

AT02667: XMEGA-E5 Xplained Hardware User's Guide

APPLICATION NOTE

Features

- Atmel® AVR® ATxmega32E5 microcontroller
- OLED display with 128×32 pixels resolution
- Ambient light sensor
- Analog filter
- Rotary Encoder with push button
- Digital I/O
 - Two mechanical buttons
 - Two user LEDs
 - Four expansion headers
- Board controller with USB interface
 - One power LED and one status LED

Description

The Atmel AVR XMEGA-E5 Xplained evaluation kit is a hardware platform to evaluate the Atmel ATxmega32E5 microcontroller.

The kit offers a larger range of features that enables the Atmel AVR XMEGA® user to get started using XMEGA peripherals right away and understand how to integrate the XMEGA device in their own design.

Figure -1. XMEGA-E5 Xplained Kit

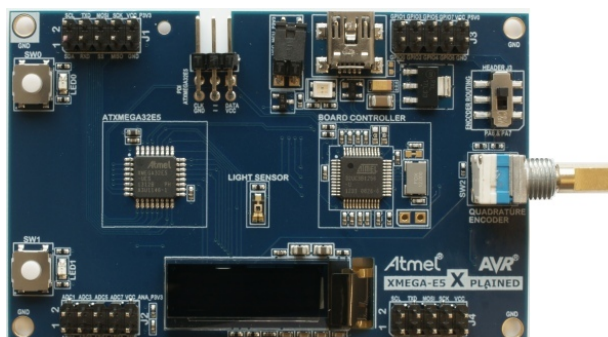


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1. Related Items

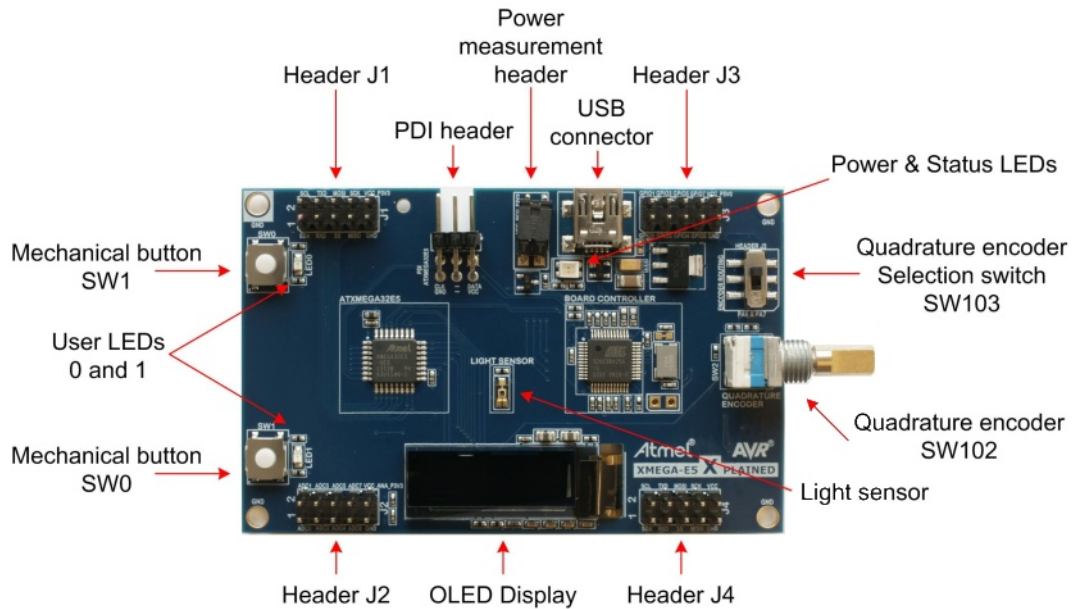
The following list contains links to the most relevant documents, software and tools for the Atmel AVR XMEGA-E5 Xplained:

- [Atmel AVR Xplained products](#)
Xplained is a series of small-sized and easy-to-use evaluation kits for 8- and 32-bit AVR microcontrollers. It consists of a series of low cost MCU boards for evaluation and demonstration of feature and capabilities of different MCU families.
- [Atmel Xplained USB CDC driver](#)
The Xplained USB CDC driver file supports both 32- and 64-bit versions of Windows® XP and Windows 7. Driver installs are not necessary on Linux® operating systems.
- [XMEGA-E5 Xplained schematics](#)
Package containing schematics, BOM, assembly drawings, 3D plots, layer plots...
- [AT02667: XMEGA-E5 Xplained Hardware Users Guide](#)
This document.
- [AT02657: XMEGA-E5 Xplained Software User Guide](#)
This application note is a user guide for the XMEGA-E5 Xplained demo software.
- [Atmel Studio 7](#)
Atmel Studio 7 is a free Atmel IDE for development of C/C++ and assembler code for Atmel microcontrollers.
- [Atmel JTAGICE3](#)
JTAGICE3 is a mid-range development tool for Atmel 8- and 32-bit AVR microcontrollers with on-chip debugging for source level symbolic debugging, NanoTrace (if supported by the device) and device programming.
- [Atmel AVR JTAGICE mkII](#)
AVR JTAGICE mkII is a mid-range development tool for Atmel 8- and 32-bit AVR devices with on-chip debugging for source level symbolic debugging, NanoTrace (if supported by the device), and device programming (superseded by JTAGICE3).
- [Atmel AVR ONE!](#)
AVR ONE! is a professional development tool for all Atmel 8- and 32-bit AVR devices with on-chip debug capability. It is used for source level symbolic debugging, program trace, and device programming. The AVR ONE! supports the complete development cycle and is the fastest debugging tool offered from Atmel.
- [Atmel AVR Dragon](#)
AVR Dragon™ sets a new standard for low cost development tools for 8- and 32-bit AVR devices with on-chip debug (OCD) capability.
- [IAR Embedded Workbench® for Atmel AVR](#)
IAR™ Embedded Workbench is a commercial C/C++ compiler that is available for 8-bit AVR. There is a 30 day evaluation version as well as a 4k (code size limited) kick-start version available from their website.

2. General Information

The Atmel AVR XMEGA-E5 Xplained kit is intended to demonstrate the Atmel AVR ATxmega32E5 microcontroller. The figure below shows the available features on the board.

Figure 2-1. Overview of the XMEGA-E5 Xplained Kit



2.1. Preprogrammed Firmware

The ATxmega32E5 on the XMEGA-E5 Xplained is pre-programmed with a default firmware. The detailed description of the software is available in the [AT02657: XMEGA-E5 Xplained Software User Guide](#). Project and source files are available in Atmel Studio and Atmel Software Framework.

2.2. Power Supply

The kit needs an external power supply that can deliver 5V and up to 500mA. The actual current requirement for the board is much less than 500mA but in order to be able to power optional expansion boards this margin is recommended.

The power can be applied to the board either via the USB connector or on pin 10 on header J3. The USB connector is the preferred input because it is then possible to connect expansion boards on top of the J3 header.

The 5V (USB supply voltage) is regulated down to 3.3V with an onboard LDO regulator, which provides power to the entire board. Expansion top boards that require 5V will get this from the header J3 pin 10.

2.3. Measuring the Atmel AVR XMEGA Power Consumption

As part of an evaluation of the Atmel AVR ATxmega32E5, it can be of interest to measure its power consumption. Because the XMEGA has a separate power plane (VCC_MCU_P3V3) on this board it is possible to measure the current consumption by measuring the current flowing into this plane. The VCC_MCU_P3V3 plane is connected via a jumper to the main power plane (VCC_P3V3) and by

replacing this with an ampere meter it is possible to determine the current consumption. To locate the power measurement header, refer to [Figure 2-1](#).



Attention:

Do not power the board without having the jumper or an ampere meter mounted since this can cause latch-up of the Atmel AVR ATxmega32E5 due to current flow into the I/O pins.

2.4. Communication through the USART-to-USB Gateway

The ATxmega32E5 USART is connected to a USART on the Atmel AT32UC3B1256. The ATxmega32E5 USART is communicating at 57600 baud using one start bit, eight data bits, one stop bit, and no parity.

When the AT32UC3B1256 device is enumerated (connected to a PC). The data transmitted from the ATxmega32E5 is passed to a (virtual) COM port. This means that it is possible to use a terminal program on a PC to receive the transmitted data. Similarly data transmitted from the PC COM port is passed to the ATxmega32E5 USART through the gateway.

2.5. Programming the Kit

The kit can be programmed using an external programming tool.

How a programmer can be connected to the kit is described in [Programming Headers](#).

3. Connectors

The Atmel AVR XMEGA-E5 Xplained kit has four 10-pin 100mil headers, and one 6-pin 100mil header. The 6-pin header is used for programming the Atmel AVR ATxmega32E5, and the 10-pin headers are used to access spare analog and digital pins on the Atmel AVR XMEGA (expansion headers).

3.1. Programming Headers

The XMEGA can be programmed and debugged by connecting an external programming/debugging tool to the PDI header shown in [Figure 2-1](#).

The gray XMEGA PDI adapter must be used on the Atmel AVR JTAGICE mkII probe when connecting to the XMEGA-E5 Xplained board.

The green standoff adaptor nr.3 (ref.A08-0254) has to be used on the Atmel AVR ONE! probe when connecting to the XMEGA-E5 Xplained board.

Table 3-1. XMEGA Programming and Debugging Interface – PDI

Pin on programming header	PDI
1	DATA
2	VCC
3	-
4	-
5	CLK
6	GND

3.2. I/O Expansion Headers

The Atmel AVR XMEGA-E5 Xplained headers J1, J2, J3, and J4 offer access to the I/Os of the microcontroller in order to expand the board, for example by mounting a top module onto the board.

The header J1 offers digital communication interfaces like UART, TWI, and SPI. The table below shows how the Atmel AVR XMEGA is connected to the header.

Note that when using TWI no pull-ups are mounted on the board from the factory, so it is required to enable the internal pull-ups of the device.

Table 3-2. Expansion Header J1

Pin on J1	Name on J1	XMEGA pin	Shared with on-board functionality
1	SDA	PC0	Connected to the Board Controller ¹
2	SCL	PC1	Connected to the Board Controller ¹
3	RXD	PC2	-
4	TXD	PC3	-
5	SS	PC4	Connected to the Board Controller ²

¹ Need to mount R408/R409 to connect TWI lines to Board Controller.

Pin on J1	Name on J1	XMEGA pin	Shared with on-board functionality
6	MOSI	PC7	Connected to the Board Controller ²
7	MISO	PC6	Connected to the Board Controller ²
8	SCK	PC5	Connected to the Board Controller ²
9	GND	-	-
10	VCC_P3V3	-	-

Header J2 is connected to analog ports of the XMEGA as shown in the table below.

Table 3-3. Expansion Header J2

Pin on J2	Name on J2	XMEGA pin	Shared with on-board functionality
1	ADC0	PA0	-
2	ADC1	PA1	-
3	ADC2	PA2	-
4	ADC3	PA3	-
5	ADC4	PA4	-
6	ADC5	PA5	Quadrature Encoder Button ³
7	ADC6	PA6	Quadrature Encoder Output ⁴
8	ADC7	PA7	Quadrature Encoder Output ⁴
9	GND	-	-
10	VCC_P3V3	-	-

Header J3 is connected to digital ports of XMEGA. The table below shows the mapping of the XMEGA I/O to J3.

Table 3-4. Expansion Header J3

Pin on J3	Name on J3	XMEGA pin	Shared with on-board functionality
1	GPIO0	PR0	Shared with OLED display: data/cmd function
2	GPIO1	PR1	Shared with OLED display: CS function
3	GPIO2	QENC_A	Quadrature Encoder Output ⁵
4	GPIO3	QENC_B	Quadrature Encoder Output ⁵
5	GPIO4	PC4/ SS	
6	GPIO5	PC7/MOSI	

² Need to mount R410/R411/R412/R413 to connect SPI lines to Board Controller.

³ Can be disconnected from on-board functionality by cut-straps.

⁴ Can be disconnected using SW103 mechanical switch.

⁵ Quadrature encoder outputs can be accessible on this header when SW103 mechanical switch is pushed up.

Pin on J3	Name on J3	XMEGA pin	Shared with on-board functionality
7	GPIO6	PC6/MISO	
8	GPIO7	PC5/SCK	
9	GND	-	-
10	VCC_P5V0	-	-

Header J4 offers digital communication interfaces such as UART and TWI, but care must be taken because some pins are also connected to on-board peripherals.

Table 3-5. Expansion Header J4

Pin on J4	Name on J4	XMEGA pin	Shared with on-board functionality
1	SDA	PD0	Shared with button SW100 (silkscreen SW0)
2	SCL	PD1	Shared with Light sensor ⁶
3	RXD	PD2	Shared with button SW101(silkscreen SW1)
4	TXD	PD3	Shared with OLED display: reset function
5	SS	PD4	Shared with LED D100 (silkscreen LED0)
6	MOSI	PD7	Connected to the Board Controller ⁷
7	MISO	PD6	Connected to the Board Controller ⁷
8	SCK	PD5	Shared with LED D101 (silkscreen LED1)
9	GND	-	-
10	VCC_P3V3	-	-

⁶ Can be disconnected from on-board functionality by cut-strap J100.

⁷ RXD and TXD lines swapped from PD3 and PD4 and used for communication with board controller.

4. Peripherals

4.1. Mechanical Buttons

Two mechanical buttons are connected to the Atmel AVR XMEGA. All buttons have no external pull-ups so the user has to activate internal pull-ups in order to use them. When a button is pressed it will drive the I/O line to GND.

Table 4-1. Mechanical Button Connection

Pin on XMEGA	Silkscreen text on PCB
PD0	SW0
PD2	SW1

4.2. LEDs

There are two yellow LEDs available on the board that can be turned ON and OFF. The LEDs can be activated by driving the connected I/O line to GND.

Table 4-2. LED Connections

Pin on XMEGA	LED
PD4	Yellow LED0
PD5	Yellow LED1

One green LED (power indicator) and one red LED (status) are also present inside the same package and therefore the colors can be mixed to orange when both are activated. The two LEDs are controlled via the Board Controller and the user has no access to them.

4.3. Quadrature Encoder

The Quadrature Encoder (SW102) is made of one mechanical button and two outputs. These outputs are connected to a mechanical switch (SW103), which enables to either connect them to the XMEGA pins or let them be accessible on the J3 header.

Table 4-3. Quadrature Encoder Connections

Pin on XMEGA	Pin on J3 header	Switch SW103	Quadrature Encoder pins
PA5 ⁸	NA	NA	5 (button)
PA6 ⁸	NA	2-1 (switch pushed down)	1 (channel A)
PA7 ⁸	NA	5-4 (switch pushed down)	3 (channel B)
NA	PIN3	2-3 (switch pushed up)	1 (channel A)
NA	PIN4	5-6 (switch pushed up)	3 (channel B)

⁸ Signal also connected to header J2.

4.4. OLED Display

The OLED display on the XMEGA-E5 Xplained board is UG-2832HSWEG04 manufactured by [WiseChip Semiconductor Inc.](#) It has a resolution of 128 × 32 pixels. In the design the display is connected via a SPI based interface. Detailed information about the display can be obtained from the display datasheet.

The connection between the MCU and the OLED display is shown in the table below.

Table 4-4. OLED Display Connection

Pin on XMEGA	Function on OLED
PR0	Data_command
PC5	SCK
PC7	MOSI
PC4	SS
PD3	RESET

4.5. Analog I/O

4.5.1. Ambient Light Sensor

The ambient light sensor TEMT6000X01 from [Vishay Semiconductors](#) is sensitive to visible light much like the human eye. The measurement circuitry is configured to measure the illuminance from ~10 to ~900lx when the internal VCC/1.6 reference is used.

The data in [Table 4-6](#) which shows the relationship between illuminance and output voltage of the sensor circuitry is generated based on the symbols and formulas shown in the table below.

Table 4-5. Symbol Description for Illuminance Calculation

Symbols	Description
I_{CA}	Calibrated sensor responsivity at 100lx. This is 50μA according to the sensor datasheet.
E_v	Illuminance
I	Current through the sensor
U	Output voltage of the sensor circuitry that is provided to the ADC
R	Series resistor of the sensor circuitry. 4.7kΩ has been chosen in this design.
$E_v = 100 \times I / I_{CA}$	Illuminance is calculated based on the relation of the actual current through the sensor to the calibrated value at 100lx
$I = U / R$	Since the ADC measures the voltage across the series resistor of the sensor circuitry it is necessary to calculate the voltage based on the current
$U = (E_v \times R \times I_{CA}) / 100$	Based on the current and the illuminance the output voltage of the sensor circuitry can be calculated

Table 4-6. Illuminance vs. ADC Input Voltage

Illuminance [lux]	ADC input [V]	Illuminance
1	0.0024	Dusk
10	0.0235	Dusk
20	0.0470	Dusk
30	0.0705	Dusk
40	0.0940	Dusk
50	0.1175	Living room
60	0.1410	Living room
70	0.1645	Living room
80	0.1880	Living room
90	0.2115	Living room
100	0.2350	Living room
200	0.4700	Office lighting
300	0.7050	Office lighting
400	0.9400	Office lighting
500	1.1750	Office lighting
600	1.4100	Office lighting
700	1.6450	Office lighting
800	1.8800	Office lighting
900	2.1150	Office lighting
1000	2.3500	Overcast day

4.6. Board Controller

The Atmel AT32UC3B1256 board controller and the Atmel ATxmega32E5 are connected through TWI, SPI, and USART interfaces. All interfaces can be used to communicate between the devices, but only the USART is implemented by default on the board controller.

Table 4-7. ATxmega32E5 and Board Controller Communication Interface

Interface	ATxmega32E5 pin	Atmel AT32UC3B1256 pin
UART RX ⁹	PD6	PA24
UART TX ⁹	PD7	PA23
TWI SCL ¹⁰	PC1	PA09

⁹ This represents the RX and TX on the ATxmega32E5. The RX is connected to TX on the other device, and vice versa.

Interface	ATxmega32E5 pin	Atmel AT32UC3B1256 pin
TWI SDA ¹⁰	PC0	PA10
SPI SS ¹¹	PC4	PA16
SPI MOSI ¹¹	PC7	PA14
SPI MISO ¹¹	PC6	PA25
SPI SCK ¹¹	PC5	PA17

¹⁰ These TWI signals can be reconnected by placing a 0Ω resistor or a solder drop on R408 and R409 footprints.

¹¹ These SPI signals can be reconnected by placing a 0Ω resistor or a solder drop on R410, R411, R412, and R413 footprints.

5. Code Examples

The example application is based on the Atmel AVR Software Framework that is included in Atmel Studio 6. The AVR Software Framework can also be found as a separate package online at:

<http://www.atmel.com/tools/avrsoftwareframework.aspx>.

For more information about the code example, see the application note [Atmel AT02657 XMEGA-E5 Xplained Software Users Guide](#).

The Atmel AT32UC3B1256 board controller is also pre-programmed with a bootloader and a USART-to-USB gateway application, which can be used to communicate with the target controller ATxmega32E5.

6. Hardware Revision History and Known Issues

To identify the revision of the kit, locate the bar-code sticker on the back side of the board. The first line on the sticker shows the product ID and the revision. For example “A09-1842/1” can be resolved to ID=A09-1842 and revision=1.

6.1. Revision 1

Revision 1 of XMEGA-E5 Xplained is the initial released version, there are no known issues.

7. Document Revision History

Revision	Date	Changes
B	08/2016	Updated pictures
A	04/2013	Initial document release

8. Evaluation Board/Kit Important Notice

This evaluation board/kit is intended for use for **FURTHER ENGINEERING, DEVELOPMENT, DEMONSTRATION, OR EVALUATION PURPOSES ONLY**. It is not a finished product and may not (yet) comply with some or any technical or legal requirements that are applicable to finished products, including, without limitation, directives regarding electromagnetic compatibility, recycling (WEEE), FCC, CE or UL (except as may be otherwise noted on the board/kit). Atmel supplied this board/kit "AS IS", without any warranties, with all faults, at the buyer's and further users' sole risk. The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies Atmel from all claims arising from the handling or use of the goods. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge and any other technical or legal concerns.

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Mailing Address:

Atmel Corporation
1600 Technology Drive
San Jose, CA 95110
USA



Atmel Corporation 1600 Technology Drive, San Jose, CA 95110 USA **T:** (+1)(408) 441.0311 **F:** (+1)(408) 436.4200 | **www.atmel.com**

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