

# Mulle Hardware Guide

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# 1 INTRODUCTION

## 1.1 THE MULLE PLATFORM

The Mulle platform is a low-power sensor node capable of transmitting sensor data directly to the Internet using Bluetooth enabled mobile phones and the TCP/IP protocol, or to a receiver using IEEE 802.15.4 (ZigBee). It is designed from the beginning for low power usage, and its multi-purpose connector makes it possible to connect virtually any sensor to the platform. The software package developed for the Mulle Platform is open source, and free to modify to suit any specific needs. General information and further documentation can be found on the web site of Eistec AB [R1].

## 1.2 SCOPE

This document describes the architecture and the features of the Mulle Platform. It gives a picture of the logic behind the Mulle concept, with individual power-partitions allowing for low power usage. It is version independent, but should be used together with the Mulle Hardware documentation found in [R4], the web site of Eistec AB for details that are specific for each version.

## 1.3 REFERENCE DOCUMENTS

- [R1] Eistec web site: <http://www.eistec.se/>
- [R2] M16C Hardware Manual rev 2.41, Renesas Technology Corp., ref: REJ09B0185-0241
- [R3] Low Power Design Methodologies for Embedded Internet Systems, Jens Eliasson, ref: ISSN: 1402-1544, available at <http://epubl.luth.se/1402-1544/2008/13/LTU-DT-0813-SE.pdf>
- [R4] Eistec web site, hardware description: <http://www.eistec.se/block.php>
- [R5] Mulle Developers Forum: [http://www.eistec.se/docs/wiki/index.php?title=Main\\_Page](http://www.eistec.se/docs/wiki/index.php?title=Main_Page)

# 2 ARCHITECTURE

Figure 1 below describes the Mulle Platform architecture. There are several blocks and components in common for all versions, while others change between versions. What is most important is that they are divided into what is called power partitions. These partitions can be individually controlled and be shut down or put to sleep by software if they are not needed for the moment. The individual voltage regulators for all partitions are controlled by the MCU. The design methodology is further documented in [R3]. The power partitions are:

1. Microcontroller Unit, Real-Time Clock, and voltage regulator

2. On board Sensor Unit and voltage regulator
3. Communication Unit and voltage regulator
4. Flash Memory and voltage regulator

Power partition 1 and 4 are the same for all versions, while the onboard sensor and communication unit differs between versions. Common for all versions are also one red and one green led, as well as a battery monitor with integrated temperature sensor. External connections are the same for all versions, and they comprise:

- A 60-pin multipurpose I/O connector
- UART0 on the MCU (accessible via solder pads on the board)
- Battery connections (solder pads)
- External led (solder pads)
- Programming ports solder pads. (Power input, programming, and serial port 1)

The external connections are further detailed in chapter 3.3.

The voltage reference in the sensor power partition is only present together with the temperature sensor in order to give a reference to the A/D converter, matched to the temperature sensor. Vref should be 1.3V for the temperature sensor, while it is 3.3V for other sensors. How this is set up is described in the Mulle Development Forum, see [R5].

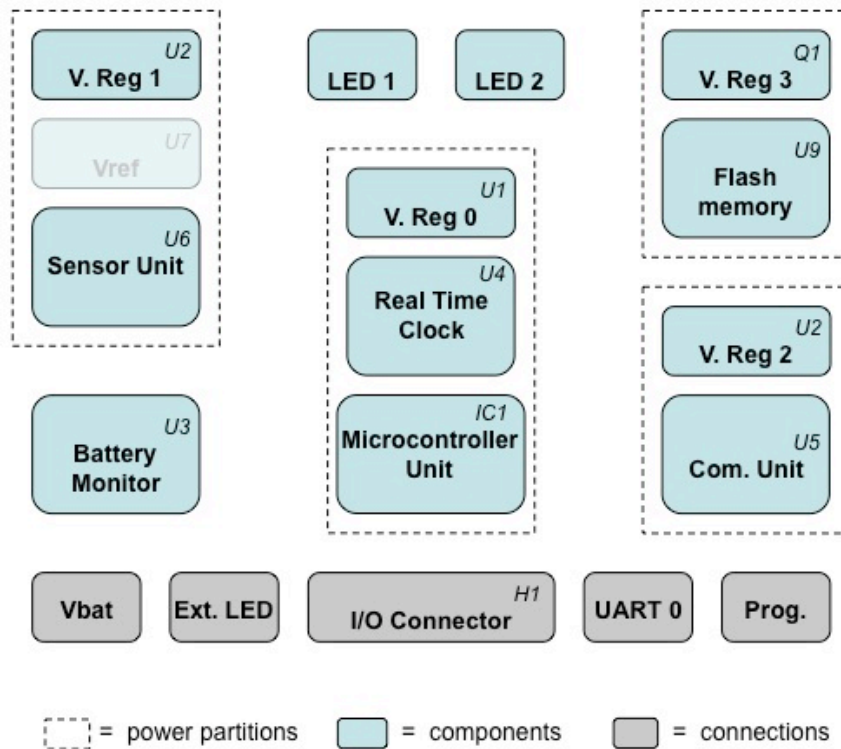


Figure 1: Mulle Platform architecture

## 3 TECHNICAL SPECIFICATIONS

### 3.1 PHYSICAL DESCRIPTION

**Size:** 24 x 26 x 5 mm.

**Weight:** 4 grams.

### 3.2 CONNECTED HARDWARE

Even though the architecture of the Mulle Platform remains the same between versions, as described in chapter 2, some of the components differ between versions. Table 1 below describes the different hardware of the power partitions of different versions.

	<b>Version 3.1</b>	<b>Version 3.2</b>	<b>Version 4.1</b>	<b>Version 5.2</b>
<i>MCU</i>	Renesas M16C/62P @10MHz	Renesas M16C/62P @10MHz	Renesas M16C/62P @10MHz	Renesas M16C/62P @10MHz
<i>Onboard Sensor</i>	Dallas DS600 Temperature Sensor	Freescale MMA7261QT three axis accelerometer	Dallas DS600 Temperature Sensor	Freescale MMA7261QT three axis accelerometer
<i>Communication Unit</i>	Mitsumi WML-C46 AHR Bluetooth Module	Mitsumi WML-C46 AHR Bluetooth Module	Mitsumi WML-C46 AHR Bluetooth Module	Atmel AT86RF230 ZigBee Transceiver
<i>Onboard Memory</i>	ATMEL AT45DB161D-MU 2 MB Serial Flash	ATMEL AT45DB161D-MU 2 MB Serial Flash	ATMEL AT45DB161D-MU 2 MB Serial Flash	ATMEL AT45DB161D-MU 2 MB Serial Flash

Table 1: Hardware in different power partitions

### 3.3 EXTERNAL CONNECTIONS

#### 3.3.1 Expansion Port

The expansion port gives access to the pins of the MCU as shown in Figure 2. The pins are named in accordance with the MCU hardware manual [R2].

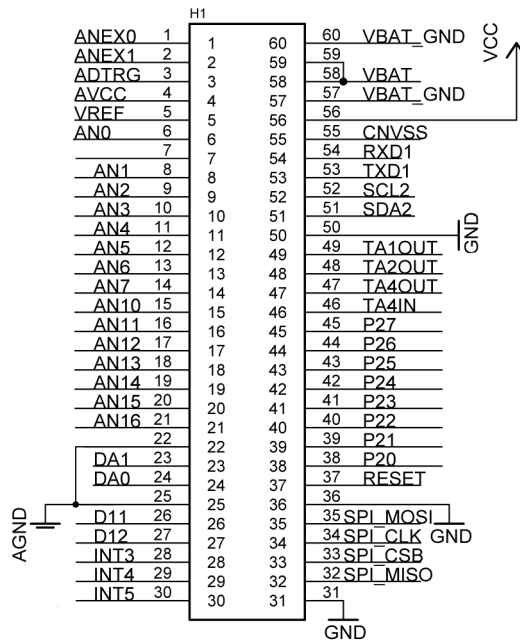


Figure 2: Expansion port connections

### 3.3.2 Solder Pads

The solder pads permit direct connection to certain pins of the MCU without using the expansion port. On the upper side of the Mulle Platform, connections are provided according to Figure 3 below. On the lower side, connections for an external battery are provided as shown in Figure 4 below.

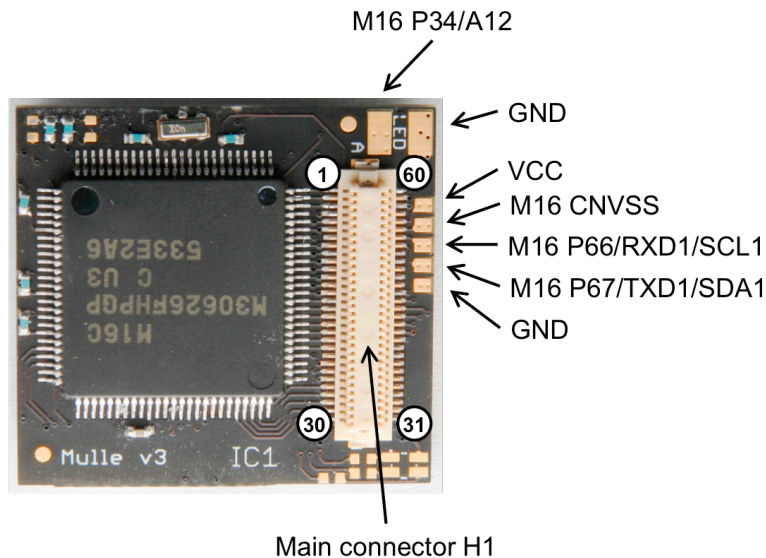


Figure 3: Solder pads, upper side

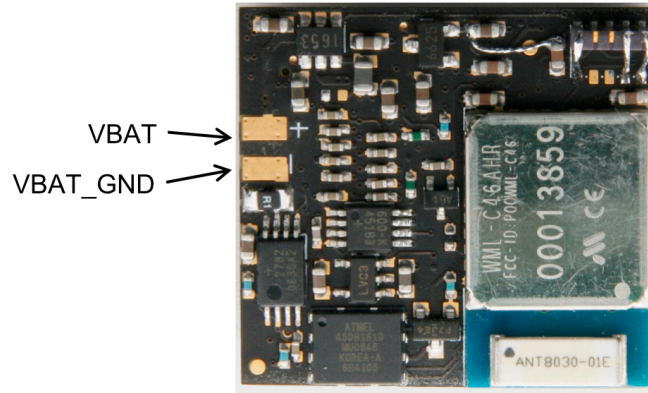


Figure 4: Solder pads, lower side

## 3.4 OPERATING DATA

### 3.4.1 Power Supply

Power supply to the Mulle Platform can be either a battery connected to the solder pads, or via the expansion port (plus to pin 58 and 59, and ground to pin 57 and 60.) All Mulle platforms should be supplied by DC in the range 3.5V – 5.5V. Absolute minimum is 3.2V and maximum is 6.0V. Supply current varies with the operating mode of the Mulle.

The power partitions of the Mulle architecture allows for a very low current consumption. The different partitions can be individually switched off by the MCU when they are not needed for the current operation. When all is switched off and the MCU is in stop mode, the consumption is as low as 4  $\mu$ A. In this mode the system may only be awakened by external or timer interrupts.

The Bluetooth chip alone, when active, consumes up to 50 mA during transmission. In order to save energy, it is advisable to let the MCU switch off the Bluetooth module when not needed, and run the Mulle in MCU only operation. In this mode, measurements can be taken from the sensors, and data can be stored in serial flash memory. The supply current ranges in this mode between 3 mA and 8 mA

### 3.4.2 Operating Temperature

Operating temperature for the Mulle Platform ranges from -40°C to +85°C.