  
 0 = No action.

**ICR\_LINK\_THRESH** **0, RW 3**  
 1 = Clear ICR\_LINK\_THRESH interrupt, clear COUNTER\_LINK\_10, clear COUNTER\_LINK\_100, and



clear COUNTER\_LINK\_1000.  
0 = No action.

**ICR\_LINK**

**0, RW 2**

1 = Clear ICR\_LINK interrupt.  
0 = No action.

**ICR\_DUPLEX**

**0, RW 1**

1 = Clear ICR\_DUPLEX interrupt.  
0 = No action.

**ICR\_JABBER**

**0, RW 0**

1 = Clear ICR\_JABBER interrupt.  
0 = No action.

#### 4.3.10 Interrupt\_Clear ICLR1 Address 0x8116

7	6	5	4	3	2	1	0
Reserved	ICR_CONFIG	ICR_LOC_RCVR_STATUS	ICR_REM_RCVR_STATUS	ICR_IEC_THRESH	RESERVED		IER_RESET

**Reserved**

**0, RW 7**

**ICR\_CONFIG**

**0, RW 6**

1 = Clear ICR\_CONFIG interrupt.  
0 = No action.

**ICR\_LOC\_RCVR\_STATUS**

**0, RW 5**

1 = Clear ICR\_LOC\_RCVR\_STATUS interrupt.  
0 = No action.

**ICR\_REM\_RCVR\_STATUS**

**0, RW 4**

1 = Clear ICR\_REM\_RCVR\_STATUS interrupt.  
0 = No action.

**ICR\_IEC\_THRESH**

**0, RW 3**

1 = Clear ICR\_IEC\_THRESH interrupt.  
0 = No action.

**Reserved**

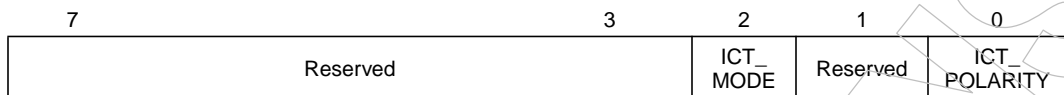
**0 [2:1]**

**ICR\_RESET**

**0, RW 0**

1 = Clear ICR\_RESET interrupt.  
0 = No action.

### 4.3.11 Interrupt\_Control ICTR Address 0x8117



**Reserved**

**0, RW [7:3]**

**ICT\_MODE**

**Interrupt Mode**

**0, RW 2**

1 = Enable interrupt (when LEDs are enabled).  
0 = Disable interrupt.

**Reserved**

**0, RW 1**

**ICT\_POLARITY**

**Interrupt Polarity**

**0 RW 0**

1 = Active HIGH.

0 = Active LOW.

### 4.3.12 AN\_THRESH Address 0x8118



**AN\_COMP\_THRESH[7:0]**

**0xFF, RW[7:0]**

Threshold value used to generate  
ISR\_AN\_COMP\_THRESH.

### 4.3.13 LINK\_THRESH Address 0x8119



**LINK\_THRESH[7:0]**

**0xFF, RW [7:0]**

Threshold value used to generate ISR\_LINK\_THRESH.

### 4.3.14 IEC\_THRESH Address 0x811A



**IEC\_THRESH[7:0]**

**0xFF, RW [7:0]**

Threshold value used to generate ISR\_IEC\_THRESH.

# Chapter 5

## Configuration Options

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This chapter includes information on the various configuration options available with the L80600. The chapter contains these sections:

- [Section 5.1, “Speed/Duplex Mode Selection”](#)
  - [Section 5.2, “Manual Mode Configurations”](#)
  - [Section 5.3, “AutoNegotiation”](#)
  - [Section 5.4, “MII Isolate Mode”](#)
  - [Section 5.5, “Loopback”](#)
  - [Section 5.6, “MII/GMII Interface and Speed of Operation”](#)
  - [Section 5.7, “Test Modes”](#)
  - [Section 5.8, “Automatic MDI/MDIX Configuration”](#)
  - [Section 5.9, “Polarity Correction”](#)
  - [Section 5.10, “Firmware Interrupt”](#)
- 

### 5.1 Speed/Duplex Mode Selection

The L80600 supports six different Ethernet protocols: 10BASE-T Full-Duplex, 10BASE-T Half-Duplex, 100BASE-TX Full-Duplex, 100BASE-TX Half-Duplex, 1000BASE-T Full-Duplex and 1000BASE-T Half-Duplex. Both the speed and the Duplex mode of operation can be determined by either AutoNegotiation (AN) or set by manual configuration. Both AutoNegotiation and manual configuration can be controlled by strap values applied to certain pins during power-on or reset. They can also be controlled by access to internal registers.

## 5.2 Manual Mode Configurations

This section describes how the speed and the Duplex mode of operation can be set by manual configuration.

### 5.2.1 Forced Speed/Duplex Selection

For manual configuration of the speed and duplex modes of operation, the AutoNegotiation function has to be disabled. This can be achieved by strapping AN\_EN LOW during power-on/reset. AutoNegotiation can also be disabled by writing a 0 to bit 12 of the [Basic Mode Register \(BMCR\) Address 0x00](#). Once AN\_EN is disabled, the strap value of the SPEED[1:0] pins determines the speed of operation, and the strap value of the LED\_DUPLEX pin determines the duplex mode.

**Table 5.1 Non-AutoNegotiation Modes**

AN_EN	SPEED [1]	SPEED [0]	Forced Mode
0	0	0	10BASE-T
0	0	1	100BASE-TX
0	1	0	1000BASE-T
0	1	1	Reserved

For all of the modes shown above, a HIGH DUPLEX strap value selects Full-Duplex, while LOW selects Half-Duplex. The strap values latched on during power-on reset can be overwritten with the [Basic Mode Register \(BMCR\) Address 0x00](#) bits 13, 12, 8, and 6.

It should be noted that Force 1000BASE-T mode is not supported by IEEE. The L80600, when in forced 1000BASE-T mode, only communicates with another L80600 where one PHY is set for Slave operation and the other is set for Master operation.

### 5.2.2 Manual Master/Slave Resolution

In 1000BASE-T mode, one device needs to be configured as a Master and the other as a Slave. The Master device by definition uses a local clock to transmit data on the wire, while the Slave device uses the clock

recovered from the incoming data for transmitting its own data. The L80600 uses the REF\_CLK signal as the local clock for transmit purposes when configured as a Master. The Master and Slave assignments can be manually set by using strap options or writing the following register bits: Manual Master/Slave Advertise [1000BASE-T Control Register \(1KTCR\) Address 0x09](#) bit 11, Manual Master/Slave Enable [Strap Option Register \(STRAP\\_REG\) Address 0x10 \(16\)](#) bit 9, and Port Type [1000BASE-T Control Register \(1KTCR\) Address 0x09](#) bit 10.

Master/Slave resolution for 1000BASE-T between a PHY and its Link Partner can be resolved to sixteen possible outcomes (see [Table 5.3](#)). The resolution outcome is based on the rankings shown in [Table 5.2](#), where a rank of 1 has the highest priority.

**Table 5.2 Master/Slave Rankings and Settings**

Rank	Configuration	Port Type Reg. 0x09 Pin 208	Manual Master/Slave Advertise Reg. 0x09 Pin 191	Manual Master/Slave Enable Reg. 0x09 Pin 195
1	Manual Master	Don't Care Don't Care	1 Pull HIGH	1 Pull HIGH
2	Multiport	1 Pull HIGH	Don't Care Don't Care	Don't Care Don't Care
3	Single Port	0 Pull LOW	Don't Care Don't Care	Don't Care Don't Care
4	Manual Slave	Don't Care Don't Care	0 Pull LOW	1 Pull HIGH

**Table 5.3 Master/Slave Outcome**

<b>L80600 Advertise</b>	<b>Link Partner Advertise</b>	<b>L80600 Outcome</b>	<b>Link Partner Outcome</b>
Manual Master	Manual Master	Unresolved No Link	Unresolved No Link
Manual Master	Manual Slave	Master	Slave
Manual Master	Multiport	Master	Slave
Manual Master	Single Port	Master	Slave
Multiport	Manual Master	Slave	Master
Multiport	Manual Slave	Master	Slave
Multiport	Multiport	M/S resolved by random seed	M/S resolved by random seed
Multiport	Single Port	Master	Slave
Single Port	Manual Master	Slave	Master
Single Port	Manual Slave	Master	Slave
Single Port	Multiport	Slave	Master
Single Port	Single Port	M/S resolved by random seed	M/S resolved by random seed
Manual Slave	Manual Master	Slave	Master
Manual Slave	Manual Slave	Unresolved No Link	Unresolved No Link
Manual Slave	Multiport	Slave	Master
Manual Slave	Single Port	Slave	Master

If both the link partner and the local device are manually given the same Master/Slave assignment, an error condition exists as indicated by bit 15 of the [1000BASE-T Status Register \(1KTSR\) Address 0x0A \(10\)](#). If one of the link partners is manually assigned a Master/Slave status while the other is not, the manual assignment takes higher priority during the resolution process.

When Manual Slave or Manual Master mode is enabled, AutoNegotiation should also be enabled according to the 802.3u IEEE specification. The L80600, however, links up to another L80600 when AutoNegotiation is disabled and one L80600 is manually configured as a Master while the other is manually configured as a Slave.

An alternative way of specifying Master or Slave mode is to use the Port\_Type strapping option (pin 208) or by writing to the [1000BASE-T Control Register \(1KTCR\) Address 0x09](#) bit 10. When pin 208 is pulled HIGH or a 1 is written to bit 10, the part advertises that it wants to be a Master. When pin 208 is pulled LOW or a 0 is written to bit 10, the part advertises that it wants to be a Slave. If two devices advertise that they want to both be Master or to both be Slaves, the AutoNegotiation state machine goes through a random number arbitration sequence to pick which one is the Master and which is the Slave. Using this method eliminates the chance of an unresolved link.

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## 5.3 AutoNegotiation

All 1000BASE-T PHYs are required to support AutoNegotiation. The AutoNegotiation function in 1000BASE-T has four primary purposes:

- AutoNegotiation Priority Resolution
- AutoNegotiation Master/Slave Resolution
- AutoNegotiation Pause/Asymmetrical Pause Resolution
- Automatic MDIX Resolution

### 5.3.1 AutoNegotiation Priority Resolution

To achieve priority resolution, the AutoNegotiation function first provides a mechanism for exchanging configuration information between two ends of a link segment and automatically selecting the highest performance mode of operation supported by both devices.

Fast Link Pulse (FLP) bursts provide the signalling used to communicate AutoNegotiation abilities between two devices at each end of a link segment. For further detail regarding AutoNegotiation, refer to Clause 28 of the IEEE 802.3u specification. The L80600 supports six different Ethernet protocols: 10BASE-T Full-Duplex, 10BASE-T Half-Duplex, 100BASE-TX Full-Duplex, 100BASE-TX Half-Duplex, 1000BASE-T Full-Duplex and 1000BASE-T Half-Duplex. The inclusion of AutoNegotiation ensures that the highest performance protocol is selected based on the advertised ability of the Link Partner.

AutoNegotiation Priority Resolution for the L80600:

- 1000BASE-T Full-Duplex (Highest Priority)
- 1000BASE-T Half-Duplex
- 100BASE-TX Full-Duplex
- 100BASE-TX Half-Duplex
- 10BASE-T Full-Duplex
- 10BASE-T Half-Duplex (Lowest Priority)

### 5.3.2 AutoNegotiation Master/Slave Resolution

The second goal of AutoNegotiation in 1000BASE-T devices is to resolve Master/Slave configuration. If both devices have disabled manual Master/Slave configuration, Master priority is given to the devices that support multiport nodes (switches and repeaters take higher priority over DTEs or single-node systems.). SPEED[0]/PORT\_TYPE is a strap option for advertising the Multinode functionality (see [Table 5.4](#)). If both PHYs advertise the same options, the Master/Slave resolution is resolved by a random number generation. See IEEE 802.3ab Clause 40.5.1.2 and [Table 5.3](#) for more details.

### 5.3.3 AutoNegotiation Pause and Asymmetrical Pause Resolution

AutoNegotiation is also used to determine the Flow Control capabilities of the two link partners. Flow control was originally introduced as a mechanism to force a busy station's Link Partner to stop sending data in the Full-Duplex mode of operation. Unlike the Half-Duplex mode of operation where a link partner could be forced to back off by simply causing collisions, the Full-Duplex operation needs a formal mechanism to slow down a link partner in the event of the receiving station's buffers



becoming full. A new MAC control layer was added to handle generation and reception of Pause Frames. This control layer contains a timer indicating the amount of Pause requested. Each MAC/Controller has to advertise whether it can handle Pause Frames, and whether they support Pause Frames in both directions (receive and transmit). If the MAC/Controller only generates Pause Frames but does not respond to Pause Frames generated by a link partner, this is called Asymmetrical Pause. Advertisement of these capabilities can be achieved by writing a 1 to bits 10 and 11 of the [AutoNegotiation Advertisement Register \(ANAR\) Address 0x04](#). The link partners Pause capabilities can be determined from [AutoNegotiation Link Partner Ability Register \(ANLPAR\) Address 0x05](#) using these same bits. The MAC/controller has to write to and read from these registers and determine which mode of Pause operation to choose. The PHY layer is not involved in Pause resolution other than the simple advertising and reporting of Pause capabilities (these capabilities are MAC capabilities and configured by the MAC into PHY registers).

### 5.3.4 AutoNegotiation Automatic MDIX Resolution

The L80600 can determine if a “straight” or “crossover” cable is being used to connect to the link partner and can automatically reassign channel A and channel B to establish link with the link partner. Although not part of the AutoNegotiation FLP exchange process, the Automatic MDIX resolution requires that AutoNegotiation is enabled. Automatic MDIX resolution precedes the actual AutoNegotiation process, which involves exchange of FLPs to advertise capabilities. If AutoNegotiation is not enabled, the MDIX function can be manually configured by disabling Automatic MDIX and forcing either a straight or a crossover cable configuration. See [Chapter 9, “L80600 Frequently Asked Questions”](#) for details.

### 5.3.5 AutoNegotiation Strap Option Control

The AutoNegotiation function within the L80600 can be controlled either by internal register access or by the use of the AN\_EN, and various strap pin values during power-on/reset. [Table 5.4](#) shows how the various strap pin values are used during AutoNegotiation to advertise different capabilities.

**Table 5.4 AutoNegotiation Modes AN\_EN = 1**

Pin #	Pin Name	Comments
184	1000FDX_ADV /LED_1000	1 = advertise 1000 Mb/s FDX capability.
185	LED_DUPLEX/1000HDX_ADV	1 = advertise 1000 Mb/s HDX capability.
181	LED_100/100_ADV	1 = advertise both 100 Mbit/s FDX and HDX capability.
180	LED_10/10_ADV/SPEED[1]	1 = advertise 10 Mbit/s FDX and HDX. 0 = advertise neither FDX nor HDX 10 Mb/s capability.
208	SPEED[0]/PORT_TYPE	1 = advertise Multinode functionality (switch or repeater, in contrast to NIC single node operation).

### 5.3.6 AutoNegotiation Register Control

The state of the AN\_EN, SPEED [1:0] and DUPLEX pins as well as the xxx\_ADV pins during power-on/reset determines whether AutoNegotiation is enabled and, if so, what specific ability (or set of abilities) is advertised as given in [Table 5.4](#). These strapping option pins allow configuration options to be selected without requiring internal register access.

The AutoNegotiation function selected at power-up or reset can be changed at any time by writing to the [Basic Mode Register \(BMCR\) Address 0x00](#), [AutoNegotiation Advertisement Register \(ANAR\) Address 0x04](#) or to [1000BASE-T Control Register \(1KTCR\) Address 0x09](#).

When AutoNegotiation is enabled, the L80600 transmits the abilities programmed into the [AutoNegotiation Advertisement Register \(ANAR\) Address 0x04](#), and [1000BASE-T Control Register \(1KTCR\) Address 0x09](#) using FLP Bursts. Any combination of 10 Mb/s, 100 Mb/s, 1000 Mb/s, Half-Duplex, and Full-Duplex modes may be selected. The AutoNegotiation protocol compares the contents of the [AutoNegotiation Link Partner Ability Register \(ANLPAR\) Address 0x05](#) and ANAR registers (for 10/100 Mbit/s operation) and the contents of 1000BASE-T status and control registers, and uses the results to automatically configure to the highest performance protocol between the local and far-end port. The results of AutoNegotiation may be accessed in registers

BMCR (Duplex Status and Speed Status), and BMSR (AutoNegotiation Complete, Remote Fault, Link).

The [Basic Mode Register \(BMCR\) Address 0x00](#) provides control for enabling, disabling, and restarting the AutoNegotiation process.

The [Basic Mode Status Register \(BMSR\) Address 0x01](#) indicates the set of available abilities for technology types, AutoNegotiation ability, and Extended Register Capability. These bits are permanently set to indicate the full functionality of the L80600.

The BMSR also provides status on:

- Whether AutoNegotiation is complete (bit 5)
- Whether the Link Partner is advertising that a remote fault has occurred (bit 4)
- Whether a valid link has been established (bit 2)

The [AutoNegotiation Advertisement Register \(ANAR\) Address 0x04](#) indicates the AutoNegotiation abilities to be advertised by the L80600. All available abilities are transmitted by default, but any ability can be suppressed by writing to the ANAR. Updating the ANAR to suppress an ability is one way for a management agent to change (force) the technology that is used.

The [AutoNegotiation Link Partner Ability Register \(ANLPAR\) Address 0x05](#) is used to receive the base link code word as well as all Next Page code words during the negotiation.

If Next Page is not being used, the ANLPAR stores the base link code word (link partner's abilities) and retains this information from the time the page is received, as indicated by a 1 in bit 1 of the [AutoNegotiate Expansion Register \(ANER\) Address 0x06](#), through the end of the negotiation and beyond.

When using the Next Page operation, the L80600 cannot wait for AutoNegotiation to complete in order to read the ANLPAR, because the register is used to store both the base and next pages. Software must be available to perform several functions. The ANER register (register 0x06) must have a page received indication (bit 1). Once the L80600 receives the first page, software must store it in memory if it wants to keep the information. AutoNegotiation keeps a copy of the base page

information but it is no longer accessible by software. After reading the base page information, software needs to write to the [AutoNegotiation Next Page Transmit Register \(ANNPTR\) Address 0x07](#) to load the next page information to be sent. Software must then continue to poll the page received bit in the ANER and, when active, read the ANLPAR. The contents of the ANLPAR register indicate if the partner has further pages to be sent. As long as the partner has more pages to send, software must write to the next page transmit register and load another page.

The [AutoNegotiate Expansion Register \(ANER\) Address 0x06](#) indicates additional AutoNegotiation status. The ANER provides status on:

- Whether a Parallel Detect Fault has occurred (bit 4, register address 0x06).
- Whether the Link Partner supports the Next Page function (bit 3, register address 0x06).
- Whether the L80600 supports the Next Page function (bit 2, register address 0x06 (the L80600 supports the Next Page function)).
- Whether the current page being exchanged by AutoNegotiation has been received (bit1, register address 0x06).
- Whether the Link Partner supports AutoNegotiation (bit 0, register address 0x06).

The [AutoNegotiation Next Page Transmit Register \(ANNPTR\) Address 0x07](#) contains the next page code word to be sent.

### 5.3.7 AutoNegotiation Parallel Detection

The L80600 supports the Parallel Detection function as defined in the IEEE 802.3u specification. Parallel Detection requires the 10/100 Mbits/s receivers to monitor the receive signal and report link status to the AutoNegotiation function. AutoNegotiation uses this information to configure the correct technology in the event that the Link Partner does not support AutoNegotiation, yet is transmitting link signals that the 10BASE-T or 100BASE-X PMA recognize as valid link signals.

If the L80600 completes AutoNegotiation as a result of Parallel Detection, without Next Page operation, bits 5 and 7 within the ANLPAR register (address 0x05) are set to reflect the mode of operation present in the Link Partner. Note that bits 4:0 of the ANLPAR are also set to 0b00001

based on a successful parallel detection to indicate a valid 802.3u selector field. Software may determine that negotiation completed through Parallel Detection by reading a zero in the [AutoNegotiate Expansion Register \(ANER\) Address 0x06](#) bit 0 once the [Basic Mode Status Register \(BMSR\) Address 0x01](#) bit 5 is set. If any condition other than a single good link occurs, the parallel detect fault bit is set (bit 4, register 0x06).

### 5.3.8 AutoNegotiation Restart

Once AutoNegotiation has completed, it may be restarted at any time by setting bit 9 (Restart AutoNegotiation) of the [Basic Mode Register \(BMCR\) Address 0x00](#) to 1. If the mode configured by a successful AutoNegotiation loses a valid link, then the AutoNegotiation process resumes and attempts to determine the configuration for the link. This function ensures that a valid configuration is maintained if the cable becomes disconnected.

A renegotiation request from any entity, such as a management agent, causes the L80600 to halt any transmit data and link pulse activity until the break\_link\_timer expires (approximately 1500 ms). Consequently, the Link Partner goes into link fail and normal AutoNegotiation resumes. The L80600 resumes AutoNegotiation after the break\_link\_timer has expired by issuing FLP (Fast Link Pulse) bursts.

### 5.3.9 Enabling AutoNegotiation through Software

It is important to note that if the L80600 has been initialized at power-up as a Non-AutoNegotiating device (forced technology), it is then required that AutoNegotiation or re-AutoNegotiation be initiated through software. Bit 12 (AutoNegotiation Enable) of the [Basic Mode Register \(BMCR\) Address 0x00](#) must first be cleared and then set for any AutoNegotiation function to take effect.

### 5.3.10 AutoNegotiation Complete Time

Completing parallel detection and AutoNegotiation takes approximately 2–3 seconds for 10/100 Mbps devices and 5–6 seconds for 1000 Mbps devices. In addition, completing AutoNegotiation with Next Page should take approximately 2–3 seconds, depending on the number of next pages sent.

Refer to Clause 28 of the IEEE 802.3u standard for a full description of the individual timers related to AutoNegotiation.

### 5.3.11 AutoNegotiation Next Page Support

The L80600 supports the optional AutoNegotiation Next Page protocol. The [AutoNegotiation Next Page Transmit Register \(ANNPTR\) Address 0x07](#) allows for the configuration and transmission of Next Page. Refer to clause 28 of the IEEE 802.3u standard for detailed information regarding the AutoNegotiation Next Page function. This functionality is also discussed in [Section 5.3.6, “AutoNegotiation Register Control”](#) above and in [Chapter 7, “User Information.”](#)

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## 5.4 MII Isolate Mode

This section describes how to put the L80600 into isolate mode.

### 5.4.1 10/100 Mb/s Isolate Mode

The L80600 can be put into MII Isolate mode by writing to bit 10 of the [Basic Mode Register \(BMCR\) Address 0x00](#) register.

With bit 10 in the BMCR set to 1, the L80600 does not respond to packet data present at TXD[3:0] or the TX\_EN, and TX\_ER inputs. In addition, the TX\_CLK, RX\_CLK, RX\_DV, RX\_ER, RXD[3:0], COL, and CRS outputs are 3-stated. The L80600 continues to respond to all management transactions on the MDIO line.

While in Isolate mode, the TD± outputs do not transmit packet data, but continue to source 100BASE-TX scrambled idles or the 10 Mb/s link pulses.

### 5.4.2 1000 Mb/s Isolate Mode

During 1000 Mb/s operation, entering the isolate mode 3-states the GMII outputs of the L80600. When the L80600 enters into the isolate mode, all media access operations are halted and the L80600 goes into power-down mode. The only way to communicate to the PHY is through the MDIO management port.

---

## 5.5 Loopback

The L80600 includes a Loopback Test mode for easy board diagnostics. The Loopback mode is selected through bit 14 (Loopback) of the [Basic Mode Register \(BMCR\) Address 0x00](#). Writing 1 to this bit enables MII/GMII transmit data to be routed to the MII/GMII receive outputs. While in Loopback mode, data is not transmitted onto the media. This is true for 10 Mbits/s, 100 Mbits/s, and 1000 Mbits/s modes.

In 10BASE-T, 100BASE-TX, and 1000BASE-T loopback modes, the data is routed through the PCS and PMA layers into the PMD sublayer before it is looped back. Therefore, in addition to serving as a board diagnostic, this mode serves as a quick functional verification of the device.

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## 5.6 MII/GMII Interface and Speed of Operation

The L80600 supports two different MAC interfaces: MII for 10 and 100 Mbits/s, and GMII for 1000 Mbits/s. The speed of operation determines the interface chosen. The speed can be determined by AutoNegotiation, strap options, or by register writes.

**Table 5.5 AutoNegotiation Disabled**

SPEED[1:0]	Link Strapped	Controller I/F
00	10BASE-T	MII
01	100BASE-TX	MII
10	1000BASE-T	GMII

**Table 5.6 AutoNegotiation Enabled**

Link Negotiated	Controller Interface
10BASE-T	MII
100BASE-TX	MII
1000BASE-T	GMII

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## 5.7 Test Modes

IEEE 802.3ab specification for 1000BASE-T requires that the Physical layer device be able to generate certain well-defined test patterns. Clause 40 section 40.6.1.1.2 “Test Modes” describes these tests in detail. There are four test modes as well as a normal mode. These modes can be selected by writing to the [1000BASE-T Control Register \(1KTCR\) Address 0x09](#) as shown.

**Table 5.7 Test Mode Select**

Bit 15	Bit 14	Bit 13	Test Mode Selected
1	0	0	Test Mode 4
0	1	1	Test Mode 3
0	1	0	Test Mode 2
0	0	1	Test Mode 1
0	0	0	Normal Operation

See IEEE 802.3ab section 40.6.1.1.2 “Test Modes” for more information.

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## 5.8 Automatic MDI/MDIX Configuration

The L80600 implements the automatic MDI/MDIX configuration functionality as described in IEEE 802.3ab Clause 40, Section 40.4.4.1. This functionality eliminates the need for crossover cables between similar devices. The switching between the +/- A port with the +/- B port is automatically taken care of, as well as switching between the +/- C port and the +/- D port.

The IEEE 802.3ab specification calls for the physical layer device to detect its Link Partner's link pulses within 62 ms. During the MDIX detection phase, the L80600 sends out link pulses that are spaced 150  $\mu$ s apart. The 150  $\mu$ s link pulse spacing was purposely selected to transmit non-FLP bursts (FLP pulses are spaced 124  $\mu$ s  $\pm$  14  $\mu$ s) so that the link partner would not mistakenly attempt to “link up” on the MDIX link pulses.



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## 5.9 Polarity Correction

The L80600 automatically detects and corrects for polarity reversal in wiring between the +/- wires for each of the four ports.

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### 5.10 Firmware Interrupt

The L80600 can be configured to generate an interrupt on pin 208 when internal status changes. The interrupt allows a MAC to act upon the status in the PHY without polling the PHY registers. The interrupt source can be selected through the interrupt register set. This register set consists of:

- Interrupt Status Registers
  - [Interrupt\\_Status ISR0 Address 0x810D](#)
  - [Interrupt\\_Status ISR1 Address 0x810E](#)
- Interrupt Enable Registers
  - [Interrupt\\_Enable IER0 Address 0x811](#)
  - [Interrupt\\_Enable IER1 Address 0x8114](#)
- Interrupt Clear Registers
  - [Interrupt\\_Clear ICLR0 Address 0x8115](#)
  - [Interrupt\\_Clear ICLR1 Address 0x8116](#)
- Interrupt Control Register
  - [Interrupt\\_Control ICTR Address 0x8117](#)
- Interrupt Raw Reason Registers
  - [Interrupt\\_Raw\\_Reason RRR0 Address 0x8111](#)
  - [Interrupt\\_Raw\\_Reason RRR1 Address 0x8112](#)
- Interrupt Reason Registers
  - [Interrupt\\_Reason IRR0 Address 0x810F](#)
  - [Interrupt\\_Reason IRR1 Address 0x8110](#)

Upon reset, interrupt is disabled and the interrupt registers are initialized with their default values.

The interrupt signal's polarity can be programmed in the ICTR register. The polarity can be configured active-HIGH or active-LOW. In the latched mode, the interrupt signal is asserted and remains asserted while the corresponding enabled status bit is asserted. The status bits are the sources of the interrupt. These bits are mapped in the ISR. When the interrupt status bit is 1, the interrupt signal is asserted if the corresponding IER bit is enabled. An interrupt status bit can be cleared by writing a 1 to the corresponding bit in the ICLR. The clear bit returns to 0 automatically after the interrupt status bit is cleared.

The RRR register contains the current status of the signals being monitored. Note that the status of the configuration, duplex, and speed are recorded in the most recent period while the link was up.

The IRR records the *reason* that an interrupt status bit is asserted. For example, if the ISR\_LINK bit is asserted in the ISR because a link is achieved, a 1 is stored in the corresponding IRR bit field. This IRR bit field is not changed until the interrupt is serviced, regardless of how many times the source status (in RRR) changes in the intervening period. The IRR bit can be cleared by writing a 1 to the corresponding bit in the ICLR register.

The purpose of the IRR is for the interrupt logic to determine the next state change to cause an interrupt. In reality, the PHY may operate at a much faster pace than the interrupt service provider. The IRR provides a mechanism for the higher layers to decipher the context of the interrupt although the context of the system may have changed by the time the interrupt is serviced. For instance, when a link is lost and regained in quick succession, it is likely that a sequence of interrupts are generated by the same event. The IRR preserves the status of the event that may have changed during the interrupt service. A new interrupt may be generated if the status is changed based on the comparison between the IRR and the RRR.

**Note:** All the interrupt registers are extended registers located in the expanded memory space. Please refer to [Chapter 4, "Registers"](#) for details.

# Chapter 6

## Applications

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This chapter provides practical information and design tips to assist in the design and layout of a system implementing the L80600 Gigabit Ethernet transceiver. This chapter contains the following sections:

- [Section 6.1, “Power Supply Filtering”](#)
  - [Section 6.2, “Twisted-Pair Interface”](#)
  - [Section 6.3, “MAC Interface”](#)
  - [Section 6.4, “Clocks”](#)
  - [Section 6.5, “LED/Strapping Options”](#)
  - [Section 6.6, “Unused Pins/Reserved Pins”](#)
  - [Section 6.7, “Hardware Reset”](#)
  - [Section 6.8, “Temperature Considerations”](#)
  - [Section 6.9, “System Design Implementation Consideration”](#)
  - [Section 6.10, “Pin List and Connections”](#)
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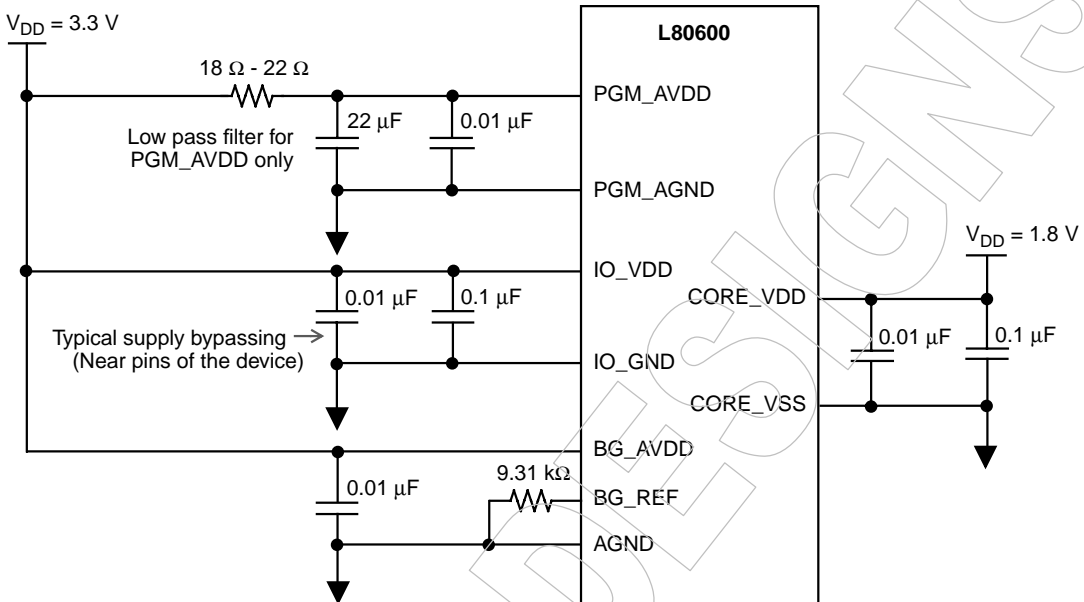
### 6.1 Power Supply Filtering

The PCB should have at least one solid ground plane, one solid 3.3 V plane, and one solid 1.8 V plane, with no breaks in any of the planes. The interplane capacitance between the supply and ground planes should be maximized by minimizing the distance between the planes. Filling unused signal planes with copper and connecting them to the proper power plane also increases the interplane capacitance. The interplane capacitance acts like a short at high frequencies to reduce supply plane impedance. Not all designs are able to incorporate the recommended suggestions because of board cost constraints.

The 3.3 V and 1.8 V supply pins come in pairs with their corresponding ground pins (a 3.3 V supply-ground pair is formed by pin 2 [RA\_AVDD] and pin 3 [RA\_AGND]). These paired pins are physically adjacent to each other. The matching pins should be bypassed with low-impedance surface mount 0.1  $\mu\text{F}$  capacitors connected directly into the power planes with vias as close as possible to the pins. This reduces the inductance in series with the bypass capacitor. Any increase in inductance lowers the capacitor's self-resonant frequency, which degrades the high frequency performance of the capacitor. It is also recommended that 0.01  $\mu\text{F}$  capacitors be connected in parallel with the 0.1  $\mu\text{F}$  capacitors, or at least “dispersed”, replacing some of the 0.1  $\mu\text{F}$  capacitors. The lower-value capacitance increases the frequency range of effectiveness of the bypassing scheme. This is due to the unavoidable inductance of the leads and connections on the board, which cause resonance at low frequencies for large value capacitors.

The Analog PGM supply requires special filtering to attenuate high frequencies. High frequencies increase the jitter of the PGM. It is also recommended to implement a low-pass filter formed by a 18–22  $\Omega$  resistor and two capacitors in parallel, as shown in Figure 6.1. One of the capacitors should be 22  $\mu\text{F}$  and the other 0.01  $\mu\text{F}$  (this implements a single-pole low-pass filter with 3 dB frequency around 360–400 Hz). The maximum supply current is 5 mA.

**Figure 6.1 Power Supply Filtering**



A 10  $\mu\text{F}$  capacitor should also be placed close to the L80600 (possibly on the bottom side of the PCB), bypassing the VCC and ground planes.

The pin checklist in [Table 6.8](#) shows the suggested connections of these capacitors for every supply, ground, and substrate pin.

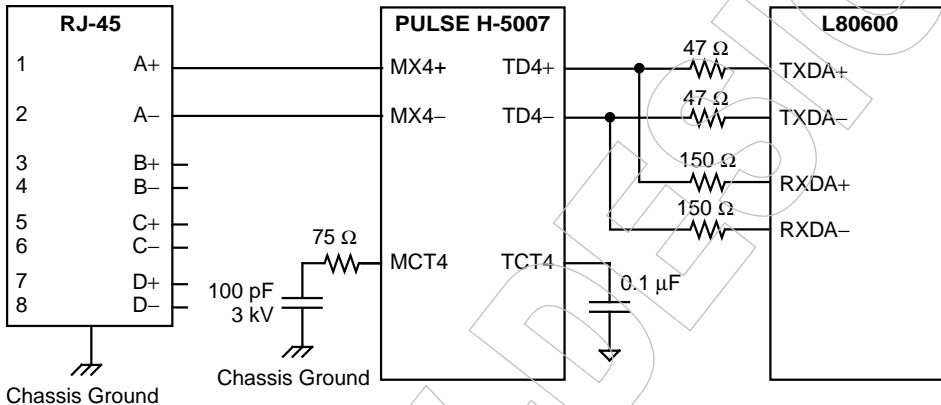
Ferrite beads can also be used to isolate power plane noise.

## 6.2 Twisted-Pair Interface

The Twisted-Pair Interface consists of four differential transmit pairs (channels A, B, C, and D) and four differential receive pairs (channels A, B, C, and D). Each transmit pair is connected to its corresponding receive pair through 47  $\Omega$  and 150  $\Omega$  resistors, respectively. The two 47  $\Omega$  resistors in combination with the source impedance of the transmitter forms a 100  $\Omega$  differential input impedance as seen from the line. This impedance is required to minimize reflections. [Figure 6.2](#) shows a typical connection for Channel A. Channels B, C, and D are identical. The combined transmit and receive trace then goes directly to 1:1 magnetics. The Pulse H-5007 or Pulse H-5008 is currently

recommended. Both magnetics are pin-for-pin compatible, but with different package orientations. The H-5007/8 has an isolation transformer followed by a common mode choke to reduce EMI. There is an additional autotransformer that is center-tapped. These transformers, as well as others from Halo, Bel Fuse, Transpower, and Midcom should be evaluated for best performance for each design.

**Figure 6.2 Twisted-Pair/Magnetics Interface (Channel A Only)**



Note: Only the connections for one of the twisted-pair channels is shown. Connections for channels B, C, D are similar.

- Place the 47  $\Omega$  1% transmit resistors as close as possible to the TXDA+/-, TXDB+/-, TXDC+/-, and TXD+/- pins
- Place the 150  $\Omega$  1% receive resistors as close as possible to the RXDA+/-, RXDB+/-, RXDC+/-, and RXDD+/- pins.
- All traces to and from the twisted-pair interface should have a controlled impedance of 50  $\Omega$  to the ground plane. This is a strict requirement. They should be as close in length to each other as possible to prevent mismatches in delay that increase common mode noise.

Ideally, there should be no crossovers or vias on the signal paths of these traces. [Table 6.1](#) lists recommended magnetics manufacturers and [Table 6.2](#) lists typical magnetics characteristics.

**Table 6.1 Magnetic Manufacturers**

Manufacturer <sup>1</sup>	Website	Part Number
Pulse Engineering	www.pulseeng.com	H5007 H5008
Bel Fuse	www.belfuse.com	S558-5999-P3 S558-599-T3
Delta	www.delta.tw	LF9203
Halo	www.haloelectronics.com	TG1G-S002NZ
Midcom	www.midcom-inc.com	
Transpower	www.trans-power.com	

1. Contact magnetics manufacturers for latest part numbers and product specifications. All magnetics should be thoroughly tested and validated before using them in production.

**Table 6.2 Typical Magnetics Characteristics**

Parameter	Min.	Typ.	Max.	Units	Conditions
Turns Ratio	—	1:1	—	—	± 2%
Insertion Loss	0.0	—	1.1	dB	0.1–1 MHz
	—	—	0.5	dB	1.0–60 MHz
	—	—	1.0	dB	60–100 MHz
	—	—	1.2	dB	100–125 MHz
Return Loss	–18	—	—	dB	1.0–30 MHz
	–14.4	—	—	dB	30–40 MHz
	–13.1	—	—	dB	40–50 MHz
	–12.0	—	—	dB	50–80 MHz
	–10.0	—	—	dB	80–100 MHz
Differential to Common Mode Rejection	–43.0	—	—	dB	1.0–30 MHz
	–37.0	—	—	dB	30–60 MHz
	–33.0	—	—	dB	60–100 MHz

**Table 6.2 Typical Magnetics Characteristics (Cont.)**

Parameter	Min.	Typ.	Max.	Units	Conditions
Cross Talk	-45.0	-	-	dB	1.0–30 MHz
	-40.0	-	-	dB	30–60 MHz
	-35.0	-	-	dB	60–100 MHz
Isolation	1500	-	-	V	-
Rise Time	-	1.6	1.8	ns	10–90%
Primary Inductance	350	-	-	μH	-

## 6.3 MAC Interface

The L80600 can be configured in one of two different modes:

- GMII (Gigabit Media Independent Interface) Mode: This interface is used to support 802.3z compliant 1000 Mb/s MACs.
- MII (Media Independent Interface) Mode: This interface is used to support 10/100 Mb/s MACs.

Only one mode can be supported at a time, because the GMII and MII share some pins.

These outputs are capable of driving 35 pF under worst case conditions, and they were not designed to drive multiple loads, connectors, backplanes, or cables. It is recommended that the outputs be series terminated through a resistor as close to the output pins as possible. The purpose of the series termination is to reduce reflections on the line. The value of the series termination and length of trace the output can drive depends on the driver output impedance, the characteristic impedance of the PCB trace (we recommend 50 Ω), the distributed trace capacitance (capacitance/inch), and the load capacitance (MAC input). For short traces (less than 0.5 inches) the series resistors may not be required, thus reducing component count. However, each specific board design should be evaluated for reflections and signal integrity to determine the need for the series terminations. As a general rule of thumb, if the trace length is less than 1/6 of the equivalent length of the rise and fall times, the series terminations may not be needed.



The equivalent length of rise time is:

Length of Rise Time = Rise time (ps)/Delay (ps/inch)

Rise and fall times are required to be less than 1 ns for some GMII signals, and are typically on the order of 500 ps for those pins (RX\_CLK, GTX\_CLK). Delay typically is 170 ps/inch on an FR4 board. Using the above numbers yields a critical trace length of  $(1/6) * (500/170) = 0.5$  inches.

In summary:

- Place series termination resistors as close to the pins as possible.
- Keep capacitance less than 35 pF as seen by the output.
- Keep output trace lengths approximately the same length to avoid skew problems.
- Keep input trace lengths approximately the same length to avoid skew problems.

All GMII traces should be impedance controlled. 50 ohms to the ground plane is recommended, but this is not a strict requirement and the board designer can experiment with different values to minimize reflections

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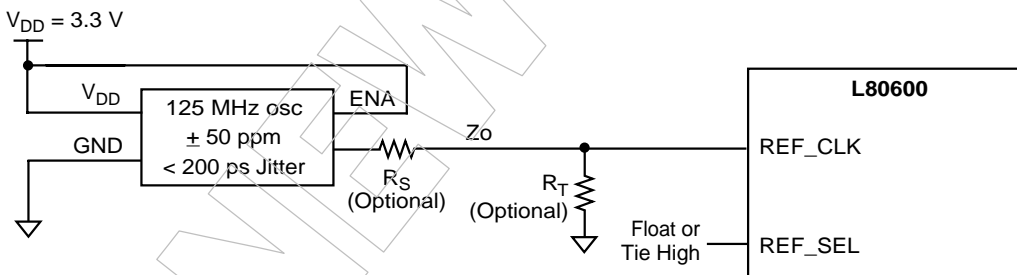
## 6.4 Clocks

The REF\_CLK pin can be driven from either a 125 MHz oscillator or a 25 MHz oscillator. The 125 MHz or 25 MHz clock is used by the internal PLL to generate the various clocks needed both internally and externally. REF\_SEL (pin 154) should be left floating when using a 125 MHz oscillator and pulled to ground through a 1 k $\Omega$  resistor when using a 25 MHz oscillator. The cycle-to-cycle jitter and the long-term cumulative jitter (cumulative jitter can be measured using an oscilloscope with a delay trigger set at 10  $\mu$ s or using a Wavecrest TIA) of both the 125 MHz and 25 MHz oscillators should be less than 200 ps for optimal cable performance. Testing using the 25 MHz oscillator shows that the L80600 exceeds the 100 meter cable length requirement in 1000 Mb/s, 100 Mb/s and 10 Mb/s modes, but the transmit jitter in 1000 Mbit/s mode is outside the IEEE specification. The specification stipulates that transmit clock jitter + transmit output jitter be less than 300 ps.

A second option for the REF\_CLK input pin is the reference clock that is common to the MAC (GTX\_CLK for 125 MHz operation) or sharing a 25 MHz oscillator that is used on some MACs. Using this option requires that the jitter be less than 200 ps, the tolerance be  $\pm 50$  ppm, and if the drive capability is too low, buffering of the clock to insure proper signal integrity.

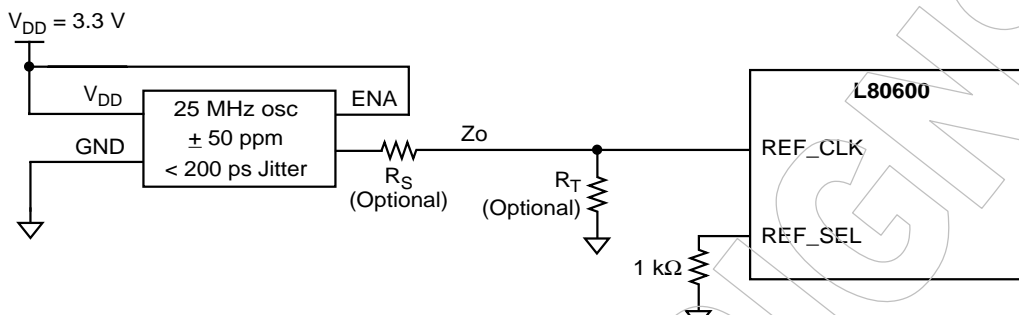
The clock signal requires the same termination considerations mentioned in the MAC interface section. The clock signal might require both series source termination ( $R_S$ ) at the output of the clock source and/or load termination ( $R_T$ ) close to the PHY to eliminate reflections. This depends on the distance of the clock source from the PHY clock input, the source impedance of the clock source, as well as the board impedance for the clock line considered as a transmission line. Typically, no series or load termination is required for short traces. For long traces, a series resistor is recommended. Unlike load termination, this does not add to the load current. The value of the series termination resistor has to be chosen to match the line impedance. As an example, if the clock source has an output impedance of  $20\ \Omega$  and the clock trace has transmission line impedance  $Z_0 = 50\ \Omega$ , then  $R_S = 50 - 20 = 30\ \Omega$ .

**Figure 6.3 125 MHz Oscillator Option**



Note: Instead of an oscillator, REF\_CLK can be driven by the MAC's 125 MHz clock

**Figure 6.4 25 MHz Oscillator Option**



Note: Instead of an oscillator, REF\_CLK can be driven by the MAC's 25 MHz clock

Typical 25 MHz and 125 MHz oscillator requirements are given in [Table 6.3](#) and [Table 6.4](#), while [Table 6.5](#) lists recommended oscillator manufacturers.

**Table 6.3 25 MHz Oscillator Requirements**

Parameter	Min.	Typ.	Max.	Units	Conditions
Frequency	–	25	–	MHz	–
Frequency Stability	– 50	0	50	ppm	0 to 70 °C
Rise/Fall Time	–	–	–	ns	20–80%
Symmetry	40	–	60	%	duty cycle
Jitter (Cycle to Cycle)	–	–	25	ns	rising edge to rising edge
Jitter (Accumulative)	–	–	200	ns	delay trigger 10 $\mu$ s
Logic 0	–	–	10% Vdd	V	VDD = 2.5 or 3.3 V nominal
Logic 1	90% Vdd	–	–	V	VDD = 2.5 or 3.3 V nominal

**Table 6.4 125 MHz Oscillator Requirements**

Parameter	Min.	Typ.	Max.	Units	Conditions
Frequency	–	125	–	MHz	–
Frequency Stability	–50	0	50	ppm	0 to 70 °C
Rise/Fall Time	–	–	3	ns	20–80%
Symmetry	40	–	60	%	duty cycle
Jitter (Cycle to Cycle)	–	–	25	ns	rising edge to rising edge
Jitter (Accumulative)	–	–	200	ns	delay trigger 10 µs
Logic 0	–	–	10% Vdd	V	VDD = 2.5 or 3.3 V nominal
Logic 1	90% Vdd	–	–	V	VDD = 2.5 or 3.3 V nominal

**Table 6.5 Oscillator Manufacturers**

Manufacturer <sup>1</sup>	Website	Part Number
Vite Technology	<a href="http://www.viteonline.com">www.viteonline.com</a>	25 MHz (VCC1-B2B-25M000) 125 MHz (VCC1-B2B-125M000)
SaRonix	<a href="http://www.saronix.com">www.saronix.com</a>	125 MHz (SCS-NS-132)
Valpey Fisher	<a href="http://www.valpeyfisher.com">www.valpeyfisher.com</a>	125 MHz (VAC570BL) 125 MHz (VFAC38L)

1. Contact oscillator manufacturers for the latest information on part numbers and product specifications. All oscillators should be thoroughly tested and validated before using them in production.

## 6.5 LED/Strapping Options

The five PHY address inputs pins are shared with the LED pins as shown below.

**Table 6.6 PHY Address Mapping**

Pin	PHYAD Function	LED Function
200	PHYAD_0	ACT
201	PHYAD_1	COL
204	PHYAD_2	LNK
205	PHYAD_3	TX
207	PHYAD_4	RX

The L80600 can be set to respond to any of 32 possible PHY addresses. However, PHY Address 0 puts the L80600 in power-down/isolate mode. When in power-down/isolate mode, the device turns off its transmitter, receiver, and GMII inputs/outputs. When in this mode, the part only responds to MDIO/MDC activity. After power-on, the PHY should be taken out of power-down isolation by resetting bit 11 of register 0x00. Each L80600 or port sharing an MDIO bus in a system must have a unique physical address.

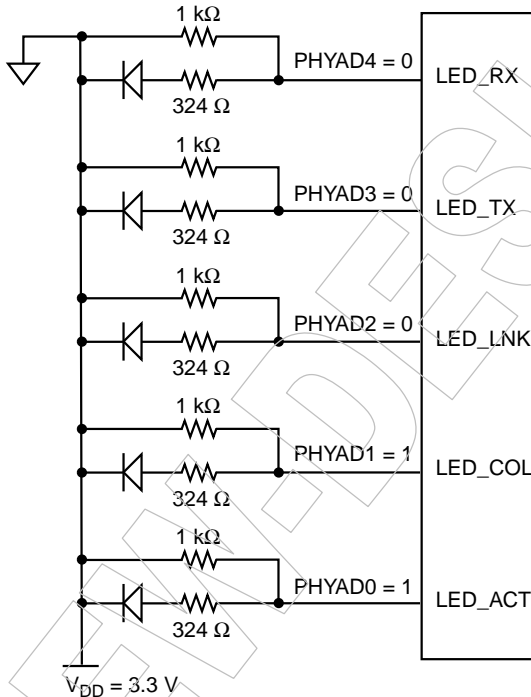
The pull-up or pull-down state of each of the PHYAD inputs is latched (register 0x10) at system power-up or reset. For further details relating to the latch-in timing requirements of the PHY Address pins, as well as the other hardware configuration pins, refer to the RESETn timing in [Section 8.5.6, “Reset Timing,” page 8-16](#).

Because the PHYAD strap options share the LED output pins, the external components required for strapping and LED usage must be considered in order to avoid contention.

Specifically, when the LED outputs are used to drive LEDs directly, the active state of each output driver is dependent on the logic level sampled by the corresponding PHYAD input upon power-up/reset. For example, if a given PHYAD input is resistively pulled LOW, the corresponding output is then configured as an active-HIGH driver. Conversely, if a given

PHYAD input is resistively pulled HIGH then the corresponding output is configured as an active-LOW driver. Refer to [Figure 6.5](#) for an example of LED and PHYAD connection to external components. In this example, the PHYAD strapping results in address 00011 (0x03).

**Figure 6.5 PHYAD Strapping and LED Loading Example**

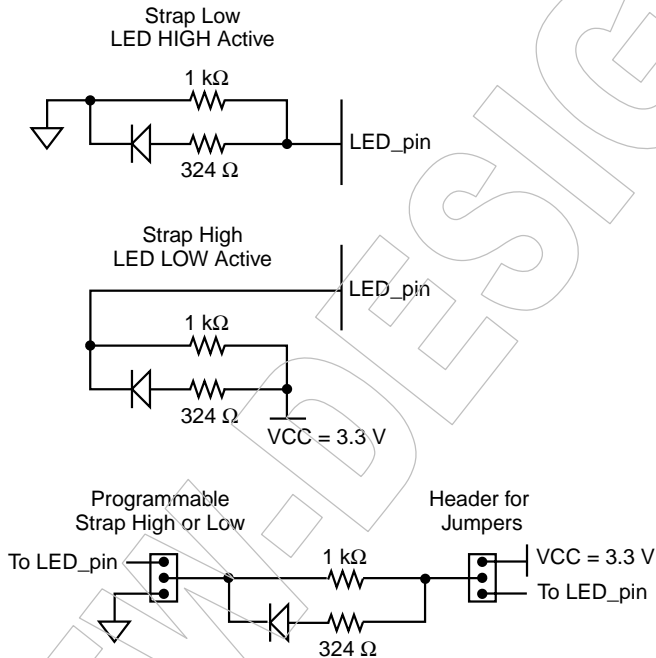


This adaptive nature for choosing the active HIGH or active LOW configuration applies to all the LED pins, not just the LED pins associated with PHYAD strap options. So all LED pins are active-HIGH if the strap value during reset on that specific LED pin was LOW. However, if the strap value was HIGH, the LED is active-LOW.

Care must be taken when using programmable strap options for pins containing LED functionality. Because the active-HIGH or active-LOW state of the LED pin changes depending on the strap low or high value, two sets of jumpers should be used, as shown in Figure 6.6. This figure shows two hardwired configurations for the LED and strap options. One of these is for the strap high/active-LOW mode, and the other is for the strap low/active-HIGH mode. Also shown in this figure is how to

implement programmable strap options using a header with jumpers. The left side jumpers should be connected for the high strap option, and the right side jumpers should be connected for the low strap option.

**Figure 6.6 LED Jumper Options**



## 6.6 Unused Pins/Reserved Pins

Unused CMOS input pins should not be left floating. This could result in inputs floating to intermediate values halfway between VCC and ground and turning on both the NMOS and the PMOS transistors, which results in high DC currents or oscillations. Therefore, unused inputs should be tied HIGH or LOW. It is recommended that unused input pins be terminated with a 5 kΩ resistor. This prevents excessive currents in case of a defect in the input structure, which may short either VCC or GND to the input. Another advantage of this method is that it reduces the chance of latch-up. As a compromise between the two approaches, one can group together adjacent unused input pins, and as a group pull them up or down using a single resistor.

Typical unused input pins can be the JTAG pins (TDI, TRST, TMS and TCK), which can be all tied together and pulled down using a 2 k $\Omega$  resistor. Some of the other reserved or unused pins include pins 186 and 206 (TEST); pins 165, 166, 169, 170, 174, 175, 176, and 177 (RESERVE\_GND); and pin 104 (SI). All of these pins except the TEST pins can be pulled down using a 2 k $\Omega$  resistor per group of pins. TEST pins can be pulled up or tied to VCC.

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## 6.7 Hardware Reset

The active-LOW RESETn signal (pin 164) should be held LOW for a minimum of 140  $\mu$ s to allow hardware reset (during hardware reset, the strap option pins are relatched, and register and state machines are reset). For timing details, see [Figure 8.13](#). There is no on-chip internal power-on reset. The L80600 requires an external reset signal applied to the RESETn pin.

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## 6.8 Temperature Considerations

The L80600 utilizes an enhanced 208-pin PQFP package that eliminates the need for heatsinks in most applications. The package has a built in heat slug at the top of the package that provides a very efficient method of removing heat from the die. The enhanced package has a low Theta Junction to Case of 2.13  $^{\circ}$ C/W and a Theta Junction to Ambient of 11.7  $^{\circ}$ C/W.

For reliability purposes, the die temperature of the L80600 should be kept below 120  $^{\circ}$ C. This translates to a package case temperature of 112  $^{\circ}$ C. For more information on how this calculation is done see [Chapter 9, "L80600 Frequently Asked Questions."](#)

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## 6.9 System Design Implementation Consideration

This section outlines certain characteristics of the L80600 that a designer should be aware of when designing the part into a system.



## 6.9.1 10 Mbits/s VOD

IEEE 802.3 specification, Clause 14, requires that the 10 Mbits/s output levels be within the following limits:

VOD = 2.2 to 2.8 V peak-differential, when terminated by a 100  $\Omega$  resistor directly at the RJ-45 outputs. The L80600 10 Mbit/s output level is typically 1.58 V peak-differential.

IEEE 802.3 specification, Clause 14, requires that a 10 Mbit/s PHY should be able to correctly receive signal levels on  $V_{in} = 585$  mV peak-differential. It also requires that any signal that is less than 300 mV peak-differential should be rejected by the PHY. The L80600 VOD level of 1.58 V peak-differential is received at the link partner with magnitudes exceeding  $V_{in} = 585$  mV peak-differential for cables up to 150 meters of CAT3 or CAT5 cables.

In 10 Mbit/s mode, the L80600 can receive and transmit up to 187 meters using CAT5 cable and up to 150 meters using CAT3 cable. There is no system level impact on the receive ability of the link partner due to the reduced levels of VOD transmitted by the L80600.

There are no plans to change the 10 Mbit/s VOD levels.

## 6.9.2 Asymmetrical Pause

IEEE 802.3ab has assigned bit 11 in register 0x04 to indicate Asymmetrical Pause capability. In the L80600 this bit is a read only bit with a default value of zero.

Asymmetrical Pause capability can be advertised by writing the PHY software registers as follows through the MDIO interface:

Write to register 0x16 the value 0x0D

Write to register 0x1E the value 0x8084

Write to register 0x1D the value 0x0001

The order of the writes is important. Register 0x1E is a pointer to the internal expanded addresses. Register 0x1D contains the data to be written to or read from the internal address pointed by register 0x1E. The contents of register 0x1E automatically increments after each read or write to register 0x1D. Therefore, if one wants to confirm that the data

write was successful, one should rewrite register 0x1E with the original address and then read register 0x1D.

There are no plans to change the Asymmetrical Pause register.

### 6.9.3 Next Page

The Next Page operation is not IEEE 802/3ab compliant. When the L80600 sends its last Next Page (register 0x04, bit 15 = 0), the L80600 stops the Next Page exchange with its Link Partner prematurely, without going through the final page. This causes the Link Partner to time out and a link is not established. This only occurs when the Link Partner has more Next Pages to send than the L80600. If the Link Partner has the same or fewer Next Pages to send than the L80600, the L80600 completes AutoNegotiation.

This problem only impacts systems that need to exchange Next page information. Firmware can be loaded either through MDIO writes or through EEPROM if Next Page operation is needed.

There are no plans to change the Next Page operation.

### 6.9.4 LED

A problem exists with the LED\_ACT (pin 200), LED\_COL (pin 201), LED\_TX (pin 205), and LED\_RX (pin 207) pins when PHY addresses other than 0b00001, 0b00100 or 0b00101 are used. Pins 200, 201, 205, and 207 are dual-purpose pins. When the part is first powered up, these pins act as inputs and load the PHY address. After power-up, these pins become outputs that drive LEDs. The outputs are either an active-HIGH output when the pin is a pull-down or an active-LOW output when the pin is a pull-up. Only certain PHY address bits are vulnerable to this failure mode:

- Pulling PHYAD\_1 (pin 200) HIGH causes the Collision LED to always remain off even when a collision event is detected.
- Pulling PHYAD\_3 (pin 205) HIGH causes the Transmit LED to always remain off even when a transmit event is detected.
- Pulling PHYAD\_4 (pin 207) HIGH causes the Receive LED to always remain off even when a receive event is detected.

- Pulling PHYAD\_3 or PHYAD\_4 HIGH causes the Activity LED to not work correctly.

This problem has no impact on system performance or the status of the internal registers. This problem only affects the operation of the Activity, Collision, Transmit, and Receive LEDs. If the LEDs are not needed, any PHY address can be used. The LEDs perform normally if the PHY address is strapped to 0b00001, 0b00100, or 0b00101. Table 6.7 shows the valid PHY address and the value to which the pins should be strapped. If a PHY address other than 0b00001, 0b00100, or 0b00101 needs to be used, firmware is available to work around the LED issue. The firmware is downloaded through MDIO writes or EEPROM.

This problem will be corrected in the next die revision.

**Table 6.7 PHY Addresses**

Pin #	PHY ADDRESS	LED FUNCTION	PHY ADDRESS 00001	PHY ADDRESS 00100	PHY ADDRESS 00101
200	PHYAD_0	ACTIVITY	Strap High	Strap Low	Strap High
201	PHYAD_1	COLLISION	Strap Low	Strap Low	Strap Low
204	PHYAD_2	LINK	Strap Low	Strap High	Strap High
205	PHYAD_3	TRANSMIT	Strap Low	Strap Low	Strap Low
207	PHYAD_4	RECEIVE	Strap Low	Strap Low	Strap Low

## 6.10 Pin List and Connections

Table 6.8 lists the L80600 pin numbers, names, and their functions. The signals are arranged in functional groups. This list should be used to make sure all pin connections and usages are correct.

**Table 6.8 Pin List**

Pin #	Pin Name	Type	Connections/ Comments
<b>MAC Interface</b>			
151	MDC	Input	<b>Management Data Clock:</b> Connect to MAC or controller using a 50 $\Omega$ impedance trace.
150	MDIO	I/O	<b>Management Data I/O:</b> Pull-up to VCC with a 1.54 k $\Omega$ resistor.
111	CRS	Output	<b>Carrier Sense:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This output is capable of driving 35 pF load and is not intended to drive connectors, cables, backplanes or multiple traces. This applies if the part is in 100 Mb/s mode or 1000 Mb/s mode.
110	COL	Output	<b>Collision:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This output is capable of driving 35 pF load and is not intended to drive connectors, cables, backplanes or multiple traces. This applies if the part is in 100 Mb/s mode or 1000 Mb/s mode.
130	TX_CLK	Output	<b>Transmit Clock/Receive Byte Clock 0:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This input has a typical input capacitance of 6 pF.
135	TXD7	Input	<b>Transmit Data 7:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This input has a typical input capacitance of 6 pF.
138	TXD6	Input	<b>Transmit Data 6:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This input has a typical input capacitance of 6 pF.
139	TXD5	Input	<b>Transmit Data 5:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This input has a typical input capacitance of 6 pF.
140	TXD4	Input	<b>Transmit Data 4:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This input has a typical input capacitance of 6 pF.

**Table 6.8 Pin List (Cont.)**

Pin #	Pin Name	Type	Connections/ Comments
141	TXD3	Input	<b>Transmit Data 3:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This input has a typical input capacitance of 6 pF.
144	TXD2	Input	<b>Transmit Data 2:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This input has a typical input capacitance of 6 pF.
145	TXD1	Input	<b>Transmit Data 1:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This input has a typical input capacitance of 6 pF.
146	TXD0	Input	<b>Transmit Data 0:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This input has a typical input capacitance of 6 pF.
134	TX_EN	Input	<b>Transmit Enable/Transmit Data 9:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This input has a typical input capacitance of 6 pF.
147	GTX_CLK	Input	<b>GMII Transmit Clock:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This input has a typical input capacitance of 6 pF.
133	TX_ER	Input	<b>Transmit Error/Transmit Data 9:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This input has a typical input capacitance of 6 pF.
126	RX_CLK	Output	<b>Receive Clock/ Receive Byte Clock 1:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This output is capable of driving 35 pF load and is not intended to drive connectors, cables, backplanes or multiple traces. This applies if the part is in 100 Mbits/s mode or 1000 Mbits/s mode.
114	RXD7	Output	<b>Receive Data 7:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This output is capable of driving 35 pF load and is not intended to drive connectors, cables, backplanes or multiple traces. This applies if the part is in 100 Mbits/s mode or 1000 Mbits/s mode.
115	RXD6	Output	<b>Receive Data 6:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This output is capable of driving 35 pF load and is not intended to drive connectors, cables, backplanes or multiple traces. This applies if the part is in 100 Mbits/s mode or 1000 Mbits/s mode.

**Table 6.8 Pin List (Cont.)**

Pin #	Pin Name	Type	Connections/ Comments
118	RXD5	Output	<b>Receive Data 5:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This output is capable of driving 35 pF load and is not intended to drive connectors, cables, backplanes or multiple traces. This applies if the part is in 100 Mb/s mode or 1000 Mb/s mode.
119	RXD4	Output	<b>Receive Data 4:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This output is capable of driving 35 pF load and is not intended to drive connectors, cables, backplanes or multiple traces. This applies if the part is in 100 Mb/s mode or 1000 Mb/s mode.
120	RXD3	Output	<b>Receive Data 3:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This output is capable of driving 35 pF load and is not intended to drive connectors, cables, backplanes or multiple traces. This applies if the part is in 100 Mb/s mode or 1000 Mb/s mode.
121	RXD2	Output	<b>Receive Data 2:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This output is capable of driving 35 pF load and is not intended to drive connectors, cables, backplanes or multiple traces. This applies if the part is in 100 Mb/s mode or 1000 Mb/s mode.
124	RXD1	Output	<b>Receive Data 1:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This output is capable of driving 35 pF load and is not intended to drive connectors, cables, backplanes or multiple traces. This applies if the part is in 100 Mb/s mode or 1000 Mb/s mode.
125	RXD0	Output	<b>Receive Data 0:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This output is capable of driving 35 pF load and is not intended to drive connectors, cables, backplanes or multiple traces. This applies if the part is in 100 Mb/s mode or 1000 Mb/s mode.
112	RX_ER	Output	<b>Receive Error/Receive Data 9:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This output is capable of driving 35 pF load and is not intended to drive connectors, cables, backplanes or multiple traces. This applies if the part is in 100 Mb/s mode or 1000 Mb/s mode.

**Table 6.8 Pin List (Cont.)**

Pin #	Pin Name	Type	Connections/ Comments
113	RX_DV	Output	<b>Receive Data Valid/Receive Data 8:</b> Connect to MAC chip through a single 50 $\Omega$ impedance trace. This output is capable of driving 35 pF load and is not intended to drive connectors, cables, backplanes or multiple traces. This applies if the part is in 100 Mbits/s mode or 1000 Mbits/s mode.
<b>Twisted-Pair Interface</b>			
9	TXDA+	Output	<b>Channel A Transmit Data Positive:</b> Connect to pin 12 of the H-5007 magnetics through a 47 $\Omega$ , 1% resistor. See <a href="#">Figure 6.2</a> .
10	TXDA-	Output	<b>Channel A Transmit Data Negative:</b> Connect to pin 11 of the H-5007 magnetics through a 47 $\Omega$ , 1% resistor. See <a href="#">Figure 6.2</a> .
13	TXDB-	Output	<b>Channel B Transmit Data Negative:</b> Connect to pin 9 of the H-5007 magnetics through a 47 $\Omega$ , 1% resistor. See <a href="#">Figure 6.2</a> .
14	TXDB+	Output	<b>Channel B Transmit Data Positive:</b> Connect to pin 8 of the H-5007 magnetics through a 47 $\Omega$ , 1% resistor. See <a href="#">Figure 6.2</a> .
39	TXDC+	Output	<b>Channel C Transmit Data Positive:</b> Connect to pin 6 of the H-5007 magnetics through a 47 $\Omega$ , 1% resistor. See <a href="#">Figure 6.2</a> .
40	TXDC-	Output	<b>Channel C Transmit Data Negative:</b> Connect to pin 5 of the H-5007 magnetics through a 47 $\Omega$ resistor (1%). See <a href="#">Figure 6.2</a> .
43	TXDD-	Output	<b>Channel D Transmit Data Negative:</b> Connect to pin 3 of the H-5007 magnetics through a 47 $\Omega$ resistor (1%). See <a href="#">Figure 6.2</a> .
44	TXDD+	Output	<b>Channel D Transmit Data Positive:</b> Connect to pin 2 of the H-5007 magnetics through a 47 $\Omega$ , 1% resistor. See <a href="#">Figure 6.2</a> .
4	RXDA+	Input	<b>Channel A Receive Data Positive:</b> Connect to pin 12 of the H-5007 magnetics through a 150 $\Omega$ , 1% resistor. See <a href="#">Figure 6.2</a> .
5	RXDA-	Input	<b>Channel A Receive Data Negative:</b> Connect to pin 11 of the H-5007 magnetics through a 150 $\Omega$ , 1% resistor. See <a href="#">Figure 6.2</a> .

**Table 6.8 Pin List (Cont.)**

Pin #	Pin Name	Type	Connections/ Comments
18	RXDB-	Input	<b>Channel B Receive Data Negative:</b> Connect to pin 9 of the H-5007 magnetics through a 150 $\Omega$ , 1% resistor. See <a href="#">Figure 6.2</a> .
19	RXDB+	Input	<b>Channel B Receive Data Positive:</b> Connect to pin 8 of the H-5007 magnetics through a 150 $\Omega$ , 1% resistor. See <a href="#">Figure 6.2</a> .
34	RXDC+	Input	<b>Channel C Receive Data Positive:</b> Connect to pin 6 of the H-5007 magnetics through a 150 $\Omega$ resistor (1%). See <a href="#">Figure 6.2</a> .
35	RXDC-	Input	<b>Channel C Receive Data Negative:</b> Connect to pin 5 of the H-5007 magnetics through a 150 $\Omega$ resistor (1%). See <a href="#">Figure 6.2</a> .
48	RXDD-	Input	<b>Channel D Receive Data Negative:</b> Connect to pin 3 of the H-5007 magnetics through a 150 $\Omega$ resistor (1%). See <a href="#">Figure 6.2</a> .
49	RXDD+	Input	<b>Channel D Receive Data Positive:</b> Connect to pin 2 of the H-5007 magnetics through a 150 $\Omega$ resistor (1%). See <a href="#">Figure 6.2</a> .
<b>JTAG Interface</b>			
156	TRST	Input	<b>JTAG Test Reset:</b> If not used connect to ground plane.
157	TDI	Input	<b>JTAG Test Data Input:</b> If not used connect to ground plane.
158	TDO	Output	<b>JTAG Test Data Output:</b> If not used leave floating.
159	TMS	Input	<b>JTAG Test Mode Select:</b> If not used connect to ground plane.
163	TCK	Input	<b>JTAG Test Clock:</b> If not used connect to ground plane.
<b>EEPROM Interface</b>			
189	SDA	I/O	<b>SDA:</b> This pin is used for EEPROM data and should be left floating if the EEPROM interface is not used.
190	SCL	I/O	<b>SCL:</b> This pin is used for EEPROM clock and should be left floating if the EEPROM interface is not used.



**Table 6.8 Pin List (Cont.)**

Pin #	Pin Name	Type	Connections/ Comments
<b>Clock Interface</b>			
153	REF_CLK	Input	<b>Reference Clock:</b> Connect to oscillator or crystal or board clock.
154	REF_SEL	Input	<b>Reference Select:</b> Leave floating or pulled HIGH for 125 MHz operation. Pull LOW for 25 MHz operation.
<b>LED/Interrupt Interface</b>			
180	LED_10/10_ADV/ SPEED [1]	I/O, Strap	<b>LED_10:</b> See <a href="#">Figure 6.5</a> for how to connect this pin.
181	LED_100/100_ADV	I/O, Strap	<b>LED_100:</b> See <a href="#">Figure 6.5</a> for how to connect this pin.
185	LED_DUPLEX/ 1000HDX_ADV	I/O, Strap	<b>LED_DUPLEX:</b> See <a href="#">Figure 6.5</a> for how to connect this pin.
200	LED_ACT/PHYAD_0	I/O, Strap	<b>Activity LED/PHY Address 0:</b> See <a href="#">Figure 6.5</a> for how to connect this pin.
201	LED_COL/PHYAD_1	I/O, Strap	<b>Collision LED/PHY Address 1:</b> See <a href="#">Figure 6.5</a> for how to connect this pin.
204	LED_LNK/PHYAD_2	I/O, Strap	<b>Link LED/PHY Address 2:</b> See <a href="#">Figure 6.5</a> for how to connect this pin.
205	LED_TX/PHYAD_3	I/O, Strap	<b>Transmit LED/PHY Address 3:</b> See <a href="#">Figure 6.5</a> for how to connect this pin.
207	LED_RX/PHYAD_4	I/O, Strap	<b>Receive LED/PHY Address 4:</b> See <a href="#">Figure 6.5</a> for how to connect this pin.
208	SPEED [0]/ PORT_TYPE/INT	I/O, Strap	<b>Speed Select [0]/Port Type:</b> See <a href="#">Figure 6.5</a> for how to connect this pin.
<b>Device Configuration interface</b>			
192	AN_EN/TX_TCLK	I/O, Strap	<b>AutoNegotiation Enable:</b> 1 k $\Omega$ pull-up or pull-down strap option. (If this pin is strapped low, then pin 184 should be strapped high.)
195	MANUAL_M/ S_ENABLE	I, Strap	<b>Manual Master/Slave Configuration Enable:</b> 1 k $\Omega$ pull-up or pull-down strap option.
191	MANUAL_M/ S_ADVERTISE	I/O, Strap	<b>Manual Master/Slave Configuration:</b> 1 k $\Omega$ pull-up or pull-down strap option.

**Table 6.8 Pin List (Cont.)**

Pin #	Pin Name	Type	Connections/ Comments
184	LED_1000/ 1000FDX_ADV	I/O, Strap	<b>LED_1000:</b> See <a href="#">Figure 6.5</a> for how to connect this pin. (If this pin is strapped low, then pin 192 should be strapped high.)
196	NC_MODE	I/O, Strap	<b>Noncompliant Mode:</b> Pull HIGH to interoperate with non-IEEE compliant transceivers.
<b>Reset Interface</b>			
164	RESET	Input	<b>Reset:</b> Connect to board reset signal.
<b>Ground</b>			
1	RA_ASUB	Ground	<b>Substrate Ground:</b> Connect to ground plane.
3	RA_AGND	Ground	<b>Receive Analog Ground:</b> Connect to ground plane.
7	RA_AGND	Ground	<b>Receive Analog Ground:</b> Connect to ground plane.
11	CDA_AGND	Ground	<b>Transmit Analog Ground:</b> Connect to ground plane.
12	CDB_AGND	Ground	<b>Transmit Analog Ground:</b> Connect to ground plane.
16	RB_AGND	Ground	<b>Receive Analog Ground:</b> Connect to ground plane.
20	RB_AGND	Ground	<b>Receive Analog Ground:</b> Connect to ground plane.
22	RB_ASUB	Ground	<b>Substrate Ground:</b> Connect to ground plane.
25	BG_AGND	Ground	<b>Bandgap Ground:</b> Connect to ground plane.
26	BG_SUB	Ground	<b>Bandgap Substrate:</b> Connect to ground plane.
28	PGM_AGND	Ground	<b>PGM Ground:</b> Connect to ground plane.
30	SHR_GND	Ground	<b>Analog Ground:</b> Connect to ground plane.
31	RC_ASUB	Ground	<b>Substrate Ground:</b> Connect to ground plane.
33	RC_AGND	Ground	<b>Receive Analog Ground:</b> Connect to ground plane.
37	RC_AGND	Ground	<b>Receive Analog Ground:</b> Connect to ground plane.
41	CDC_AGND	Ground	<b>Transmit Analog Ground:</b> Connect to ground plane.
42	CDD_AGND	Ground	<b>Transmit Analog Ground:</b> Connect to ground plane.
46	RD_AGND	Ground	<b>Receive Analog Ground:</b> Connect to ground plane.

**Table 6.8 Pin List (Cont.)**

Pin #	Pin Name	Type	Connections/ Comments
50	RD_AGND	Ground	<b>Receive Analog Ground:</b> Connect to ground plane.
52	RD_ASUB	Ground	<b>Substrate Ground:</b> Connect to ground plane.
57	IO_VSS	Ground	<b>I/O Ground:</b> Connect to ground plane.
63	IO_VSS	Ground	<b>I/O Ground:</b> Connect to ground plane.
67	CORE_SUB	Ground	<b>Digital Core Substrate:</b> Connect to ground plane.
68	CORE_VSS	Ground	<b>Digital Core Ground:</b> Connect to ground plane.
72	IO_VSS	Ground	<b>I/O Ground:</b> Connect to ground plane.
78	IO_VSS	Ground	<b>I/O Ground:</b> Connect to ground plane.
82	CORE_VSS	Ground	<b>Digital Core Ground:</b> Connect to ground plane.
86	IO_VSS	Ground	<b>I/O Ground:</b> Connect to ground plane.
92	IO_VSS	Ground	<b>I/O Ground:</b> Connect to ground plane.
96	CORE_SUB	Ground	<b>Digital Core Substrate:</b> Connect to ground plane.
97	CORE_VSS	Ground	<b>Digital Core Ground:</b> Connect to ground plane.
101	IO_VSS	Ground	<b>I/O Ground:</b> Connect to ground plane.
108	IO_VSS	Ground	<b>I/O Ground:</b> Connect to ground plane.
116	IO_VSS	Ground	<b>I/O Ground:</b> Connect to ground plane.
122	IO_VSS	Ground	<b>I/O Ground:</b> Connect to ground plane.
127	CORE_SUB	Ground	<b>Digital Core Substrate:</b> Connect to ground plane.
128	CORE_VSS	Ground	<b>Digital Core Ground:</b> Connect to ground plane.
131	IO_VSS	Ground	<b>I/O Ground:</b> Connect to ground plane.
136	CORE_VSS	Ground	<b>Digital Core Ground:</b> Connect to ground plane.
142	IO_VSS	Ground	<b>I/O Ground:</b> Connect to ground plane.
148	IO_VSS	Ground	<b>I/O Ground:</b> Connect to ground plane.
152	OSC_VSS	Ground	<b>Oscillator Ground:</b> Connect to ground plane.
161	CORE_VSS	Ground	<b>Digital Core Ground:</b> Connect to ground plane.

**Table 6.8 Pin List (Cont.)**

Pin #	Pin Name	Type	Connections/ Comments
162	CORE_SUB	Ground	<b>Digital Core Substrate:</b> Connect to ground plane.
168	IO_VSS	Ground	<b>I/O Ground:</b> Connect to ground plane.
172	CORE_VSS	Ground	<b>Digital Core Ground:</b> Connect to ground plane.
173	CORE_SUB	Ground	<b>Digital Core Substrate:</b> Connect to ground plane.
179	IO_VSS	Ground	<b>I/O Ground:</b> Connect to ground plane.
183	CORE_VSS	Ground	<b>Digital Core Ground:</b> Connect to ground plane.
188	IO_VSS	Ground	<b>I/O Ground:</b> Connect to ground plane.
194	IO_VSS	Ground	<b>I/O Ground:</b> Connect to ground plane.
198	CORE_VSS	Ground	<b>Digital Core Ground:</b> Connect to ground plane.
199	CORE_SUB	Ground	<b>Digital Core Substrate:</b> Connect to ground plane.
203	IO_VSS	Ground	<b>I/O Ground:</b> Connect to ground plane.
<b>Power</b>			
2	RA_AVDD	Power	<b>Receive Analog 3.3 V Supply:</b> Bypass to pin 3 using a 0.1 $\mu$ F capacitor.
6	RA_AVDD	Power	<b>Receive Analog 3.3 V Supply:</b> Bypass to pin 7 using a 0.1 $\mu$ F capacitor.
8	CDA_AVDD	Power	<b>Transmit Analog 3.3 V Supply:</b> Bypass to pin 11 using a 0.1 $\mu$ F capacitor.
15	CDB_AVDD	Power	<b>Transmit Analog 3.3 V Supply:</b> Bypass to pin 12 using a 0.1 $\mu$ F capacitor.
17	RB_AVDD	Power	<b>Receive Analog 3.3 V Supply:</b> Bypass to pin 16 using a 0.1 $\mu$ F capacitor.
21	RB_AVDD	Power	<b>Receive Analog 3.3 V Supply:</b> Bypass to pin 20 using a 0.1 $\mu$ F capacitor.
23	BG_AVDD	Power	<b>Bandgap 3.3 V Supply:</b> Connect to pin 25 using a 0.01 $\mu$ F capacitor.

**Table 6.8 Pin List (Cont.)**

Pin #	Pin Name	Type	Connections/ Comments
24	BG_REF	Input	<b>Bandgap Reference:</b> Connect to pin 25 using a 9.31 k $\Omega$ , 1% resistor. The resistor should be placed as close to pin 24 as possible to reduce trace inductance and reduce the possibility of picking up noise through crosstalk.
27	PGM_AVDD	Power	<b>PGM Analog 3.3 V Supply:</b> See Figure 6.1
29	SHR_VDD	Power	<b>Analog 3.3 V Supply:</b> Connect to pin 30 using a 0.1 $\mu$ F capacitor.
32	RC_AVDD	Power	<b>Receive Analog 3.3 V Supply:</b> Bypass to pin 33 using a 0.1 $\mu$ F capacitor.
36	RC_AVDD	Power	<b>Receive Analog 3.3 V Supply:</b> Bypass to pin 37 using a 0.1 $\mu$ F capacitor.
38	CDC_AVDD	Power	<b>Transmit Analog 3.3 V Supply:</b> Bypass to pin 41 using a 0.1 $\mu$ F capacitor.
45	CDD_AVDD	Power	<b>Transmit Analog 3.3 V Supply:</b> Bypass to pin 42 using a 0.1 $\mu$ F capacitor.
47	RD_AVDD	Power	<b>Receive Analog 3.3 V Supply:</b> Bypass to pin 46 using a 0.1 $\mu$ F capacitor.
51	RD_AVDD	Power	<b>Receive Analog 3.3 V Supply:</b> Bypass to pin 50 using a 0.1 $\mu$ F capacitor.
58	IO_VDD	Power	<b>I/O 3.3 V Supply:</b> Bypass to pin 57 using a 0.1 $\mu$ F capacitor.
64	IO_VDD	Power	<b>I/O 3.3 V Supply:</b> Bypass to pin 63 using a 0.1 $\mu$ F capacitor.
69	CORE_VDD	Power	<b>Digital Core 1.8 V Supply:</b> Bypass to pin 68 using a 0.1 $\mu$ F capacitor.
73	IO_VDD	Power	<b>I/O 3.3 V Supply:</b> Bypass to pin 72 using a 0.1 $\mu$ F capacitor.
79	IO_VDD	Power	<b>I/O 3.3 V Supply:</b> Bypass to pin 78 using a 0.1 $\mu$ F capacitor.
83	CORE_VDD	Power	<b>Digital Core 1.8 V Supply:</b> Bypass to pin 82 using a 0.1 $\mu$ F capacitor.
87	IO_VDD	Power	<b>I/O 3.3 V Supply:</b> Bypass to pin 86 using a 0.1 $\mu$ F capacitor.

**Table 6.8 Pin List (Cont.)**

Pin #	Pin Name	Type	Connections/ Comments
93	IO_VDD	Power	<b>I/O 3.3 V Supply:</b> Bypass to pin 92 using a 0.1 $\mu$ F capacitor.
98	CORE_VDD	Power	<b>Digital Core 1.8 V Supply:</b> Bypass to pin 97 using a 0.1 $\mu$ F capacitor.
102	IO_VDD	Power	<b>I/O 3.3 V Supply:</b> Bypass to pin 101 using a 0.1 $\mu$ F capacitor.
109	IO_VDD	Power	<b>I/O 3.3 V Supply:</b> Bypass to pin 108 using a 0.1 $\mu$ F capacitor.
117	IO_VDD	Power	<b>I/O 3.3 V Supply:</b> Bypass to pin 116 using a 0.1 $\mu$ F capacitor.
123	IO_VDD	Power	<b>I/O 3.3 V Supply:</b> Bypass to pin 122 using a 0.1 $\mu$ F capacitor.
129	CORE_VDD	Power	<b>Digital Core 1.8 V Supply:</b> Bypass to pin 128 using a 0.1 $\mu$ F capacitor.
132	IO_VDD	Power	<b>I/O 3.3 V Supply:</b> Bypass to pin 131 using a 0.1 $\mu$ F capacitor.
137	CORE_VDD	Power	<b>Digital Core 1.8 V Supply:</b> Bypass to pin 136 using a 0.1 $\mu$ F capacitor.
143	IO_VDD	Power	<b>I/O 3.3 V Supply:</b> Bypass to pin 142 using a 0.1 $\mu$ F capacitor.
149	IO_VDD	Power	<b>I/O 3.3V Supply:</b> Bypass to pin 148 using a 0.1 $\mu$ F capacitor.
155	OSC_VDD	Power	<b>Oscillator 3.3 V Supply:</b> Bypass to pin 152 using a 0.1 $\mu$ F capacitor.
160	CORE_VDD	Power	<b>Digital Core 1.8 V Supply:</b> Bypass to pin 161 using a 0.1 $\mu$ F capacitor.
167	IO_VDD	Power	<b>I/O 3.3 V Supply:</b> Bypass to pin 168 using a 0.1 $\mu$ F capacitor.
171	CORE_VDD	Power	<b>Digital Core 1.8 V Supply:</b> Bypass to pin 172 using a 0.1 $\mu$ F capacitor.
178	IO_VDD	Power	<b>I/O 3.3 V Supply:</b> Bypass to pin 179 using a 0.1 $\mu$ F capacitor.

**Table 6.8 Pin List (Cont.)**

Pin #	Pin Name	Type	Connections/ Comments
182	CORE_VDD	Power	<b>Digital Core 1.8 V Supply:</b> Bypass to pin 183 using a 0.1 $\mu$ F capacitor.
187	IO_VDD	Power	<b>I/O 3.3 V Supply:</b> Bypass to pin 188 using a 0.1 $\mu$ F capacitor.
193	IO_VDD	Power	<b>I/O 3.3 V Supply:</b> Bypass to pin 194 using a 0.1 $\mu$ F capacitor.
197	CORE_VDD	Power	<b>Digital Core 1.8 V Supply:</b> Bypass to pin 198 using a 0.1 $\mu$ F capacitor.
202	IO_VDD	Power	<b>I/O 3.3 V Supply:</b> Bypass to pin 203 using a 0.1 $\mu$ F capacitor.
<b>Reserved</b>			
53	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
54	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
55	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
56	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
59	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
60	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
61	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
62	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
65	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
66	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
70	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
71	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
74	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
75	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
76	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
77	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.

**Table 6.8 Pin List (Cont.)**

Pin #	Pin Name	Type	Connections/ Comments
80	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
81	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
88	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
89	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
90	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
91	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
84	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
85	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
94	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
95	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
99	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
100	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
103	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
106	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
107	RESERVE_FLOAT		<b>Reserved:</b> Leave floating.
165	RESERVE_GND		<b>Reserved:</b> Pull-down to ground plane.
166	RESERVE_GND		<b>Reserved:</b> Pull-down to ground plane.
169	RESERVE_GND		<b>Reserved:</b> Pull-down to ground plane.
170	RESERVE_GND		<b>Reserved:</b> Pull-down to ground plane.
174	RESERVE_GND		<b>Reserved:</b> Pull-down to ground plane.
175	RESERVE_GND		<b>Reserved:</b> Pull-down to ground plane.
176	RESERVE_GND		<b>Reserved:</b> Pull-down to ground plane.
177	RESERVE_GND		<b>Reserved:</b> Pull-down to ground plane.



**Table 6.8 Pin List (Cont.)**

Pin #	Pin Name	Type	Connections/ Comments
<b>Special</b>			
104	SI		<b>SI:</b> Leave floating.
105	SO		<b>SO:</b> Leave floating.
186	TEST		<b>Special pin:</b> Pull-up to VCC.
206	TEST		<b>Special pin:</b> Pull-up to VCC

NO-NEW-DESIGNS

# Chapter 7

## Test Conditions

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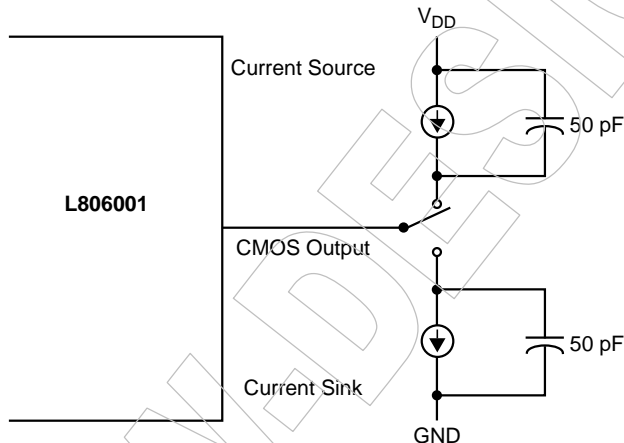
This section contains information relating to the specific test environments, (including stimulus and loading parameters), used for the L80600. These test conditions are categorized by pin/interface type in the following subsections:

- [Section 7.1, “CMOS Outputs \(GMII/MII and LED\)”](#)
- [Section 7.2, “TXD+/- Outputs \(Sourcing 100BASE-TX\)”](#)
- [Section 7.3, “TXD+/- Outputs \(sourcing 1000BASE-T\)”](#)
- [Section 7.4, “IDD Measurement Conditions”](#)
- [Section 7.5, “GMII Point-to-Point Test Conditions”](#)
- [Section 7.6, “GMII Setup and Hold Test Conditions”](#)

## 7.1 CMOS Outputs (GMII/MII and LED)

Each of the GMII/MII and LED outputs are loaded with a controlled current source to either ground or  $V_{DD}$  for testing  $V_{OH}$ ,  $V_{OL}$ , and AC parametrics. The associated capacitance of this load is 50 pF. The diagram in [Figure 7.1](#) illustrates the test configuration.

**Figure 7.1 CMOS Output Test Load**

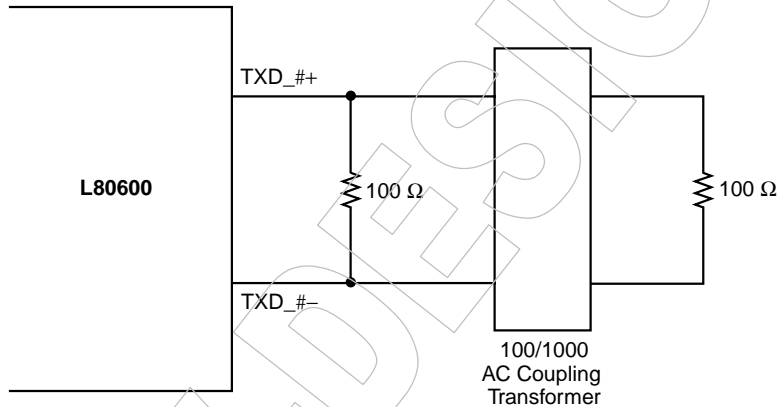


It should be noted that the current source and sink limits are set to 4.0 mA when testing/loading the GMII/MII output pins. The current source and sink limits are set to 2.5 mA when testing/loading the LED output pins.

## 7.2 TXD+/- Outputs (Sourcing 100BASE-TX)

When the L80600 is configured for 100BASE-TX operation, the TXD differential outputs source scrambled 125 Mbits/s data at MLT-3 logic levels. These outputs are loaded as illustrated in [Figure 7.2](#).

**Figure 7.2 100 Mbits/s Twisted-Pair Load (Zero Meters)**



Note that the transmit amplitude and rise/fall time measurements are made across the secondary of the transmit transformer as specified by the IEEE 802.3u Standard. This test is done at nominal VCC levels.

## 7.3 TXD+/- Outputs (sourcing 1000BASE-T)

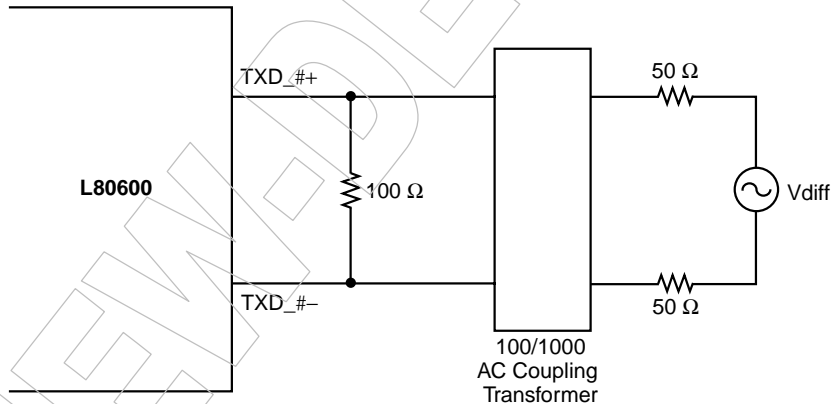
When configured for 1000BASE-T operation, the differential outputs (four pairs) source the test pattern shown below at 125 Mbits/s using PAM-17 levels.

Test Pattern:

{{+2 followed by 127 0 symbols}, {-2 followed by 127 0 symbols}, {+1 followed by 127 0 symbols}, {-1 followed by 127 0 symbols}, (128 +2 symbols, 128 -2 symbols), {1024 0 symbols}}

The outputs are loaded as illustrated in [Figure 7.3](#).

**Figure 7.3 1000 Mbits/s Twisted-Pair Load (Zero Meters)**



Note that the transmit amplitude and rise/fall time measurements are made across the secondary of the transmit transformer as specified by the IEEE 802.3ab/D5.1 Specification.

## 7.4 IDD Measurement Conditions

The L80600 is currently tested for total device  $I_{DD}$  under the following operational modes:

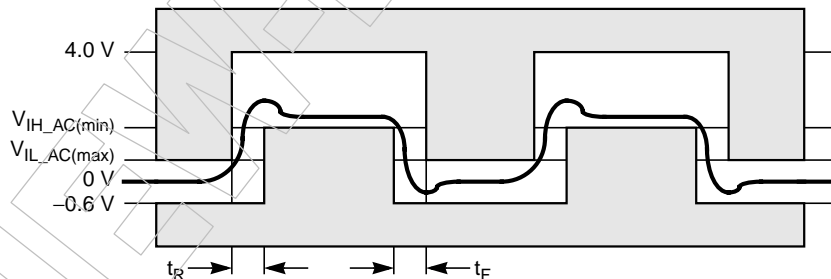
- 100BASE-TX Full-Duplex (max packet length/min IPG)
- 1000BASE-T Full-Duplex (max packet length/min IPG)

The device loading described in each of the preceding sections is present during  $I_{DD}$  test execution.

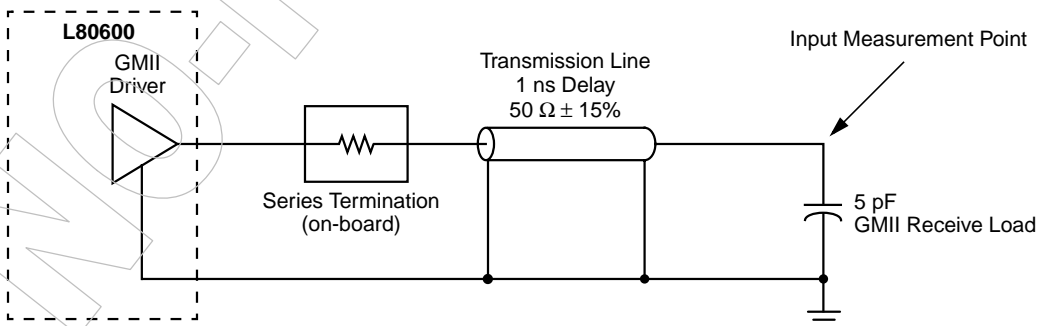
## 7.5 GMII Point-to-Point Test Conditions

To meet the requirements of supporting point-to-point links, RX\_CLK must comply with the potential template shown in [Figure 7.4](#) using the test circuit in [Figure 7.5](#).

**Figure 7.4 GMII Receiver Input Potential Template**



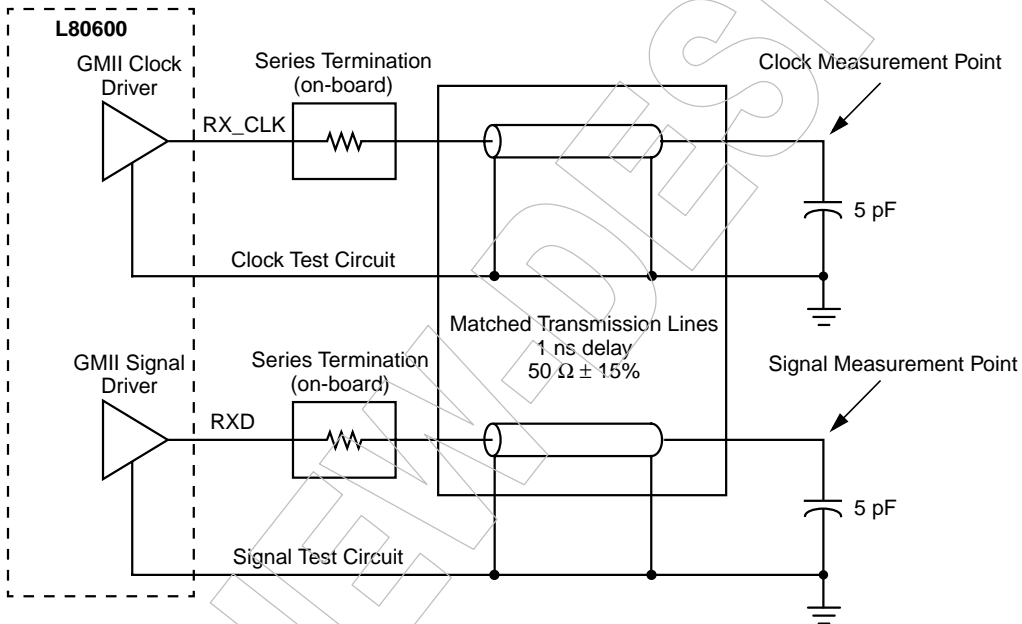
**Figure 7.5 GMII Point-to-Point Test Circuit**



## 7.6 GMII Setup and Hold Test Conditions

To meet the requirements to support point-to-point links, GMII drivers (RXD[7:0], RX\_DV, RX\_ER) must comply with the potential template shown in Figure 7.4 using the test circuit in Figure 7.6 and meet the setup and hold times specified in [Table 8.8](#) on [page 8-9](#).

**Figure 7.6 GMII Setup and Hold Time Test Circuit**





# Chapter 8

## Specifications

This chapter provides specifications for the L80600, including the AC timing and a pin summary.

This chapter has the following sections:

- Section 8.1, “Absolute Maximum Ratings”
- Section 8.2, “Recommended Operating Conditions”
- Section 8.3, “Thermal Characteristics”
- Section 8.4, “DC Electrical Specifications”
- Section 8.5, “Timing”
- Section 8.6, “Packaging and Pinout”

### 8.1 Absolute Maximum Ratings

The absolute maximum ratings are summarized in [Table 8.1](#).

**Table 8.1 Absolute Maximum Ratings**

Supply Voltage ( $V_{DD}$ )	–0.5 V to 4.2 V
Input Voltage ( $DC_{IN}$ )	–0.5 V to $V_{DD} + 0.5$ V
Output Voltage ( $DC_{OUT}$ )	–0.5 V to $V_{DD} + 0.5$ V
Storage Temperature	–65 °C to 150 °C
ESD Protection	6000 V

**Note:** Absolute maximum ratings are those values beyond which the safety of the device cannot be guaranteed. They are not meant to imply that the device should be operated at these limits.

## 8.2 Recommended Operating Conditions

The recommended operating conditions are summarized in [Table 8.2](#).

**Table 8.2 Recommended Operating Conditions**

	Min	Typ	Max	Units
Supply Voltage I/O, Analog	3.135	3.3	3.465	V
Supply Voltage Digital Core	1.71	1.8	1.89	
Ambient Temperature ( $T_A$ )	0		70	°C
REF_CLK Input Freq. Stability (over temperature)	-50		+50	ppm
REF_CLK Input Jitter pk-pk			200	ps
REF_CLK Input Duty Cycle	35		65	%
Center Frequency ( $f_c$ )		125		MHz

## 8.3 Thermal Characteristics

The device thermal characteristics are summarized in [Table 8.3](#).

**Table 8.3 Thermal Characteristics**

	Max	Units
Maximum Case Temperature @ 4.0 W	110	°C
Theta Junction to Case ( $T_{jc}$ )	2.13	°C/W
Theta Junction to Ambient ( $T_{ja}$ ) degrees Celsius/Watt - No Airflow @ 4.0 W	11.7	°C/W
Theta Junction to Ambient ( $T_{ja}$ ) degrees Celsius/Watt - 225 LFPM Airflow @ 4.0 W	8.0	°C/W

## 8.4 DC Electrical Specifications

Table 8.4 lists the L80600 DC electrical specifications.

**Table 8.4 DC Electrical Specifications**

Symbol	Pin Types	Parameter	Conditions	Min	Typ	Max	Units
$V_{IH}$ GMII inputs	I I/O I/O_Z	Input High Voltage	$V_{DD} = 3.3\text{ V}$	1.7			V
$V_{IL}$ GMII inputs	I I/O I/O_Z	Input Low Voltage	$V_{DD} = 3.3\text{ V}$			0.9	V
$V_{IH}$ non-GMII inputs	I I/O I/O_Z	Input High Voltage	$V_{DD} = 3.3\text{ V}$	2.0			V
$V_{IL}$ non-GMII inputs	I I/O I/O_Z	Input Low Voltage	$V_{DD} = 3.3\text{ V}$			0.8	V
$I_{IH}$	I I/O I/O_Z	Input High Current	$V_{IN} = V_{DD}$ $V_{DD} = V_{DD(max)}$			10	$\mu\text{A}$
$I_{IL}$	I I/O I/O_Z	Input Low Current	$V_{IN} = 0\text{ V}$ $V_{DD} = V_{DD(max)}$			10	$\mu\text{A}$
R strap	Strap	PU/PD internal resistor value.			35–65		$\text{k}\Omega$
R strap	JTAG	PU/PD internal resistor value.			20–40		$\text{k}\Omega$
$V_{OL}$ GMII outputs	O, I/O I/O_Z	Output Low Voltage	$I_{OL} = 1.0\text{ mA}$ $V_{DD} = V_{DD(min)}$	Gnd		0.5	V
$V_{OH}$ GMII outputs	O, I/O I/O_Z	Output High Voltage	$I_{OH} = -1\text{ mA}$ $V_{DD} = V_{DD(min)}$	2.1		3.6	V

**Table 8.4 DC Electrical Specifications (Cont.)**

Symbol	Pin Types	Parameter	Conditions	Min	Typ	Max	Units
$V_{OL}$ non-GMII outputs	O, I/O I/O_Z	Output Low Voltage	$I_{OL} = 4 \text{ mA}$ $V_{DD} = V_{DD(min)}$	Gnd		0.4	V
$V_{OH}$ non-GMII outputs	O, I/O I/O_Z	Output High Voltage	$I_{OH} = -4 \text{ mA}$ $V_{DD} = V_{DD(min)}$	2.4			V
$V_{OL}$	LED	Output Low Voltage	$I_{OL} = 2.5 \text{ mA}$			0.4	V
$V_{OH}$	LED	Output High Voltage	$I_{OH} = -2.5 \text{ mA}$	2.4			V
$I_{OZ1}$	I/O_Z	3-State Leakage	$V_{OUT} = V_{DD}$			10	$\mu\text{A}$
$I_{OZ2}$	I/O_Z	3-State Leakage	$V_{OUT} = \text{GND}$			-10	$\mu\text{A}$
$R_{INdiff}$	RXD_B $\pm$	Differential Input Resistance	see Chapter 7, "Test Conditions"		2.4		k $\Omega$
$V_{TXD\_100}$	TXD_A $\pm$	100 M Transmit $V_{DIFF}$	see Chapter 7, "Test Conditions"	0.950	1.0	1.05	V peak differential
$V_{TXDsym}$	TXD_A $\pm$	100 M Transmit Voltage Symmetry	see Chapter 7, "Test Conditions"		$\pm 2$		%
$V_{TXD\_100}$ [0:2]	TXD# $\pm$	1000 M Transmit $V_{DIFF}^1$	see Chapter 7, "Test Conditions"		0.75		V peak differential
$V_{TXD\_100}$ [0:1]	TXD# $\pm$	1000 M Transmit $V_{DIFF}^2$	see Chapter 7, "Test Conditions"		0.375		V peak differential
$C_{IN1}$	I	CMOS Input Capacitance			8		pF

**Table 8.4 DC Electrical Specifications (Cont.)**

Symbol	Pin Types	Parameter	Conditions	Min	Typ	Max	Units
$C_{OUT1}$	O, I/O I/O_Z	CMOS Output Capacitance			8		pF
3.3 V $I_{dd1000}$	3.3 V Supply	1000BASE-T (Full-Duplex)	see Chapter 7, "Test Conditions"		680		mA
1.8 V $I_{dd1000}$	1.8 V Supply	1000BASE-T (Full-Duplex)	see Chapter 7, "Test Conditions"		900		mA

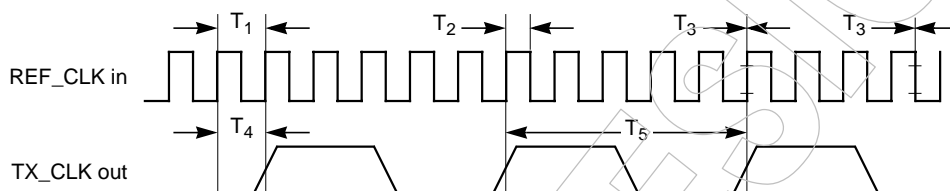
1. IEEE test mode 1, points A and B as described in Clause 40, section 40.6.1.2.1.
2. IEEE test mode 1, points C and D as described in Clause 40, section 40.6.1.2.1.

## 8.5 Timing

This section contains typical timing diagrams and associated timing parameters for key areas of L80600 operation.

### 8.5.1 PGM Clock Timing

**Figure 8.1 PGM Clock Timing Diagram**



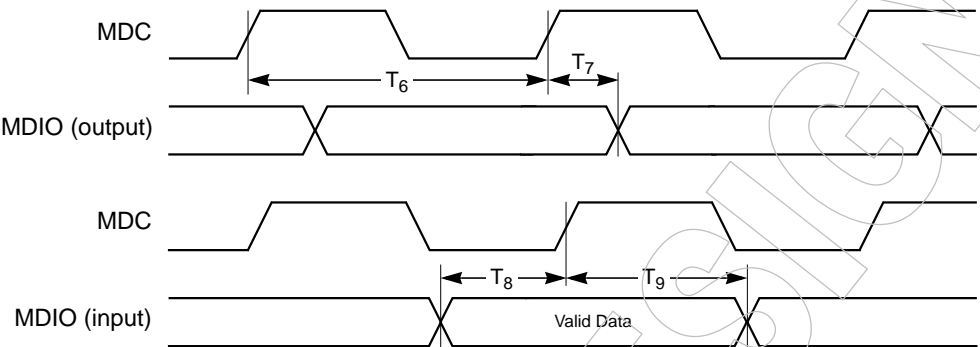
**Table 8.5 PGM Clock Timing**

Parameter	Description	Notes	Min	Typ	Max	Units
T1	REF_CLK frequency		-50		+50	125 MHz ± ppm
T2	REF_CLK Duty Cycle		40		60	%
T3	REF_CLK $t_R/t_F$	10% to 90%		200–500		ps
T4	REF_CLK to TX_CLK Delay		-3 <sup>1</sup>		+3	ns
T5	TX_CLK Duty Cycle		40		60	%

1. Guaranteed by design. Not tested.

# 8.5.2 Serial Management Interface Timing

**Figure 8.2 Serial Management Interface Timing Diagram**

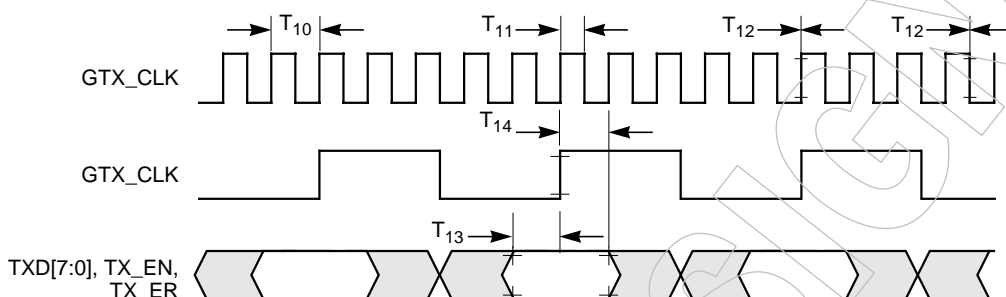


**Table 8.6 Serial Management Interface Timing**

Parameter	Description	Notes	Min	Typ	Max	Units
T6	MDC Frequency				2.5	MHz
T7	MDC to MDIO (Output) Delay Time		0		300	ns
T8	MDIO (Input) to MDC Setup Time		10			ns
T9	MDIO (Input) to MDC Hold Time		10			ns

## 8.5.3 1000 Mbits/s Timing

**Figure 8.3 GMII Transmit Interface Timing Diagram**



**Table 8.7 GMII Transmit Interface Timing**

Parameter	Description	Notes	Min	Typ	Max	Units
T10	GTX_CLK Stability <sup>1</sup>		-100		+100	ppm
T11	GTX_CLK Duty Cycle		40		60	%
T12	GTX_CLK $t_R/t_F$ (Note 5)	2, 3			1	ns
T13	Setup from valid TXD, TX_EN and TXER to $\uparrow$ GTX_CLK	4, 2	2.0			ns
T14	Hold from $\uparrow$ GTX_CLK to invalid TXD, TX_EN and TXER	5, 2	0.0			ns

1. Guaranteed by design. Not tested.

2.  $t_r$  and  $t_f$  are measured from  $V_{IL\_AC}(MAX) = 0.7$  V to  $V_{IH\_AC}(MIN) = 1.9$  V.

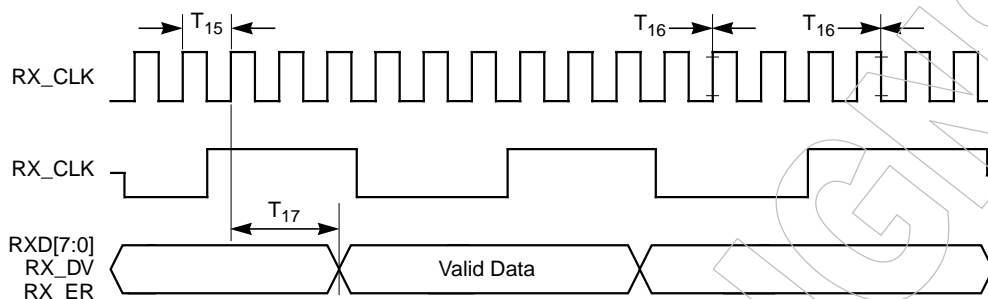
3. GMII Receiver input template measured with "GMII point-to-point test circuit", see [Chapter 7, "Test Conditions"](#).

4.  $t_{setup}$  is measured from data level of 1.9 V to clock level of 0.7 V for data = '1'; and data level of 0.7 V to clock level 0.7 V for data = '0'.

5.  $t_{hold}$  is measured from clock level of 1.9 V to data level of 1.9 V for data = '1'; and clock level of 1.9 V to data level 0.7 V for data = '0'.



**Figure 8.4 GMII Receive Timing Diagram**



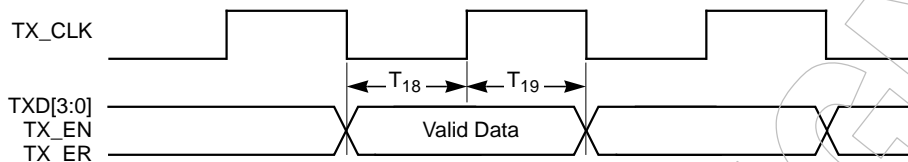
**Table 8.8 GMII Receive Timing**

Parameter	Description	Notes	Min	Typ	Max	Units
T15	RX_CLK Duty Cycle		40		60	%
T16	RX_CLK $t_R/t_F$ <sup>1</sup>	2, 5			1	ns
T17	$\uparrow$ RX_CLK to RXD, RX_DV and RX_ER delay	3, 4, 5	0.5		5.5	ns

1. Guaranteed by design. Not tested.
2.  $t_R$  and  $t_F$  are measured from  $V_{IL\_AC}(MAX) = 0.7$  V to  $V_{IH\_AC}(MIN) = 1.9$  V.
3.  $t_{delay}$  max is measured from clock level of 0.7 V to data level of 1.9 V for data = '1'; and clock level of 0.7 V to data level 0.7 V for data = '0'.
4.  $t_{delay}$  min is measured from clock level of 1.9 V to data level of 1.9 V for data = '1'; and clock level of 1.9 V to data level 0.7 V for data = '0'.
5. GMII Receiver input template measured with "GMII point-to-point test circuit", see [Chapter 7, "Test Conditions"](#).

## 8.5.4 100 Mbits/s Timing

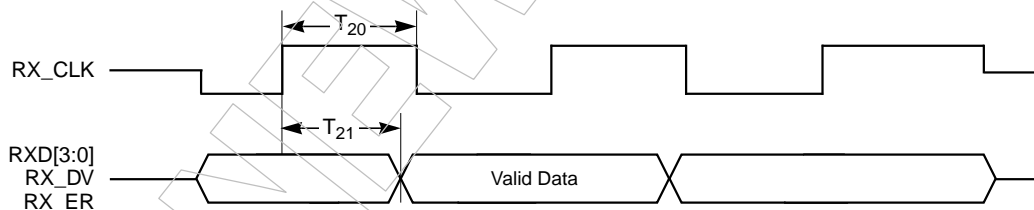
**Figure 8.5 100 Mbits/s MII Transmit Timing Diagram**



**Table 8.9 100 Mbits/s MII Transmit Timing**

Parameter	Description	Notes	Min	Typ	Max	Units
T18	TXD[3:0], TX_EN, TX_ER Setup to $\uparrow$ TX_CLK		10			ns
	TXD[4:0] Setup to $\uparrow$ TX_CLK		10			ns
T19	TXD[3:0], TX_EN, TX_ER Hold from $\uparrow$ TX_CLK		-1			ns
	TXD[4:0] Hold from $\uparrow$ TX_CLK	100 Mbits/s Symbol Mode	-1			ns

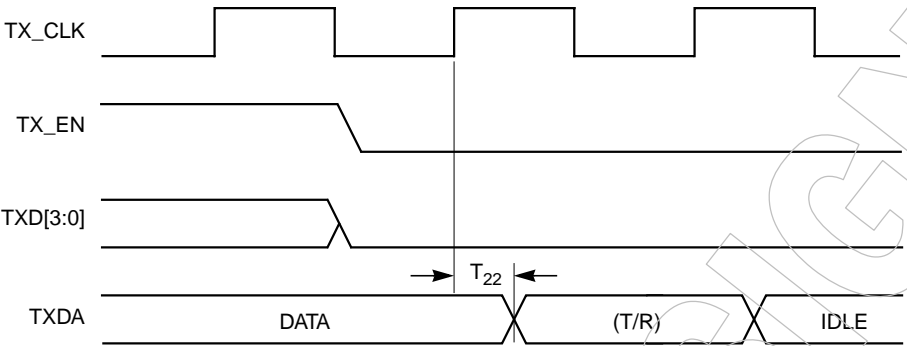
**Figure 8.6 100 Mbits/s MII Receive Timing Diagram**



**Table 8.10 100 Mbits/s MII Receive Timing**

Parameter	Description	Notes	Min	Typ	Max	Units
T20	RX_CLK Duty Cycle		35		65	%
T21	$\uparrow$ RX_CLK to RXD[3:0], RX_DV, RX_ER Delay		10		30	ns

**Figure 8.7 100BASE-TX Transmit Packet Deassertion Timing Diagram**

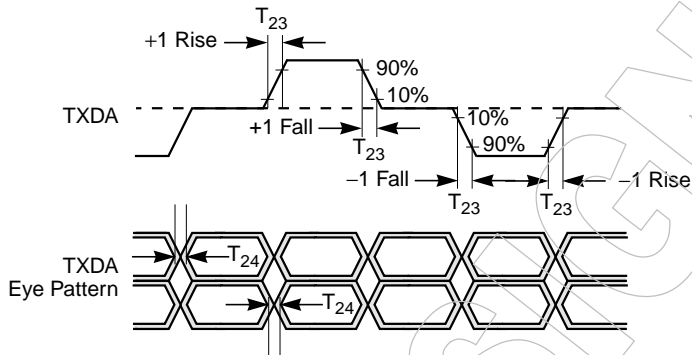


**Table 8.11 100BASE-TX Transmit Packet Deassertion Timing<sup>1</sup>**

Parameter	Description	Notes	Min	Typ	Max	Units
T22	TX_CLK to TXDA± Idling				6.0	Bits
		100 Mbits/s Symbol mode			6.0	Bits

- Deassertion is determined by measuring the time from the first rising edge of TX\_CLK occurring after the deassertion of TX\_EN to the first bit of the “T” code group as output from the TXDA pins. For Symbol mode, because TX\_EN has no meaning, Deassertion is measured from the first rising edge of TX\_CLK occurring after the deassertion of a data nibble on the Transmit MII to the last bit (LSB) of that nibble when it deasserts on the wire. 1 bit time = 10 ns in 100 Mbits/s mode.

**Figure 8.8 100BASE-TX Transmit Timing Diagram ( $t_{R/F}$  & Jitter)**

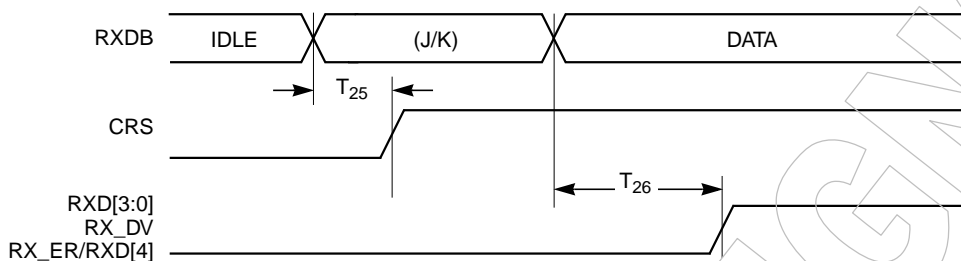


**Table 8.12 100BASE-TX Transmit Timing**

Parameter	Description <sup>1</sup>	Notes	Min	Typ	Max	Units
$T_{23}$ <sup>2</sup>	100 Mbits/s TXDA $\pm t_R$ and $t_F$	See <a href="#">Chapter 7, "Test Conditions"</a>	3	4	5	ns
	100 Mbits/s $t_R$ and $t_F$ Mismatch			500		ps
$T_{24}$	100 Mbits/s TXDA $\pm$ Transmit Jitter				1.4	ns

1. Normal mismatch is the difference between the maximum and minimum of all rise and fall times.
2. Rise and fall times taken at 10% and 90% of the +1 or -1 amplitude.

**Figure 8.9 100BASE-TX Receive Packet Latency Timing Diagram**

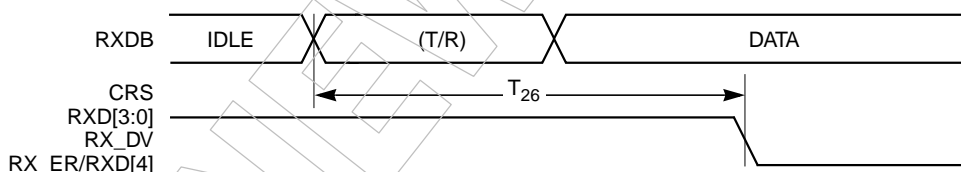


**Table 8.13 100BASE-TX Receive Packet Latency Timing**

Parameter	Description	Notes	Min	Typ	Max	Units <sup>1</sup>
T25 <sup>2</sup>	Carrier Sense ON Delay <sup>3</sup>				17.5	Bits
T26	Receive Data Latency				21	Bits
		100 Mbits/s Symbol Mode			12	Bits

- 1 bit time = 10 ns in 100 Mbits/s mode.
- RXDB± voltage amplitude is greater than the Signal Detect Turn-On Threshold Value.
- Carrier Sense On Delay is determined by measuring the time from the first bit of the “J” code group to the assertion of Carrier Sense.

**Figure 8.10 100BASE-TX Receive Packet Deassertion Timing Diagram**



**Table 8.14 100BASE-TX Receive Packet Deassertion Timing**

Parameter	Description	Notes	Min	Typ	Max	Units
T27	Carrier Sense OFF Delay				21.5	Bits

## 8.5.5 AutoNegotiation Fast Link Pulse (FLP) Timing

Figure 8.11 AutoNegotiation Fast Link Pulse (FLP) Timing Diagram

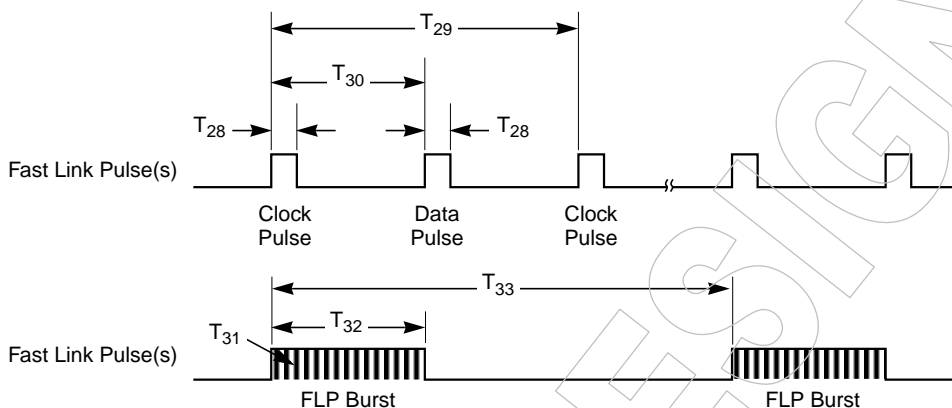
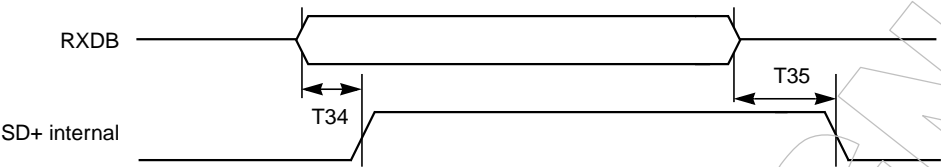


Table 8.15 AutoNegotiation Fast Link Pulse (FLP) Timing<sup>1</sup>

Parameter	Description	Notes	Min	Typ	Max	Units
T28	Clock/Data Pulse Width			100		ns
T29	Clock Pulse to Clock Pulse Period		111	125	139	$\mu$ s
T30	Clock Pulse to Data Pulse Period	Data = 1	55.5	62.5	69.5	$\mu$ s
T31	Number of Pulses in a Burst		17		33	#
T32	Burst Width			2		ms
T33	FLP Burst to FLP Burst Period		8		24	ms

1. These specifications represent both transmit and receive timings

**Figure 8.12 100BASE-TX Signal Detect Timing Diagram**



The signal amplitude at RXDB+/- is TP-PMD compliant.

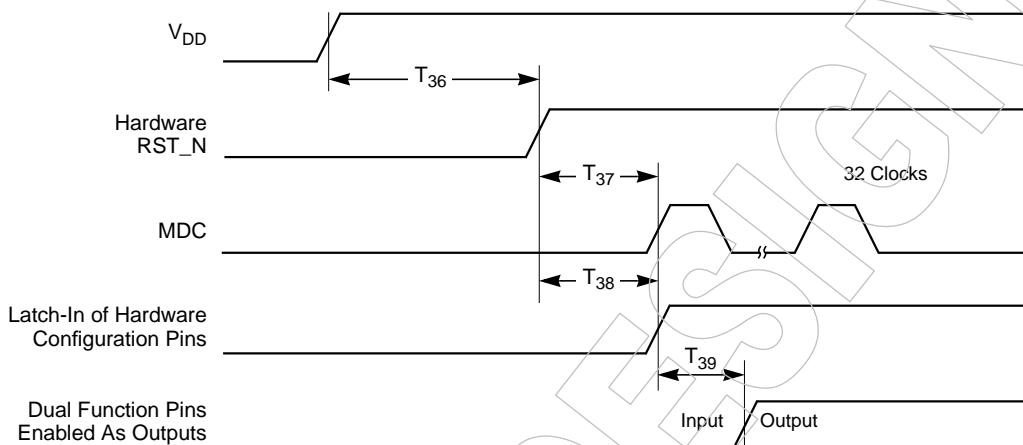
**Table 8.16 100BASE-TX Signal Detect Timing**

Parameter	Description	Notes	Min	Typ	Max	Units
T34	SD Internal Turn-on Time <sup>1</sup>				1	ms
T35	SD Internal Turn-off Time				300	μs

1. The SD internal signal is available as an external signal in Symbol mode.

## 8.5.6 Reset Timing

**Figure 8.13 Reset Timing Diagram**



**Table 8.17 Reset Timing<sup>1</sup>**

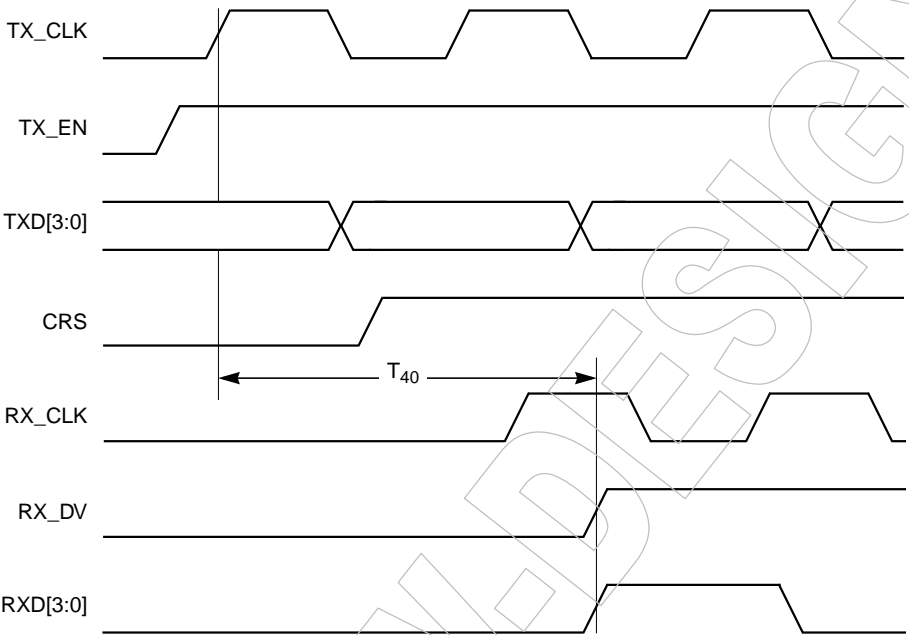
Parameter	Description	Notes	Min	Typ	Max	Units
T36	Hardware RESET Pulse Width <sup>2</sup>		140			$\mu$ s
T37	Post-RESET Stabilization time prior to MDC preamble for register accesses	MDIO is pulled high for 32-bit serial management initialization		3		$\mu$ s
T38	Hardware Configuration Latch-in Time from the Deassertion of RESET (either soft or hard)	Hardware Configuration Pins are described in the <a href="#">Chapter 3, "Signals"</a> .		3		$\mu$ s
T39	Hardware Configuration pins transition to output drivers	It is important to choose pull-up and/or pull-down resistors for each of the hardware configuration pins that provide fast RC time constants in order to latch-in the proper value prior to the pin transitioning to an output driver		50		ns

1. Software Reset should be initiated no sooner than 500  $\mu$ s after power-up or the deassertion of hardware reset.
2. The timing for Hardware Reset Option 2 is equal to parameter T1 plus parameter T2 (501  $\mu$ s total).



# 8.5.7 Loopback Timing

**Figure 8.14 Loopback Timing Diagram**



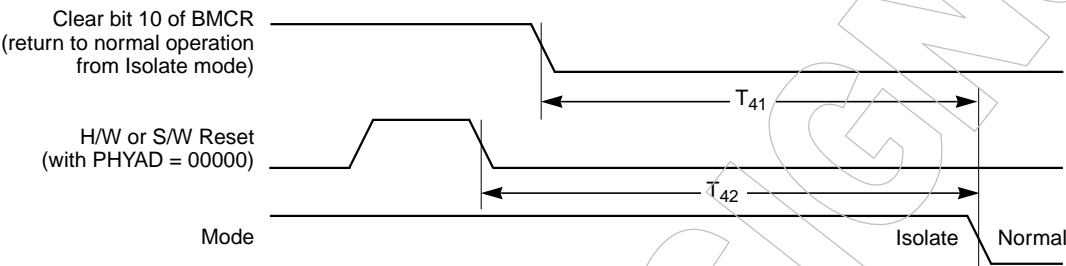
**Table 8.18 Loopback Timing<sup>1, 2</sup>**

Parameter	Description	Notes	Min	Typ	Max	Units
T40	TX_EN to RX_DV Loopback	100 Mbits/s			240	ns

1. Due to the nature of the descrambler function, all 100BASE-X Loopback modes cause an initial “dead-time” of up to 550  $\mu$ s during which time no data is present at the receive MII outputs. The 100BASE-X timing specified is based on device delays after the initial 550  $\mu$ s “dead-time”
2. During loopback (all modes) both the TD $\pm$  outputs remain inactive by default.

# 8.5.8 Isolation Timing

**Figure 8.15 Isolation Timing Diagram**



**Table 8.19 Isolation Timing**

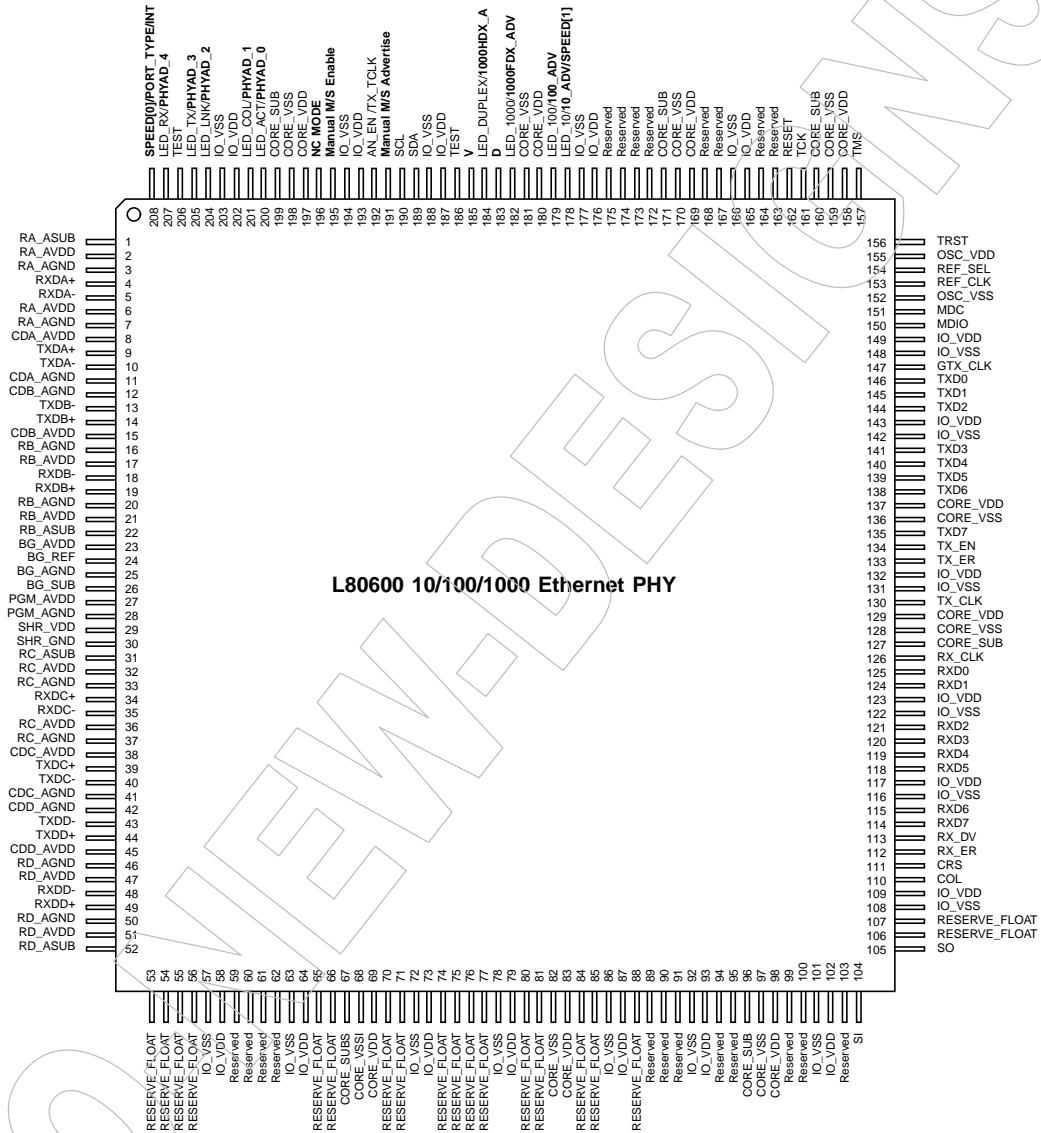
Parameter	Description	Notes	Min	Typ	Max	Units
T41	From software clear of bit 10 in the <a href="#">Basic Mode Register (BMCR) Address 0x00</a> to the transition from Isolate to Normal Mode.				100	$\mu\text{s}$
T42	From Deassertion of S/W or H/W Reset to transition from Isolate to Normal mode.				500	$\mu\text{s}$

# 8.6 Packaging and Pinout

## 8.6.1 Pin Layout

[Figure 8.16](#) is a diagram of the L80600 package pin locations and the corresponding pin signal names.

Figure 8.16 PQFP (VQM) Pin Layout



Bold pin names are strap options (e.g. AN\_EN)

## 8.6.2 PQFP Package Pin Summary

Table 8.20 lists the L80600 pins in numerical order.

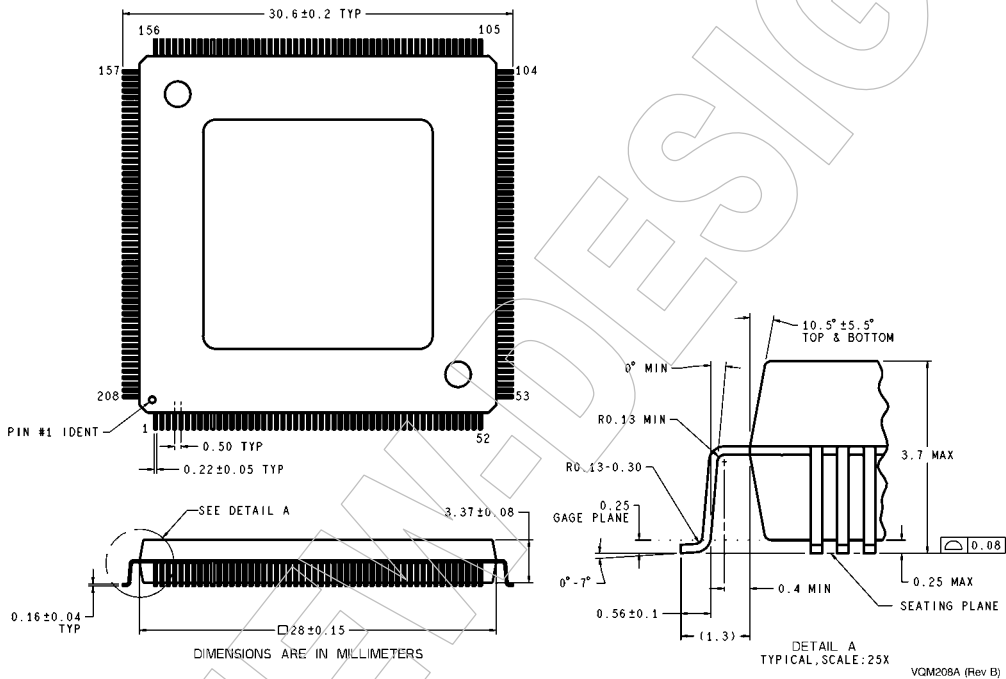
**Table 8.20 PQFP Package Pin Assignments**

Signal	Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal	Pin
RA_ASUB	1	RD_ASUB	52	RESERVE_		RXD0	125	RESERVE_GND	177
RA_AVDD	2	RESERVE_		FLOAT	85	RX_CLK	126	IO_VDD	178
RA_AGND	3	FLOAT	53	IO_VSS	86	CORE_SUB	127	IO_VSS	179
RXDA+	4	RESERVE_		IO_VDD	87	CORE_VSS	128	LED_10/10_	
RXDA-	5	FLOAT	54	RESERVE_		CORE_VDD	129	ADV/SPEED [1]	180
RA_AVDD	6	RESERVE_		FLOAT	88	TX_CLK	130	LED_100/100_	
RA_AGND	7	FLOAT	55	RESERVE_		IO_VSS	131	ADV	181
CDA_AVDD	8	RESERVE_		FLOAT	89	IO_VDD	132	CORE_VDD	182
TXDA+	9	FLOAT	56	RESERVE_		TX_ER	133	CORE_VSS	183
TXDA-	10	IO_VSS	57	FLOAT	90	TX_EN	134	LED_1000/	
CDA_AGND	11	IO_VDD	58	RESERVE_		TXD7	135	1000FDX_ADV	184
CDB_AGND	12	RESERVE_		FLOAT	91	CORE_VSS	136	LED_DUPLEX/	
TXDB-	13	FLOAT	59	IO_VSS	92	CORE_VDD	137	1000HDX_ADV	185
TXDB+	14	RESERVE_		IO_VDD	93	TXD6	138	TEST	186
CDB_AVDD	15	FLOAT	60	RESERVE_		TXD5	139	IO_VDD	187
RB_AGND	16	RESERVE_		FLOAT	94	TXD4	140	IO_VSS	188
RB_AVDD	17	FLOAT	61	RESERVE_		TXD3	141	SDA	189
RXDB-	18	RESERVE_		FLOAT	95	IO_VSS	142	SCL	190
RXDB+	19	FLOAT	62	CORE_SUB	96	IO_VDD	143	MANUAL_M/	
RB_AGND	20	IO_VSS	63	CORE_VSS	97	TXD2	144	S_ADVERTISE	191
RB_AVDD	21	IO_VDD	64	CORE_VDD	98	TXD1	145	AN_EN/TX_	
RB_ASUB	22	RESERVE_		RESERVE_		TXD0	146	TCLK	192
BG_AVDD	23	FLOAT	65	FLOAT	99	GTX_CLK	147	IO_VDD	193
BG_REF	24	RESERVE_		RESERVE_		IO_VSS	148	IO_VSS	194
BG_AGND	25	FLOAT	66	FLOAT	100	IO_VDD	149	MANUAL_M/	
BG_SUB	26	CORE_SUB	67	IO_VSS	101	MDIO	150	S_ENABLE	195
PGM_AVDD	27	CORE_VSS	68	IO_VDD	102	MDC	151	NC_MODE	196
PGM_AGND	28	CORE_VDD	69	RESERVE_		OSC_VSS	152	CORE_VDD	197
SHR_VDD	29	RESERVE_		FLOAT	103	REF_CLK	153	CORE_VSS	198
SHR_GND	30	FLOAT	70	SI	104	REF_SEL	154	CORE_SUB	199
RC_ASUB	31	RESERVE_		SO	105	OSC_VDD	155	LED_ACT	
RC_AVDD	32	FLOAT	71	RESERVE_		TRST	156	/PHYAD_0	200
RC_AGND	33	IO_VSS	72	FLOAT	106	TDI	157	LED_COL	
RXDC+	34	IO_VDD	73	RESERVE_		TDO	158	/PHYAD_1	201
RXDC-	35	RESERVE_		FLOAT	107	TMS	159	IO_VDD	202
RC_AVDD	36	FLOAT	74	IO_VSS	108	CORE_VDD	160	IO_VSS	203
RC_AGND	37	RESERVE_		IO_VDD	109	CORE_VSS	161	LED_LNK	
CDC_AVDD	38	FLOAT	75	COL	110	CORE_SUB	162	/PHYAD_2	204
TXDC+	39	RESERVE_		CRS	111	TCK	163	LED_TX/	
TXDC-	40	FLOAT	76	RX_ER	112	RESET	164	PHYAD_3	205
CDC_AGND	41	RESERVE_		RX_DV	113	RESERVE_GND	165	TEST	206
CDD_AGND	42	FLOAT	77	RXD7	114	RESERVE_GND	166	LED_RX/PHY	
TXDD-	43	IO_VSS	78	RXD6	115	IO_VDD	167	AD_4	207
TXDD+	44	IO_VDD	79	IO_VSS	116	IO_VSS	168	SPEED [0]/PORT_	
CDD_AVDD	45	RESERVE_		IO_VDD	117	RESERVE_GND	169	TYPE/INT	208
RD_AGND	46	FLOAT	80	RXD5	118	RESERVE_GND	170		
RD_AVDD	47	RESERVE_		RXD4	119	CORE_VDD	171		
RXDD-	48	FLOAT	81	RXD3	120	CORE_VSS	172		
RXDD+	49	CORE_VSS	82	RXD2	121	CORE_SUB	173		
RD_AGND	50	CORE_VDD	83	IO_VSS	122	RESERVE_GND	174		
RD_AVDD	51	RESERVE_		IO_VDD	123	RESERVE_GND	175		
		FLOAT	84	RXD1	124	RESERVE_GND	176		

### 8.6.3 208-Pin Package Dimensions

Figure 8.17 is a diagram showing the detailed dimensions of the L80600 208-pin package.

Figure 8.17 Package Dimensions



208 Lead Plastic Quad Flat Pack  
Order Number L80600  
NS Package-208A

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# Chapter 9

## L80600 Frequently Asked Questions

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**Q1:** What is the difference between TX\_CLK, TX\_TCLK, and GTX\_CLK?

**A1:** All three clocks are related to transmitting data. However, their functions are completely different:

**TX\_CLK:** Used for 10/100 Mbits/s transmit activity. It has two separate functions:

Synchronizes the data sent by the MAC and to latch this data into the PHY.

Clocks transmit data on the twisted-pair.

The TX\_CLK is an output of the PHY and is part of the MII interface as described in the IEEE 802.3u specification, Clause 28.

**GTX\_CLK:** This is used for 1000 Mbits/s transmit activity. It has only one function, to synchronize the data sent by the MAC and to latch this data into the PHY.

The GTX\_CLK is *not* used to transmit data on the twisted-pair wire. For 1000 Mbit/s operation, the Master PHY uses the X1 clock to transmit data on the wire, while the Slave PHY uses the clock recovered from the channel A receiver, as the transmit clock for all four pairs.

The GTX\_CLK is an output of the MAC and is part of the GMII interface as described in the IEEE 802.3z specification, Clause 35.

**TX\_TCLK:** This is used for 1000 Mbits/s transmit activity. It has only one function, to measure jitter in the data transmitted on the wire in Test Modes 2 and 3.

As explained above during the discussion of GTX\_CLK, either the X1 clock or the clock recovered from received

data is used for transmitting data, depending on whether the PHY is a Master or a Slave. TX\_TCLK represents the actual clock being used to transmit data.

The TX\_TCLK is an output of the PHY and can be enabled to output t on pin 192 (during Test Mode 2 and 3 it is automatically enabled). This is a requirement from the IEEE 802.3ab specification, Clause 40.6.1.2.5 (this clock is only available in the next generation L80600).

**Q2:** What happens to TX\_CLK during 1000 Mbit/s operation? Similarly what happens to RXD[4:7] during 10/100 Mbits/s operation?

**A2:** As mentioned in A1 above, TX\_CLK is not used during 1000 Mbit/s operation, and the RXD[4:7] lines are not used for 10/100 operation. These signals are outputs of the L80600. To simplify the MII/GMII interface, these signals are driven actively to a zero volt level, which eliminates the need for pull-down resistors that would have been needed if these pins were left floating when unused.

**Q3:** What happens to the TX\_CLK and RX\_CLK signals during AutoNegotiation and during idles?

**A3:** During AutoNegotiation, the L80600 drives a 25 MHz clock on the TX\_CLK and RX\_CLK lines. In 10 Mbit/s mode, these lines are driven by a 2.5 MHz clock during idles. In 100 Mbit/s mode they are driven by a 25 MHz clock during idles. In 1000 Mbit/s mode they are driven by a 125 MHz clock during idles.

**Q4:** Why doesn't the L80600 complete AutoNegotiation if the link partner is a forced 1000 Mbits/s PHY?

**A4:** IEEE specifications only define "parallel detection" for 10/100 Mbits/s operation. Parallel detection is the name given to the AutoNegotiation process where one of the link partners is AutoNegotiating while the other is in forced 10 or 100 Mbit/s mode. In this case, its expected that the AutoNegotiating PHY establishes a Half-Duplex link, at the forced speed of the link partner.

However, for 1000 Mbit/s operation the parallel detection mechanism is not defined. Instead, any 1000BASE-T PHY can establish 1000 Mbit/s operation with a link partner for the following two cases:



- When both PHYs are AutoNegotiating,
- When both PHYs are forced 1000 Mbits/s and when one of the PHYs is manually configured for Master and the other is manually configured for Slave.

**Q5:** My two L80600s won't talk to each other, but they talk to another vendor's PHY.

**A5:** Avoid using Manual Master/Slave Configuration. If all PHYs on a switch box are configured for the same Master/Slave value, they can't talk to each other, because one of the link partners has to be a slave while the other has to be a Master.

**Q6:** You advise not to use Manual Master/Slave configuration. How come it's an option?

**A6:** Manual Master/Slave configuration is similar to manual forcing 10 or 100 Mbit/s operation. The only way it can work is if both link partners are forced to a compatible speed of operation, or if at least one of them is AutoNegotiating. Since there is no way of knowing ahead of time, if the link partner also uses a hardwired manual Master/Slave setting, there is no way to guarantee that there won't be a conflict (both PHYs are assigned as Master, or both PHYs are as Slave).

Some applications automatically hardwire a switch for Master and a Node card for Slave. However, this is wrong, since most of the early use for 1000BASE-T is for switch-to-switch backplane uplink ports, and hence this results in both link partners assigned to Master status. This causes a conflict and prevents establishment of link.

**Q7:** How can I write to L80600 expanded address or RAM locations? Why do I need to write to these locations?

**A7:** The following functions require access to expanded address:

- Asymmetric Pause Advertise
- Next Page
- Programmable Interrupt
- Read Latest Firmware Revision
- Read ROM Revision

The L80600 requires reads and writes to RAM to accomplish these tasks. As a sample procedure, an example is given on how to advertise Asymmetrical Pause.

The following software register writes are required if Asymmetrical Pause needs to be advertised:

1. Power down the L80600 (set bit 11, register 0x00, to make sure that during RAM writes, the standard operation of the part doesn't interfere with writing to the RAM.)
2. Write to register 0x16 the value 0x000D (this allows access to expanded access for 8 bit read/write).
3. Write to register 0x1E the value 0x8084.
4. Write to register 0x1D the value 0x0001.
5. Take the L80600 out of power-down mode (clear bit 11 of register 0x00.)

Note: The order of the writes is important. Register 0x1E is a pointer to the internal expanded addresses. Register 0x1D contains the data to be written to or read from the internal address pointed by register 0x1E. The content of register 0x1E automatically increments after each read or write to register 0x1D. Therefore, if one wants to confirm that the data write was successful, one should rewrite register 0x1E with the original address and then read register 0x1D.

All register writes are 16 bits. However, the RAM data is 8-bits wide. In the 8-bit read/write mode as described above in step 2, the lowest 8-bits of the register are written to the RAM location pointed to by register 0x1E.

For each one of the desired functions listed above (for example, disable jabber), steps 1, 2, and 5 have to be followed. Depending on the exact functionality required, a different register location and different data value have to be entered at steps 3) and 4).

**Q8:** What specific addresses and values do I have to use for each of the functions mentioned in Q7 above?

**A8:**

- Advertise Asymmetrical Pause: address 0x8084, value 0x01
- Read Latest Firmware Revision: addresses 0x8402 and 0x8403 contain a two character revision number. These are ASCII coded characters: The latest version of L80600 has revision code = 09 which corresponds to 0 = 0x30 and 9 = 0x39.
- Read Latest Hardware (ROM) Revision: addresses 0xD002 and 0xD003 contain a two-character revision number. These are ASCII coded characters: the production version of L80600 has rev code = 0x3B, which corresponds to 3 = 0x33 and B = 0x42.
- EEPROM checksum: RAM location 0x83FE contains the value of the computed checksum, and RAM location 0x83FF contains the checksum indicated by the firmware which was loaded.

**Q9:** How can I do firmware updates? What are some of the benefits of the firmware updates?

**A9:** Firmware updates have many uses. Some of these uses are:

- If future bugs are discovered, they may be fixed (or workarounds implemented) using firmware updates. Typically for hardwired PHYs without the firmware update option, the customer has to live with the bug, or try to implement a software workaround.
- Enhancements and additional functionality can be added to the L80600. For example, the L80600 might be able to detect cable length and indicate this length in a register. These functions are not implemented in hardware at this time, but they may be added as enhancements using firmware updates.

To update firmware, there are two options:

1) Use EEPROM.

2) Using the driver and/or management interface (MDC/MDIO). The procedure is similar to what is described in answer 7. The main difference is that 16-bit read/write mode is used. As discussed earlier in answer 7, all register writes are 16 bits. However the RAM data is 8-bits wide. In the 8-bit read/write mode as described earlier, the lowest 8-bits

of register 0x1D are written to the RAM location pointed to by register 0x1E. This is sufficient for single register writes and this mode was used to make the necessary RAM write in answer 7. However, for loading the entire 14 Kbytes of RAM, this method is not efficient. Since each MDC/MDIO read/write accesses a 16 bit register, it is more efficient to use one MII register write, and let the internal software break this into two 8 bit RAM writes. To achieve this, we program a 16-bit read/write mode into register 0x16, instead of the earlier 8-bit mode as described in answer 7. In this mode, each 16-bit write into register 0x1D is broken into two internal 8-bit RAM writes. The internal hardware automatically increments the RAM address pointer register 0x1E after each 8-bit write. It first uses the lowest 8 bits of register 0x1D to write to the RAM location pointed to by register 0x1E. Then it increments the address pointed to by 0x1E by one, and writes the most significant 8 bits of 0x1D into the next RAM location. This is all transparent to the user, who only has to set the 16 bit read/write mode as described in step 2 below and then do regular 16 bit MDC/MDIO writes.

1. Power down the L80600 (set bit 11, register 0x00, to make sure that during RAM writes, the standard operation of the part doesn't interfere with writing to the RAM).
2. Write to register 0x16 the value 0x0006 (this allows access to expanded access for 16 bit read/write).
3. Write to register 0x1E the value 0x8400 (the starting address of RAM).
4. Write to register 0x1D the desired value. The higher 8 bits of this register are written into the location pointed to by register 0x1E above. Then the location pointed to by register 0x1E is incremented by one automatically to point to the next location. Next, the 8 least significant bits of register 0x1D are written to the RAM location pointed to by register 0x1E.
5. Write to register 0x1D the next desired value.
6. Continue repeating step 5 for all data to be written.
7. Write 0x8400 to register 0x1F. This starts execution of down loaded code at address 0x8400.
8. Wait for 1.024 ms. (no MDC/MDIO access for 1.024 ms).
9. Read register 0x00 (this read is needed to clear an interrupt problem).

10. Take the L80600 out of power down mode (reset bit 11 of register 0x00.)

**Q10:** How long does AutoNegotiation take?

**A10:** Two L80600s typically complete AutoNegotiation and establish 1000 Mb/s operation within 5 seconds. 1000BASE-T AutoNegotiation process takes longer than the 10/100 Mb/s. One of the reasons for this is the use of Next Page exchanges during 1000 Mb/s negotiation.

**Q11:** I know I have good link, but register 0x01, bit 2 “Link Status” is not set to 1 (indicating good link).

**A11:** This bit is defined by IEEE 802.3u Clause 22. It indicates if the link was lost since the last time this register was read. Its name (given by IEEE) is perhaps misleading. A more accurate name would have been the “Link Lost” bit. If the actual present link status is desired, then either this register should be read twice, or register 0x11 bit 2 should be read. Register 0x11 shows the actual status of link, speed, and duplex regardless of what was advertised or what has happened in the interim.

**Q12:** I have forced 100 Mbit/s operation but the 100 Mbit/s speed LED doesn’t come on.

**A12:** Speed LEDs are actually an AND function of the speed and link status. Regardless of whether the speed is forced or AutoNegotiated, there has to be good link before the speed LEDs illuminate.

**Q13:** Can you clarify the pull-up or pull-down information?

**A13:** The pull-up or pull-down information specified in [Chapter 3, “Signals”](#) indicates if there is an internal pull-up or pull-down resistor at the IO buffer used for that specific pin. These internal resistors are between 25–65 k $\Omega$ . They determine the default strap value if the pin is left floating. If the default value is desired to be overwritten, an external 1 k $\Omega$  pull-up or pull-down resistor can be used.

**Q14:** What are some other applicable documents?

**A14:**

- IEEE 802.3z “MAC Parameters, Physical Layer, Repeater and Management Parameters for 1000 Mbit/s Operation.”

- IEEE 802.3ab “Physical layer specification for 1000 Mbit/s operation on four pairs of category 5 or better balanced twisted-pair cable (1000BASE-T)“.
- IEEE 802.3 and 802.3u (For 10/100 Mbit/s operation.)

**Q15:** How is the maximum junction temperature calculated?

**A15:** The maximum die temperature is calculated using the following equations:

$$T_J = T_A + P_d(O_{JA})$$

$$T_J = T_C + P_d(O_c)$$

$$T_C = T_J - P_d(O_c)$$

Where:

$T_J$  = Junction temperature of the die in °C

$T_C$  = Case temperature of the package in °C

$P_d$  = Power dissipated in the die in Watts

$O_{JA}$  = 11.7 °C/watt

$O_c$  = 2.13 °C/watt

For reliability purposes, the maximum junction temperature should be kept below 120 °C. If the ambient temperature is 70 °C and the power dissipation is 4.0 watts, the Maximum Case Temperature is:

$$T_{C \text{ max}} = 120 \text{ °C} - 4.0 \text{ watts} (2.13 \text{ °C/watt})$$

$$T_{C \text{ max}} = 111.48 \text{ °C}$$

**Q16:** How do I measure Fast Link Pulses (FLPs)?

**A16:** To measure FLPs, you must first disable the Automatic MDIX function. When in Automatic MDIX mode, the L80600 generates link pulses every 150 μs. The MDIX pulse could be confused with the FLP pulses, which occur every 125 μs ± 14 μs.

To disable MDIX, the following register writes need to be done:

**Table 9.1 MDIX Configuration**

Register	Write	Comments
0x00	bit 11 = 1	This puts the L80600 into power down mode.
0x16	0x000D	This allows access to expanded memory mode.
0x1E	0x808B	This allows access to expanded memory 808B.
0x1D	0x0001	This disables MDIX mode.
0x00	bit 11 = 0	This takes the L80600 out of power down mode.

Once MDIX is disabled, the L80600 randomly comes up in crossover mode or straight cable mode and outputs FLPs on either pins 1 and 2 or 3 and 6 on the RJ45 connector.

**Q17:** The L80600 establishes Link in 10 Mbits/s and 100Mbits/s mode with a Broadcom part, but it does not establish link in 1000 Mbit/s mode. When this happens the L80600 Link LED blinks on and off.

**A17:** We have received a number of questions regarding interoperability between the L80600 and the Broadcom BCM5400. The L80600 is compliant to IEEE 802.3ab and it is also interoperable with the BCM5400 as well as other Gigabit Physical Layer products. However, there are certain situations that might require extra attention when interoperating with the BCM5400.

There are mainly two types of BCM5400's, those with silicon revisions earlier than C5 and those with silicon revisions of C5 and older. There is a fundamental problem with earlier silicon revisions of the BCM 5400, whereby the part was designed with faulty start-up conditions (wrong polynomials were used), which prevented the Broadcom BCM5400 from ever linking to an IEEE 802.3ab compliant part.

This problem was observed in early interoperability testing. A solution was put together that allows the L80600 to interoperate with any IEEE 802.3ab compliant Gigabit PHY as well as with earlier revisions of the BCM5400 that are noncompliant. To enter into this mode of operation you can either pull pin 196 (NC\_MODE) high through a 1 kΩ resistor or write a 1 to register 0x10 bit 10.

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