AVR1615: Atmel AVR XMEGA B1 ADC Voltmeter

Features

- **Atmel® ATxmega128B1 microcontroller**
  - **Two Eight-channel, 12-bit, 200ksps Analog to Digital Converters**
    - **Cyclic architecture**
    - **Up to 200.000 samples per second**
    - **Up to 12-bit resolution**
    - **Signed and unsigned mode**
    - **Selectable gain**
    - **1.4MHz maximum ADC frequency**
- **Four Atmel QTouch® buttons**
- **Analog inputs to ATxmega128B1 ADC:**
  - **Potentiometer**
  - **External voltage**

1 Introduction

The Atmel® AVR® XMEGA®-B1 Xplained evaluation kit is a hardware platform to evaluate the ATxmega128B1 microcontroller.

This application note describes an example using the AVR XMEGA ADC through a voltmeter application with mV accuracy. An external multimeter can be used to verify measurement accuracy shown on the AVR XMEGA-B1 Xplained LCD display.

In addition, offset and gain calibrations are proposed via QTouch button selection.

The goal of this document is to quickly start with:

- AVR XMEGA-B1 Xplained
- ATxmega128B1 ADC
- ADC Gain and Offset calibration
- ASF drivers and services (ASF for Advanced Software Framework).

8-bit Atmel Microcontrollers

Application Note

Rev. 8448A-AVR-10/2011

2 Xplained B1 overview

The kit is powered via the USB connector.

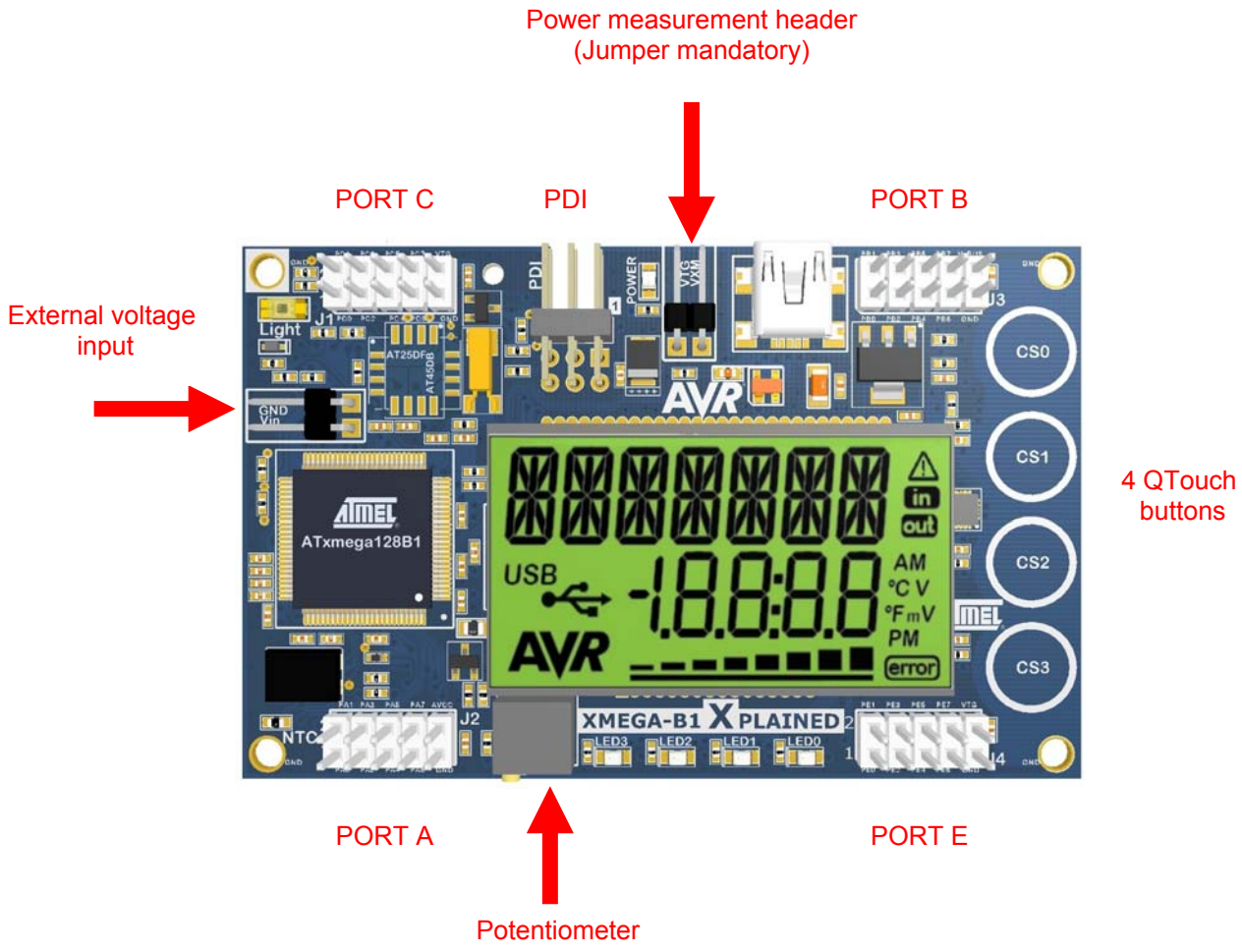
The Atmel ATxmega128B1 can be programmed and debugged by connecting an external tool to the PDI header (JTAGICE3, JTAGICE mkII, AVRONE or other).

The ATxmega128B1 can also be programmed through the USB interface. This can be performed using the USB bootloader preprogrammed in the device.

External input (top left on Figure 2-1) and potentiometer (bottom left on Figure 2-1) are connected to ADC inputs.

For more details, XMEGA-B1 Xplained user guide is available on:
http://www.atmel.com/AVR (AVR1912).

Figure 2-1. XMEGA-B1 Xplained kit for demo.



Note: A jumper must be present on power measurement header to power-on the microcontroller.

3 ATxmega128B1 ADC overview

The AVR ATxmega128B1 ADC has 12-bit resolution and is capable of converting up to 200K samples per second. Both single ended and differential modes can be done. The ADC can provide both signed and unsigned results in single ended mode and only signed results in differential mode.

3.1 Voltage reference

The following voltages can be used as the voltage reference (V_{REF}) for the ADC:

- Accurate internal 1.00V voltage
- Internal V_{CC}/1.6 voltage
- External voltage from AREFA or AREFB
- Internal V_{CC}/2 voltage

The internal 1.00V voltage comes from the bandgap (1.1V) through a unitary gain stage. This reference allows using ADC without external voltage reference.

3.2 Single ended mode

The unsigned single-ended mode allows a 12-bit result (0 to 4095). A fixed offset is added for zero crossing detection:

$$\Delta V = V_{REF} \times 0.05$$

During calibration operation, this offset value is measured.

The positive pin of the comparator is connected to signal to measure. The negative pin of the comparator is connected to ($V_{REF}/2 - \Delta V$).

The signed single ended mode allows theoretical values from -2048 to 2047 (11-bit plus sign). As the minimum voltage on ATxmega128B1 input pin is -0.5V, all negative values are not reachable.

3.3 Differential mode

The differential mode is offered with or without gain. The signal to measure is connected between positive and negative pins of the comparator.

Only the signed mode is allowed. The result range is from -2048 to 2047 (11-bit plus sign).

4 ATxmega128B1 voltmeter application: ADC mode selection

4.1 Voltage reference

The 1V voltage reference from the bandgap is selected for the ADC example. This accurate voltage fits to the two input ranges.

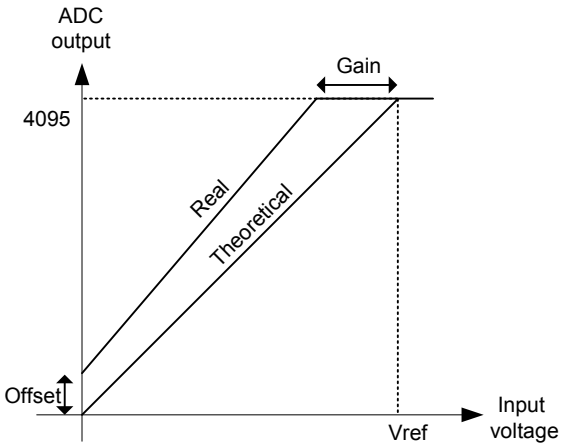
The external input voltage is connected to an external resistor bridge (division by 8). It allows an input range from 0 to 8V in this example.

The potentiometer voltage range is from 0 to 0.625V.

4.2 Single ended mode

The single-ended mode is selected to have a 12-bit accuracy conversion. The offset calibration suppresses the ΔV offset is not needed for this application (see § 5.3).

Figure 4-1. Offset and gain error



4.3 Hardware description

The Atmel ATxmega-B1 evaluation kit proposes an external voltage input available on a two pins connector (J7). The input voltage in divided by 8 with a resistor bridge. It allows an input range from:

- 0V to 8V if 1V voltage reference is selected
- 0V to 13.2V if $V_{CC}/2$ voltage reference is selected
- 0V to 16.5V if $V_{CC}/1.6$ voltage reference is selected.

In this example, 1V voltage reference is selected.

The potentiometer voltage range is from 0V to 0.625V.

5 Firmware application description

The firmware package is available in ASF. The AVR Software Framework is a collection of production-ready source code, written and optimized by experts and tested in hundreds of production designs.

The software framework works across with both GNU and IAR™ C compilers.

ASF is included in AVR Studio® 5. The application location is:

xmega/applications/xmega_b1_xplained_demo/adc_demo_cal

5.1 Qtouch® buttons description

The human interface is managed by QTouch buttons.

Table 5-1. QTouch buttons selection

Button	Function	Description	Display
CS0	Gain calibration	Adjust 7V with a power supply on external voltage input, Adjust 0.6V with potentiometer, Then press CS0.	Scrolling: GAIN CALIBRATION
CS1	Offset calibration	Connect Vin to GND, Adjust 0V with potentiometer, Then press CS1.	Scrolling: OFFSET CALIBRATION
CS2	Potentiometer voltage measurement	Voltage in mV	POTENTIOMETER VOLTAGE
CS3	External input voltage measurement	Voltage in mV	EXTERNAL VOLTAGE

5.2 Gain calibration

The gain calibration consists in applying a fixed voltage on ADC input. The result on ADC output is compared to the theoretical value. Each ADC output value is then multiplied by a coefficient to correct gain calibration error.

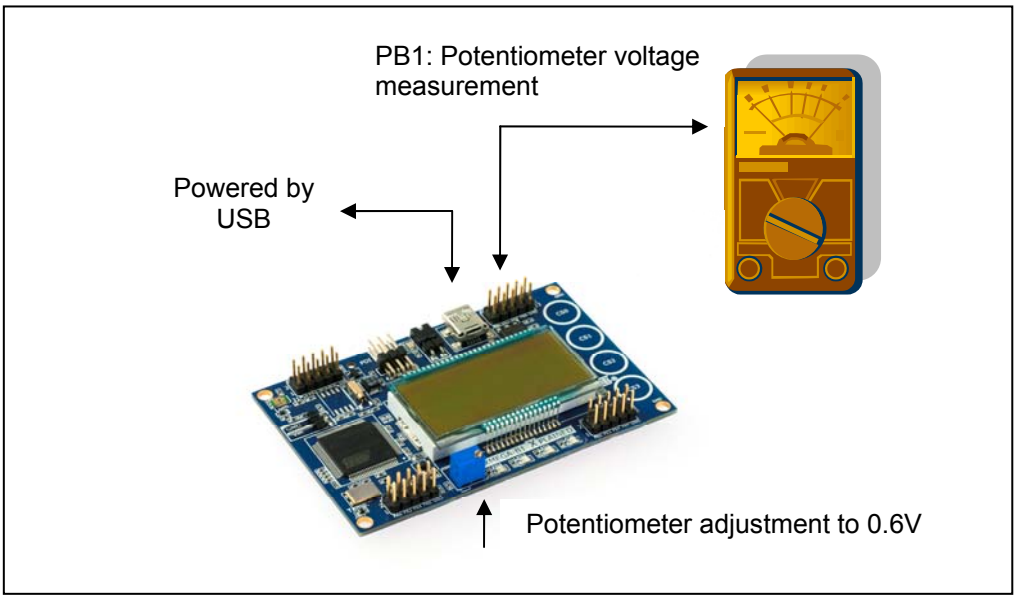
After gain calibration, potentiometer and external input values are stored in ATxmega128B1 EEPROM. Gain calibration is executed once and calibration parameters are available for further measurements.

If gain calibration button is pressed by mistake without calibration voltage on inputs, the calibration is aborted and EEPROM values are not updated. A range of correct values is stored in firmware to avoid wrong calibration values.

5.2.1 Gain calibration sequence:

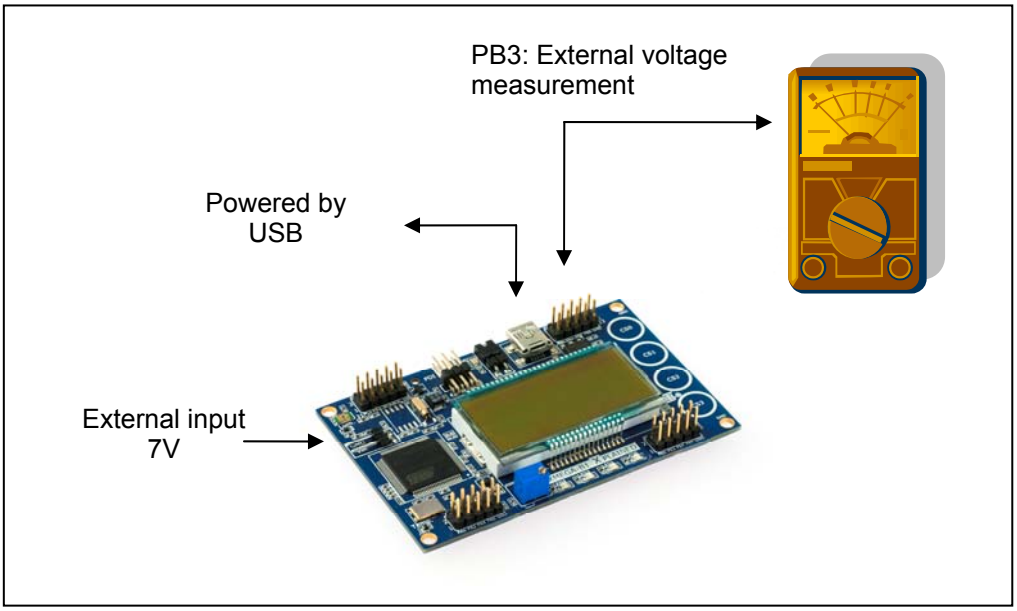
5.2.1.1 Potentiometer voltage adjustment to 0.6V

Figure 5-1. Potentiometer voltage (gain)



5.2.1.2 External voltage adjustment to 7V

Figure 5-2. External voltage (gain)



5.2.1.3 Press CS0 to confirm gain calibration.

5.3 Offset calibration

The offset calibration consists in applying ground voltage on ADC input. The result on ADC output is the offset calibration value. This value is then subtracted to each ADC output.

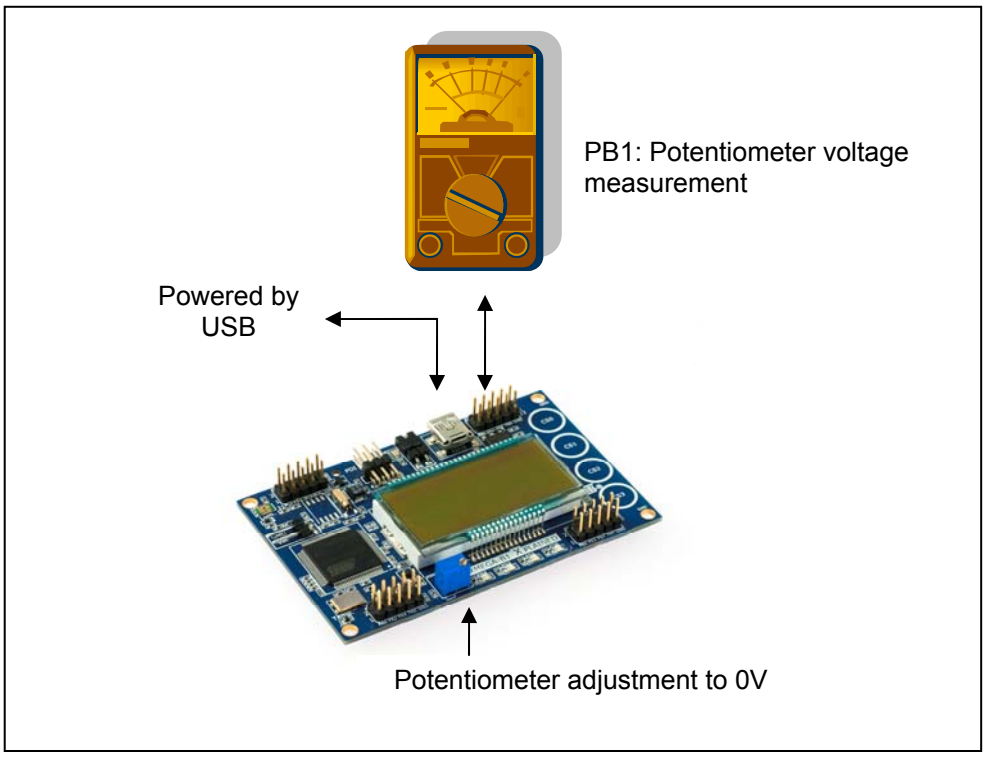
After offset calibration, potentiometer and external input values are stored in ATxmega128B1 EEPROM. Offset calibration is executed one time and calibration parameters are available for further uses.

If offset calibration button is pressed by mistake without calibration voltage on inputs, the calibration is aborted and EEPROM values are not updated.

5.3.1 Offset calibration sequence:

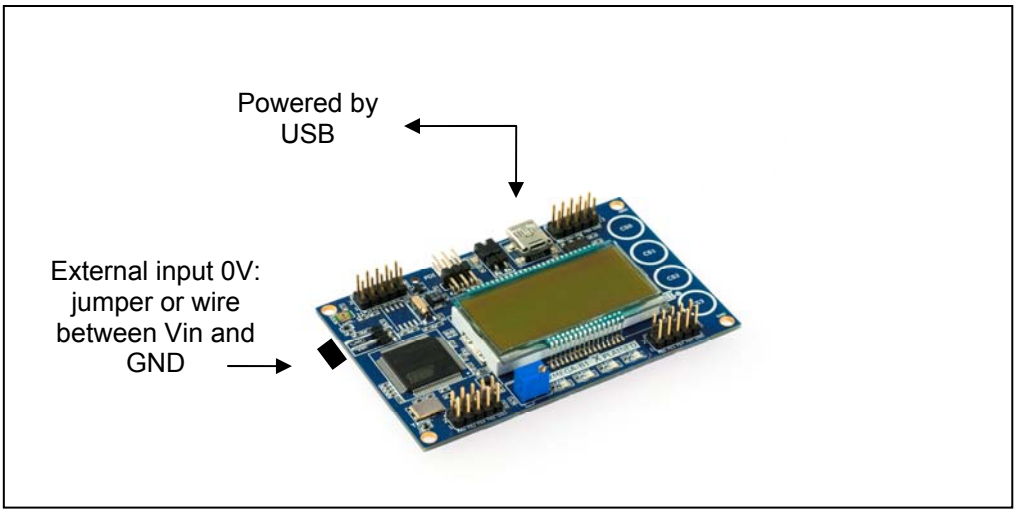
5.3.1.1 Potentiometer voltage adjustment to 0V

Figure 5-3. Potentiometer voltage (offset)



5.3.1.2 External voltage adjustment to 0V

Figure 5-4. External voltage (offset)



5.3.1.3 Press CS2 to confirm gain calibration.

6 Table of Contents

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