DP83TD510E Ultra Low Power 802.3cg 10Base-T1L 10M Single Pair Ethernet PHY

1 Features

- Long cable reach
  - 1200 meters+ with 1-V p2p
  - 1200 meters+ with 2.4-V p2p
- Ultra-low power
  - 45 mW for 1-V p2p mode
  - 99 mW for 2.4-V p2p mode
- Compliant to IEEE 802.3cg 10Base-T1L
- IEC 61000-4-4 EFT ±4 KV at 5 KHz, 100 KHz
- CISPR22 radiated emission class B
- External MDI terminations for intrinsic safety
- MAC interface:
  - MII mode
  - RMII master/slave mode
  - RGMII mode
  - RMII master low-power 5-MHz mode
  - RMII back-2-back mode for range extender
- Power supply
  - single supply operations from 3.3 V
  - dual supply operations for lowest power dissipation
- I/O voltages: 1.8 V, 2.5 V or 3.3 V
- Diagnostics tool kit
  - cable open and short detection
  - receiver SQI to measure cable degradation
  - active link cable diagnostics
- Clock output: 25 MHz, 50 MHz (RMII master)
- ±6-kV HBM ESD protection on MDI pins
- Operating temperature range: –40°C to 105°C
- Package: 5 mm x 5 mm, 32 pin with 0.5 mm pitch

2 Applications

- Process automation
  - Field transmitters and switches
- Building automation
  - HVAC controllers
  - Elevators and escalators
  - Fire safety
- Factory automation and control

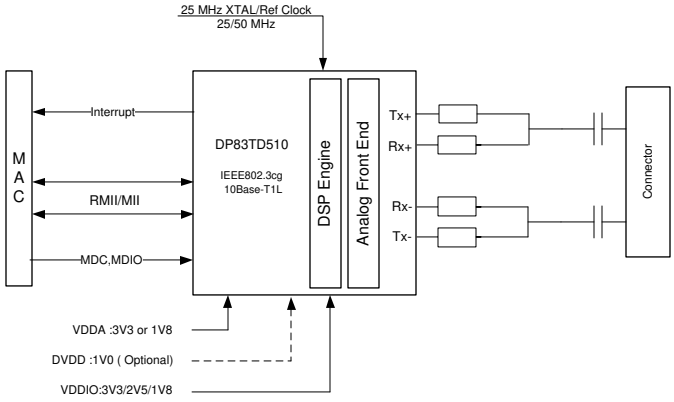
3 Description

The DP83TD510E is an ultra-low power Ethernet physical layer transceiver compliant with the IEEE 802.3cg 10Base-T1L specification. The PHY has very low noise coupled receiver architecture enabling long cable reach and very low power dissipation. The DP83TD510E has external MDI termination to support intrinsic safety requirements. It interfaces with MAC layer through MII, Reduced MII (RMII) , RGMII, and RMII low power 5-MHz master mode. It also supports RMII back-to-back mode for applications that require cable reach extension beyond 1200 meters. It supports a 25MHz reference clock output to clock other modules on the system. The DP83TD510E offers integrated cable diagnostic tools; built-in self-test, and loopback capabilities for ease of design or debug.

Device Information

PART NUMBER(1)	PACKAGE	BODY SIZE (NOM)
DP83TD510E	QFN (32)	5.00 mm × 5.00 mm

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



DP83TD510E Application Diagram

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4 Revision History

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

DATE	REVISION	NOTES
August 2020	*	Advance Information Release

5 Pin Configuration and Functions

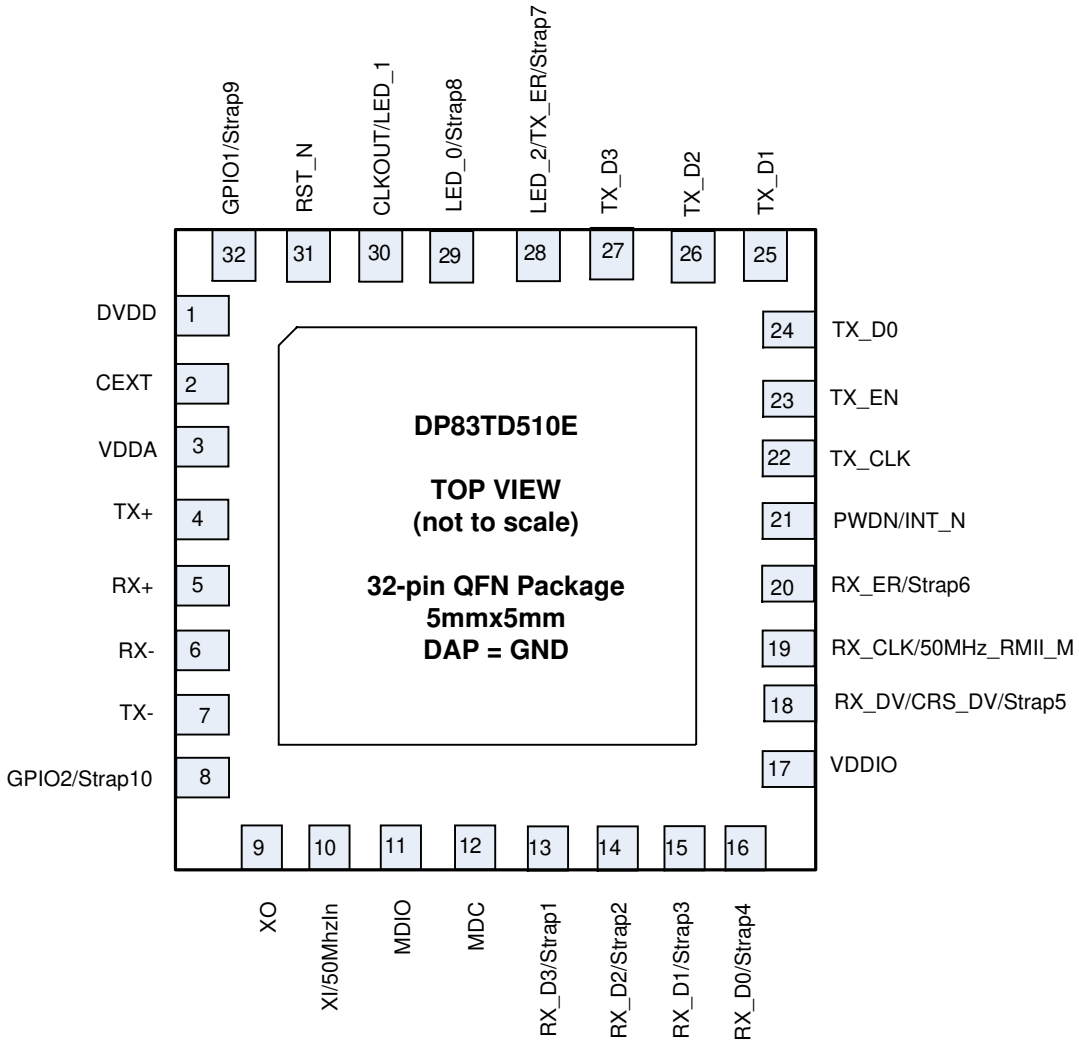

Figure 5-1. RMQ Package 32-Pin VQFN Top View

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Pin Functions

PIN		TYPE	DESCRIPTION
NAME	NO		
DVDD	1	A	Digital supply 1.0 V • For single-supply operation: Short this pin with CEXT (Pin 2) • Optional (dual-supply operation): Connect external 1.0 V to achieve lowest power Refer to Power Connection Diagram in Application section
CEXT	2	A	External capacitor for internal LDO • For single-supply operation: Connect 0.01- µF capacitor and short it with pin 1 • For dual-supply operation, leave unconnected Refer to Power Connection Diagram in Application section
VDDA	3	A	Supply 3.3 V to support both long reach and short reach. Supply 1.8 V to support only short reach. Supplied voltage will be reflected in bit 13 of auto negotiation base page as capability to support 2.4-V p2p or 1-V p2p. 0x20E, bit 13 = 1 when 3.3 V is selected. 0x20E, bit 13 = 0 when 1.8 V is selected. Ensure the Strap7 "Reach Selection" strap is selected appropriately to request the output voltage level in the auto negotiation page.
TX+	4	A	TX+, TX- : Differential Transmit Output (PMD): These differential outputs are configured to 2.4-V p2p or 1-V p2p signaling mode based on configuration chosen for PHY and auto negotiation with Link Partner.
RX+	5	A	RX+, RX- : These differential inputs are automatically configured to accept 2.4-V p2p or 1-V p2p signaling mode based on configuration chosen for PHY.
RX-	6	A	
TX-	7	A	TX+, TX- : Differential Transmit Output (PMD): These differential outputs are configured to 2.4-V p2p or 1-V p2p signaling mode based on configuration chosen for PHY and auto negotiation with Link Partner.
GPIO2	8	Strap	GPIO: This pin can be configured for multiple configuration thru register configuration. It has mandatory PU or PD strap. Refer to Straps sections for details.
XO	9	A	Crystal Output: Reference Clock output. XO pin is used for crystal only. This pin should be left floating when a CMOS-level oscillator is connected to XI.
XI/50MHzIn	10	A	Crystal / Oscillator Input Clock MII, RMII master mode: 25-MHz ±50 ppm-tolerance crystal or oscillator clock RMII slave mode: 50-MHz ±50 ppm-tolerance CMOS-level oscillator clock
MDIO	11		Management Data I/O: Bi-directional management data signal that may be source by the management station or the PHY. This pin requires an external pull of 2.2kΩ - 4.0 kΩ.
MDC	12		Management Data Clock: Synchronous clock to the MDIO serial management input/output data. This clock may be asynchronous to the MAC transmit and receive clocks. The maximum clock rate is 1.75 MHz.
RX_D3	13	Strap	Receive Data: Symbols received on the cable are decoded and presented on these pins synchronous to the rising edge of RX_CLK. They contain valid data when RX_DV is asserted. A nibble RX_D[3:0] is received in MII modes. 2-bits RX_D[1:0] is received in RMII mode.
RX_D2	14	Strap	
RX_D1	15	Strap	
RX_D0	16	Strap	
VDDIO	17	Power	I/O Supply : 3.3 V/2.5 V/1.8 V. For decoupling capacitor requirements, refer to Application section of data sheet.
RX_DV/ CRS_DV	18	Strap	Receive Data Valid: This pin indicates valid data is present on the RX_D[3:0] for MII mode and on RX_D[1:0] for RMII mode. In RMII mode, this pin acts as CRS_DV and combines the RMII arrier and Receive Data Valid indications. This pin can be configured to RX_DV to enable RMII repeater mode using strap or register configuration. RGMII mode: RGMII Receive Control: RX_CTRL combines receive data valid and receive error signals. RX_DV is presented on the rising edge of RX_CLK and RX_ER on the falling edge of RX_CLK.

PIN		TYPE	DESCRIPTION
NAME	NO		
RX_CLK/ 50MHz_RMII _M	19		MII Receive Clock: MII Receive Clock provides a 25-MHz reference clock for 100-Mbps speed and a 2.5-MHz reference clock for 10-Mbps speed, which is derived from the received data stream. In RMII master mode, this provides 50-MHz reference clock. In RMII slave mode, this pin is not used and remains Input/PD. RGMII Receive Clock: RGMII Receive Clock provides a 2.5-MHz reference clock for 10-Mbps speed, which is derived from the receive data stream.
RX_ER	20	Strap	Receive Error: This pin indicates that an error symbol has been detected within a received packet in both MII and RMII mode. In MII mode, RX_ER is asserted high synchronously to the rising edge of RX_CLK. In RMII mode, RX_ER is asserted high synchronously to the rising edge of the reference clock. RX_ERR is asserted high for every reception error, including errors during Idle. Unused in RGMII mode.
PWDN/INT	21		Power Down(Default)/Interrupt: The default function of this pin is power down. Register access is required to configure this pin as an interrupt. In power down function, an active low signal on this pin places the device in power down mode. When this pin is configured as an interrupt pin, this pin is asserted low when an interrupt condition occurs. The pin has an open-drain output with a weak internal pullup (9.5 kΩ). Some applications may require an external PU resistor.
TX_CLK	22		MII Transmit Clock: MII Transmit Clock provides a 25-MHz reference clock for 100-Mbps speed and a 2.5-MHz reference clock for 10-Mbps speed. Note that in MII mode, this clock has constant phase referenced to the reference clock. Applications requiring such constant phase may use this feature. Unused in RMII mode. RGMII Transmit Clock: The clock is sourced from the MAC layer to the PHY. When operating at 10-Mbps speed, this clock must be 2.5-MHz.
TX_EN	23		Transmit Enable: TX_EN is presented on the rising edge of the TX_CLK. TX_EN indicates the presence of valid data inputs on TX_D[3:0] in MII mode and on TX_D[1:0] in RMII mode. TX_EN is an active high signal. RGMII Transmit Control: TX_CTRL combines transmit enable and transmit error signals. TX_EN is presented on the rising edge of TX_CLK and TX_ER on the falling edge of TX_CLK.
TX_D0	24		Transmit Data: In MII mode, the transmit data nibble received from the MAC is synchronous to the rising edge of TX_CLK. In RMII mode, TX_D[1:0] received from the MAC is synchronous to the rising edge of the reference clock.
TX_D1	25		
TX_D2	26		
TX_D3	27		
LED_2/ TX_ER	28	Strap	This pin acts as LED_2 by default. It can be configured as GPIO or TX_ER as well. The LED is ON when link is negotiated for 10M (short reach). LED remains OFF otherwise.
LED_0	29	Strap	LED : Activity Indication LED indicates transmit and receive activity in addition to the status of the link. The LED is ON when link is good. The LED blinks when the transmitter or receiver is active. This pin can also act as GPIO using register configuration.
CLKOUT/ LED_1	30		This pin provides Reference CLKOUT of 25 MHz as default to clock other module on the board. The pin can be configured to act as LED_1 using strap or register configuration. The LED is ON when link is negotiated for 10M (long reach). The LED remains OFF otherwise. When configured for CLK_OUT, reference clock is not affected by reset and switches off only at IEEE Power Down.
RST_N	31		RST_N: This pin is an active low reset input. Asserting this pin low for at least 25µs will force a reset process to occur. Initiation of reset causes strap pins to be re-scanned and resets all the internal registers of the PHY to default value.
GPIO1	32	Strap	General Purpose Input or Output.

Table 5-1. Internal PU/PD in various states

Pin #	Reset State	Active State (MII Mode)	Active State (RMII Master Mode)	Active State (RMII Slave Mode)	Active State (RGMII Mode)
1	A	A	A	A	A

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Table 5-1. Internal PU/PD in various states (continued)

Pin #	Reset State	Active State (MII Mode)	Active State (RMII Master Mode)	Active State (RMII Slave Mode)	Active State (RGMII Mode)
2	A	A	A	A	A
3	A	A	A	A	A
4	A	A	A	A	A
5	A	A	A	A	A
6	A	A	A	A	A
7	A	A	A	A	A
8	I,PD	I,PD	I,PD	I,PD	I,PD
9	A	A	A	A	A
10	A	A	A	A	A
11	IO	IO	IO	IO	IO
12	I	I	I	I	I
13	I,PD	O,Hi-Z	I,PD	I,PD	O,Hi-Z
14	I,PD	O,Hi-Z	I,PD	I,PD	O,Hi-Z
15	I,PD	O,Hi-Z	O,Hi-Z	O,Hi-Z	O,Hi-Z
16	I,PD	O,Hi-Z	O,Hi-Z	O,Hi-Z	O,Hi-Z
17	A	A	A	A	A
18	I,PD	O,Hi-Z	O,Hi-Z	O,Hi-Z	O,Hi-Z
19	I,PD	O,Hi-Z	O,Hi-Z	O,Hi-Z	O,Hi-Z
20	I,PD	O,Hi-Z	O,Hi-Z	O,Hi-Z	I,PD
21	I,PU-9.5KΩ/ OPEN DRAIN	I,PU-9.5KΩ/ OPEN DRAIN	I,PU-9.5KΩ/OPEN DRAIN	I,PU-9.5KΩ/OPEN DRAIN	I,PU-9.5KΩ/OPEN DRAIN
22	I,PD	O,Hi-Z	I,PD	I,PD	I,PD
23	I,PD	I,PD	I,PD	I,PD	I,PD
24	I,PD	I,PD	I,PD	I,PD	I,PD
25	I,PD	I,PD	I,PD	I,PD	I,PD
26	I,PD	I,PD	I,PD	I,PD	I,PD
27	I,PD	I,PD	I,PD	I,PD	I,PD
28	I,PD	O,Hi-Z	O,Hi-Z	O,Hi-Z	O,Hi-Z
29	I,PD	O,Hi-Z	O,Hi-Z	O,Hi-Z	O,Hi-Z
30	I,PD(Only at POR)	O,Hi-Z	O,Hi-Z	O,Hi-Z	O,Hi-Z
31	I,PU	I,PU	I,PU	I,PU	I,PU
32	I,PD	O,Hi-Z	O,Hi-Z	O,Hi-Z	O,Hi-Z

6 Specifications

6.1 Absolute Maximum Ratings

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

PARAMETER		MIN	MAX	UNIT
Supply voltage	DVDD 1.0	-0.3	1.4	V
	VDDA 1.8	-0.3	4	V
	VDDA 3.3	-0.3	4	V
	VDDIO (3.3)	-0.3	4	V
	VDDIO (2.5)	-0.3	3	V
	VDDIO (1.8)	-0.3	2.1	V
Pins	MDI (Tx+, Tx-, Rx+, Rx-)	-0.3	4	V
Pins	MAC Interface, MDIO, MDC, GPIO, LED	-0.3	VDDIO + 0.3	V
Pins	INT/PWDN, RESET	-0.3	VDDIO + 0.3	V
Pins	XI Oscillator Input	-0.3	VDDIO+0.3	V

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

6.2 ESD Ratings

Parameter				VALUE	UNIT
$V_{(ESD)}$	V(ESD) Electrostatic discharge	Human-body model (HBM), perANSI/ESDA/JEDEC JS-001(1)	All pins except MDI	+/-2000	V
$V_{(ESD)}$	V(ESD) Electrostatic discharge	Human-body model (HBM), perANSI/ESDA/JEDEC JS-001(1)	MDI pins	+/-6000	V
$V_{(ESD)}$	V(ESD) Electrostatic discharge	Charged-device model (CDM), per JEDEC specification JESD22-C101(2)	All Pins	+/-500	V

(1) JEDEC document JEP155 states that 500 V HBM allows safe manufacturing with a standard ESD control process. Manufacturing withless than 500 V HBM is possible with the necessary precautions.

(2) JEDEC document JEP157 states that 250 V CDM allows safe manufacturing with a standard ESD control process. Manufacturing withless than 250 V CDM is possible with the necessary precautions. Pins listed as ±500 V may actually have higher performance.

6.3 Recommended Operating Conditions

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

Parameter		MIN	NOM	MAX	UNIT
DVDD 1.0	Digital Supply	0.90	1.0	1.1	V
VDDA 1.8	Analog Supply	1.62	1.8	1.98	V
VDDA 3.3	Analog Supply	3.0	3.3	3.6	V
VDDIO	Digital Supply Voltage, 1.8V operation	1.62	1.8	1.98	V
	Digital Supply Voltage, 2.5V operation	2.25	2.5	2.75	
	Digital Supply Voltage, 3.3V operation	3.0	3.3	3.6	
T_A	Operating Ambient Temperature	-40		105	℃
Pins	TX_D[0:3],RX_D[0:3], TX_CLK, RX_CLK, TX_EN, RX_DV, RX_ER, MDIO, MDC, LED0, LED1, LED2	VDDIO-10 %	VDDIO	VDDIO +10%	V
Pins	INT/PWDN, RESET_N	VDDIO-10 %	VDDIO	VDDIO +10%	V
Pins	XI Oscllator Input	VDDIO-10 %	VDDIO	VDDIO +10%	V

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

Parameter		MIN	NOM	MAX	UNIT
Pins	GPIO	VDDIO-10 %	VDDIO	VDDIO +10%	V

6.4 Thermal Information

THERMAL METRIC(1)		32PIN QFN	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	52	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	42	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	31.5	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	2.1	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	31.4	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	11.9	°C/W

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

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6.5 Electrical Characteristics

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
IEEE Tx CONFORMANCE (10BaseT1L External Terminations)						
1V p2p	Vod : Output Differential Voltage		0.85	1.0	1.05	V
2.4-V p2p	Vod : Output Differential Voltage		2.04	2.4	2.56	V
POWER CONSUMPTION (Dual Analog Supply, 1-V p2p mode)						
	DVDD1.0	100% Traffic, Random Size : 64 to 1512 Bytes, Random Content		5		mA
	AVDD1.8	100% Traffic, Random Size : 64 to 1512 Bytes, Random Content		18		mA
	DVDD1.0	Reset		3		mA
	AVDD1.8	Reset		5		mA
POWER CONSUMPTION (Dual Analog Supply, 2.4V p2p mode)						
	DVDD1.0	100% Traffic, Random Size : 64 to 1512 Bytes, Random Content		5		mA
	AVDD3.3	100% Traffic, Random Size : 64 to 1512 Bytes, Random Content		26.5		mA
Power Consumption VDDIO (MII Interface)						
	VDDIO1.8	100% Traffic, Random Size : 64 to 1512 Bytes, Random Content		4		mA
	VDDIO2.5	100% Traffic, Random Size : 64 to 1512 Bytes, Random Content		5		mA
	VDDIO3.3	100% Traffic, Random Size : 64 to 1512 Bytes, Random Content		6		mA
Power Consumption VDDIO (RMII Master Interface)						
	VDDIO1.8	100% Traffic, Random Size : 64 to 1512 Bytes, Random Content		8.5		mA
	VDDIO2.5	100% Traffic, Random Size : 64 to 1512 Bytes, Random Content		12		mA
	VDDIO3.3	100% Traffic, Random Size : 64 to 1512 Bytes, Random Content		16		mA

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Power Consumption VDDIO (RMII Slave Interface)						
	VDDIO1.8	100% Traffic, Random Size : 64 to 1512 Bytes, Random Content		4		mA
	VDDIO2.5	100% Traffic, Random Size : 64 to 1512 Bytes, Random Content		5		mA
	VDDIO3.3	100% Traffic, Random Size : 64 to 1512 Bytes, Random Content		6		mA
Power Consumption VDDIO (RMII Master 5 MHz)						
	VDDIO1.8	100% Traffic, Random Size : 64 to 1512 Bytes, Random Content		4		mA
	VDDIO2.5	100% Traffic, Random Size : 64 to 1512 Bytes, Random Content		5		mA
	VDDIO3.3	100% Traffic, Random Size : 64 to 1512 Bytes, Random Content		6		mA
Power Consumption VDDIO (RGMII Interface)						
	VDDIO1.8	100% Traffic, Random Size : 64 to 1512 Bytes, Random Content		4		mA
	VDDIO2.5	100% Traffic, Random Size : 64 to 1512 Bytes, Random Content		5		mA
	VDDIO3.3	100% Traffic, Random Size : 64 to 1512 Bytes, Random Content		6		mA
BOOTSTRAP DC CHARACTERISTICS (2 Level)						
V_{IH_3v3}	High Level Bootstrap Threshold : 3V3		1.3			V
V_{IL_3v3}	Low Level Bootstrap Threshold : 3V3				0.6	V
V_{IH_2v5}	High Level Bootstrap Threshold: 2V5		1.3			V
V_{IL_2v5}	Low Level Bootstrap Threshold : 2V5				0.6	V
V_{IH_1v8}	High Level Bootstrap Threshold:1V8		1.3			V
V_{IL_1v8}	Low Level Bootstrap Threshold :1V8				0.6	V

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
IO CHARACTERISTICS						
V_{IH}	High Level Input Voltage	VDDIO = 3.3V ±10%	2			V
V_{IL}	Low Level Input Voltage	VDDIO = 3.3V ±10%			0.8	V
V_{OH}	High Level Output Voltage	I_{OH} = -2mA, VDDIO = 3.3V ±10%	2.4			V
V_{OL}	Low Level Output Voltage	I_{OL} = 2mA, VDDIO = 3.3V ±10%			0.4	V
V_{IH}	High Level Input Voltage	VDDIO = 2.5V ±10%	1.7			V
V_{IL}	Low Level Input Voltage	VDDIO = 2.5V ±10%			0.7	V
V_{OH}	High Level Output Voltage	I_{OH} = -2mA, VDDIO = 2.5V ±10%	2			V
V_{OL}	Low Level Output Voltage	I_{OL} = 2mA, VDDIO = 2.5V ±10%			0.4	V
V_{IH}	High Level Input Voltage	VDDIO = 1.8V ±10%	0.65*VDDIO			V
V_{IL}	Low Level Input Voltage	VDDIO = 1.8V ±10%			0.35*VDDIO	V
V_{OH}	High Level Output Voltage	I_{OH} = -2mA, VDDIO = 1.8V ±10%	VDDIO-0.45			V
V_{OL}	Low Level Output Voltage	I_{OL} = 2mA, VDDIO = 1.8V ±10%			0.45	V
I_{IH}	Input High Current	T_A = -40℃ to 105℃, VIN=VDDIO		15		µA
I_{IL}	Input Low Current	T_A = -40℃ to 105℃, VIN=GND		15		µA
R_{pulldn}	Internal Pull Down Resistor			9		kΩ
R_{pullup}	Internal Pull Up Resistor			9		kΩ
XI V_{IH}	High Level Input Voltage		1.2			V
XI V_{IL}	Low Level Input Voltage				0.6	V
C_{IN}	Input Capacitance XI			1		pF
C_{IN}	Input Capacitance INPUT PINS (TX_D[3:0], TX_EN, TX_CLK, MDC)			5		pF
C_{OUT}	Output Capacitance XO			1		pF
C_{OUT}	Output Capacitance OUTPUT PINS			5		pF
R_{series}	Integrated MAC Series Termination Resistor	RX_D[3:0], RX_ER, RX_DV, RX_CLK		50		Ω
	LED drive strength			8		mA

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6.6 Timing Requirements

PARAMETER		TEST CONDITIONS	MIN	NOM	MAX	UNIT
POWER-UP TIMING (Single and Dual supply mode)						
	Supply ramp rate: For all supplies (DVDD, VDDA, VDDIO)	(20% to 80%)	0.2		40	ms
	Supply ramp delay offset: For all supplies (DVDD, VDDA, VDDIO)	First Supply ramp to last supply ramp			200	ms
T1	Last Supply power up to RESET_N High				60	ms
T2	Powerup to SMI ready: Post power-up stabilization time prior to MDC preamble for register access				60	ms
T3	Powerup to Strap latchin: Hardware configuration pins transition to output drivers				60	ms
	Pedestal Voltage on DVDD, VDDA, VDDIO before Power Ramp				0.3	V
RESET TIMING						
T1	Reset to SMI ready: Post reset stabilization time prior to MDC preamble for register access		30			us
T3	RESET PULSE Width: Miminum Reset pulse width to be able to reset		10			us
T5	Reset to MAC clock (MII RX_CLK)			995		us
MII 10M Timings						
10M	TX_CLK High / Low Time		190	200	210	ns
	TX_D[3:0], TX_ER, TX_EN Setup to TX_CLK		25			ns
	TX_D[3:0], TX_ER, TX_EN Hold from TX_CLK		0			ns
	RX_CLK High / Low Time		160	200	240	ns
	RX_D[3:0], RX_ER, RX_DV Delay from RX_CLK rising		100		300	ns
RGMII OUTPUT TIMING (10M)						
T_{skewT}	Data to Clock Output Skew (Non-Delay Mode)	5 pF Load	-2		2	ns
T_{skewR}	Data to Clock Output Setup (Integrated Delay)		30			ns
T_{skewR}	Data to Clock Output Hold \((Integrated Delay)		30			ns
T_{cyc}	Clock Cycle Duration		-360	400	440	ns
	Duty Cycle		45	50	55	%
	Rise / Fall Time (20% to 80%)				3	ns
RGMII INPUT TIMING (10M)						
T_{skewR}	TX data to clock input skew (Integrated Delay Mode)		-4		4	ns
T_{setupR}	TX data to clock input setup (Non-Delay Mode)		40			ns
T_{holdR}	TX clock to data input hold (Non-Delay Mode)		40			ns
RMII MASTER TIMING						
	RMII Master Clock Period			20		ns
	RMII Master Clock Duty Cycle		35		65	%
	TX_D[1:0], TX_ER, TX_EN Setup to RMII Master Clock	25 pF Load	4			ns
	TX_D[1:0], TX_ER, TX_EN Hold from RMII Master Clock	25 pF Load	2			ns
	RX_D[1:0], RX_ER, CRS_DV Delay from RMII Master Clock rising edge	25 pF Load	4	10	14	ns
RMII SLAVE TIMING						
	Input Reference Clock Period			20		ns
	Reference Clock Duty Cycle		35		65	%
	TX_D[1:0], TX_ER, TX_EN Setup to XI Clock rising		4			ns
	TX_D[1:0], TX_ER, TX_EN Hold from XI Clock rising		2			ns
	RX_D[1:0], RX_ER, CRS_DV Delay from XI Clock rising		4		14	ns

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PARAMETER		TEST CONDITIONS	MIN	NOM	MAX	UNIT
RMII Master Timing (5 MHz)						
	Frequency			5		MHz
	Duty Cycle		40		60	%
	TX_D[3:0], TX_ER, TX_EN setup to Master Clock		10			ns
	TX_D[3:0], TX_ER, TX_EN from Master Clock		10			ns
	RX_D[3:0], RX_ER, RX_DV Delay from 5 MHz Clock		50	100	150	ns
SMI TIMING						
T1	MDC to MDIO (Output) Delay Time		0		10	ns
T2	MDIO (Input) to MDC Setup Time		10			ns
T3	MDIO (Input) to MDC Hold Time		10			ns
T4	MDC Frequency			1	1.75	MHz
OUTPUT CLOCK TIMING (25MHz clockout)						
	Frequency (PPM)		-100		100	-
	Duty Cycle		40		60	%
	Rise Time				5000	ps
	Fall Time				5000	ps
	Frequency			25		MHz
Output Clock 50 MHz timing						
	Frequency (PPM)		-50		50	ppm
	Duty Cycle		35		65	%
	Rise time				5000	ps
	Fall Time				5000	ps
25MHz INPUT CLOCK tolerance						
	Frequency Tolerance		-100		+100	ppm
	Rise / Fall Time (10%-90%)				8	ns
	Duty Cycle		40		60	%
50MHz Input Clock Tolerance						
	Frequency Tolerance		-100		+100	ppm
	Rise / Fall Time (10%-90%)				8	ns
	Duty Cycle		40		60	%

6.7 Timing Diagrams

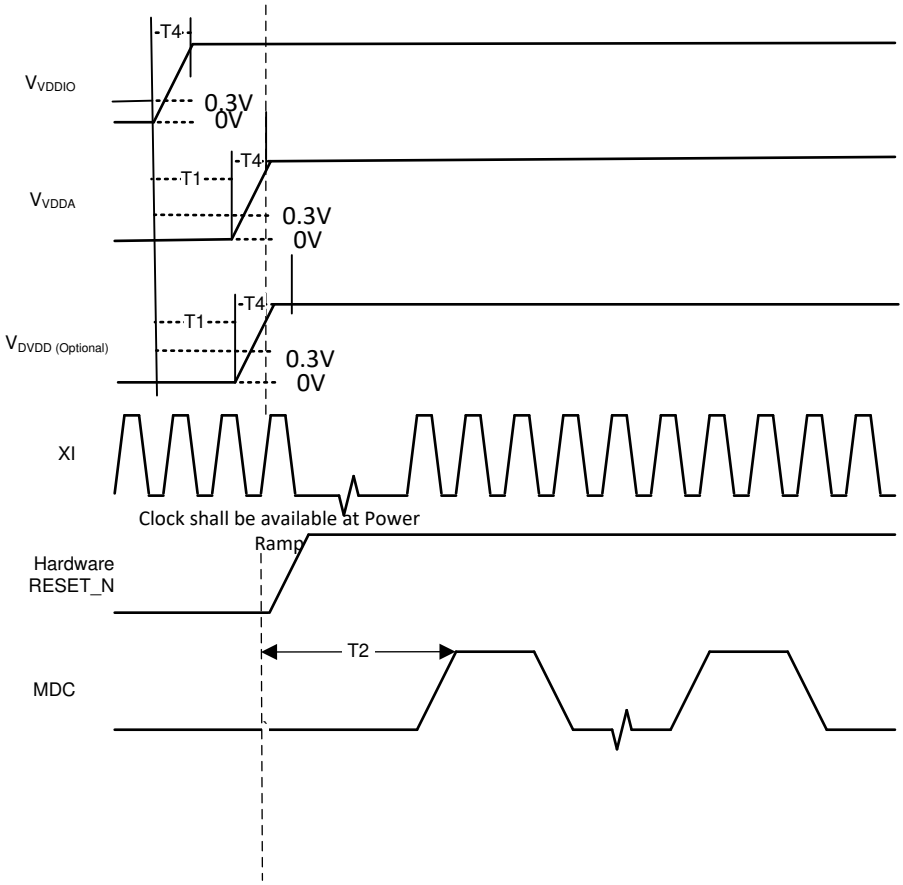


Figure 6-1. Power-Up Timing

ADVANCE INFORMATION

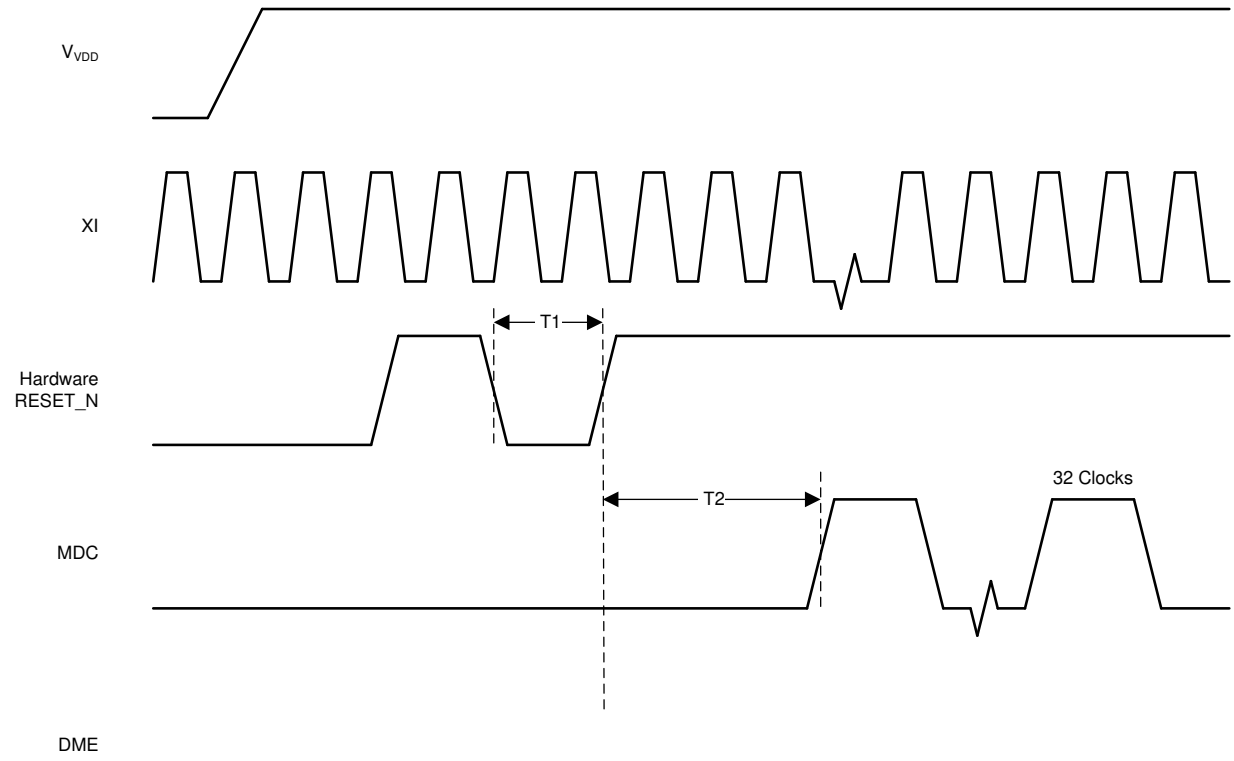


Figure 6-2. Reset Timing

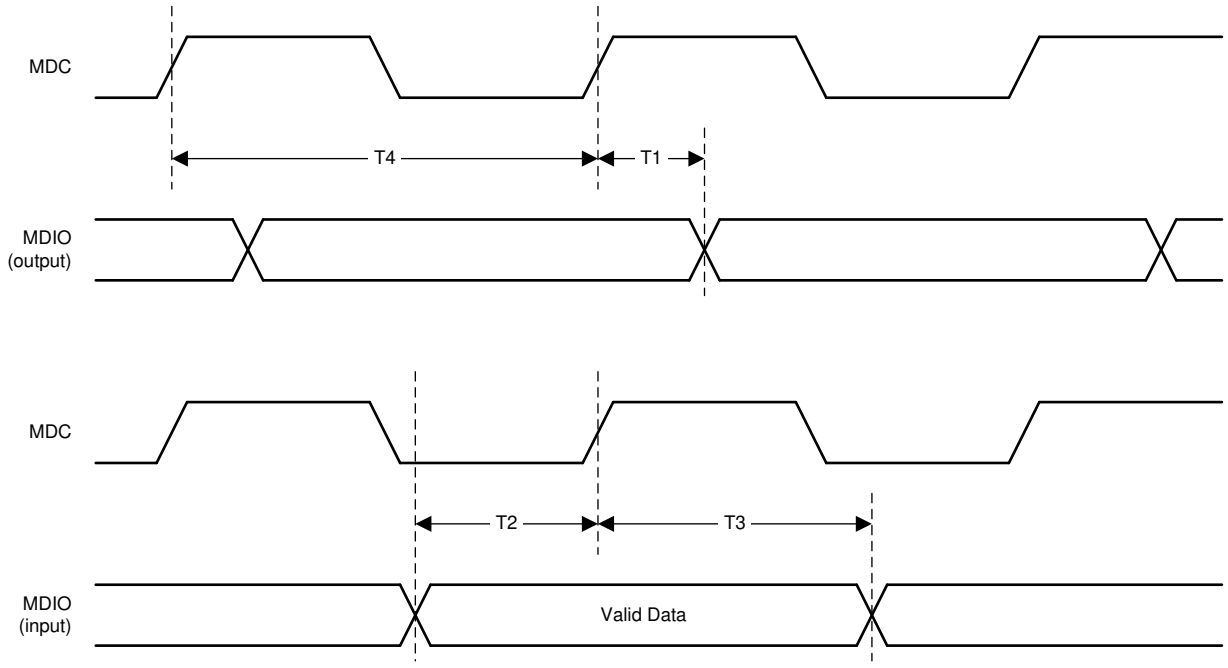


Figure 6-3. Serial Management Timing

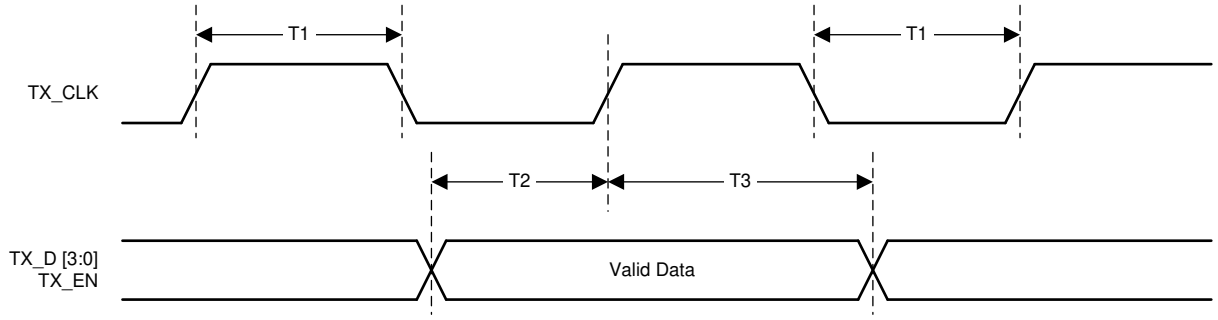


Figure 6-4. 10-Mbps MII Transmit Timing

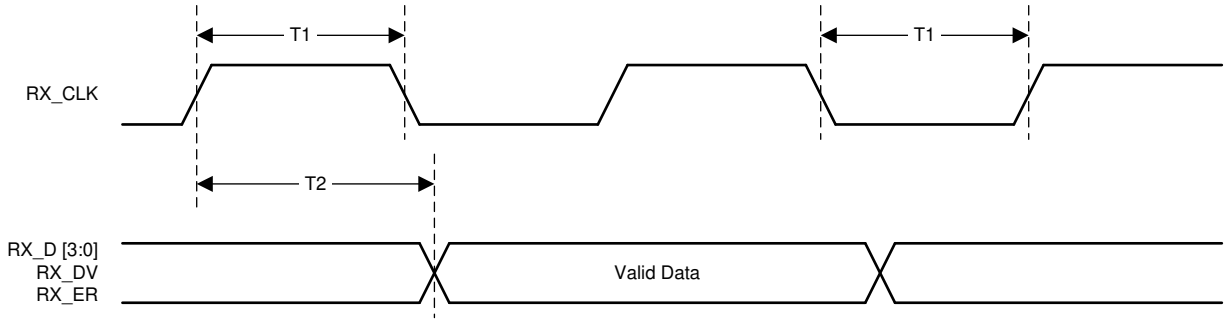


Figure 6-5. 10-Mbps MII Receive Timing

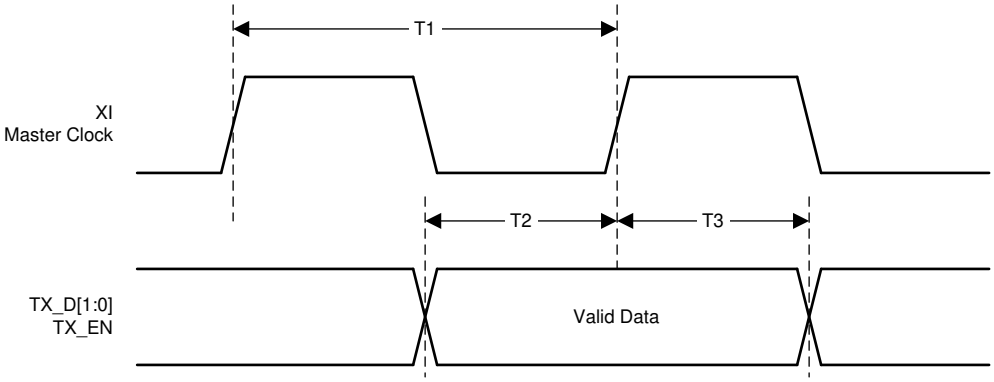


Figure 6-6. RMII Transmit Timing

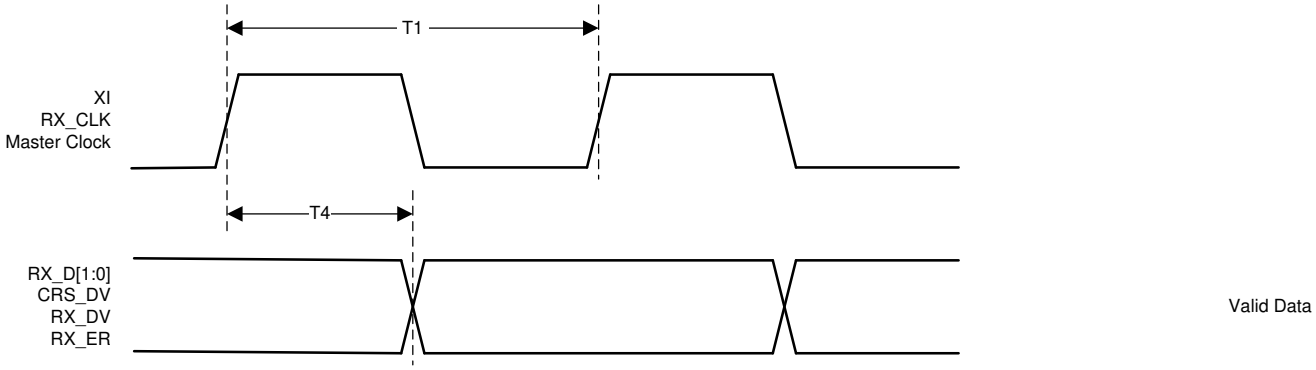


Figure 6-7. RMII Receive Timing

ADVANCE INFORMATION

7 Detailed Description

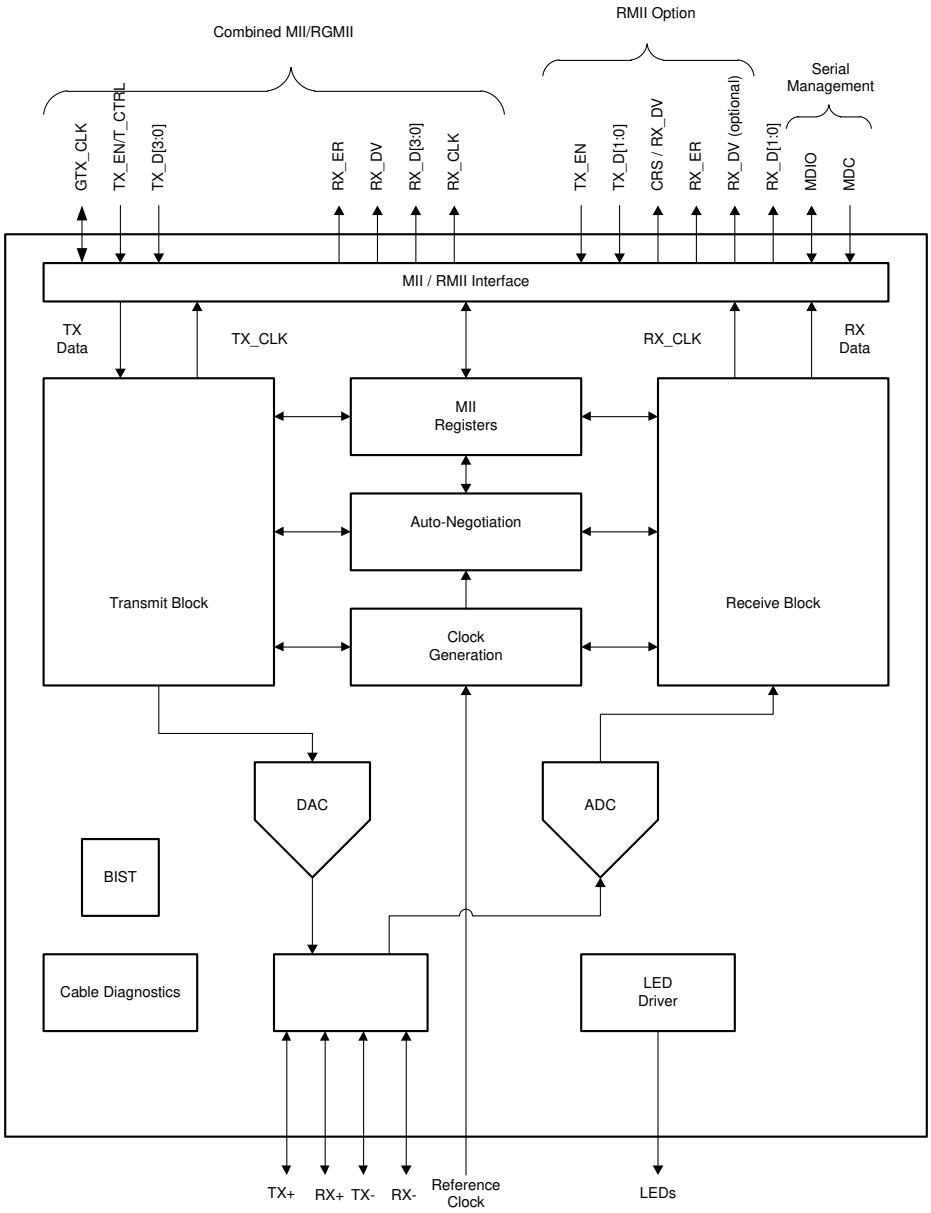
7.1 Overview

The DP83TD510E is a physical-layer transceiver compliant to IEEE 802.3cg 10BaseT1L standards. The PHY use low noise coupled signal processing reciever architecture to offer longer cable reach along with ultra-low power consumption. The device supports both 2.4-V p2p and 1-V p2p out put voltage as defined by IEEE 802.3cg 10Base-T1L specfications. It supports mulitple MAC interface (MII, Reduced Media Independent Interface (RMII), RGMII and low power Reduced MII) for direct connection to Media Access Controller (MAC). The device also supports back-to-back RMII mode in unmanaged mode to provide range extension and repeater functionality.

The device is designed to operate from a single 3.3-V power supply and has integrated LDO to provide the voltage rails required for internal blocks. The device has an option to feed digital power externally to achieve lowest power consumption. The device allows I/O voltage interfaces for 3.3 V, 2.5 V or 1.8 V. Automatic supply configuration within the DP83TD510E allows for any combination of VDDIO supply without the need for additional configuration settings.

The DP83TD510E Diagonstic Tool includes TDR (Time Domain Reflectometry), ALCD (Active Link Cable Diagnostics), SQI (Signal Quality Indicator), mulitple Loopbacks and Integrated PRBS Packet Generator to ease debugging during development and detecting faulty conditions in field.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 Auto-Negotiation (Speed Selection)

Auto-Negotiation provides a mechanism for exchanging configuration information between the two ends of a link segment. The DP83TD510E supports auto-negotiation for Low Speed Modes (LSM) as defined in IEEE 802.3cg specification for 10BaseT1L. Auto-negotiation ensures that the highest common speed is selected based on the advertised abilities of the link partner and the local device.

7.3.2 RMII Repeater Mode

The DP83TD510E provides an option to enable repeater mode functionality to extend the cable reach. Two DP83TD510E can be connected in back to back mode without any external configuration. A hardware strap is provided to configure the CRS_DV pin of RMII interface to RX_DV pin for back to back operation. Refer to Figure 7-1 for the RMII pin connection to enable repeater mode on the DP83TD510E.

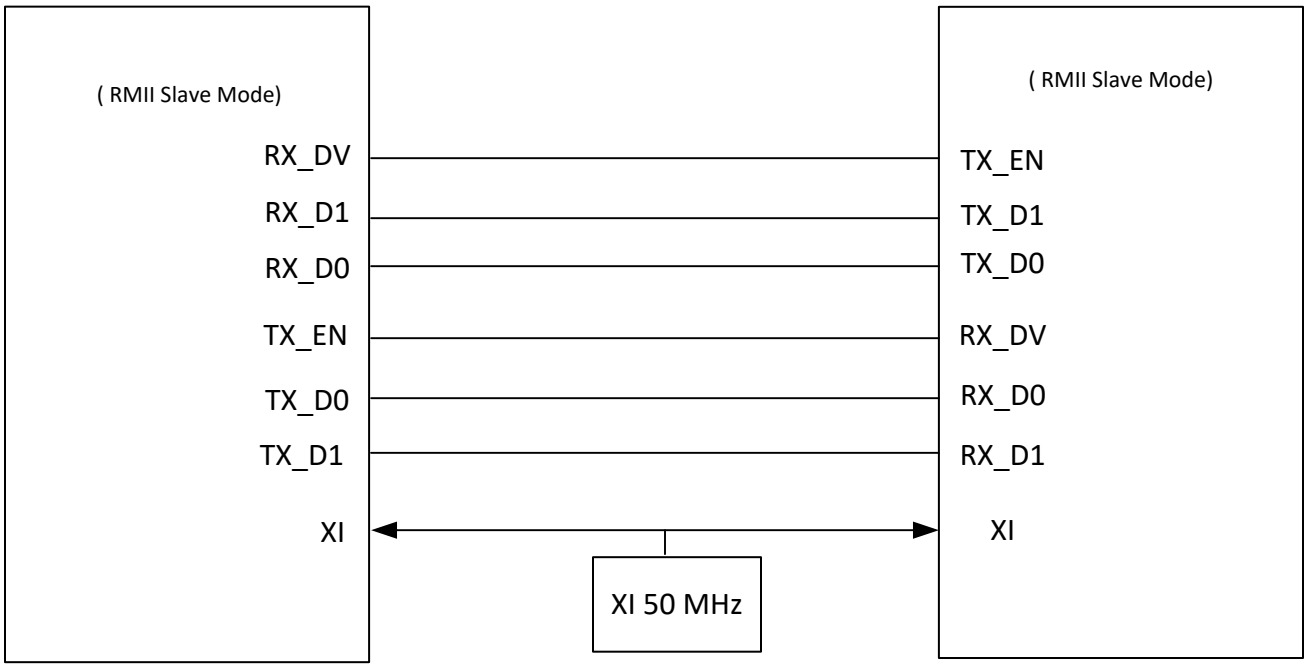


Figure 7-1. RMII Repeater Mode

7.3.3 Clock Output

The DP83TD510E has several clock output configuration options. An external crystal or CMOS-level oscillator provides the stimulus for the internal PHY reference clock. The local reference clock acts as the central source for all clocking within the device.

All clock configuration options are enabled using the IO MUX GPIO Control Register **TBD**

Clock options supported by the DP83TD510E include:

- MAC IF clock
- XI clock
- Free-running clock
- Recovered clock

7.3.4 Media Independent Interface (MII)

The Media Independent Interface is a synchronous 4-bit wide nibble data interface that connects the PHY to the MAC. The MII is fully compliant with IEEE 802.3-2002 clause 22.

The MII signals are summarized in Table 7-1.

Table 7-1. MII Signals

FUNCTION	PINS
Data Signals	TX_D[3:0]
	RX_D[3:0]
Transmit and Receive Signals	TX_EN
	RX_DV

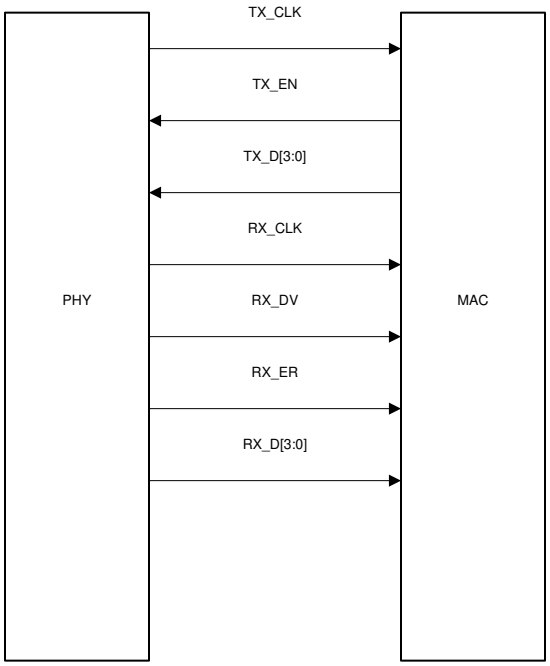


Figure 7-2. MII Signaling

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

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7.3.5 Reduced Media Independent Interface (RMII)

The DP83TD510E incorporates the Reduced Media Independent Interface (RMII) as specified in the RMII specification v1.2. The purpose of this interface is to provide a reduced pin count alternative to the IEEE 802.3 MII as specified in Clause 22. Architecturally, the RMII specification provides an additional reconciliation layer on either side of the MII, but can be implemented in the absence of an MII. The DP83TD510E offers two types of RMII operations: RMII Slave and RMII Master. In RMII Master operation, the DP83TD510E operates off of either a 25-MHz CMOS-level oscillator connected to XI pin or a 25-MHz crystal connected across XI and XO pins. A 50-MHz output clock referenced from DP83TD510E can be connected to the MAC. In RMII Slave operation, the DP83TD510E operates off of a 50-MHz CMOS-level oscillator connected to the XI pin and shares the same clock as the MAC. Alternatively, in RMII Slave mode, the PHY can run from a 50-MHz clock provided by the Host MAC.

The RMII specification has the following characteristics:

- Single clock reference sourced from the MAC to PHY (or from an external source)
- Independent 2-bit wide transmit and receive data paths
- Usage of CMOS signal levels, the same levels as the MII interface

In this mode, data transfers are two bits for every clock cycle using the internal 50-MHz reference clock for both transmit and receive paths.

The RMII signals are summarized inTable 7-2.

Table 7-2. RMII Signals

FUNCTION	PINS
Receive Data Lines	TX_D[1:0]
Transmit Data Lines	RX_D[1:0]
Receive Control Signal	TX_EN
Transmit Control Signal	CRS_DV

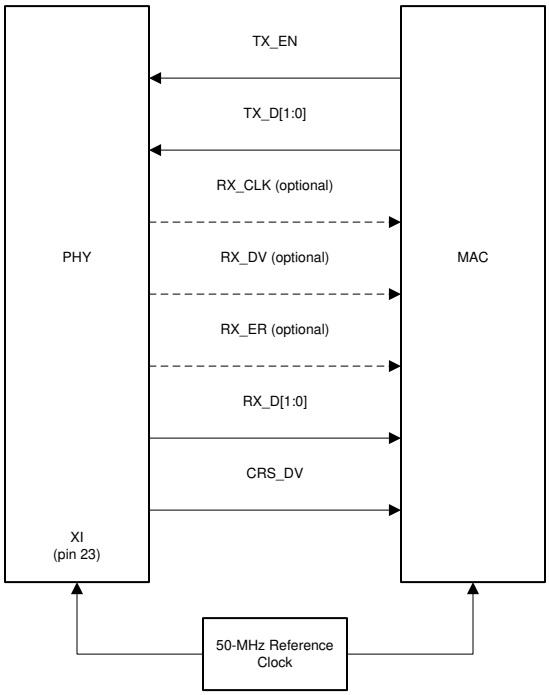

Figure 7-3. RMII Slave Signaling

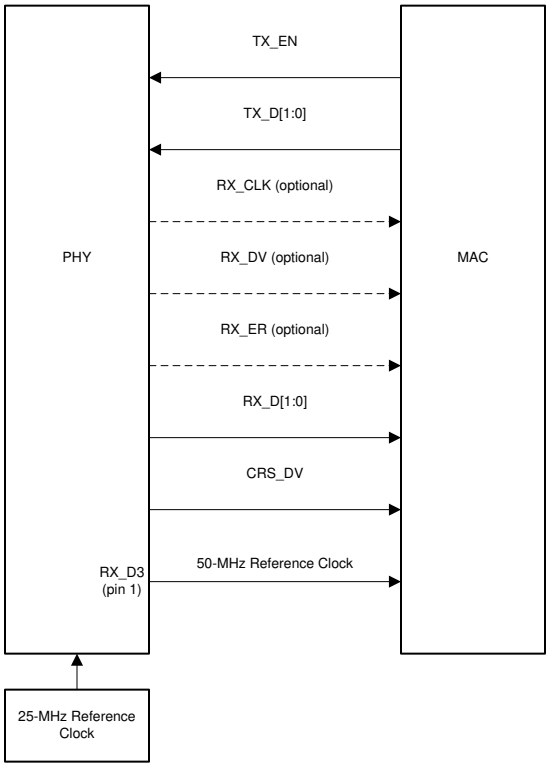

Figure 7-4. RMII Master Signaling

Data on TX_D[1:0] are latched at the PHY with reference to the clock edges on the XI pin. Data on RX_D[1:0] are latched at the MAC with reference to the same clock edges on the XI pin.

In addition, CRX_DV can be configured as RX_DV signal. It allows a simpler method of recovering receive data without the need to separate RX_DV from the CRS_DV indication.

7.3.6 RMII Low Power 5-MHz Mode

DP83TD510E supports a new MAC Mode called RMII Master Low Power Mode. The interface is similar to the RMII master mode but runs at 5 MHz resulting in power dissipation savings. DP83TD510E offers 5-MHz clock output and data is aligned to this clock. An application can use the same pin map as RMII for this mode.

7.3.7 RGMI Interface

DP83TD510E offers RGMII mode which runs at 2.5 MHz. The timing specifications are relaxed compared to RGMII at 125 MHz. Refer to timing sections on timing specifications for this mode.

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7.3.8 Serial Management Interface

The Serial Management Interface provides access to the DP83TD510E internal register space for status information and configuration. The SMI is compatible with IEEE 802.3 clause 22 and clause 45. The implemented register set consists of the registers required by IEEE 802.3 plus several others to provide additional visibility and controllability of the DP83TD510E.

The SMI includes the management clock (MDC) and the management input/output data pin (MDIO). MDC is sourced by the external management entity, also called Station (STA), and can run at a maximum clock rate of 25 MHz. MDC is not expected to be continuous and can be turned off by the external management entity when the bus is idle.

MDIO is sourced by the external management entity and by the PHY. The data on the MDIO pin is latched on the rising edge of the MDC. The MDIO pin requires a pullup resistor (2.2 kΩ) which pulls MDIO high during IDLE and turnaround.

Up to 16 PHYs can share a common SMI bus. To distinguish between the PHYs, during power up or hardware reset, the DP83TD510E latches the Phy_Address[3:0] configuration pins to determine its address.

The management entity must not start an SMI transaction in the first cycle after power up or hardware reset. To maintain valid operation, the SMI bus must remain inactive at least one MDC cycle after reset is de-asserted. In normal MDIO transactions, the register address is taken directly from the management-frame reg_addr field, thus allowing direct access to 32 16-bit registers (including those defined in IEEE 802.3 and vendor specific). The data field is used for both reading and writing. The Start code is indicated by a <01> pattern. This pattern ensures that 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 may actively drive the MDIO signal during the first bit of turnaround. The addressed DP83TD510E drives the MDIO with a zero for the second bit of turnaround and follows this with the required data.

For write transactions, the station-management entity writes data to the addressed DP83TD510E, thus eliminating the requirement for MDIO Turnaround. The turnaround time is filled by the management entity by inserting <10>.

Table 7-3. SMI Protocol

SMI PROTOCOL	<idle><start><op code><PHY address><reg addr><turnaround><data><idle>
Read Operation	<idle><01><10><AAAAA><RRRRR><Z0><XXXX XXXX XXXX XXXX><idle>
Write Operation	<idle><01><01><AAAAA><RRRRR><10><XXXX XXXX XXXX XXXX><idle>

7.3.9 Loopback Modes

There are several loopback options within the DP83TD510E that test and verify various functional blocks within the PHY. Enabling loopback modes allow for in-circuit testing of the digital and analog data paths. The DP83TD510E may be configured to any one of the Near-End Loopback modes or to the Far-End (reverse) Loopback mode. MII Loopback is configured using the Control Register (BMCR, address TBD). All other loopback modes are enabled using the BIST Control Register (BISCR, address TBD).

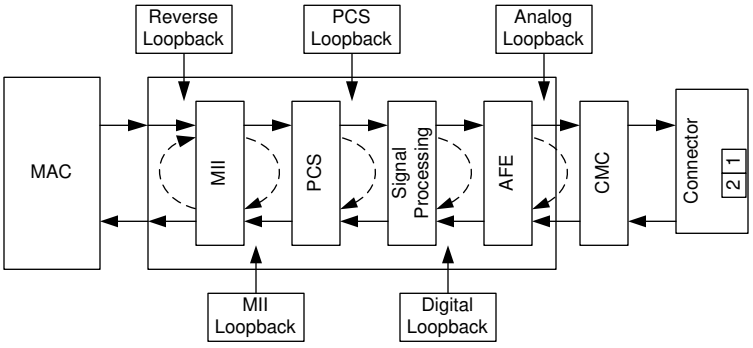

Figure 7-5. Loopback Test Modes

7.3.9.1 MII Loopback

MII Loopback is the shallowest loop through the PHY. It is a useful test mode to validate communications between the MAC and the PHY. When in MII Loopback, data transmitted from a connected MAC on the TX path is internally looped back in the DP83TD510E to the RX pins where it can be checked by the MAC.

7.3.9.2 PCS Loopback

PCS Loopback occurs in the PCS layer of the PHY. No signal processing is performed when using PCS Loopback.

7.3.9.3 Digital Loopback

Digital Loopback includes the entire digital transmit and receive paths. Data is looped back prior to the analog circuitry.

Digital Loopback is enabled by setting bit[2] in the BISCR.

7.3.9.4 Analog Loopback

Analog Signals can be looped back after the analog front-end. Detials: TBD.

7.3.9.5 Far-End (Reverse) Loopback

Far-End (Reverse) loopback is a special test mode to allow PHY testing with a link partner. In this mode, data that is received from the link partner passes through the PHY's receiver, is looped back at the MAC interface and then transmitted back to the link partner. While in Reverse Loopback mode, all data signals that come from the MAC are ignored.

7.3.10 BIST Configurations

The DP83TD510E incorporates an internal PRBS Built-in Self-Test (BIST) circuit to accommodate in-circuit testing and diagnostics. The BIST circuit can be used to test the integrity of transmit and receive data paths. The BIST can be performed using both internal loopbacks (digital or analog) or external loopback using a cable fixture. The BIST simulates pseudo-random data transfer scenarios in format of real packets and Inter-Packet Gap (IPG) on the lines. The BIST allows full control of the packet lengths and the IPG.

7.4 Device Functional Modes

DP83TD510E can be used in MII Mode, RMII Master Mode and Slave Mode. Refer to RMII section for connection diagram.

7.4.1 Straps Configuration

The DP83TD510E uses many of the functional pins as strap options to place the device into specific modes of operation. The values of these pins are sampled at power up or hard reset. During software resets, the strap options are internally reloaded from the values sampled at power up or hard reset. The strap option pin assignments are defined below. Configuration of the device may be done through the strap pins or through the management register interface. A pullup resistor or a pulldown resistor of suggested values may be used to set the voltage ratio of the strap pin input and the supply to select one of the possible selected modes. The MAC interface pins must support I/O voltages of 3.3 V, 2.5 V, and 1.8 V. As the strap inputs are implemented on these pins, the straps must also support operation at 3.3-V, 2.5-V, and 1.8-V supplies depending on what voltage was selected for I/O. All strap pins have two levels.

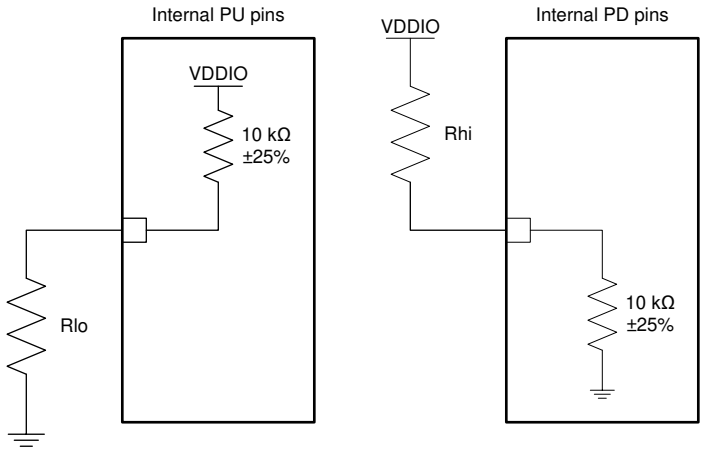

Figure 7-6. Strap Circuit

Table 7-4. 2-Level Strap Resistor Ratio

MODE	IDEAL RESISTORS	
	Rhi (kΩ)	Rlo (kΩ)
0	OPEN	2.49
1	2.49	OPEN

7.4.1.1 Straps for PHY Address

Table 7-5. PHY Address Strap Table

PIN NAME	STRAP NAME	PIN #	DEFAULT		
GPIO1	Strap9	32	0		PHY_ADD0
				MODE 0	0
				MODE 1	1
RX_ERR	Strap6	20	0		PHY_ADD1
				MODE 0	0
				MODE 1	1
RX_D0	Strap4	16	0		PHY_ADD2
				MODE 0	0
				MODE 1	1
RX_D3	Strap1	13	0		PHY_ADD3
				MODE 0	0
				MODE 1	1
PHY Address strap is 4 bit strap on pin 13, 16, 20 and 32. It shall be read as [3:2:1:0] respectively. Default PHY Address is 0000.					

Table 7-6. Reach Selection Strap

PIN NAME	STRAP NAME	PIN #	DEFAULT		
LED_2	Strap7	28	0	0	This Strap defines the voltage level requested by PHY during auto negotiation. It is reflected in bit 12 of 0x20E. While using Force mode for Linkup, the strap controls the output voltage and reflects in bit 12 of 0x18F6 0 : 1-V p2p
				1	1: 2.4-V p2p

Table 7-7. MAC Mode Strap Table

PIN NAME	STRAP NAME	PIN #	DEFAULT	Strap8	Strap 3	
RX_D1	Strap3	15	0	0	0	MII (default)
				0	1	RMII Master
LED_0	Strap8	29	0	1	0	Reserved
				1	1	RMII Slave

Table 7-8. RMII MAC Mode Strap Table

PIN NAME	STRAP NAME	PIN #	DEFAULT		
RX_D2	Strap2	14	0	0	CRS_DV/RX_DV Pin 18 is configured as CRS_DV (default)
				1	CRS_DV/RX_DV Pin 18 is configured as RX_DV (For RMII Repeater Mode)

Table 7-9. Terminations Selection

PIN NAME	STRAP NAME	PIN #	DEFAULT		
GPIO2	Strap10	8	Mandatory PU/PD	0	Receiver with tapping at 50 Ω (Recommended)
				1	Receiver tapping at < 40 Ω

Table 7-10. Clockout/LED_1

PIN NAME	STRAP NAME	PIN #	DEFAULT		
RX_DV/CRS_DV	Strap5	18	0	0	Clockout 25 M(default)
				1	LED1

7.5 Programming

DP83TD510E provides an IEEE defined register set for programming and status. It also provides an additional register set to configure other features not supported thru IEEE registers.

ADVANCE INFORMATION

7.6 Register Maps

7.6.1 MMD Register Address Map

Table 7-11. MMD Register Map Address Table

Register Address Range	MMD	Example Usage
0x1000 to 0x18F8	0x1	MMD=0x1, Address=0x08F8
0x3000 to 0x38E7	0x3	MMD=0x3, Address=0x08E7
0x200 to 0x20F	0x7	MMD=07, Address=0x20F
0x0000 to 0x0130, 0x0300-0x0E01	0x1F	MMD=0x1F, Address=0x0000

8 Application and Implementation

Note

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

8.1 Application Information

When using the device for Ethernet applications, it is necessary to meet certain requirements for normal operation. The following subsections are intended to assist in appropriate component selection and required circuit connections.

8.2 Typical Applications

Figure 8-1 shows a typical application for the DP83TD510E.

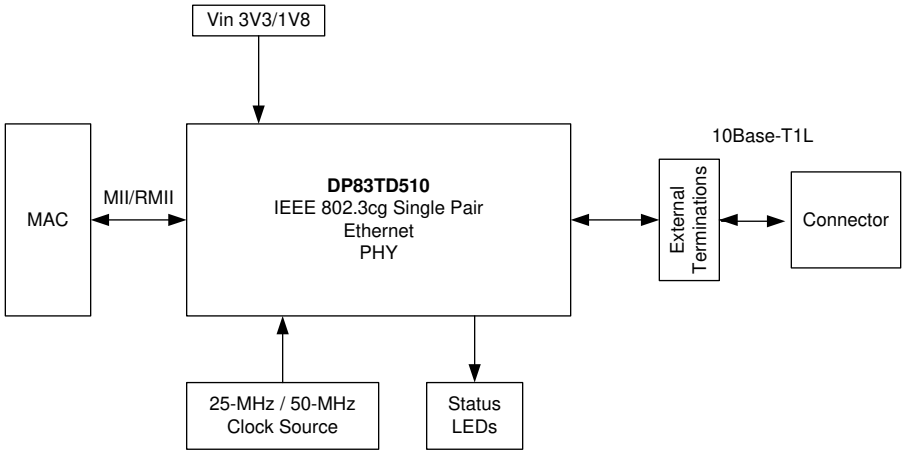

Figure 8-1. Typical DP83TD510E Application

ADVANCE INFORMATION

8.2.1 Termination Circuit

DP83TD510E is expected to be used in Intrinsic Safe and non Intrinsic Safe Applications. Please refer to appropriate termination circuit based on the application needs, see Figure 8-2 .

Note

Termination circuit and passive values are initial estimates and subject to change

8.2.1.1 Termination Circuit for Intrinsic Safe Applications

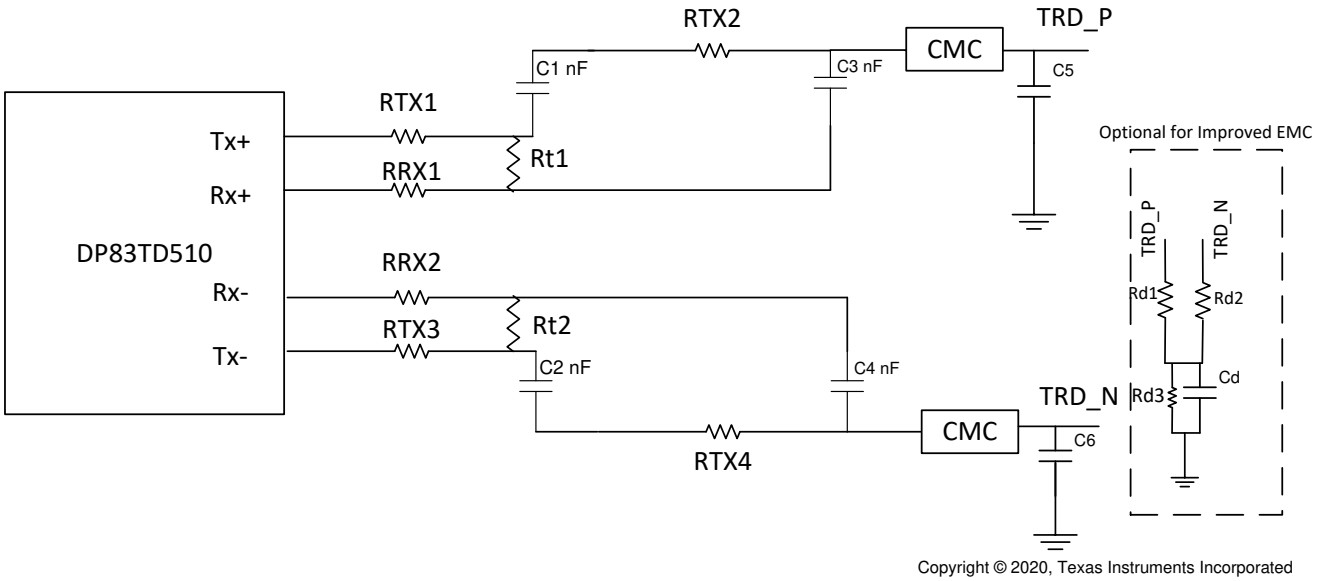

Figure 8-2. Termination Circuit for Intrinsic Safe Applications

Table 8-1. Termination Circuit Component Value for Intrinsic Safe Applications

	Applications	1v p2p Intrinsic Safe Config 1	1v p2p Intrinsic Safe Config 2
1	RTX1, RTX3	26.5	50
2	RTX2, RTX4 (Ω)	23.5	0
3	RRX1, RRX2 (Ω)	2K	2K
4	Rt1(Ω)	NC	0
5	Rt2(Ω)	NC	0
6	Rd1(Ω)	1K	1K
7	Rd2(Ω)	1K	1K
8	Rd3(Ω)	160K	160K
9	C1	230 nF	230 nF
10	C2	230 nF	230 nF
11	C3	5 nF	NC
12	C4	5 nF	NC
13	C5	100 pF < C < 400 pF (default: 100 pF	100 pF < C < 400 pF (default: 100 pF
14	C6	100 pF < C < 400 pF (default: 100 pF	100 pF < C < 400 pF (default: 100 pF
15	Cd	0.01 uF	0.01 uF

Please ensure over all impedance on the Transmitter shall be 50Ω. If additional components on path adding the impedance, it shall be compensated by reducing Rtx1/Rtx3.

8.2.1.2 Components Range for Power Coupling/Decoupling

Below table provides recommended component ranges for Power/Data decoupling network

Table 8-2. Recommended Components Range for Power Coupling/Decoupling

	Components	Range
1	Cap of ESD diode between MDI lines (Surge protection)	< 100 pF (Differential Cap)
2	Cap of TVS Diode (MDI line to ground)*	< 75 pF
3	Cap of Clamping Diodes (parallel to power coupling inductor)	< 50 pF
4	Power coupling inductor	• Inductance 500 uH < L <1.5 mH, • DC Resistance < 200 mΩ
5	Cap of Rectifier Diodes	<50 pF

8.2.1.3 Termination Circuit for Non-Intrinsic Safe Applications

Following termination circuit is recommended for application in non intrinsic safe application like in Building Automation, Factory Automation etc

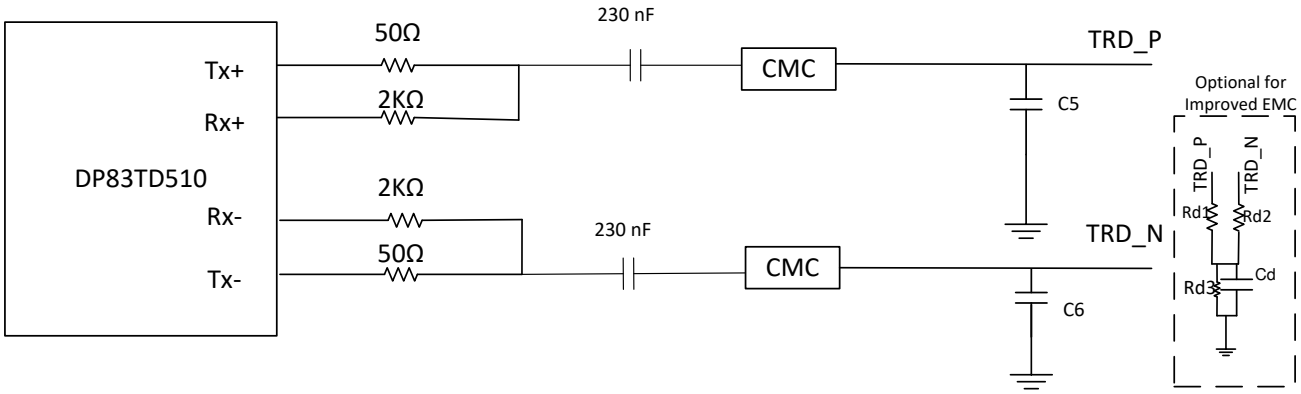

Figure 8-3. Termination Circuit for Non-Intrinsic Safe Applications

8.2.1.4 CMC Specifications

Table 8-3. CMC Specifications

Parameters	Range
Inductance	450 uH
Leakage Inductance	< 500 nH
DC Resistance	< 200 mΩ

8.2.2 Design Requirements

The design requirements for the DP83TD510E are:

1. AVD Supply = 3.3 V
2. VDDIO Supply = 3.3 V or 1.8 V
3. Reference Clock Input = 25 MHz or 50 MHz (RMII Slave)

8.2.2.1 Clock Requirements

The DP83TD510E supports an external CMOS-level oscillator source or an internal oscillator with an external crystal.

ADVANCE INFORMATION

8.2.2.1.1 Oscillator

If an external clock source is used, XI should be tied to the clock source and XO should be left floating. The amplitude of the oscillator should be a nominal voltage of VDDIO.

8.2.2.1.2 Crystal

The use of a 25-MHz, parallel resonant, 20-pF load crystal is recommended if operating with a crystal. A typical connection diagram is shown below for a crystal resonator circuit. The load capacitor values will vary with the crystal vendors; check with the vendor for the recommended loads.

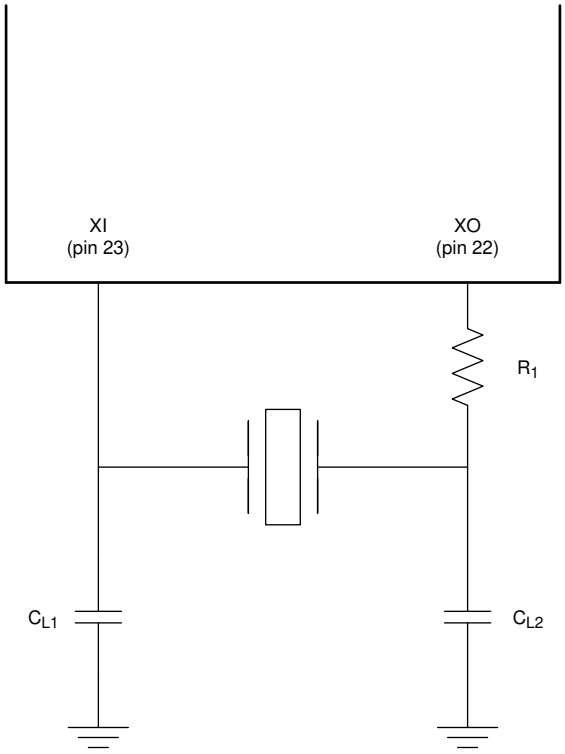

Figure 8-4. Crystal Oscillator Circuit

Table 8-4. 25-MHz Crystal Specification

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Frequency			25		MHz
Frequency Tolerance	Including all parameters (Temperature, aging etc)	-100		100	ppm
Load Capacitance			15	30	pF
ESR			50	150	Ohm

9 Power Supply Recommendations

The DP83TD510E is capable of operating from Single Supply 3V3. It supports single supply operations from 1V8 for Short Reach (1v p2p) mode. It also supports Dual Supply Operations for Lowest Power Dissipation. It also supports VDDIO to work at 3.3-V, 2.5-V or 1.8-V supply voltages PHY has capability to detect the power supply levels automatically for both AVDD and VDDIO..

Single Power Supply Operations : Analog supply shall be powered by 3.3 V or 1.8 V. AVDD of 3V3 can support both Long Reach (2.4-v p2p) and Short Reach(1-v p2p).

Please note with AVDD 1.8 V, only Short Cable mode of 1-V p2p will be supported.

Appropriate straps shall be configured to ensure Auto Negotiation transmits the correct capabilities of the PHY.

The recommended power supply de-coupling network is shown below:

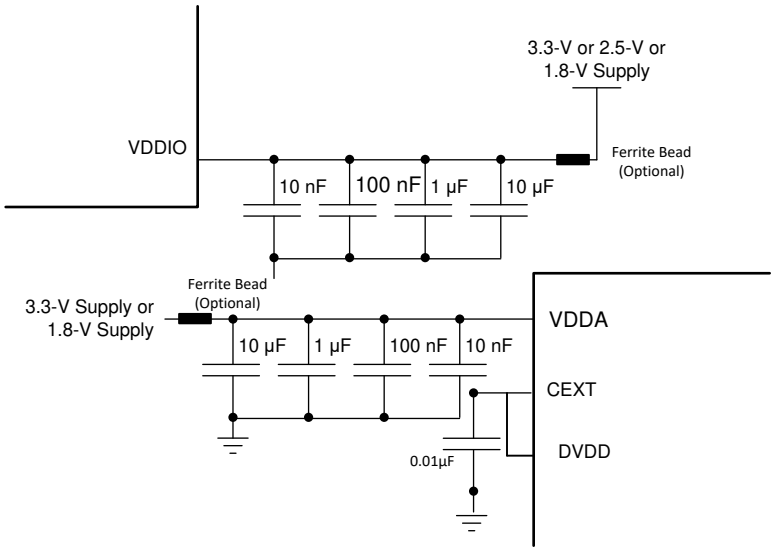

Figure 9-1. DP83TD510E Single Power Supply Decoupling Recommendation

For Dual Supply Operations, digital voltage rail of 1.0 V externally shall be supplied seperately. This help reduce the power consumption further of the DP83TD510E. See below connections for Dual Power Supply.

ADVANCE INFORMATION

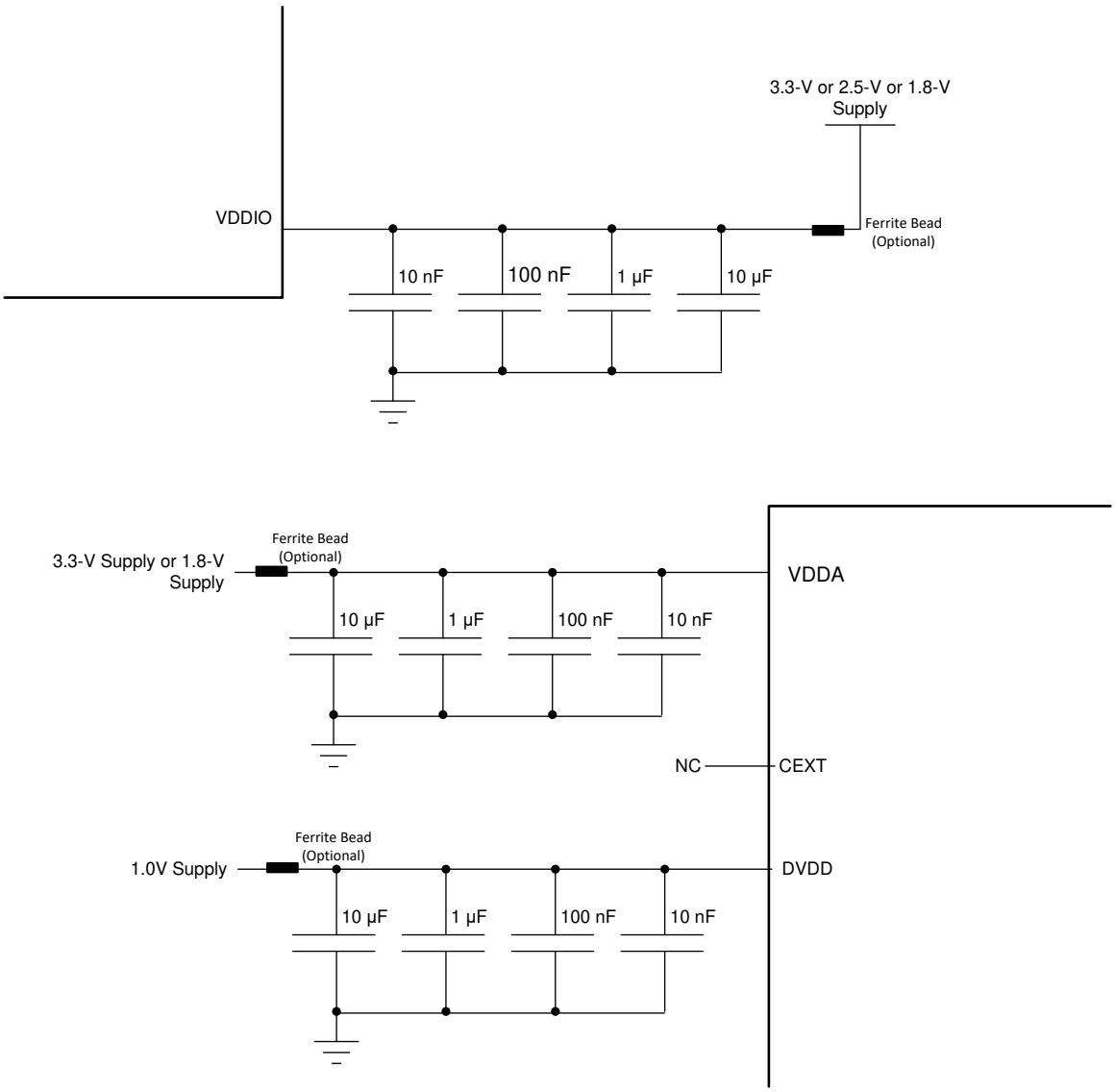

Figure 9-2. DP83TD510E Dual Supply Power Supply Decoupling Recommendation

10 Layout

10.1 Layout Guidelines

10.1.1 Signal Traces

PCB traces are lossy and long traces can degrade signal quality. Keep traces as short as possible. Unless mentioned otherwise, all signal traces must be 50-Ω single-ended impedance. Differential traces must 100-Ω differential. Take care to ensure impedance is controlled throughout. Impedance discontinuities cause reflections leading to emissions and signal integrity issues. Stubs should be avoided on all signal traces, especially differential signal pairs.

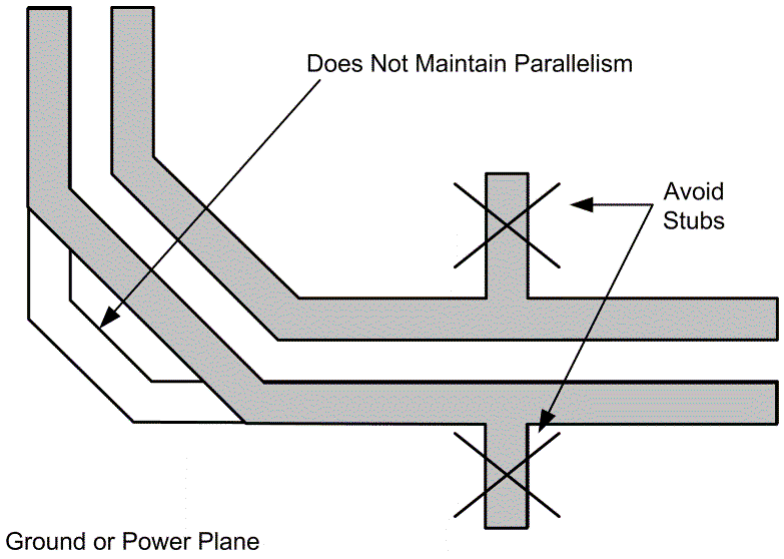

Figure 10-1. Differential Signal Traces

Within the differential pairs, trace lengths should be run parallel to each other and matched in length. Matched lengths minimize delay differences, avoiding an increase in common mode noise and emissions. Length matching is also important for MAC interface connections. All RMII transmit signal traces should be length matched to each other and all RMII receive signal traces should be length matched to each other.

Ideally, there should be no crossover or vias on signal path traces. Vias present impedance discontinuities and should be minimized when possible. Route trace pairs on the same layer. Signals on different layers should not cross each other without at least one return path plane between them. Differential pairs should always have a constant coupling distance between them. For convenience and efficiency, TI recommends routing critical signals first (that is, MDI differential pairs, reference clock, and MAC IF traces).

10.1.2 Return Path

A general best practice is to have a solid return path beneath all MDI signal traces. This return path can be a continuous ground or DC power plane. Reducing the width of the return path can potentially affect the impedance of the signal trace. This effect is more prominent when the width of the return path is comparable to the width of the signal trace. Breaks in return path between the signal traces should be avoided at all cost. A signal crossing a split plane may cause unpredictable return path currents and could impact signal quality and result in emissions issues.

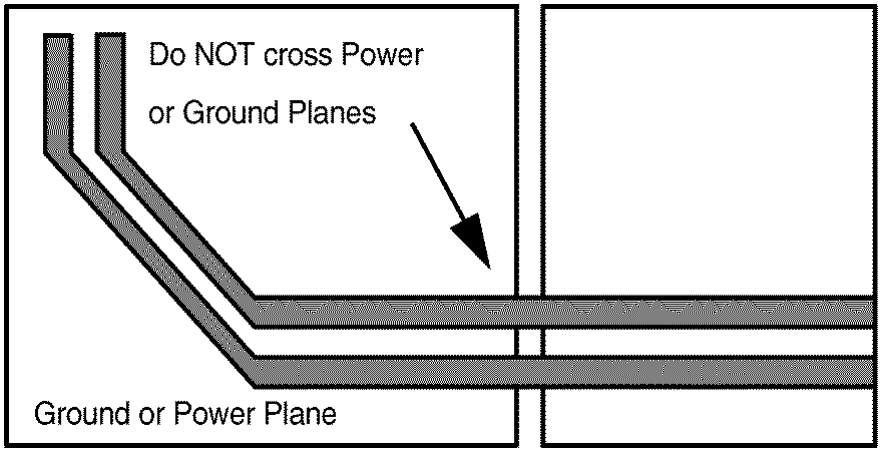

Figure 10-2. Differential Signal Pair and Plane Crossing

10.1.3 Metal Pour

All metal pours that are not signals or power must be tied to ground. There must be no floating metal in the system, and there must be no metal between differential traces.

10.1.4 PCB Layer Stacking

To meet signal integrity and performance requirements, a minimum four-layer PCB is recommended. However, a six-layer PCB should be used when possible.

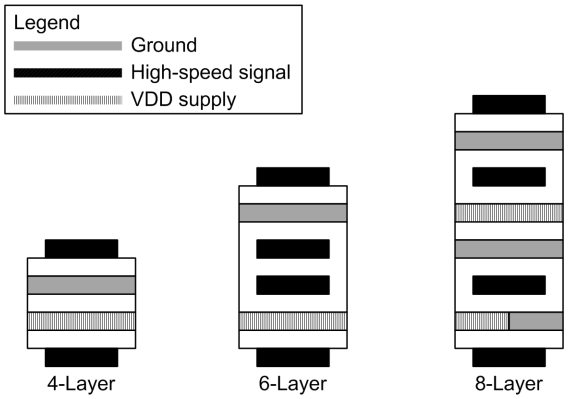

Figure 10-3. Recommended Layer Stack-Up

10.2 Layout Example

Please refer DP83TD510E EVM for information regarding layout.

ADVANCE INFORMATION

11 Device and Documentation Support

11.1 Device Support

11.2 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

11.3 Trademarks

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All other trademarks are the property of their respective owners.

11.4 Electrostatic Discharge Caution

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

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

11.5 Glossary

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

ADVANCE INFORMATION

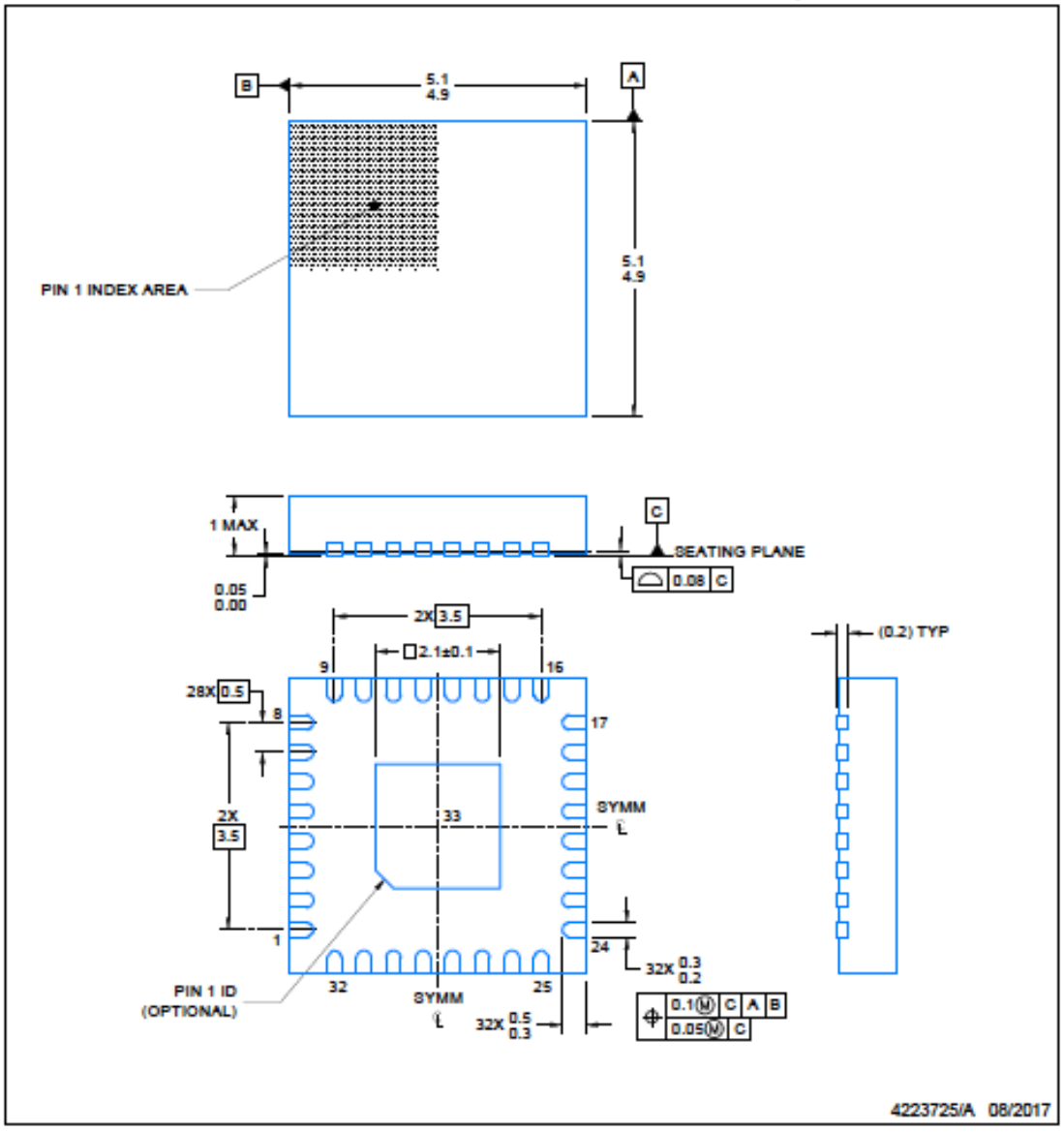
12 Mechanical, Packaging, and Orderable Information

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

PACKAGE OUTLINE

RHB0032M — **VQFN - 1 mm max height**

PLASTIC QUAD FLATPACK-NO LEAD



NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for optimal thermal and mechanical performance.

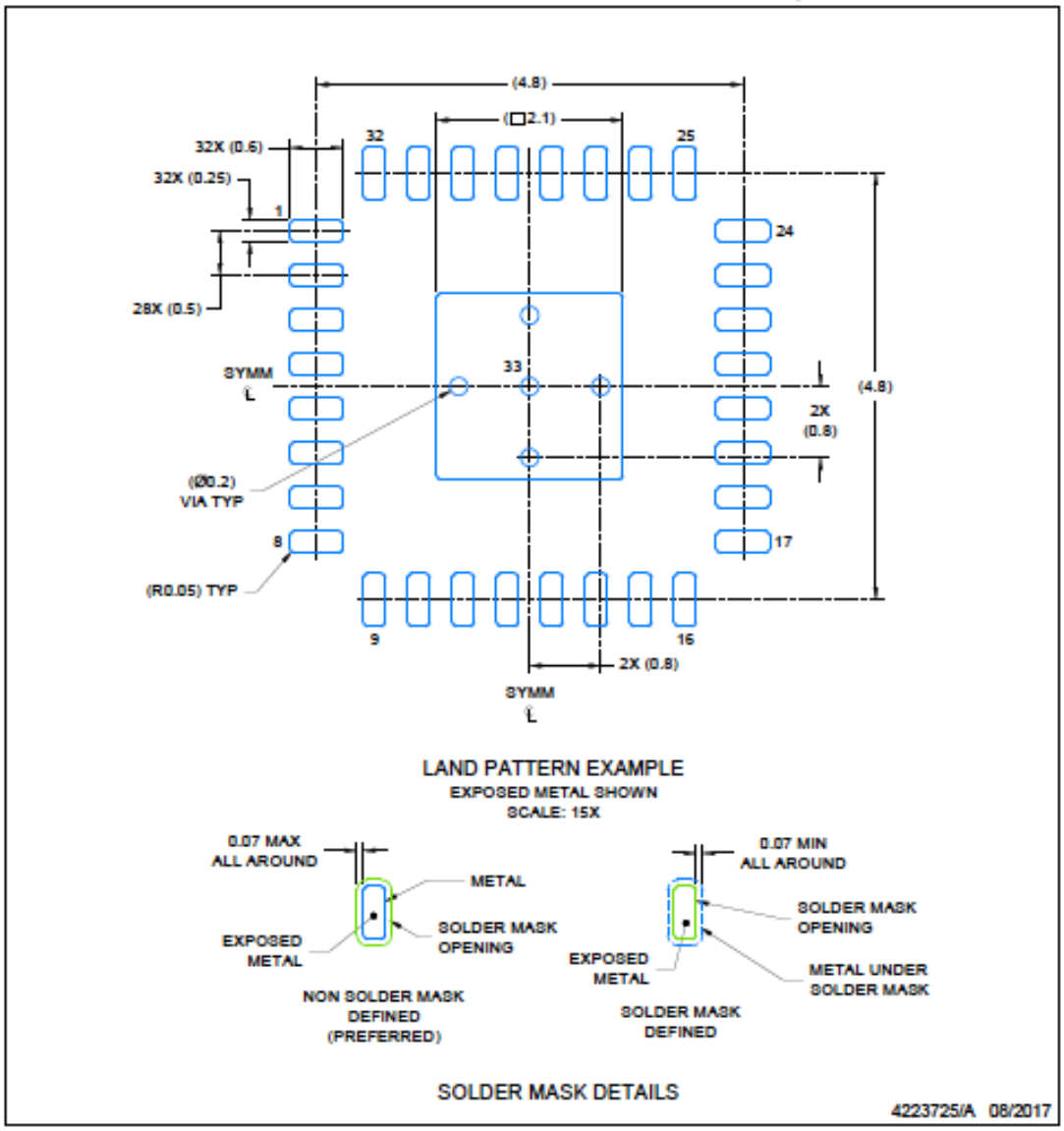
Figure 12-1. DP83TD510E Package Drawing

ADVANCE INFORMATION

EXAMPLE BOARD LAYOUT

RHB0032M — **VQFN - 1 mm max height**

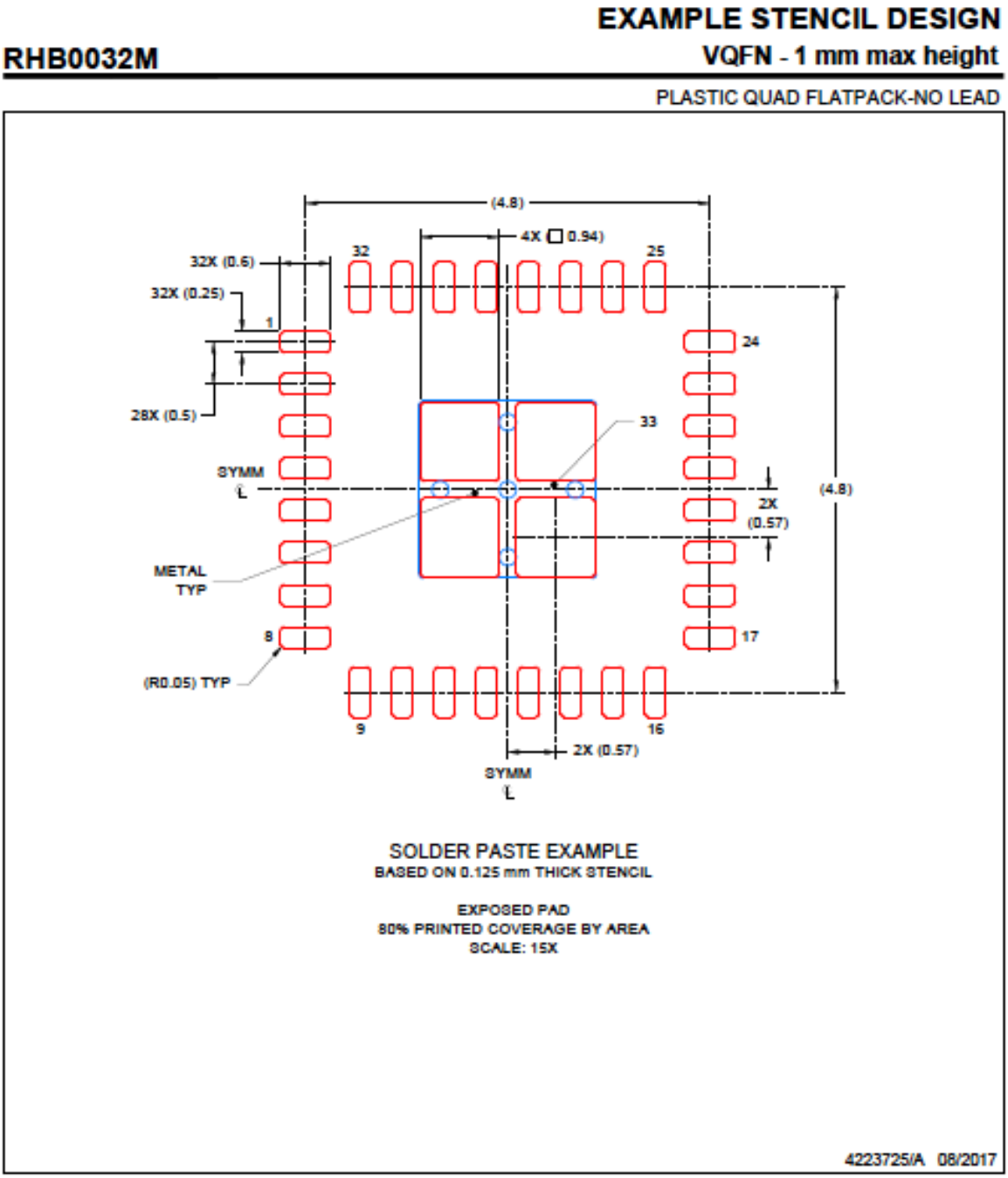
PLASTIC QUAD FLATPACK-NO LEAD



NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

Figure 12-2. DP83TD510E Package Drawing



NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

Figure 12-3. DP83TD510E Package Drawing

ADVANCE INFORMATION

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
DP83TD510ERHBR	PREVIEW	VQFN	RHB	32	3000	TBD	Call TI	Call TI	-40 to 105		
DP83TD510ERHBT	PREVIEW	VQFN	RHB	32	250	TBD	Call TI	Call TI	-40 to 105		
PDP83TD510ERHBR	ACTIVE	VQFN	RHB	32	3000	TBD	Call TI	Call TI	-40 to 105		Samples

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

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

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

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

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

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

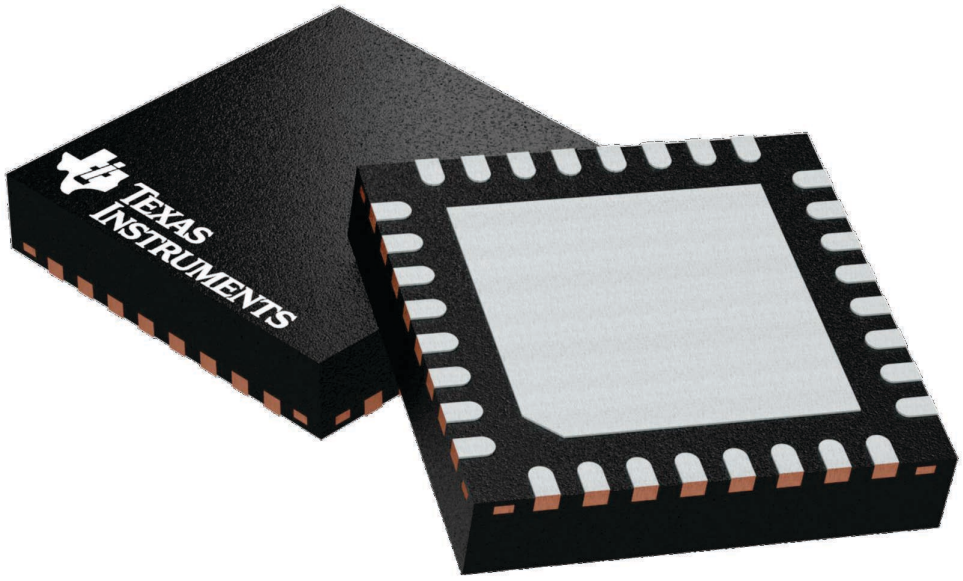
GENERIC PACKAGE VIEW

RHB 32

VQFN - 1 mm max height

5 x 5, 0.5 mm pitch

PLASTIC QUAD FLATPACK - NO LEAD



Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

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