

### Atmel AVR1925: XMEGA-C3 Xplained Hardware User's Guide

#### Atmel XMEGA C

#### Features

- Atmel® AVR® ATxmega384C3 microcontroller
- OLED display with 128×32 pixels resolution
- Analog sensors
  - Ambient light sensor
  - Temperature sensor
- Analog filter
- Digital I/O
  - Two mechanical buttons
  - Two user LEDs, one power LED and one status LED
  - Four expansion headers
- Touch
  - Two Atmel AVR QTouch® button
- Memory
  - microSD Card

#### Description

The Atmel AVR XMEGA-C3 Xplained evaluation kit is a hardware platform to evaluate the Atmel ATxmega384C3 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-C3 Xplained evaluation 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-C3 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-C3 Xplained schematics](#)

Package containing schematics, BOM, assembly drawings, 3D plots, layer plots...

### [AVR1925: XMEGA-C3 Xplained Hardware Users Guide](#)

This document.

### [AVR1939: XMEGA-C3 Xplained Getting Started Guide](#)

This application note is a getting started guide for the XMEGA-C3 Xplained.

### [AVR1940: XMEGA-C3 Xplained Software User Guide](#)

This application note is a user guide for the XMEGA-C3 Xplained demo software.

### [AVR1916: XMEGA USB DFU Boot Loaders](#)

This application note is a user guide for the XMEGA USB DFU boot loaders.

### [Atmel Studio 6](#)

Atmel Studio 6 is a free Atmel IDE for development of C/C++ and assembler code for Atmel microcontrollers.

### [Atmel FLIP \(Flexible In-system Programmer\)](#)

BatchISP (FLIP) is a command line tool for programming the flash and EEPROM memories of the AVR and is part of the FLIP installation. It can be used to communicate with the preprogrammed USB DFU boot loader.

### [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.

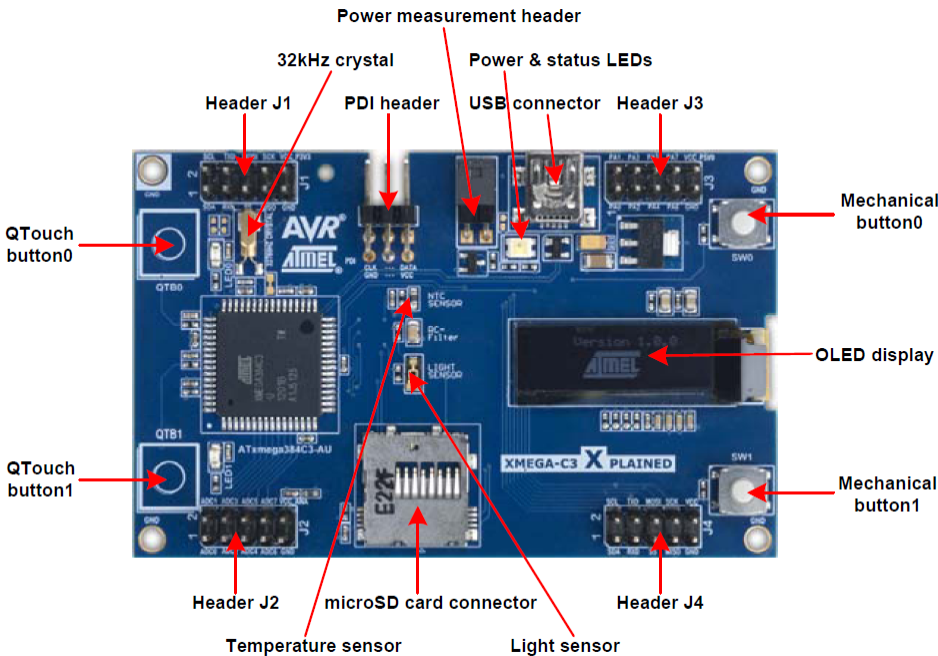
### [IAR Embedded Workbench® for Atmel AVR](#)

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-C3 Xplained kit is intended to demonstrate the Atmel AVR ATXmega384C3 microcontroller. [Figure 2-1](#) shows the available feature on the board.

**Figure 2-1. Overview of XMEGA-C3 Xplained kit.**



### 2.1 Preprogrammed firmware

The ATXmega384C3 on the XMEGA-C3 Xplained is pre-programmed with a boot loader and a default firmware. The detailed description of the software is available in the AVR1940 XMEGA-C3 Xplained Software User Guide.

### 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 the 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 ATXmega384C3, 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 that is flowing into this plane. The VCC\_MCU\_P3V3 plane is connected via a jumper to the main power plane (VCC\_P3V3) and by replacing the jumper with an amperemeter it is possible to determine the current consumption. To locate the power measurement header, please refer to [Figure 2-1](#).

**Warning:** Do not power the board without having the jumper or an amperemeter mounted since this can cause latch-up of the Atmel AVR ATxmega384C3 due to current flow into the I/O pins.

## 2.4 Programming the kit

The kit can be programmed either from an external programming tool or through an USB boot loader which is pre-programmed on the device.

The boot loader is evoked by pushing the push button (SW0) during power-on, that is push and hold the button and hence connect an USB cable to the kit. Programming can be performed through the DFU programmer FLIP.

How a programmer can be connected to the kit is described in Section [3.1](#).

### 3. Connectors

The Atmel AVR XMEGA-C3 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 ATxmega384C3, 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 grey XMEGA PDI adapter on the Atmel AVR JTAGICE mkII probe has to be used when connecting to the XMEGA-C3 Xplained board.

The green standoff adaptor nr.3 (ref.A08-0254) on the Atmel AVR ONE! probe has to be used when connecting to the XMEGA-C3 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-C3 Xplained headers J1, J2, J3, and J4 offer access to the I/O 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. [Table 3-2](#) shows how the Atmel AVR XMEGA is connected to the header.

Note: When using TWI please note that no pull-ups are mounted on the board from the factory, so it is required to either enable the internal pull-ups of the device or to mount the external pull-ups on the available footprints (R200 and R201). Please refer to the assembly drawing in the design documentation for the location of these footprints.

**Table 3-2. Expansion header J1.**

Pin on J1	Name on J1	XMEGA pin	Shared with onboard functionality
1	SDA	PC0	-
2	SCL	PC1	-
3	RXD	PC2	-
4	TXD	PC3	-
5	SS	PC4	-
6	MOSI	PC5	-
7	MISO	PC6	-
8	SCK	PC7	-
9	GND	-	-
10	VCC_P3V3	-	-

The header J2 is connected to analog ports of the XMEGA as shown in [Table 3-3](#).

**Table 3-3. Expansion header J2.**

Pin on J2	Name on J2	XMEGA pin	Shared with onboard functionality
1	ADC0	PB0	-
2	ADC1	PB1	-
3	ADC2	PB2	-
4	ADC3	PB3	-
5	ADC4	PB4	-
6	ADC5	PB5	-
7	ADC6	PB6	-
8	ADC7	PB7	-
9	GND	-	-
10	VCC_P3V3	-	-

The header J3 is connected to digital ports of XMEGA. [Table 3-4](#) 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 onboard functionality
1	PA0	PA0	Light sensor <sup>(1)</sup>
2	PA1	PA1	Temperature sensor <sup>(1)</sup>
3	PA2	PA2	Filter output <sup>(1)</sup>
4	PA3	PA3	Display reset
5	PA4	PA4	
6	PA5	PA5	
7	PA6	PA6	
8	PA7	PA7	
9	GND	-	-
10	VCC_P5V0	-	-

Note: 1. Can be disconnected from onboard functionality by cut-straps.

The 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 onboard functionality
1	SDA	PE0	-
2	SCL	PE1	-
3	RXD	PE2	-
4	TXD	PE3	-
5	SS	PD0	Display data and command select <sup>(1)</sup>
6	MOSI	PD3	Display and microSD card MOSI
7	MISO	PD2	microSD card MISO
8	SCK	PD1	Display and microSD card clock input
9	GND	-	-
10	VCC_P3V3	-	-

Note: 1. Can be disconnected from onboard functionality by cut-strap (J204).

## 4. Peripherals

### 4.1 microSD card

The Atmel AVR XMEGA-C3 Xplained has a microSD card standard connector mounted. The SWA is used for detecting the microSD card. When a microSD card plugs in, the SWA will be pulled to GND. The connection to the MCU is shown in [Table 4-1](#).

**Table 4-1. microSD card connection.**

Pin on XMEGA	microSD card
PD1	SCK
PD3	MOSI
PD2	MISO
PE5	SS
PE4	SWA

### 4.2 Atmel AVR QTouch button

The XMEGA-C3 Xplained kit has one Atmel QTouch button and the connection to the Atmel AVR XMEGA is shown in [Table 4-2](#). The QTouch sensor, a copper fill, is located on the second layer of the board (same as GND layer). The sensor is shielded by the third layer (VCC layer) and therefore the sensor is not affected by any touches from the back side of the board.

**Table 4-2. QTouch button connection.**

Pin on XMEGA	QButton
PF4	SNS0
PF5	SNSK0
PF6	SNS1
PF7	SNSK1

### 4.3 Mechanical buttons

Two mechanical buttons are connected to Atmel AVR XMEGA. All buttons have external pull-ups so there is no need 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 4-3. Mechanical button connection.**

Pin on XMEGA	Silkscreen text on PCB
PF1	SW0
PF2	SW1

### 4.4 LEDs

There are four LEDs available on the board that can be turned on and off. Two yellow LEDs, one green LED (power indicator LED), and one red LED (status LED). The green and red LEDs are inside the same package and therefore the colors can be mixed to orange when both are activated. The yellow LEDs and the red LED can be activated by driving the connected I/O line to GND. The green LED is controlled via a FET and is by default on when the board is powered. However, this power indicator LED can also be turned off by driving the gate of the FET to GND.



**Table 4-4. LED connections.**

Pin on XMEGA	LED
PR0	Yellow LED0
PR1	Yellow LED1
PD4	Red status LED
PD5	Green power indicator LED

## 4.5 OLED display

The OLED display on the XMEGA-C3 Xplained board is UG-2832HSWEG04 which comes from 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 [Table 4-5](#).

**Table 4-5. OLED display connection.**

Pin on XMEGA	QButton
PD0	Data_command
PD1	SCK
PD3	MOSI
PF3	SS
PA3	RESET

## 4.6 Analog I/O

### 4.6.1 Temperature sensor

The temperature sensor circuitry consists of a serial connection of a normal and a NTC resistor. The NTC sensor is from Murata and some part details are shown in [Table 4-6](#), more information can be obtained from the manufacturer's website.

**Table 4-6. NTC characteristics.**

Global part number	NCP18WF104J03RB
Resistance (25°C)	100kΩ ±5%
B-Constant (25/50°C) (reference value)	4250K ±2%
B-Constant (25/80°C) (reference value)	4303K
B-Constant (25/85°C) (reference value)	4311K
B-Constant (25/100°C) (reference value)	4334K

[Table 4-7](#) shows the temperature vs. resistance characteristic. The values are available from Murata in the datasheet of the NTC.

**Table 4-7. Resistance vs. temperature (from Murata).**

Temp. [°C]	NTC resistance [kΩ]	Temp. [°C]	NTC resistance [kΩ]	Temp. [°C]	NTC resistance [kΩ]	Temp. [°C]	NTC resistance [kΩ]
-30	2197.225	0	357.012	30	79.222	60	22.224
-29	2055.558	1	338.006	31	75.675	61	21.374
-28	1923.932	2	320.122	32	72.306	62	20.561
-27	1801.573	3	303.287	33	69.104	63	19.782
-26	1687.773	4	287.434	34	66.061	64	19.036
-25	1581.881	5	272.500	35	63.167	65	18.323
-24	1483.100	6	258.426	36	60.415	66	17.640
-23	1391.113	7	245.160	37	57.797	67	16.986
-22	1305.413	8	232.649	38	55.306	68	16.360
-21	1225.531	9	220.847	39	52.934	69	15.760
-20	1151.037	10	209.710	40	50.677	70	15.184
-19	1081.535	11	199.196	41	48.528	71	14.631
-18	1016.661	12	189.268	42	46.482	72	14.101
-17	956.080	13	179.890	43	44.533	73	13.592
-16	899.481	14	171.028	44	42.675	74	13.104
-15	846.579	15	162.651	45	40.904	75	12.635
-14	797.111	16	154.726	46	39.213	76	12.187
-13	750.834	17	147.232	47	37.601	77	11.757
-12	707.524	18	140.142	48	36.063	78	11.344
-11	666.972	19	133.432	49	34.595	79	10.947
-10	628.988	20	127.080	50	33.195	80	10.566
-9	593.342	21	121.066	51	31.859	81	10.200
-8	559.931	22	115.368	52	30.584	82	9.848
-7	528.602	23	109.970	53	29.366	83	9.510
-6	499.212	24	104.852	54	28.203	84	9.185
-5	471.632	25	100.000	55	27.091	85	8.873
-4	445.772	26	95.398	56	26.028	86	8.572
-3	421.480	27	91.032	57	25.013	87	8.283
-2	398.652	28	86.889	58	24.042	88	8.006
-1	377.193	29	82.956	59	23.113	89	7.738

Two common approximations can be used to model the temperature vs. resistance characteristic; these are the B parameter and the Steinhart-Hart equations. Coefficients for both formulas can be calculated from [Table 4-7](#).

When the internal reference VCC/1.6 is used and the ADC is measuring in signed single ended mode the codes in [Table 4-8](#) can be read from the ADC at the various temperatures. The calculation is based on [Table 4-7](#).

**Table 4-8. ADC codes vs. temperature (signed single ended mode with internal VCC/1.6 reference).**

ADC input [V]	Temp. [°C]	ADC codes	ADC input [V]	Temp. [°C]	ADC codes
2.076	-14	2047	0.347	38	345
2.030	-13	2014	0.334	39	332
1.983	-12	1968	0.321	40	319
1.936	-11	1921	0.309	41	307
1.889	-10	1875	0.297	42	295
1.841	-9	1828	0.286	43	283

ADC input [V]	Temp. [°C]	ADC codes	ADC input [V]	Temp. [°C]	ADC codes
1.794	-8	1781	0.275	44	273
1.747	-7	1734	0.264	45	262
1.700	-6	1687	0.254	46	252
1.653	-5	1640	0.244	47	243
1.606	-4	1594	0.235	48	233
1.560	-3	1548	0.226	49	225
1.514	-2	1503	0.218	50	216
1.469	-1	1458	0.209	51	208
1.425	0	1414	0.202	52	200
1.380	1	1370	0.194	53	193
1.337	2	1327	0.187	54	185
1.294	3	1285	0.180	55	178
1.252	4	1243	0.173	56	172
1.211	5	1202	0.167	57	165
1.171	6	1162	0.161	58	159
1.131	7	1123	0.155	59	154
1.093	8	1084	0.149	60	148
1.055	9	1047	0.144	61	142
1.018	10	1010	0.138	62	137
0.982	11	975	0.133	63	132
0.947	12	940	0.128	64	127
0.913	13	907	0.124	65	123
0.880	14	874	0.119	66	118
0.848	15	842	0.115	67	114
0.817	16	811	0.111	68	110
0.787	17	781	0.107	69	106
0.758	18	752	0.103	70	102
0.730	19	724	0.100	71	99
0.702	20	697	0.096	72	95
0.676	21	671	0.093	73	92
0.650	22	645	0.090	74	89
0.626	23	621	0.086	75	86
0.602	24	597	0.083	76	83
0.579	25	575	0.081	77	80
0.557	26	553	0.078	78	77
0.535	27	531	0.075	79	75
0.515	28	511	0.073	80	72
0.495	29	491	0.070	81	70
0.476	30	472	0.068	82	67
0.458	31	454	0.065	83	65
0.440	32	437	0.063	84	63
0.423	33	420	0.061	85	61
0.407	34	404	0.059	86	59
0.391	35	388	0.057	87	57
0.376	36	373	0.055	88	55
0.361	37	359	0.053	89	53

## 4.6.2 Ambient light sensor

The ambient light sensor TEMA6000X01 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 4-10](#) which shows the relationship between illuminance and output voltage of the sensor circuitry is generated based on the symbols and formulas in [Table 4-9](#).

**Table 4-9. Symbol description for illuminance calculation.**

Symbols	Description
ICA	Calibrated sensor responsivity at 100lx. This is 50 $\mu$ A according to the sensor datasheet
Ev	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. 4.7k $\Omega$ has been chosen in this design
$Ev = 100 \times I / ICA$	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
$U = (Ev \times R \times ICA) / 100$	Based on the current and the illuminance the output voltage of the sensor circuitry can be calculated

**Table 4-10. 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

## 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 AVR1940 XMEGA-C3 Xplained Software Users Guide.

## 6. Revision history

### 6.1 Revision history of the document

Doc. Rev.	Date	Comments
42053A	02/2013	Initial document release

### 6.2 Revision history of the kit

To identify the revision of the Atmel AVR XMEGA-C3 Xplained 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 “A09-1607/2” can be resolved to ID=A09-1607 and revision=2.

#### 6.2.1 Revision 2

Revision 2 of the XMEGA-C3 Xplained kit is the initially released version. This revision of the kit has the following product ID: A09-1607/2.

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