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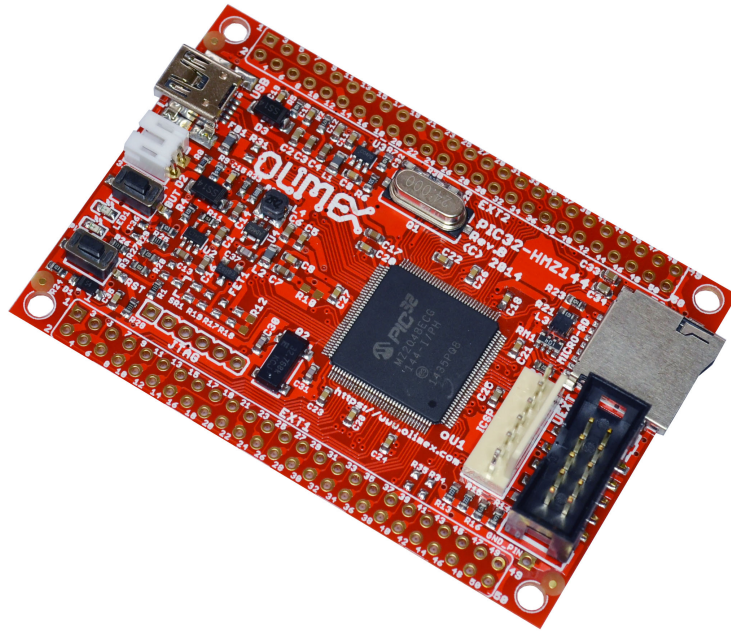
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PIC32-HMZ144

General-purpose development board

USER'S MANUAL

Document revision D, October 2017
Designed by OLIMEX Ltd, 2015



All boards produced by Olimex LTD are ROHS compliant

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The hardware design of PIC32-HMZ144 development board is considered open source. Anyone can download the original schematics and board design files. The files describing the hardware are made with CadSoft's EAGLE PCB design software.

The part of the software written by Olimex is released under GPL. However, note that the examples that we distribute are based on the libraries and projects released by Microchip. Make sure that you are acquainted with Microchip's license agreement before using, publishing, or distributing any code based on our software.

It is possible that the pictures in this manual differ from the latest revision of the board.

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CHAPTER 1: INTRODUCTION

Thank you for choosing this general-purpose development board designed and assembled by Olimex LTD! This document provides a user's guide for the PIC32-HMZ144 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-HMZ144 development board allows code development of applications running on the PIC32MZ144 processor, manufactured by Microchip Technology Inc from the U.S.A.

PIC32-HMZ144 board is an open-source, open-hardware project and all documents needed to manufacture the board are available to the customer.

The software code written by Olimex LTD is released under GPL. However, the examples that we distribute are heavily based on the libraries and projects released by Microchip Technology Inc, which are non-GPL. Make sure that you are acquainted with Microchip's license agreement before using, publishing, or distributing any code based on the demo software released by Olimex LTD.

1.1 BOARD FEATURES

PIC32-HMZ144 board features a PIC32MZ2048EFG144 processor. It is one of the most-capable PIC32 processors ever made and it has a lot of interfaces available (FPU, 6 x UARTs; 6 x SPIs; 5 x I2Cs; 120 x IO pins; 48-channel ADC; two analog comparators; Ethernet; USB-OTG; JTAG; TRACE; etc.) The board has several ready-to-use interfaces exposed and available on connectors: a microSD card connector; mini USB connector (with OTG functionality); ICSP connector for programming and debugging; UEXT connector for extension modules; user-programmable LED; user-programmable button; 100 pinholes in two rows for measurements and access to IO processor pins; etc.

Starting 20th of October 2017 the PIC32MZ2048ECG144 chip was replaced by a PIC32MZ2048EFG144. The PIC32MZ2048ECG144 was officially declared "not recommended for new designs" by Microchip and we decided to switch to the officially suggested replacement. The chips are pretty much the same except that the new EFG chip has a floating point unit (FPU), better maximum A/D resolution (12 v 10) and better maximum A/D sample rate (18000KSPS vs 5000KSPS).

The most notable board features are listed below:

- PIC32MZ2048EFG144 with 512KB RAM and 2MB flash (PIC32MZ2048ECG144 was used before)
- USB-OTG functionality with mini USB connector
- MicroSD card connector
- ICSP for debugging and programming
- JTAG pins exposed on 0.1" step 6 pins
- EXT1 and EXT2 50 pin 0.1" connectors that ease the access to the processor
- RESET and USER buttons
- PWR and STATUS LEDs
- Li-Po battery connector and charger
- UEXT connector
- Dimensions: (77×52)mm ~ (3×2)mm

1.2 MINIMAL BOARD USE REQUIREMENTS

- **Hardware required for programming**

In order to upload code on the board you would need a PIC32 compatible debugger or programmer. Older tools might lack support for PIC32 processor. Please ensure your programmer/debugger is compatible with the PIC32MZ processor family.

The board has no bootloader loaded. You need either a debugger or a programmer tool to upload software to the board. The on-board ICSP interface is available at a 6-pin (1×6) 0.1” step connector.

- **Software required for programming**

You would need software that supports PIC32MZ family of processors. The most commonly used tool for software development for PIC32MZ applications is MPLAB X. The most used tool for binary upload to PIC32MZ is MPLAB IPE. Microchip provides a set of libraries and demo projects for the PIC32MZ family in their “Harmony Integrated Software Framework”.

Note that MPLAB 8.xx does NOT support PIC32MZ.

- **(Optional) hardware to power the board.**

The board requires power supply. If your debugger/programmer is not capable of powering the board via the ICSP connector then you would need either: USB cable (1); or Li-Po battery (2); or 5V external power supply (3).

(1) The USB cable should have male mini USB connector to be able to fit the board's female mini USB connector.

(2) The battery requires a male DW02R connector (CI0102) to fit in the on-board female DW02R connector.

(3) There are only pinholes available on the board. You would need wires to establish a connection between the external power supply (adapter) with the board.

1.3 TARGET MARKET OF THE BOARD

PIC32-HMZ144 would attract PIC enthusiasts and veterans who want to evaluate the features of the PIC32MZ2048EFG144 processor. Any experience with the development tools required for general-purpose development of code for boards featuring PIC32MZ boards is a great plus.

The board is not suitable for complete beginners – it lacks a bootloader which means that you can't upload software via the USB. You need at least a PIC32-compatible programmer with 6-pin 0.1” step ICSP connector.

In case you are a complete beginner you might want to start with a board with bootloader, like PIC32-PINGUINO-OTG or DUINOMITE. You can upload code to such boards via an USB cable.

1.4 ELECTROSTATIC WARNING

The PIC32-HMZ144 board is shipped in protective anti-static packaging. The board must not be subject to high electrostatic potentials. General practice for working with static sensitive devices should be applied when working with this board.

The product box includes 4 rubber feet – it is recommended to place them in the holes near the edges of the board. This way the board would be safe if placed on conductive surfaces!

1.5 DOCUMENT ORGANIZATION

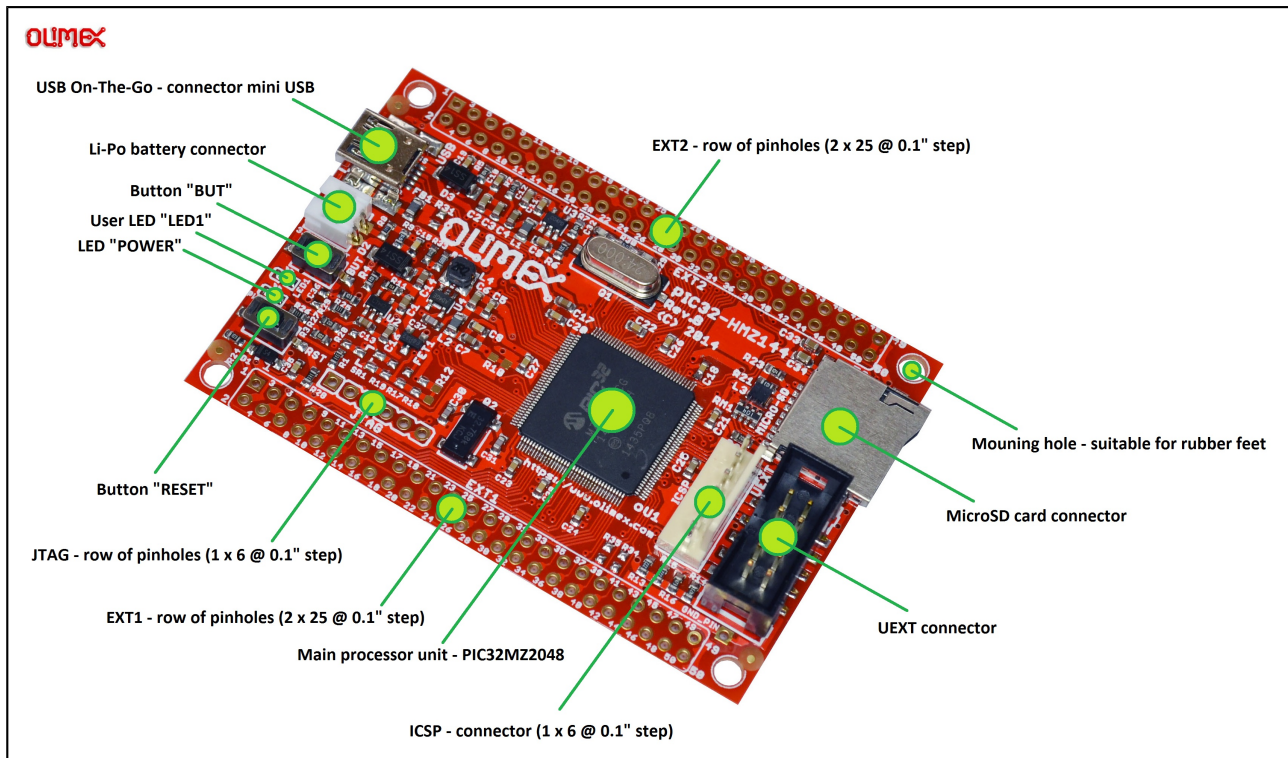
Each section in this document covers a separate topic, organized as follows:

- Chapter 1 is an overview of the board usage and features
- Chapter 2 contains the general board diagram and layout
- Chapter 3 provides the schematics and the dimensions of the board
- Chapter 4 provides a guide for quickly setting up the board and software notes
- Chapter 5 describes the component that is the heart of the board: the Microchip's PIC32MZ2048 processor
- Chapter 6 is an explanation of the control circuitry associated with the processor
- Chapter 7 covers the connector pinout, peripherals and jumper description
- Chapter 8 contains the revision history, useful links and support information
- Chapter 9 contains the warranty information

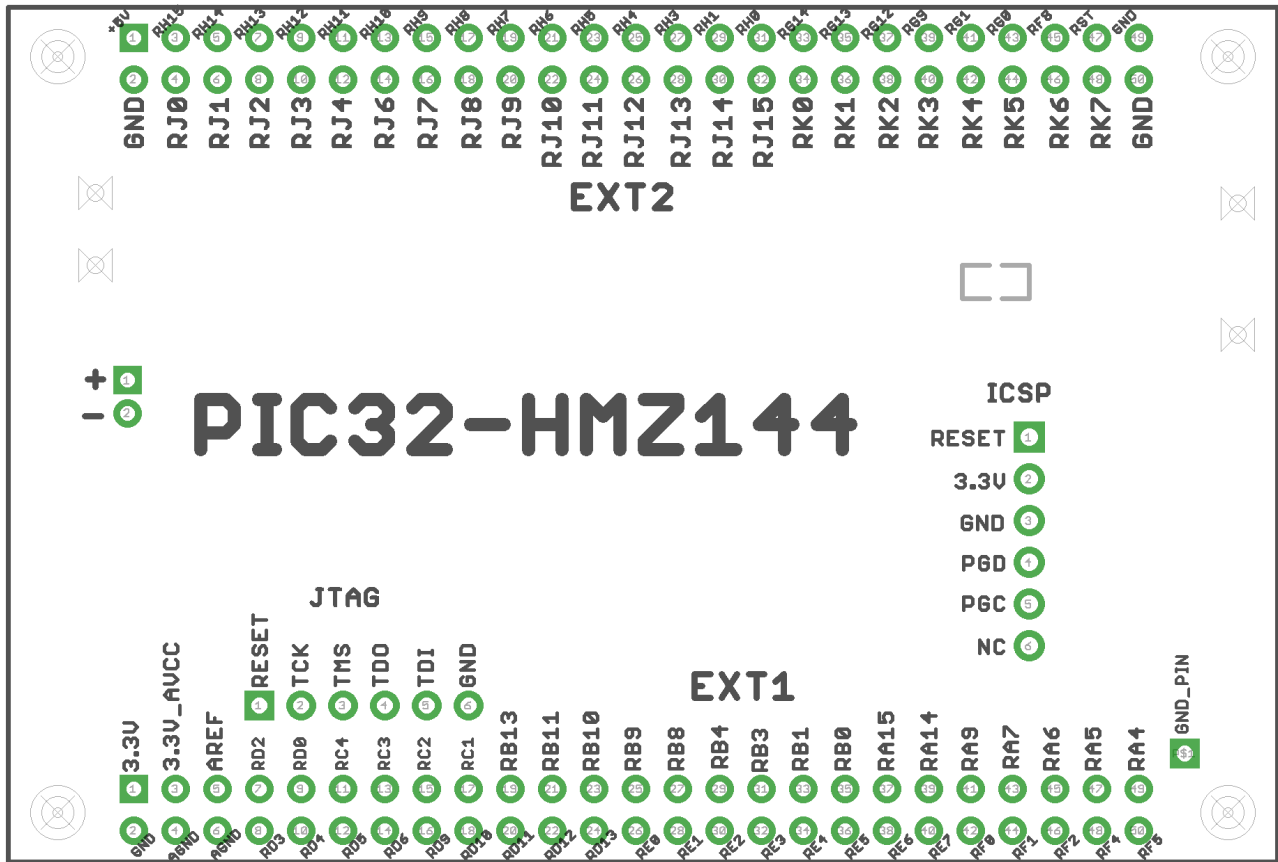
CHAPTER 2: BOARD DESCRIPTION

2.1 LAYOUT (TOP VIEW)

The picture below shows the top side of the board and highlights the most important parts:



2.2 PINOUT



CHAPTER 3: BOARD SCHEMATIC AND DIMENSIONS

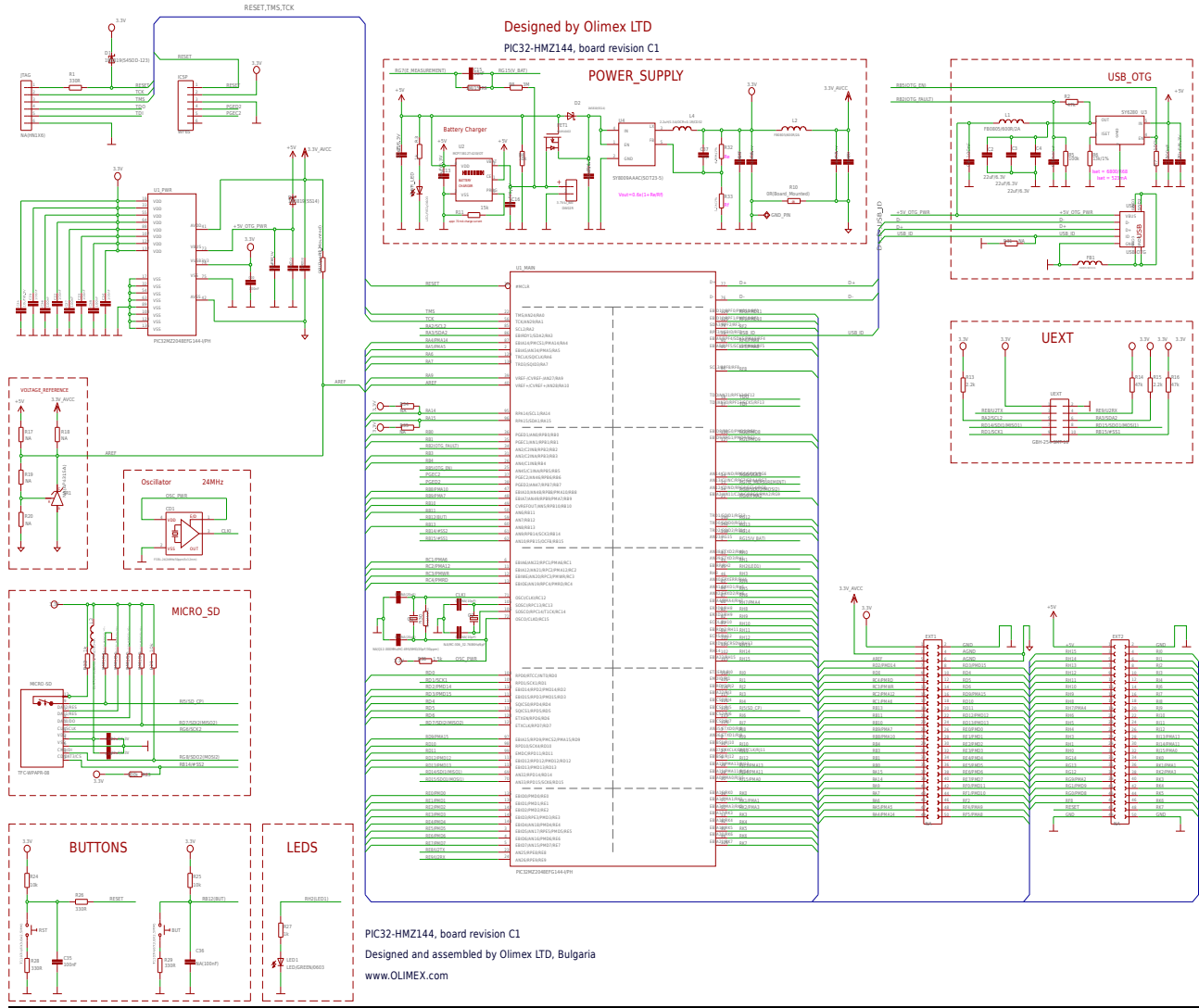
In this chapter you may find information about the schematics describing logically and physically PIC32-HMZ144.

3.1 SCHEMATIC

The schematic of PIC32-HMZ144 is available for reference on the next page.

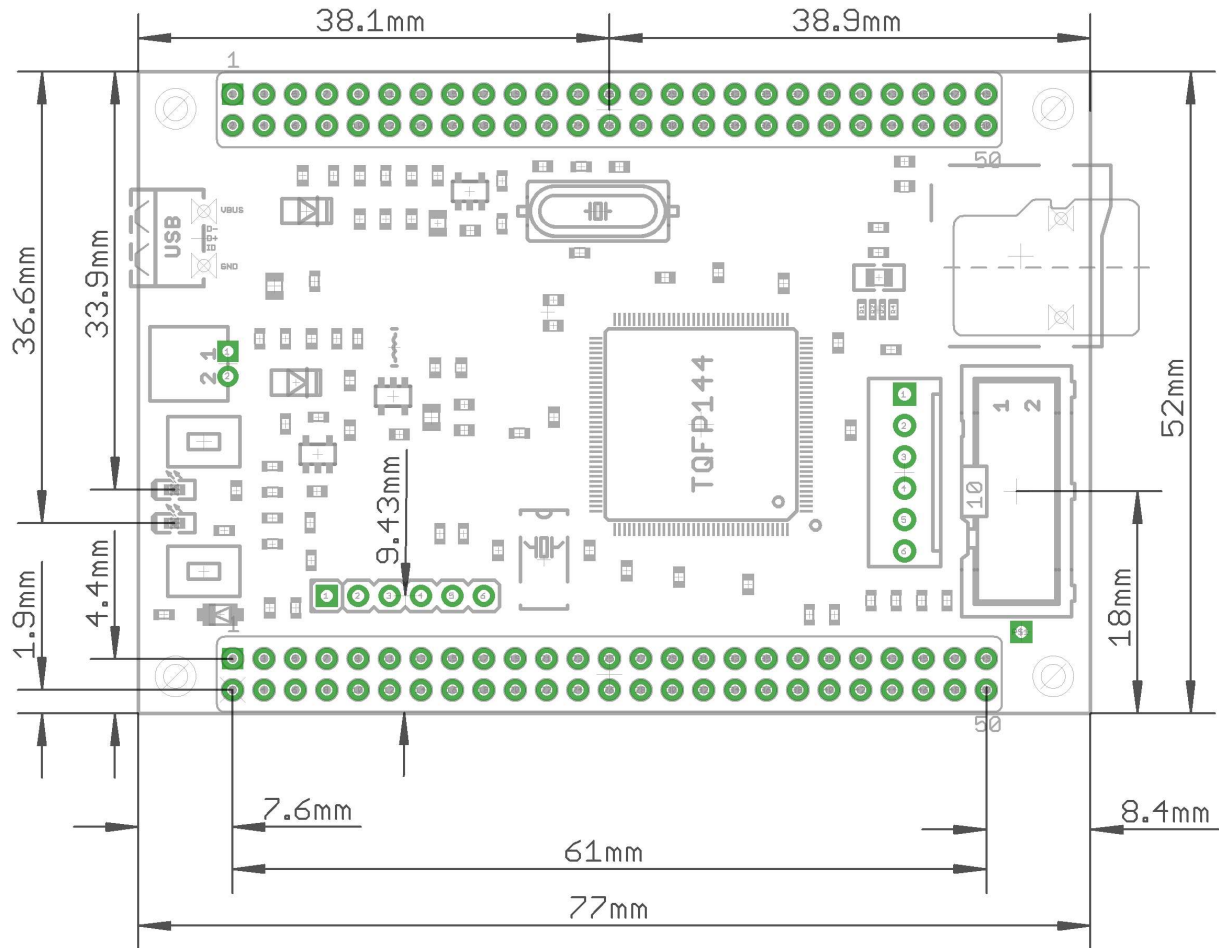
The design files are available at our GitHub repository. Refer to chapter 8 to find the link to our repository.

If you are looking for a schematic of an older revision of the board and it isn't available at our web site you may request it by the support e-mail.



3.2 PHYSICAL DIMENSIONS

Note that all dimensions are in millimeters.



CHAPTER 4: PROCESSOR DETAILS

Some of the details about the main processor in the design of PIC32-HMZ144 (PIC32MZ2048EFG144) are mentioned in this chapter. It is highly recommended to refer to the original datasheet which might be downloaded from the Microchip's official web-side.

4.1 FEATURES

PIC32-HMZ144 board uses MCU PIC32MZ2048EFG144 from Microchip Technology. The main processor of the board is one of the biggest processors of the PIC32MZ family. It has the following features that distinguish it from the rest of the family:

- **Programmable memory (KB): 2048**
- **Data memory (KB): 512**
- **Pins count: 144**
- **I/O pins: 120**
- **Reprogrammable pins: 53**
- **ADC channels: 48**
- **SPI/I2S interfaces: 6**
- **CAN interface: No**

Note that previously PIC32-HMZ144 came with PIC32MZ2048ECG144 which lacked FPU unit. The design was upgraded to PIC32MZ2048EFG144 following a number of requests to change the chip (since the ECG144 chip was no longer recommended for new products).

The PIC32MZ family of processors are 32-bit MCUs that pack the following shared features:

Operating Conditions

- 2.1V to 3.6V, -40°C to +85°C, DC to 252 MHz
- 2.1V to 3.6V, -40°C to +125°C, DC to 180 MHz

Core: 200 MHz (up to 330 DMIPS) microAptiv™

- 16 KB I-Cache, 4 KB D-Cache
- FPU for 32-bit and 64-bit floating point math
- MMU for optimum embedded OS execution
- microMIPS™ mode for up to 35% smaller code size
- DSP-enhanced core:
 - Four 64-bit accumulators
 - Single-cycle MAC, saturating and fractional math
 - IEEE 754-compliant
- Code-efficient (C and Assembly) architecture

Clock Management

- Programmable PLLs and oscillator clock sources
- Fail-Safe Clock Monitor (FSCM)
- Independent Watchdog Timers (WDT) and Deadman
- Timer (DMT)
- Fast wake-up and start-up

Power Management

- Low-power modes (Sleep and Idle)
- Integrated Power-on Reset and Brown-out Reset

Memory Interfaces

- 50 MHz External Bus Interface (EBI)
- 50 MHz Serial Quad Interface (SQI)

Audio and Graphics Interfaces

- Graphics interfaces: EBI or PMP
- Audio data communication: I2S, LJ, and RJ
- Audio control interfaces: SPI and I2C
- Audio master clock: Fractional clock frequencies with USB synchronization

High-Speed (HS) Communication Interfaces (with Dedicated DMA)

- USB 2.0-compliant Hi-Speed On-The-Go (OTG) controller
- 10/100 Mbps Ethernet MAC with MII and RMII interface

Security Features

- Crypto Engine with a RNG for data encryption/decryption and authentication (AES, 3DES, SHA, MD5, and HMAC)
- Advanced memory protection:
 - Peripheral and memory region access control

Direct Memory Access (DMA)

- Eight channels with automatic data size detection
- Programmable Cyclic Redundancy Check (CRC)

Advanced Analog Features

- 12-bit ADC module:
 - 18 Msps with up to six Sample and Hold (S&H) circuits (five dedicated and one shared)
 - Up to 48 analog inputs
 - Can operate during Sleep and Idle modes
 - Multiple trigger sources
 - Six Digital Comparators and six Digital Filters
- Two comparators with 32 programmable voltage references
- Temperature sensor with $\pm 2^{\circ}\text{C}$ accuracy

Communication Interfaces

- Two CAN modules (with dedicated DMA channels):
- 2.0B Active with DeviceNet™ addressing support
- Six UART modules (25 Mbps):
 - Supports LIN 1.2 and IrDA® protocols
- Six 4-wire SPI modules
- SQI configurable as an additional SPI module (50 MHz)
- Five I2C modules (up to 1 Mbaud) with SMBus support
- Parallel Master Port (PMP)
- Peripheral Pin Select (PPS) to enable function remap

Timers/Output Compare/Input Capture

- Nine 16-bit or up to four 32-bit timers/counters
- Nine Output Compare (OC) modules
- Nine Input Capture (IC) modules
- PPS to enable function remap
- Real-Time Clock and Calendar (RTCC) module

Input/Output

- 5V-tolerant pins with up to 32 mA source/sink
- Selectable open drain, pull-ups, pull-downs, and slew rate controls
- External interrupts on all I/O pins
- PPS to enable function remap

Qualification and Class B Support

- Class B Safety Library, IEC 60730
- Back-up internal oscillator

Debugger Development Support

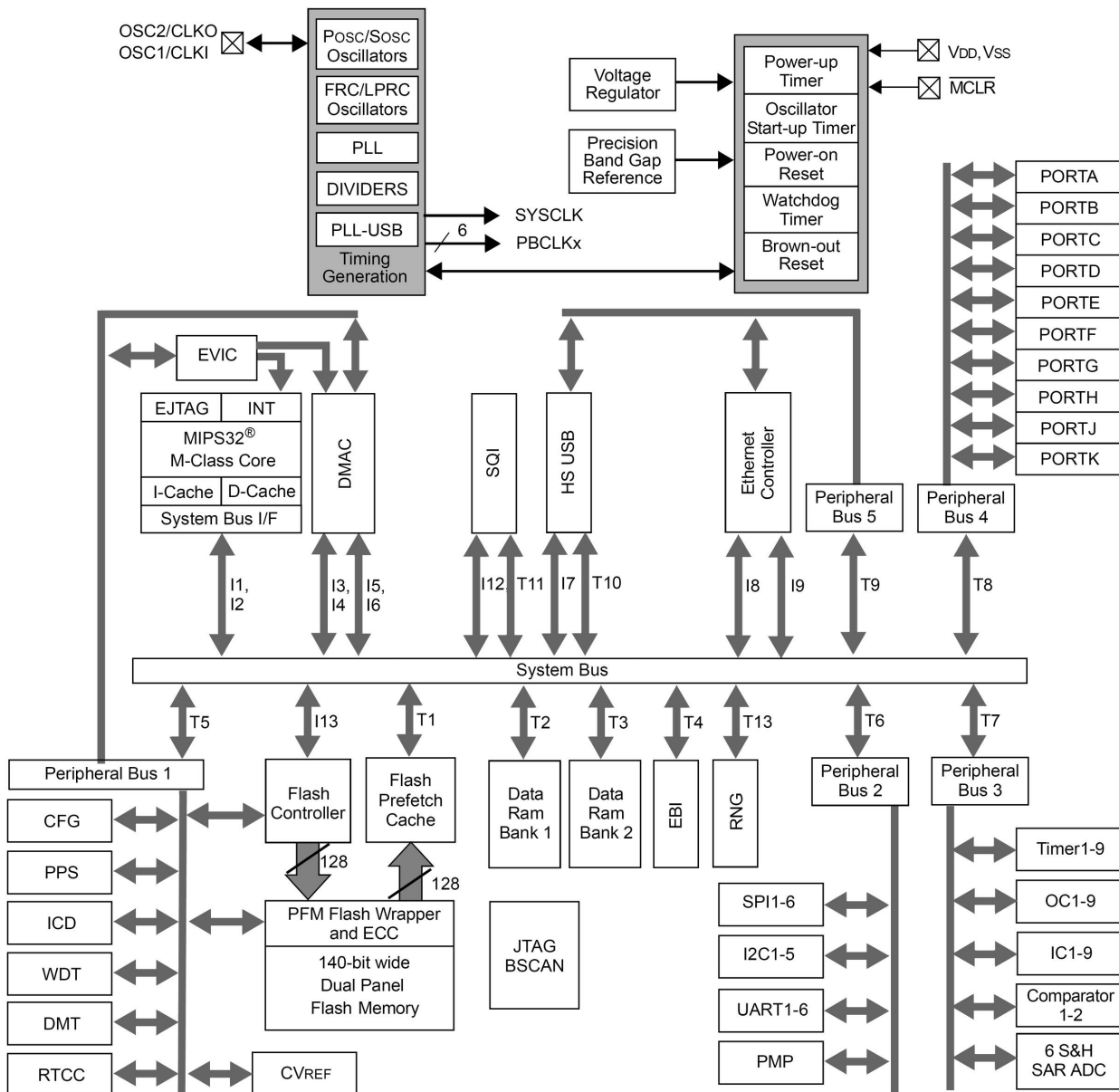
- In-circuit and in-application programming
- 4-wire MIPS® Enhanced JTAG interface
- Unlimited software and 12 complex breakpoints
- IEEE 1149.2-compatible (JTAG) boundary scan
- Non-intrusive hardware-based instruction trace

Software and Tools Support

- C/C++ compiler with native DSP/fractional support
- MPLAB® Harmony Integrated Software Framework
- TCP/IP, USB, Graphics, and mTouch™ middleware
- MFi, Android™, and Bluetooth® audio frameworks
- RTOS Kernels: Express Logic ThreadX, FreeRTOS™, OPENRTOS®, Micrium® µC/OS™, and SEGGER embOS®

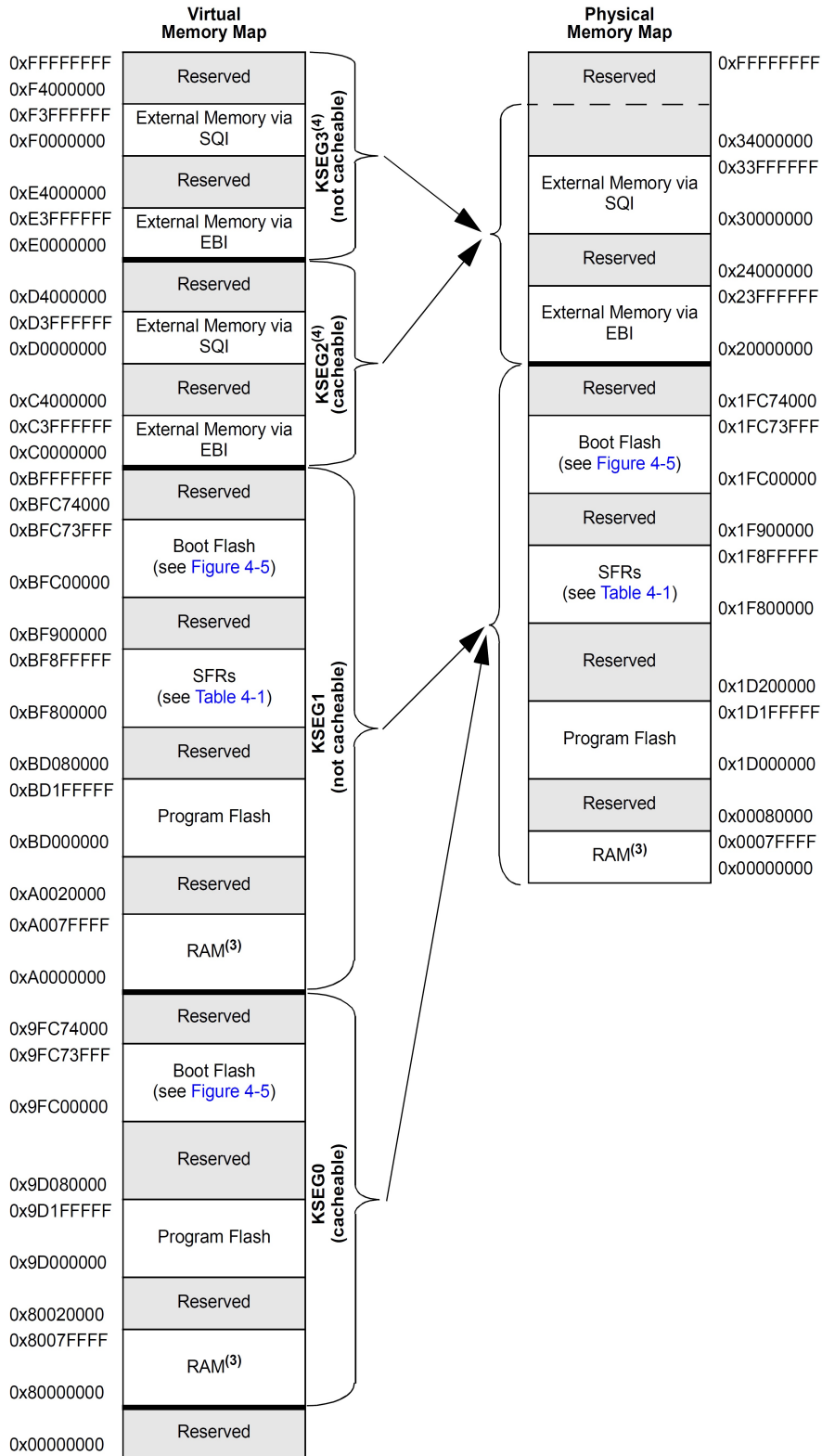
4.2 MICROCONTROLLER BLOCK DIAGRAM

A block diagram with main functional parts of the microcontroller as seen in the official Microchip documentation.



4.3 MICROCONTROLLER MEMORY MAP

The microcontroller's memory regions as seen in the official Microchip documentation.



- Note**
- 1: Memory areas are not shown to scale.
 - 2: The Cache, MMU, and TLB are initialized by compiler start-up code.
 - 3: RAM memory is divided into two equal banks: RAM Bank 1 and RAM Bank 2 on a half boundary.
 - 4: The MMU must be enabled and the TLB must be set up to access this segment.

CHAPTER 5: CONTROL CIRCUITRY

5.1 POWER SUPPLY CIRCUIT

You have options on powering PIC32-HMZ144. You can power the board by providing:

- **5V on the mini USB connector**

You can power the board from your personal computer via an USB cable; the USB ports of a personal computer typically provide around 5V of voltage and 500mA of current.

Avoid using USB cables longer than 2 meters. Avoid the cheapest cables with high inner resistance.

- **(3.6 – 4.2)V on the Li-Po battery connector**

The board can be powered the board from a Li-Po battery with a fitting connector; a Li-Po battery typically provides between 3.6V and 4.2V of voltage.

- **3.3V on the ICSP connector**

PIC32-HMZ144 can be powered by your debugger (programmer) tool, as long as the tool is capable of powering targets. You would need to set and enable the powering voltage to 3.3V in the software options of MPLAB.

- **5V to pin 1 of the EXT2 connector**

The board can be powered by external power supply (adapter) capable of providing 5V of voltage. You should connect the 5V wire to pin #1 of EXT2 connector. You also need to connect the ground wire to pin #2 of the same (EXT2) connector. The names of the pins are printed at the bottom of the board.

Different methods of powering would lead to different maximum current available. Consider powering the board with an external power supply connected to EXT2 if you need extra current (in case you have to power additional hardware via PIC32-HMZ144).

You can have more than one power supply connected at the same time. Note that the board has built-in battery charger. If you have another power source connected to the board at the same time as the battery (for example, USB) – the charger circuit would attempt to recharge the battery. This would raise the current consumption of the whole board.

With no extra peripherals connected, the board's current consumption is about 100mA at 5V when running the default demo program.

5.2 RESET CIRCUIT

PIC32-HMZ144's reset signal (processor pin #20, “#MCLR”) can be found on the pads of the JTAG connector (pad #1); on the ICSP connector (connector pin #1); and it is also connect to a button.

The reset circuit of the button consists of RC group R24 – 10k Ω and C35 – 100nF. Serial resistor R26 – 330 Ω is used to prevent fast C35 charge and discharge when PIC32MZ2048 is being programmed.

Manual reset is possible by the RESET button.

5.3 CLOCK CIRCUIT

Oscillator CD1 24MHz handles the clocks.

Previous hardware revisions used crystals due to the different chip. Make sure to refer to the errata sheets the chips if you investigating the clocks.

CHAPTER 6: JUMPERS, CONNECTORS AND INTERFACES

In this chapter you will find the description of the jumpers and what signals might be found on the different connectors.

6.1 JUMPER DESCRIPTION

PIC32-HMZ144 has no re-configurable jumpers.

6.2 INPUT/OUTPUT

User button with name BUT – connected to PIC32MZ's pin #59 (AN7/RB12). BUT can be accessed via software means.

Reset button with name RST – connected to PIC32MZ's pin #20 (#MCLR).

Status LED (green) with name LED1 – connected to PIC32MZ's pin #45 (EBIRP/RG2). LED1's behavior can be programmed.

Power supply red LED with name PWR – indicates that 5V power supply is available. Cannot be programmed.

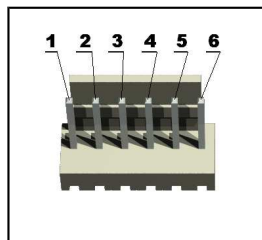
6.3 EXTERNAL CONNECTOR DESCRIPTION

In this sub-chapter you would find the pinout of the most interfaces. It is also a good practice to refer to the latest schematic.

6.3.1 ICSP CONNECTOR

The ICSP connector is used for serial programming. It is the place where most common PIC32-compatible programmers and debuggers are connected. The pins have 0.1" step. If your programmer/debugger has only the smaller 0.05" connector you might need an adapter or you should use jumper wires.

Pin #	Signal name
1	RSTN
2	3.3V
3	GND
4	PGED2
5	PGEC2
6	NC



PGED2 conducts I/O operations for the “Program Data” signal. Serial data for programming. **PGEC2** serves only as input for the “Program Clock” signal. Clock used for transferring the serial data (output from ICSP, input for the MCU).

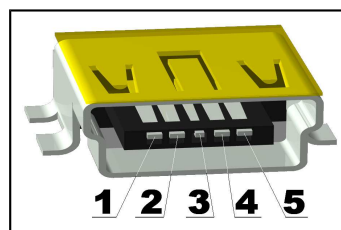
6.3.2 JTAG ROW

The 6-signal JTAG interface at the board lacks a connector. The board has a JTAG row of pin holes.

Pin #	Signal name
1	RESET
2	TCK
3	TMS
4	TDO
5	TDI
6	GND

6.3.3 USB_OTG

Pin #	Signal name
1	+5V_OTG_PWR
2	D-
3	D+
4	USB_ID
5	GND

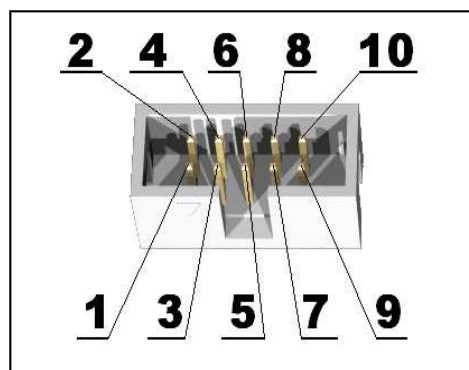


6.3.3 UEXT

The 10-pin UEXT connectors are typically mounted on Olimex boards. They pack three common interfaces in a single connector – UART, I2C and SPI. You can use the UEXT connector to access this interfaces easier (via jumper wires, for example).

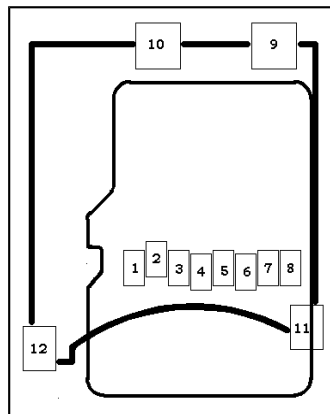
You can also connect expansion modules to the UEXT connectors. More on UEXT might be found here: <https://www.olimex.com/Products/Modules/UEXT/>

Pin #	Wire name
1	3.3V
2	GND
3	RE8/U2TX
4	RE9/U2RX
5	RA2/SCL2
6	RA3/SDA2
7	RD14/SDI1(MISO1)
8	RD15/SDO1(MOSI1)
9	SCK1RD1/SCK1
10	RB15/#SS1



6.3.4 MICROSD CARD

Pin #	Wire name
1	MCIDAT2
2	RB14/#SS2
3	RG8/SDO2 (MOSI2)
4	VDD (3.3 V)
5	AC1TX/SCK3A
6	GND
7	MISO3A
8	MCIDAT1
9	Card presence
10	Not Connected
11	Not Connected
12	Not Connected



CHAPTER 7: AVAILABLE DEMO SOFTWARE

There are two example projects available for the board. A simple blinking LED demo and a more complex demo that demonstrates a number of features.

7.1 BLINKING LED MPLABX DEMO

This is the most basic example. It requires just MPLABX. Build info (tested with):

Board: PIC32-HMZ144 rev. B
IDE: MPLABX 3.40
Compiler: XC32 1.42
Programmer: PIC-Kit3

7.2 FULL HARMONY DEMO

This example them is more complex and uses the Harmony framework. This example demonstrates several features of the board: LED, Button, UART, RTC, SD card, USB. The demo project should be downloaded from the official product page of PIC32-HMZ144.

Build info (tested with):

Integrated development environment:	MPLABX v3.15
Compiler:	XC32 v1.40
Harmony framework:	v1.06.01

You can either build the project and program the board with MPLABX IDE, or use MPIPE and the prebuilt file (PIC32-HMZ144_v2.hex). It is recommended to use the same compiler if you decide to compile the project!

If you want to follow the messages on the console you need to use a USB ↔ serial cable (like Olimex USB-SERIAL-CABLE-F or MOD-USB-RS232) to the UART pins of the UEXT (pin 3 is TX, pin 4 is RX). In order to switch between the different demos push the button.

Upon reset a fast external clock test will be done to ensure that the clock is OK. After that SD card demo would start start. It will read a file on the SD card with the name:

"FILE_TOO_LONG_NAME_EXAMPLE_123.JPG" (make sure you have such file in the card)

The program would make a copy of that file in a sub-directory named "Dir1". The generated directory and file must not exist prior to the software test (otherwise you will receive an error).

IMPORTANT NOTE: Microchip Harmony Configurator requires write protect pin but on PIC32-HMZ144 board there is no such pin; the one selected by default is used (PORTF1). Since we can't set it to low level, in order to make SD card demo work properly, RF1 should be set as output in low level! If you decide to change it make sure that the new WP pin is also low!

After the SD card demo is over you can see LED blinking with 1 Hz frequency controlled by the RTC oscillator.

Then the USB demo gets started – the board would initialize as an USB device (mouse). When you

hold the button the mouse cursor will start moving.

On the terminal you can send characters and it will return echo (next symbol) followed by '*'.

Microchip Harmony Configurator (MHC) requires all *.configs available in order to be initialized. But having all of them in the project would make the archive too big. So in the archive are left only the libraries that are necessary for rebuilding. So if you want to change the configurations from MHC you have to copy the project inside the Microchip harmony directory "..\apps\usb\device\" and then open the MHC from MPLABX.

CHAPTER 8: ORDERING INFORMATION AND REVISIONS

You can purchase directly from our online shop or from any of our distributors. Note that usually it is faster and cheaper to purchase Olimex products from our distributors. List of confirmed Olimex LTD distributors and resellers: <https://www.olimex.com/Distributors>.

Please visit <https://www.olimex.com/> for more info.

Trouble finding a product mentioned above? Product name of the board discussed in this document:

PIC32-HMZ144 – fully assembled and tested.

Below are listed some of the related products (you can type the name of a product in the search box of our web site to find it easily):

PIC-KIT3 – PIC32-HMZ144-compatible debugger, works fine with MPLAB X, MPLAB IPE. Fits the 6-pin on-board connector.

USB-MINI-CABLE – a standard USB cable with type A ↔ mini connectors.

BATTERY-LIPO1400 – a standard Li-Po battery equipped with a connector that fits the one located on PIC32-HMZ144. Olimex sells a range of such batteries with different capacity.

JW-200x10 – jumper wires with male-male connectors and 240mm of length; perfect for breadboarding; there are different lengths and configurations of connectors (m-m; f-m; f-f).

You can also find a big number of extension boards that can be connected to the UEXT of the board and also some of the components (if damage occurs and you want to replace the part yourself). Make sure to use the search box.

8.1 DOCUMENT REVISION

Document revision	Changes	Modified page
A, 12.11.15	Initial manual release	All
B, 14.12.15	Updated the information about the demo	22
C, 09.02.17	Added hardware revision changes; added information about the simple blinking LED demo	22, 25
D, 18.10.17	Added info about new hardware revision; changed schematic; the major change is the new chip with floating point unit. PIC32MZ144EFG instead of PIC32MZ144ECG.	4, 12

8.2 BOARD REVISION

Remember to check the schematics and the board design files to verify any differences between the different board revisions.

Board revision	Notable changes
B	Initial release of the board
C	<ol style="list-style-type: none">1. Q1 crystal Q1 gets properly labeled as Q12.000MHz/HC-49S/SMD/20pF/30ppm (changed from 24MHz); the same quartz was placed in previous hardware revisions but the schematic value was not updated2. Crystal capacitors (C29, C32) were changed from 27pF to 20pF as is required in the errata: "C2=Cload, C1=Cload-2pF" and to have reserve of several pFs, because during production, always the capacitance is a little higher than expected3. R36=10k pull-up to 3.3V was added to the OSC0 pin, i.e. MCU pin<72>;
C1	<ol style="list-style-type: none">1. The main processor was changed from PIC32MZ2048ECG144-I/PH to PIC32MZ2048EFG144-I/PH (the ECG was declared "not recommended for new designs" by Microchip);2. R36 was changed from 10k to 1.5k;3. Removed quartz Q1. Q1, C29, C32 and R30 were changed to NA – this is because of the errata sheets of both chips. Refer to 4;4. Added oscillator CD1 instead. CD1 is 24MHz oscillator;5. Q2, C30 and C31 were changed to NA.

8.3 USEFUL WEB LINKS

Visit the links below for more information and resources for the product:

- PIC32-HMZ144 official product page: <https://www.olimex.com/Products/PIC/Development/PIC32-HMZ144/>
- PIC32-HMZ144 at GitHub (EAGLE CAD source files): <https://github.com/OLIMEX/PIC32-HMZ144>
- MPLAB Harmony framework – flexible, abstracted, fully integrated firmware development platform for PIC32 microcontrollers: [MPLAB Harmony page](#)
- Official Olimex forums: <https://www.olimex.com/forum/index.php?board=21.0>