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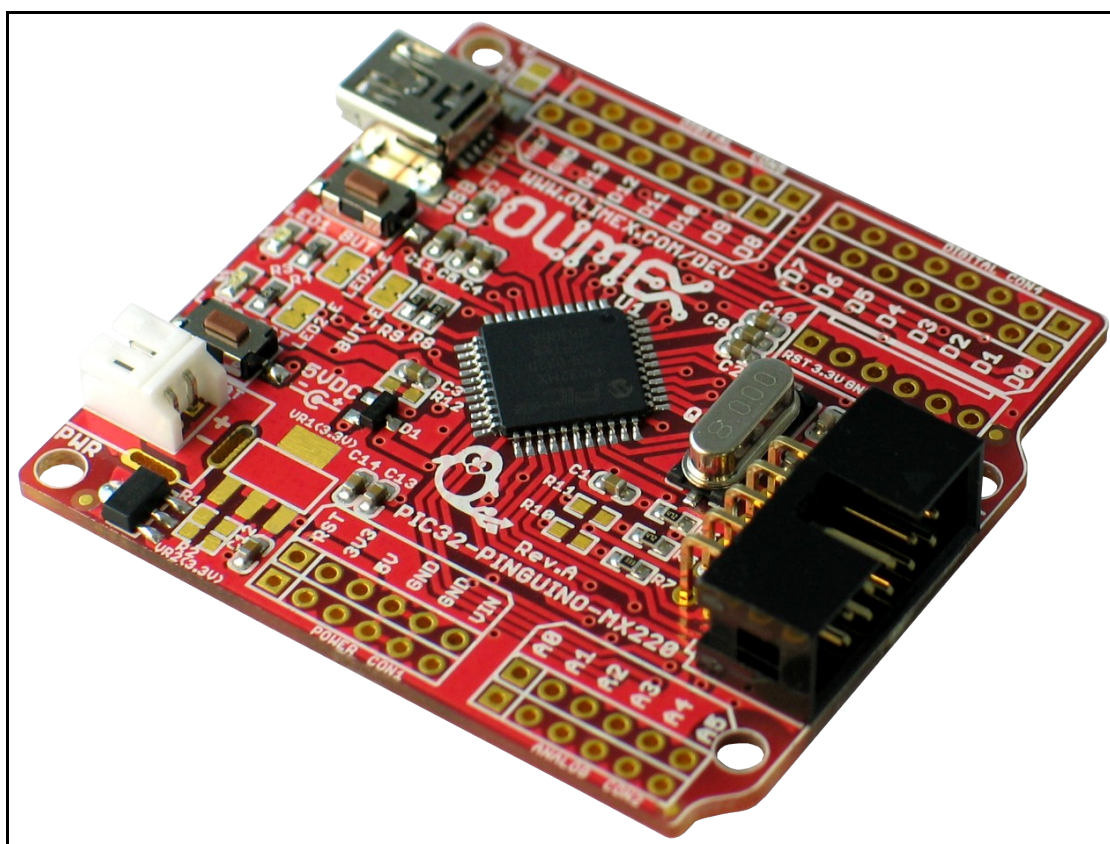
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PIC32-PINGUINO-MX220 development board USER'S MANUAL

Initial release, March 2012
Designed by OLIMEX Ltd, 2011



All boards produced by Olimex LTD are ROHS compliant

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**Thank you for purchasing PIC32-PINGUINO-MX220 development board
assembled by OLIMEX LTD**

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CHAPTER 1

OVERVIEW

1. Introduction to the chapter

Thank you for choosing the PIC32-PINGUINO-MX220 development board from Olimex! This document provides a User's Guide for the Olimex PIC32-PINGUINO-MX220 development board. As an overview, this chapter gives the scope of this document and lists the board's features. The document's organization is then detailed.

The PIC32-PINGUINO-MX220 development board enables code development of applications running on the PIC32MX220F032D microcontroller, manufactured by Microchip technology.

1.1 Features

- PIC32MX220F032D 32 bit, 40 Mhz microcontroller 32KB Flash 8KB RAM
- Ultra Low Power design
- PINGUINO IDE ready
- Li-Po battery connector for handheld applications
- Arduino/Pinguino/Maple shield pinout on the top
- [UEXT connector](#) which allows many extensions modules like RF, ZIGBEE, GSM, GPS to be connected
- Two LEDs
- One USER BUTTON
- RESET button
- Mini USB connector is used which is common and used in most cell phones, so you do not have to buy other cables
- All PIC ports available on 0.1" connectors matching ARDUINO platform and second row with correct 0.1" step
- ICSP signals provided on 0.1" step connector if you do not want to use Pinguino IDE and want to program this board with PIC-KIT3.

1.2 Similar boards

PIC32-PINGUINO-MX220 is ARDUINO-UNO like board with PIC32MX220F032D. Generally

this board outperform ARDUINO-UNO as hardware capabilities as you can see from the table below while being considerably cheaper:

	PIC32-PINGUINO-MX220	ARDUINO-UNO
CPU	32bit	32bit
CLOCK	40MHz	20MHz
FLASH	32KB	32KB
RAM	8KB	1KB
USB	YES	NO
LOW PWR	YES	NO
GPIO MAX	40MHz	5MHz
ADC	1.1MSPS	15KSPS
DMA	YES 4 Channel	NO
UEXT	YES	NO

PIC32-PINGUINO-MX220 is a powerful considering its low price but yet a starter board for the PINGUINO family. If you are searching for powerful Pinguino board with a faster processor, more memory, more peripherals, wider range of options be sure to check the PIC32-PINGUINO-OTG: <http://olimex.com/dev/pic32-pinguino-otg.html>

1.3 Organization

Each section in this document covers a separate topic, organized as follow:

- Chapter 1 is an overview of the board usage and features
- Chapter 2 has a short introduction to Arduino platform and its derivatives Pinguino and Maple
- Chapter 3 provides a guide for quickly setting up the board
- Chapter 4 contains the general board diagram and layout
- Chapter 5 describes the component that is the heart of the board: the PIC32MX220F032D microcontroller
- Chapter 6 is an explanation of the control circuitry associated with the microcontroller to reset. Also shows the clocks on the board

- Chapter 7 covers the connector pinout, peripherals and jumper description
- Chapter 8 shows the processor diagram and memory map
- Chapter 9 provides the schematics
- Chapter 10 contains the revision history

CHAPTER 2

INTRODUCTION TO ARDUINO/PINGUINO/MAPLE

2. What is Arduino?

Arduino is an open-source electronics prototyping platform, designed to make the process of using electronics in multidisciplinary projects easily accessible. The hardware consists of a simple open hardware design for the Arduino board with an Atmel AVR processor and on-board I/O support. The software consists of a standard programming language and the boot loader that runs on the board.

Arduino hardware is programmed using a Wiring-based language (syntax + libraries), similar to C++ with some simplifications and modifications, and a Processing-based Integrated Development Environment (IDE).

The project began in Ivrea, Italy in 2005 aiming to make a device for controlling student-built interaction design projects less expensively than other prototyping systems available at the time. As of February 2010 more than 120,000 Arduino boards had been shipped. Founders Massimo Banzi and David Cuartielles named the project after a local bar named Arduino. The name is an Italian masculine first name, meaning "strong friend". The English pronunciation is "Hardwin", a namesake of Arduino of Ivrea.

More information could be found at the creators web page <http://arduino.cc/> and in the Arduino Wiki <http://en.wikipedia.org/wiki/Arduino>

To make the story short - Arduino is easy for beginners who lack Electronics knowledge, but also does not restrict professionals as they can program it in C++ or mix of Arduino/C++ language. There are thousands of projects which makes it easy to startup as there is barely no field where Arduino enthusiasts to have not been already.

Arduino has inspired two other major derivatives - MAPLE and PINGUINO. Based on 8-bit AVR technology the computational power of Arduino boards is modest, this is why a team from MIT developed the MAPLE project which is based on ARM7 STM32F103RBT6 microcontroller. The board have same friendly IDE as Arduino and offers the same capabilities as hardware and software but runs the Arduino code much faster. The Maple project can be found at <http://leaflabs.com>

In parallel with Arduino another project was started called PINGUINO. This project chose its first implementation to be with PIC microcontrollers, as AVRs were hard to find in some parts of the world like South America so it is likely to see lot of PINGUINO developers are from that part of the

world. PINGUINO project founders decided to go with Python instead Java for processing language. For the moment PINGUINO is much more flexible than Arduino as it is not limited to 8bit microcontrollers. Currently the IDE, which has GCC in background, can support 8-bit PIC microcontrollers, 32bit PIC32 (MIPS) microcontrollers and ARM7/CORTEXM3 microcontrollers which makes PINGUINO very flexible because once you make your project you can migrate easily through different hardware platforms and not being bound to a single microcontroller manufacturer. The PINGUINO project can be found at: <http://www.pinguino.cc>.

2.1 First steps with Pinguino IDE

Download the latest Pinguino IDE distribution depending on your operation system and install it. Connect your device in bootloader mode to the computer (for PIC32-PINGUINO-MX220 hold BUT and press RST after connected). Start the IDE from it's shortcut. From Preferences choose board (for PIC32-PINGUINO-MX220 that would be PIC32-Pinguino_220). From File->Open navigate to the examples folder which is found in the Pinguino IDE installation folder. Choose a simple example to begin with like BlinkWithoutDelay.pde and open it. Click "Compile" (blue arrow) and after it compiles click "Upload to Pinguino" (green arrow). Voila, you have uploaded code to your Pinguino device.

Now start exploring the world of Pinguino! More info and help on the software can be found and the official pinguino web site. You can leave your feedback on the project and report bugs at the forum: <http://forum.pinguino.cc/>.

CHAPTER 3

SETTING UP THE PIC32-PINGUINO-MX220 BOARD

3. Introduction to the chapter

This section helps you set up the PIC32-PINGUINO-MX220 development board for the first time. Please consider first the electrostatic warning to avoid damaging the board, then discover the hardware and software required to operate the board.

The procedure to power up the board is given, and a description of the default board behavior is detailed.

3.1 Electrostatic warning

PIC32-PINGUINO-MX220 is shipped in a protective anti-static package. The board must not be exposed to high electrostatic potentials. A grounding strap or similar protective device should be worn when handling the board. Avoid touching the component pins or any other metallic element.

3.2 Requirements

In order to set up the PIC32-PINGUINO-MX220, the following items are required:

If using the free PINGUINO IDE the ONLY requirement is a miniUSB to USB-A cable to connect to a computer.

If you want to upgrade the bootloader, or program the board without the PINGUINO-IDE there are pinouts for ICSP programmer (note that there isn't a connector mounted). You can use our PIC-KIT3 programmer for custom programming without PINGUINO IDE.

3.3 Powering the board

The PIC32-PINGUINO-MX220 board is self-powered by the miniUSB if it is connected to a USB hub of a computer.

To enter the bootloader mode hold the button BUT and then connect the miniUSB. Or after plugging the miniUSB hold the button BUT and then press RST.

On powering the board the AND starting bootloader mode LED1 and LED2 should start blinking consecutively.

3.4 Prebuilt software

The board comes with prebuilt PINGUINO bootloader. To enter this mode hold BUT and press RST then release BUT. Or connect the USB when BUT is pressed and then release BUT.

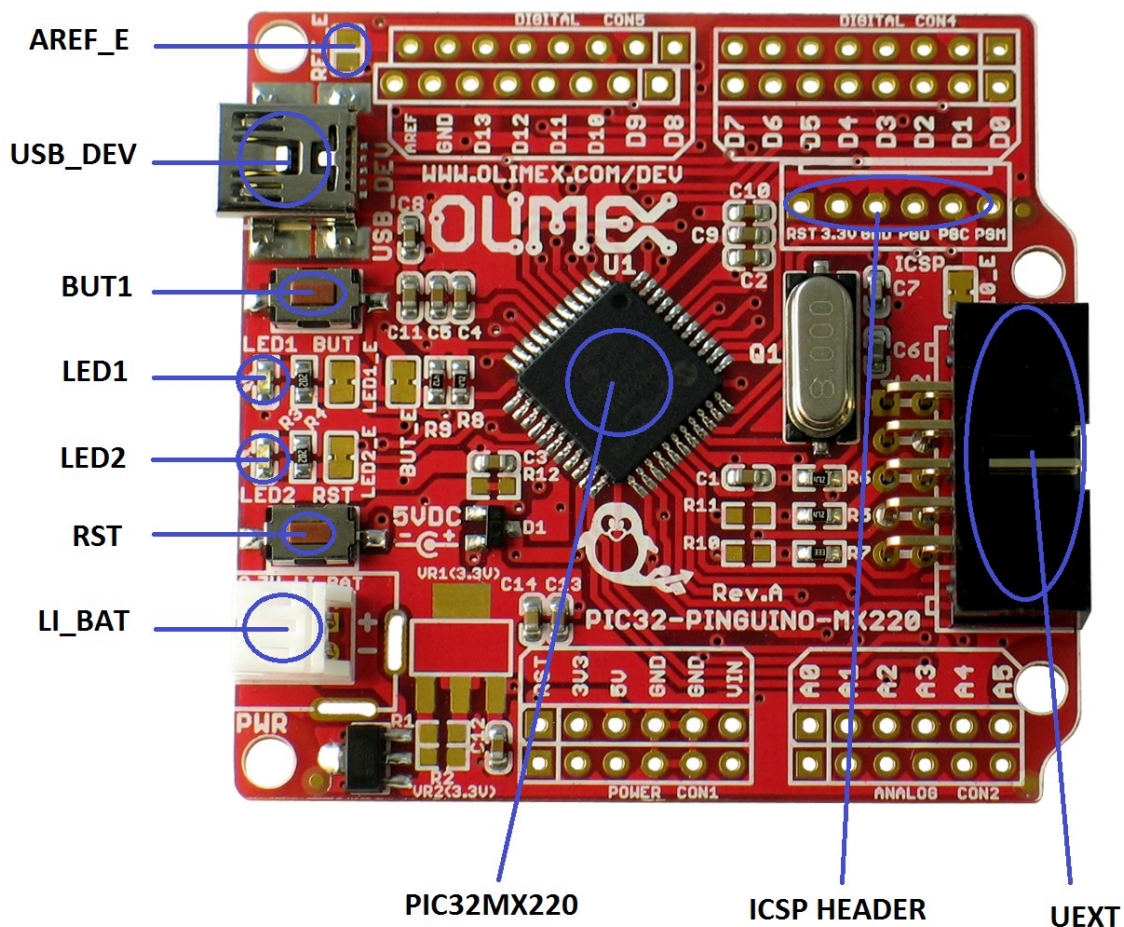
CHAPTER 4

PIC32-PINGUINO-MX220 BOARD DESCRIPTION

4. Introduction to the chapter

Here you get acquainted with the main parts of the board. Note the names used on the board differ from the names used to describe them. For the actual names check the PIC32-PINGUINO-MX220 board itself.

4.1 Layout (top view)



CHAPTER 5

THE PIC32MX220F032D MICROCONTROLLER

5. Introduction to the chapter

In this chapter is located the information about the heart of PIC32-PINGUINO-MX220 – its microcontroller. The information is a modified version of the datasheet provided by its manufacturers.

5.1 The microcontroller

Operating Conditions

- 2.3V to 3.6V, -40°C to +105°C, DC to 40 MHz

Core: 40 MHz MIPS32® M4K®

- MIPS16e® mode for up to 40% smaller code size
- 1.56 DMIPS/MHz (Dhrystone 2.1) performance
- Code-efficient (C and Assembly) architecture
- Single-cycle (MAC) 32x16 and two-cycle 32x32 multiply

Clock Management

- 0.9% internal oscillator
- Programmable PLLs and oscillator clock sources
- Fail-Safe Clock Monitor (FSCM)
- Independent Watchdog Timer
- Fast wake-up and start-up

Power Management

- Low-power management modes (Sleep, Idle)
- Integrated Power-on Reset and Brown-out Reset
- 0.5 mA/MHz dynamic current (typical)
- 20 µA IPD current (typical)

Audio Interface Features

- Data communication: I2S, LJ, RJ, DSP modes
- Control interface: SPI and I2C™
- Master clock:
 - Generation of fractional clock frequencies
 - Can be synchronized with USB clock
 - Can be tuned in run-time

Advanced Analog Features

- ADC Module:
 - 10-bit 1.1 Msps rate with one S&H
 - 13 analog inputs
- Flexible and independent ADC trigger sources
- Charge Time Measurement Unit (CTMU):
 - Supports mTouch™ capacitive touch sensing
 - Provides high-resolution time measurement (1 ns)
 - On-chip temperature measurement capability
- Comparators:
 - Up to three Analog Comparator modules
 - Programmable references with 32 voltage points

Timers/Output Compare/Input Capture

- Five General Purpose Timers:
 - Five 16-bit and up to two 32-bit Timers/Counters
- Five Output Compare (OC) modules
- Five Input Capture (IC) modules
- Peripheral Pin Select (PPS) to allow function remap
- Real-Time Clock and Calendar (RTCC) module

Communication Interfaces

- USB 2.0-compliant Full-speed OTG controller
- Two UART modules (10 Mbps)
 - Supports LIN 2.0 protocols and IrDA® support
- Two 4-wire SPI modules (20 Mbps)
- Two I2C modules (up to 1 Mbaud) with SMBus support
- Peripheral Pin Select (PPS) to allow function remap
- Parallel Master Port (PMP)

Direct Memory Access (DMA)

- Four channels of hardware DMA with automatic data size detection
- Two additional channels dedicated for USB
- Programmable Cyclic Redundancy Check (CRC)

Input/Output

- 15 mA source/sink on all I/O pins
- 5V-tolerant pins
- Selectable open drain, pull-ups, and pull-downs
- External interrupts on all I/O pins

Qualification and Class B Support

- AEC-Q100 REVG (Grade 2 -40°C to +105°C) planned

- Class B Safety Library, IEC 60730

Debugger Development Support

- In-circuit and in-application programming
- 4-wire MIPS® Enhanced JTAG interface
- Unlimited program and six complex data breakpoints
- IEEE 1149.2-compatible (JTAG) boundary scan

For comprehensive information on the microcontroller visit the Microchip's web page for a datasheet.

At the moment of writing the microcontroller datasheet can be found at the following link:

<http://ww1.microchip.com/downloads/en/DeviceDoc/61168D.pdf>

CHAPTER 6

CONTROL CIRCUITY

6. Introduction to the chapter

Here you can find information about reset circuit, power circuit and quartz crystal locations.

6.1 Reset

PIC32-PINGUINO-MX220 reset circuit includes R8 (4.7 K Ω), PIC32MX220F032D pin 18 (#MCLR) and a RESET button. Note that it also can be found at the ICSP header pin 1.

6.2 Clock

8 MHz quartz crystal Q1 is found at pins 30 and 31 of the processor.

CHAPTER 7

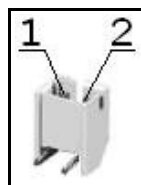
HARDWARE

7. Introduction to the chapter

In this chapter are presented the connectors that can be found on the board all together with their pinout. Proto area is shown. Jumpers functions are described. Notes and info on specific peripherals are presented. Notes regarding the interfaces are given.

7.1 Battery connector

Pin #	Signal Name
1	VBAT
2	GND



7.2 ICSP pin holes

The 6 pin ICSP header provides interface for custom programming/debugging outside of the PINGUINO IDE. Note the pin holes doesn't have a connector mouted over – you have to mount it/solder it yourself. The pinout can be found in the table below. It is important to check the jumper configuration for proper use of the ICSP pin hole .

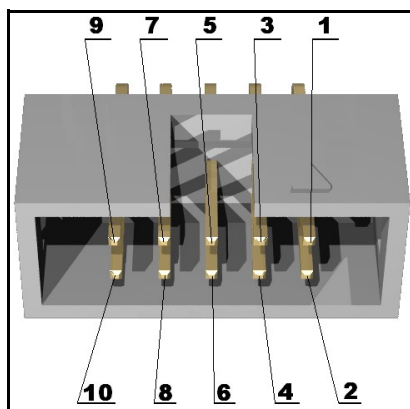
ICSP pin holes			
Pin #	Signal Name	Pin #	Signal Name
1	RESET	4	PGED3
2	+3.3V	5	PGEC3
3	GND	6	Not connected

7.3 UEXT

PIC32-PINGUINO-MX220 board has UEXT connector and can interface Olimex's UEXT modules. For more information on our UEXT modules please visit:

<http://www.olimex.com/dev/OTHER/UEXT.pdf>

Pin #	Signal Name
1	+3.3V
2	GND
3	U1TX
4	U2RX
5	SCL1
6	SDA1
7	SDI1
8	SDO1
9	SCK1
10	CS



7.4 Arduino shield pin holes

For your convenience the pads are named individually near each of them. Please take extra care about the numbering but consider that there might be offset.

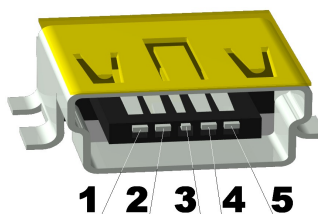
Also note that the board comes with no connectors soldered on the pin holes. Before being able to connect with a shield you have to solder connectors yourself.

Pad Name	Signal	Pad Name	Signal
POWER CON1		DIGITAL CON2	
RST	RESET	A0	AN6/RPC0/RC0
3V3	+3.3 V	A1	AN7/RPC1/RC1
5V	+5 V	A2	PGED1/AN2/C1IND/C2INB/C3 IND/RPB0/PMD0/RB0
GND	GROUND	A3	PGEC1/AN3/C1INC/C2INA/RP B1/CTED12/PMD1/RB1
GND	GROUND	A4	AN4/C1INB/C2IND/RPB2/SDA 2/CTED13/PMD2/CNB2/RB2
VIN	V in	A5	AN5/C1INA/C2INC/RTCC/RPB 3/SCL2/PMWR/CNB3/RB3
DIGITAL CON5		DIGITAL CON4	
AREF	A ref	D7	RPC7/PMA0/RC7
GND	GROUND	D6	RPC6/PMA1/RC6
D13	SCK2/LED1	D5	RPC5/PMA3/RC5
D12	SDI2	D4	RPC4/PMA4/RC4
D11	SDO2	D3	AN12/RPC3/RC3
D10	PGEC3	D2	AN8/RPC2/PMA2/RC2
D9	LED2	D1	U2TX
D8	BUT	D0	U2RX

7.5 USB mini connector

Note that the USB is configured only as device.

Pin #	Signal Name
1	+5V
2	D-
3	D+
4	Not connected
5	GND



7.7 Jumper description



D10_E

If open disconnects D10 (on CON5 from the ARDUINO shield connector), so you can use ICSP programming

Default state is closed.



AREF_E

When open provides AREF on the ICSP pin holes.
 If closed AREF on CON5 pin D8

Default state is open.



LED1_E

If closed excludes LED1.

Default state is open.



LED2_E

If closed excludes LED2.

Default state is open.



BUT_E

If closed excludes button BUT.

Default state is open.

7.9 Additional hardware components

The components below are mounted on the PIC32-PINGUINO-MX220 board but are not discussed above. They are listed here for completeness:

General purpose button

2 LEDs

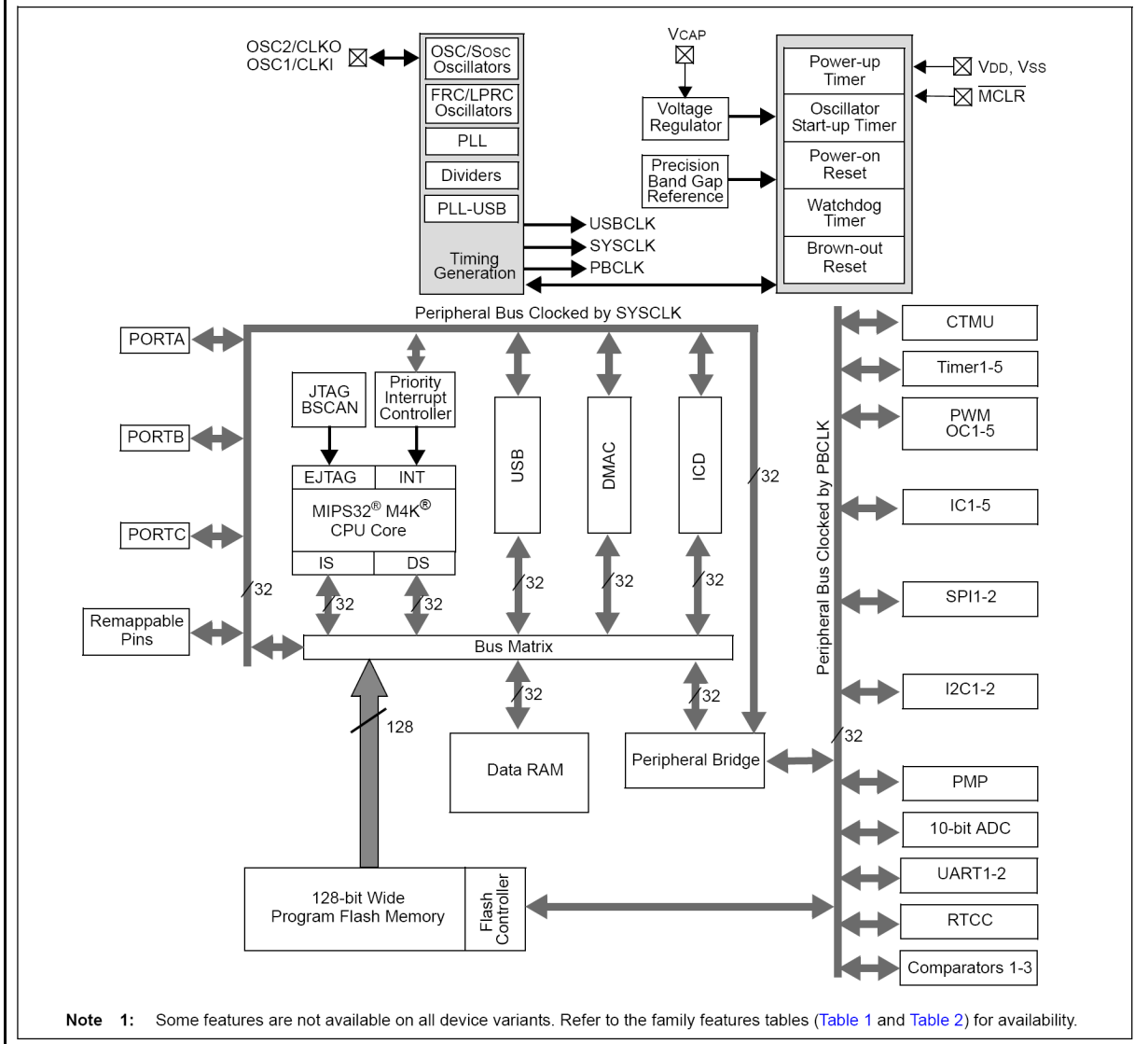
CHAPTER 8

MEMORY AND BLOCK DIAGRAM

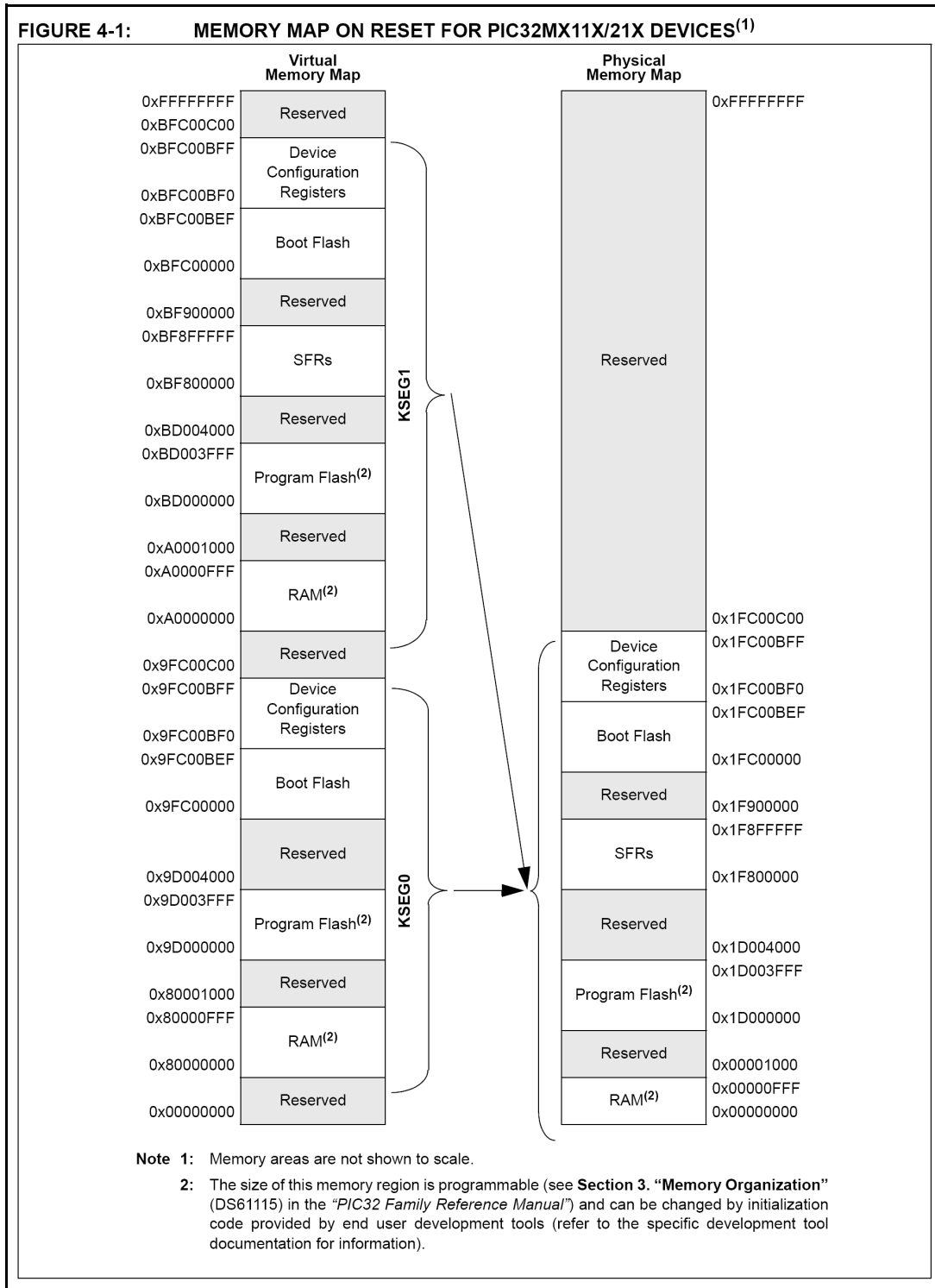
8. Introduction to the chapter

Below is located the block diagram of the processor and on the next page you can find a memory map for this family of processors. It is strongly recommended to refer to the original datasheet (DS61168D) released by Microchip for ones of higher quality.

FIGURE 1-1: BLOCK DIAGRAM⁽¹⁾



8.1 Memory organization



CHAPTER 9

SCHEMATICS

9. Introduction to the chapter

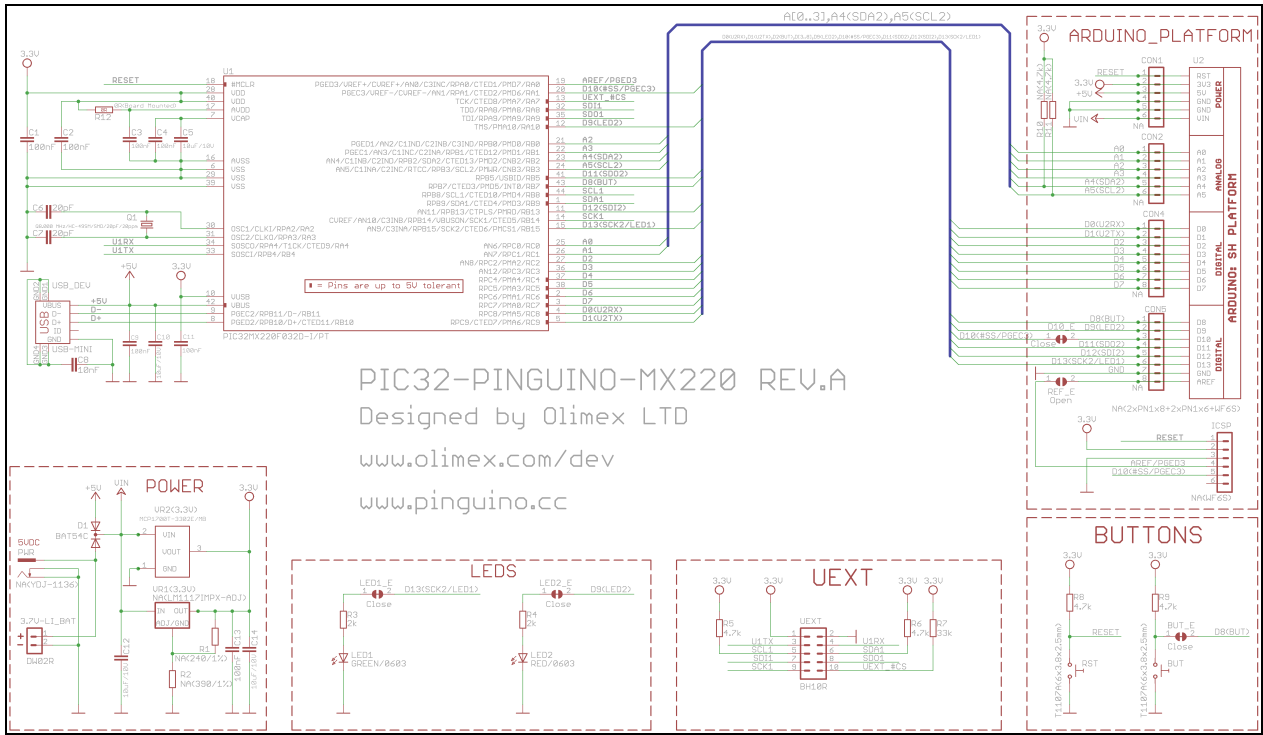
In this chapter are located the schematics describing logically and physically PIC32-PINGUINO-MX220.

9.1 Eagle schematic

PIC32-PINGUINO-MX220 schematic is visible for reference here. You can also find them on the web page for PIC32-PINGUINO-MX220 at our site: <http://www.olimex.com/dev/PIC32-PINGUINO-MX220.html>. They are located in HARDWARE section.

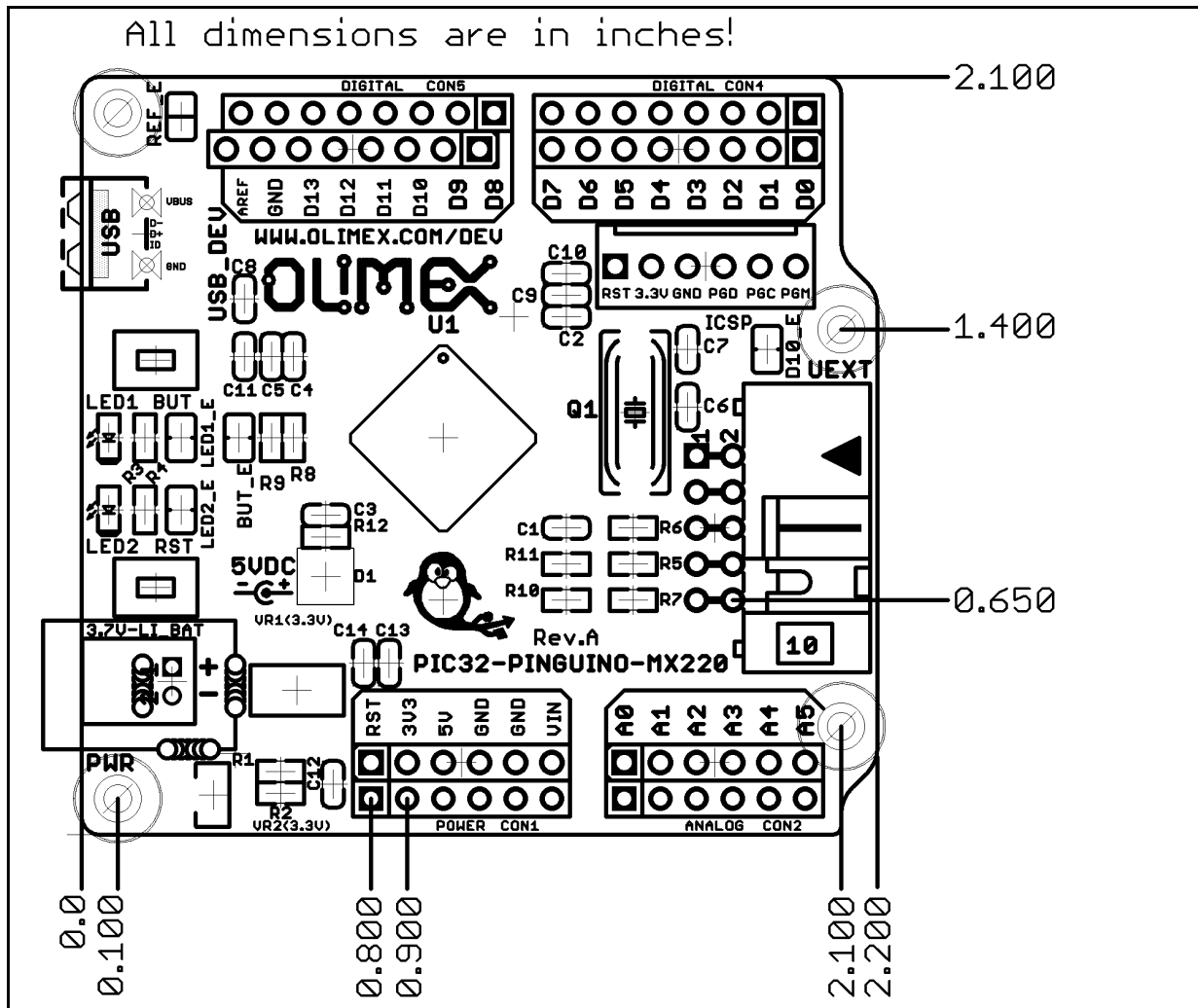
Note that PIC32-PINGUINO-MX220 schematic is released under [Creative Commons Attribution-Share Alike 3.0 United States License](#) and the whole project is released under

The EAGLE schematic is situated on the next page for quicker reference.



9.2 Physical dimensions

Note that all dimensions are in inches.



CHAPTER 10

REVISION HISTORY

10. Introduction to the chapter

In this chapter you will find the current and the previous version of the document you are reading. Also the web-page for your device is listed. Be sure to check it after a purchase for the latest available updates and examples.

10.1 Document revision

Revision	Changes	Modified Pages
Initial	Initial Creation	All
A	Added “Open Hardware” exception; replaced “headers” with “pin holes”; fixed various spelling errors	2; various; various

10.2 Web page of your device

The web page you can visit for more info on your device is <http://www.olimex.com/dev/PIC32-PINGUINO-MX220.html>. There you can find more info and some examples.

ORDER CODES:

PIC32-PINGUINO-MX220 - completely assembled and tested

PIC-KIT3 + PIC-ICSP – PIC programmer + adapter for different types of ICSP connectors

SHIELD-LOL – Duino compatible shield with a matrix of LEDs

SHIELD-EKG-EMG – Duino compatible shield for electrocardiography

How to order?

You can order to us directly or by any of our distributors.

Check our webpage <http://www.olimex.com/> for more info.