

## 5 Output HiFlex™ Ethernet Network Clock Generator

### Features

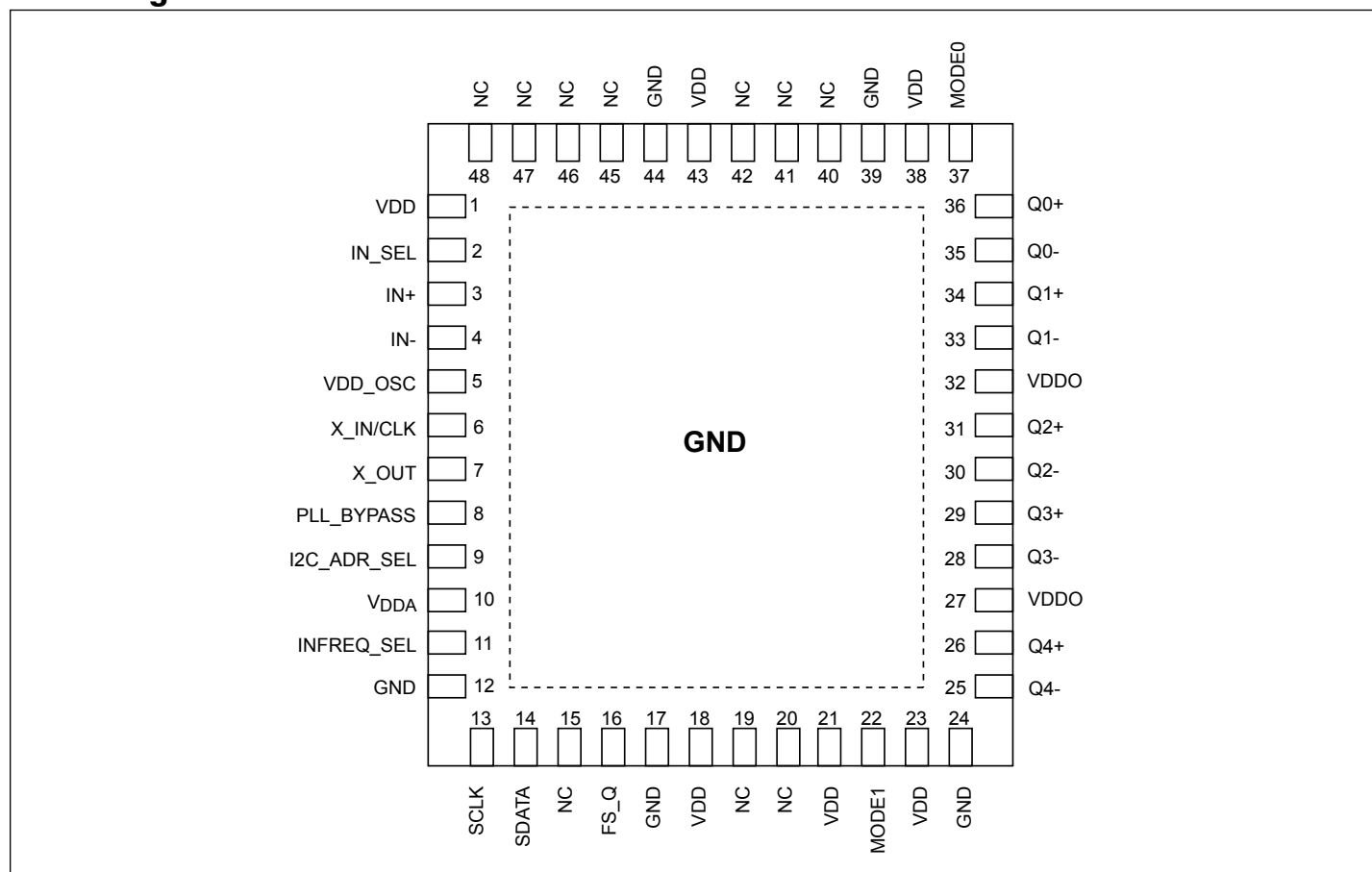
- 3.3V & 2.5V supply voltage
- Crystal/CMOS input: 25 MHz
- Differential input: 25MHz, 125MHz, and 156.25 MHz
- Output frequencies: 156.25, 125, 100, 50, 25MHz
- 5 outputs with selectable output signaling: LVPECL or LVDS
- Low 0.3ps typical integrated phase noise design: 156.25MHz (12kHz to 20MHz)
- PLL Bypass mode
- Power supply noise rejection: -52 dBc typical @ VDD
- Packaging (Pb-free & Green): 48 Contact 6×6mm TQFN
- Industrial temperature support: -40C to 85C

### Description

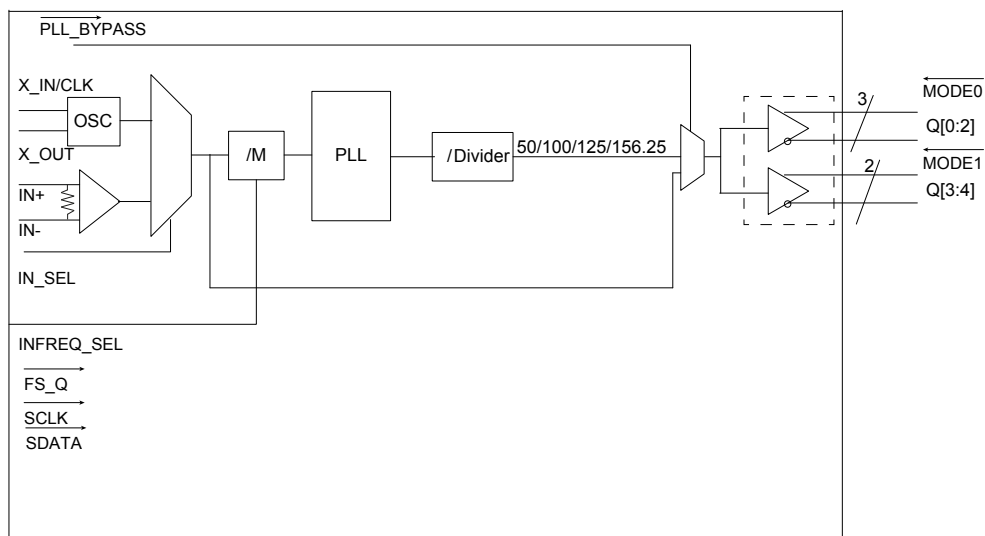
The PI6LC48S0401 is an LC VCO based low phase noise design intended for Ethernet applications. Typical 10GbE usage assumes a 25MHz crystal input, while the PLL loop is used to generate the 156.25MHz and other Ethernet clock frequencies.

For Ethernet applications other than 10GbE, programmable dividers allow for outputs of 156.25, 125, 100, 50, and 25MHz. This device offers both pin selection and I<sup>2</sup>C interface to give more options to meet various system needs.

### Pin Configuration



## Block Diagram



100MHz output frequency can be selected only in I<sup>2</sup>C mode

## Pin Description

Pin Number	Pin Name	Type		Description
1, 18, 21, 23, 38, 43	VDD	Power	-	Core supply
2	IN_SEL	Input	CMOS	Input select between Xtal and differential input
3	IN+	Input	LVPECL	Differential reference input, also accepts AC-coupled LVDS, CML, HCSL or LVPECL. Differential inputs have an internal 100Ω cross resistor.
4	IN-	Input		
5	VDD_OSC	Power	-	Power supply for Xtal Oscillator circuit
6	X_IN/CLK	Input		Xtal or clock input, connect to a 25MHz Xtal or single-ended clock
7	X_OUT	Output		Xtal output
8	PLL_BYPASS	Input	CMOS	PLL bypass, provide input frequency to outputs
9	I2C_ADR_SEL	Input	CMOS	I2C address selection.
10	VDDA	Power	-	Analog supply
11	INFREQ_SEL	Input	Tri-level	Input frequency selection for reference input
12, 17, 24, 39, 44	GND	Power		Connect to ground
15, 19, 20, 40, 41, 42, 45, 46, 47, 48	NC	-		No connect

## Pin Description (cont.)

Pin Number	Pin Name	Type		Description
13	SCLK	Input		I <sup>2</sup> C clock input
14	SDATA	Input/ Output		I <sup>2</sup> C Data line
16	FS_Q	Input	Tri-level	Output frequency select
22	MODE1	Input	Tri-level	Q3 ~ Q4 output control
25, 26	Q4-, Q4+	Output	LVPECL/ LVDS	Differential outputs
27, 32	VDDO	Power		Power supply for differential outputs
28, 29	Q3-, Q3+	Output	LVPECL/ LVDS	Differential outputs
30, 31	Q2-, Q2+	Output	LVPECL/ LVDS	Differential outputs
33, 34	Q1-, Q1+	Output	LVPECL/ LVDS	Differential outputs
35, 36	Q0-, Q0+	Output	LVPECL/ LVDS	Differential outputs
37	MODE0	Input	Tri-level	Q0 ~ Q2 output control
E-pad	GND	Power		Connect to ground, use thermal vias

## Input MUX Selection

IN_SEL	Input Source
0	Crystal Input (X_IN/CLK, X_OUT)
1	Differential Input (IN+, IN-)
NC	Crystal Input (X_IN/CLK, X_OUT)

## Reference Input Frequency Select Table

INFREQ_SEL	Reference Input
0	25MHz
1	125MHz
NC	156.25MHz

## PLL Bypass Control Function

PLL_BYPASS	PLL operation
0	PLL enabled
1	PLL bypassed

## Differential Output Control

MODE0	Q[0:2]	MODE1	Q[3:4]
0	LVPECL	0	LVPECL
1	LVDS	1	LVDS
NC	Hi-Z	NC	Hi-Z

## Output Frequency Control Table

FS_Q	Output Freq.
0	156.25MHz
1	125MHz
NC	50MHz

## I2C Address Selection Table

I <sup>2</sup> C_ADR_SEL	I2C Address
0	DC (h)
1	DE (h)

## Maximum Ratings

(Above which useful life may be impaired. For user guidelines, not tested.)

Storage Temperature.....	–65°C to +150°C
Supply Voltage to Ground Potential, $V_{DD}$ , $V_{DDA}$ , $V_{DDO}$ .....	–0.5V to +4.6V
ESD Protection (HBM) .....	2000 V
Junction Temperature .....	125 °C max

Note: Stresses greater than those listed under MAXIMUM RATINGS may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

## Operating Conditions

Symbol	Parameters	Conditions	Min..	Typ.	Max.	Units
$V_{DD}$	Core Power Supply Voltage		2.97	3.3	3.63	V
			2.375	2.5	2.625	V
$V_{DDO}$	Output Power Supply Voltage		2.97	3.3	3.63	V
			2.375	2.5	2.625	V
$V_{DDA}$	Analog Power Supply Voltage		2.97	3.3	3.63	V
			2.375	2.5	2.625	V
$I_{DD}$	Power Supply Current				100	mA
$I_{DDO}$	Power Supply Current for Outputs	All outputs loaded, Diff. outputs are LVPECL			300	mA
		All outputs loaded, Diff. outputs are LVDS			130	mA
$I_{DDA}$	Analog Power Supply Current				45	mA
$T_A$	Ambient Temperature		–40		85	°C

## Input Electrical Characteristics

Symbol	Parameters	Conditions	Min.	Typ.	Max.	Units
$R_{pu}$	Internal pull up resistance			51		K $\Omega$
$R_{dn}$	Internal pull down resistance			51		K $\Omega$
$C_{XTAL}$	Internal capacitance on X_IN and X_OUT pins			12		pF

## LVCMOS DC Electrical Characteristics

Symbol	Parameters	Conditions	Min..	Typ.	Max.	Units
V <sub>IH</sub>	Input High Voltage	V <sub>DD</sub> = 3.3V ±10%	2		V <sub>DD</sub> +0.3	V
		V <sub>DD</sub> = 2.5V ±5%	1.7		V <sub>DD</sub> +0.3	V
V <sub>IL</sub>	Input Low Voltage	V <sub>DD</sub> = 3.3V ±10%	-0.3		0.8	V
		V <sub>DD</sub> = 2.5V ±5%	-0.3		0.5	V
I <sub>IH</sub>	Input High Current	V <sub>IN</sub> = V <sub>DD max.</sub>			150	μA
I <sub>IL</sub>	Input Low Current	V <sub>IN</sub> = 0V	-150			μA
T <sub>DC</sub>	Input Duty Cycle		35		65	%
C <sub>IN</sub>	Input Capacitance			3.5		pF

## Differential Input DC Characteristics

Symbol	Parameters	Conditions	Min..	Typ.	Max.	Units
V <sub>IH</sub>	Input High Voltage				V <sub>DD</sub> - 0.7	V
V <sub>IL</sub>	Input Low Voltage		V <sub>DD</sub> - 2.0			V
V <sub>CM</sub>	Input Bias Voltage		0.5		V <sub>DD</sub> - 0.85	V
R <sub>IN</sub>	Input Differential Impedance <sup>1</sup>		80	100	120	Ω
V <sub>IN-PP</sub>	Input Differential Swing	Differential peak to peak	0.3		2.6	V

**Note: 1.** Differential input can be AC or DC coupled.

## Crystal Characteristic

Parameters	Description	Min.	Typ	Max.	Units
OSCmode	Mode of Oscillation	Fundamental			
FREQ	Frequency	10	25	40	MHz
ESR <sup>1</sup>	Equivalent Series Resistance			50	Ω
Cload	Load Capacitance		18		pF
Cshunt	Shunt Capacitance			7	pF
	Drive Level			250	uW

**Note: 1.** ESR value is dependent upon frequency of oscillation

**LVPECL Output DC Characteristics <sup>(1)</sup>**

Symbol	Parameters	Condition	Min.	Typ.	Max.	Units
V <sub>OPP</sub>	Output peak-peak Voltage	Single-ended		0.78		V
V <sub>OH</sub>	Output High Voltage	Outputs terminated with 50Ω to V <sub>DDO</sub> - 2V	V <sub>DDO</sub> - 1.4		V <sub>DDO</sub> - 0.7	V
V <sub>OL</sub>	Output Low Voltage		V <sub>DDO</sub> - 2.0		V <sub>DDO</sub> - 1.3	V

**LVDS Output DC Characteristics <sup>(1)</sup>**

Symbol	Parameters	Condition	Min.	Typ.	Max.	Units
V <sub>OPP</sub>	Output Peak-peak Voltage	Single-ended	0.247		0.454	V
DV <sub>OPP</sub>	V <sub>OPP</sub> Magnitude Change				50	mV
V <sub>OS</sub>	Output Offset Voltage		1.125		1.375	V
DV <sub>OS</sub>	V <sub>OS</sub> Magnitude Change				50	mV

**AC Output Characteristics (see test configurations) <sup>(1)</sup>**

T<sub>A</sub> = -40C to 85C; V<sub>DD</sub> = 3.3V ± 10%, V<sub>DDO</sub> = 3.3V ± 10%

Symbol	Parameters	Condition	Min..	Typ.	Max.	Units
f <sub>OUT</sub>	Output Frequency	LVPECL			156.25	MHz
		LVDS			156.25	MHz
t <sub>R</sub> / t <sub>F</sub>	Rise and Fall Time; 20% ~80%	LVPECL, LVDS		250	400	ps
t <sub>DC</sub>	Duty Cycle	LVPECL, LVDS	48		52	%
t <sub>j</sub> PHASE	Integrated phase jitter (RMS)	12kHz-20MHz @ 156.25MHz, 25MHz Xtal input		0.25	0.4	ps
		10kHz-5MHz @ 25MHz, 25MHz Xtal input		0.33	0.4	ps
t <sub>j</sub> c-c	Cycle to cycle jitter			28	30	ps
t <sub>j</sub> pk-pk	Peak to Peak jitter			30	35	ps
f <sub>N</sub>	Single-Side Band Phase Noise	156.25MHz, 25MHz Xtal input	Offset 1kHz	-117		dBc/ Hz
			Offset 10kHz	-130		
			Offset 100kHz	-134		
			Offset 1MHz	-139		
			Offset 10MHz	-154		

## AC Output Characteristics (continued)

$T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$ ;  $V_{DD} = 3.3\text{V} \pm 10\%$ ,  $V_{DDO} = 3.3\text{V} \pm 10\%$

Symbol	Parameters	Condition	Min..	Typ.	Max.	Units
PSNR	Power Supply Noise Rejection	$V_{DD}$ , 50mVpp, 10k-1.5MHz		-52		dBc
		$V_{DDA}$ , 50mVpp, 10k-1.5MHz		-65		
		$V_{DDO}$ , 50mVpp, 10k-1.5MHz		-50		
$t_{\text{STARTUP}}$	Start time				10	ms
$t_{\text{LOCK}}$	PLL lock time				20	ms

### Note:

- $V_{DDO} = 3.3\text{V}$  is not valid with  $V_{DD} = 2.5\text{V}$



## Serial Data Interface (I<sup>2</sup>C compatible)

PI6LC48S0401 is a slave only device that supports block read and block write protocol using a single 7-bit address and read/write bit as shown below.

Read and write block transfers can be stopped after any complete byte transfer.

For full electrical I2C compliance, it is recommended to use external pull-up resistors for SDATA and SCLK. The internal pull-up resistors have a size of 50kΩ typical.

### Address Assignment

A6	A5	A4	A3	A2	A1	A0	R/W
1	1	0	1	1	1	I <sup>2</sup> C_ADR_SEL	1/0

### How to Write

1 bit	7 bits	1 bit	1 bit	8 bits	1 bit	8 bits	1 bit		8 bits	1 bit	1 bit
Start bit	Address	W(0)	Ack	Data Byte (D)	Ack	Data Byte (D+1)	Ack	.....	Data Byte (D+N)	Ack	Stop bit

### How to Read

1 bit	7 bits	1 bit	1 bit	8 bits	1 bit	8 bits	1 bit		8 bits	1 bit	1 bit
Start bit	Address	R(1)	Ack	Data Byte (D)	Ack	Data Byte (D+1)	Ack	.....	Data Byte (D+N)	Ack	Stop bit

## Output Frequency I2C bit Control Table

FS_Q (2-bit)	Output Freq.
0 0	156.25MHz
0 1	50MHz
1 0	125MHz
1 1	100MHz

## Input Freq. I2C bit Control Table

INFREQ_SEL (2-bit)	Input Freq.
0 0	25MHz
0 1	156.25MHz
1 0	125MHz
1 1	100MHz

## Byte 0: Output Frequency Selection Register

Bit	Control Function	Description	Type	Power Up Condition	0	1
7	Reserved					
6	Reserved					
5	FS_Q (1)	Output divider	RW	0	See FS_Q I <sup>2</sup> C control table	
4	FS_Q (0)		RW	0		
3	Reserved					
2	Reserved					
1	Vendor ID		RW	0		
0	Vendor ID		RW	0		

## Byte 1: Output Frequency Selection and Misc. Register

Bit	Control Function	Description	Type	Power Up Condition	0	1
7	I <sup>2</sup> C pin control	Determine external pins or I <sup>2</sup> C control mode	RW	0	External pins	I <sup>2</sup> C
6	I2C_ADR_SEL	Select I <sup>2</sup> C write address	RW	0	DC(h)	DE(h)
5	INFREQ_SEL (1)	Input frequency selection	RW	0	See INFREQ_SEL I <sup>2</sup> C control table	
4	INFREQ_SEL (0)		RW	0		
3	Reserved					
2	Reserved					
1	Reserved					
0	Reserved					

## Byte 2: Output Enable Selection

Bit	Control Function	Description	Type	Power Up Condition	0	1
7	Reserved					
6	Reserved					
5	OE for Q4	Output enable bit for Q4	RW	0	Enable	Disable
4	OE for Q3	Output enable bit for Q3	RW	0	Enable	Disable
3	OE for Q2	Output enable bit for Q2	RW	0	Enable	Disable
2	OE for Q1	Output enable bit for Q1	RW	0	Enable	Disable
1	OE for Q0	Output enable bit for Q0	RW	0	Enable	Disable
0	Reserved					

## Byte 3: Reserved

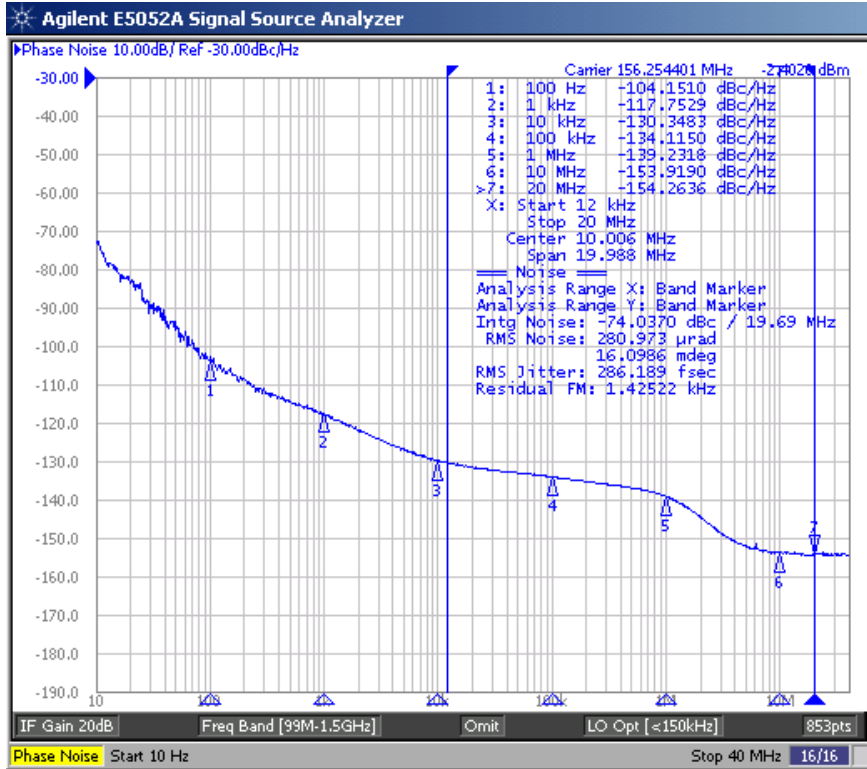
## Byte 4: Output Type Selection

Bit	Control Function	Description	Type	Power Up Condition	0	1
7	Reserved					
6	Reserved					
5	Q4	Output Type Select Q4	RW	0	LVPECL	LVDS
4	Q3	Output Type Select Q3	RW	0	LVPECL	LVDS
3	Q2	Output Type Select Q2	RW	0	LVPECL	LVDS
2	Q1	Output Type Select Q1	RW	0	LVPECL	LVDS
1	Q0	Output Type Select Q0	RW	0	LVPECL	LVDS
0	Reserved					

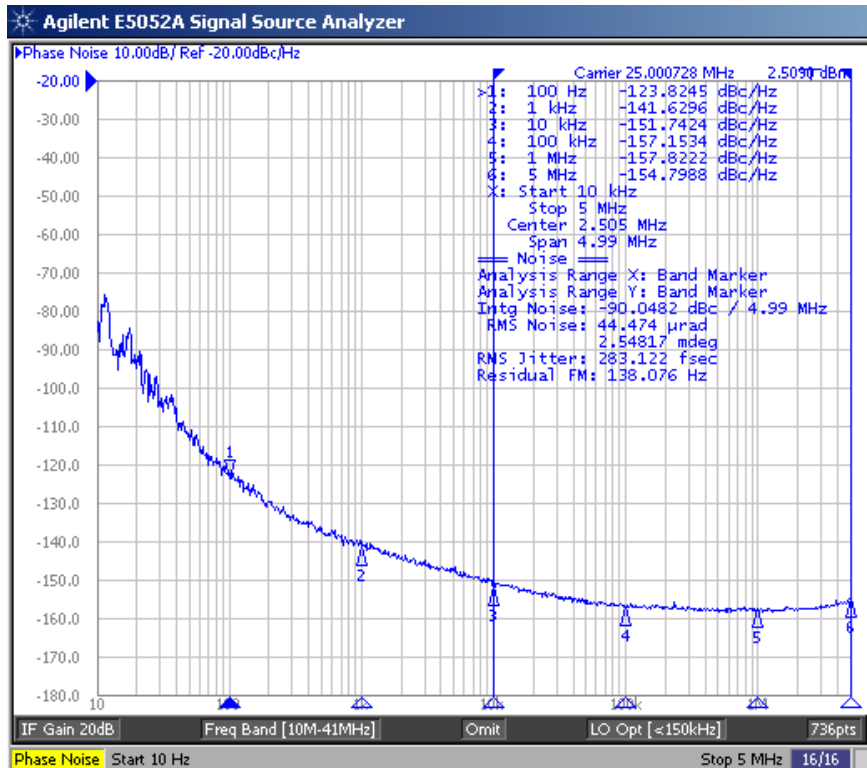
## Byte 5: Misc. Register

Bit	Control Function	Description	Type	Power Up Condition	0	1
7	Reserved					
6	Reserved					
5	Reserved					
4	Reserved					
3	PLL_BYPASS	PLL bypass function	RW	0	PLL is enabled	PLL is by-passed
2	Reserved					
1	Reserved					
0	IN_SEL	Input selection	RW	0	Crystal	Reference

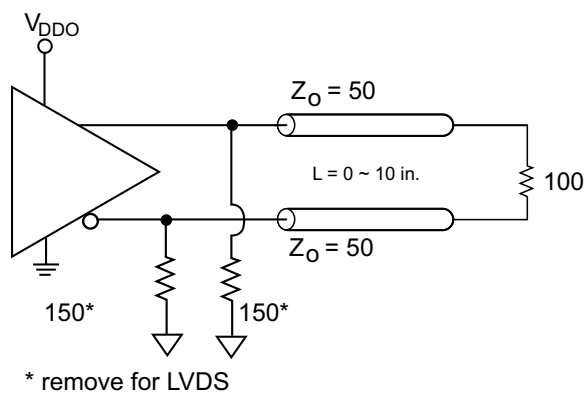
## Phase Noise Plots 156.25MHz LVDS Clock



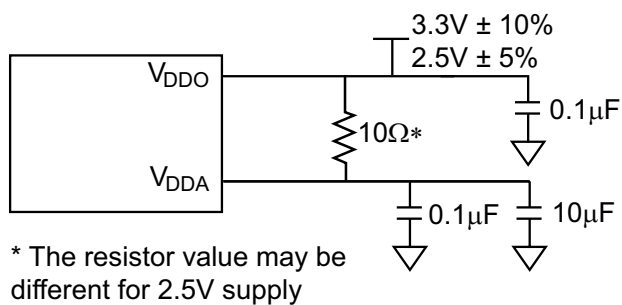
## 25MHz LVPECL Clock



LVPECL/LVDS Buffer



**Figure 1. LVPECL and LVDS Test Circuit**

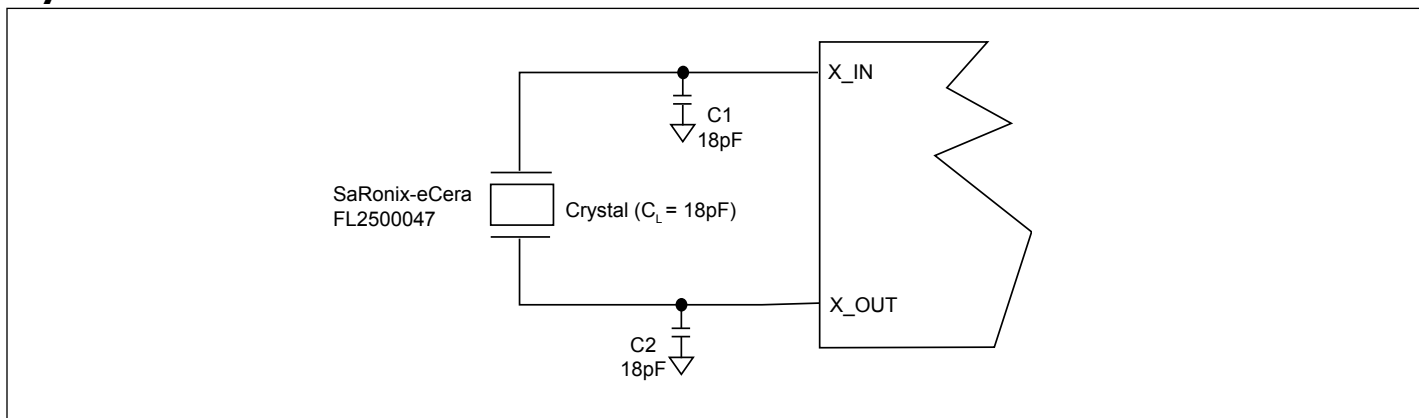


**Figure 2. Power Supply Filter**

## Crystal circuit connection

The following diagram shows PI6LC48S0401 crystal circuit connection with a parallel crystal. For the  $CL=18pF$  crystal, it is suggested to use  $C1=18pF$ ,  $C2=18pF$ .  $C1$  and  $C2$  can be adjusted to fine tune to the target ppm of crystal oscillator according to different board layouts.

## Crystal Oscillator Circuit



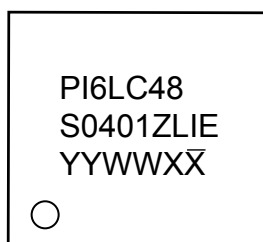
## Crystal Circuit Oscillator

## Recommended Crystal Specification

Pericom recommends:

- a) FY2500081, SMD 5x3.2(4P), 25MHz,  $CL=18pF$ ,  $\pm 30ppm$ , [http://www.pericom.com/pdf/datasheets/se/FY\\_F9.pdf](http://www.pericom.com/pdf/datasheets/se/FY_F9.pdf)
- b) FL2500047, SMD 3.2x2.5(4P), 25MHz,  $CL=18pF$ ,  $\pm 20ppm$ , <http://www.pericom.com/pdf/datasheets/se/FL.pdf>

## Part Marking

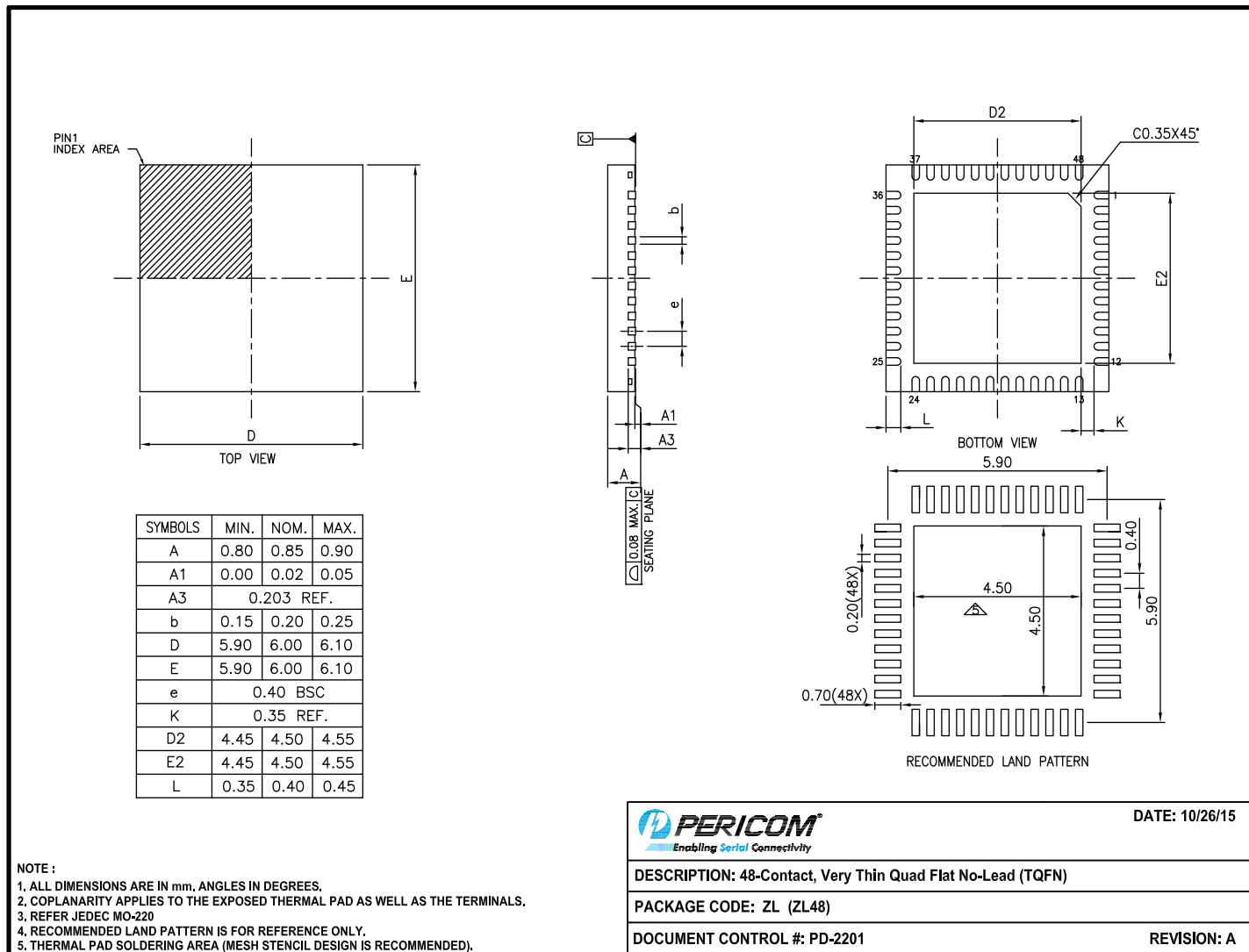


YY : Year  
WW : Workweek  
1st X : Assembly Code  
2nd X : Fab Code

### Note:

1. For latest datecode info, please check: <https://www.diodes.com/assets/MediaList-Attachments/Pericom-Datecode-Format-Explanation.pdf>

## Packaging Mechanical: 48-Contact TQFN (ZL)



15-0244

### Note:

- For latest package info, please check: <https://www.diodes.com/design/support/packaging/pericom-packaging/>

## Ordering Information<sup>(1-3)</sup>

Ordering Code	Package Code	Package Description	Operating Temperature
PI6LC48S0401ZLIEX	ZL	48-Contact, Pb-free & Green (TQFN), Tape & Reel	Industrial

### Notes:

- Thermal characteristics can be found on the company web site at <https://www.diodes.com/design/support/packaging/pericom-packaging/>
- E = Pb-free and Green
- Adding an X suffix = Tape/Reel

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