

Hi-Speed USB 2.0 to 10/100 Ethernet Controller

PRODUCT FEATURES

Datasheet

Highlights

- Single Chip Hi-Speed USB 2.0 to 10/100 Ethernet Controller
- Integrated 10/100 Ethernet MAC with Full-Duplex Support
- Integrated 10/100 Ethernet PHY with HP Auto-MDIX support
- Integrated USB 2.0 Hi-Speed Device Controller
- Integrated USB 2.0 Hi-Speed PHY
- Implements Reduced Power Operating Modes
- ±8kV HBM ESD protection (component level)
- ±8kV contact-discharge, ±15kV air discharge ESD protection per IEC61000-4-2

Target Applications

- Embedded Systems
- Set-Top Boxes
- PVR's
- CE Devices
- Networked Printers
- USB Port Replicators
- Standalone USB to Ethernet Dongles
- Test Instrumentation
- Industrial

Key Benefits

- USB Device Controller
 - Fully compliant with Hi-Speed Universal Serial Bus Specification Revision 2.0
 - Supports HS (480 Mbps) and FS (12 Mbps) modes
 - Four endpoints supported
 - Supports vendor specific commands
 - Integrated USB 2.0 PHY
 - Remote wakeup supported
- High-Performance 10/100 Ethernet Controller
 - Fully compliant with IEEE802.3/802.3u
 - Integrated Ethernet MAC and PHY
 - 10BASE-T and 100BASE-TX support

- Full- and half-duplex support
- Full- and half-duplex flow control
- Preamble generation and removal
- Automatic 32-bit CRC generation and checking
- Automatic payload padding and pad removal
- Loop-back modes
- TCP/UDP/IP/ICMP checksum offload support
- Flexible address filtering modes
 - One 48-bit perfect address
 - 64 hash-filtered multicast addresses
 - Pass all multicast
 - Promiscuous mode
 - Inverse filtering
 - Pass all incoming with status report
- Wakeup packet support
- Integrated Ethernet PHY
 - Auto-negotiation
 - Automatic polarity detection and correction
 - HP Auto-MDIX support
 - Link status change wake-up detection
- Support for 3 status LEDs
- External MII and Turbo MII support HomePNA™ and HomePlug® PHY
- Power and I/Os
 - Various low power modes
 - 11 GPIOs
 - Supports bus-powered and self-powered operation
 - Integrated power-on reset circuit
 - External 3.3v I/O supply
 - Internal 1.8v core supply regulator
- Miscellaneous Features
 - EEPROM Controller
 - IEEE 1149.1 (JTAG) Boundary Scan
 - Requires single 25 MHz crystal
- Software
 - Windows XP/Vista Driver
 - Linux Driver
 - Win CE Driver
 - MAC OS Driver
 - EEPROM Utility
- Packaging
 - 56-pin QFN (8x8 mm) Lead-Free RoHS Compliant package
- Environmental
 - Commercial Temperature Range (0°C to +70°C)
 - Industrial Temperature Range (-40°C to +85°C)

ORDER NUMBER(S):**LAN9500-ABZJ FOR 56-PIN, QFN LEAD-FREE ROHS COMPLIANT PACKAGE (0 TO +70°C TEMP RANGE)****LAN9500i-ABZJ FOR 56-PIN, QFN LEAD-FREE ROHS COMPLIANT PACKAGE (-40 TO +85°C TEMP RANGE)**

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Chapter 1 Introduction

1.1 Block Diagram

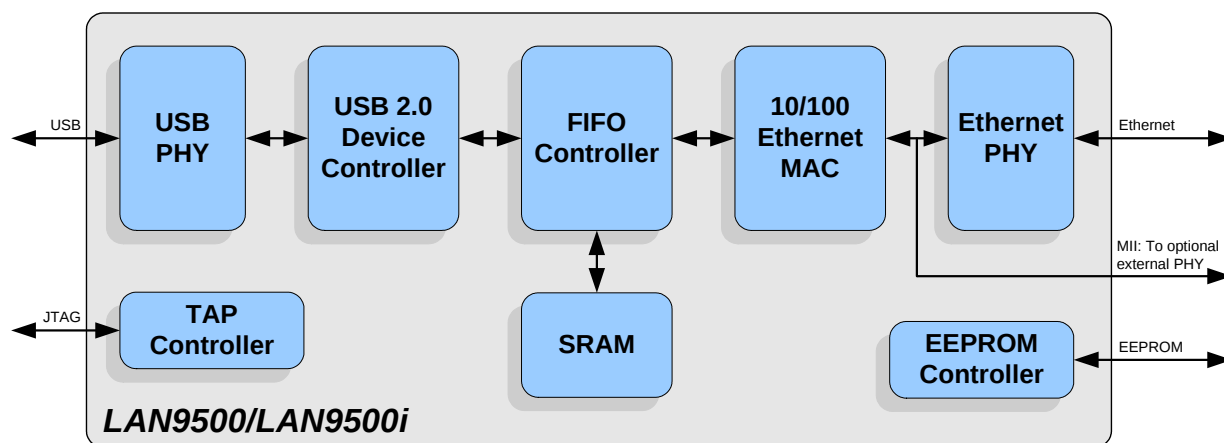


Figure 1.1 LAN9500/LAN9500i System Diagram

1.1.1 Overview

The LAN9500/LAN9500i is a high performance Hi-Speed USB 2.0 to 10/100 Ethernet controller. With applications ranging from embedded systems, set-top boxes, and PVR's, to USB port replicators, USB to Ethernet dongles, and test instrumentation, the LAN9500/LAN9500i is a high performance and cost competitive USB to Ethernet connectivity solution.

The LAN9500/LAN9500i contains an integrated 10/100 Ethernet PHY, USB PHY, Hi-Speed USB 2.0 device controller, 10/100 Ethernet MAC, TAP controller, EEPROM controller, and a FIFO controller with a total of 30 KB of internal packet buffering.

The internal USB 2.0 device controller and USB PHY are compliant with the USB 2.0 Hi-Speed standard. The LAN9500/LAN9500i implements Control, Interrupt, Bulk-in, and Bulk-out USB Endpoints.

The Ethernet controller supports auto-negotiation, auto-polarity correction, HP Auto-MDIX, and is compliant with the IEEE 802.3 and IEEE 802.3u standards. An external MII interface provides support for an external Fast Ethernet PHY, HomePNA, and HomePlug functionality.

Multiple power management features are provided, including various low power modes and "Magic Packet", "Wake On LAN", and "Link Status Change" wake events. These wake events can be programmed to initiate a USB remote wakeup.

An internal EEPROM controller exists to load various USB configuration information and the device MAC address. The integrated IEEE 1149.1 compliant TAP controller provides boundary scan via JTAG.

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1.1.2 USB

The USB portion of the LAN9500/LAN9500i integrates a Hi-Speed USB 2.0 device controller and USB PHY.

The USB device controller contains a USB low-level protocol interpreter which implements the USB bus protocol, packet generation/extraction, PID/Device ID parsing, and CRC coding/decoding, with autonomous error handling. The USB device controller is capable of operating in USB 2.0 Hi-Speed and Full-Speed compliant modes and contains autonomous protocol handling functions such as handling of suspend/resume/reset conditions, remote wakeup, and stall condition clearing on Setup packets. The USB device controller also autonomously handles error conditions such as retry for CRC and data toggle errors, and generates NYET, STALL, ACK and NACK handshake responses, depending on the endpoint buffer status.

The LAN9500/LAN9500i implements four USB endpoints: Control, Interrupt, Bulk-in, and Bulk-out. The Bulk-in and Bulk-out Endpoints allow for Ethernet reception and transmission respectively. Implementation of vendor-specific commands allows for efficient statistics gathering and access to the LAN9500/LAN9500i system control and status registers.

1.1.3 FIFO Controller

The FIFO controller uses an internal SRAM to buffer RX and TX traffic. Bulk-out packets from the USB controller are directly stored into the TX buffer. Ethernet Frames are directly stored into the RX buffer and become the basis for bulk-in packets.

1.1.4 Ethernet

The LAN9500/LAN9500i integrates an IEEE 802.3 PHY for twisted pair Ethernet applications and a 10/100 Ethernet Media Access Controller (MAC).

The PHY can be configured for either 100 Mbps (100BASE-TX) or 10 Mbps (10BASE-T) Ethernet operation in either full- or half-duplex configurations and includes auto-negotiation, auto-polarity correction, and Auto-MDIX. Minimal external components are required for the utilization of the Integrated PHY.

Optionally, an external PHY may be used via the MII (Media Independent Interface) port, effectively bypassing the internal PHY. This option allows support for HomePNA and HomePlug applications.

The Ethernet MAC/PHY supports numerous power management wakeup features, including "Magic Packet", "Wake on LAN", and "Link Status Change".

1.1.5 Power Management

The LAN9500/LAN9500i features three variations of USB suspend: SUSPEND0, SUSPEND1, and SUSPEND2. These modes allow the application to select the ideal balance of remote wakeup functionality and power consumption.

- **SUSPEND0:** Supports GPIO, "Wake On LAN", and "Magic Packet" remote wakeup events. This suspend state reduces power by stopping the clocks of the MAC and other internal modules.
- **SUSPEND1:** Supports GPIO and "Link Status Change" for remote wakeup events. This suspend state consumes less power than SUSPEND0.
- **SUSPEND2:** Supports only GPIO assertion for a remote wakeup event. This is the default suspend mode for the LAN9500/LAN9500i.

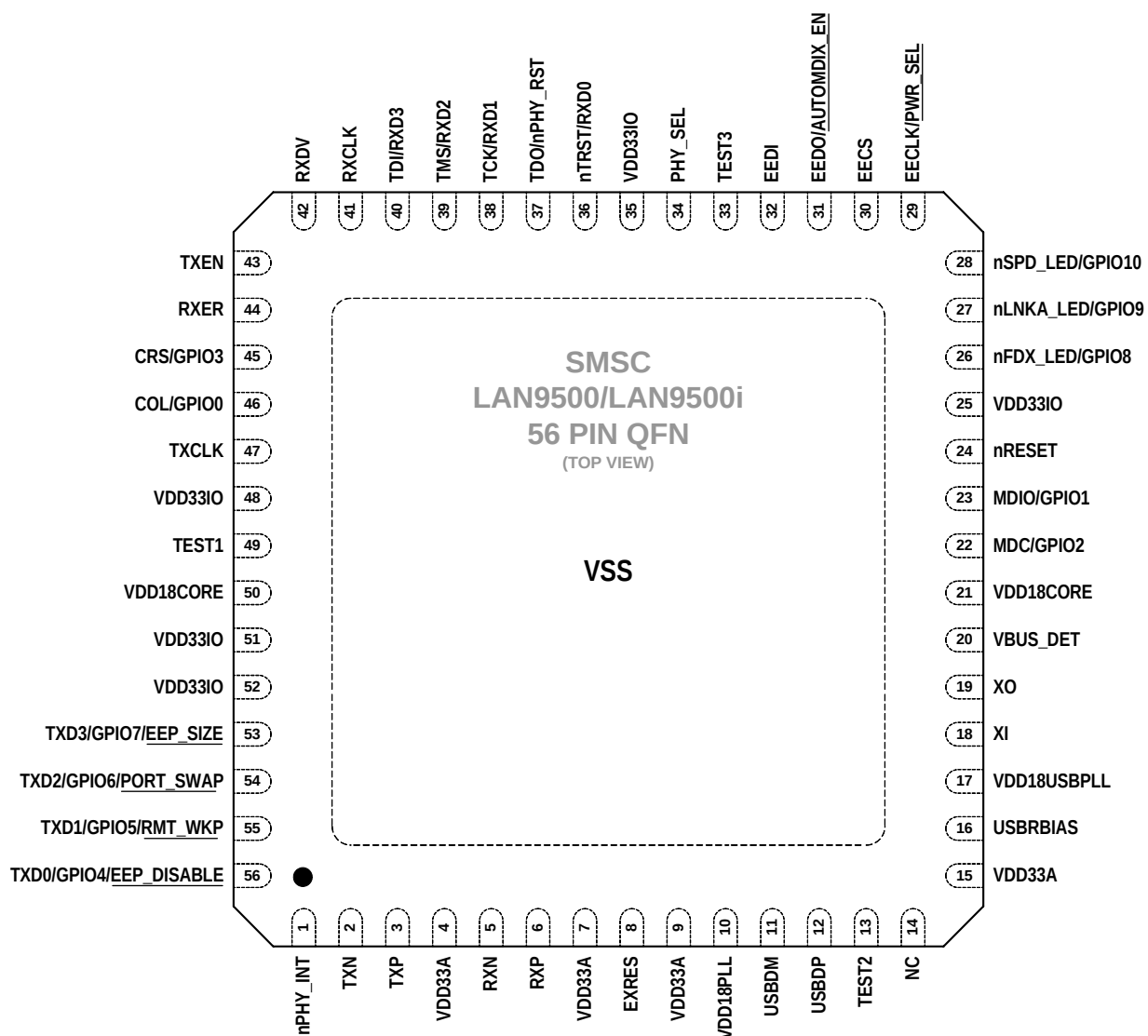
1.1.6 EEPROM Controller

The LAN9500/LAN9500i contains an EEPROM controller for connection to an external EEPROM. This allows for the automatic loading of static configuration data upon power-on reset, pin reset, or software reset. The EEPROM can be configured to load USB descriptors, USB device configuration, and MAC address.

1.1.7 General Purpose I/O

When configured for internal PHY mode, up to eleven GPIOs are supported. All GPIOs can serve as remote wakeup events when the LAN9500/LAN9500i is in a suspended state.

Chapter 2 Pin Description and Configuration



NOTE: When HP Auto-MDIX is activated, the TXN/TXP pins can function as RXN/RXP and vice-versa

NOTE: Exposed pad (VSS) on bottom of package must be connected to ground

Figure 2.1 LAN9500/LAN9500i 56-QFN Pin Assignments (TOP VIEW)

Table 2.1 MII Interface Pins

NUM PINS	NAME	SYMBOL	BUFFER TYPE	DESCRIPTION
1	Receive Error (External PHY Mode)	RXER	IS (PD)	Receive Error: In external PHY mode, the signal on this pin is input from the external PHY and indicates a receive error in the packet. In internal PHY mode, this pin is not used.
1	Transmit Enable (External PHY Mode)	TXEN	O8 (PD)	Transmit Enable: In external PHY mode, this pin output to the external PHY and indicates valid data on TXD[3:0]. In internal PHY mode, this pin is not used.
1	Receive Data Valid (External PHY Mode)	RXDV	IS (PD)	Receive Data Valid: In external PHY mode, the signal on this pin is input from the external PHY and indicates valid data on RXD[3:0]. In internal PHY mode, this pin is not used.
1	Receive Clock (External PHY Mode)	RXCLK	IS (PD)	Receive Clock: In external PHY mode, this pin is the receiver clock input from the external PHY. In internal PHY mode, this pin is not used.
1	Carrier Sense (External PHY Mode)	CRS	IS (PD)	Carrier Sense: In external PHY mode, the signal on this pin is input from the external PHY and indicates a network carrier.
	General Purpose I/O 3 (Internal PHY Mode Only)	GPIO3	IS/O8/OD8 (PU)	General Purpose I/O 3
1	MDI Collision Detect (External PHY Mode)	COL	IS (PD)	MDI Collision Detect: In external PHY mode, the signal on this pin is input from the external PHY and indicates a collision event.
	General Purpose I/O 0 (Internal PHY Mode Only)	GPIO0	IS/O8/OD8 (PU)	General Purpose I/O 0
1	Management Data (External PHY Mode)	MDIO	IS/O8 (PD)	Management Data: In external PHY mode, this pin provides the management data to/from the external PHY.
	General Purpose I/O 1 (Internal PHY Mode Only)	GPIO1	IS/O8/OD8 (PU)	General Purpose I/O 1
1	Management Clock (External PHY Mode)	MDC	O8 (PD)	Management Clock: In external PHY mode, this pin outputs the management clock to the external PHY.
	General Purpose I/O 2 (Internal PHY Mode Only)	GPIO2	IS/O8/OD8 (PU)	General Purpose I/O 2

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Table 2.1 MII Interface Pins (continued)

NUM PINS	NAME	SYMBOL	BUFFER TYPE	DESCRIPTION
1	Transmit Data 3 (External PHY Mode)	TXD3	O8 (PU)	Transmit Data 3: In external PHY mode, this pin functions as the transmit data 3 output to the external PHY.
	General Purpose I/O 7 (Internal PHY Mode Only)	GPIO7	IS/O8/ OD8 (PU)	General Purpose I/O 7
	EEPROM Size Configuration Strap	<u>EEP_SIZE</u>	IS (PU)	EEPROM SIZE: The EEP_SIZE strap selects the size of the EEPROM attached to the LAN9500/LAN9500i. 0 = 128 byte EEPROM is attached and a total of seven address bits are used. 1 = 256/512 byte EEPROM is attached and a total of nine address bits are used. Note: A 3-wire style 1K/2K/4K EEPROM that is organized for 128 x 8-bit or 256/512 x 8-bit operation must be used. See Note 2.1 for more information on configuration straps.
1	Transmit Data 2 (External PHY Mode)	TXD2	O8 (PD)	Transmit Data 2: In external PHY mode, this pin functions as the transmit data 2 output to the external PHY.
	General Purpose I/O 6 (Internal PHY Mode Only)	GPIO6	IS/O8/ OD8 (PU)	General Purpose I/O 6
	USB Port Swap Configuration Strap	<u>PORT_SWAP</u>	IS (PD)	USB Port Swap Configuration Strap: Swaps the mapping of USBDP and USBDM. 0 = USBDP maps to the USB D+ line and USBDM maps to the USB D- line. 1 = USBDP maps to the USB D- line. USBDM maps to the USB D+ line. See Note 2.1 for more information on configuration straps.

Table 2.1 MII Interface Pins (continued)

NUM PINS	NAME	SYMBOL	BUFFER TYPE	DESCRIPTION
1	Transmit Data 1 (External PHY Mode)	TXD1	O8 (PD)	Transmit Data 1: In external PHY mode, this pin functions as the transmit data 1 output to the external PHY.
	General Purpose I/O 5 (Internal PHY Mode Only)	GPIO5	IS/O8/OD8 (PU)	General Purpose I/O 5
	Remote Wakeup Configuration Strap	<u>RMT_WKP</u>	IS (PD)	Remote Wakeup Configuration Strap: This strap configures the default descriptor values to support remote wakeup. 0 = Remote wakeup is not supported. 1 = Remote wakeup is supported. See Note 2.1 for more information on configuration straps.
1	Transmit Data 0 (External PHY Mode)	TXD0	O8 (PD)	Transmit Data 0: In external PHY mode, this pin functions as the transmit data 0 output to the external PHY.
	General Purpose I/O 4 (Internal PHY Mode Only)	GPIO4	IS/O8/OD8 (PU)	General Purpose I/O 4
	EEPROM Disable Configuration Strap	<u>EEP_DISABLE</u>	IS (PD)	EEPROM Disable Configuration Strap: This strap disables the autoloading of the EEPROM contents. The assertion of this strap does not prevent register access to the EEPROM. 0 = EEPROM is recognized if present. 1 = EEPROM is not recognized even if it is present. See Note 2.1 for more information on configuration straps.
1	Transmit Clock (External PHY Mode)	TXCLK	IS (PU)	Transmit Clock: In external PHY mode, this pin is the transmitter clock input from the external PHY. In internal PHY mode, this pin is not used.

Note 2.1 Configuration strap values are latched on power-on reset and system reset. Configuration straps are identified by an underlined symbol name. Signals that function as configuration straps must be augmented with an external resistor when connected to a load.

Table 2.2 EEPROM Pins

NUM PINS	NAME	SYMBOL	BUFFER TYPE	DESCRIPTION
1	EEPROM Data In	EEDI	IS (PD)	EEPROM Data In: This pin is driven by the EEDO output of the external EEPROM.
1	EEPROM Data Out	EEDO	O8 (PU)	EEPROM Data Out: This pin drives the EEDI input of the external EEPROM.
	Auto-MDIX Enable Configuration Strap	<u>AUTOMDIX_EN</u>	IS (PU)	Auto-MDIX Enable Configuration Strap: Determines the default Auto-MDIX setting. 0 = Auto-MDIX is disabled. 1 = Auto-MDIX is enabled. See Note 2.2 for more information on configuration straps.
1	EEPROM Chip Select	EECS	O8	EEPROM chip select: This pin drives the chip select output of the external EEPROM.
1	EEPROM Clock	EECLK	O8 (PD)	EEPROM Clock: This pin drives the EEPROM clock of the external EEPROM.
	Power Select Configuration Strap	<u>PWR_SEL</u>	IS (PD)	Power Select Configuration Strap: Determines the default power setting when no EEPROM is present. 0 = The LAN9500/LAN9500i is bus powered. 1 = The LAN9500/LAN9500i is self powered. See Note 2.2 for more information on configuration straps.

Note 2.2 Configuration strap values are latched on power-on reset and system reset. Configuration straps are identified by an underlined symbol name. Signals that function as configuration straps must be augmented with an external resistor when connected to a load.

Table 2.3 JTAG Pins

NUM PINS	NAME	SYMBOL	BUFFER TYPE	DESCRIPTION
1	JTAG Test Port Reset (Internal PHY Mode)	nTRST	IS (PU)	JTAG Test Port Reset (Active-Low): In internal PHY mode, this pin functions as the JTAG test port reset input.
	Receive Data 0 (External PHY Mode)	RXD0	IS (PD)	Receive Data 0: In external PHY mode, this pin functions as the receive data 0 input from the external PHY.
1	JTAG Test Data Out (Internal PHY Mode)	TDO	O8	JTAG Data Output: In internal PHY mode, this pin functions as the JTAG data output.
	PHY Reset (External PHY Mode)	nPHY_RST	O8	PHY Reset (Active-Low): In external PHY mode, this pin functions as the PHY reset output.

Table 2.3 JTAG Pins (continued)

NUM PINS	NAME	SYMBOL	BUFFER TYPE	DESCRIPTION
1	JTAG Test Clock (Internal PHY Mode)	TCK	IS (PU)	JTAG Test Clock: In internal PHY mode, this pin functions as the JTAG test clock. The maximum operating frequency of this clock is 25MHz.
	Receive Data 1 (External PHY Mode)	RXD1	IS (PD)	Receive Data 1: In external PHY mode, this signal functions as the receive data 1 input from the external PHY.
1	JTAG Test Mode Select (Internal PHY Mode)	TMS	IS (PU)	JTAG Test Mode Select: In internal PHY mode, this pin functions as the JTAG test mode select.
	Receive Data 2 (External PHY Mode)	RXD2	IS (PD)	Receive Data 2: In external PHY mode, this signal functions as the receive data 2 input from the external PHY.
1	JTAG Test Data Input (Internal PHY Mode)	TDI	IS (PU)	JTAG Data Input: When in internal PHY mode, this pin functions as the JTAG data input.
	Receive Data 3 (External PHY Mode)	RXD3	IS (PD)	Receive Data 3: In external PHY mode, this pin functions as the receive data 3 input from the external PHY.

Table 2.4 Miscellaneous Pins

NUM PINS	NAME	SYMBOL	BUFFER TYPE	DESCRIPTION
1	PHY Select	PHY_SEL	IS (PD)	PHY Select: Selects whether to use the internal Ethernet PHY or the external PHY connected to the MII port. 0 = Internal PHY is used. 1 = External PHY is used.
1	System Reset	nRESET	IS (PU)	System Reset (Active-Low)
1	Ethernet Full-Duplex Indicator LED	nFDX_LED	OD12 (PU)	Ethernet Full-Duplex Indicator LED (Active-Low): This signal is driven low (LED on) when the Ethernet link is operating in full-duplex mode.
	General Purpose I/O 8	GPIO8	IS/O12/OD12 (PU)	General Purpose I/O 8 Note: By default this pin is configured as a GPIO.

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Table 2.4 Miscellaneous Pins (continued)

NUM PINS	NAME	SYMBOL	BUFFER TYPE	DESCRIPTION
1	Ethernet Link Activity Indicator LED	nLNKA_LED	OD12 (PU)	Ethernet Link Activity Indicator LED (Active-Low): This signal is driven low (LED on) when a valid link is detected. This pin is pulsed high (LED off) for 80mS whenever transmit or receive activity is detected. This pin is then driven low again for a minimum of 80mS, after which time it will repeat the process if TX or RX activity is detected. Effectively, LED2 is activated solid for a link. When transmit or receive activity is sensed, LED2 will function as an activity indicator.
	General Purpose I/O 9	GPIO9	IS/O12/OD12 (PU)	General Purpose I/O 9 Note: By default this pin is configured as a GPIO.
1	Ethernet Speed Indicator LED	nSPD_LED	OD12 (PU)	Ethernet Speed Indicator LED (Active-Low): This pin is driven low (LED on) when the Ethernet operating speed is 100Mbps, or during auto-negotiation. This pin is driven high during 10Mbps operation, or during line isolation.
	General Purpose I/O 10	GPIO10	IS/O12/OD12 (PU)	General Purpose I/O 10 Note: By default this pin is configured as a GPIO.
1	Detect Upstream VBUS Power	VBUS_DET	IS_5V (PD)	Detect Upstream VBUS Power: Detects state of upstream bus power. This pin must be tied to VDD33IO when operating in bus powered mode.
1	Test 1	TEST1	-	Test 1: This pin must always be connected to VDD33IO for proper operation.
1	Test 2	TEST2	-	Test 2: This pin must always be connected to VSS for proper operation.
1	Test 3	TEST3	-	Test 3: This pin must always be connected to VSS for proper operation.

Table 2.5 USB Pins

NUM PINS	NAME	SYMBOL	BUFFER TYPE	DESCRIPTION
1	USB DMINUS	USBDM	AIO	USB DMINUS Note: The functionality of this pin may be swapped to USB DPLUS via the <u>PORT_SWAP</u> configuration strap.
1	USB DPLUS	USBDP	AIO	USB DPLUS Note: The functionality of this pin may be swapped to USB DMINUS via the <u>PORT_SWAP</u> configuration strap.
1	External USB Bias Resistor.	USBRBIAS	AI	External USB Bias Resistor: Used for setting HS transmit current level and on-chip termination impedance. Connect to an external 12K 1.0% resistor to ground.
1	USB PLL +1.8V Supply	VDD18USBPLL	P	USB PLL +1.8V Supply: This pin must be connected to VDD18CORE for proper operation. Refer to the LAN9500/LAN9500i reference schematic for additional connection information.
1	Crystal Input	XI	ICLK	Crystal Input: External 25 MHz crystal input. Note: This signal can also be driven by a single-ended clock oscillator. When this method is used, XO should be left unconnected
1	Crystal Output	XO	OCLK	Crystal Output: External 25 MHz crystal output.

Table 2.6 Ethernet PHY Pins

NUM PINS	NAME	SYMBOL	BUFFER TYPE	DESCRIPTION
1	Ethernet TX Data Out Negative	TXN	AIO	Ethernet Transmit Data Out Negative: The transmit data outputs may be swapped internally with receive data inputs when Auto-MDIX is enabled.
1	Ethernet TX Data Out Positive	TXP	AIO	Ethernet Transmit Data Out Positive: The transmit data outputs may be swapped internally with receive data inputs when Auto-MDIX is enabled.
1	Ethernet RX Data In Negative	RXN	AIO	Ethernet Receive Data In Negative: The receive data inputs may be swapped internally with transmit data outputs when Auto-MDIX is enabled.
1	Ethernet RX Data In Positive	RXP	AIO	Ethernet Receive Data In Positive: The receive data inputs may be swapped internally with transmit data outputs when Auto-MDIX is enabled.

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Table 2.6 Ethernet PHY Pins (continued)

NUM PINS	NAME	SYMBOL	BUFFER TYPE	DESCRIPTION
1	PHY Interrupt (Internal PHY Mode)	nPHY_INT	O8	PHY Interrupt (Active-Low): In internal PHY mode, this signal can be configured to output the internal PHY interrupt signal. Note: The internal PHY interrupt signal is active-high.
	PHY Interrupt (External PHY Mode)	nPHY_INT	IS (PU)	PHY Interrupt (Active-Low): In external PHY mode, the signal on this pin is input from the external PHY and indicates a PHY interrupt has occurred.
4	+3.3V Analog Power Supply	VDD33A	P	+3.3V Analog Power Supply Refer to the LAN9500/LAN9500i reference schematic for connection information.
1	External PHY Bias Resistor	EXRES	AI	External PHY Bias Resistor: Used for the internal bias circuits. Connect to an external 12.4K 1.0% resistor to ground.
1	Ethernet PLL +1.8V Power Supply	VDD18PLL	P	Ethernet PLL +1.8V Power Supply: This pin must be connected to VDD18CORE for proper operation. Refer to the LAN9500/LAN9500i reference schematic for additional connection information.

Table 2.7 I/O Power Pins, Core Power Pins, and Ground Pad

NUM PINS	NAME	SYMBOL	BUFFER TYPE	DESCRIPTION
5	+3.3V I/O Power	VDD33IO	P	+3.3V Power Supply for I/O Pins Refer to the LAN9500/LAN9500i reference schematic for connection information.
2	Digital Core +1.8V Power Supply Output	VDD18CORE	P	Digital Core +1.8V Power Supply Output Refer to the LAN9500/LAN9500i reference schematic for connection information.
Exposed pad on package bottom (Figure 2.1)	Ground	VSS	P	Common Ground

Table 2.8 No-Connect Pins

NUM PINS	NAME	SYMBOL	BUFFER TYPE	DESCRIPTION
1	No Connect	NC	-	No Connect: These pins must be left floating for normal device operation

Table 2.9 56-QFN Package Pin Assignments

PIN NUM	PIN NAME	PIN NUM	PIN NAME	PIN NUM	PIN NAME	PIN NUM	PIN NAME
1	nPHY_INT	15	VDD33A	29	EECLK/ <u>PWR_SEL</u>	43	TXEN
2	TXN	16	USBRBIAS	30	EECS	44	RXER
3	TXP	17	VDD18USBPLL	31	EEDO/ <u>AUTOMDIX_EN</u>	45	CRS/GPIO3
4	VDD33A	18	XI	32	EEDI	46	COL/GPIO0
5	RXN	19	XO	33	TEST3	47	TXCLK
6	RXP	20	VBUS_DET	34	PHY_SEL	48	VDD33IO
7	VDD33A	21	VDD18CORE	35	VDD33IO	49	TEST1
8	EXRES	22	MDC/GPIO2	36	nTRST/RXD0	50	VDD18CORE
9	VDD33A	23	MDIO/GPIO1	37	TDO/nPHY_RST	51	VDD33IO
10	VDD18PLL	24	nRESET	38	TCK/RXD1	52	VDD33IO
11	USBDM	25	VDD33IO	39	TMS/RXD2	53	TXD3/GPIO7/ <u>EEP_SIZE</u>
12	USBDP	26	nFDX_LED/ GPIO8	40	TDI/RXD3	54	TXD2/GPIO6/ <u>PORT_SWAP</u>
13	TEST2	27	nLNKA_LED/ GPIO9	41	RXCLK	55	TXD1/GPIO5/ <u>RMT_WKP</u>
14	NC	28	nSPD_LED/ GPIO10	42	RXDV	56	TXD0/GPIO4/ <u>EEP_DISABLE</u>
EXPOSED PAD MUST BE CONNECTED TO VSS							

2.1 Buffer Types

Table 2.10 Buffer Types

BUFFER TYPE	DESCRIPTION
IS	Schmitt-triggered Input
IS_5V	5V Tolerant Schmitt-triggered Input
O8	Output with 8mA sink and 8mA source
OD8	Open-drain output with 8mA sink
O12	Output with 12mA sink and 12mA source
OD12	Open-drain output with 12mA sink
PU	50uA (typical) internal pull-up. Unless otherwise noted in the pin description, internal pull-ups are always enabled. Note: Internal pull-up resistors prevent unconnected inputs from floating. Do not rely on internal resistors to drive signals external to the LAN9500/LAN9500i. When connected to a load that must be pulled high, an external resistor must be added.
PD	50uA (typical) internal pull-down. Unless otherwise noted in the pin description, internal pull-downs are always enabled. Note: Internal pull-down resistors prevent unconnected inputs from floating. Do not rely on internal resistors to drive signals external to the LAN9500/LAN9500i. When connected to a load that must be pulled low, an external resistor must be added.
AI	Analog input
AIO	Analog bi-directional
ICLK	Crystal oscillator input pin
OCLK	Crystal oscillator output pin
P	Power pin

Chapter 3 EEPROM Controller (EPC)

LAN9500/LAN9500i may use an external EEPROM to store the default values for the USB descriptors and the MAC address. The EEPROM controller supports most “93C46” type EEPROMs. The EEP_SIZE strap selects the size of the EEPROM attached to LAN9500/LAN9500i. When this strap is set to “0”, a 128 byte EEPROM is attached and a total of seven address bits are used. When this strap is set to “1” a 256/512 byte EEPROM is attached and a total of nine address bits are used.

Note: A 3-wire style 1K/2K/4K EEPROM that is organized for 128 x 8-bit or 256/512 x 8-bit operation must be used.

The MAC address is used as the default Ethernet MAC address and is loaded into the MAC’s ADDRH and ADDRRL registers. If a properly configured EEPROM is not detected, it is the responsibility of the Host LAN Driver to set the IEEE addresses.

After a system-level reset occurs, LAN9500/LAN9500i will load the default values from a properly configured EEPROM. LAN9500/LAN9500i will not accept USB transactions from the Host until this process is completed.

The LAN9500/LAN9500i EEPROM controller also allows the Host system to read, write and erase the contents of the Serial EEPROM.

3.1 EEPROM Format

Table 3.1 illustrates the format in which data is stored inside of the EEPROM.

Note the EEPROM offsets are given in units of 16-bit word offsets. A length field with a value of zero indicates that the field does not exist in the EEPROM. The LAN9500/LAN9500i will use the field’s HW default value in this case.

Note: For the device descriptor, the only valid values for the length are 0 and 18.

Note: For the configuration and interface descriptor, the only valid values for the length are 0 and 18.

Note: The EEPROM programmer must ensure that if a string descriptor does not exist in the EEPROM, the referencing descriptor must contain 00h for the respective string index field.

Note: If all string descriptor lengths are zero, then a Language ID will not be supported.

Table 3.1 EEPROM Format

EEPROM ADDRESS	EEPROM CONTENTS
00h	0xA5
01h	MAC Address [7:0]
02h	MAC Address [15:8]
03h	MAC Address [23:16]
04h	MAC Address [31:24]
05h	MAC Address [39:32]
06h	MAC Address [47:40]
07h	Full-Speed Polling Interval for Interrupt Endpoint
08h	Hi-Speed Polling Interval for Interrupt Endpoint

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Table 3.1 EEPROM Format (continued)

09h	Configuration Flags
0Ah	Language ID Descriptor [7:0]
0Bh	Language ID Descriptor [15:8]
0Ch	Manufacturer ID String Descriptor Length (bytes)
0Dh	Manufacturer ID String Descriptor EEPROM Word Offset
0Eh	Product Name String Descriptor Length (bytes)
0Fh	Product Name String Descriptor EEPROM Word Offset
10h	Serial Number String Descriptor Length (bytes)
11h	Serial Number String Descriptor EEPROM Word Offset
12h	Configuration String Descriptor Length (bytes)
13h	Configuration String Descriptor Word Offset
14h	Interface String Descriptor Length (bytes)
15h	Interface String Descriptor Word Offset
16h	Hi-Speed Device Descriptor Length (bytes)
17h	Hi-Speed Device Descriptor Word Offset
18h	Hi-Speed Configuration and Interface Descriptor Length (bytes)
19h	Hi-Speed Configuration and Interface Descriptor Word Offset
1Ah	Full-Speed Device Descriptor Length (bytes)
1Bh	Full-Speed Device Descriptor Word Offset
1Ch	Full-Speed Configuration and Interface Descriptor Length (bytes)
1Dh	Full-Speed Configuration and Interface Descriptor Word Offset

Note: EEPROM byte addresses past 1Dh can be used to store data for any purpose.

Table 3.2 describes the Configuration Flags.

Table 3.2 Configuration Flags Description

BIT	NAME	DESCRIPTION
7:3	RESERVED	-
2	Remote Wakeup Support	0 = LAN9500/LAN9500i does not support remote wakeup. 1 = LAN9500/LAN9500i supports remote wakeup.
1	RESERVED	-
0	Power Method	0 = LAN9500/LAN9500i is bus powered. 1 = LAN9500/LAN9500i is self powered.

3.2 EEPROM Defaults

The signature value of 0xA5 is stored at address 0. A different signature value indicates to the EEPROM controller that no EEPROM or an un-programmed EEPROM is attached to LAN9500/LAN9500i. In this case, the hardware default values are used, as shown in [Table 3.3](#).

Table 3.3 EEPROM Defaults

FIELD	DEFAULT VALUE
MAC Address	FFFFFFFFFFFFh
Full-Speed Polling Interval (mS)	01h
Hi-Speed Polling Interval (mS)	04h
Configuration Flags	04h
Maximum Power (mA)	FAh
Vendor ID	0424h
Product ID	9500h

Note: The Configuration Flags are affected by the PWR_SEL and RMT_WKP straps.

3.3 EEPROM Auto-Load

Certain system level resets (USB reset, POR, nRESET, and SRST) cause the EEPROM contents to be loaded into LAN9500/LAN9500i. After a reset, the EEPROM controller attempts to read the first byte of data from the EEPROM. If the value 0xA5 is read from the first address, then the EEPROM controller will assume that an external Serial EEPROM is present.

Note: The USB reset only loads the MAC address.

3.4 An Example of EEPROM Format Interpretation

Table 3.4 and Table 3.5 provide an example of how the contents of a EEPROM are formatted. Table 3.4 is a dump of the EEPROM memory (256-byte EEPROM), while Table 3.5 illustrates, byte by byte, how the EEPROM is formatted.

Table 3.4 Dump of EEPROM Memory

OFFSET BYTE	VALUE
0000h	A5 12 34 56 78 9A BC 01
0008h	04 04 09 04 0A 0F 10 14
0010h	10 1C 00 00 00 00 12 24
0018h	12 2D 12 36 12 3F 0A 03
0020h	53 00 4D 00 53 00 43 00
0028h	10 03 4C 00 41 00 4E 00
0030h	39 00 35 00 30 00 30 00
0038h	10 03 30 00 30 00 30 00
0040h	35 00 31 00 32 00 33 00
0048h	12 01 00 02 FF 00 01 40
0050h	24 04 00 95 00 01 01 02
0058h	03 01 09 02 27 00 01 01
0060h	00 A0 FA 09 04 00 00 03
0068h	FF 00 FF 00 12 01 00 02
0070h	FF 00 01 40 24 04 00 95
0078h	00 01 01 02 03 01 09 02
0080h	27 00 01 01 00 A0 FA 09
0088h	04 00 00 03 FF 00 FF 00
0090h - 00FFh	

Table 3.5 EEPROM Example - 256 Byte EEPROM

EEPROM ADDRESS	EEPROM CONTENTS (HEX)	DESCRIPTION
00h	A5	EEPROM Programmed Indicator
01h - 06h	12 34 56 78 9A BC	MAC Address 12 34 56 78 9A BC
07h	01	Full-Speed Polling Interval for Interrupt Endpoint (1ms)
08h	04	Hi-Speed Polling Interval for Interrupt Endpoint (4ms)
09h	04	Configuration Flags - LAN9500/LAN9500i is bus powered and supports remote wakeup.
0Ah - 0Bh	09 04	Language ID Descriptor 0409h, English
0Ch	0A	Manufacturer ID String Descriptor Length (10 bytes)
0Dh	0F	Manufacturer ID String Descriptor EEPROM Word Offset (0Fh) Corresponds to EEPROM Byte Offset 1Eh
0Eh	10	Product Name String Descriptor Length (16 bytes)
0Fh	14	Product Name String Descriptor EEPROM Word Offset (14h) Corresponds to EEPROM Byte Offset 28h
10h	10	Serial Number String Descriptor Length (16 bytes)
11h	1C	Serial Number String Descriptor EEPROM Word Offset (1Ch) Corresponds to EEPROM Byte Offset 38h
12h	00	Configuration String Descriptor Length (0 bytes - NA)
13h	00	Configuration String Descriptor Word Offset (Don't Care)
14h	00	Interface String Descriptor Length (0 bytes - NA)
15h	00	Interface String Descriptor Word Offset (Don't Care)
16h	12	Hi-Speed Device Descriptor Length (18 bytes)
17h	24	Hi-Speed Device Descriptor Word Offset (24h) Corresponds to EEPROM Byte Offset 48h
18h	12	Hi-Speed Configuration and Interface Descriptor Length (18 bytes)
19h	2D	Hi-Speed Configuration and Interface Descriptor Word Offset (2Dh) Corresponds to EEPROM Byte Offset 5Ah
1Ah	12	Full-Speed Device Descriptor Length (18 bytes)
1Bh	36	Full-Speed Device Descriptor Word Offset (36h) Corresponds to EEPROM Byte Offset 6Ch
1Ch	12	Full-Speed Configuration and Interface Descriptor Length (18bytes)
1Dh	3F	Full-Speed Configuration and Interface Descriptor Word Offset (3Fh) Corresponds to EEPROM Byte Offset 7Eh
1Eh	0A	Size of Manufacturer ID String Descriptor (10 bytes)
1Fh	03	Descriptor Type (String Descriptor - 03h)

Table 3.5 EEPROM Example - 256 Byte EEPROM (continued)

EEPROM ADDRESS	EEPROM CONTENTS (HEX)	DESCRIPTION
20h-27h	53 00 4D 00 53 00 43 00	Manufacturer ID String ("SMSC" in UNICODE)
28h	10	Size of Product Name String Descriptor (16 bytes)
29h	03	Descriptor Type (String Descriptor - 03h)
2Ah-37h	4C 00 41 00 4E 00 39 00 35 00 30 00 30 00	Product Name String ("LAN9500" in UNICODE)
38h	10	Size of Serial Number String Descriptor (16 bytes)
39h	03	Descriptor Type (String Descriptor - 03h)
3Ah-47h	30 00 30 00 30 00 35 00 31 00 32 00 33 00	Serial Number String ("0005123" in UNICODE)
48h	12	Size of Hi-Speed Device Descriptor in Bytes (18 bytes)
49h	01	Descriptor Type (Device Descriptor - 01h)
4Ah-4Bh	00 02	USB Specification Number that the device complies with (0200h)
4Ch	FF	Class Code
4Dh	00	Subclass Code
4Eh	01	Protocol Code
4Fh	40	Maximum Packet Size for Endpoint 0
50h-51h	24 04	Vendor ID (0424h)
52h-53h	00 95	Product ID (9500h)
54h-55h	00 01	Device Release Number (0100h)
56h	01	Index of Manufacturer String Descriptor
57h	02	Index of Product String Descriptor
58h	03	Index of Serial Number String Descriptor
59h	01	Number of Possible Configurations
5Ah	09	Size of Hi-Speed Configuration Descriptor in bytes (9 bytes)
5Bh	02	Descriptor Type (Configuration Descriptor - 02h)
5Ch-5Dh	27 00	Total length in bytes of data returned (0027h = 39 bytes)
5Eh	01	Number of Interfaces
5Fh	01	Value to use as an argument to select this configuration
60h	00	Index of String Descriptor describing this configuration
61h	A0	Bus powered and remote wakeup enabled
62h	FA	Maximum Power Consumption is 500 mA
63h	09	Size of Descriptor in Bytes (9 Bytes)

Table 3.5 EEPROM Example - 256 Byte EEPROM (continued)

EEPROM ADDRESS	EEPROM CONTENTS (HEX)	DESCRIPTION
64h	04	Descriptor Type (Interface Descriptor - 04h)
65h	00	Number identifying this Interface
66h	00	Value used to select alternative setting
67h	03	Number of Endpoints used for this interface (Less endpoint 0)
68h	FF	Class Code
69h	00	Subclass Code
6Ah	FF	Protocol Code
6Bh	00	Index of String Descriptor Describing this interface
6Ch	12	Size of Full-Speed Device Descriptor in Bytes (18 Bytes)
6Dh	01	Descriptor Type (Device Descriptor - 01h)
6Eh-6Fh	00 02	USB Specification Number that the device complies with (0200h)
70h	FF	Class Code
71h	00	Subclass Code
72h	01	Protocol Code
73h	40	Maximum Packet Size for Endpoint 0
74h-75h	24 04	Vendor ID (0424h)
76h-77h	00 95	Product ID (9500h)
78h-79h	00 01	Device Release Number (0100h)
7Ah	01	Index of Manufacturer String Descriptor
7Bh	02	Index of Product String Descriptor
7Ch	03	Index of Serial Number String Descriptor
7Dh	01	Number of Possible Configurations
7Eh	09	Size of Full-Speed Configuration Descriptor in bytes (9 bytes)
7Fh	02	Descriptor Type (Configuration Descriptor - 02h)
80h-81h	27 00	Total length in bytes of data returned (0027h = 39 bytes)
82h	01	Number of Interfaces
83h	01	Value to use as an argument to select this configuration
84h	00	Index of String Descriptor describing this configuration
85h	A0	Bus powered and remote wakeup enabled
86h	FA	Maximum Power Consumption is 500 mA
87h	09	Size of Full-Speed Interface Descriptor in Bytes (9 Bytes)

Table 3.5 EEPROM Example - 256 Byte EEPROM (continued)

EEPROM ADDRESS	EEPROM CONTENTS (HEX)	DESCRIPTION
88h	04	Descriptor Type (Interface Descriptor - 04h)
89h	00	Number identifying this Interface
8Ah	00	Value used to select alternative setting
8Bh	03	Number of Endpoints used for this interface (Less endpoint 0)
8Ch	FF	Class Code
8Dh	00	Subclass Code
8Eh	FF	Protocol Code
8Fh	00	Index of String Descriptor Describing this interface
90h- FFh	-	Data storage for use by Host as desired

Chapter 4 Operational Characteristics

4.1 Absolute Maximum Ratings*

Supply Voltage (VDD33IO, VDD33A) (Note 4.1)	0V to +3.6V
Positive voltage on signal pins, with respect to ground (Note 4.2)	+6V
Negative voltage on signal pins, with respect to ground (Note 4.3)	-0.5V
Positive voltage on XI, with respect to ground.	+4.6V
Positive voltage on XO, with respect to ground.	+2.5V
Ambient Operating Temperature in Still Air (T _A)	Note 4.4
Storage Temperature	-55°C to +150°C
Lead Temperature Range	Refer to JEDEC Spec. J-STD-020
HBM ESD Performance	+/-8kV
IEC61000-4-2 Contact Discharge ESD Performance (Note 4.5)	+/-8kV
IEC61000-4-2 Air-Gap Discharge ESD Performance (Note 4.5)	+/-15kV

Note 4.1 When powering this device from laboratory or system power supplies, it is important that the absolute maximum ratings not be exceeded or device failure can result. Some power supplies exhibit voltage spikes on their outputs when AC power is switched on or off. In addition, voltage transients on the AC power line may appear on the DC output. If this possibility exists, it is suggested that a clamp circuit be used.

Note 4.2 This rating does not apply to the following pins: XI, XO, EXRES, USBRBIAS.

Note 4.3 This rating does not apply to the following pins: EXRES, USBRBIAS.

Note 4.4 0°C to +70°C for commercial version, -40°C to +85°C for industrial version.

Note 4.5 Performed by independant 3rd party test facility.

*Stresses exceeding those listed in this section could cause permanent damage to the device. This is a stress rating only. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. Functional operation of the device at any condition exceeding those indicated in Section 4.2, "Operating Conditions**", Section 4.4, "DC Specifications", or any other applicable section of this specification is not implied. Note, device signals are *NOT* 5 volt tolerant unless specified otherwise.

4.2 Operating Conditions**

Supply Voltage (VDD33A, VDD33BIAS, VDD33IO)	+3.3V +/- 300mV
Ambient Operating Temperature in Still Air (T _A)	Note 4.4

**Proper operation of LAN9500/LAN9500i is guaranteed only within the ranges specified in this section.

4.3 Power Consumption

This section details the power consumption of LAN9500/LAN9500i as measured during various modes of operation. Power consumption values are provided for both the device-only, and for the device plus Ethernet components. Power dissipation is determined by temperature, supply voltage, and external source/sink requirements.

4.3.1 SUSPEND0

Table 4.1 SUSPEND0 Current Consumption and Power Dissipation (VDD33IO = VDD33A = 3.3V)

PARAMETER	MIN	TYPICAL	MAX	UNIT
Supply current (VDD33IO, VDD33A)		77.9		mA
Power Dissipation (Device Only)		257.3		mW
Power Dissipation (Device and Ethernet components)		394.6		mW

4.3.2 SUSPEND1

Table 4.2 SUSPEND1 Current Consumption and Power Dissipation (VDD33IO = VDD33A = 3.3V)

PARAMETER	MIN	TYPICAL	MAX	UNIT
Supply current (VDD33IO, VDD33A)		19.9		mA
Power Dissipation (Device Only)		65.7		mW
Power Dissipation (Device and Ethernet components)		65.7		mW

4.3.3 SUSPEND2

Table 4.3 SUSPEND2 Current Consumption and Power Dissipation (VDD33IO = VDD33A = 3.3V)

PARAMETER	MIN	TYPICAL	MAX	UNIT
Supply current (VDD33IO, VDD33A)		0.624		mA
Power Dissipation (Device Only)		2.1		mW
Power Dissipation (Device and Ethernet components)		2.1		mW

4.3.4 Operational

Table 4.4 Operational Current Consumption and Power Dissipation (VDD33IO = VDD33A = 3.3V)

PARAMETER	MIN	TYPICAL	MAX	UNIT
100BASE-TX Full Duplex (USB High-Speed)				
Supply current (VDD33IO, VDD33A)		137.3		mA
Power Dissipation (Device Only)		453.0		mW
Power Dissipation (Device and Ethernet components)		591.2		mW
10BASE-T Full Duplex (USB High-Speed)				
Supply current (VDD33IO, VDD33A)		99.2		mA
Power Dissipation (Device Only)		327.6		mW
Power Dissipation (Device and Ethernet components)		665.7		mW
100BASE-TX Full Duplex (USB Full-Speed)				
Supply current (VDD33IO, VDD33A)		135.2		mA
Power Dissipation (Device Only)		446.4		mW
Power Dissipation (Device and Ethernet components)		583.7		mW
10BASE-T Full Duplex (USB Full-Speed)				
Supply current (VDD33IO, VDD33A)		97.5		mA
Power Dissipation (Device Only)		322.1		mW
Power Dissipation (Device and Ethernet components)		660.6		mW

4.3.5 Customer Evaluation Board Operational Current Consumption***

Table 4.5 Customer Evaluation Board Operational Current Consumption (USB VBUS = 5.0V)

PARAMETER	MIN	TYPICAL	MAX	UNIT
100BASE-TX Full Duplex (USB High-Speed)				
Total SMSC Customer Evaluation Board Current Consumption			208.0	mA

***Total system current consumption as measured on the the 5V USB VBUS input to a bus-powered Customer Evaluation Board, where VBUS = 5.0V and VDD33IO = VDD33A = 3.3V

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4.4 DC Specifications

Table 4.6 I/O Buffer Characteristics

PARAMETER	SYMBOL	MIN	TYP	MAX	UNITS	NOTES
IS Type Input Buffer						
Low Input Level	V_{ILI}	-0.3			V	
High Input Level	V_{IHI}			3.6	V	
Negative-Going Threshold	V_{ILT}	1.01	1.18	1.35	V	Schmitt trigger
Positive-Going Threshold	V_{IHT}	1.39	1.6	1.8	V	Schmitt trigger
SchmittTrigger Hysteresis ($V_{IHT} - V_{ILT}$)	V_{HYS}	345	420	485	mV	
Input Leakage ($V_{IN} = V_{SS}$ or V_{DD33IO})	I_{IH}	-10		10	uA	Note 4.6
Input Capacitance	C_{IN}			3	pF	
IS_5V Type Input Buffer						
Low Input Level	V_{ILI}	-0.3			V	
High Input Level	V_{IHI}			5.5	V	
Negative-Going Threshold	V_{ILT}	1.01	1.18	1.35	V	Schmitt trigger
Positive-Going Threshold	V_{IHT}	1.39	1.6	1.8	V	Schmitt trigger
SchmittTrigger Hysteresis ($V_{IHT} - V_{ILT}$)	V_{HYS}	345	420	485	mV	
Input Leakage ($V_{IN} = V_{SS}$ or V_{DD33IO})	I_{IH}	-10		10	uA	Note 4.6
Input Leakage ($V_{IN} = 5.5V$)	I_{IH}			79	uA	Note 4.6, Note 4.7
Input Capacitance	C_{IN}			4	pF	
O8 Type Buffers						
Low Output Level	V_{OL}			0.4	V	$I_{OL} = 8mA$
High Output Level	V_{OH}	$V_{DD33IO} - 0.4$			V	$I_{OH} = -8mA$
OD8 Type Buffer						
Low Output Level	V_{OL}			0.4	V	$I_{OL} = 8mA$
O12 Type Buffers						
Low Output Level	V_{OL}			0.4	V	$I_{OL} = 12mA$
High Output Level	V_{OH}	$V_{DD33IO} - 0.4$			V	$I_{OH} = -12mA$
OD12 Type Buffer						
Low Output Level	V_{OL}			0.4	V	$I_{OL} = 12mA$
ICLK Type Buffer (XI Input)						
Low Input Level	V_{ILI}	-0.3		0.5	V	Note 4.8
High Input Level	V_{IHI}	1.4		3.6	V	

Note 4.6 This specification applies to all inputs and tri-stated bi-directional pins. Internal pull-down and pull-up resistors add +/- 50uA per-pin (typical).

Note 4.7 This is the total 5.5V input leakage for the entire device.

Note 4.8 XI can optionally be driven from a 25MHz single-ended clock oscillator.

Table 4.7 100BASE-TX Transceiver Characteristics

PARAMETER	SYMBOL	MIN	TYP	MAX	UNITS	NOTES
Peak Differential Output Voltage High	V_{PPH}	950	-	1050	mVpk	Note 4.9
Peak Differential Output Voltage Low	V_{PPL}	-950	-	-1050	mVpk	Note 4.9
Signal Amplitude Symmetry	V_{SS}	98	-	102	%	Note 4.9
Signal Rise and Fall Time	T_{RF}	3.0	-	5.0	nS	Note 4.9
Rise and Fall Symmetry	T_{RFS}	-	-	0.5	nS	Note 4.9
Duty Cycle Distortion	D_{CD}	35	50	65	%	Note 4.10
Overshoot and Undershoot	V_{OS}	-	-	5	%	
Jitter				1.4	nS	Note 4.11

Note 4.9 Measured at line side of transformer, line replaced by 100 Ω (+/- 1%) resistor.

Note 4.10 Offset from 16nS pulse width at 50% of pulse peak.

Note 4.11 Measured differentially.

Table 4.8 10BASE-T Transceiver Characteristics

PARAMETER	SYMBOL	MIN	TYP	MAX	UNITS	NOTES
Transmitter Peak Differential Output Voltage	V_{OUT}	2.2	2.5	2.8	V	Note 4.12
Receiver Differential Squelch Threshold	V_{DS}	300	420	585	mV	

Note 4.12 Min/max voltages guaranteed as measured with 100 Ω resistive load.

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4.5 AC Specifications

This section details the various AC timing specifications of the LAN9500/LAN9500i.

Note: The MII timing adheres to the IEEE 802.3 specification. Refer to the IEEE 802.3 specification for detailed MII timing information.

Note: The USBDP and USBDM pin timing adheres to the USB 2.0 specification. Refer to the Universal Serial Bus Revision 2.0 specification for detailed USB timing information.

4.5.1 Equivalent Test Load

Output timing specifications assume the 25pF equivalent test load illustrated in [Figure 4.1](#) below, unless otherwise specified.

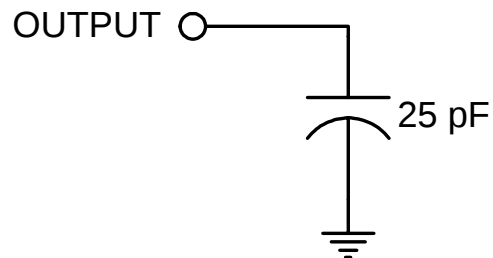


Figure 4.1 Output Equivalent Test Load

4.5.2 Power-On Configuration Strap Valid Timing

Figure 4.2 illustrates the configuration strap valid timing requirement in relation to power-on. In order for valid configuration strap values to be read at power-on, the following timing requirements must be met.

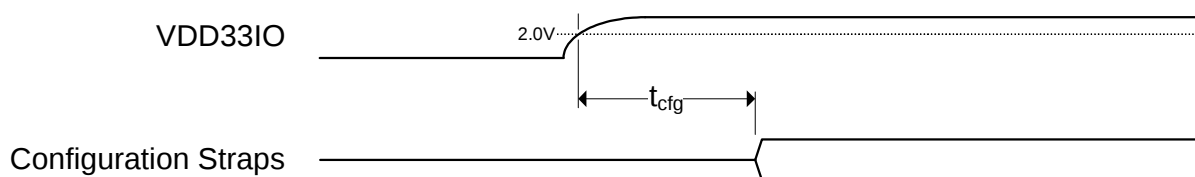


Figure 4.2 Power-On Configuration Strap Valid Timing

Table 4.9 Power-On Configuration Strap Valid Timing

SYMBOL	DESCRIPTION	MIN	TYP	MAX	UNITS
t_{cfg}	Configuration strap valid time			15	mS

Datasheet

4.5.3 Reset and Configuration Strap Timing

Figure 4.3 illustrates the nRESET pin timing requirements and its relation to the configuration strap pins and output drive. Assertion of nRESET is not a requirement. However, if used, it must be asserted for the minimum period specified.

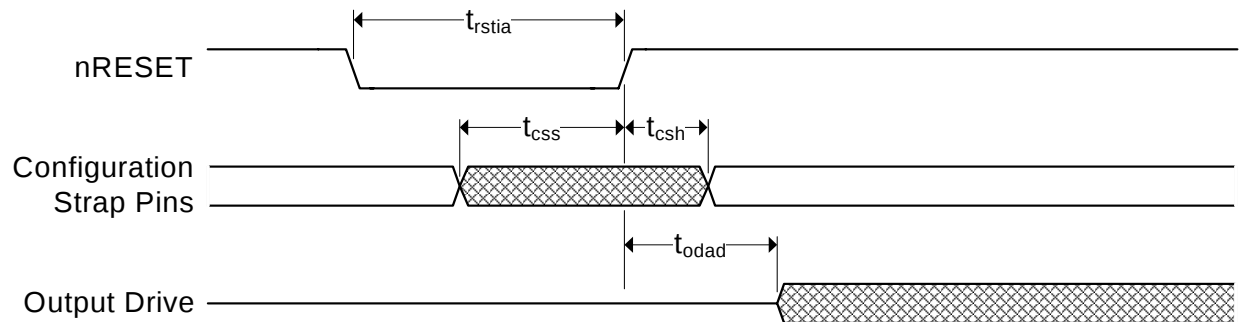


Figure 4.3 nRESET Reset Pin Timing

Table 4.10 nRESET Reset Pin Timing Values

SYMBOL	DESCRIPTION	MIN	TYP	MAX	UNITS
t_{rstia}	nRESET input assertion time	1			μ S
t_{css}	Configuration strap pins setup to nRESET deassertion	200			nS
t_{csh}	Configuration strap pins hold after nRESET deassertion	10			nS
t_{odad}	Output drive after deassertion	30			nS

4.5.4 EEPROM Timing

The following specifies the EEPROM timing requirements for LAN9500/LAN9500i:

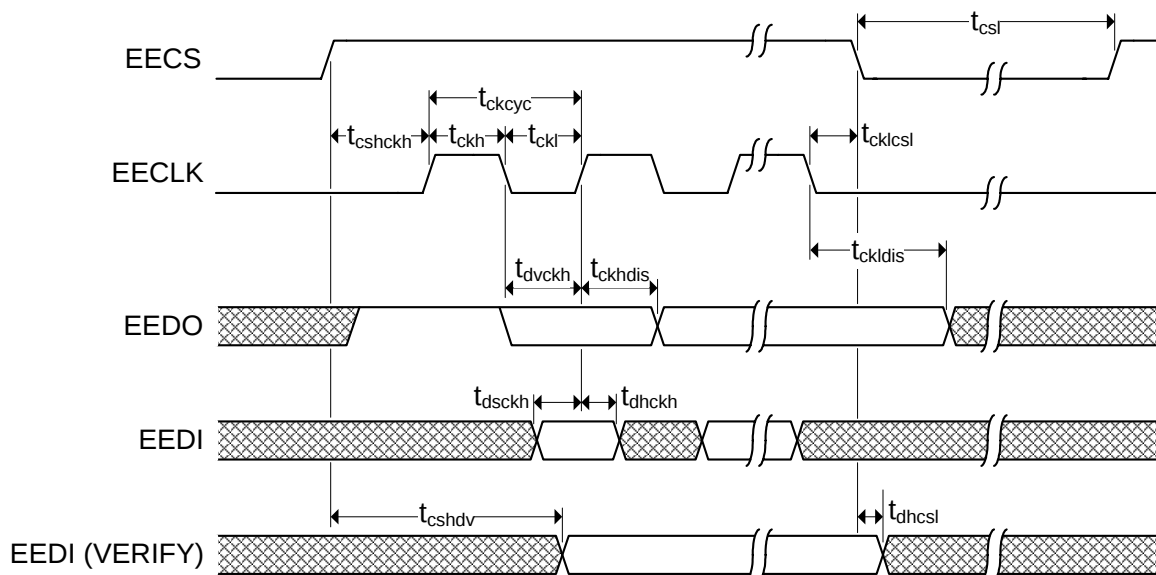


Figure 4.4 EEPROM Timing

Table 4.11 EEPROM Timing Values

SYMBOL	DESCRIPTION	MIN	TYP	MAX	UNITS
t_{ckcyc}	EECLK Cycle time	1110		1130	ns
t_{ckh}	EECLK High time	550		570	ns
t_{ckl}	EECLK Low time	550		570	ns
t_{cshckh}	EECS high before rising edge of EECLK	1070			ns
t_{cklcsl}	EECLK falling edge to EECS low	30			ns
t_{dvckh}	EEDO valid before rising edge of EECLK	550			ns
t_{ckhdis}	EEDO disable after rising edge EECLK	550			ns
t_{dsckh}	EEDI setup to rising edge of EECLK	90			ns
t_{dhckh}	EEDI hold after rising edge of EECLK	0			ns
t_{ckldis}	EECLK low to data disable (OUTPUT)	580			ns
t_{cshdv}	EEDIO valid after EECS high (VERIFY)			600	ns
t_{dhcsl}	EEDIO hold after EECS low (VERIFY)	0			ns
t_{csi}	EECS low	1070			ns

4.5.5 Turbo MII Interface Timing

The external MII supports Turbo MII and the interface timing is as follows.

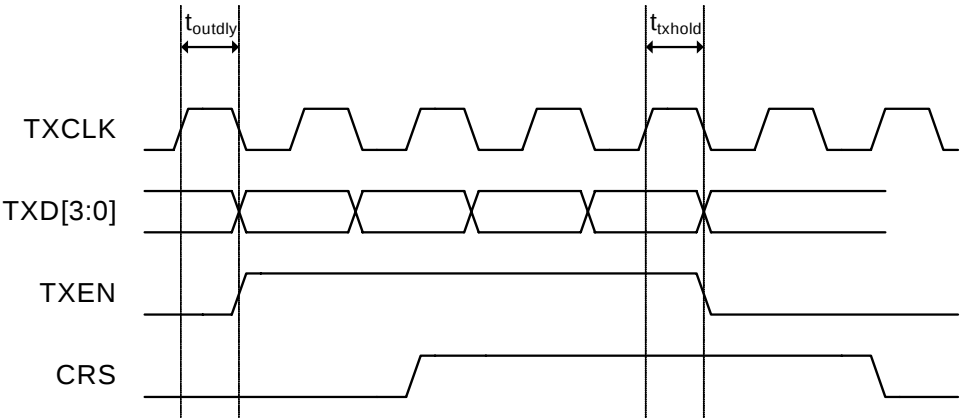
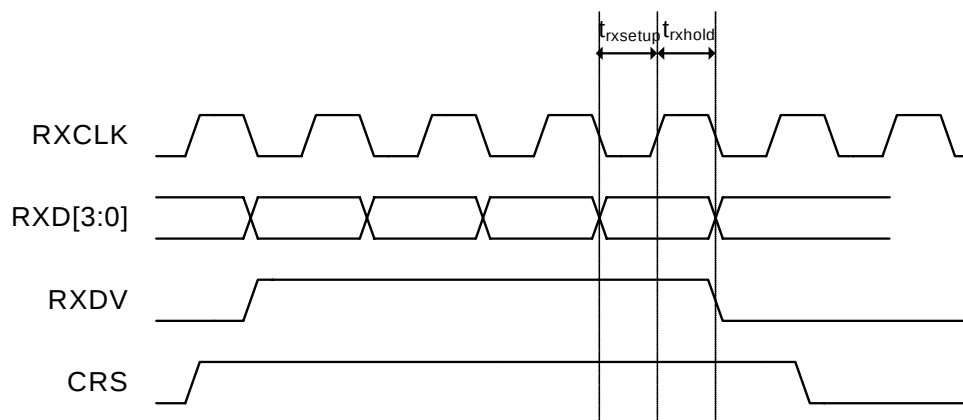


Figure 4.1 Turbo MII Output Timing

Table 4.12 Turbo MII Output Timing Values

SYMBOL	DESCRIPTION	MIN	MAX	UNITS	NOTES
t_{outdly}	Clock to output delay for TXD and TXEN		12.5	ns	Note 4.13
t_{txhold}	TXD and TXEN hold time after TXCLK	1.5		ns	Note 4.13

Note 4.13 Timing was designed for system load between 5 pf and 15 pf.


Figure 4.2 Turbo MII Input Timing
Table 4.13 Turbo MII Interface Timing Values

SYMBOL	DESCRIPTION	MIN	MAX	UNITS	NOTES
$t_{rxsetup}$	RXD and RXDV setup time prior to rising edge of RXCLK	5.5		ns	Note 4.14
t_{rxhold}	RXD and RXDV hold time after the rising edge of RXCLK	0		ns	Note 4.14

Note 4.14 These values satisfy the 10-ns setup and hold time requirements that are necessary for the Turbo MII specification.

4.6 Clock Circuit

LAN9500/LAN9500i can accept either a 25MHz crystal (preferred) or a 25MHz single-ended clock oscillator (+/- 50ppm) input. If the single-ended clock oscillator method is implemented, XO should be left unconnected and XI should be driven with a nominal 0-3.3V clock signal. The input clock duty cycle is 40% minimum, 50% typical and 60% maximum.

It is recommended that a crystal utilizing matching parallel load capacitors be used for the crystal input/output signals (XI/XO). See [Table 4.14](#) for the recommended crystal specifications.

Table 4.14 LAN9500/LAN9500i Crystal Specifications

PARAMETER	SYMBOL	MIN	NOM	MAX	UNITS	NOTES
Crystal Cut	AT, typ					
Crystal Oscillation Mode	Fundamental Mode					
Crystal Calibration Mode	Parallel Resonant Mode					
Frequency	F_{fund}	-	25.000	-	MHz	
Frequency Tolerance @ 25°C	F_{tol}	-	-	+/-50	PPM	Note 4.15
Frequency Stability Over Temp	F_{temp}	-	-	+/-50	PPM	Note 4.15
Frequency Deviation Over Time	F_{age}	-	+/-3 to 5	-	PPM	Note 4.16
Total Allowable PPM Budget		-	-	+/-50	PPM	Note 4.17
Shunt Capacitance	C_O	-	7 typ	-	pF	
Load Capacitance	C_L	-	20 typ	-	pF	
Drive Level	P_W	300	-	-	uW	
Equivalent Series Resistance	R_1	-	-	50	Ohm	
Operating Temperature Range		Note 4.18	-	Note 4.19	°C	
LAN9500/LAN9500i XI Pin Capacitance		-	3 typ	-	pF	Note 4.20
LAN9500/LAN9500i XO Pin Capacitance		-	3 typ	-	pF	Note 4.20

Note 4.15 The maximum allowable values for Frequency Tolerance and Frequency Stability are application dependant. Since any particular application must meet the IEEE +/-50 PPM Total PPM Budget, the combination of these two values must be approximately +/-45 PPM (allowing for aging).

Note 4.16 Frequency Deviation Over Time is also referred to as Aging.

Note 4.17 The total deviation for the Transmitter Clock Frequency is specified by IEEE 802.3u as +/- 50 PPM.

Note 4.18 0°C for commercial version, -40°C for industrial version.

Note 4.19 +70°C for commercial version, +85°C for industrial version.

Note 4.20 This number includes the pad, the bond wire and the lead frame. PCB capacitance is not included in this value. The XO/XI pin and PCB capacitance values are required to accurately calculate the value of the two external load capacitors. These two external load capacitors determine the accuracy of the 25.000 MHz frequency.

Chapter 5 Package Outline

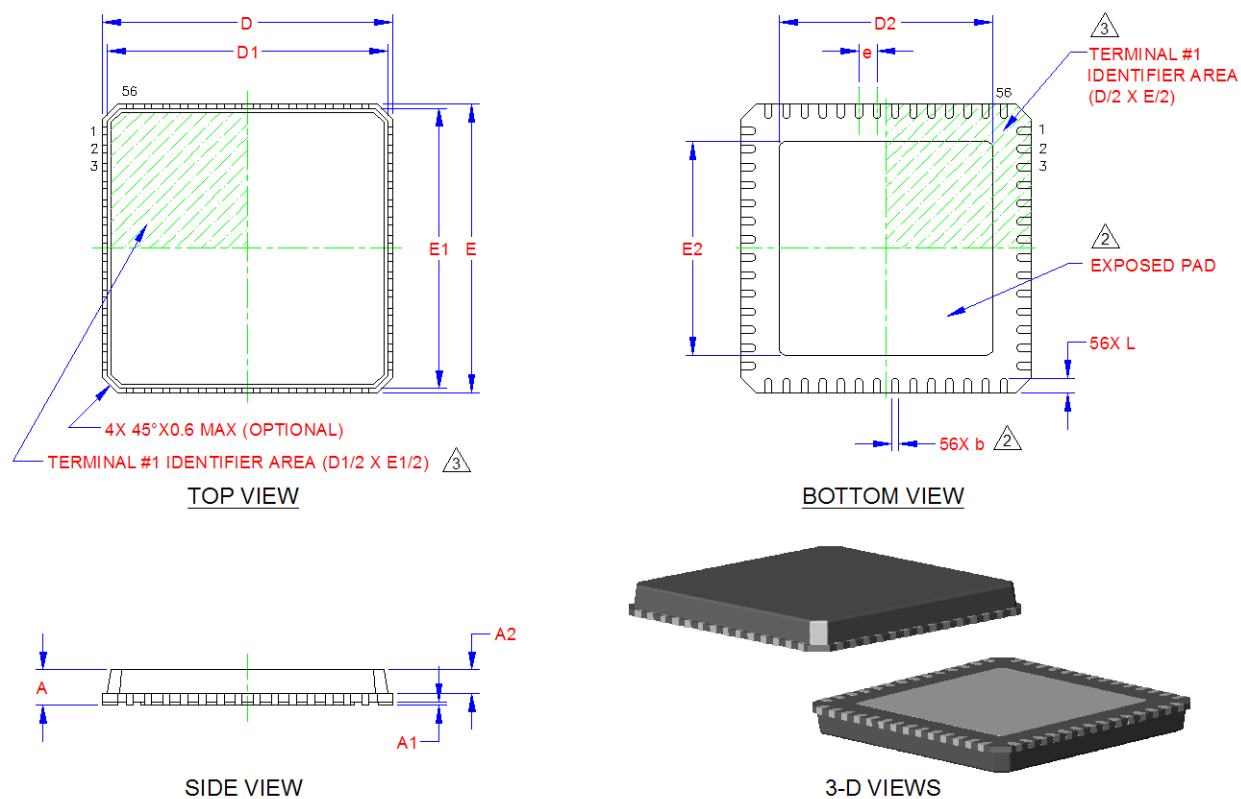


Figure 5.1 LAN9500/LAN9500i 56-QFN Package

Table 5.1 LAN9500/LAN9500i 56-QFN Dimensions

	MIN	NOMINAL	MAX	REMARKS
A	0.70	-	1.00	Overall Package Height
A1	0.00	0.02	0.05	Standoff
A2	-	-	0.90	Mold Cap Thickness
D/E	7.85	8.00	8.15	X/Y Body Size
D1/E1	7.55	-	7.95	X/Y Mold Cap Size
D2/E2	5.75	5.90	6.05	X/Y Exposed Pad Size
L	0.30	-	0.50	Terminal Length
b	0.18	0.25	0.30	Terminal Width
e	0.50 BSC			Terminal Pitch

Notes:

1. All dimensions are in millimeters unless otherwise noted.
2. Position tolerance of each terminal and exposed pad is +/- 0.05 mm at maximum material condition. Dimension "b" applies to plated terminals and is measured between 0.15 and 0.30 mm from the terminal tip.
3. The pin 1 identifier may vary, but is always located within the zone indicated.

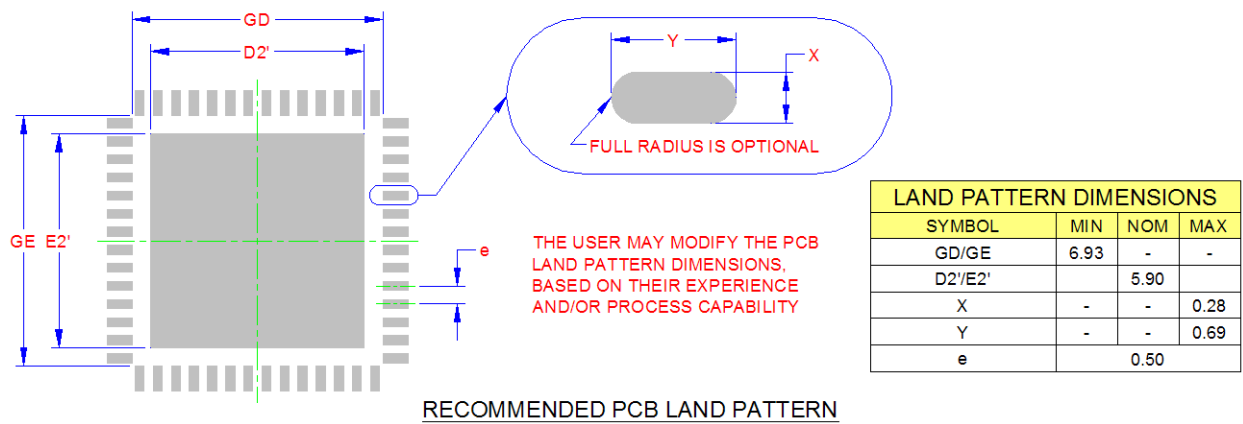


Figure 5.2 LAN9500/LAN9500i 56-QFN Recommended PCB Land Pattern

Chapter 6 Revision History

Table 6.1 Customer Revision History

REVISION LEVEL AND DATE	SECTION/FIGURE/ENTRY	CORRECTION
Rev. 1.9 (12-17-08)	Cover	USB Certification logo added
Rev. 1.8 (11-19-08)	All	Fixed various typos.
	Table 4.5, "Customer Evaluation Board Operational Current Consumption (USB VBUS = 5.0V)," on page 30	Updated table title to correctly reflect that power consumption was measured with supply and current @ 5.0V.
	Section 4.1, "Absolute Maximum Ratings*," on page 28	Added maximum HBM and IEC6100-4-2 ESD performance ratings.
	Cover	Added ESD bullets to highlights section: ■ ±8kV HBM ESD protection (component level) ■ ±8kV contact-discharge, ±15kV air discharge ESD protection per IEC61000-4-2
	Section 4.5.5, "Turbo MII Interface Timing," on page 37	Removed errant note.
Rev. 1.6 (09-09-08)	All	Fixed various typos
	Table 3.4, "Dump of EEPROM Memory," on page 23	Fixed typos in example
	Table 3.5, "EEPROM Example - 256 Byte EEPROM," on page 24	Fixed typos in example
	Table 2.4, "Miscellaneous Pins," on page 14	Added note to GPIO8, GPIO9, and GPIO10 stating "By default this pin is configured as a GPIO"
Rev. 1.5 (08-27-08)	All	Fixed various typos
	Table 4.6, "I/O Buffer Characteristics," on page 31	Input leakage and input capacitance values added for IS and IS_5V buffer types.
	Table 2.1, "MII Interface Pins," on page 10	Added note to EEP_SIZE pin definition: "A 3-wire style 1K/2K/4K EEPROM that is organized for 128 x 8-bit or 256/512 x 8-bit operation must be used."
	Chapter 3, "EEPROM Controller (EPC)," on page 20	EEPROM Controller section added.
Rev. 1.3 (06-30-08)	Section 4.3, "Power Consumption," on page 29	Added SUSPEND0 and SUSPEND1 power consumption tables. Reformatted all power consumption tables and added typical values, except for customer evaluation board, for which maximum value was specified.

Table 6.1 Customer Revision History (continued)

REVISION LEVEL AND DATE	SECTION/FIGURE/ENTRY	CORRECTION
Rev. 1.2 (06-18-08)	Chapter 2, "Pin Description and Configuration," on page 9	Added IS buffer type to following pins when operating in Internal PHY Mode: RXER, TXEN, RXDV, RXCLK, CRS, COL, MDIO, MDC, TXD3, TXD2, TXD1, TXD0, TXCLK.
	Chapter 2, "Pin Description and Configuration," on page 9	Added PD buffer type to following pins when operating in Internal PHY Mode: TXEN, RXDV, COL, MDIO, MDC, TXD3, TXD2, TXD1, TXD0, TXCLK.
	Chapter 2, "Pin Description and Configuration," on page 9	Changed buffer type from PU to PD for following pins: TXD2 (Internal PHY Mode), TXD1 (Internal PHY Mode), TXD0 (Internal PHY Mode).
	Chapter 2, "Pin Description and Configuration," on page 9	Changed buffer type from PD to PU for following pins: TXD3 (External PHY Mode).
Rev. 1.2 (06-16-08)	Table 4.14, "LAN9500/LAN9500i Crystal Specifications," on page 39	Changed ESR value from 30 ohms max to 50 ohms max.
Rev. 1.2 (06-10-08)	Table 2.9, "56-QFN Package Pin Assignments," on page 18	Changed pin 33 from "NC" to "TEST3"
	Table 2.8, "No-Connect Pins," on page 17	Reduced pin count to one. Removed hidden TESTMODE entry from the table.
	Table 2.4, "Miscellaneous Pins," on page 14	Added new TEST3 entry, which must always be grounded. Modified buffer types for TEST1 and TEST2 entries to indicate "-" as buffer type. Buffer type now hidden. TEST3 corresponds to hidden TESTMODE pin.
	Figure 2.1 LAN9500/LAN9500i 56-QFN Pin Assignments (TOP VIEW) on page 9	Updated figure with Rev B strap changes and pin 33 change from "NC" to "TEST3"
	Table 2.1, "MII Interface Pins," on page 10 and Table 2.2, "EEPROM Pins," on page 13	Modified strap locations in Table 2.1 as follows: EEP_DISABLE moved from RXER to TXD0, RMT_WKP moved from RXCLK to TXD1, and EEP_SIZE moved from TXCLK to TXD3. Moved PORT_SWAP strap from EEDI pin in Table 2.2 to TXD2 in Table 2.1 .
	Note 2.1 on page 12 and Note 2.2 on page 13	Modified listed items to indicate straps are loaded on both POR and nRESET.
	Section 4.5.3, "Reset and Configuration Strap Timing," on page 35	Replaced previous "3.5.3 Reset Timing" section with this section.
	Section 4.5.5, "Turbo MII Interface Timing," on page 37	Added section.