AVR2042: REB Controller Base Board - Hardware User Manual

Features

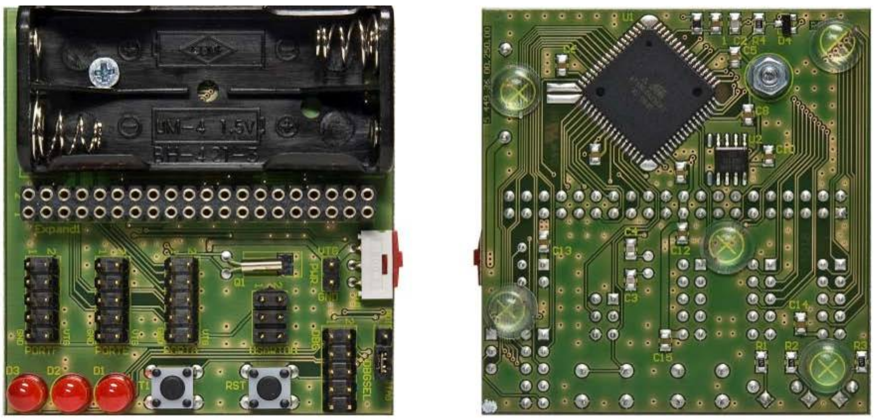
- High-performance, low-power Atmel® 8/16-bit AVR® XMEGA® microcontroller ATxmega256A3
  - 256KB in-system, self-programmable flash
  - 8KB boot code section with independent lock bits
  - 16KB internal SRAM
  - 4KB EEPROM
- 2Mb serial flash for support of over-the-air (OTA) upgrades
- Programming interface
- Fully functional wireless node in combination with the Atmel radio extender board (REB)
- Powered by two AAA batteries for stand-alone operation

1 Introduction

This application note describes the Atmel REB controller base board (REB-CBB). Detailed information about its functionality, its interfaces, the microcontroller programming, and the PCB design is given in the individual sections.

The REB-CBB is intended to serve as a microcontroller platform for Atmel's radio extender board (REB) family. The REB connected to a REB-CBB forms a battery powered, fully functional, and portable wireless node.

Figure 1-1. REB controller base board.



8-bit AVR® Microcontrollers

Application Note

Rev. 8334A-AVR-11/10

2 Disclaimer

Typical values contained in this application note are based on simulations and on testing of individual examples.

Any information about third-party materials or parts is included in this document for convenience. The vendor may have changed the information that has been published. Check the individual vendor information for the latest changes.

3 Overview

The Atmel REB-CBB is designed to interface directly to a radio extender board. The combination of the two boards form a battery powered, fully functional, portable wireless node. The setup provides an ideal platform to:

- Evaluate the outstanding performance of Atmel's radio transceivers
- Test the unique radio transceiver hardware support for the IEEE® 802.15.4 standard [3]
- Test the enhanced radio transceiver feature set
- Develop applications capable of hosting a ZigBee® stack

The following table lists the available radio extender boards and related radio transceivers.

Table 3-1. Supported radio extender boards.

Board Name	Comment	Radio Transceiver
REB230	SMA connector	AT86RF230
REB231	SMA connector	AT86RF231
REB231ED	Antenna diversity	AT86RF231
REB212	SMA connector	AT86RF212

The REB-CBB is assembled with an Atmel 8-bit AVR ATxmega256A3 microcontroller. It offers a connector for programming and debugging, suitable to connect an Atmel JTAGICE mkII programmer. A connector to attach an asynchronous serial interface allows interfacing to a PC host for control and data exchange tasks.

Figure 3-1 shows a development and evaluation setup using the REB-CBB in combination with the REB231ED radio extender board.

Figure 3-1. Atmel REB-CBB connected to an Atmel REB231ED with an RS232 cable plugged in and an Atmel JTAGICE mkII programming interface.

4 Mechanical description

The REB-CBB is manufactured using a two-layer printed circuit board (PCB). All active components are mounted on the bottom side, and all connectors and user I/Os are located on the top side using through-hole components. The radio extender board is plugged into the 2 x 20 female header, Expand1, vertically.

Figure 4-1. Mechanical outline.

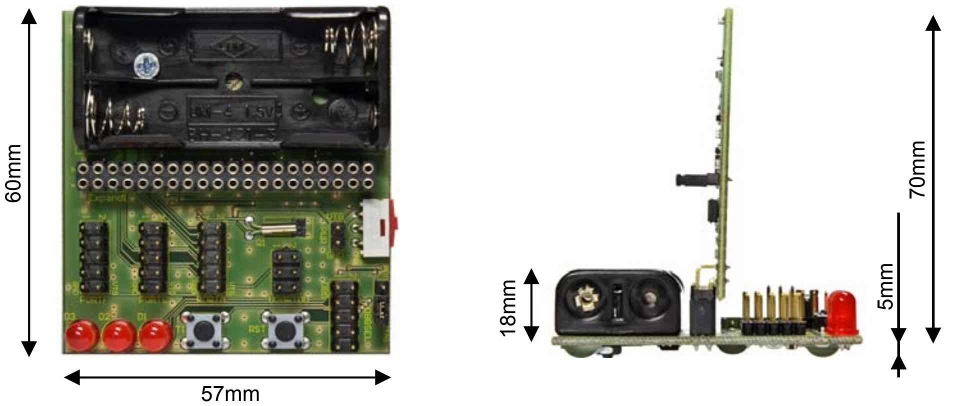


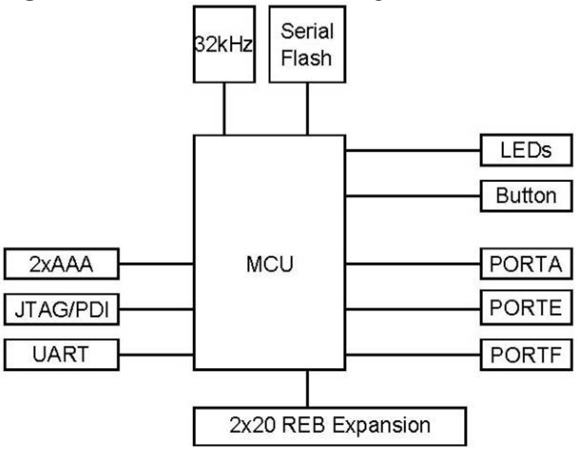
Table 4-1. REB-CBB mechanical dimensions.

Dimension	Value
Width x	57mm
Width y	60mm
PCB standoff height	5mm
Height without REB	18mm
Height with REB231ED plugged in	70mm

5 Functional description

The Atmel REB-CBB carries a high-performance Atmel AVR XMEGA microcontroller, which connects to the radio extender board and various peripheral units (see Figure 5-1). It is powered by two AAA batteries or optionally by applying an external voltage source.

Figure 5-1. REB-CBB block diagram.

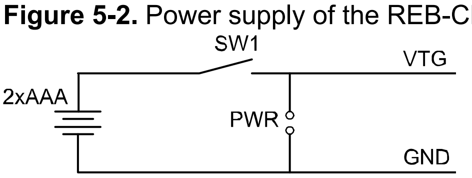


5.1 Power supply

The board is powered by two AAA batteries. The power switch, SW1, disconnects batteries from the entire board. External power is not routed through the power switch.

For debugging and test purposes, power can also be supplied at pin header PWR. Note - there is no protection against over voltage. Take care when applying power from an external source. Refer to Section 7.1 for allowable input voltage range. Exceeding these limits may destroy the board. In addition, avoid applying reverse currents into batteries by switching SW1 to the off position, or by removing the batteries when using external power.

Figure 5-2. Power supply of the REB-CBB.



5.2 Microcontroller

The Atmel XMEGA A3 is a family of low-power, high–performance, and peripheral-rich CMOS 8/16-bit microcontrollers based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the Atmel XMEGA A3 achieves throughputs of up to 1 million instructions per second (MIPS) per MHz, allowing the system designer to optimize power consumption versus processing speed. A detailed description of the Atmel ATxmega256A3 can be found in the datasheet [2].

Table 5-1. ATxmega256A3 ordering information.

Ordering Code	Flash	EEPROM	SRAM	Speed (MHz)	Power Supply	Package	Temp
ATxmega256A3-AU	256KB + 8KB	4KB	16KB	32	1.6V – 3.6V	64A TQFP-64	-40°C – 85°C

5.3 Clock sources

The XMEGA has a flexible clock system, supporting a large number of clock sources. It incorporates both calibrated integrated oscillators and external crystal oscillators, and resonators. The Atmel AVR XMEGA family allows dynamic switching between the clock sources.

Internal clock sources are:

- 32kHz RC oscillator
- 2MHz RC oscillator
- 32MHz RC oscillator

The 2/32MHz oscillators can be calibrated using an automatic runtime calibration feature.

In addition to the internal clock sources, two different external clock sources are supported:

- The 32.768kHz crystal oscillator connected to TOSC1/2 delivers an accurate clock for a real-time counter, or optionally a system clock for XMEGA
- The transceiver clock, CLKM, can be used as an accurate clock derived from the 16MHz radio transceiver oscillator. This signal is routed to the controller input at pin 59 (PR1)

A crystal oscillator failure monitor can be enabled to issue a non-maskable interrupt and switch to internal oscillator if the external oscillator fails.

A high frequency phase-locked loop (PLL) and a clock prescaler are available to generate a wide range of clock frequencies. After reset, the device will always start up running from the 2MHz internal oscillator. During normal operation, the system clock source and prescalers can be changed from software at any time.

5.3.1 32kHz crystal oscillator

The 32.768kHz crystal oscillator is a low-power oscillator using an external crystal. The oscillator can be used as a clock source for the system clock, the RTCs, and as a reference clock for the PLL.

A low-power mode with reduced voltage swing on TOSC2 is available.

The 32kHz crystal is connected to PE6,7. Note that these pins cannot be used as general purpose I/O on header PORTE.

Figure 5-3. 32kHz crystal connection.

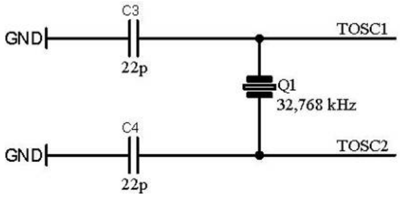


Table 5-2. 32kHz crystal connection.

ATxmega256A3	32kHz crystal
PE6 (42)	TOSC2
PE7 (43)	TOSC1

5.3.2 Transceiver clock (CLKM)

To make use of the transceiver clock, CLKM, an Atmel REB has to be connected to the Atmel REB-CBB and the radio transceiver has to be set up properly on the REB. The transceiver delivers a 1MHz clock frequency after power on. Although it is possible to set the clock frequency up to 16MHz by writing to the transceiver register, no frequencies above 1MHz should be used to drive the microcontroller. This is because the signal is filtered directly at the output pin for EMI suppression to ensure the best RF performance for the REB. To reach a system clock frequency higher than 1MHz, the Atmel XMEGA internal PLL should be used.

Table 5-3. Transceiver clock (CLKM) connection.

ATxmega256A3	Clock source
PD0 (26)	CLKM 1MHz

The REB has to be modified to deliver the CLKM signal to PD0. Therefore, the appropriate solder jumper (0Ω resistor) has to be mounted. Designators of the 0Ω resistor are different for REB variants, and they are listed in the following table.

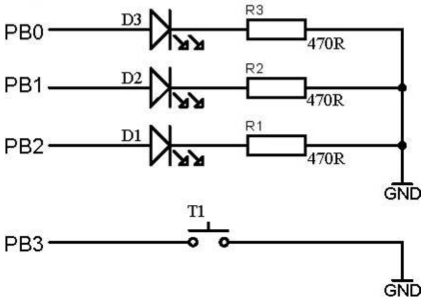
Table 5-4. REB specific CLKM solder jumpers.

REB name	Solder jumper designator (REB)
REB230	R02
REB231	R02
REB231ED	R3
REB212	R3

5.4 User I/O

For simple applications and debugging purposes, or just to deliver status information, a basic user interface is provided directly on the board consisting of three LEDs and a pushbutton.

Figure 5-4. User I/Os.



The LEDs are connected to PB0..2 for active-high operation. The key will pull PB3 to GND. The key is intended to be used in combination with the internal pull-up resistor.

Table 5-5. LED/Button connection.

ATxmega256A3	**I/O**
PB0 (6)	D1
PB1 (7)	D2
PB2 (8)	D3
PB3 (9)	T1

To get full accessibility to all I/O pins of the Atmel ATxmega256A3, three 8-bit ports are routed to 10-pin headers. Each header provides additional pins for VTG and GND. Figure 5-5 shows the pin-out for a single port.

Figure 5-5. General pin-out of I/O port headers.

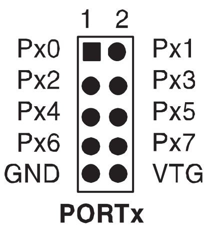


Table 5-6. PORTA header connection.

Header PORTA	**ATxmega256A3**
1	PA0 (62)
2	PA1 (63)
3	PA2 (64)
4	PA3 (1)
5	PA4 (2)
6	PA5 (3)
7	PA6 (4)
8	PA7 (5)
9	GND
10	VTG

Table 5-7. PORTE header connection.

Header PORTE	ATxmega256A3
1	PE0 (62)
2	PE1 (63)
3	PE2 (64)
4	PE3 (1)
5	PE4 (2)
6	PE5 (3)
7	
8	
9	GND
10	VTG

Table 5-8. PORTF header connection.

Header PORTF	ATxmega256A3
1	PF0 (62)
2	PF1 (63)
3	PF2 (64)
4	PF3 (1)
5	PF4 (2)
6	PF5 (3)
7	PF6 (4)
8	PF7 (5)
9	GND
10	VTG

5.5 Serial flash

The Atmel REB-CBB is populated with a 2MB serial flash device (Atmel AT25DF021) for persistent data storage. It is capable of storing one complete firmware image of the Atmel ATxmega256A3, which makes it suitable for over-the-air upgrades (OTA). It is connected to SPID PD4..7.

Table 5-9. Serial flash connection.

ATxmega256A3	AT25DF021
PD4 (30)	#CS
PD5 (31)	SI
PD6 (32)	SO
PD7 (33)	SCK

The AT25DF021 supports SPI frequencies of up to 50MHz on supply voltages down to 2.3V. When operating the board below 2.3V, the serial flash can not be accessed, see datasheet [3] for more information.

Table 5-10. AT25DF021 ordering information.

Ordering Code	Flash	Maximum freq.	Power supply	Package	Temperature
AT25DF021-SSHF-B	256KB + 8KB	50MHz	2.3V – 3.6V	8S1 SOP-8	-40°C – 85°C

5.6 UART

The serial asynchronous interface, USARTD0, of the Atmel ATxmega256A3 is connected to header USARTD0. Additionally, the MCU reset line is connected to pin 5 of the header. This can be used to work with a serial boot loader. No level conversion is done; therefore, an external RS232/TTL conversion circuit is required.

The header pin-out mates with the available RS232/TTL converter (art. no. de28560).

Table 5-11. Connection of USARTD0.

ATxmega256A3	Header USARTD0	Description
PD2 (28)	RxD (4)	Asynchronous serial in
PD3 (29)	TxD (1)	Asynchronous serial out
RESET (57)	RESET (5)	MCU reset

6 Programming

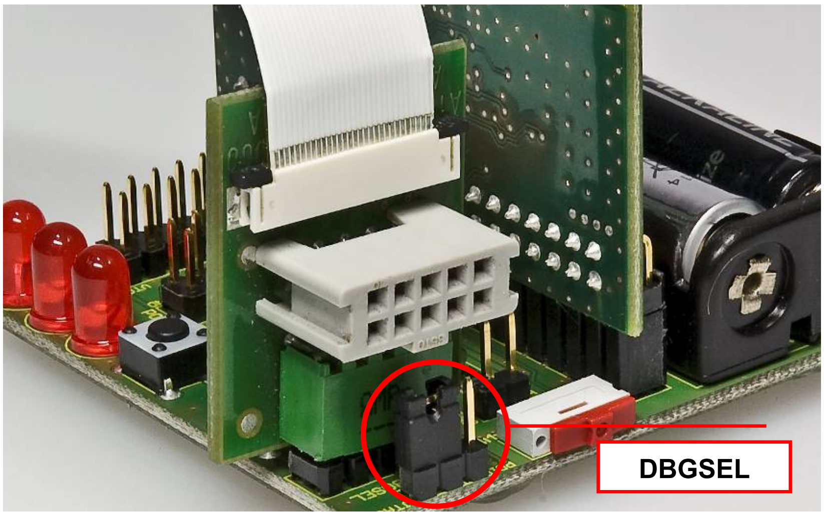
On the ATxmega256A3, both programming and debugging can be done through two physical interfaces.

The primary interface is the program and debug interface (PDI). This is a two-pin interface using the reset pin for the clock input (PDI_CLK) and the dedicated test pin for data input and output (PDI_DATA).

Programming and debugging can also be done through the four-pin JTAG interface. The JTAG interface is IEEE 1149.1 standard compliant and supports boundary scan. Any external programmer or on-chip debugger/emulator can be directly connected to these interfaces, and no external components are required.

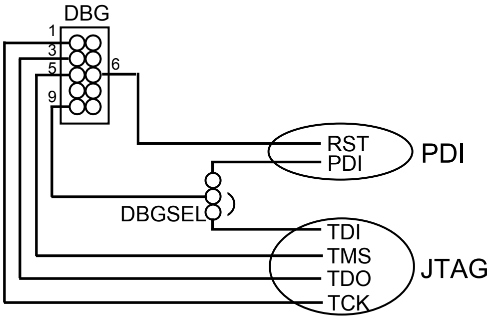
The Atmel REB-CBB provides a 10-pin header to connect the Atmel JTAGICE mkII probe. This connection can be used for both protocols, JTAG and PDI.

Figure 6-1. Connection between JTAGICE mkII and REB-CBB.



To select between one of the protocols, the jumper DBGSEL has to be set to the appropriate position. It routes test data input (signal TDI) to either TDI of the JTAG interface or PDI of Atmel's proprietary PDI interface.

Figure 6-2. Debug interface.



Note: Atmel JTAGICE mkII units with hardware revision 0 do not have PDI capabilities.

Table 6-1. Connection of header DBG.

DBG Connector	DBGSEL=JTAG	DBGSEL=PDI
TMS (5)	PB4 (10)	PB4 (10) unused
TDI (9)	PB5 (11)	PDI (56)
TCK (1)	PB6 (12)	PB6 (12) unused
TDO (3)	PB7 (13)	PB7 (13) unused
nSRST (6)	RESET (57)	RESET (57)

7 Electrical characteristics

7.1 Absolute maximum ratings

Stresses beyond those listed under "Absolute maximum ratings" may cause permanent damage to the board. This is a stress rating only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this manual are not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. For more details about these parameters, refer to individual datasheets of the components used.

Table 7-1. Absolute maximum ratings.

No.	Parameter	Condition	Minimum	Typical	Maximum	Units
7.1.1	Storage temperature range		-40		+85	°C
7.1.2	Humidity	Non-condensing			90	%
7.1.3	Supply voltage		-0.3		+3.6	V
7.1.4	EXT I/O pin voltage		-0.3		Vcc + 0.3	V
7.1.5	Supply current from batteries	Sum over all power pins			-0.5	A
7.1.6	Battery charge current (1)				0	mA

Note: 1. Keep power switch off or remove battery from REB-CBB when external power is supplied.

7.2 Recommended operating range

Table 7-2. Recommended operating range.

No.	Parameter	Condition	Minimum	Typical	Maximum	Units
7.2.1	Temperature range		-10		+60	°C
7.2.2	Supply voltage (Vcc)	Plain REB-CBB	1.6	3.0	3.6	V
7.2.3		REB plugged on REB-CBB	1.8	3.0	3.6	V
7.2.4		Serial flash access in usage	2.3	3.0	3.6	V

7.3 Current consumption

Test conditions (unless otherwise stated):

V_{DD} = 3.0V, T_{OP} = 25°C

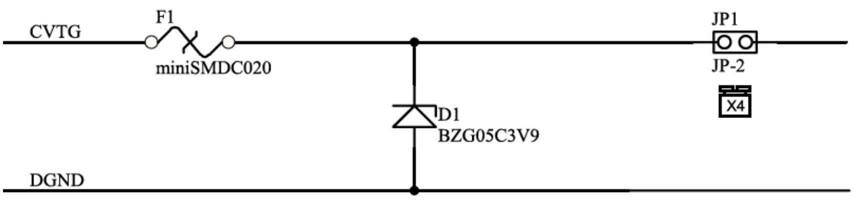
The following table lists current consumption values for typical scenarios of a complete system composed of Atmel REB-CBB and Atmel REB231. The z-diode has been removed as described above.

Table 7-3. Current consumption of REB-CBB populated with REB231.

No.	Parameter	Condition	Minimum	Typical	Maximum	Units
7.3.1	Supply current	MCU @ power-down, transceiver in state SLEEP, serial flash in Deep-Sleep		17		µA
7.3.2	Supply current	MCU @ 2MHz, transceiver in state TRX_OFF		3		mA
7.3.3	Supply current	MCU @ 16MHz (int. RC 32MHz), transceiver in state TRX_OFF		15		mA
7.3.4	Supply current	MCU @ 16MHz (int. RC 32MHz), transceiver in state RX_ON		28		mA
7.3.5	Supply current	MCU @ 16MHz (int. RC 32MHz), transceiver in state BUSY_TX		26		mA

For current consumption measurements, please regard the z-diode mounted on the REB. It prevents applying overvoltage stress to the radio transceiver circuit as well as protection against reverse polarity.

Figure 7-1. REB overvoltage protection mechanism.



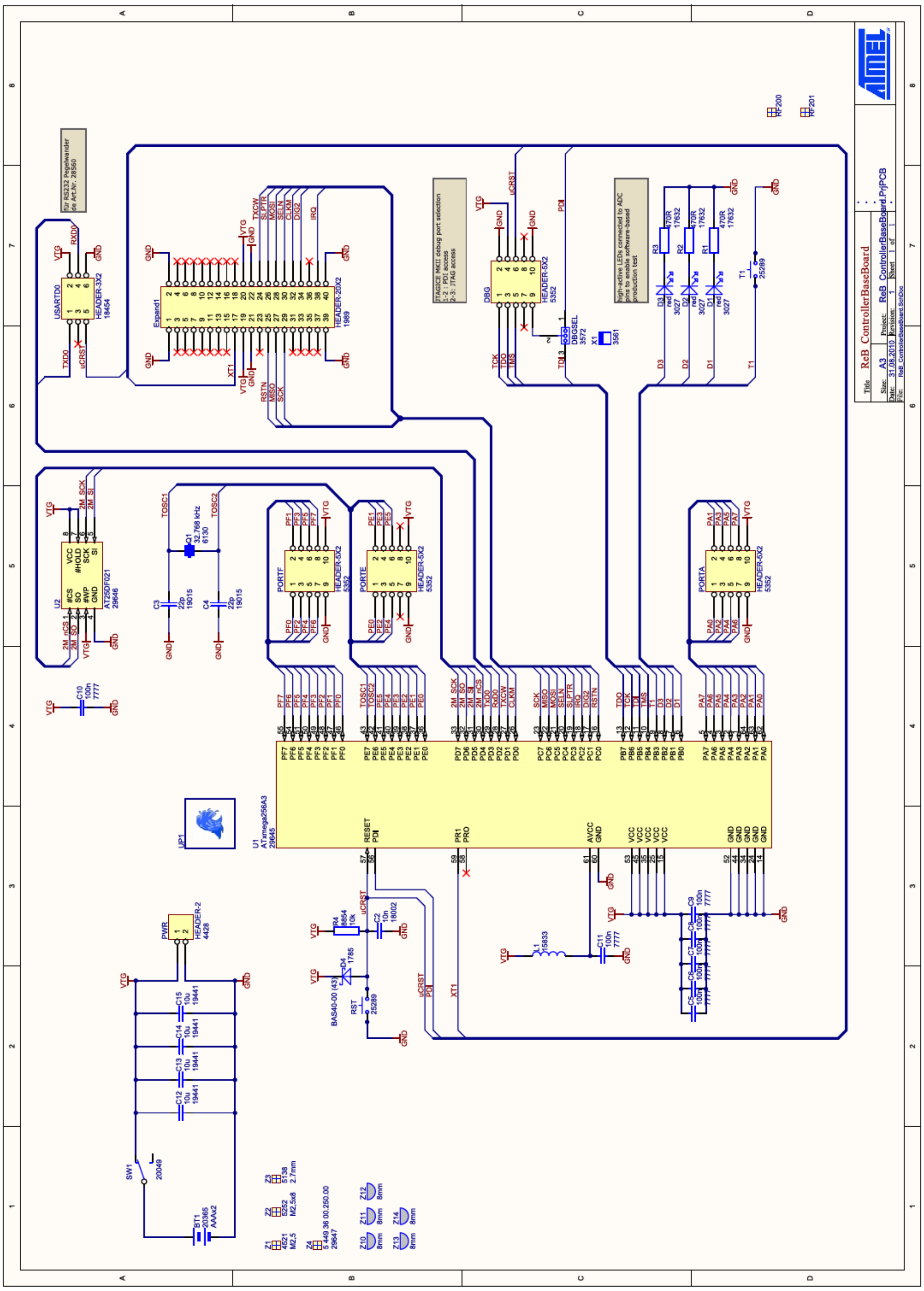
The z-diode draws approximately 6mA at 3.0V (type: BZG05-C3V9), which should be considered in overall current consumption. The z-diode shall be removed for low-power designs or in case of current measurements.

8 Abbreviations

CBB	-	Controller base board
DFLL	-	Digital frequency-locked loop
JTAG	-	Joint Test Action Group
PDI	-	Program/debug interface
REB	-	Radio extender board
RTC	-	Real time counter
SPI	-	Serial peripheral interface
USART	-	Universal synchronous/asynchronous receiver/transmitter
XOSC	-	Crystal oscillator

Appendix A - PCB design data

A.1 Schematic



A.2 Assembly drawing

Figure 8-1. Assembly top.

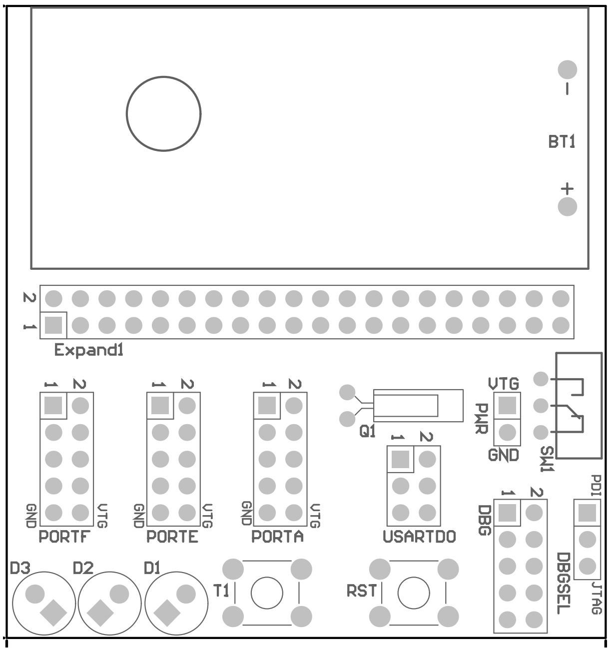
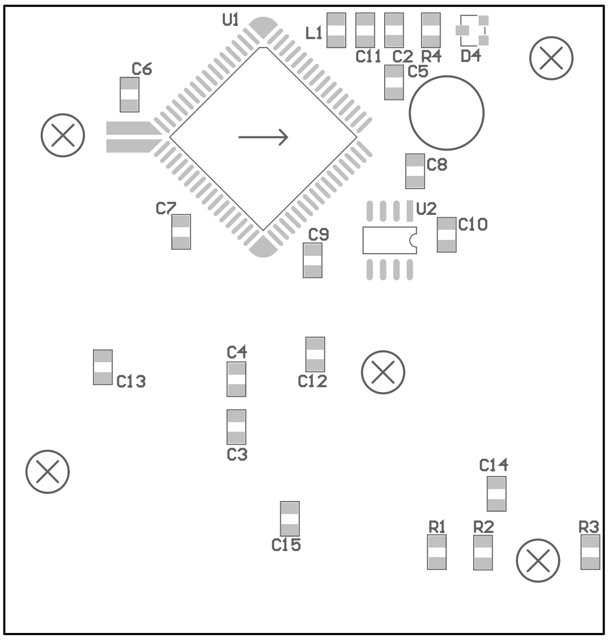


Figure 8-2. Assembly bottom.



A.3 Bill of materials

Designator	Description	Value	Manufacturer	Part Number	Comment
BT1	Battery holder	2 x AAA		BH 421-3	
C2	Capacitor	10nF			
C3, C4	Capacitor	22pF			
C5, C6, C7, C8, C9, C10, C11	Capacitor	100nF			
C12, C13, C14, C15	Capacitor	10µF			
D1, D2, D3	LED	red		WU-2-69HD/LC	
D4	Schottky diode		Vishay	BAS40-00 (43)	
DBG, PORTA, PORTE, PORTF	Header 5 x 2 100mil				
DBGSEL	Header 3 x 1 100mil				
Expand1	Header female 20 x 2 100mil				
L1	Inductor				
PWR	Header 2 x 1 100mil				
Q1	Quartz	32.768kHz			
R1, R2, R3	Resistor	470Ω			
R4	Resistor	10kΩ			
RST, T1	Pushbutton				
SW1	Switch, single-pole				
U1	8/16-bit AVR XMEGA microcontroller	ATxmega256A3	Atmel	ATxmega256A3-MH	
U2	2 MB SPI serial flash memory	AT25DF021	Atmel	AT25DF021-SSHF	
USARTD0	Header 3 x 2 100mil				
X1	Jumper 100mil				
Z1	Nut	M2.5			
Z2	Countersink screw	M2.5 x 8		DIN965/4.8/gal ZN	
Z3	Nylon washer M2.5	2.7mm		DIN125	
Z10, Z11, Z12, Z13, Z14	Rubber foot 8.0 x 2.5mm	8mm			

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References

[1]	Atmel ATxmega256A3; High-performance, Low-power 8/16-bit AVR XMEGA Microcontroller; Datasheet; Rev. 8068P – 02/10; Atmel Corporation
[2]	Atmel AT25DF021; 2-Megabit 2.3-volt or 2.7-volt Minimum SPI Serial Flash Memory; Datasheet; Revision D – April 2009; Atmel Corporation
[3]	IEEE Std 802.15.4™-2006: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low-Rate Wireless Personal Area Networks (LR-WPANs)

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