INTERGALAKTIK

Vižovljanska ulica 4
10 000 Zagreb
OIB: 20377969701
Kontakt: 091 517 7844
Mail: warp@intergalaktik.eu

MANUAL FOR THE USE OF MODULAR TILES

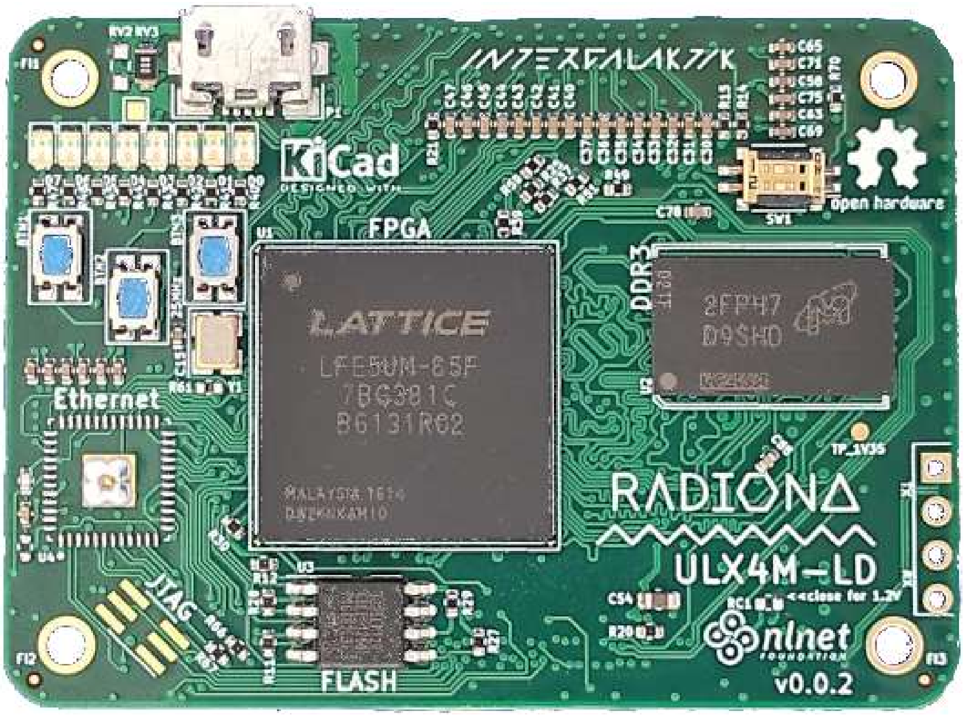
ULX4M-LD

Vižovljanska ulica 4
10 000 Zagreb
OIB: 20377969701
Kontakt: 091 517 7844
Mail: warp@intergalaktik.eu

SADRŽAJ

Vižovljanska ulica 4
10 000 Zagreb
OIB: 20377969701
Kontakt: 091 517 7844
Mail: warp@intergalaktik.eu

ULX4M-LD (Lattice+DDR3)



Slika 1. ULX4M-LD modular plate

FPGA: Lattice ECP5 LFE5U-85F-6BG381C (12/25/45/85K LUT)

Vižovljanska ulica 4
10 000 Zagreb
OIB: 20377969701
Kontakt: 091 517 7844
Mail: warp@intergalaktik.eu

1. Introduction

ULX4M-LD (Lattice + DDR3) is a system on a module (SoM) board that can be used on CM4 compatible base boards or as a standalone board.

1.1. Main parts

- LFE5UM-85F-8BG381C
- MT41K256M16TW-107 512MB DDR3
- W25Q128JVSIM NOR Flash spiFlash, 3V, 128M-bit, 4Kb Uniform Sector
- Ethernet – KSZ9031RNXCA

1.2. Programing options

External JTAG programming connector

JTAG connected to GPIO (programming with FTDI or ESP32)

USB (bootloader)

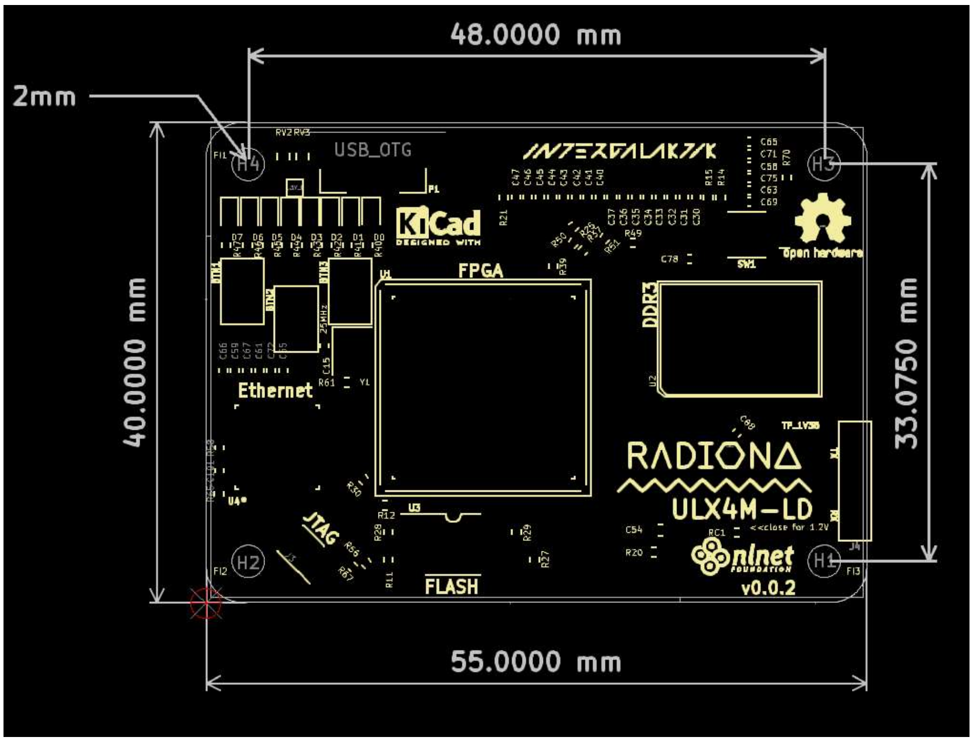
1.3. Periferije

- 2 lane CSI camera port CAM0 and CAM1
- 2 lane DSI display port DISP0 (fake differential)
- SerDes pair connected to second DSI connector DISP1
- SerDes pair (TX/RX) connected to 2.0 header (radio experiments)
- True differential GPDI video output
- Fake differential GPDI video output

Vižovljanska ulica 4
10 000 Zagreb
OIB: 20377969701
Kontakt: 091 517 7844
Mail: warp@intergalaktik.eu

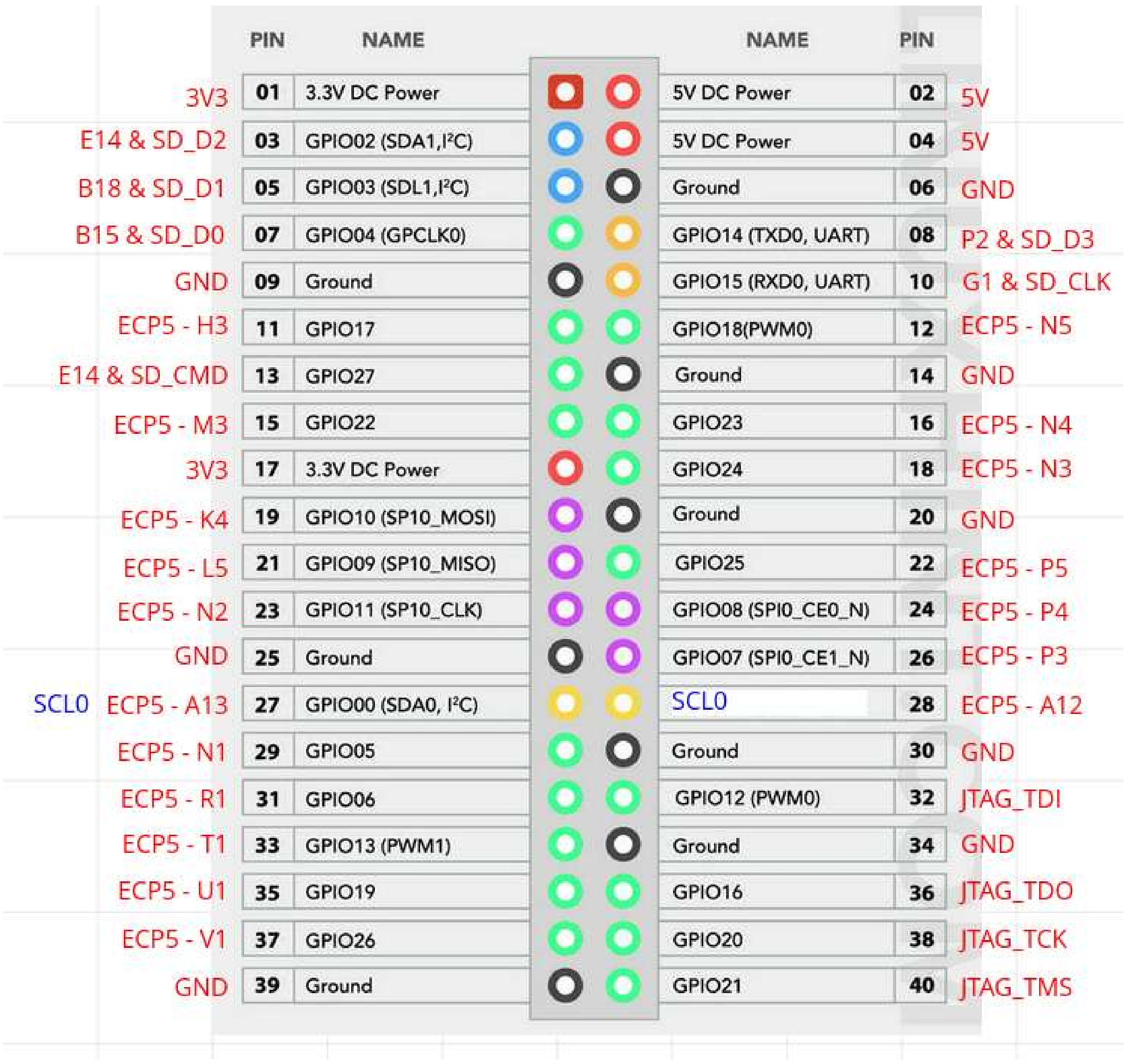
- SD card connection - shared with HAT pins
- SerDes connected to PCIe 1x
- 2x SerDes pairs connected over capacitors to connector
- GPIOs
- 3 Buttons
- 2 DIP SW
- 8 LEDs

1.4. Electrical and mechanical specifications



Slika 2. Electrical and mechanical specifications

1.5. Pinout



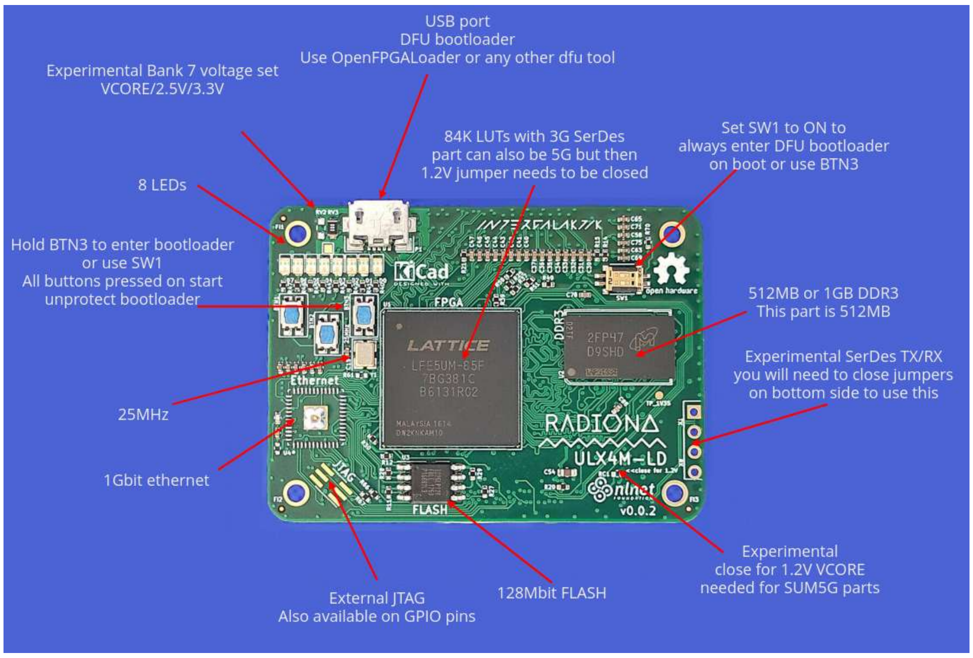
	PIN	NAME			NAME	PIN	
3V3	01	3.3V DC Power	🟥	🔴	5V DC Power	02	5V
E14 & SD_D2	03	GPIO02 (SDA1,I²C)	🔵	🔴	5V DC Power	04	5V
B18 & SD_D1	05	GPIO03 (SDL1,I²C)	🔵	⚫	Ground	06	GND
B15 & SD_D0	07	GPIO04 (GPCLK0)	🟢	🟡	GPIO14 (TXD0, UART)	08	P2 & SD_D3
GND	09	Ground	⚫	🟡	GPIO15 (RXD0, UART)	10	G1 & SD_CLK
ECP5 - H3	11	GPIO17	🟢	🟢	GPIO18(PWM0)	12	ECP5 - N5
E14 & SD_CMD	13	GPIO27	🟢	⚫	Ground	14	GND
ECP5 - M3	15	GPIO22	🟢	🟢	GPIO23	16	ECP5 - N4
3V3	17	3.3V DC Power	🔴	🟢	GPIO24	18	ECP5 - N3
ECP5 - K4	19	GPIO10 (SPI0_MOSI)	🟣	⚫	Ground	20	GND
ECP5 - L5	21	GPIO09 (SPI0_MISO)	🟣	🟢	GPIO25	22	ECP5 - P5
ECP5 - N2	23	GPIO11 (SPI0_CLK)	🟣	🟣	GPIO08 (SPI0_CE0_N)	24	ECP5 - P4
GND	25	Ground	⚫	🟣	GPIO07 (SPI0_CE1_N)	26	ECP5 - P3
SCL0 ECP5 - A13	27	GPIO00 (SDA0, I²C)	🟡	🟡	SCL0	28	ECP5 - A12
ECP5 - N1	29	GPIO05	🟢	⚫	Ground	30	GND
ECP5 - R1	31	GPIO06	🟢	🟢	GPIO12 (PWM0)	32	JTAG_TDI
ECP5 - T1	33	GPIO13 (PWM1)	🟢	⚫	Ground	34	GND
ECP5 - U1	35	GPIO19	🟢	🟢	GPIO16	36	JTAG_TDO
ECP5 - V1	37	GPIO26	🟢	🟢	GPIO20	38	JTAG_TCK
GND	39	Ground	⚫	🟢	GPIO21	40	JTAG_TMS

Slika 3. Input/output pins

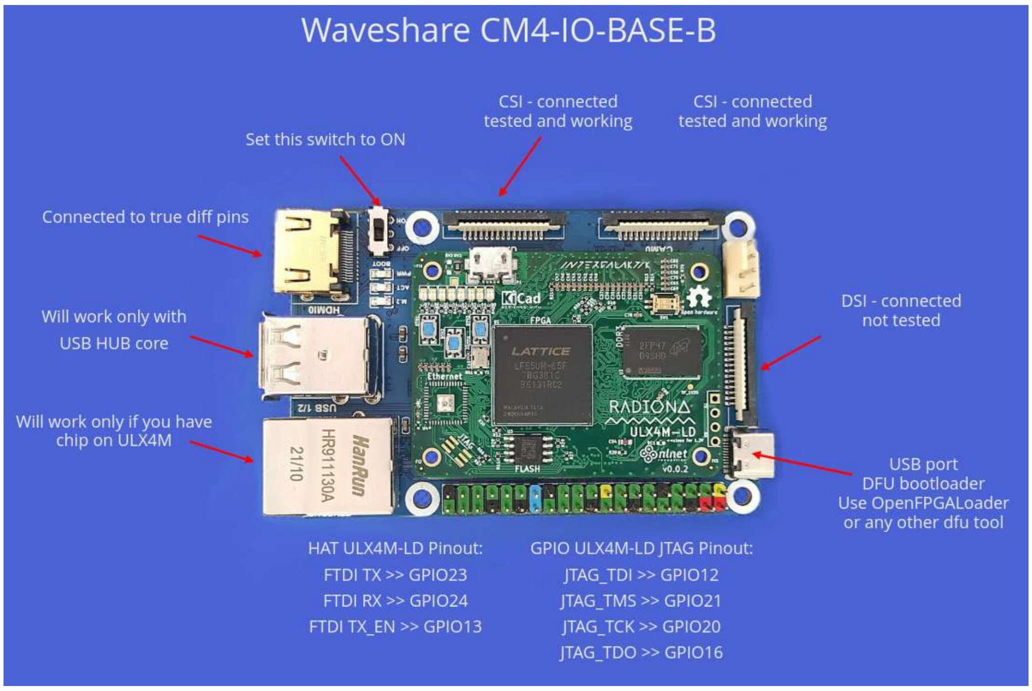
1.6. Power

ULX4M requires at least 500mA to function safely. A 5V power supply can be provided over a USB port or over GPIO. 3.3V OUTPUT from ULX3S can handle up to 1A if appropriate input power is used.

2. ULX4M-LD description and instructions


USB port
DFU bootloader
Use OpenFPGALoader or any other dfu tool
Experimental Bank 7 voltage set
VCORE/2.5V/3.3V
84K LUTs with 3G SerDes
part can also be 5G but then
1.2V jumper needs to be closed
Set SW1 to ON to
always enter DFU bootloader
on boot or use BTN3
8 LEDs
Hold BTN3 to enter bootloader
or use SW1
All buttons pressed on start
unprotect bootloader
512MB or 1GB DDR3
This part is 512MB
Experimental SerDes TX/RX
you will need to close jumpers
on bottom side to use this
25MHz
1Gbit ethernet
Experimental
close for 1.2V VCORE
needed for SUM5G parts
External JTAG
Also available on GPIO pins
128Mbit FLASH

Slika 4. Board parts (instructions)



HAT ULX4M-LD Pinout:	GPIO ULX4M-LD JTAG Pinout:
FTDI TX >> GPIO23	JTAG_TDI >> GPIO12
FTDI RX >> GPIO24	JTAG_TMS >> GPIO21
FTDI TX_EN >> GPIO13	JTAG_TCK >> GPIO20
	JTAG_TDO >> GPIO16

Slika 5. ULX4M-LD on Waveshare baseboard

On this version SD_CARD is also connected to GPIO pins, so we can share it with ESP32 as on ULX3S.

On this version FPGA JTAG pins are connected to some GPIO pins so you will not be able to use them as GPIOs, but you can access JTAG over GPIO.

If a Waveshare IO board is used it can be powered from USB-C.

If you are using a Raspberry IO board then you will need 12V DC input as micro USB does not have 5V connected. There is one wire hack that can provide 5V from USB to the board. If this hack is used USB HOST will not work as it will disable HUB chip.

3. ULX4M-LD on the internet

3.1. ULX4M-LD design files

https://github.com/intergalaktik/ulx4m/tree/ulx4m-ls

3.2. ULX4M-LD v2 schematics

https://github.com/intergalaktik/ulx4m/blob/ulx4m-ld/doc/schematics.pdf

3.3. ULX4M-LD v2 LPF

https://github.com/intergalaktik/ulx4m/blob/ulx4m-ls/doc/constraints/prototype/ulx4m-ld_v002.lpf

3.4. ULX4M examples

https://github.com/lawrie/ulx4m_examples

https://github.com/lawrie/ulx4m_amaranth_examples

https://github.com/emard/ulx3s-misc

https://github.com/emard/had2019-playground/tree/master/projects/bootloader

https://github.com/goran-mahovlic/mipi-csi-2

https://github.com/hdl4fpga/hdl4fpga

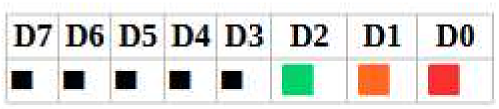
4. DFU bootloader for ULX4M

USB DFU at US1 port for FPGA flashing. DFU is very fast.

Source is based on HAD2019 badge bootloader modified to ULX3S bootloader

Bootloader by default skips to the user's bitstream. If FLASH doesn't contain a valid user's bitstream, LEDs will blink because the bootloader is constantly restarting. This is normal.

To enter bootloader, hold BTN2 or set DIP SW1=ON and plug US1 In bootloader mode, LEDs 0-2 should be ON, other LEDs 3-7 OFF:



D7	D6	D5	D4	D3	D2	D1	D0
■	■	■	■	■	🟩	🟧	🟥

```
lsusb
```

```
Bus 001 Device 117: ID 1d50:614b OpenMoko, Inc. ULX4M-LD(DFU)
```

On linux, it's practical to add a udev rule which allows normal users members of "dialout" group to also run dfu-util, otherwise it should be run as root:

```
# file: /etc/udev/rules.d/80-fpga-dfu.rules

# this is for DFU 1d50:614b libusb access

ATTRS{idVendor}=="1d50", ATTRS{idProduct}=="614b", \

GROUP="dialout", MODE="666"
```

DFU is very fast, writes bitstreams in a few seconds.

4.1. Usage

To upload a user bitstream, hold BTN2 or turn on DIP SW1 and plug USB. Here are some commandline examples:

```
openFPGALoader -b ulx3s-dfu blink.bit
```

or

```
dfu-util -a 0 -D blink.bit
```

To exit the launcher and execute the user bitstream, use the

Vižovljanska ulica 4
10 000 Zagreb
OIB: 20377969701
Kontakt: 091 517 7844
Mail: warp@intergalaktik.eu

command DFU:

```
dfu-util -a 0 -e
```

To upgrade bootloader, hold BTN1 and BTN2 and plug USB:

4.2. Write Protecting Bootloader

To prevent accidental overwriting, flash chips have options to protect a range of address space.

16MB ISSI and Winbond FLASH chips are supported

Different FLASH chips have standard/compatible commands for reading and writing but different commands for write protection. On ULX3S usual 16MB chips are ISSI IS25LP128 or Winbond W25Q128, both are supported by esp32ecp5 and work.

4MB ISSI FLASH chip is not supported

ISSI IS25LP032 4MB is actually "supported", it has the same datasheet and commands as IS25LP128 but the onboard chip probably has some bug, it can't protect the address range where the bootloader is.

Protected range: first 2MB

For this bootloader, the first 2MB (address 0 - 0x1FFFFF) should be write protected. It contains a bootloader bitstream and some data structure that can jump to the user's bitstream which starts from 0x200000.

From what it protects

FLASH protection applied here is based on non-OTP bits so it's reversible and protects from accidental overwriting with "fujprog", "esp32ecp5" and DFU bootloader itself. "fujprog" will segfault early, "esp32ecp5" will stop after the first block verify, bootloader will upload data without error but content will not be written.

The current version of "openFPGALoader" will silently remove non-OTP write protection, overwrite the bootloader and leave the FLASH chip unprotected.

ISSI FLASH should be always safe and reversible. Winbond FLASH protection can set non-reversible OTP status register lock bit and in that case, there is no known way to remove protection.

Vižovljanska ulica 4
10 000 Zagreb
OIB: 20377969701
Kontakt: 091 517 7844
Mail: warp@intergalaktik.eu

5. Chat and support

Discord channel

- https://discord.gg/qwMUk6W (problems/question/general chat)

5.1. Instructions for safe use

This product shall be connected to a computer/laptop USB port or external power supply rated at 5V DC with maximum current of 2A. Any external power supply used with ULX4M shall comply with relevant regulations and standards applicable in the country of intended use. This product should be operated in a well ventilated environment and should not be covered.

This product should be placed on a stable, flat, non-conductive surface in use and should not be contacted by conductive items. The connection of unapproved devices to any receptacle may affect compliance or results in damage to the unit and invalidate the warranty.

Do not expose it to water, moisture or place on a conductive surface whilst in operation Do not expose it to heat from any source; ULX4M is designed for reliable operation at normal ambient room temperatures. Take care whilst handling to avoid mechanical or electrical damage to the printed circuit board and connectors. Avoid handling ULX4M while it is powered.

Only handled by the edges to minimize the risk of electrostatic discharge damage. All peripherals used with ULX4M should comply with relevant standards for the country of use and be marked accordingly to ensure that safety and performance requirements are met. ULX4M requires at least 500mA to function safely.