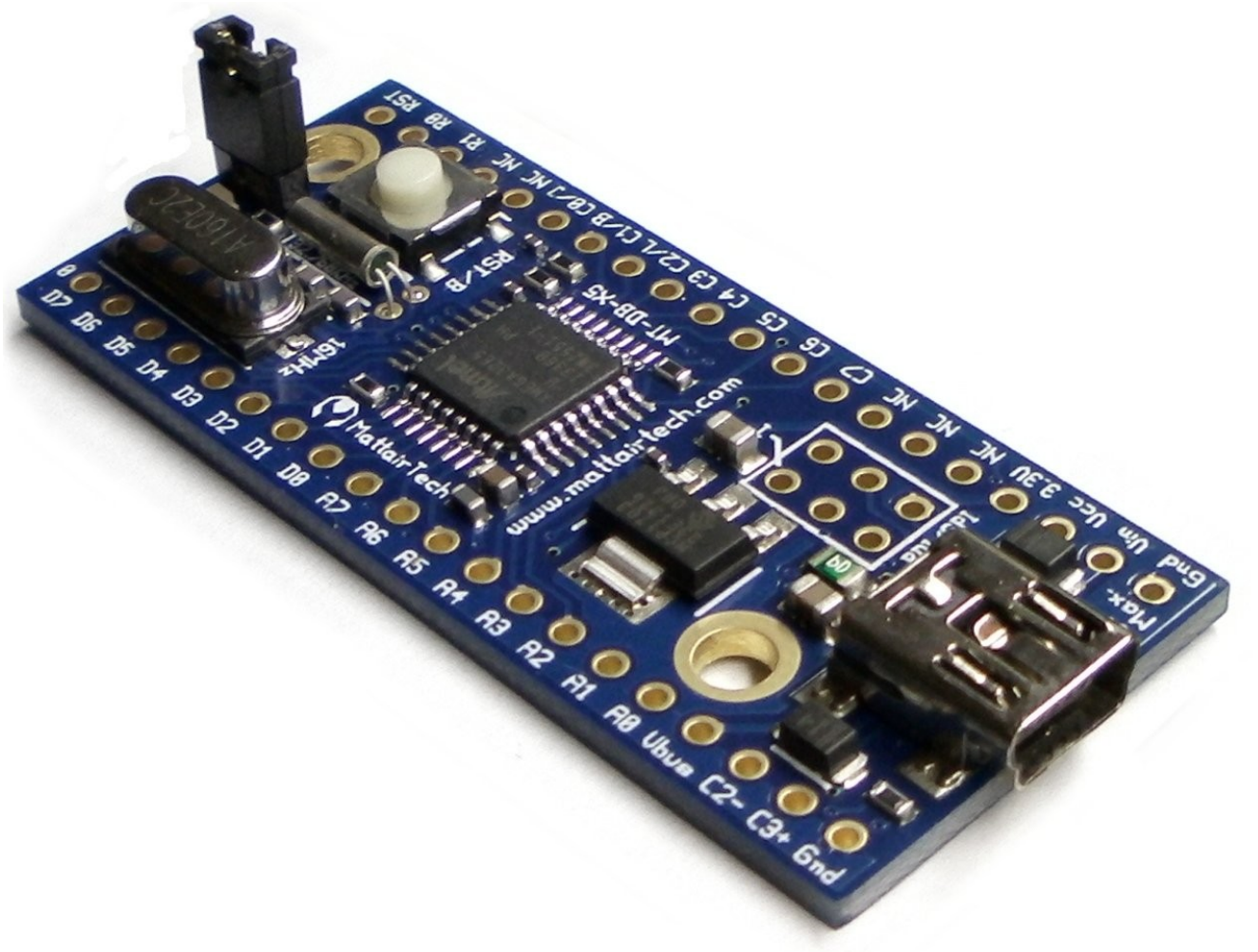
MT-DB-X5 User Guide



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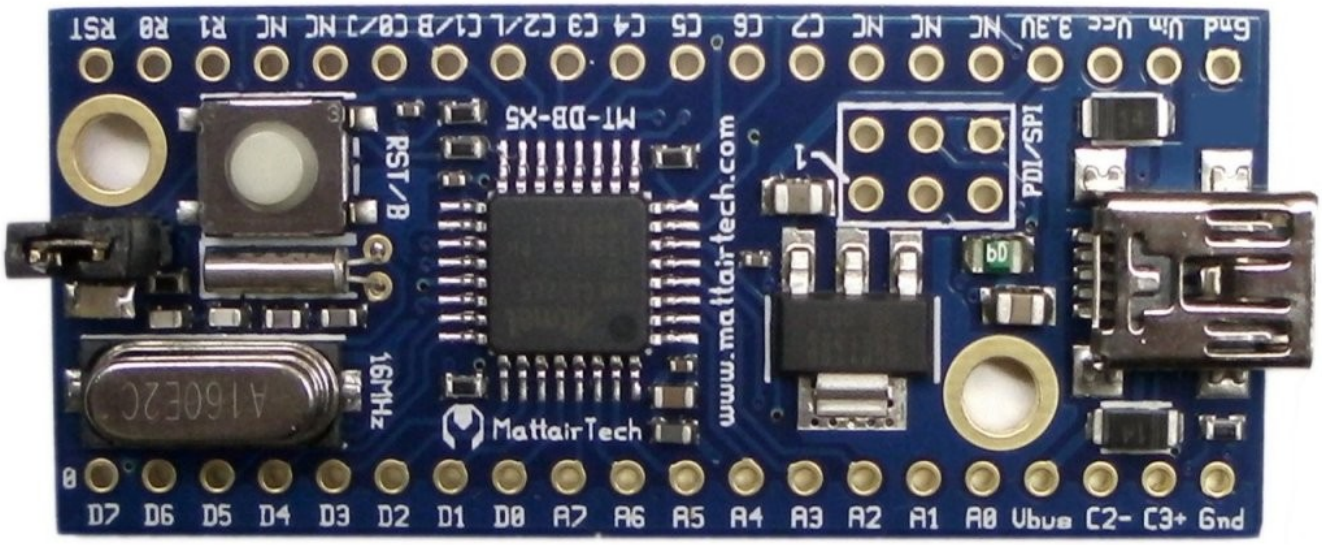
Overview



Introduction

The MT-DB-X5 is a development board for the 32-pin Atmel AVR XMEGA E microcontroller. It can be powered from USB or from the Vin pin. Two schottky diodes facilitate simple switching (and reverse-polarity protection) between the two power sources. This voltage is regulated to 3.3V by the onboard 250mA, extremely low quiescent current (2uA) LDO regulator that supports up to 16V DC input voltage. Overcurrent protection is provided by a 180mA hold (400mA trip) PTC resettable fuse. Also mounted is a mini USB connector (power only), green LED, 16MHz crystal, 32.768KHz RTC crystal, reset/user button, and a user jumper. The board has 40 main dual inline header pins with 100 mil pin spacing and 700 mil row spacing which allows for mounting on a breadboard or perfboard. The PDI/SPI header can be used with an external programmer, or be reconfigured to be used as a SPI master or slave. There are 2 3mm mounting holes. The PCB measures approx. 2.1” x 0.9” x 0.062” (52mm x 23mm x 1.6mm).

Board Features

- **Atmel AVR XMEGA E 32-pin microcontroller**
  - ATxmega32E5, ATxmega16E5, or ATxmega8E5
  - Features the XMEGA Custom Logic Module
- **Onboard 3.3V, 250mA LDO regulator**
  - up to 16V DC input
  - extremely low quiescent current (2.0uA typical)
  - low dropout (525mV typical @ 250mA, 725mV max. @ 250mA)
  - 0.4% output tolerance typical
  - Over-current and over-temperature protection
- **Simple power source switching**
  - 2 schottky diodes (Vbus and Vin)
  - Low voltage drop (250mV @ 50mA, 375mV @ 500mA)
  - Reverse-polarity protection
  - Vbus can be disconnected (solder jumper)
  - Vin schottky can be shorted (solder jumper) to eliminate voltage drop (battery use)
  - Either Vin or Vbus can be routed through a resistor divider to pin A1 (ADC)
- **PTC resettable fuse (180mA hold / 400mA trip) (SEE TROUBLESHOOTING / FAQ)**
- **PDI/SPI header (PDI by default)**
  - As a PDI header, it is used to program the AVR with an external programmer
  - Header can be converted to a SPI (master or slave) header
  - Can mount the MT-SD MicroSD card slot directly to this header
- **16MHz crystal for main clock**
- **32.768KHz crystal for real-time counter (pins shared with 16MHz crystal)**
- **Green Status LED (can be disconnected)**
- **Button configurable for reset or general use (pin C1) with optional debouncing**
- User jumper
- Mini USB connector (power only)
- USB pins routed to header pins (for panel-mount USB connector)
- Powered by USB or external power source (up to 16V) on Vin
- Ferrite bead and 2 capacitors on analog supply
- **21 solder jumpers on PCB bottom for configuration flexibility**
- All PORT pins routed to headers
- 2 main headers are on 0.1” spacing (breadboard/perfboard mounting)
- **Two 3mm mounting holes (~5mm pad)**
- High-quality PCB with gold-plated finish
- Measures approx. 2.1” x 0.9” (52mm x 23mm) and 0.062” (1.6mm) thick.

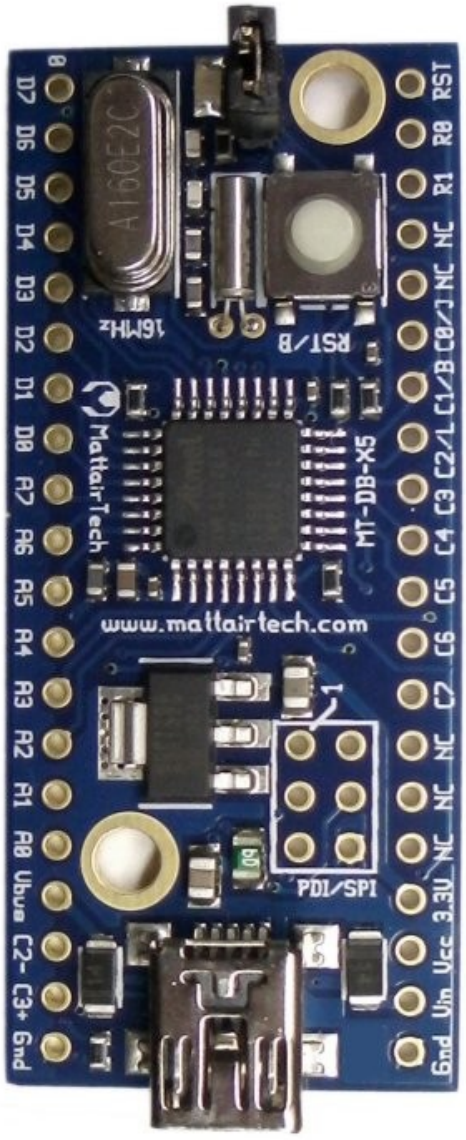
ATxmegaXXE5 Features

- **High-performance, low-power Atmel® AVR® XMEGA® 8/16-bit Microcontroller**
- **Nonvolatile program and data memories**
  - 8K - 32KB of in-system self-programmable flash
  - 2K - 4KB boot section
  - 512B - 1KB EEPROM
  - 1K - 4KB internal SRAM
- **Peripheral Features**
  - Four-channel enhanced DMA controller with 8/16-bit address match
  - Eight-channel event system
    - Asynchronous and synchronous signal routing
    - Quadrature encoder with rotary filter
  - Three 16-bit timer/counters
    - One timer/counter with 4 output compare or input capture channels
    - Two timer/counters with 2 output compare or input capture channels
    - High resolution extension enabling down to 4ns PWM resolution
    - Waveform extension for control of motor, LED, lighting, H-bridge, high drives and more
    - Fault extension for safe and deterministic handling and/or shut-down of external driver
  - CRC-16 (CRC-CCITT) and CRC-32 (IEEE 802.3) generator
  - XMEGA Custom Logic (XCL) module with timer, counter and logic functions
    - Two 8-bit timer/counters with capture/compare and 16-bit cascade mode
    - Connected to one USART to support custom data frame length
    - Connected to I/O pins and event system to do programmable logic functions
      - MUX, AND, NAND, OR, NOR, XOR, XNOR, NOT, D-Flip-Flop, D Latch, RS Latch
  - Two USARTs with full-duplex and single wire half-duplex configuration
    - Master SPI mode
    - Support custom protocols with configurable data frame length up to 256-bit
    - System wake-up from deep sleep modes when used with internal 8MHz oscillator
  - One two-wire interface with dual address match (I2C and SMBus compatible)
    - Bridge configuration for simultaneous master and slave operation
    - Up to 1MHz bus speed support
  - One serial peripheral interfaces (SPI)
  - 16-bit real time counter with separate oscillator and digital correction
  - One sixteen-channel, 12-bit, 300ksps Analog to Digital Converter with:
    - Offset and gain correction
    - Averaging
    - Over-sampling and decimation
  - One two-channel, 12-bit, 1Msps Digital to Analog Converter
  - Two Analog Comparators with window compare function and current sources
  - External interrupts on all general purpose I/O pins
  - Programmable watchdog timer with separate on-chip ultra low power oscillator
  - QTouch® library support
    - Programmable watchdog timer with separate on-chip ultra low power oscillator
- **Special microcontroller features**
  - Power-on reset and programmable brown-out detection
  - Internal and external clock options with PLL
  - Programmable multilevel interrupt controller
  - Five sleep modes
  - Programming and debug interfaces
    - PDI (program and debug interface)
  - 26 Programmable I/O pins
  - Up to 32MHz Fcpu

MT-DB-X5 Hardware

Top View / Pinout

D7, ADC15, XCLIN3
D6, ADC14, XCLIN0
D5, ADC13, XCLIN2
D4, ADC12, XCLIN1OUT0
D3, ADC11, XCLIN3
D2, ADC10, XCLIN0
D1, ADC9, XCLIN2
D0, ADC8, XCLIN1OUT0
A7, ADC7, AC7, AC0OUT
A6, ADC6, AC6, AC1OUT
A5, ADC5, AC5
A4, ADC4, AC4
A3, ADC3, AC3, DAC1
A2, ADC2, AC2, DAC0
A1, ADC1, AC1, VDIV
A0, ADC0, AC0, AREF
Vbus
C2-, USB D-, RXD0
C3+, USB D+, TXD0
Gnd



RST
R0, XTAL2, TOSC2, CLKOUT
R1, XTAL1, TOSC1, EXTCLK
NC
NC
C0/J, Jumper, OC4A, SDA
C1/B, Button, OC4B, SCL
C2/L, LED, OC4C, RXD0
C3, OC4D, TXD0
C4, OC4A, SS, XCLIN1OUT0
C5, OC4B, SCK, XCLIN2
C6, OC4C, MISO, XCLIN0
C7, OC4D, MOSI, XCLIN3
NC
NC
NC
3.3V
Vcc
Vin (up to 15V)
Gnd

Main Header Pins (Power)

Pin	Description
Gnd (2)	Ground
Vbus	Vbus is connected directly to the Vbus pin (5V) of the USB connector. It is routed through a schottky diode and through J6 to the regulator input circuitry, which includes a 4.7uF capacitor. Vbus voltage can be measured on pin A1 by connecting J14 and setting J3 toward the Vbus side of the board. J14 will connect A1 to a resistor divider consisting of a 200Kohm (top) and a 47Kohm resistor (bottom), and J3 connects to Vbus. The resistor divider will pull A1 to near ground level when Vbus is disconnected. Because of a small leakage current from the schottky diode, a small voltage should be interpreted as USB disconnected.
Vin	Vin is the external power input pin. Up to 16V can be connected. It is routed through a schottky diode to the regulator input circuitry, which includes a 4.7uF, 25V capacitor. The schottky diode can be shorted with J1, eliminating the voltage drop across the diode, which can be useful for battery applications. Note that when the diode is shorted, reverse-polarity protection is disabled, and J6 should be disconnected to prevent Vbus current from flowing into Vin. Vin voltage can be measured on pin A1 by connecting J14 and setting J3 toward the Vin side of the board. J14 will connect A1 to a resistor divider consisting of a 200Kohm (top) and a 47Kohm resistor (bottom), and J3 connects to Vin. The resistor divider will pull A1 to near ground level when Vin is disconnected. Because of a small leakage current from the schottky diode, a small voltage should be interpreted as Vin disconnected. **Ignore the original silkscreen printing which states a maximum voltage of 6V, the actual maximum is 15V. On boards ordered after Nov. 1, 2014, it is 16V.**
Vcc	This pin is connected to the Vcc and AVcc (through a ferrite bead) pins on the XMEGA, the PDI/SPI header Vcc pin, the reset pullup, and the TWI pullup resistor pads (unpopulated). Vcc is connected to 3.3V through J5, which in turn is connected to the output of the onboard regulator. The Vcc pin can also be used as an input. Disconnect J5 to supply power from an external source to the Vcc pin.
3.3V	3.3V is connected to the output of the onboard 3.3V regulator. There is a 10uF capacitor on this line. 3.3V is normally connected to Vcc through J5.

CAUTION

Higher regulator input voltages mean larger voltage drops and thus higher thermal dissipation for a given amount of current. Be sure to limit current consumption to prevent excessive heat when using higher voltages and/or currents. The regulator will enter thermal shutdown if it gets too hot. All capacitors are X7R, X7S, or NP0, so they can deal with the higher temperatures of the regulator. Note that the PTC fuse is located near the regulator, so high temperatures will lower the PTC trip and hold currents.

Main Header Pins (Signal)

Pin	Description
A0 - A7	Port A. These can be used for analog functions (ADC, AC, or DAC) or for GPIO. Pin A0 can be used as AREF. When used as AREF, connect J11 to enable a 100nF capacitor. Pin A1 can be connected to the voltage divider for measurement of Vin or Vbus by setting J3 and J14 appropriately.
D0 - D7	Port D. These can be used for analog functions (ADC), for custom logic module functions, for digital functions (USART, etc.), or for GPIO.
C0 - C7	Port C. These can be used for digital functions (TC, WEXC, USART, TWI, SPI), for for custom logic module functions, or for GPIO. Pins C4 – C7 can be connected to the PDI/SPI header by using jumpers J8, J9, J12, and J13. To convert the header to SPI mode, connect J9 and J13, then change J8 and J12 to the alternate positions.
C2-, C3+	These pins are connected to pins D- and D+ of the USB connector. They can also be routed to C2 and C3 of the XMEGA through J4 and J7 for possible use with software USB (use the pads for 0603 resistors). These pins, along with the adjacent Vbus and Ground pins can be used for a panel-mount USB connector.
C0 / J	This pin is connected to a general purpose jumper (though a 249 ohm resistor) and to pin C0 of the XMEGA. The jumper in turn connects to ground. The 249 ohm resistor provides short-circuit protection in case the pin is used as an output and the jumper is installed.
C1 / B	This pin may be connected to the button by setting J17 appropriately. When this pin is connected to the button, a debouncing capacitor may be enabled by soldering J16. A 249ohm resistor is connected in series with the button to eliminate voltage spikes due to the capacitor and to prolong button life. When using the button as reset (default setting), the capacitor should be disconnected to allow for PDI programming.
C2 / L	This pin is connected to the green LED and to pin C2 of the XMEGA. The LED is connected to C2 through a 249 ohm resistor and jumper J15. Drive pin C2 high to turn on the LED. Disconnect J15 to disable the LED.
R0, R1	Pin R0 can be used as CLKOUT, EVOUT, RTCOUT, AC1 OUT, or as GPIO by soldering J18 and unsoldering J19 (both positions). Pin R1 can be used as EXTCLK (input), AC0 OUT, or as GPIO by soldering J20 and unsoldering J21 (both positions). Otherwise, R0 and R1 from the XMEGA are routed to either the 16MHz or 32.768KHz crystals using J19 and J21.
RST	RST connects to the reset pin of the XMEGA, the reset button (depending on J17), and through J8 to the PDI/SPI header. A 10K pullup resistor is connected to this pin. J8 is used along with other jumpers to set the header to PDI or SPI mode. Note that the XMEGA reset pin is also used as the PDI clock.
NC	These pins are not connected to anything. There are 5 pins marked NC.

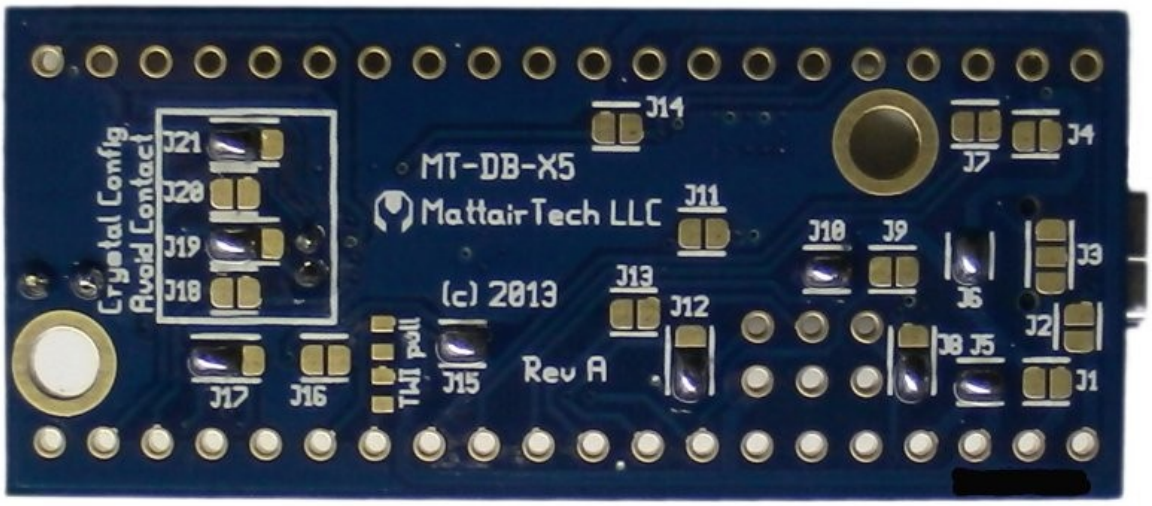
Inboard Header Pins

Pin	Description
PDI/SPI Header	This header can be connected to an external PDI programmer/debugger. Alternatively, this header can be used for SPI communications (master or slave). To convert the header to SPI mode, connect J9 and J13, then change J8 and J12 to the alternate positions. This will route 4 header pins to pins C4 – C7 of the XMEGA (there is a SPI peripheral here). Pin C4 can be used as a chip select (or as a slave select if in slave mode). See schematic for pinout information.
Jumper	This jumper can be used for your application. The jumper shorts XMEGA pin C0 to ground through a 249 ohm resistor. The 249 ohm resistor provides short-circuit protection in case the pin is used as an output and the jumper is installed.

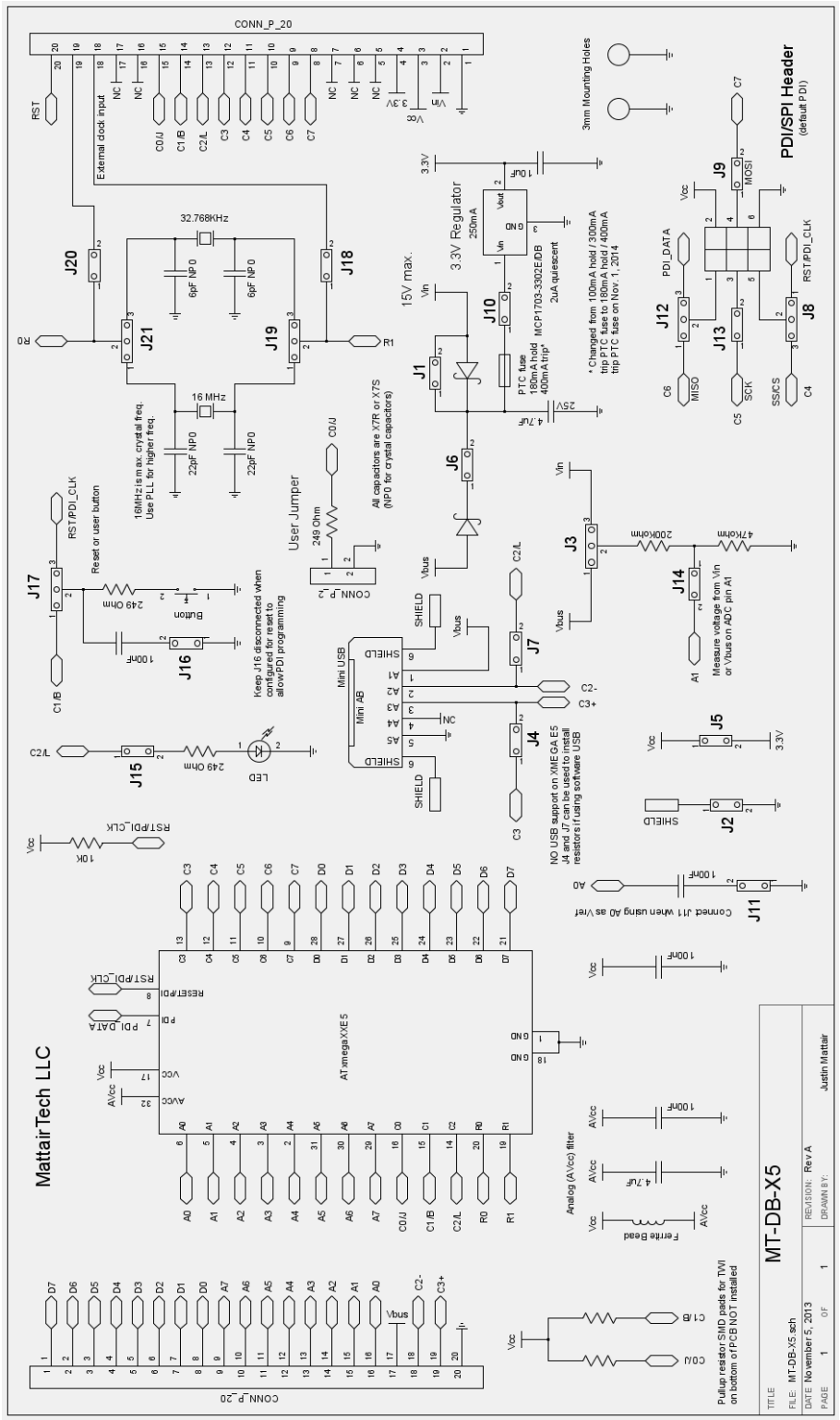
Solder Jumpers

Jumper	Description
J1: Vin diode disable	Vin is the external power input pin. Up to 16V can be connected. It is routed through a schottky diode to the regulator input circuitry. The schottky diode can be shorted with J1, eliminating the voltage drop across the diode, which can be useful for battery applications. Note that when the diode is shorted, reverse-polarity protection is disabled, and J6 should be disconnected to prevent Vbus current from flowing into Vin.
J2: USB Shield Ground	Jumper J2 can be soldered to connect the USB shield to ground. The USB specification calls for the USB shield to be connected to ground on the host side only. However, some prefer to have it grounded. An 0603 component may be soldered on the pads.
J3: Voltage divider input	Vin or Vbus voltage can be measured on pin A1 by connecting J14 and setting J3 toward either the Vin or Vbus side of the board. J14 will connect A1 to a resistor divider consisting of a 200Kohm (top) and a 47Kohm resistor (bottom), and J3 connects to Vin or Vbus. The resistor divider will pull A1 to near ground level when Vin or Vbus is disconnected. Because of a small leakage current from the schottky diode, a small voltage should be interpreted as Vin or Vbus disconnected.
J4: USB D+ / Pin C3	The C2- and C3+ pins are connected to pins D- and D+ of the USB connector. They can also be routed to C2 and C3 of the XMEGA through J4 and J7 for possible use with software USB (use the pads for 0603 resistors). These pins, along with the adjacent Vbus and Ground pins can be used for a panel-mount USB connector.
J5: Vcc – 3.3V	This connects the 3.3V regulator output rail to Vcc. Disconnect if supplying a regulated voltage (3.6V or less) externally on the Vcc pin.
J6: Vbus Power	This routes Vbus to the regulator input circuitry. There are two schottky diodes, one for Vin and one for Vbus. They facilitate automatic power switching between these two sources. If only external power will be used (Vin), disconnect J6. This will prevent Vbus power from being used when a USB cable is plugged in for communications.
J7: USB D- / Pin C2	see J4
J8: PDI/SPI Selection	The PDI/SPI header can be connected to an external PDI programmer/debugger. Alternatively, this header can be used for SPI communications (master or slave). To convert the header to SPI mode, connect J9 and J13, then change J8 and J12 to the alternate positions. This will route 4 header pins to pins C4 – C7 of the XMEGA (there is a SPI peripheral here). Pin C4 can be used as a chip select (or as a slave select if in slave mode). See schematic for pinout information.
J9: PDI/SPI Selection	see J8
J10: Regulator Input	May be used for planned MattairTech IO board. See schematic. **(SEE TROUBLESHOOTING / FAQ)**
J11: AREF capacitor	Pin A0 can be used as AREF. When used as AREF, connect J11 to enable a 100nF capacitor.
J12: PDI/SPI Selection	see J8

J13: PDI/SPI Selection	see J8
J14: Pin A1 to voltage divider	see J3
J15: LED	Header pin C2/L is connected to the green LED and to pin C2 of the XMEGA. The LED is connected to C2 through a 249 ohm resistor and jumper J15. Drive pin C2 high to turn on the LED. Disconnect J15 to disable the LED.
J16: Button debouncing capacitor	Pin C1/B may be connected to the button by setting J17 appropriately. When this pin is connected to the button, a debouncing capacitor may be enabled by soldering J16. A 249ohm resistor is connected in series with the button to eliminate voltage spikes due to the capacitor and to prolong button life. When using the button as reset (default setting), the capacitor should be disconnected to allow for PDI programming.
J17: Button function selection	See J16
J18: R1 header pin enable	Pin R0 can be used as CLKOUT, EVOUT, RTCOUT, AC1 OUT, or as GPIO by soldering J18 and unsoldering J19 (both positions). Pin R1 can be used as EXTCLK (input), AC0 OUT, or as GPIO by soldering J20 and unsoldering J21 (both positions). Otherwise, R0 and R1 from the XMEGA are routed to either the 16MHz or 32.768KHz crystals using J19 and J21.
J19: R1 crystal selection	R0 and R1 can be connected to either the 16MHz crystal (XTAL) or the 32.768KHz crystal (TOSC). To use the 16MHz crystal, set J19 and J21 away from the USB connector and disconnect J18 and J20. To use the 32.768KHz crystal, set toward the USB connector and disconnect J18 and J20.
J20: R0 header pin enable	See J18
J21: R0 crystal selection	See J19



Schematic


MattairTech LLC
MT-DB-X5
ATxmegaXXE5
PDI/SPI Header
(default PDI)
3.3V Regulator
15V max.
32.768KHz
16 MHz
User Jumper
Mini USB
Reset or user button
Button
LED
Measure voltage from Vin or Vbus on ADC pin A1
Connect J11 when using A0 as Vref
NO USB support on XMEGA E5
J4 and J7 can be used to install resistors if using software USB
Analog (AVcc) filter
Ferrite Bead
Pullup resistor SMD pads for TWI on bottom of PCB NOT installed
3mm Mounting Holes
Justin Mattair

Fuse and Lock Settings

The Blink program was pre-installed with the following commands (ATxmega32e5 shown):

```
avrdude -p x32e5 -c avrisp2 -P usb -e
avrdude -p x32e5 -c avrisp2 -P usb -U fuse1:w:0x00:m -U fuse2:w:0xFF:m -U fuse4:w:0xFF:m -U
fuse5:w:0xFF:m
avrdude -p x32e5 -c avrisp2 -P usb -U flash:w:"Blink_32e5.hex"
```

The lockbits are not set.

Blink Demo

A demo program comes pre-installed. It simply blinks the LED at 1Hz using the 16MHz crystal as the clock source.
The hex files and source code can be found at http://www.mattairtech.com/software/MT-DB-X5/MT-DB-X5_Blink.zip.

Troubleshooting / FAQ

- An error in layout resulted in the PTC fuse being placed in series between the 4.7uF input capacitor and the regulator input. The PTC fuse has a DC resistance of 0.7ohm to 6ohms. The regulator datasheet indicates that 10ohms or less of input impedance should be OK, thus this should not cause instability. However, you may wish to remove the PTC fuse and short the terminals for improved AC performance.

- **Changed from 100mA hold / 300mA trip PTC fuse to 180mA hold / 400mA trip PTC fuse on Nov. 1, 2014.**

- **Are there any alternatives to Atmel Studio?**
  The Atmel Standalone Toolchain (based on GCC) is available for Windows (http://www.atmel.com/tools/atmelavrtoolchainforwindows.aspx) and Linux (http://www.atmel.com/tools/atmelavrtoolchainforlinux.aspx). Atmel is the primary contributer to AVR support in GCC. As such, their own toolchain has the latest support/fixes. I would recommend using only this toolchain. It is more up to date than either the latest stock GCC or the distro builds. WinAVR is very old and does not support XMEGAs at all.

Support Information

Please check the MattairTech website (http://www.MattairTech.com/) for firmware and software updates. Email me if you have any feature requests, suggestions, or if you have found a bug. If you need support, please contact me (email is best). You can also find support information at the MattairTech website. A support forum is planned. Support for AVRs in general can be found at AVRfreaks (http://www.avrfreaks.net/). There, I monitor the forums section as the user physicist.

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Acknowledgments

Thanks to Dean Camera (http://www.fourwalledcubicle.com/) for his excellent LUFA library, CDC bootloader, DFU bootloader, and AVRISP mkII clone programmer. Thanks to the members of AVRfreaks (http://www.avrfreaks.net/) for their support. Finally, thanks to Atmel for creating a great product, the AVR microcontroller.

Legal

Copyright Notices

Software Warranty Disclaimer

Hardware Disclaimer

Trademarks

Appendix A: Precautions

CAUTION
Do not change power configuration, or solder any jumper while unit is powered. Do not short Vin, Vbus, 3.3V, or ground to each other (ie: solder jumpers on bottom shorting on clipped lead).

CAUTION
Higher regulator input voltages mean larger voltage drops and thus higher thermal dissipation for a given amount of current. Be sure to limit current consumption to prevent excessive heat when using higher voltages and/or currents. The regulator will enter thermal shutdown if it gets too hot. All capacitors are X7R, X7S, or NP0, so they can deal with the higher temperatures of the regulator. Note that the PTC fuse is located near the regulator, so high temperatures will lower the PTC trip and hold currents.

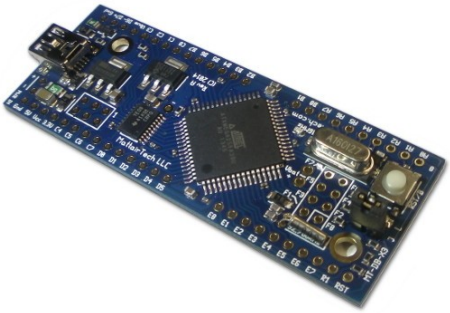
CAUTION
Normally, power is supplied from Vin or Vbus. However, it is possible to disconnect the regulator and supply an externally regulated voltage on the 3.3V and/or Vcc pins. When doing this, care must be taken to limit inrush current on these pins due to the low ESR of the ceramic capacitors. Failure to do so may cause damaging inductive voltage spikes due to any wire inductance (ie: benchtop power supply leads). Inrush current is normally controlled by the PTC fuse, which has a small series resistance.

CAUTION
The MT-DB-X5 contains static sensitive components. Use the usual ESD procedures when handling.

Appendix B: Other MattairTech Products

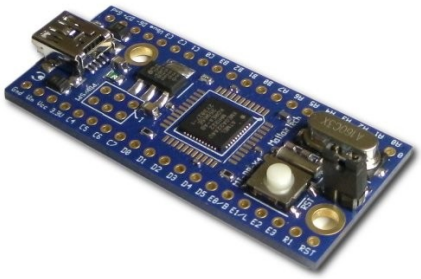
ZeptoProg II AVRISP mkII Programmer

- AVRISPmkII compatible AVR Programmer
- Supports all AVRs with ISP, PDI, or TPI
- Optional 5V output via headers to target board, with standard jumper and PTC fuse
- 4-channel Logic Analyzer
- Serial bridge / pattern generator / SPI interface
- GPIO / PWM / frequency input & output
- Atmel Studio / AVRDUDE support
- Target board voltage of 2V to 5.5V via level-shifted pins on two main headers



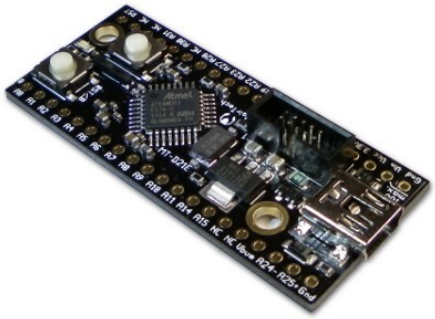
MT-DB-X3 USB AVR XMEGA board

- XMEGA A3U, A3BU, C3, and D3 (64-pin)
- 32KB - 384KB FLASH, 4KB – 32KB SRAM
- 3.3V 250mA regulator (2uA quiescent current)
- Optional 5V 500mA regulator (23uA quiescent current)
- Optional auto-direction sensing level shifter
- 16MHz and 32.768KHz crystals, optional coin cell holder
- LED, boot jumper, PDI header, button, TWI pullups
- USB DFU bootloader preinstalled (except D variant)



MT-DB-X4 USB AVR XMEGA board

- ATxmega128A4U USB XMEGA AVR
- 128KB FLASH, 8KB SRAM, 2KB EEPROM
- 3.3V LDO regulator (low quiescent current)
- 16MHz and 32.768KHz crystals
- LED, boot jumper, PDI header
- Reset button, mounting holes
- USB DFU bootloader preinstalled



MT-D21E USB ARM Cortex M0+ board

- ATSAMD21E17A or ATSAMD21E18A (32-pin)
- 128KB/256KB FLASH, 16KB/32KB SRAM
- Onboard 3.3V, 250mA LDO regulator (2uA quiescent)
- 16MHz and 32.768KHz crystals
- USB connector (power by USB or external up to 16V)
- Blue LED, 10-pin Cortex header, 2 buttons, I2C pullups
- USB Mass Storage Bootloader (no programmer required)