Atmel AVR2063: Sensor Terminal Board - Hardware User's Manual

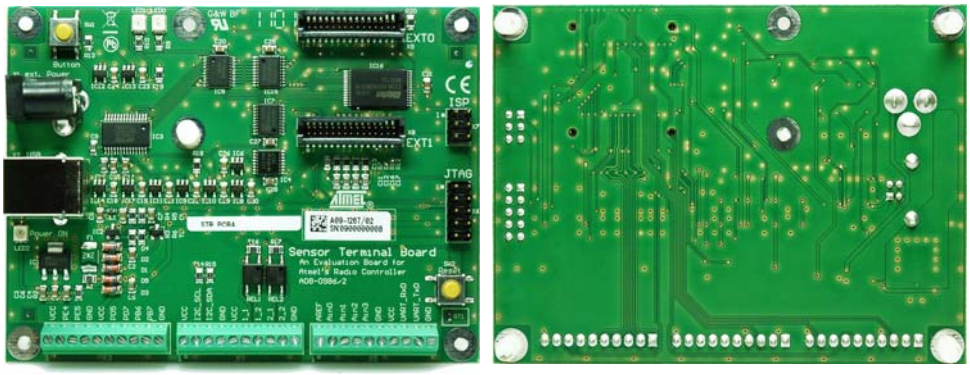
Features

- Radio controller board (RCB) general purpose I/O (GPIO) interface
  - Screw terminals for connecting external circuitry
  - Onboard GPIO circuit protection and digitally controlled relays
- Atmel® AVR® JTAGICE mkII and AVRISP programming access for RCBs
- USB to virtual COM port support via fast parallel bus connection
- External power circuitry
- External 32Kbyte SRAM
- Temperature sensor
- Low power consumption in RCB battery mode

1 Introduction

This application note provides a detailed hardware description of the individual function blocks of the sensor terminal board (STB). The STB is used in conjunction with an Atmel radio controller board (RCB) in order to provide various interfaces for evaluating and creating wireless sensor type applications.

Figure 1-1. Sensor terminal board (STB).



8-bit Atmel Microcontrollers

Application Note

Rev. 8359B-AVR-01/12

2 Disclaimer

Typical values contained in this application note are based on simulations and testing of individual examples.

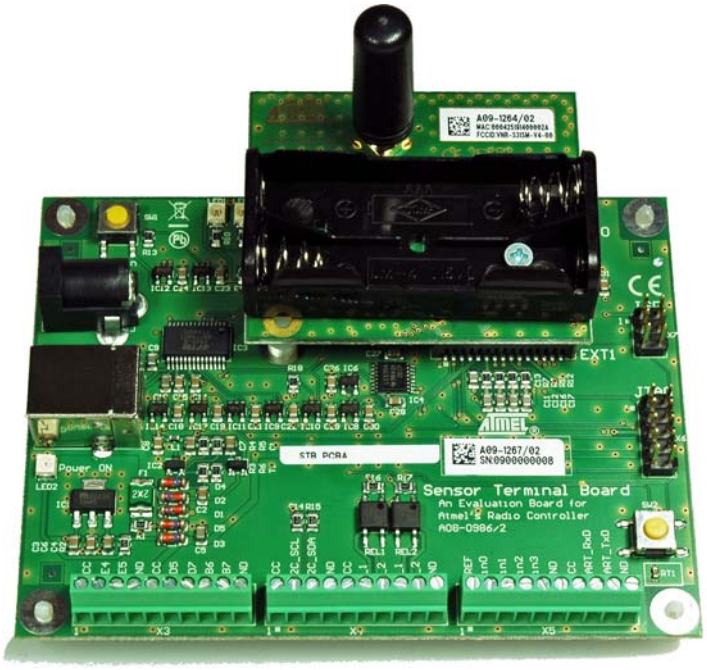
Any information about third-party materials or parts is included in this document for convenience. The vendor may have changed the information since then. Check the individual part information for the latest changes.

3 Overview

The STB allows a user to interface to Atmel RCBs via general purpose I/O (GPIO), USB to virtual COM port, and programming interfaces. An external power jack is also available, along with external SRAM for future application development. The GPIO interface provides access to peripherals within the RCB microcontroller, such as ADC, TWI, USART, etc., allowing a user to add additional circuitry such as sensors into the wireless evaluation and development stages.

Alternate applications like IEEE® 802.15.4 MAC, ZigBee® PRO, RF4CE, and IPv6/6LoWPAN can be run on the RCB in conjunction with the STB to demonstrate and evaluate those solutions. Figure 3-1 shows the Atmel RCB128RFA1 mounted on the STB.

Figure 3-1. STB with the RCB128RFA1 mounted.



4 RCB support

To evaluate different radio transceiver hardware solutions at different frequency bands, various RCBs are available. Single- and dual-chip solutions for IEEE 802.15.4 and ISM applications are supported, as well as different operating frequencies at 2.4GHz and sub-1GHz. The STB cannot be operated in a standalone manner. An appropriate RCB, listed in Table 4-1, has to be equipped for the microcontroller and radio transceiver functionality.

Table 4-1. RCB configurations.

RCB name	Frequency	Comment
RCB128RFA1 (1)	2.4GHz	Atmel ATmega128RFA1 - Single-chip solution [1]
RCB230 (2)	2.4GHz	Atmel AT86RF230 [2] with Atmel ATmega1281V [5]
RCB231 (2)	2.4GHz	Atmel AT86RF231 [3] with ATmega1281V
RCB231LPA (2)	2.4GHz	AT86RF231 [3] +amplifier, with ATmega1281V
RCB231ED (2)	2.4GHz	AT86RF231 [3] +antenna diversity, with ATmega1281V
RCB212SMA (2)	868/915MHz	Atmel AT86RF212 [4] with ATmega1281V

Notes: (1) Available with Evaluation Kit ATRF4CE-EU
(2) Purchasable on http://www.dresden-elektronik.de

The differences between the RCBs are related to port allocations, where the single-chip solution, ATmega128RFA1 [1], does not provide ports A and C, and the ATmega1281V [5] based dual-chip solutions already use Port B to control the radio transceiver.

Table 4-2 and Table 4-3 describe the compatibility between each RCB and the STB, along with how it correlates to the microcontroller I/O.

Table 4-2. RCB compatibility, EXT0.

RCB with ATmega1281	Pin	RCB128RFA1	Function on Sensor Terminal Board
PC0	EXT0.21	GND	H address
PC1	EXT0.22	GND	H address
PC2	EXT0.23	GND	H address
PC3	EXT0.24	GND	H address
PC4	EXT0.25	PD4 = EXT0.13	H address
PC5	EXT0.26	PD5 = EXT0.14	H address
PC6	EXT0.27	PD6 = EXT0.15	H address
PC7	EXT0.28	PD7 = EXT0.16	H address
PG0	EXT0.17	PE4	#WR
PG1	EXT0.18	PE5	#RD
PB6	EXT0.1	PG0 (DIG3)	GPIO
PB7	EXT0.2	PG1 (DIG1)	GPIO
XTAL1	EXT0.7	CLKI	Not in use

Table 4-3. RCB compatibility, EXT1.

RCB with Atmel ATmega1281	Pin	RCB128RFA1	Function on SensorTerminalBoard
PA0	EXT1.23	PB0	Data bus
PA1	EXT1.24	PB1	Data bus
PA2	EXT1.25	PB2	Data bus
PA3	EXT1.26	PB3	Data bus
PA4	EXT1.27	PB4	Data bus
PA5	EXT1.28	PB5	Data bus
PA6	EXT1.29	PB6	Data bus
PA7	EXT1.30	PB7	Data bus
PE4	EXT1.6	RSTON	X3.2
PE5	EXT1.5	TST	X3.3 - Do not connect!

5 Peripheral blocks

The STB contains different peripheral blocks in order to provide the proper tools and interface to the user. These blocks are described in the following sections.

5.1 Power supply

The STB can be powered in two different ways, either from USB power or from external power. The STB contains the MIC2920A-3.3WS low-dropout (LDO) voltage regulator [6]. It will regulate the USB 5V source to 3.3V, and will also allow external power within the range of 4.3V to 26V to be regulated safely down to 3.3V. (See Table 6-1.) The recommended external voltage operation is between 5V and 15V, and the USB standard is 5V. (See Table 6-2.)

The LDO regulator also provides ample current supply (400mA) for external sensor circuitry, as described below. In order to avoid any safety concerns, it is recommended to not exceed this current rating so as to not destroy the regulator or cause severe temperature increases on the board.

When the power circuit is active either with an external power source or with the FTDI USB device properly enumerated to the host PC, a power on LED (LED2) will turn on accordingly. See Section 5.2.1 for details about installing the FTDI USB device.

When using the external power supply, make sure the RCB battery holder is empty. Otherwise charge currents could destroy the battery. The RCB power switch can also be used to disconnect the battery. For long-term operation, the battery cells should be removed.

The gates and buffers used to connect the USB are specially selected logic families with a high impedance input when no USB power is available. This will ensure that no current is consumed through the logic lines during battery operation.

5.2 External bus peripherals

The following sections provide detailed information about how to configure and operate individual peripherals on the STB.

5.2.1 USB to virtual COM port

For USB connectivity, the FTDI FT245RL parallel USB to virtual COM port [7] was selected and designed on the STB. The FT245RL can provide up to 400mA of power to the target RCB and external circuitry (see Section 5.1 for more detailed information about the power supply).

The FT245RL driver files have been patched from the FTDI original files, and can be downloaded online from:
http://www.atmel.com/dyn/products/tools_card.asp?tool_id=4835. Simply locate the documents tab and select the application note AVR2018 for download of the driver package.

Following the installation application notes found on the FTDI website for the user's preferred PC operating system (OS), the user will be able to properly enumerate the FT245RL using the patched USB driver files mentioned above. Once enumerated to the PC of choice, the power status LED will turn on and provide power to the rest of the board.

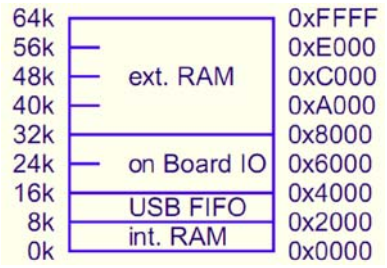
If Microsoft® Windows® is the target OS, the Windows Device Manger should contain two newly installed devices. One, which shows up in the USB category, is entitled "SensTermBoard USB<->Serial," and the other, which shows up in the ports (COM & LPT) category, is entitled "USB Serial Port (COMxx)."

If an installed COM port is not the ideal number, this can be changed by right-clicking on the “USB Serial Port (COMxx)” device and selecting Properties (Windows XP). Once the pop-up menu is active, select the Port Settings tab across the top of the pop-up window. Next, select the Advanced window and notice the COM port number with the active COMxx selection box to the right. Simply select the new COM port of interest and click OK twice to apply this new setting. Finally, manually re-scan the Device Manager by right-clicking on “USB Serial Port (COMxx)” and selecting “Scan for Hardware changes.”

FTDI provides several application notes, which can be found on the FTDI website, with more detailed and advanced configuration options that can be used with the FT245RL.

Communication with the FT245RL device is done with a memory-mapped interface. When using the Atmel ATmega1281V, the external memory bus interface puts the FT245RL in an addressable memory location, as shown in Figure 5-1.

Figure 5-1. Address map configuration.



If the FT245RL needs to send or receive data, it is mapped outside of the limit of the internal SRAM of the ATmega1281V, between addresses 0x2000 through 0x4000. Port G pins 0 and 1 are also used to control the RX and TX pins on the FT245RL automatically once the external memory bus interface is enabled within the ATmega1281V. The IEEE 802.15.4 MAC sub-layer, available from the Atmel application note AVR2025 [10], shows several examples of how to configure the FT245RL with the appropriate address map (that is, pal_config.h #define USB_FIFO_AD).

If a RCB128RFA1 is connected to the STB, the Atmel ATmega128RFA1 operates as the FT245RL host microcontroller. A virtual address bus is created by implementing a software interface via ports B and D. This interface is a byte-banged type interface with which the FT245RL can still be addressed with the address shown in Figure 5-1. AVR2025 also shows several examples of how the ATmega128RFA1 is configured (that is, pal_usb_ftdi.c #define USB_DATA_SETINP()). In replacing the automatic control of the RX and TX pins, Port E pins 4 and 5 need to be manually controlled during the byte-banged communication between the ATmega128RFA1 and the FT245RL.

NOTE

When accessing the USB port from an ATmega1281V-based RCB using the memory controller, bus contention will occur as long as internal RAM or USB is selected. This is a known hardware issue that can cause increased power consumption, but has no influence on the USB functionality. This issue is caused by the default data direction of the data latch, IC5. In each ALE low address phase, this buffer and the AVR are both driving data to the same data bus. The MAC Software Package [10] has implemented a software workaround to avoid this issue.

5.2.2 External SRAM

The STB contains a CS18LV0256 32K-byte SRAM device [8], which offers extra memory space for a user's application development.

All ATmega1281V-based RCBs can access this external SRAM. The ATmega1281V external memory bus is provided to communicate with the external SRAM device.

Based on the address map shown in Figure 5-1, the external SRAM can be communicated with by addressing 0x8000 through 0xFFFF. Port A is used for both address and data in a bidirectional mode with the use of a D-type latch device controlled by the ALE signal from the microcontroller. Port C is simply an address port. Port G pins 0 and 1 are also used to control the RD and WR pins on the latch automatically once the external memory bus interface is enabled.

It is recommended to operate the SRAM with one wait state. This low-power device has an access time of 150ns. Further information for zero-wait-state operation has to be acquired from the datasheets because the clock speed and the supply voltage have to be taken into account as well.

The external SRAM chip-enable pin is controlled by a digital MUX device that will automatically enable the memory based on the address map value that is accessed.

If the RCB128RFA1 is used in combination with the STB, the external SRAM memory is unusable. There is no external memory bus interface for the application to use to properly operate the external memory.

5.3 RCB GPIO interface

Two buttons, two LEDs, a temperature sensor (thermistor), and screw terminal connections for external circuitry interface are available on the STB. The following sections describe these features more in detail.

5.3.1 Buttons

The buttons are provided to reset the RCB and allow user input on GPIO Port A, pin 0. The buttons are connected between GND and their appropriate RCB GPIO signal line.

In order to read the SW1 button, the firmware has to access I/O memory map location 0x4000 with an appropriate read command. This will provide the access needed to read bit position 0 (Port A, pin 0).

5.3.2 LEDs

The LEDs are controlled by data latch IC7, and are controlled simultaneously. The state has to be applied to I/O memory map location 0x4000 with an appropriate write command. Applying a short, high pulse (minimum 3.2ns) on signal IO_#CE (issued from the multiplexer driven from the address value) stores the new state. In order to start this process, first apply a new state to the data bus, and then set the corresponding address signal high and then low. This signaling cycle avoids spikes on the other lines.

The register state inside IC7 can't be read by the microcontroller. The software has to maintain a variable that mirrors the state inside IC7.

When one LED state is updated, it may be necessary to ensure that the other three signals are not changed. LED0 is configured by writing to bit position 0. LED1 is configured by writing to bit position 1.

5.3.3 Temperature sensor (thermistor)

Similar to the LEDs, the temperature sensor, RT1, is shared on the IC7 latch device, and must be configured via memory map location 0x4000 with an appropriate write command. When writing to bit position 2, the latch enables the ultra-high-speed (UHS) buffer, allowing Port F, pin 3 to read the analog value from the sensor with the

microcontroller's ADC. If Port F, pin 3 needs to be used for external circuitry, simply disable the UHS buffer with the appropriate value written to the IC7 latch.

Figure 5-2 shows the equivalent temperature circuit, where a 47kΩ resistor is matched with the 47kΩ thermistor operating at Vcc. The circuit is enabled when the appropriate address is selected, as mentioned above. Table 5-1 shows the precalculated temperature voltage range when using the Murata Electronics NCP18WB473J03RB device, as discussed in the datasheet [9].

When operated with RCB128RFA1, using the controller's internal temperature sensor may also be considered.

Figure 5-2. Temperature circuit.

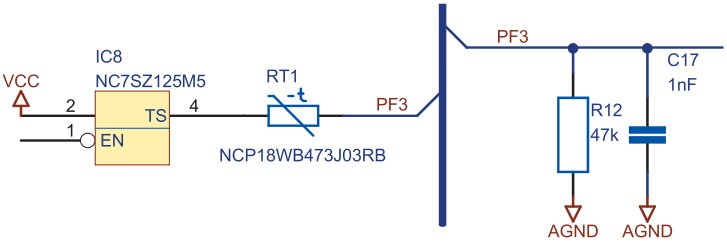


Table 5-1. Precalculated temperature voltage.

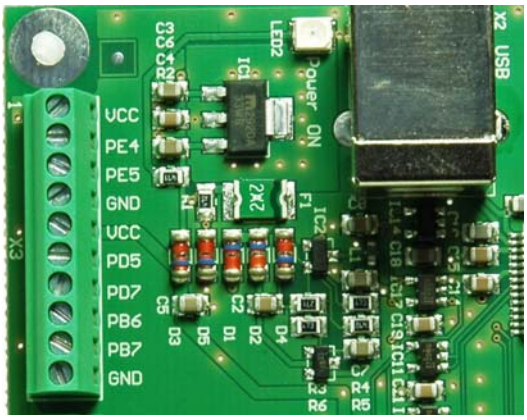
Temperature (°C)	Rthermistor (kΩ)	Vadc (mV)
-40	1.748	86
-35	1.245	120
-30	898	164
-25	656	221
-20	484	292
-15	361	380
-10	272	487
-5	206	612
0	158	756
5	122	916
10	95	1091
15	75	1274
20	59	1462
25	47	1650
30	38	1832
35	30	2006
40	25	2166
45	20	2313
50	16	2445
55	14	2562
60	11	2665
65	9	2754
70	8	2830
75	7	2897

5.3.4 Screw-terminal interface

Three 10-row screw terminals are mounted on the STB on the edge opposite the RCB providing access to peripherals such as ADC, TWI, USART, etc. within the RCB microcontroller. These screw terminals, which are shown in Figure 5-3, provide a method for a user to connect various external circuits, such as sensors, motors, etc.

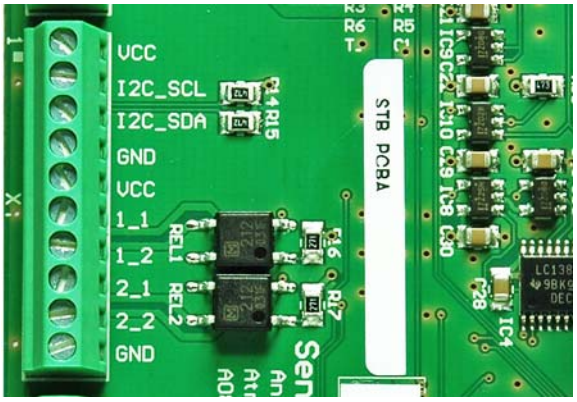
Terminal X3 provides a combination of power and ground connections along with spare microcontroller GPIO lines.

Figure 5-3. STB X3 terminal.



Terminal X4 provides more power and ground connections along with TWI/I^{2}C and relay terminal connections.

Figure 5-4. STB X4 terminal.



Terminal X5 is more of an analog-based interface, as it contains ADC, AREF, and AGND connections to the microcontroller. The ADC inputs have signal conditioning circuits in order to filter and/or protect the microcontroller. It is also a connection to the spare microcontroller USART, which can be used to interface to a user's custom application.

Each terminal has 100mil spacing. If single-pin headers are desired instead, single-row, 100mil pin headers may be fitted into the screw terminals directly.

Figure 5-5. STB X5 terminal.

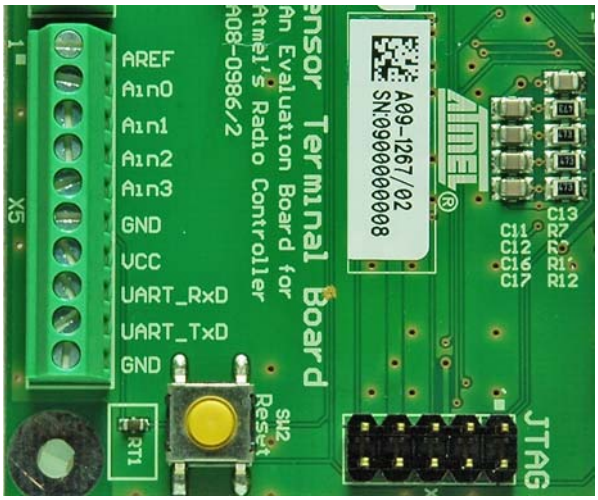


Table 5-2 shows the GPIO configuration for the STB and the microcontroller options on the RCBs.

Table 5-2. Signaling with different RCBs.

STB signals	RCB with ATmega1281V	RCB with ATmega128RFA1	Comment
X3 pin1	VCC	VCC	Standard GPIO connection to/from the microcontroller
pin2	PE4 – GPIO	RSTON	
pin3	PE5 – GPIO	TST	
pin4	GND	GND	
pin5	VCC	VCC	
pin6	PD5 – GPIO	PD5 – GPIO	
pin7	PD7 – GPIO	PD7 – GPIO	
pin8	PB6 – GPIO	PG0 – DIG3	
pin9	PB7 – GPIO	PG1 – DIG1	
pin10	GND	GND	
X4 pin1	VCC	VCC	TWI/I^2C and relay terminal connections
pin2	PD0 – I2C_SCL	PD0 – I2C_SCL	
pin3	PD1 – I2C_SDA	PD1 – I2C_SDA	
pin4	GND	GND	
pin5	VCC	VCC	
pin6	PE2 – REL1_1	PE2 – REL1_1	
pin7	PE2 – REL1_2	PE2 – REL1_2	
pin8	PE3 – REL2_1	PE3 – REL2_1	
pin9	PE3 – REL2_2	PE3 – REL2_2	
pin10	GND	GND	
X5 pin1	AREF	AREF	Analog power and input connections
pin2	PF0 – Ain0	PF0 – Ain0	
pin3	PF1 – Ain1	PF1 – Ain1	
pin4	PF2 – Ain2	PF2 – Ain2	
pin5	PF3 – Ain3	PF3 – Ain3	
pin6	AGND	GND	
pin7	VCC	VCC	
pin8	PD2 – UART_RxD	PD2 – UART_RxD	
pin9	PD3 – UART_TxD	PD3 – UART_TxD	
pin10	GND	GND	

5.4 Programming access

The standalone RCB does not support user programming interfaces. It has to be mounted on a development platform such as the STB in order to give the user a method for programming the microcontroller on the RCB.

There are two supporting interfaces that provide optional methods for programming and debugging the host application on the microcontroller. They are AVRISP and JTAGICE mkII.

When using the AVRISP programming interface, the user has access to a 6-pin header that allows the fuses and the flash of the Atmel ATmega1281V to be programmed. The AVRISP does not support application level debugging. See Figure 5-6 for the proper connector orientation between the STB and the AVRISP.

The ISP pin location for the Atmel ATmega128RFA1 differs from the ATmega1281V. Therefore the AVRISP can only be used with 1281V-based RCB boards.

Figure 5-6. STB and AVRISP connection.

In order to provide extra developmental features beyond simple fuse and flash programming, such as application-level debugging, the JTAGICE mkII should be used. The STB also provides the required 10-pin header for proper JTAGICE mkII connection. See Figure 5-7 as a connection reference.

Figure 5-7. STB and JTAGICE mkII connection.

The AVRISP and JTAGICE mkII can be ordered from most local distributors.

6 Electrical characteristics

6.1 Absolute maximum ratings

Stresses beyond those listed in Table 6-1 may cause permanent damage to the board. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this manual are not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability. For more details about these parameters, refer to individual datasheets of the components used.

Table 6-1. Absolute maximum ratings.

No.	Parameter	Condition	Minimum	Typical	Maximum	Units
6.1.1	Storage temperature range		-40		+85	°C
6.1.2	Humidity	Non-condencing			90	%
6.1.3	External supply voltage		-20		+60	V
6.1.4	USB supply voltage		-0.5		+5	V
6.1.5	Maximum input supply current	Sum over all power pins			0.5	A

6.2 Recommended operating range

Table 6-2. Recommended operating range.

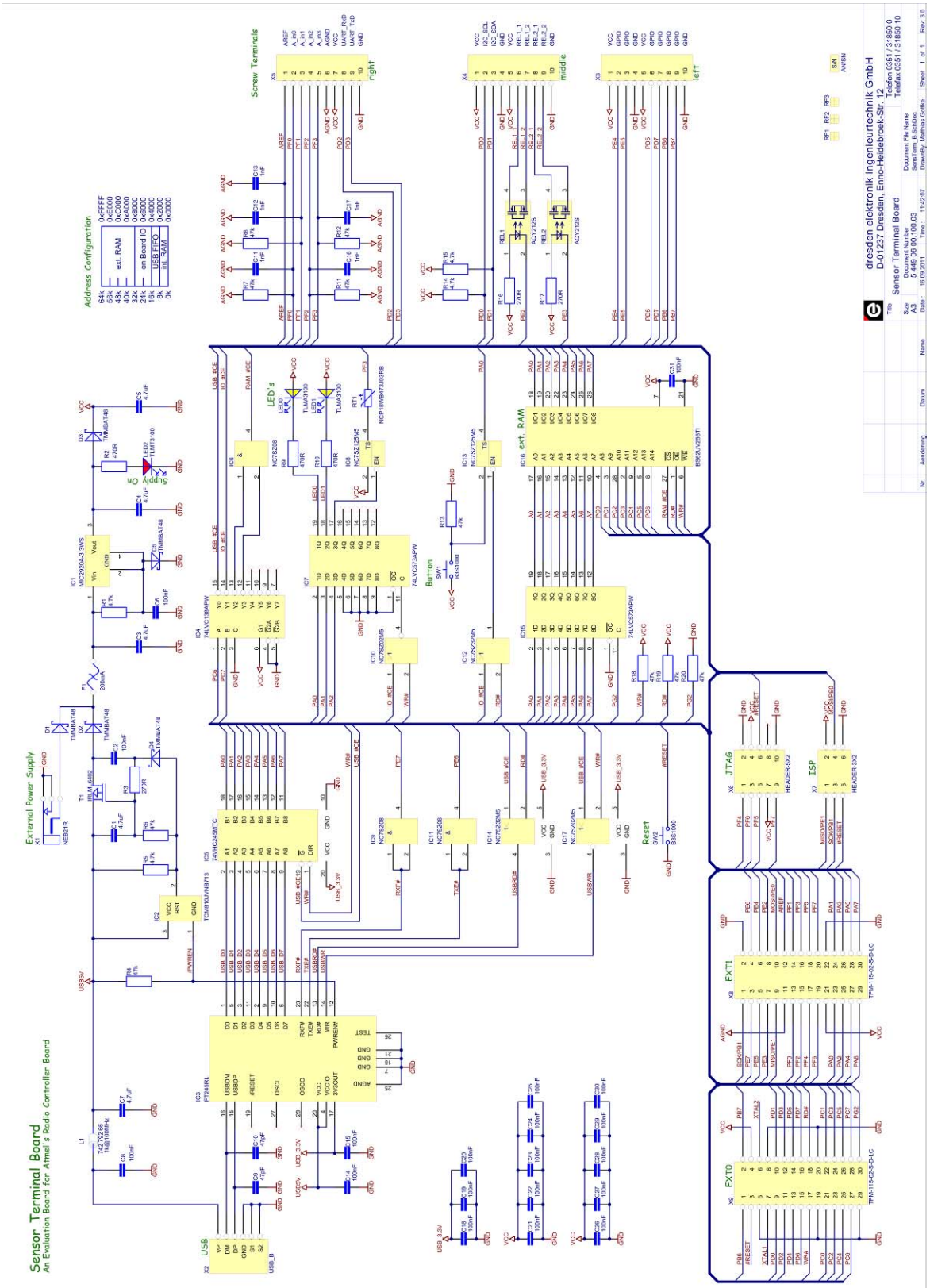
No.	Parameter	Condition	Minimum	Typical	Maximum	Units
6.2.1	Temperature range		-10		+60	°C
6.2.2	External supply voltage		2	12	26	V
6.2.3	USB supply voltage		4	5	5.25	V
6.2.4	External/USB current limit				0.4	A

7 Abbreviations

ADC	-	Analog-to-digital converter
ALE	-	Address Latch Enable
COM	-	Communications
FTDI	-	Future Technology Devices International (the company)
GND	-	Ground
GPIO	-	General purpose input and output
I^2C	-	Inter-integrated circuit
I/O	-	Input/output
ISM	-	Industrial, scientific and medical band
ISP	-	In-system programming
LDO	-	Low-dropout (regulator)
LED	-	Light emitting diode
LPT	-	Line print terminal
MUX	-	Multiplexer
OS	-	Operating system
PCB	-	Printed circuit board
RCB	-	Radio controller board
RD	-	Read (memory bus signal)
SRAM	-	Static random access memory
STB	-	Sensor terminal board
TWI	-	Two-wire interface
UHS	-	Ultra-high-speed
USART	-	Universal synchronous/asynchronous receiver transmitter
USB	-	Universal serial bus
WR	-	Write (memory bus signal)

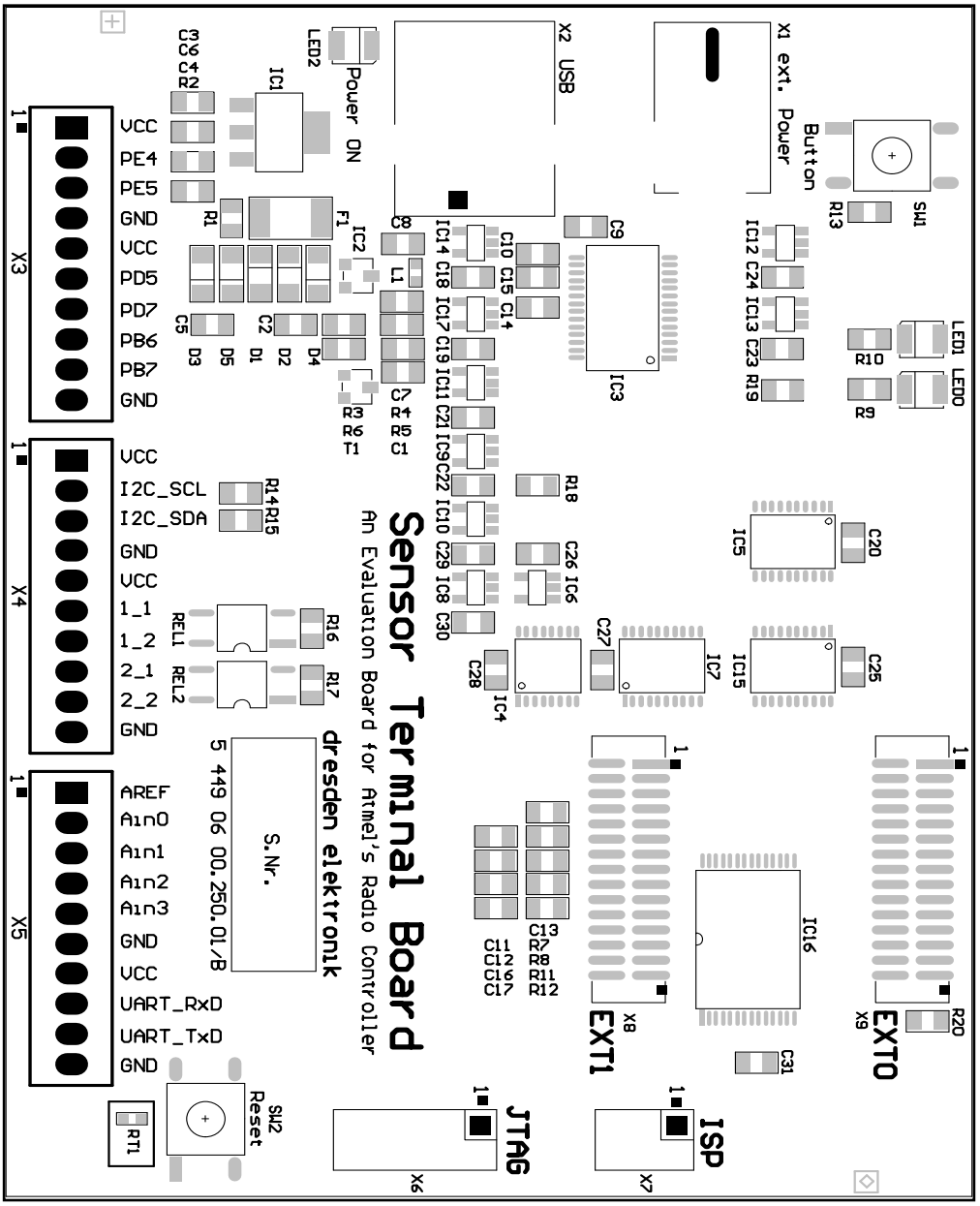
Appendix A - Hardware documentation

A.1 Schematic



A.2 Assembly drawing

Figure A-1. Assembly top.



A.3 Bill of materials

Table A-1. Bill of materials.

Qty.	Designator	Description	Footprint	Part#/Value	Comment	Rating
2	C9, C10	Capacitor	0805	47pF	100V	C0G
19	C2, C6, C8, C14, C15, C18, C19, C20, C21, C22, C23, C24, C25, C26, C27, C28, C29, C30, C31	Capacitor	0805	100nF	50V	X7R
5	C11, C12, C13, C16, C17	Capacitor	0805	1nF	50V	C0G
5	C1, C3, C4, C5, C7	Capacitor	0805	4.7µF	6.3V	X5R
3	IC6, IC9, IC11	2-input AND gate, UHS	SOT-23/5	NC7SZ08M5_NL	1.65V-5.5V	
2	IC8, IC13	Buffer, 3-state, UHS	SOT-23/5	NC7SZ125M5_NL(7Z25)	1.65V-5.5V	
2	IC12, IC14	2-input OR gate, UHS	SOT-23/5	NC7SZ32M5_NL (7Z32)	1.65V-5.5V	
2	IC10, IC17	2-input NOR gate, UHS	SOT-23/5	NC7SZ02M5_NL (7Z02)	1.65V-5.5V	
1	IC1	LDO voltage regulator. 3.3V	SOT-223	MIC2920A-3.3WS	26V/400mA	
1	IC16	SRAM, 32K x 8 bit	TSOP-28	BS62UV256TIG	1.8V-3.6V	
2	IC7, IC15	Octal transpar. D-latch, 3-state	TSSOP-20	74LVC573APW	2.7V-3.6V	
1	IC2	Supervisor/RST	SOT-23/3	TCM810JVNB713	4.00V	
1	IC3	USB-FIFO fast parallel data transfer	SSOP-28	FT245RL	3.3V-5.25V	
1	IC4	Decoder, 3 to 8 line	TSSOP-16	SN74LVC138APW	1.65V-3.6V	
1	IC5	Octal bus transceiver, 3-state	TSSOP-20	74VHC245MTC	2.0V-5.5V	
1	T1	Transistor, power MOSFET-P	SOT-23	IRLML6402PBF	20V	
5	D1, D2, D3, D4, D5	Schottky diode	MINIMELF/SOD-80	TMMBAT48	40V/350mA	Vf=0.75V/ 200mA
2	LED2, LED3	LED, yellow	PLCC-2	TLMA3100	2mA	
1	LED1	LED, red	PLCC-2	TLMT3100	2mA	
1	L1	Ferrite, SMD	0603	742 792 66	200mA	
3	R3, R16, R17	Resistor	0805	270Ω	150V	125mW
3	R2, R9, R10	Resistor	0805	470Ω	150V	125mW
4	R1, R5, R14, R15	Resistor	0805	4.70KΩ	150V	125mW
10	R4, R6, R7, R8, R11, R12, R13, R18, R19, R20	Resistor	0805	47KΩ	150V	125mW
1	RT1	Thermistor, NTC	0603	47KΩ		100mW

Qty.	Designator	Description	Footprint	Part#/Value	Comment	Rating
1	F1	Fuse, Polyswitch	miniSMDC020F/18 12	200mA	30V max	
3	X3, X4, X5	Terminal, screw-in, 10P	1725737	MPT0.5/10-2.54		
1	X8	Header, 10P	2-row	1002-121-010		
1	X9	Header, 6P	2-row	1002-121-006		
1	X1	Jack, power, 2P	NEB	NEB21R / 2.1mm	12V/1A	
1	X2	Female jack, USB 2.0 type B	through-holed	2411 02		
2	X6, X7	Header, 30P	2-row/SMD	TFM-115-02-SM-D-LC		
2	SW1, SW2	Switch, micro	SMD/6x6x4.3	B3S1000		
2	Rel1, Rel2	Relay, MOS	SOP-4	AQY212S	60V/500mA	
6	4x for PCB feet / 2x for RCB spacing	Spacer, LP	6.4mm/Dm:2.5	PST-4-01		

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[3] Atmel AT86RF231; Low Power 2.4GHz Transceiver for ZigBee, IEEE 802.15.4, 6LoWPAN, RF4CE, SP100, WirelessHART, and ISM Applications, Datasheet; Rev C; 09/09; Atmel Corporation

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[9] Murata NCP18WB473J03RB; NTC Thermistor; Datasheet; Rev E; 08/08; Murata Electronics

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PCBA Revision History

Revision	Description
A09-1267/01	Initial release
A09-1267/02	Replacement of IC2 Supervisor/RST LM810M3 by TCM810JVNB713

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