

# TEI0003 TRM

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## Overview

The Trenz Electronic TEI0003 is a low cost small-sized FPGA module integrating a Intel Cyclone 10LP 10CL025 FPGA SoC, 2 MByte serial memory for configuration and operation, 8 MByte SDRAM and a 3-axis accelerometer.

## Key Features

- Intel Cyclone 10LP 10CL025 FPGA SoC
- 8 MByte SDRAM
- 2 MByte serial configuration memory
- ST Microelectronics LIS3DH 3-axis accelerometer
- JTAG and UART over Micro USB2 connector
- 1x6 pin header for JTAG access to FPGA SoC

- 1x PMOD header providing 8 GPIOs
- 2x 14-pin headers (2,54 mm pitch) providing 23 GPIOs
- 1x 3-pin header providing 2 GPIOs
- 8x user LEDs
- 1x user push button
- 5.0V single power supply with on-board voltage regulators
- Size: 61.5 x 25 mm

Additional assembly options are available for cost or performance optimization upon request.

## Block Diagram

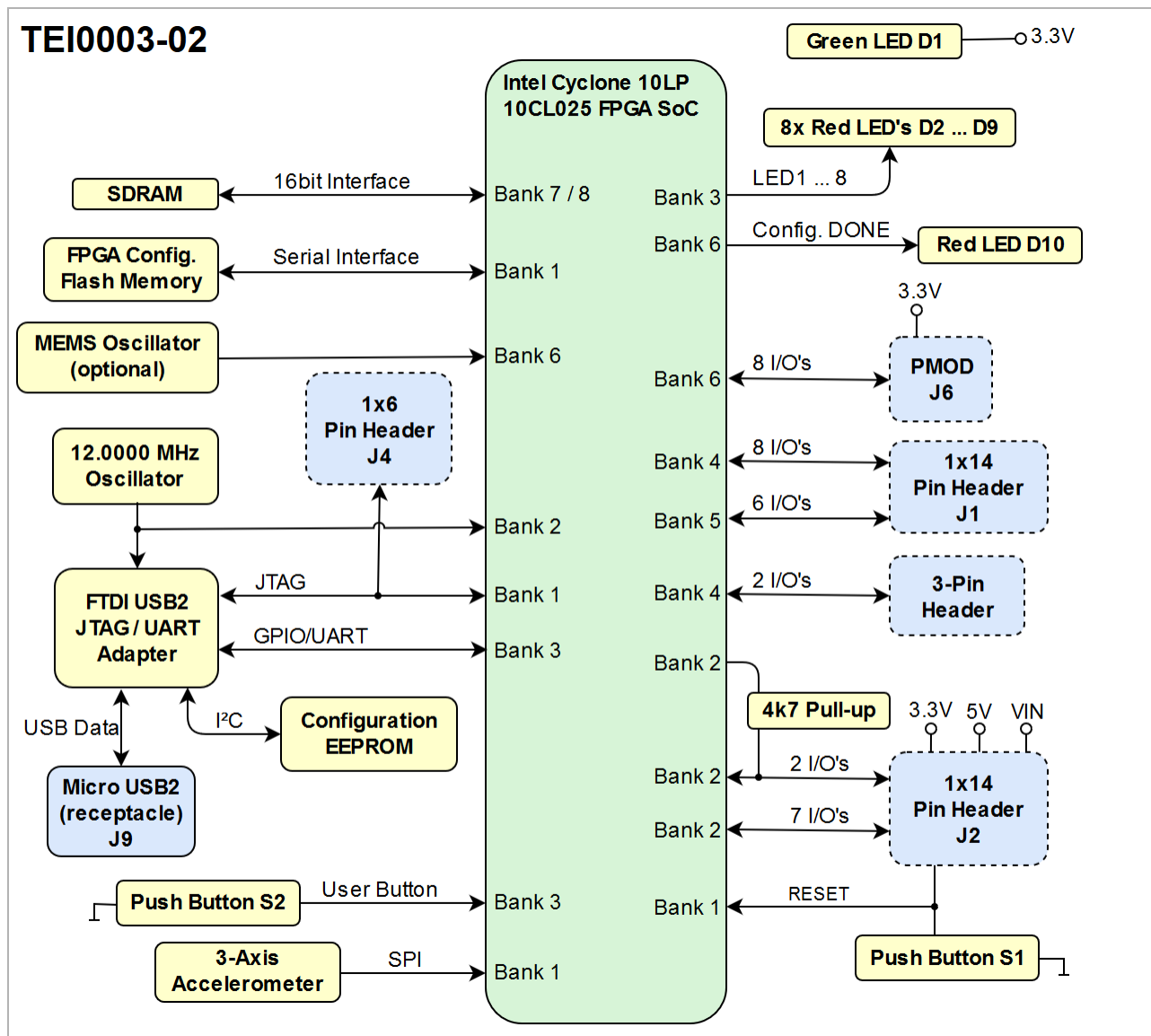


Figure 1: TEI0003-02 block diagram

## Main Components

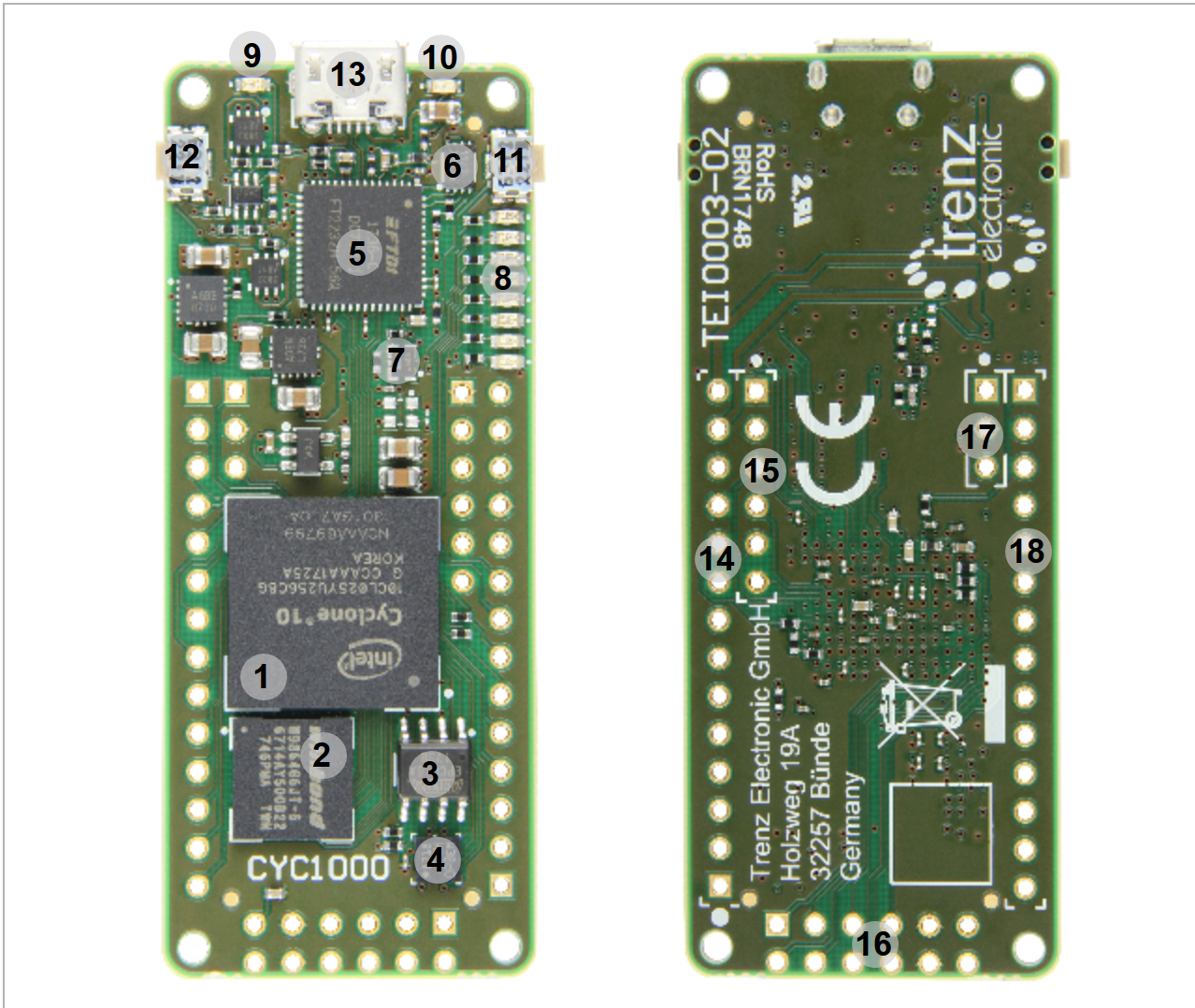


Figure 2: TEI0003-02 FPGA module

1. Intel Cyclone 10LP 10CL025 FPGA SoC, U1
2. 8 Mbyte SDRAM 166MHz, U2
3. 2 MByte serial configuration memory, U5
4. ST Microelectronics LIS3DH 3-axis accelerometer, U4
5. FTDI USB2 to JTAG/UART adapter, U3
6. Configuration EEPROM for FTDI chip, U9
7. 12.0000 MHz oscillator, U7
8. 8x red user LEDs, D2 ... D9
9. Red LED (Conf. DONE), D10
10. Green LED (indicating supply voltage), D1
11. Push button (user), S2
12. Push button (reset), S1
13. Micro USB2 B socket (receptacle), J9
14. 1x14 pin header (2.54mm pitch), J2
15. 1x6 pin header (2.54mm pitch), J4
16. 2x6 Pmod connector, J6
17. 3-pin header (2.54mm pitch), J3
18. 1x14 pin header (2.54mm pitch), J1

## Initial Delivery State

Storage device name	Content	Notes
Serial configuration memory, U5	DEMO Design	-
I <sup>2</sup> C Configuration EEPROM, U9	Programmed	-

Table 1: Initial delivery state of programmable devices on the module

## Boot Process

By default the configuration mode pins of the FPGA are set to load the FPGA design from the serial configuration memory at system start-up. The JTAG interface of the module is provided for storing the initial FPGA configuration data to the serial configuration memory.

## Signals, Interfaces and Pins

### I/Os on Pin Headers and Connectors

I/O signals of the FPGA SoC's I/O banks connected to the board's pin headers and connectors:

Bank	Connector Designator	I/O Signal Count	Bank Voltage	Notes
2	J2	9 I/O's	3.3V	2 I/O's of bank 2 can be pulled-up to 3.3V (4K7 resistors) with 2 I/O's of same bank or pins can be shared
4	J1	8 I/O's	3.3V	-
	J3	2 I/O's	3.3V	-
5	J1	6 I/O's	3.3V	-
6	J6	8 I/O's	3.3V	Pmod Connector
1	J4	4 I/O's	3.3V	JTAG interface
	J2	1 Input	3.3V	low active Reset input

Table 2: General overview of single ended I/O signals connected to pin headers and connectors

### FPGA I/O banks

Bank	I/O's Count	Connected to	Notes
1	6	LIS3DH digital motion sensor, U4	SPI interface, 2 interrupt lines
	4	1x6 pin header, J4	JTAG interface
	4	2 MByte serial configuration memory, U5	FPGA configuration memory with active serial (AS) x1 interface
	1	J2-10, push button S1	low active reset input
2	9	1x14 pin header, J2	GPIOs (2 I/O's of bank 2 can be pulled-up to 3.3V (4K7 resistors) with 2 I/O's of same Bank or pins can be shared)
3	8	LEDs D2 ... D9	8 x red user LEDs

	8	FTDI FT2232H JTAG/UART Adapter, U3	configurable as GPIO/UART or other serial interfaces
	1	push button S2	user button
4	10	pin headers J1, J3	GPIOs
5	6	pin headers J1	GPIOs
6	8	Pmod connector J6	GPIOs
	1	Red LED, D10	Configuration DONE Led (ON when configuration in progress, OFF when configuration is done)
7	19	8 Mbyte SDRAM 166MHz, U2	16bit SD-RAM memory interface
8	21		

**Table 3:** General overview of FPGA I/O banks

## JTAG Interface

Primary JTAG access to the FPGA SoC device U1 is provided through Micro USB2 B connector J9. The JTAG interface is created by the FTDI FT2232H USB2 to JTAG/UART adapter IC U3.

Optionally 1x6 male pin header J4 can be fitted on board for access to the JTAG interface on board. The pin assignment of header J4 is shown on table below:

JTAG Signal	Pin on Header J4	Note
TCK	3	-
TDI	5	-
TDO	4	-
TMS	6	-

**Table 4:** optional JTAG pin header

## On-board Peripherals

### Serial Configuration Memory

On-board serial configuration memory (U5) is provided by Intel EPCQ16ASI8N (EPCQ16SI8N in board revision TEI0003-02A) with 16 MBit (2 MByte) storage capacity. This non volatile memory is used to store initial FPGA configuration via JTAG interface. The memory is connected to FPGA bank 1 via active serial (AS) x1 interface.

Serial Memory U5 Pin	Signal Schematic Name	Connected to	Notes
Pin 2, DATA1	AS_DATA0	FPGA bank 1, pin H2	Data out
Pin 5, DATA0	AS_ASDO	FPGA bank 1, pin C1	Data in
Pin 1, nCS	AS_NCS	FPGA bank 1, pin D2	chip select
Pin 6, DCLK	AS_DCLK	FPGA bank 1, pin H1	clock

**Table 5:** Serial configuration memory interface connections

## SDRAM

The FPGA module is equipped with a Winbond W9864G6JT 64 MBit (8 MByte) SDRAM chip U2. This SDRAM chip is connected to the FPGA bank 7 and 8 via 16-bit memory interface with 166MHz clock frequency and CL3 CAS latency.

SDRAM I/O Signals	Signal Schematic Name	Connected to	Notes
Address inputs	A0 ... A13	bank 8	-
Bank address inputs	BA0 / BA1	bank 8	-
Data input/output	DQ0 ... DQ15	bank 7	-
Data mask	DQM0 ... DQM1	bank 7	-
Clock	CLK	bank 7	
Control Signals	CS	bank 8	Chip select
	CKE	bank 8	Clock enable
	RAS	bank 8	Row Address Strobe
	CAS	bank 8	Column Address Strobe
	WE	bank 8	Write Enable

Table 6: 16bit SDRAM memory interface

## FTDI FT2232H Chip

The FTDI chip U3 converts signals from USB2.0 to a variety of standard serial and parallel interfaces. Refer to the FTDI [data sheet](#) to get information about the capacity of the FT2232H chip.  
FTDI FT2232H chip is used in MPPSE mode for JTAG, 2 I/O's of channel A and 6 I/O's of Channel B are routed to FPGA bank 3 of the FPGA SoC and are usable for example as GPIOs, UART or other standard interfaces.

The configuration of FTDI FT2232H chip is pre-programmed on the EEPROM U9.

FTDI Chip U3 Pin	Signal Schematic Name	Connected to	Notes
Pin 12, ADBUS0	TCK	FPGA bank 1, pin H3	JTAG interface
Pin 13, ADBUS1	TDI	FPGA bank 1, pin H4	
Pin 14, ADBUS2	TDO	FPGA bank 1, pin J4	
Pin 15, ADBUS3	TMS	FPGA bank 1, pin J5	
Pin 17, ADBUS4	ADBUS4	FPGA bank 3, pin M8	user configurable
Pin 20, ADBUS7	ADBUS7	FPGA bank 3, pin N8	user configurable
Pin 32, BDBUS0	BDBUS0	FPGA bank 3, pin	user configurable
Pin 33, BDBUS1	BDBUS1	FPGA bank 3, pin	user configurable
Pin 34, BDBUS2	BDBUS2	FPGA bank 3, pin	user configurable
Pin 35, BDBUS3	BDBUS3	FPGA bank 3, pin	user configurable
Pin 37, BDBUS4	BDBUS4	FPGA bank 3, pin	user configurable
Pin 38, BDBUS5	BDBUS5	FPGA bank 3, pin	user configurable

Table 7: FTDI chip interfaces and pins

## 3-Axis Accelerometer

On the TEI0003 FPGA board there is a 3-axis accelerometer present. This accelerometer provided by ST Microelectronics LIS3DH offers many function to detect motion and has also a temperature sensor integrated. It also has a FIFO buffer for storing output data. The sensor is connected to the FPGA through SPI interface and two interrupt lines.

Accelerometer U4 Pin	Signal Schematic Name	Connected to	Notes
Pin 11, INT1	SEN_INT1	FPGA bank 1, pin B1	Interrupt lines
Pin 9, INT2	SEN_INT2	FPGA bank 1, pin C2	
Pin 6, SDA/SDI/SDO	SEN_SDI	FPGA bank 1, pin G2	SPI interface
Pin 7, SDO/SA0	SEN_SDO	FPGA bank 1, pin G1	
Pin 4, SCL/SPC	SEN_SPC	FPGA bank 1, pin F3	
Pin 8, CS	SEN_CS	FPGA bank 1, pin D1	
Pin 13, ADC3	ADC3	5V	Sense 5V input voltage

**Table 8:** 3-axis accelerometer interfaces and pins

## System Clock Oscillator

The FPGA SoC module has following reference clocking signals provided by on-board oscillators:

Clock Source	Schematic Name	Frequency	Clock Input Destination
Microchip MEMS Oscillator, U7	CLK12M	12.0000 MHz	FTDI FT2232 U3, pin 3; FPGA SoC bank 2, pin M2
optional Microchip MEMS Oscillator, U6 (not fitted)	CLK_X	-	FPGA SoC bank 6, pin E15

**Table 9:** Clock sources overview

## On-board LEDs

There are 10 LEDs fitted on the FPGA module board. The LEDs are user configurable to indicate for example any system status.

LED	Color	Signal Schematic Name	FPGA	Notes
D1	Green	-	-	Indicating 3.3V board supply voltage
D2	Red	'LED1'	bank 6, pin M6	user
D3	Red	'LED2'	bank 6, pin T4	user
D4	Red	'LED3'	bank 6, pin T3	user
D5	Red	'LED4'	bank 6, pin R3	user
D6	Red	'LED5'	bank 6, pin T2	user
D7	Red	'LED6'	bank 6, pin R4	user
D8	Red	'LED7'	bank 6, pin N5	user
D9	Red	'LED8'	bank 6, pin N3	user
D10	Red	'CONF_DONE'	bank 6, pin H14	indication configuration is DONE when LED is off

**Table 10:** LEDs of the module

## Push Buttons

The FPGA module is equipped with two push buttons S1 and S2:

Button	Signal Schematic Name	FPGA	Notes
--------	-----------------------	------	-------

S1	'USER_BTN'	bank 3, pin N6	user configurable
S2	'RESET'	bank 1, pin H5	system reset

**Table 11:** Push buttons of the module

## Connectors

All connectors are for 100mil headers, all connector locations are in 100mil (2.54mm) grid. The module's PCB provides footprints to mount and solder optional pin headers, if those are not factory-fitted on module.

## Power and Power-On Sequence

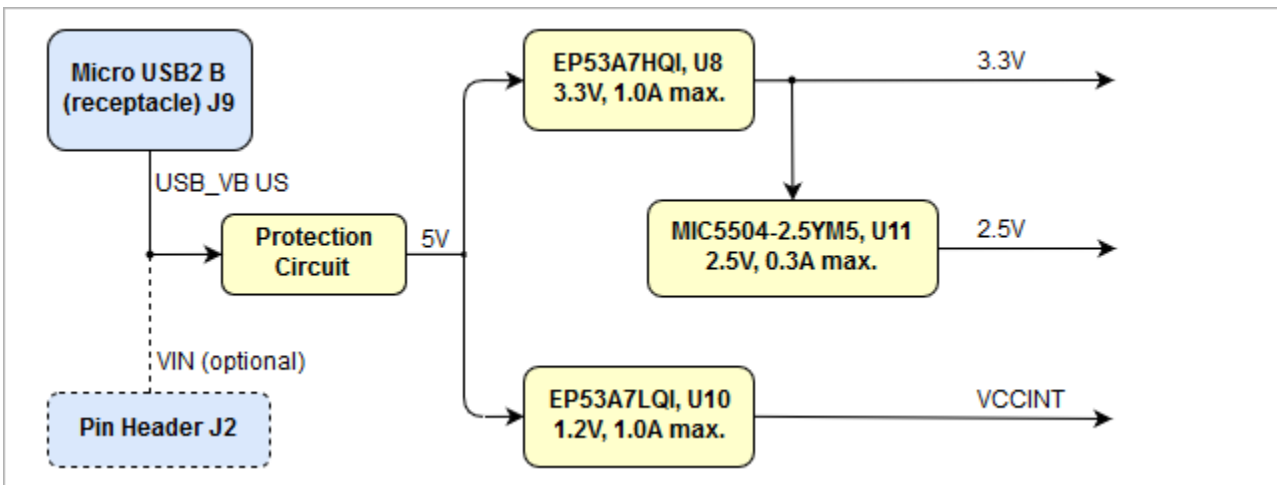
To power-up a module, power supply with minimum current capability of 1A is recommended.

## Power Supply

The FPGA module can be power-supplied through Micro USB2 connector J9 with supply voltage 'USB-VBUS' or alternative through pin header J2 with supply voltage 'VIN'.

The TEI0003 module needs one single power supply of 5.0V nominal.

There are following dependencies how the initial voltage of the extern power supply is distributed to the on-board DCDC converters:



**Figure 3:** Power Distribution Diagram

## Power Consumption

FPGA	Design	Typical Power, 25C ambient
Intel Cyclone 10LP 10CL025 FPGA SoC	Not configured	TBD*

**Table 12:** Module power consumption

\*TBD - To Be Determined.

Actual power consumption depends on the FPGA design and ambient temperature.



## Power-On Sequence

There is no specific or special power-on sequence, just one single power source is needed.

## Power Rails

Connector Designator	VCC / VCCIO Schematic Name	Voltage	Direction	Pins	Notes
J2	5V	5.0V	Out	Pin 14	-
	VIN	5.0V	In	Pin 13	-
	3.3V	3.3V	Out	Pin 12	-
J6	3.3V	3.3V	Out	Pin 6, 12	-
J9	USB_VBUS	5.0V	In	Pin 1	-

Table 13: Connector power pin description

## Bank Voltages

Bank	Voltage	Voltage Range
1	3.3V	all bank voltages fixed
2	3.3V	
3	3.3V	
4	3.3V	
5	3.3V	
6	3.3V	
7	3.3V	
8	3.3V	

Table 14: FPGA SoC VCCO bank voltages

## Technical Specifications

### Absolute Maximum Ratings

Parameter	Min	Max	Units	Reference document
VIN supply voltage (5.0V nominal)	-0.3	6.0	V	EP53A7HQI / EP53A7LQI datasheet
I/O Input voltage for FPGA I/O bank	-0.5	4.2	V	Intel Cyclone 10 LP datasheet
Storage Temperature	-40	+90	°C	LED R6C-AL1M2VY/3T datasheet

Table 15: Absolute maximum ratings

## Recommended Operating Conditions

Parameter	Min	Max	Units	Reference document
VIN supply voltage (5.0V nominal)	4.75	5.25	V	same as USB-VBUS specification
I/O Input voltage for FPGA I/O bank	-0.5	3.6	V	Intel Cyclone 10 LP datasheet
Operating temperature range	0	+70	°C	Winbond datasheet <a href="#">W9864G6GT</a>

**Table 16:** Recommended operating conditions

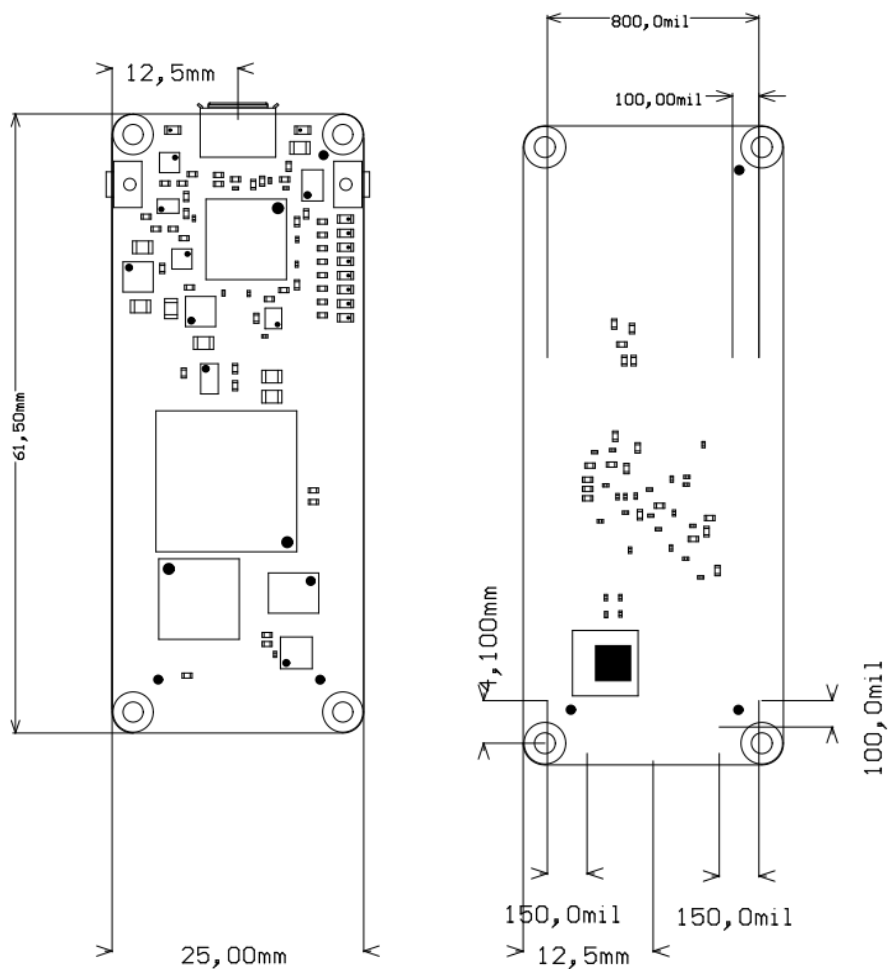


Please check Intel Cyclone 10 LP datasheet for complete list of absolute maximum and recommended operating ratings for the FPGA device.

## Physical Dimensions

Please note that two different units are used on the figures below, SI system millimeters (mm) and imperial system thousandths of an inch(mil). This is because of the 100mil pin headers used, see also explanation below. To convert mils to millimeters and vice versa use formula  $100\text{mil's} = 2,54\text{mm}$ .

- Board size: PCB 25mm × 61,5mm. Notice that some parts the are hanging slightly over the edge of the PCB like the the Micro USB2 B connector, which determine the total physical dimensions of the carrier board. Please download the assembly diagram for exact numbers.
- PCB thickness: ca. 1.65mm
- Highest part on the PCB without fitted headers and connectors is the Micro USB2 B connector, which has an approximately hight of 3 mm. Please download the step model for exact numbers.



**Figure 4: Module physical dimensions drawing**

## Revision History

### Hardware Revision History

Date	Revision	Notes	PCN	Documentation Link
-	02	First Production Release	-	<a href="#">TEI0003-02</a>
-	01	Prototypes	-	-

**Table 17:** Module hardware revision history

Hardware revision number is printed on the PCB board together with the module model number separated by the dash.

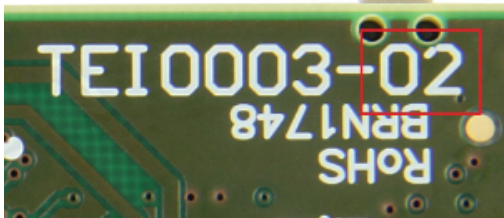



Figure 5: Module hardware revision number

Document Change History

Date	Revision	Contributors	Description
<div><p><b>Error rendering macro 'page-info'</b></p><p>Ambiguous method overloading for method jdk.proxy279.\$Proxy4022#hasContentLevelPermission. Cannot resolve which method to invoke for [null, class java.lang.String, class com.atlassian.confluence.pages.Page] due to overlapping prototypes between: [interface com.atlassian.confluence.user.ConfluenceUser, class java.lang.String, class com.atlassian.confluence.core.ContentEntityObject] [interface com.atlassian.user.User, class java.lang.String, class com.atlassian.confluence.core.ContentEntityObject]</p></div>	<div><p><b>Error rendering macro 'page-info'</b></p><p>Ambiguous method overloading for method jdk.proxy279.\$Proxy4022#hasContentLevelPermission. Cannot resolve which method to invoke for [null, class java.lang.String, class com.atlassian.confluence.pages.Page] due to overlapping prototypes between: [interface com.atlassian.confluence.user.ConfluenceUser, class java.lang.String, class com.atlassian.confluence.core.ContentEntityObject] [interface com.atlassian.user.User, class java.lang.String, class com.atlassian.confluence.core.ContentEntityObject]</p></div> <div><p> <b>Unknown macro: 'metadata'</b></p></div>	<div><p><b>Error rendering macro 'page-info'</b></p><p>Ambiguous method overloading for method jdk.proxy279.\$Proxy4022#hasContentLevelPermission. Cannot resolve which method to invoke for [null, class java.lang.String, class com.atlassian.confluence.pages.Page] due to overlapping prototypes between: [interface com.atlassian.confluence.user.ConfluenceUser, class java.lang.String, class com.atlassian.confluence.core.ContentEntityObject] [interface com.atlassian.user.User, class java.lang.String, class com.atlassian.confluence.core.ContentEntityObject]</p></div>	<div><ul style="list-style-type: none"><li>• First TRM release</li></ul></div>

**Table 18:** Document change history

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