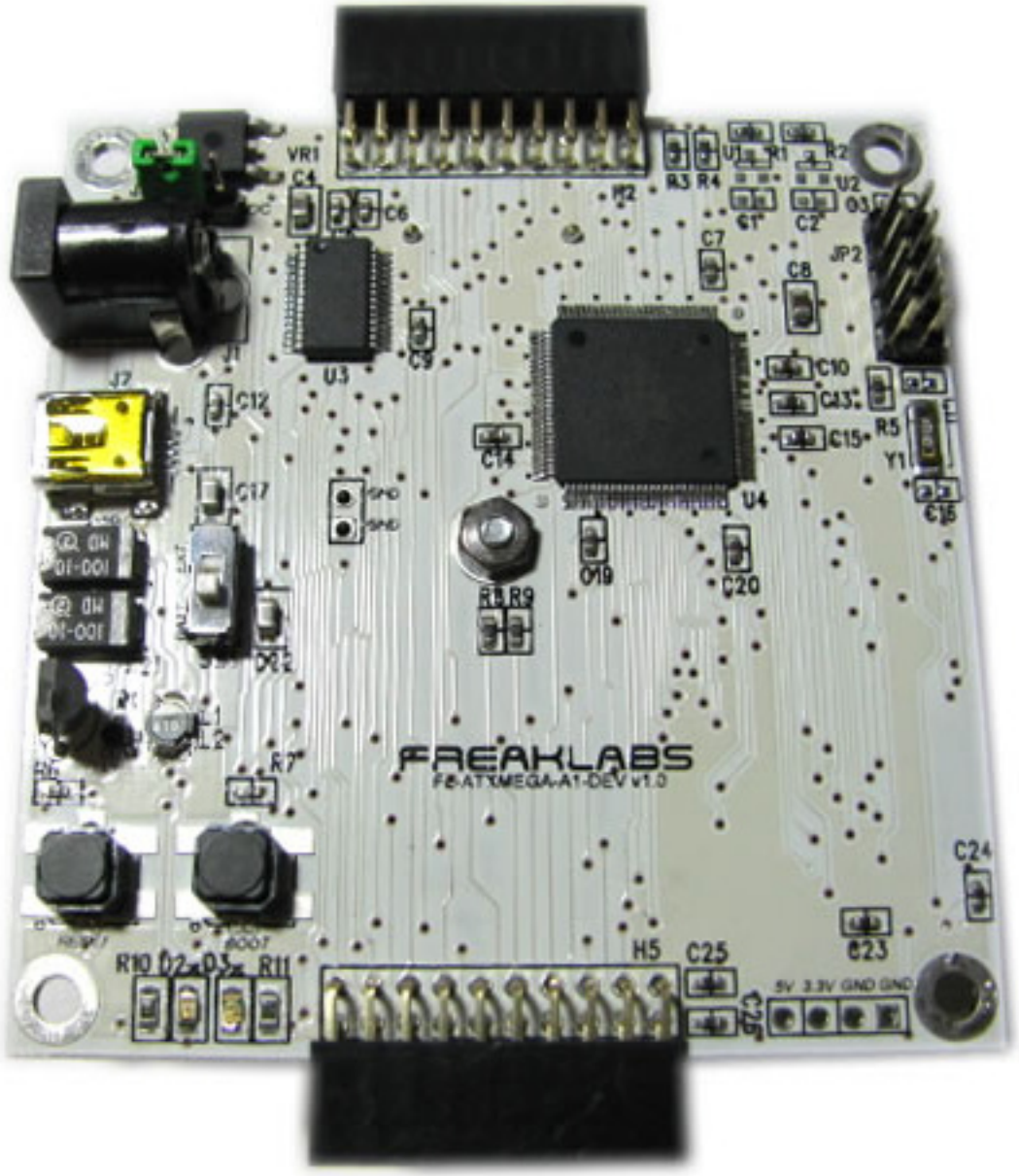
FREAKLABS

Rapid Prototyping Platform

FL-ATXMEGA-A1-DEV

MCU Board v1.0

User Guide v1.0A



Document Revision History

Date	*Description*
2010-06-24	v1.0A Document creation

Specifications

The FreakLabs ATXMEGA-A1 development board is designed for rapid prototyping and evaluation of wireless sensor networks. The MCU board is expandable through the use of the universal serial connectors which can accomodate different types of radios and sensors.

Quick Specs

MCU: ATXMega128A1

Flash: 128 kB

RAM: 8kB internal, 32 kB external

Connectors: 2 USC, USB

Power: Ext 5VDC, USB, Battery

Debug: JTAG

Program: JTAG, Bootloader

As the wireless sensor networking standards progress, RAM usage is increasing much faster than flash usage, which is why this board was designed. It has 8 kB RAM for internal memory, but also has 32 kB of external RAM. If that isn't enough, the external RAM can also be upgraded to a maximum of 512 kB. That makes this board an ideal platform to develop standards-based wireless sensor network software on without having to worry about resource constraints.

The ATXMega family is the latest generation of Atmel's AVR series microcontrollers and features an extremely enhanced peripheral set. Many of the enhancements are perfect for wireless sensor networking. Here's a quick list of just a few of the features:

1. **Configurable Clock PLL.** The clock frequency can now be configured on the fly to change internal clocking frequency. This allows dynamic clock scaling so that software can tell the MCU to run at full speed 32 MHz during compute-intensive tasks and then switch to a lower speed for normal tasks. It can also run at 32 kHz for extremely low power operation.

2. **Integrated AES-128 Encryption.** AES-128 is the standard encryption for wireless sensor networks and having it integrated into the MCU removes the chance to extract the keys via SPI sniffing.

3. **Event System.** The hardware event system is one of the newest features of the ATXMega. Because of it, the MCU can actually take ADC samples periodically and move them to memory, all while the MCU is asleep.

4. **Real Time Clock.** The RTC allows accurate time keeping which enables sensor data to be precisely timestamped. This is important in a sensor network when multiple samples need to be synchronized.

5. **Multiple Serial Interfaces.** Due to the dramatic increase in serial interfaces, each universal serial connector on this board has its own dedicated I2C, SPI, and UART.

6. **Increased Interrupt pins.** All IO pins on the device can be used for external interrupts. There are also dedicated asynchronous interrupt pins which can trigger the MCU to

wake when an interrupt occurs. Each universal serial connector on this board has both an asynchronous interrupt and standard interrupt pins.

The development board has two universal serial connectors for interfacing to wireless radios, sensor peripheral boards, other types of peripheral boards, and of course custom peripherals. These connectors have standard 0.1" headers with pinouts that are standardized across the FreakLabs rapid prototyping platforms.

All boards can be powered by DC wall wart, USB, or batteries using standard AA cells. The battery supply also has a DC-DC boost converter to regulate the system voltage to a constant 3.3V output no matter what voltage the actual battery cells have drained to. The boards also come with an open source bootloader which can be enabled via button sequence. The only programming hardware required is a USB cable.

Power

The ATXMEGA-A1 development board can be powered by either the USB, external 5V DC power supply, or 2 AA batteries. The DC connector is a 2.1mm barrel jack and accepts standard 2.1mm DC plugs. The external voltage source should be 5V DC. This is because the 5V power line is directly fed to the universal serial connectors which may be used by other peripherals. If no peripherals are using the 5V source, then its safe to power the external DC input with a source up to 10V. The board can also be powered via the USB's 5V power line which is a convenient way to both power the board and interface it to a PC.

The board also comes with a battery case that can hold 2 AA standard cell batteries. The battery voltage depends on the material and the amount of charge left. Two new alkaline batteries will provide 3V to the system but can drop to less than 2.5V over time as they discharge. Two NiMH rechargeable batteries have a maximum voltage of 2.4V and will drop in voltage as the charge decreases. To deal with this, the development board comes with a 3.3V boost converter.

The boost converter takes any input over 0.7V and boosts it up to 3.3V. This allows the system to stay at a constant voltage as the batteries discharge. This is especially important when dealing with sensors where the measurements are dependent on the voltage supply. If the supply changes significantly, inaccuracies will be introduced.

The voltage source can be switched via a jumper between the DC source and the USB source. This jumper will choose which source to feed into the voltage regulator.

There is also a power switch that chooses between battery power and external DC power. If no battery is present, then that side of the switch will be the OFF position. The same is true if no DC power is connected.

There are two LEDs on the board to indicate power. The 5V LED is red and indicates that 5V is present. This LED is directly connected to the 5V supply. When using batteries, there is no 5V supply thus no battery drainage occurs due to the LED.

Note: If in battery operation, even though no 5V supply is available, leakage can occur from the MCU's UART pins to the FTDI USB-Serial bridge. This gets into the 5V supply and can power the 5V LED. This is not desirable for battery operation. To prevent the current leakage, the jumper on JP1 should be moved from the VBUS position to the DC position.

There is also a green LED which can be used to indicate 3.3V power. This LED is connected to a general purpose IO of the MCU. This was done because having an LED that is always on is not desirable in a battery-powered circuit due to the constant energy drain. It's up to the user if they want the green LED to be used as a 3.3V power indicator and it can be enabled in software.

Peripherals

The ATXMEGA-A1 development board comes with an FTDI USB to serial converter which allows it to interface to a PC or Mac easily. It will show up as a standard serial port when connected to any computing platform via USB.

Connectors

The universal serial connector (USC) interface is standard between MCU boards which all carry at least one USC port with a right angle female connector. All peripheral boards will have similar USC ports with at least one right angle male connector to interface to MCU boards. With this type of setup, its possible to swap peripheral boards while using the same MCU board or use the same peripheral boards while changing MCUs.

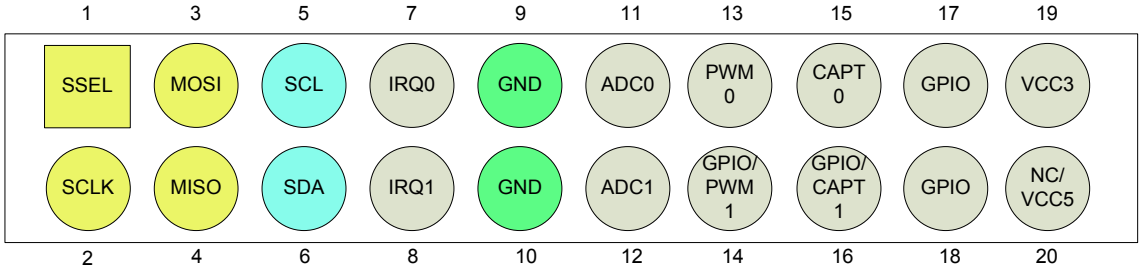
Universal Serial Connector Pinouts

The ATXMEGA-A1 board supports the universal serial connector v1.1. It contains an SPI bus, I2C bus, 2 interrupts, 2 analog inputs, 1 PWM output, 1 timer/capture input, 6 GPIOs, VCC3, GND, and optional VCC5. All pins except power pins can also be used as GPIO or interrupts if there is no need for the principal function.

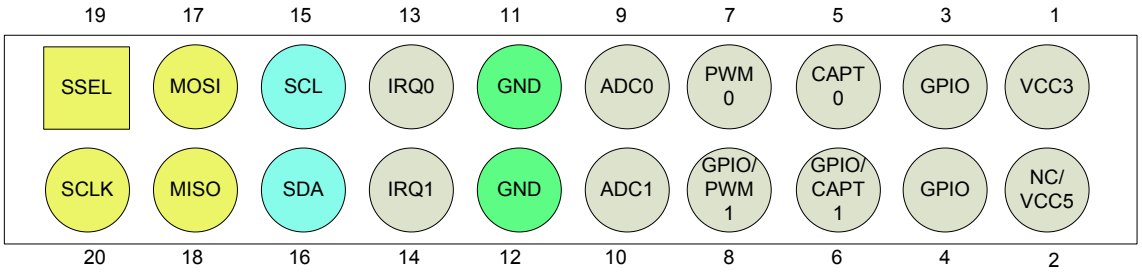
The connector consists of a host MCU side which is a 20-pin, female, right-angle header and a peripheral side which is a 20-pin, male, right-angle header. The host side connector will always be on MCU boards and the peripheral connector will be found on peripheral boards.

The following diagram shows the pinouts of the connectors:

Universal Serial Connector v1.1 – Host (MCU) side



Universal Serial Connector v1.1 – Peripheral side



The specific pin functions were chosen to create a generic connector optimized for wireless and sensor circuits. Most radios interface through some sort of serial bus such as SPI or I2C. Also, most sensors use either a digital serial interface such as I2C/SPI, an analog output, or generate a frequency that can be measured using the timer/capture pins. The PWM outputs can be used to control motors and other types of actuator circuits as well.

For people integrating the connector into their designs, it's not recommended to assume that a 5V supply will always be available. This is because on battery powered boards, 5V will not be present due to the requirement for a boost regulator. If 5V is required, its best to build in the circuitry for a boost converter from 3.3V to 5V on to the peripheral board directly. All MCU boards can only guarantee the presence of 5V when the board is being powered by the USB or a 5VDC power supply.

USC Port 1 Pinout (H2)			
Pin	*Description*	*Pin*	*Description*
1	PC4/SSEL	2	PC7/SCLK
3	PC5/MOSI	4	PC6/MISO
5	PC1/SCL_C	6	PC0/SDA_C
7	PC2/AINT/RXD_C	8	PC3/INT/TXD_C
9	GND	10	GND
11	PA1/ADC_A1	12	PA4/ADC_A4

USC Port 1 Pinout (H2)			
Pin	Description	Pin	Description
13	PD0/0CA_D0	14	PD1/OCB_D0
15	PF2/OCF_C0	16	OF3/OCF_D0
17	PA2/ADC_A2/DAC_A0	18	PA3/ADC_A3/DAC_A1
19	VCC3	20	VCC5

USC Port 2 Pinout (H5)			
Pin	Description	Pin	Description
1	PD4/SSEL	2	PD7/SCK
3	PD5/MOSI	4	PD6/MISO
5	PE1/SCL_E	6	PE0/SDA_E
7	PE2/AINT/RXD_E	8	PE3/INT/TXD_E
9	GND	10	GND
11	PB1/ADC_B1	12	PB2/ADC_B2/DAC_B0
13	PF0/OCA_F0	14	PF1/OCB_F0
15	PE4/OCA_E1	16	PE5/OCB_E1
17	PB3/ADC_B3/DAC_B1	18	PA5/ADC_A5
19	VCC3	20	VCC5

Jumpers

There are multiple jumpers that need to be set in order to select the correct operating mode for the board. The following should be chosen based on the use case:

Power Jumper		
Jumper	1-2	2-3
JP1	External 5VDC input	VBUS 5V Input
The power jumper chooses between the power source for the board. It is marked “VBUS” or “DC”. If in the VBUS position, the board will be powered by the power derived from the USB interface. Otherwise, it will be powered by the DC input from the external DC barrel jack.		

Power Switch		
Jumper	Top	Bottom
SW1	External Power	Battery
The power switch determines the power source for the board. If in the “BATT” position, it will use the battery input. If in the “EXT” position, it will use the power supplied by the DC source.		

Downloading Code

All boards come with a bootloader that makes it very easy to program the devices. Also, the bootloader resides in the boot section of the flash which cannot be overwritten except by a hardware programmer. That means that the board is basically unbrickable by interrupted firmware downloads or bugs that hang the system.

Note: Fuse settings cannot be changed via the bootloader. You must use a JTAG device such as the AVR Dragon or the JTAG ICE MK-II to change the fuses.

AVRDude

The code can be downloaded with AVRDude. There are versions for Windows, Linux, and Mac. All that's needed is to put the board into Bootloader mode. For more information, check out the FreakLabs ATXMega Test Tutorial.

Bootloader sequence

To go into bootloader mode, you need to perform a button sequence to jump to the boot section of flash. Basically, the IO pin designated as the boot pin is sampled for a brief time after reset. If it's low, then the microcontroller will go to the boot section.

This is the sequence to download the flash using the bootloader:

1. *Hold down the BOOT button (S2)*
2. *While keeping the BOOT button down, press and release the RESET button (S1)*
3. *You should now be in Bootloader mode. You can then use AVRDude to download software to the flash.*

AVR Dragon

Alternatively, its possible to use the AVR Dragon In Circuit Emulator to program the board. The AVR Dragon has a JTAG connector which connects to the JTAG on the ATXMEGA-A1 board. Once connected, the emulator behaves as a normal In-System Programmer and you would use AVR Studio to download code to the device. Fuse settings can also be changed using this device.

JTAG ICE MK-II

The JTAG ICE MK-II is the professional debugging tool and interfaces to the board via the JTAG interface. Downloading code via the JTAG ICE MK-II is the same as via the AVR Dragon. Once connected to the JTAG interface, downloading is accomplished via AVR Studio. Fuse settings can also be changed using this device.

Debugging

The board comes with a JTAG ICE interface for debugging using an Atmel JTAG ICE MKII

debugger. It can also be used as a programming interface with the AVR Dragon low cost programmer/debugger.

If you are using the JTAG interface, you will need to ensure that the JTAGEN fuse is set. The JTAGEN fuse is set by default so the only way this would be unset would be with a JTAG ICE or other hardware programmer.

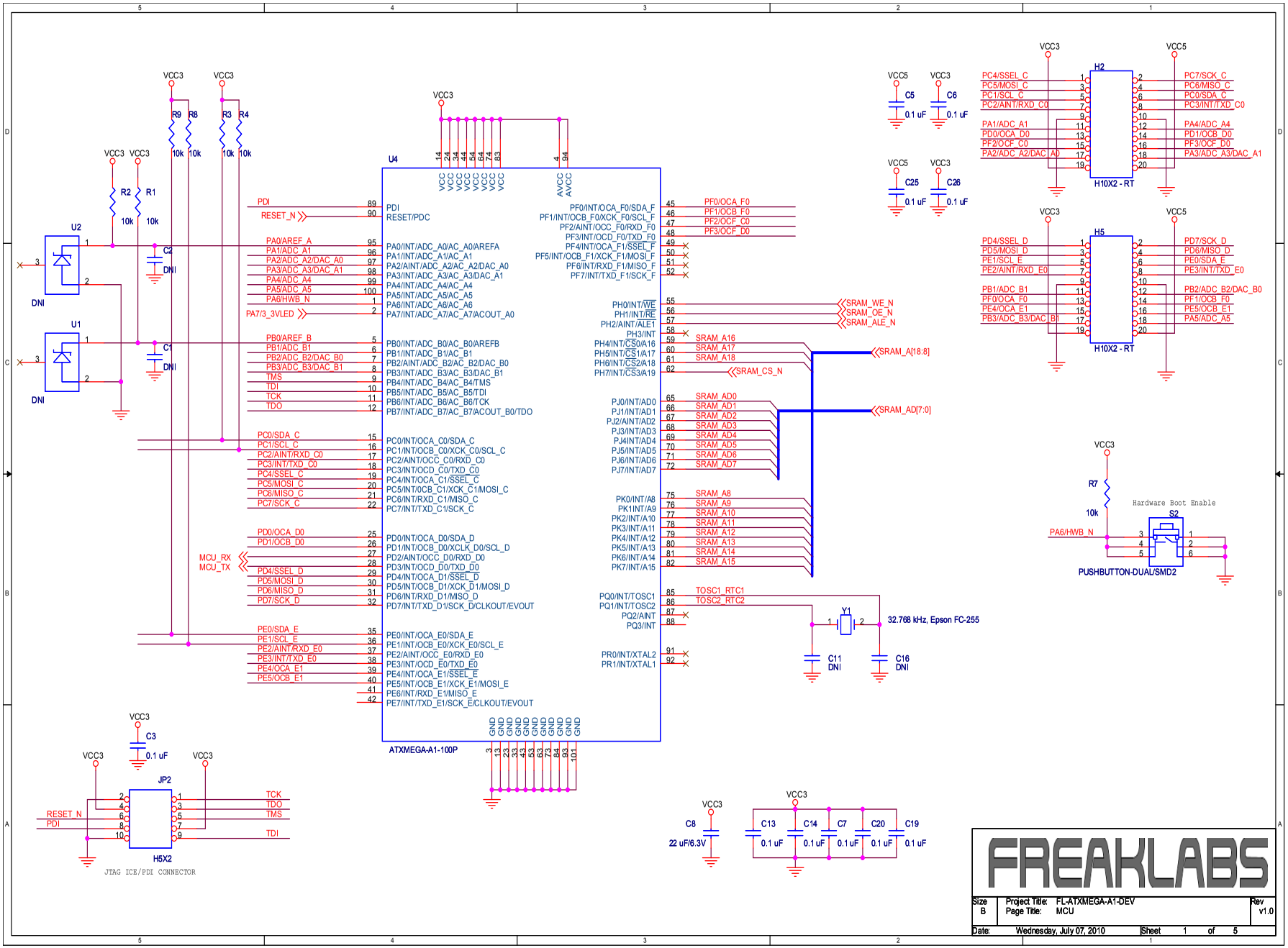
To debug the code, you will need to download Atmel's AVR Studio tool and follow the instructions on project setup and debug. The AVR Studio software debugger will connect via USB to the JTAG ICE MK-II. Please see the JTAG ICE MK-II documentation for details.

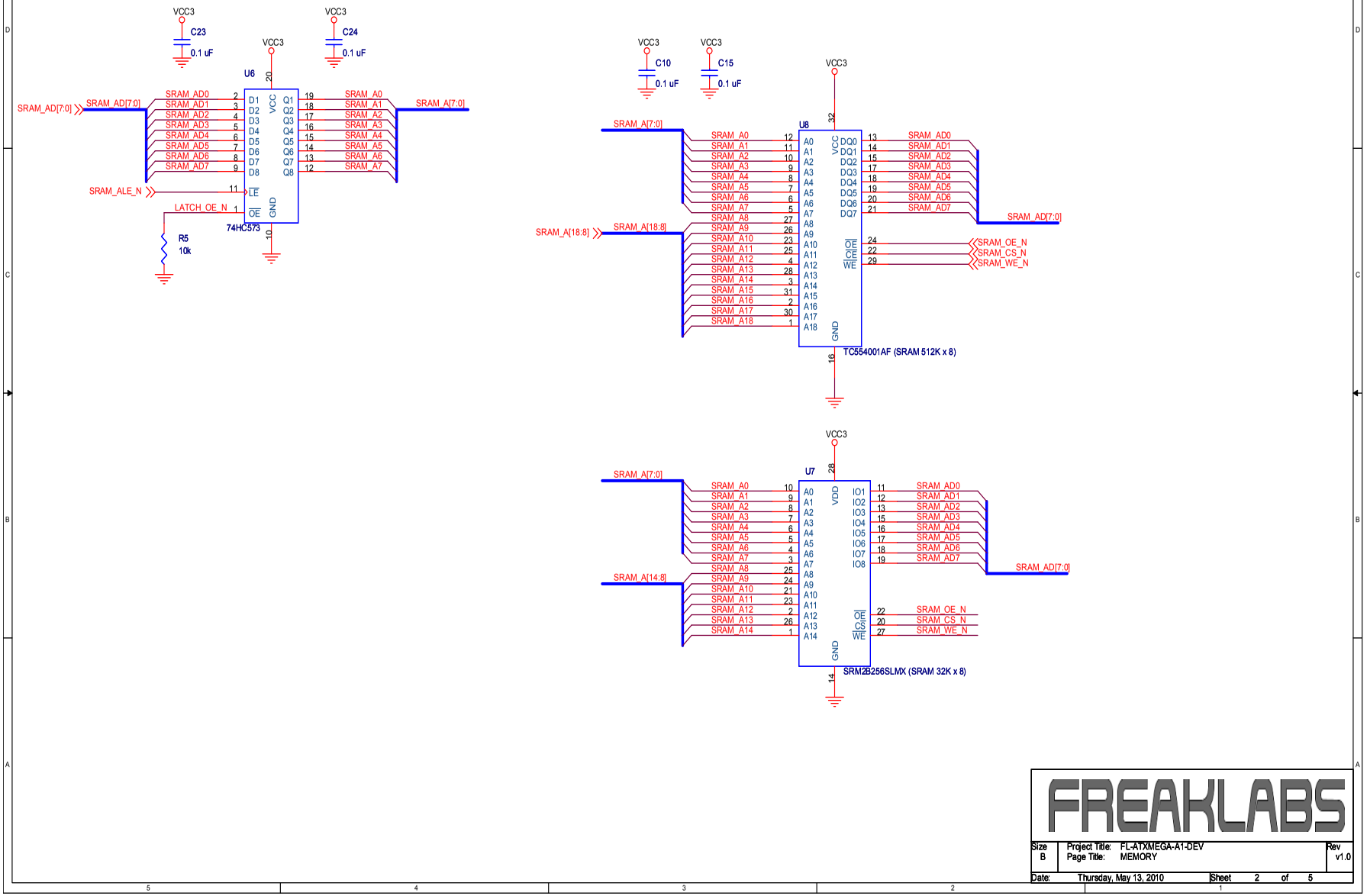
Disclaimer

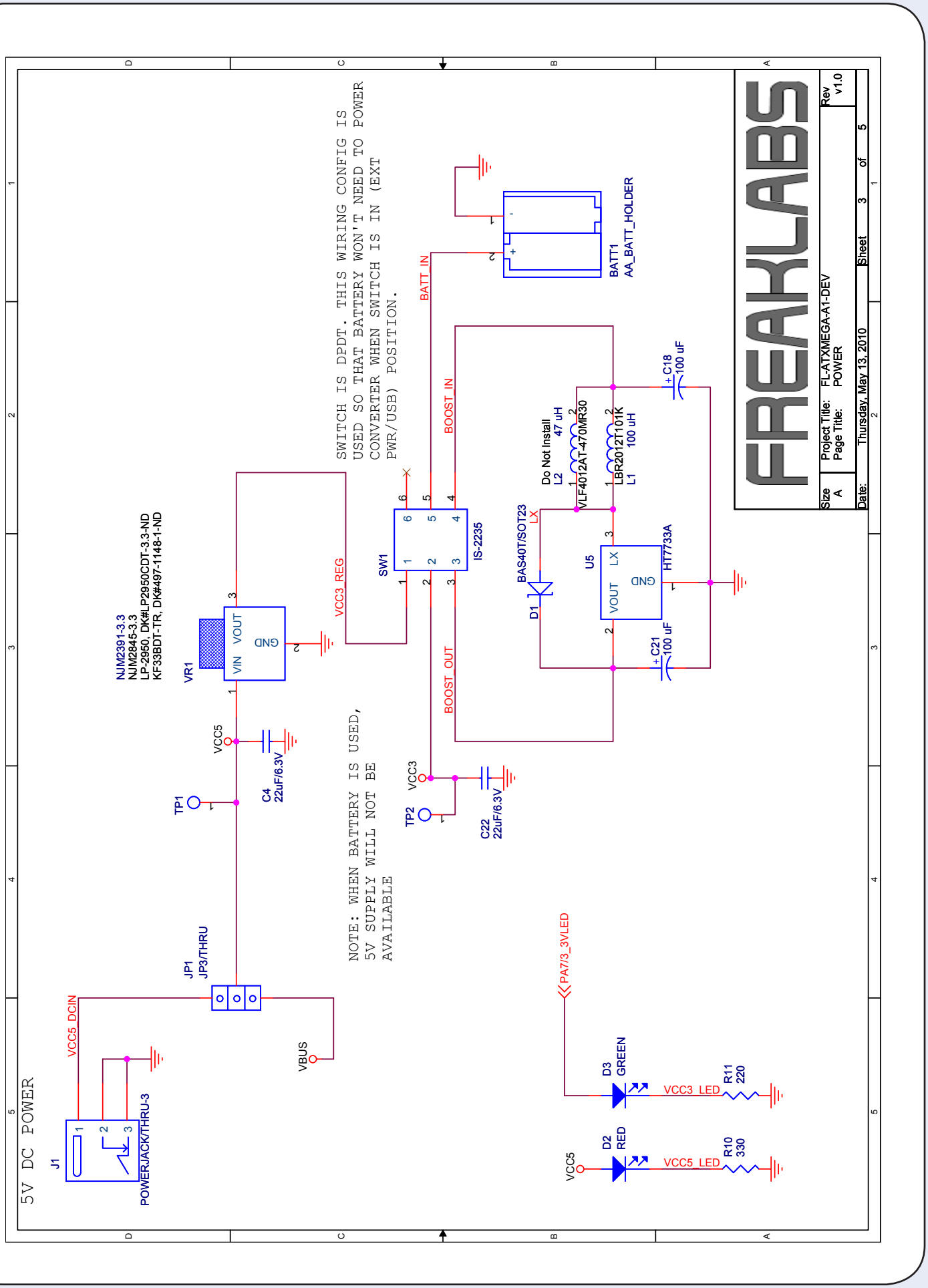
The ATXMEGA-A1 board is NOT FCC approved. It is designed to comply with FCC Part 15 rules. However this board is not in a finished product form and is only intended for experimental and research/development purposes. If you wish to use this board in an actual product, you will need to attain certification with the appropriate local regulatory body for the complete system. Additionally, please use the wireless equipment in a responsible manner with regard for others and your surroundings.

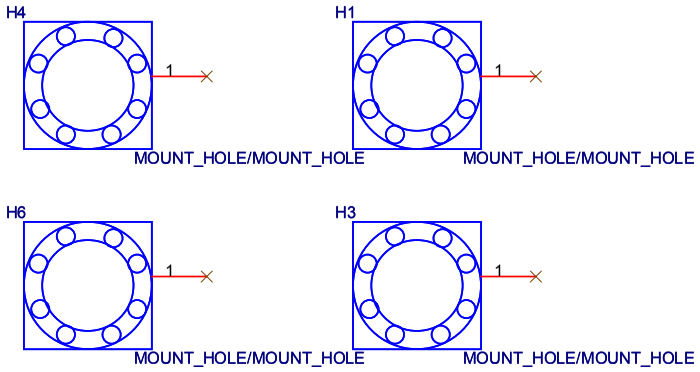
Schematics

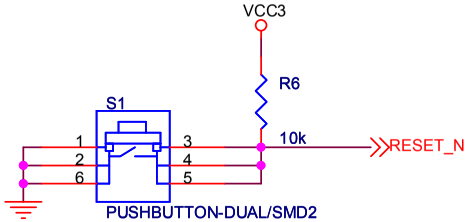
Schematics can be found on the following page:


U4
ATXMEGA-A1-100P
PDI
RESET/PDC
PA0/AREF_A
PA1/ADC_A1
PA2/ADC_A2/DAC_A0
PA3/ADC_A3/DAC_A1
PA4/ADC_A4
PA5/ADC_A5
PA6/HWB_N
PA7/3_3VLED
PB0/AREF_B
PB1/ADC_B1
PB2/ADC_B2/DAC_B0
PB3/ADC_B3/DAC_B1
TMS
TDI
TCK
TDO
PC0/SDA_C
PC1/SCL_C
PC2/AINT/RXD_C0
PC3/INT/TXD_C0
PC4/SSEL_C
PC5/MOSI_C
PC6/MISO_C
PC7/SCK_C
PD0/OCA_D0
PD1/OCB_D0
MCU_RX
MCU_TX
PD4/SSEL_D
PD5/MOSI_D
PD6/MISO_D
PD7/SCK_D
PE0/SDA_E
PE1/SCL_E
PE2/AINT/RXD_E0
PE3/INT/TXD_E0
PE4/OCA_E1
PE5/OCB_E1
PF0/OCA_F0
PF1/OCB_F0
PF2/OCF_C0
PF3/OCF_D0
SRAM_WE_N
SRAM_OE_N
SRAM_ALE_N
SRAM_A[18:8]
SRAM_CS_N
SRAM_AD[7:0]
SRAM_A16
SRAM_A17
SRAM_A18
SRAM_AD0
SRAM_AD1
SRAM_AD2
SRAM_AD3
SRAM_AD4
SRAM_AD5
SRAM_AD6
SRAM_AD7
SRAM_A8
SRAM_A9
SRAM_A10
SRAM_A11
SRAM_A12
SRAM_A13
SRAM_A14
SRAM_A15
TOSC1_RTC1
TOSC2_RTC2
32.768 kHz, Epson FC-255
U1
U2
JP2
H5X2
JTAG ICE/PDI CONNECTOR
H2
H5
H10X2 - RT
S2
PUSHBUTTON-DUAL/SMD2
Hardware Boot Enable
FREAKLABS
Project Title: FL-ATXMEGA-A1-DEV
Page Title: MCU
Rev v1.0
Date: Wednesday, July 07, 2010
Sheet 1 of 5

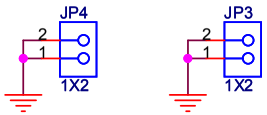

VCC3
C23
0.1 uF
VCC3
C24
0.1 uF
VCC3
U6
20
SRAM_AD[7:0]
SRAM_AD0
SRAM_AD1
SRAM_AD2
SRAM_AD3
SRAM_AD4
SRAM_AD5
SRAM_AD6
SRAM_AD7
D1
D2
D3
D4
D5
D6
D7
D8
VCC
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
SRAM_A0
SRAM_A1
SRAM_A2
SRAM_A3
SRAM_A4
SRAM_A5
SRAM_A6
SRAM_A7
SRAM_A[7:0]
SRAM_ALE_N
LATCH_OE_N
LE
OE
GND
74HC573
10
R5
10k
VCC3
C10
0.1 uF
VCC3
C15
0.1 uF
VCC3
U8
32
SRAM_A[7:0]
SRAM_A[18:8]
SRAM_A0
SRAM_A1
SRAM_A2
SRAM_A3
SRAM_A4
SRAM_A5
SRAM_A6
SRAM_A7
SRAM_A8
SRAM_A9
SRAM_A10
SRAM_A11
SRAM_A12
SRAM_A13
SRAM_A14
SRAM_A15
SRAM_A16
SRAM_A17
SRAM_A18
A0
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
A12
A13
A14
A15
A16
A17
A18
VCC
DQ0
DQ1
DQ2
DQ3
DQ4
DQ5
DQ6
DQ7
SRAM_AD0
SRAM_AD1
SRAM_AD2
SRAM_AD3
SRAM_AD4
SRAM_AD5
SRAM_AD6
SRAM_AD7
SRAM_AD[7:0]
OE
CE
WE
SRAM_OE_N
SRAM_CS_N
SRAM_WE_N
GND
16
TC554001AF (SRAM 512K x 8)
VCC3
U7
28
SRAM_A[7:0]
SRAM_A[14:8]
SRAM_A0
SRAM_A1
SRAM_A2
SRAM_A3
SRAM_A4
SRAM_A5
SRAM_A6
SRAM_A7
SRAM_A8
SRAM_A9
SRAM_A10
SRAM_A11
SRAM_A12
SRAM_A13
SRAM_A14
A0
A1
A2
A3
A4
A5
A6
A7
A8
A9
A10
A11
A12
A13
A14
VDD
IO1
IO2
IO3
IO4
IO5
IO6
IO7
IO8
SRAM_AD0
SRAM_AD1
SRAM_AD2
SRAM_AD3
SRAM_AD4
SRAM_AD5
SRAM_AD6
SRAM_AD7
SRAM_AD[7:0]
OE
CS
WE
SRAM_OE_N
SRAM_CS_N
SRAM_WE_N
GND
14
SRM2B256SLMX (SRAM 32K x 8)
FREAKLABS
Size
B
Project Title: FL-ATXMEGA-A1-DEV
Page Title: MEMORY
Rev
v1.0
Date: Thursday, May 13, 2010
Sheet 2 of 5


5V DC POWER
J1
POWERJACK/THRU-3
VCC5_DCIN
JP1
JP3/THRU
VBUS
NOTE: WHEN BATTERY IS USED, 5V SUPPLY WILL NOT BE AVAILABLE
SWITCH IS DPDT. THIS WIRING CONFIG IS USED SO THAT BATTERY WON'T NEED TO POWER CONVERTER WHEN SWITCH IS IN (EXT PWR/USB) POSITION.
VR1
NJM2391-3.3
NJM2845-3.3
LP-2950, DK#LP2950CDT-3.3-ND
KF33BDT-TR, DK#497-1148-1-ND
VIN
VOUT
GND
VCC5
C4
22uF/6.3V
TP1
VCC3_REG
SW1
IS-2235
BATT_IN
BOOST_IN
BOOST_OUT
VCC3
TP2
C22
22uF/6.3V
BATT1
AA_BATT_HOLDER
Do Not Install
L2
47 uH
VLF4012AT-470MR30
L1
100 uH
LBR2012T101K
BAS40T/SOT23
D1
LX
U5
VOUT
GND
HT7733A
C18
100 uF
C21
100 uF
PA7/3_3VLED
D3
GREEN
VCC3_LED
R11
220
D2
RED
VCC5_LED
R10
330
FREAKLABS
Size
A
Project Title:
FL-ATXMEGA-A1-DEV
Page Title:
POWER
Rev
v1.0
Date:
Thursday, May 13, 2010
Sheet
3
of
5



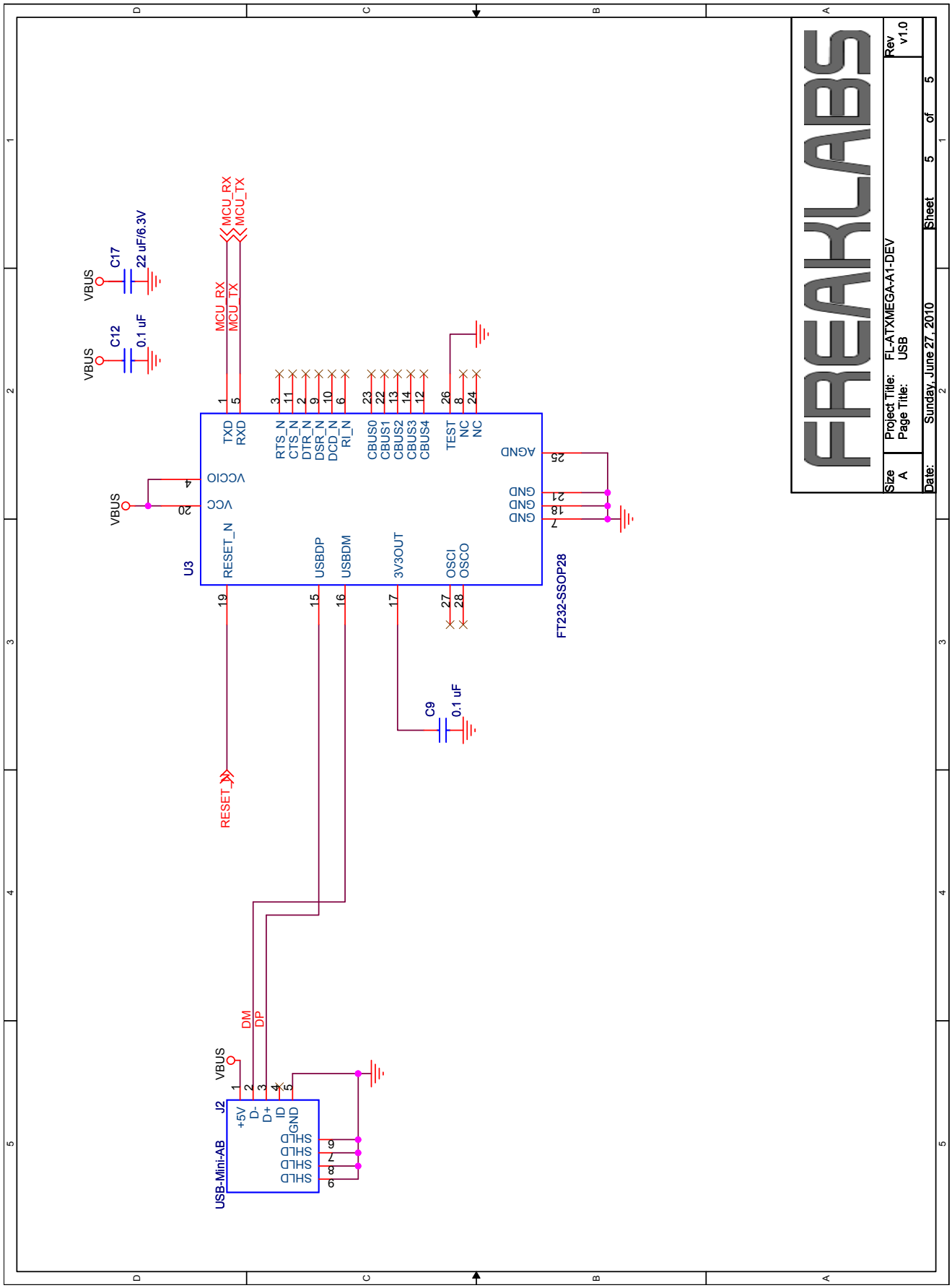


GND TESTPOINTS FOR DEBUGGING



FREAKLABS

Size	Project Title:	Rev
A	FL-ATXMEGA-A1-DEV	v1.0
	Page Title: RESET/MISC	
Date: Tuesday, May 11, 2010	Sheet 4 of 5	


FREAKLABS
Size A
Project Title: FL-ATXMEGA-A1-DEV
Page Title: USB
Rev v1.0
Date: Sunday, June 27, 2010
Sheet 5 of 5
U3
FT232-SSOP28
TXD
RXD
RTS_N
CTS_N
DTR_N
DSR_N
DCD_N
RI_N
CBUS0
CBUS1
CBUS2
CBUS3
CBUS4
TEST
NC
NC
AGND
VCCIO
VCC
GND
GND
GND
RESET_N
USBDP
USBDM
3V3OUT
OSCI
OSCO
MCU_RX
MCU_TX
VBUS
C17
22 uF/6.3V
C12
0.1 uF
C9
0.1 uF
RESET_N
DM
DP
J2
USB-Mini-AB
+5V
D-
D+
ID
GND
SHLD

Bill of Materials

Quantity	Reference	Manufacturer	Part Number	Description
1	BATT1	COMF	BH321-1P24	AA Battery Holder
8	U1, R1, C1, U2, R2, C2, C11, C16 L1, U8	DNI		Do Not Install
16	C3, C5, C6, C7, C9, C10, C12, C13, C14, C15, C19, C20, C23, C24, C25, C26	Various		0.1 uF/50V, 0603
2	C4 ,C22	Various		22uF/6.3V, 0805, MLCC
1	C8, C17	Various		10 uF/6.3V, 0805, MLCC
2	C18, C21	Various		100 uF/10V, Case-D,Tantalum
1	D1	Diodes, Inc	BAS40T/R	Schottky Diode
1	D2	Various		RED LED, 0805
1	D3	Various		GREEN LED, 0805
1	JP1	Various		1x3 Straight male header, 0.100”
1	JP2	Various		5x2 Straight male header, 0.100”
2	JP3, JP4	Various		1x2 Straight male header, 0.100”
1	J1	4UCON	05537	DC Power Jack, 2.0 mm center conductor
1	J2	4UCON	09558	USB Mini-AB connector
1	L2	TDK	VLF4012AT	47 uH/360 mA SMD inductor
7	R3, R4, R5, R6, R7, R8, R9	Various		10 kohm, 0603
1	R10	Various		330 ohm, 0805
1	R11	Various		220 ohm, 0805
1	SW1	Switronic	IS-2235	DPDT slide switch
2	S1, S2	Various		SMD SPST Tactile Switch/Push-button
1	U3	FTDI	FT232RL	USB to Serial converter IC
1	U4	Atmel	ATXMEGA 128A1-AU	ATXMega MCU, A1 family
1	U5	Holtek	HT7733A	3.3V boost switching regulator, 200 mA
1	U6	Various	75HC573A	IC bus latch

Quantity	Reference	Manufacturer	Part Number	Description
1	U7	Epson	SRM2B-256SLMX55	SRAM, 32K x 8
1	VR1	NJRC	NJM2391-3.3	3.3V LDO voltage regulator, 1A
1	Y1	Epson	FC-255	32.768 kHz watch crystal