MPR - Mote Processor Radio Board

MIB - Mote Interface / Programming Board User's Manual

MPR500CA, MPR510CA, MPR520CA

MPR400CB, MPR410CB, MPR420CB

MPR300CA, MPR310CA

MIB300CA, MIB500CA

MIB510CA, MIB600CA

Rev. A, December 2003

Document 7430-0021-05

Crossbow

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1 Introduction

This User's Manual describes the hardware features of the mote Processor-Radio (MPR) wireless nodes. Currently, Crossbow sells three main varieties: MICA, MICA2, and MICA2DOT motes. It is intended for understanding and leveraging the mote hardware design in real-world sensor network applications. This User's Manual also describes and explains the mote Interface Boards (MIB) for base station and programming requirements.

This manual is **not** a software guide to programming the motes in TinyOS/nesC, nor is it a guide to pre-built software packages that run on top of the motes. The following two resources are available regarding software:

- *TinyOS Getting Started Guide* (Document 7430-0022-03) by Crossbow Technology, Inc.
- http://webs.cs.berkeley.edu/tos

Mote Hardware Platform	MICA2	MICA2DOT	MICA
Models (as of Nov. 2003)	MPR400/410/420	MPR500/510/520	MPR300/310
10-Bit ADC	✓	✓	✓
Digital I/O	✓	✓	✓
UART	✓		✓
LEDs	3	1	3
AM Radio			✓
FM Tunable Radio	✓	✓	
Base Radio Frequency (MHz)	916/433/315	916/433/315	916/433
Flash Data Logger Memory	✓	✓	✓
Antenna Connector	✓		
3.3V Booster			✓

2 MPR400/MPR410/MPR420 (MICA2)

The MPR400 (916 MHz), MPR410 (433 MHz), and MPR420 (315 MHz) Series hardware is Crossbow's latest generation of mote technology. All models utilize a powerful Atmega128L micro-controller and a frequency tunable radio with extended range. The MPR4X0 and MPR5X0 radios are compatible and can communicate with each other.

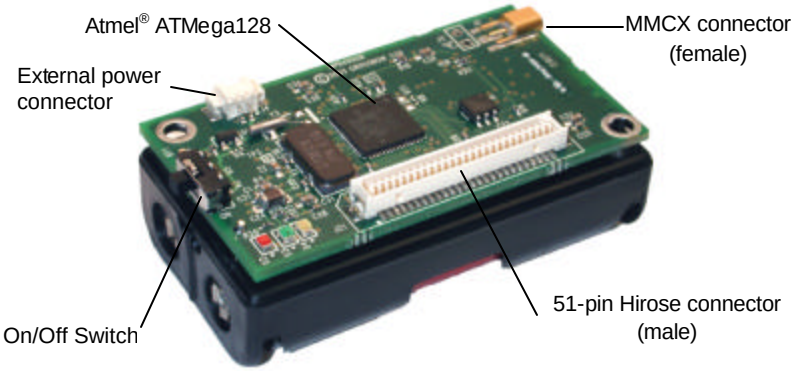


Figure 2-1. Photo of a MICA2 (MPR4X0) without an antenna

2.1 Powering the mote

2.1.1 Battery Operation

The MPR400 is battery powered. The form factor of the MPR400 was designed to match up with two AA batteries; however any battery combination (AAA, C, D, etc., cells) can be used provided that the output is between 2.7–3.3VDC.

Care should be used in selecting the battery and its capacity to match the energy needs of the motes and their required operating span. Also make sure that the temperature range and associated capacity degradation are looked at prior to deployment. Table II-1 below provides some useful guidance on how to predict battery life. The spreadsheet can be found at http://www.xbow.comunder the Support section.

Table 2-1. Battery Lifetime Estimates

SYSTEM SPECIFICATIONS		
Currents		**Example Duty Cycle**
Processor		
current (full operation)	8 mA	1
current sleep	8 uA	99
Radio		
current in receive	8 mA	0.75
current transmit	12 mA	0.25
current sleep	2 uA	99
Logger Memory		
write	15 mA	0
read	4 mA	0
sleep	2 uA	100
Sensor Board		
current (full operation)	5 mA	1
current sleep	5 uA	99
Computed mA-hr used each hour		
Processor		0.0879
Radio		0.0920
Logger Memory		0.0020
Sensor Board		0.0550
Total current (mA-hr) used		**0.2369**
Computed battery life vs. battery size		
Battery Capacity (mA-hr)		Battery Life (months)
250		1.45
1000		5.78
3000		17.35

NOTE: In most mote applications, the processor and radio run for a brief period of time, followed by a sleep cycle. During sleep, current consumption is in the micro-amps as opposed to milli-amps. This results in very low-current draw the majority of the time, and short duration spikes while processing, receiving, and transmitting data. This method extends battery life; however, due to the current surges, it reduces specified battery capacity. Battery capacity is typically specified by the manufacturer for a constant nominal current drawn .

2.1.2 External Power

The MICA2 can be externally powered through either:

1. The 51-pin connector will supply power and ground to the unit. Refer to connector des cription.
2. The 2 pin Molex connector. Molex part number 53261-0290, Digi-Key part number WM1753-ND.

2.2 Radio/Antenna Considerations

The radio on the MICA2 is capable of multiple channel operation, within the intended band of operation. The MPR420 can span up to 4 channels of operation in the 315 MHz band, the MPR410 can span up to 4 channels of operation in the 433 MHz band (433.05–434.79 MHz). The MPR400 can operate in two frequency regions: 868–870 MHz (up to 4 channels) and 902–928 MHz (up to 54 channels). The actual number of possible channels is higher for all the MICA2 motes. However, it is recommended that the adjacent channel spacing should be **at least** 500 kHz to avoid adjacent channel interference thereby reducing the number of available channels. A tutorial on how to change frequency is available at http://www.tinyos.net/tinyos-1.x/doc/mica2radio/CC1000.html.

2.2.1 Radio Transmission Power

The radio on the MICA2 can be adjusted for a range of output power levels. The register in the radio that controls the RF power level is designated PA_POW at address 0x0B, and the values and their corresponding RF outputs are provided on **Table 2-2** below. It shows the closest programmable value for output powers in steps of 1 dBm. For power down mode the Chipcon datasheet says, “the PA_POW should be set to 00h [0x00] for minimum leakage current.”

Table 2-2. Chipcon® CC1000 Ouput Power (PA_POW) Settings and Typical Current Consumption. From *Smart RF® CC1000 Preliminary Datasheet (rev. 2.1), 2002*-04-19, p. 29 of 48.

Pout (dBm)	PA_POW (hex) 433/315 MHz	Current Consumption, typ. (mA)	PA_POW (hex) 915 MHz	Current Consumption, typ. (mA)
-20	0x01	5.3	0x02	8.6
-19	0x01	6.9	0x02	8.8
-18	0x02	7.1	0x03	9.0
-17	0x02	7.1	0x03	9.0
-16	0x02	7.1	0x04	9.1
-15	0x03	7.4	0x05	9.3
-14	0x03	7.4	0x05	9.3
-13	0x03	7.4	0x06	9.5
-12	0x04	7.6	0x07	9.7
-11	0x04	7.6	0x08	9.9
-10	0x05	7.9	0x09	10.1
-9	0x05	7.9	0x0b	10.4
-8	0x06	8.2	0x0c	10.6
-7	0x07	8.4	0x0d	10.8
-6	0x08	8.7	0x0f	11.1
-5	0x09	8.9	0x40	13.8
-4	0x0a	9.4	0x50	14.5
-3	0x0b	9.6	0x50	14.5
-2	0x0c	9.7	0x60	15.1
-1	0x0e	10.2	0x70	15.8
0	0x0f	10.4	0x80	16.8
1	0x40	11.8	0x90	17.2
2	0x50	12.8	0xb0	18.5
3	0x50	12.8	0xc0	19.2
4	0x60	13.8	0xf0	21.3
5	0x70	14.8	0xff	25.4
6	0x80	15.8		
7	0x90	16.8		
8	0xc0	20.0		
9	0xe0	22.1		
10	0xff	26.7		

The radio on the MICA2 also provides a measurement of the received signal strength, referred to as RSSI. This output is measured on ADC channel 0 and is available to the software. Some versions of TinyOS

provide this measurement automatically, and others must be enabled by the user. The conversion from ADC counts to RSSI in dBm is given by:

$$V_{RSSI} = V_{batt} \times ADC\_Counts/1024$$

$$RSSI(dBm) = -51.3 \times V_{RSSI} - 49.2 \text{ for 433 and 315 MHz motes}$$

$$RSSI(dBm) = -50.0 \times V_{RSSI} - 45.5 \text{ for 915 MHz motes}$$

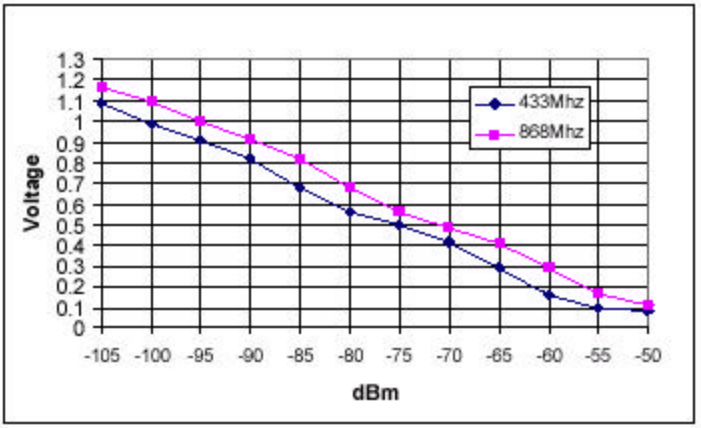


Figure 2-2. Graph showing V_{RSSI} versus the received signal strength indicator (dBm). From the ChipCon's *SmartRF® CC1000 PRELIMINARY Datasheet (rev. 2.1)*, p. 30. 2002.

Care should be taken to provide an antenna that provides proper coverage for the environment expected. Range and performance are **strongly** affected by choice of antenna and antenna placement within the environment. In addition, care must be taken to ensure compliance with FCC article 15 regulations for intentional radiators. An omni directional antenna such as a quarter wavelength whip should be sufficient to meet most user requirements.

WARNING: The radio on the MICA2 has an extremely sensitive receiver, which can be interfered with by an adjacent local oscillator from another MICA2. A distance of at least 2 feet should be maintained between MICA2 units to avoid local oscillator interference.

2.2.2 Antennas

Antenna lengths for three frequencies are provided **Table 2-3**. The antennas available from Crossbow are the 8060-0010-0# and 8060-0011-0# solder and connectorized antennas, respectively. See **Figures 2-4** and **2-5**.

Table 2-3. Antenna lengths for quarter wavelength whip antennas.

Model	Whip Antenna Length (inches)
MPR400 (916 MHz)	3.2
MPR410 (433 MHz)	6.8
MPR420 (315 MHz)	9.4

Antennas are also available from Linx Technologies, such as part number ANT-433-PW-QW for 433 MHz and ANT-916-PW-QW for 916 MHz. These antennas are terminated in a coax pigtail, and must have an MMCX connector installed. They also function best with a ground plane installed, as shown **Figure 2-3** below. The ground plane can be a layer of aluminum or copper tape attached to the lid of a plastic enclosure, or the lid of a metal enclosure.

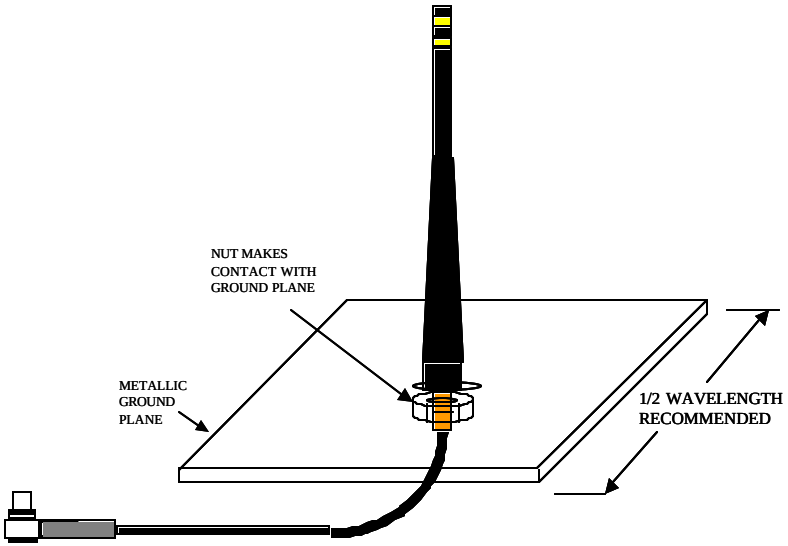


Figure 2-3. Illustration of an antenna option for the motes using a Linx antenna and ground plane

2.2.3 Connectors for the MICA2 and Whip Antennas

The MICA2 has an MMCX connector for attaching an external antenna. These mating connectors can be purchased from Digi-Key. There are two manufacturers—Johnson Components and Hirose Electric Ltd. The mating connectors come in straight and right angle. They also support two different standard varieties of Coaxial cable—RG178 /U and RG 316/U. There are also other vendors who sell MMCX to SMA conversion cables.

Table 2-4. Johnson Components' MMCX mating connectors.*

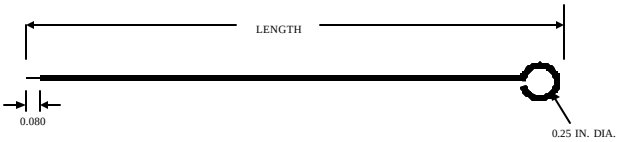
Type	Coax	Digi-Key PN	Johnson PN
Straight Plug	RG178/U	J589-ND	135-3402-001
Straight Plug	RG316/U	J590-ND	135-3403-001
Right Angle	RG178/U	J593-ND	135-3402-101
Right Angle	RG316/U	J594-ND	135-3403-101
Right Angle	RG 316 DS	J595-ND	135-3404-101

*These connectors require the following hand crimp and die set (Digi-Key part # / Johnson part #): a) Hand crimp (J572-ND / 140-0000-952), b) Die (JD604-ND / 140-0000-953).

Table 2-5. Hirose MMCX connectors

Type	Coax	Digi-Key PN	Hirose PN
Straight Plug	RG178/U	H3224-ND	MMCX-J-178B/U
Right Angle	RG178/U	H3221-ND	MMCX-LP-178B/U
Right Angle	RG316/U	H3222-ND	MMCX-LP-316/U

DATE	BY	DESCRIPTION	ECO
5/13/03	M. GRIMMER	REV A-MICA ANTENNA NEW RELEASE	0432
6/30/03	M. GRIMMER	REV B- ADDED 315 MHZ ANTENNA	0521



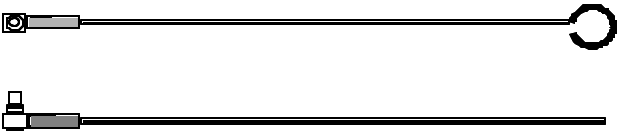
WIRE IS SOLID CONDUCTOR 20 AWG WITH BLACK INSULATION

LENGTH	FREQUENCY	MODEL	PART NUMBER
3.20 inches	915 MHz	MPR400/MPR500	8060-0010-01
6.80 inches	433 MHz	MPR410/MPR510	8060-0010-02
9.35 inches	315 MHz	MPR420/MPR520	8060-0010-03

DATE	BY	CROSSBOW TECHNOLOGY	
		DWG 8060-0010	REV B
5/13/03	M. GRIMMER	MICA ANTENNA ASSY	
		5/13/03	PAGE 1 OF 1

Figure 2-4. Wire antenna w/o MMCX connector. Part nos. 8060-0010-0X

DATE	BY	DESCRIPTION	ECO
5/13/03	M. GRIMMER	REV AMICA ANTENNA NEW RELEASE	0432
6/24/03	M. GRIMMER	REV BMODIFIED SHRINK TUBE LENGTH	0393
6/30/03	M. GRIMMER	REV CADDED 315 MHZ ANTENNA	0521



LENGTH	FREQUENCY	MODEL	PART NUMBER
3.20 inches	915 MHz	MPR400	8060-0011-01
6.80 inches	433 MHz	MPR410	8060-0011-02
9.35 inches	315 MHz	MPR420	8060-0011-03

DATE	BY	CROSSBOW TECHNOLOGY	
		DWG 8060-0011	REV C
5/13/03	M. GRIMMER	MICA ANTENNA ASSY	
		5/13/03	PAGE 5 OF 5

Figure 2-5. Wire antenna with MMCX connector. Part nos. 8060-0011-0X

2.3 Data Logger and Other Features

The MICA2 mote features a 4-Mbit serial flash for storing data, measurements, and other user-defined information. TinyOS supports a micro file system that runs on top of this flash/data logger component. The serial flash device supports over 100,000 measurement readings. Also on the MICA2 is a 64-bit serial ID chip.

NOTE: This device consumes 15 mA of current when writing data.

2.4 Battery Voltage Monitor

The MICA2 has an accurate voltage reference that can be used to measure battery voltage (V_{batt}). Since the eight-channel, Atmega128 ADC uses the battery voltage as a full scale reference, the ADC full scale voltage value changes as the battery voltage changes. In order to calibrate the battery voltage a precision external voltage reference is required. The MICA2 uses an LM4041, 1.223 volt reference (V_{ref}) attached to ADC channel 7.

NOTE: ADC channel 7 is also used for JTAG debugging on the Atmega128 processor. MICA2s and MICA2DOTs ship with the JTAG fuse enabled. When this fuse is enabled the input impedance of channel 7 is lowered which affects the voltage reference measurement. The fuse should be disabled if ADC channel 7 is used. See below for information on setting Atmega128 fuses.

To compute the battery voltage:

1. Set the BAT_MON processor pin (PA5/AD5) high.
2. Program the application code to measure ADC channel 7.
3. Compute battery voltage, V_{batt}, from channel 7's data by:

   $$V_{batt} = V_{ref} \times ADC\_FS / ADC\_Count$$

   where:

   V_{batt} = Battery voltage

   ADC_FS = 1024

   V_{ref} = External voltage reference = 1.223 volts

   ADC_Count = Data from the ADC measurement of channel 7

2.5 Atmega128 Fuses

The Atmega128 processor on the MICA2 has many programmable fuses to control various parameters. Refer to Atmel's technical information for the Atmega128 for a complete discussion of the fuses

(http://www.atmel.com/dyn/resources/prod_documents/2467s.pdf). There are two fuses that TOS users should be aware of as setting these fuses incorrectly will cause the unit to not operate correctly.

2.5.1 Atmega103 compatibility mode fuse

This fuse put the Atmega128 in the Atmega103 compatible mode. This fuse was set for the older generation MICA units. It must be disabled for MICA2 and MICA2DOTs.

2.5.2 JTAG fuse

This fuse enables users to use the Atmel JTAG pod for in-circuit code debugging. Units are shipped with JTAG enabled. As discussed in the previous section on battery voltage monitoring, if JTAG is enabled, it will cause inaccurate measurements on ADC channel 7.

2.5.3 Using UISP to set fuses

The UISP utility used to download code to the MICA2 on a programming board can also be used to set and unset fuses of the Atmel® ATMega128.

Table 2-6. UISP Commands for Setting the ATMega128's Fuses

Action	Command
Disable JTAG fuse	`uisp -dprog=<programmer>* --wr_fuse_h=0xD9`
Enable JTAG fuse	`uisp -dprog=<programmer> --wr_fuse_h=0x19`
Enable native 128 mode	`uisp -dprog=<programmer> --wr_fuse_e=ff`

* **<programmer>** is the device you are using to interface to the mote from a computer. The current options are **dapa** (for an MIB500), **dev/ttyS<#>** for an MIB510 (**<#>** = **0** for COM1, **1** for COM1, **2** for COM3, etc.), and **AVRSP** for an AVRSP and EPRB for an EPRB.

Users can also edit the filed called `profile` in the `cygwin/etc` directory and enter an alias. One example is this alias to disable the JTAG fuse:

```
alias fuse_dis="uisp -dprog=<programmer> --wr_fuse_h=0xD9"
```

When `fuse_dis` is typed from a Cygwin command line, the script will be executed.

2.6 Sensor Boards

Crossbow supplies a variety of sensor boards for the MICA2s. Information for customized sensor board design is available on the Crossbow web site.

2.7 Expansion Connector

The expansion connector provides a user interface for additional sensor boards. The connector includes interfaces for power and ground, power control of peripheral sensors, ADC inputs for reading sensor outputs, a UART interface, and I2C interface, general-purpose digital IO, and others.

Table 2-7. MICA2 Sensor Interface

Pin	Name	Description	Pin	Name	Description
1	GND	Ground	27†	UART_RXDO	Uart Receive
2	VSNR	Voltage (battery	28†	UART_TXDO	Uart Transmit
3	INT3	GPIO	29	PWO	GPIO/PWM
4	INT2	GPIO	30	PW1	GPIO/PWM
5	INT1	GPIO	31	PW2	GPIO/PWM
6	INT0	GPIO	32	PW3	GPIO/PWM
7†	BAT_MON	Battery Voltage Monitor	33	PW4	GPIO/PWM
8†	LED3	Green LED	34	PW5	GPIO/PWM
9†	LED2	Yellow LED	35	PW6	GPIO/PWM
10†	LED1	Red LED	36†	ADC7	GPIO/ADC CH7, JTAG
11	RD	GPIO	37†	ADC6	GPIO/ADC CH6, JTAG
12	WR	GPIO	38†	ADC5	GPIO/ACD CH5, JTAG
13	ALE	GPIO	39†	ADC4	GPIO/ADC CH4, JTAG
14	PW7	GPIO	40	ADC3	GPIO/ADC CH3
15	USART_CLK	Usart Clock	41	ADC2	GPIO/ADC CH2
16††	PROG_MOSI	Programmer Pin	42	ADC1	GPIO/ADC CH1
17††	PROG_MISO	Programmer Pin	43	ADC0	GPIO/ADC CH0
18††	SPI_CLK	Radio Clock	44	THERM_PWR	GPIO
19	USART1_RXD	Usart1 Receive	45	THRU1	Thru User Connect
20	USART1_TXD	Usart1 Transmit	46	THRU2	Thru User Connect
21	I2C_CLK	I2C Bus Clock	47	THRU3	Thru User Connect
22	I2C_DATA	I2C Bus Clock	48††	RSTN	Micro Processor Reset
23	PWMIO	GPIO	49	PWM1B	GPIO
24	PWMIA	GPIO	50	VCC	Voltage (battery)
25	AC+	GPIO	51	GND	Ground
26	AC-	GPIO			

†OK to use but has shared functionality
††Do NOT use.

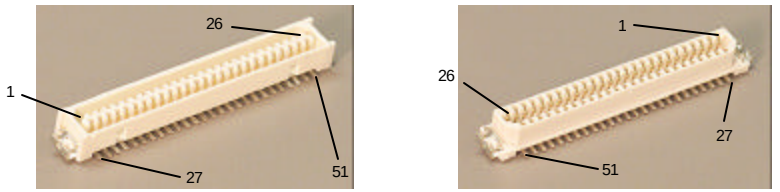


Figure 2-0-1. Hirose DF-9(S on left; P on right)-1V(54)

3 MPR500/MPR510/MPR520 (MICA2DOT)

3.1 Powering the Mote

The MPR500 (916 MHz), MPR510 (433 MHz), and MPR520 (315 MHz) are battery powered. The form factor of the MPR500 was designed to match up with a single coin cell battery; however any battery combination (AAA, C, D, etc., cells) can be used provided that the output is between 2.7–3.3VDC.

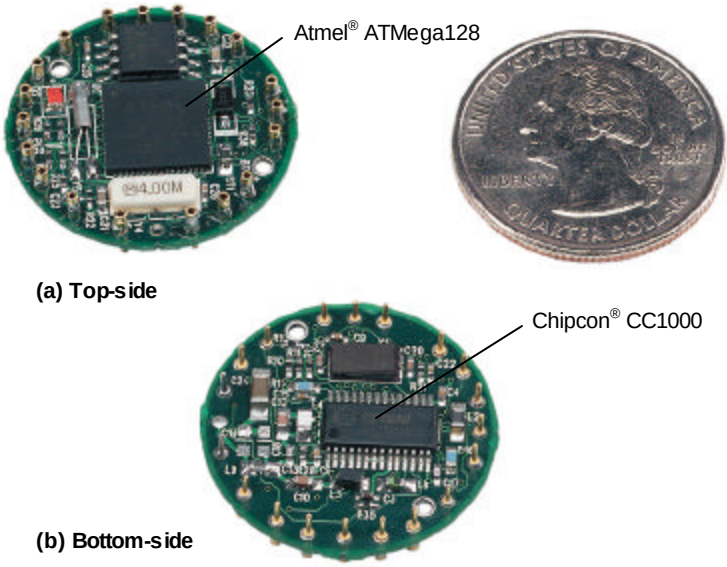


Figure 3-1. Photos of the MICA2DOT shown next to a US quarter: a) Top-side and b) Bottom-side. Typically the MICA2DOT has a 3V coin-cell battery holder attached to the bottom-side, but it has been removed to show the details.

Care should be used in selecting the battery and its capacity to match the energy needs of the motes and their deployment mission. Also make sure that the temperature range and associated capacity degradation are looked at prior to deployment. The section below provides some useful guidance on how to predict battery life. The spreadsheet can be found at http://www.xbow.comunder the Support section.

3.2 Radio/Antenna Considerations

Care should be taken to provide an antenna that provides proper coverage for the environment expected. Range and performance are strongly affected by choice of antenna and antenna placement within the environment. In

addition, care must be taken to ensure compliance with FCC article 15 regulations for intentional radiators. Because of its small physical size, the usual antenna chosen is a length of insulated wire one-quarter wavelength long for the frequency of interest (˜ 3.2 inches at 915 MHz, ˜ 6.8 inches at 433 MHz, and ˜ 9.4 inches at 315 MHz). (For information about the number of channels for each type of MICA2DOT, please refer to Section 2.2.

Table 3-1. Antenna lengths for quarter wavelength whip antennas

Model	Whip Antenna Length (inches)
MPR500 (916 MHz)	3.2
MPR510 (433 MHz)	6.8
MPR520 (315 MHz)	9.4

3.3 Data Logger

The MICA2DOT mote features a 4-Mbit serial flash (non-volatile) memory for storing data, measurements, and other user-defined information. TinyOS supports a micro file system that runs on top of this flash/data logger component. The serial flash device supports over 100,000 measurement readings.

NOTE: This device consumes 15 mA of current when writing data.

3.4 Battery Voltage Monitor

Unlike the MICA2, the MICA2DOT uses a Schottky reference diode as a voltage reference that can be used to measure battery voltage (V_{batt}). Since the eight-channel, Atmega128 ADC uses the battery voltage as a full-scale reference, the ADC full scale voltage value changes as the battery voltage changes. In order to calibrate the battery voltage an external voltage reference (V_{ref}) is required.

To compute the battery voltage:

1. Set processor pins PW7 (PC7/A15) to LO and PW5 (PC5/A13) to HI.
2. Program the application code to measure ADC channel 1 (ADC1).
3. Compute battery voltage, V_{batt}, from channel 1's data by:

   $$V_{batt} = V_{ref} \times ADC\_FS / ADC\_Count$$

   where:

   V_{batt} = Battery voltage

   ADC_FS = 1024

V_{ref} = External voltage reference = 0.6 volts

ADC_Count = Data from the ADC measurement of channel 1

3.5 Atmega128 Fuses

Refer to the Atmega128 fuse section for the MICA2 product.

3.6 On-board Thermistor

The MICA2DOT has an on board thermistor (Panasonic ERT-J1VR103J) which is a surface mount component. It is one the ATmega side of the board at the location labeled "RT1." Its output is at ADC1 and is enabled by setting PW6 (PC6/A14) to LO and PW7 (PC7/A15) to HI.

The mote's ADC output can be converted to degrees Kelvin using the following approximation over 0–50 degrees Celsius:
$1/T(K) = a + b \times \ln(R_{thr}) + c \times [\ln(R_{thr})]^3$

where:

$R_{thr} = R1 \times ADC/(ADC\_FS - ADC)$

a = 0.00130705

b = 0.000214381

c = 0.000000093

R1 = 10 k?

ADC_FS = 1023

ADC = output value from mote's ADC measurement.

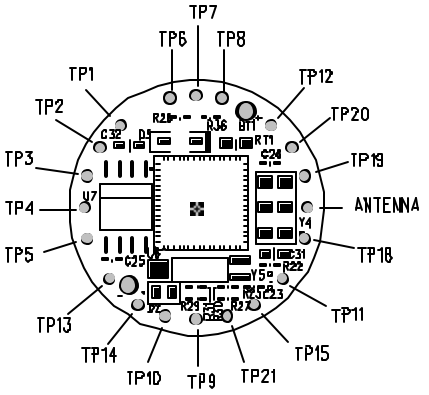
3.7 Sensor Boards

Crossbow has a customizable, sensor prototyping board called the MDA500CA for the MICA2DOT. Information for customized sensor board design is available on the Crossbow web site.

3.8 Expansion Connector

The interface to the MPR500 is through a series of 19 pins spaced around the circumference of the MPR500. They represent a subset of the pins available on the MPR400. They include a set of power control pins, ADC channels, power, ground, some general purpose digital IO, and the serial programming port. For applications with more digital IO, the ADC pins can be reconfigured as digital input/output but **not** both.

WARNING: The TP12 SPI_CK Pin is controlled by the Radio. In the majority of applications it should not be used. It is also used for programming the processor.



Pin	Name	Description
TP1	GND	Ground
TP2	ADC7	ADC Channel 7
TP3	ADC6	ADC Channel 6
TP4	ADC5	ADC Channel 5
TP5	ADC4	ADC Channel 5
TP6	VCC	Voltage (battery)
TP7	PW1	GPIO/PWM
TP8	PW0	GPIO/PWM
TP9	UART_TXD	UART Transmit
TP10	UART_RXD	UART Receive
TP11	RESETN	µProcessor Reset
TP12	SPI_CLK	Radio Clock
TP13	ADC3	ADC Channel 3
TP14	ADC2	ADC Channel 2
TP15	PWM1B	GPIO
TP18	GND	Ground
TP19	INT0	GPIO
TP20	INT1	GPIO
TP21	THERM_PWR	GPIO

Figure 3-2. MICA2DOT Pin Diagram and Sensor Interface Description

4 MPR300/MPR310 (MICA)

4.1 Powering the mote

The MPR300/MPR310 is battery powered. The form factor of the MPR300 was designed to match up with two AA batteries; however any battery combination (AAA, C, D, etc., cells) can be used provided that the output is between 2.7–3.3VDC.

Care should be used in selecting the battery and its capacity to match the energy needs of the motes and their deployment mission. Also make sure that the temperature range and associated capacity degradation are looked at prior to deployment. The section below provides some useful guidance on how to predict battery life. The spreadsheet can be found at http://www.xbow.comunder the Support section.

4.2 Radio/Antennae

Care should be taken to provide an antenna that provides proper coverage for the environment expected. Range and performance are strongly affected by choice of antenna and antenna placement within the environment. In addition, care must be taken to ensure compliance with FCC article 15 regulations for intentional radiators. Because of its small physical size, the usual antenna chosen is a length of insulated wire one-quarter wavelength long for the frequency of interest (~3.5 inches at 915 MHz, and ~8 inches at 433 MHz).

4.3 Data Logger

The MICA mote features a 4-Mbit serial flash (non-volatile) memory for storing data, measurements, and other user-defined information. TinyOS supports a micro file system that runs on top of this flash/data logger component. The serial flash device supports over 100,000 measurement readings. Also on the MICA is a 64-bit serial ID chip.

NOTE: This device consumes 15 mA of current when writing data.

4.4 Expansion Connector

The expansion connector provides a user interface for additional sensor boards. The connector includes interfaces for power and ground, power control of peripheral sensors, ADC inputs for reading sensor outputs, a UART interface, and I2C interface, general purpose digital IO, and others.

PIN	DESCRIPTION	PIN	DESCRIPTION
1	GND	27	UART_RXD0
2	VDD_ANALOG	28	UART_TXD0
3	INT3	29	PW0
4	INT2	30	PW1
5	INT1	31	PW2
6	INT0	32	PW3
7	DC_BOOST_SHDN	33	PW4
8	LED3	34	PW5
9	LED2	35	PW6
10	LED1	36	ADC7
11	RD	37	ADC6
12	WR	38	ADC5
13	ALE	39	ADC4
14	PW7	40	ADC3
15	FLASH_CLK	41	ADC2
16	UART_RXD0	42	ADC1
17	UART_TXD0	43	ADC0
18	SPI_CLK	44	LITTLE_GUY_RST
19	FLASH_SO	45	LITTLE_GUY_SPI_CLK
20	FLASH_SI	46	LITTLE_GUY_MISO
21	I2C_BUS1_CLK	47	UART_RXD0
22	I2C_BUS1_DATA	48	RESET
23	PWM0	49	PWM1B
24	PWM1A	50	VCC
25	AC+	51	GND
26	AC-		

4.5 Schematic

Schematics for this mote design are found at:

http://today.cs.berkeley.edu/tos/hardware/hardware.html

5 MIB300 / MIB500 Interface Boards

WARNING: When programming a MICA2 with the MIB500, turn off the battery switch. For a MICA2DOT, remove the battery before inserting into the MIB500. The MICA2s and MICA2DOTs do not have switching diodes to switch between external and battery power.

5.1 Programming the mote

The MIB300/MIB500 interface boards are multi-purpose interface boards used in conjunction with the MICA Family of products. They supply power to the devices through an external power adapter option, and provide interfaces for an RS232 serial port and reprogramming port (using the parallel printer interface). The MIB300 can only be used with an external 3 VDC supply, or it can take advantage of the battery power supplied from the mote.

The MIB500 has an on-board regulator that will **accept 5 to 7 VDC**, and supplies a regulated 3 VDC to the MICA The MIB500 is delivered with a wall power supply. It also has a monitor LEDs that mirror the LEDs on the MICA.

There is a built-in low voltage monitor that disables reprogramming if the power supply voltage is dangerously low. When the proper programming voltage exists—the Green LED adjacent the parallel port is lit—D6. If the voltage goes below 2.95V, the Green LED D6 will turn off, programming is disabled.

The MIB500 also has an interface connector for reprogramming the MICA2DOT. Programming the mote is accomplished by connecting the MIB300/MIB500 to the parallel port of the computer, and executing the required programming software—UISP—supplied with the TinyOS install.

NOTE: There have been numerous reported difficulties with programming motes through the MIB500CA. These include program failure, flash verification errors, and dead motes. The root cause of these problems is almost always one of two issues: 1) low programming voltage or 2) UISP problems on the Host PC. A detailed application note is posted at http://www.xbow.com under Support. Please review this application note, if you have trouble programming. Programming the motes improperly or with a bad UISP install can result in permanent damage to the mote CPU.

5.2 RS-232 Interface

The RS-232 interface is a standard single channel bi-directional interface with a DB9 connector to interface to an external computer. It uses transmit and receive lines only.

6 MIB510 Serial Interface Boards

NOTE: The MIB510 will only work with Atmega128 processors used on the MIC2 and MICA2DOT. It will work for older mica units that have the Atmega128 processor but not earlier processors such as the Atmega103.

6.1 Programming the mote

The MIB510 interface board is a multi-purpose interface board used with the MICA2 and MICA2DOT family of products. It supplies power to the devices through an external power adapter option, and provides an interface for a RS-232 mote serial port and reprogramming port.

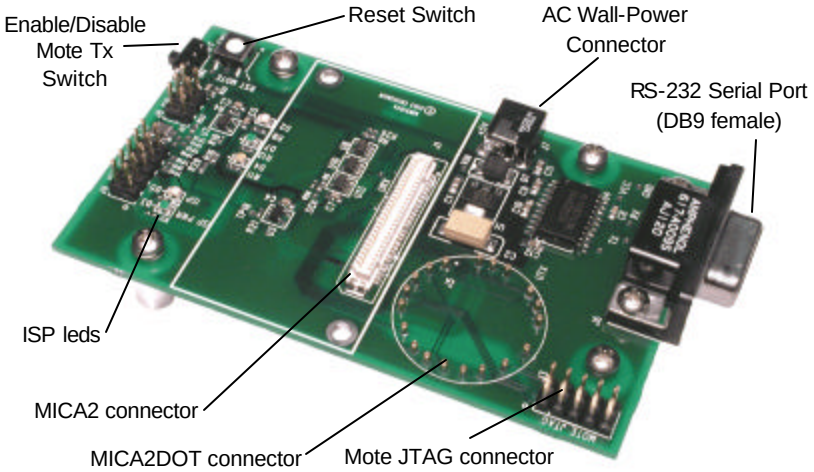


Fig 6.1 Photo of top view of an MIB510CA

6.2 ISP

The MIB510 has an on-board in-system processor (ISP) to program the motes. Code is downloaded to the ISP, over the serial port, and the ISP programs the code into the mote. The ISP and mote share the same serial port. The ISP runs at a fixed baud rate of 115 kbaud. The ISP continually monitors incoming serial packets for a special multi-byte pattern. Once this pattern is detected it disables the mote's serial Rx and Tx, then takes control of the serial port.

WARNING: Some USB to DB9 serial port adapters cannot run at 115 kbaud.

The ISP processor has two LEDs, 'SP PWR' (green) and ISP (red). SP PWR is used to indicate the power state of the MIB510 (see below). If the ISP led is on, the MIB510 has control of the serial port. It will blink when the RESET button is activated.

6.3 Device programming using MIB510

To program motes with MIB510 you precede all downloading commands with **`MIB510=/dev/<port>`** where **`<port>`** is the name of the serial port where the device is attached. (If using a USB to DB9 serial port converter, you need to know which COM number it assigned to the converter device.)

For example:

```
$ MIB510=/dev/ttyS0 make (re)install <hardware>
```

assuming the serial port you're using is COM1. Otherwise it is **`ttyS1`** for COM2, **`ttyS2`** for COM3, **`ttyS3`** for COM4, etc. Using the standard commands (e.g. **`make mica install`**) will default to the MIB500 programmer board. **`<hardware>`** will either be **`mica2`** or **`mica2dot`**.

To save keystrokes during programming, you can create (or edit) a `Makelocal` file in your `apps` directory. To make the MIB510 the default programmer, add the following line in `Makelocal`.

```
MIB510=/dev/ttyS<#>
```

Again the "<#>" refers to the number your computer assigned to the standard COM port or the assigned port number for users of a USB to DB9 serial port converter. Please refer to http://www.tinyos.net/tinyos-1.x/doc/tutorial/buildenv.html for more details on creating and editing a `Makelocal` file.

WARNING: Under cygwin the ISP may not get control of the serial port if the mote is continually sending packets over the serial Tx line at a high rate. If this happens uisp will hang. This can be fixed by:

1. Type Cntrl C and try again.
2. Turn SW2 to the 'on' position. This will disable the mote's Tx line. Be sure to set SW2 to 'off' after programming the mote if you are using the mote as a base station (ex: GenericBase).

6.4 MICA2 and MICA2DOT connectors

The MIB510 has connectors for both the MICA2 and MICA2DOT. See the picture below. For the MICA2 there is another connector on the bottom side

of the MIB510 for sensor boards. MICA2DOTs with battery connectors can be mounted, also, to the bottom side of the board.

6.4.1 Reset

The RST MOTE switch resets both the ISP and mote processors. RST resets the ISP; after the ISP powers-up it resets the mote's processor.

6.4.2 JTAG

The MIB510 has a connector, J3 (MOTE JTAG) which connects to an Atmel JTAG pod for in-circuit debugging. This connector will supply power to the JTAG pod; no external power supply is required for the pod.

WARNING: The MIB510 also has JTAG and ISP connectors for the ISP processor. These are for factory use only.

6.4.3 Power

The MIB510 has an on-board regulator that will accept 5 to 7 VDC, and supply a regulated 3V to the MICA. The MIB510 is delivered with a wall power supply.

WARNING: Applying more than 7 VDC will damage the onboard linear regulator.

There is a built-in low voltage monitor that disables reprogramming if the power supply voltage is dangerously low. When the proper programming voltage exists the ISP PWR led is on. If the voltage goes below 2.9 V, the ISP PWR led will blink and disable the mote from any code downloads. If the voltage is too low to power the ISP then the ISP PWR led will be off.

WARNING: When programming a MICA2 with the MIB510, turn off the battery switch. For a MICA2DOT, remove the battery before inserting into the MIB510. The MICA2s and MICA2DOTs do not have switching diodes to switch between external and battery power.

6.4.4 RS-232 Interface

The RS-232 interface is a standard single channel bi-directional interface with a DB9 connector to interface to an external computer. It uses the transmit and receive lines only.

7 MIB600CA

7.1 Introduction

The MIB600CA provides Ethernet (10/100 Base-T) connectivity to MICA2 family motes for communication and in-system programming. Its two standard configurations are a) an Ethernet Gateway for a mote network and b) a mote network programming and out-band diagnostic channel.

The MIB600CA device contains, on a 4.5" × 2.25" platform a

- MICA2 mote 54-pin connector (J1),
- Mote umbilical connector (J11),
- Mote target JTAG port (J12),
- TCP/IP serial server,
- In-system programmer compatible with UISP STK500,
- On-board power regulation and monitor, and a
- Power Over Ethernet (POE) power supply

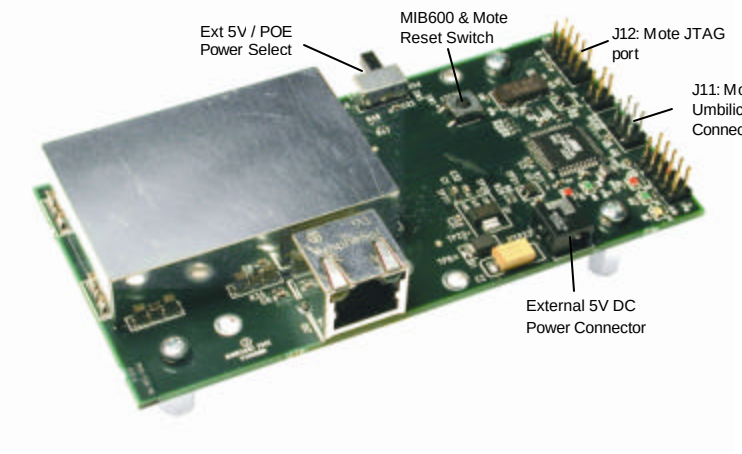


Figure 7-1. Photo of top side of an MIB600CA.

7.1.1 Mote Network – Ethernet Gateway

A MICA2 mote running TOSBase or GenericBase is permanently installed on the MIB600. This forms a mote RF to Ethernet bridge.

7.1.2 Mote Network Programming and Out-Band Diagnostic Channel

MICA2 connect to the MIB600 for UISP programming from LAN connected host computers. Out band (non-RF) diagnostics can be forwarded from the mote via its UART port over the LAN to host monitor/control computers.

7.2 Setup / Installation

This section describes MIB600 installation and configuration for use in a TinyOS v1.1 environment.

7.2.1 Physical

For other than temporary installations, the MIB600 should be installed in a ground isolated enclosure.

7.2.2 MICA Mote Connection

MICA and MICA2 motes connect to the MIB600 directly via the standard mote 51-pin HIROSE connector at J1. Two mounting holes are provided for securing the MICA2 mote when installed at J1. It is recommended that these mounting points be used to ensure a reliable mechanical and electrical connection to the MIB600.

7.2.3 Power

Two power supply sources are available with the MIB600

- External 5VDC from AC wall-power adaptor
- Power Over Ethernet

External 5VDC Power Supply

- Connect the external 5VDC power supply to an AC 110-240V power source.
- Place the MIB600 SW2 in the POE position
- Connect the DC plug to J7 of the MIB600

NOTE Turn-on the MIB by placing the SW2 in the 5V position. Turn-off by placing the SW2 in the POE position.

Power Over Ethernet / IEEE802.3af (POE).

WARNING! The MOTE “ground” is at POE potential (-48V). DO NOT connect MIB600 to facility/building ground when using POE.

An IEEE 802.3af compliant power supply is provided for POE equipped facilities. Ethernet appliance power (-48 V) is supplied at pins 4/5 and 7/8 of the 10/100 Base-T RJ45 plug. Refer to Appendix A for Base-T wiring information.

The MIB600 POE circuit contains IEEE 802.13f compliant power sequencing and classification circuitry. Reversed and over-voltage protection is provided.

NOTE: The MIB600 only supports POE over "spare wires 4/5 & 7/8". It does NOT support POE shared on the Base-T signaling lines.

- Connect the MIB600 to a POE-equipped LAN port.
- Turn-On the MIB600 by placing the MIB600 SW2 in the POE position
- Turn-Off by placing SW2 in 5V position (with External 5VDC supply disconnected)

7.2.4 MIB600–LAN Connection

The MIB600 Serial Server connects directly to a 10 Base-T LAN as any other network device. Straight cables are used to connect to a hub or switch. If your connection is an MIB600 to PC you **must** use a crossed cable. Refer to Appendix A for LAN wiring information.

Table 7-1. Pin Outs for a LAN Connection

Pin No.	Strand Color	Name
1	white and orange	TX+
2	orange	TX-
3	white and green	RX+
4	blue	0V POE
5	White and blue	0V POE
6	green	RX-
7	Brown and white	-48V POE
8	Brown	-48V POE

7.3 Host Software

7.3.1 UISP

UISP version 20030820tinyos or newer is required. This version is included in the TinyOS 1.1.0 September 2003 release package. Verify your system is using a compatible UISP version by entering **`uisp --version`** in a Cygwin window (see the example below in Figure 7-2).

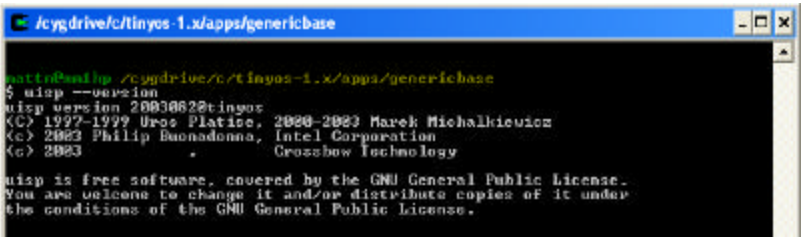


Figure 7-2. Screen shot of the output after typing in `uisp --version`.

7.4 MIB600 Use

7.4.1 Controls and Indicators

Power. MIB600 power (and power to attached mote) is controlled by the switch labeled "SW2."

WARNING! Always turn-off the MIB600's power before installing/removing a mote.

Table 7-3. SW2 Switch Settings

Position	Function
5V	External 5V DC power supply selected
POE	Power Over Ethernet supply selected

When valid power is detected, the green LED at D5 is ON.

LAN Activity Indicators (RJ45). Green indicates a network connection is present. Yellow indicates Active ISP serial port traffic is present.

RESET. Pressing the RESET pushbutton (SW1) causes the MIB600 and any installed/attached MOTE to reset. Note the Serial Server is NOT reset.

Serial Server RESET. Pressing the S1 switch on the server sub-module (U15) manually resets the Ethernet serial server.

NOTE The MIB600 and attached MOTE are NOT reset. The serial server can also be reset via Telnet at Port 9999.

ISP LED. During in-system programming of a mote the ISP LED (D3) is ON.

Mote LEDs. Three LEDs (red, green, yellow) correspond to the attached mote's indicators.

7.4.2 Mote UART (Serial Port)

The mote's serial port can be accessed via Telnet using Port# 10002.

Factory default serial rate on the Serial Server is 57.6 kbaud for compatibility with the standard TinyOS v1.1 release of TOSBase & GenericBase.

If other baud rates or communication parameters are used in your mote application, the serial server configuration must be changed.

7.4.3 In-System Programming

The MIB600 ISP micro-controller is attached to Port#10001. UISP assumes this port assignment by default.

UISP at the Cygwin command line is the standard TinyOS programming tool. The MIB600 compatible command switches

- **`-dprog=stk500`**
- **`-dhost=<IP address>`**
- **`-dpart=Atmega128`**

can be added to the `Makerules` file under …/tinyos/apps. The command line is

```
uisp –dprog=stk500 –dhost=<IP address or HostID> -
dpart=Atmega128 <standard uisp commands>
```

See **Figure 7-3** below as an example for downloading a compiled application into a MICA2 mote (in the example, `Genericbase` is being loaded). When the ISP is active the red LED at D3 on the MIB600 illuminates.

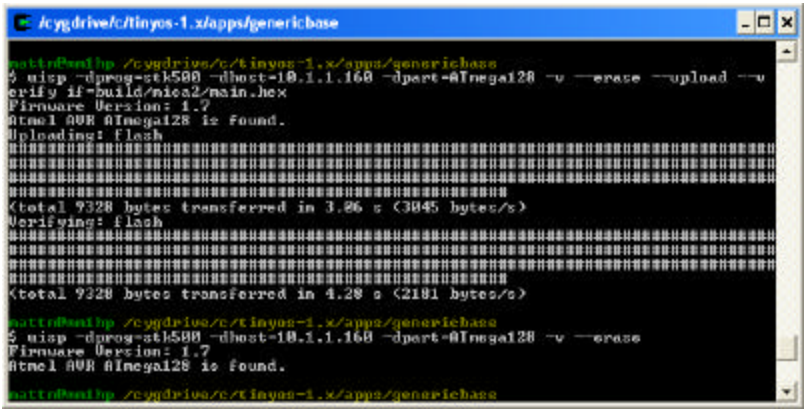


Figure 7-3. Screen shot of response from mote when programming.
Note that during in-system programming, Telenet port #10002 (the MICA2 UART port) may display garbage/extraneous characters.

The MICA2's Atmel® ATmega128 fuses

To poll the ATmega128 for its fuse settings, type in the command line (see result in Figure 7-4).

```
uisp –dprog=stk500 –dhost=<IP address or HostID>  –
dpart=ATmega128 –v –-rd_fuses
```

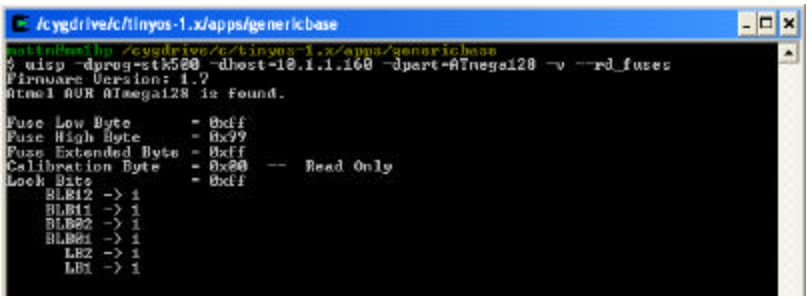


Figure 7-4. Screen shot of output when checking fuses of mote.

7.5 JTAG

JTAG connection to the attached MICA2 mote is via J12. Note PIN1 orientation (square pad) is indicated by the J12 legend. Power for the JTAG

pod is provided by the MIB600 at J12 pin 4. Please use the tables in this section as references when using the JTAG connection. Table 7-4 has information about the controls, indicators, and connector summary; Table 7-5 has information on the JT12 Mote JTAG pins.

Table 7-4. Controls, Indicators, and Connector Summary

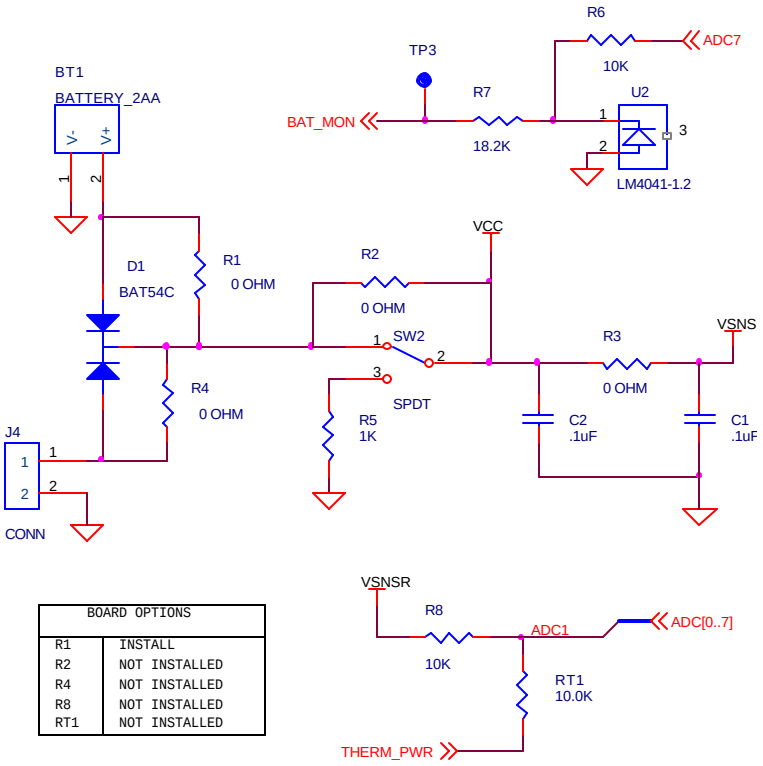
ID	NAME	DESCRIPTION
		CONTROLS
SW1	RESET	MIB600 Manual RESET pushbutton. Resets MIB600 ISP controller and attached MOTE.
SW2	POWER SELECT	
	5V	Selects External 5VDC power source at J7
	POE	Selects Power Over Ethernet provided at RJ45/J10
	Serial Server Reset	Reset Serial Server. Located on Server sub module U15
		CONNECTORS
J1	MOTE I/O 51	Standard 51 Position MICA mote interface
J7	External 5VDC Input	Connects to external 5VDC +/-20% power supply
J9	JTAG-ISP	JTAG connection to MIB600 ISP Controller. For Factory Test only
J10	RJ45 / LAN	Ethernet 10Base-T connection (w/ IEEE 802.3af option)
J11	MOTE Umbilical	Umbilical connection to mote Adapter PCB. Used for connection to MICA2 and MICA2DOT motes.
J12	JTAG-MOTE	JTAG connection to attached MICA2/MICA2DOT mote. Provides JTAG connectivity between external JTAG pod and mote.
	COM1	Factory use only. Do not use
		INDICATORS
D2	MOTE-YELLOW	Corresponds to attached mote's Yellow LED
D4	MOTE-RED	Corresponds to attached mote's Red LED
D7	MOTE-GREEN	Corresponds to attached mote's Green LED
D3	ISP Active	Indicates MIB600 in PROGRAMMING mode – RED
D5	Power OK	Indicated MIB600 input power is OK

Table 7-5. J12 Mote JTAG

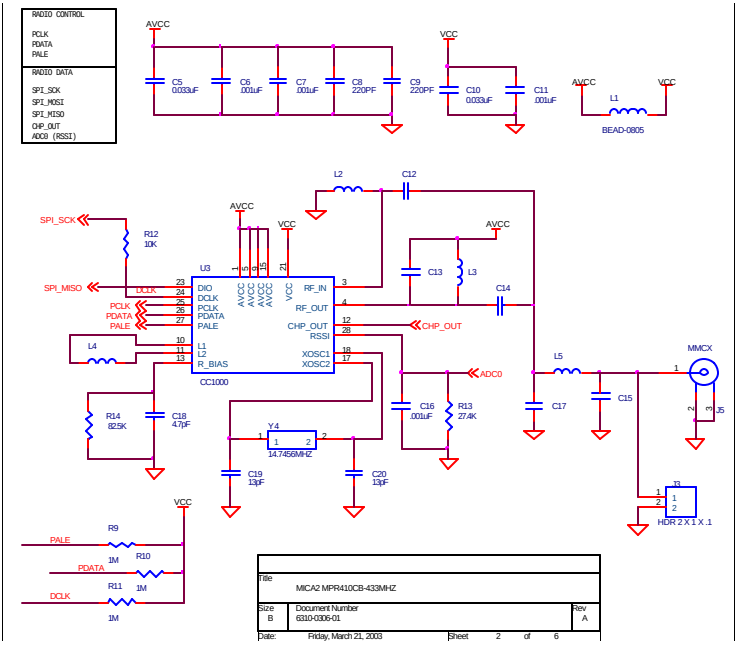
PIN	NAME	DESCRIPTION
1	TCK/ADC4	MICA2(DOT) JTAG Clock
2	GND	Ground
3	TDO	MICA2(DOT) JTAG Data Out
4	VCC	3.3V Power
5	TMS	MICA2 (DOT) JTAG Sync
6	RSTN	MICA2 (DOT) Reset
7	VCC	3.3V Power to JTAG Pod
8	N/C	Not connected
9	TDI	MICA2(DOT) JTAG Data In
10	GND	Ground

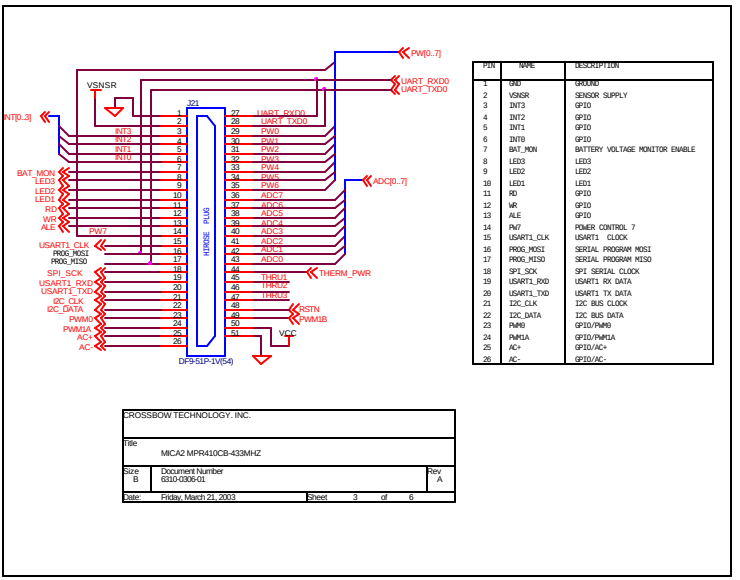
8 Schematics

8.1 MPR400/410/420, MICA2 Schematics



BOARD OPTIONS	
R1	INSTALL
R2	NOT INSTALLED
R4	NOT INSTALLED
R8	NOT INSTALLED
RT1	NOT INSTALLED


RADIO CONTROL
PCLK
PDATA
PALE
RADIO DATA
SPI_SCK
SPI_MOSI
SPI_MISO
CHP_OUT
ADC0 (RSSI)
AVCC
VCC
C5 0.033uF
C6 .001uF
C7 .001uF
C8 220PF
C9 220PF
C10 0.033uF
C11 .001uF
L1
BEAD-0805
L2
C12
R12 10K
U3
DIO
DCLK
PCLK
PDATA
PALE
RF_IN
RF_OUT
CHP_OUT
RSSI
XOSC1
XOSC2
R_BIAS
CC1000
C13
L3
C14
L4
L5
MMCX
J5
C15
C16 .001uF
R13 27.4K
C17
R14 825K
C18 47pF
Y4
14.7456MHZ
C19 18pF
C20 18pF
R9 1M
R10 1M
R11 1M
J3
HDR 2 X 1 X .1
MICA2 MPR410CB-433MHZ
Document Number 6310-0306-01
Rev A
Friday, March 21, 2003
Sheet 2 of 6


PW[0..7]
UART_RXD0
UART_TXD0
VSNSR
J21
ADC[0..7]
THERM_PWR
RSTN
PWM1B
VCC
DF9-51P-1V(54)
PIN NAME DESCRIPTION
1 GND GROUND
2 VSNSR SENSOR SUPPLY
3 INT3 GPIO
4 INT2 GPIO
5 INT1 GPIO
6 INT0 GPIO
7 BAT_MON BATTERY VOLTAGE MONITOR ENABLE
8 LED3 LED3
9 LED2 LED2
10 LED1 LED1
11 RD GPIO
12 WR GPIO
13 ALE GPIO
14 PW7 POWER CONTROL 7
15 USART1_CLK USART1 CLOCK
16 PROG_MOSI SERIAL PROGRAM MOSI
17 PROG_MISO SERIAL PROGRAM MISO
18 SPI_SCK SPI SERIAL CLOCK
19 USART1_RXD USART1 RX DATA
20 USART1_TXD USART1 TX DATA
21 I2C_CLK I2C BUS CLOCK
22 I2C_DATA I2C BUS DATA
23 PWM0 GPIO/PWM0
24 PWM1A GPIO/PWM1A
25 AC+ GPIO/AC+
26 AC- GPIO/AC-
CROSSBOW TECHNOLOGY, INC.
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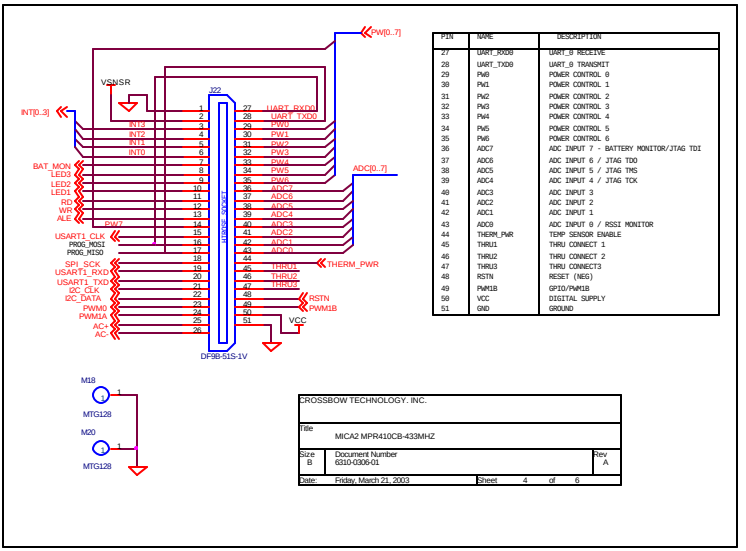
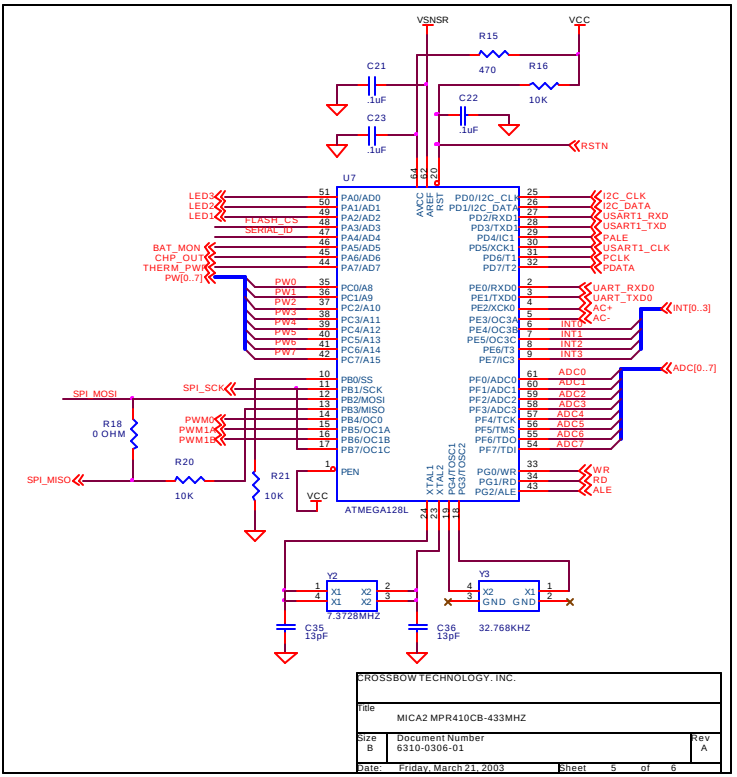


PIN	NAME	DESCRIPTION
27	UART_RXD0	UART_0 RECEIVE
28	UART_TXD0	UART_0 TRANSMIT
29	PW0	POWER CONTROL 0
30	PW1	POWER CONTROL 1
31	PW2	POWER CONTROL 2
32	PW3	POWER CONTROL 3
33	PW4	POWER CONTROL 4
34	PW5	POWER CONTROL 5
35	PW6	POWER CONTROL 6
36	ADC7	ADC INPUT 7 - BATTERY MONITOR/JTAG TDI
37	ADC6	ADC INPUT 6 / JTAG TDO
38	ADC5	ADC INPUT 5 / JTAG TMS
39	ADC4	ADC INPUT 4 / JTAG TCK
40	ADC3	ADC INPUT 3
41	ADC2	ADC INPUT 2
42	ADC1	ADC INPUT 1
43	ADC0	ADC INPUT 0 / RSSI MONITOR
44	THERM_PWR	TEMP SENSOR ENABLE
45	THRU1	THRU CONNECT 1
46	THRU2	THRU CONNECT 2
47	THRU3	THRU CONNECT3
48	RSTN	RESET (NES)
49	PWM1B	GPIO/PWM1B
50	VCC	DIGITAL SUPPLY
51	GND	GROUND

CROSSBOW TECHNOLOGY, INC.					
Title: MICA2 MPR410CB-433MHZ					
Size: B	Document Number: 6310-0306-01				Rev: A
Date: Friday, March 21, 2003		Sheet 4 of 6			


VSNSR
VCC
R15
470
R16
10K
C21
.1uF
C22
.1uF
C23
.1uF
RSTN
U7
LED3
LED2
LED1
FLASH_CS
SERIAL_IO
BAT_MON
CHP_OUT
THERM_PWR
PW[0..7]
PA0/AD0
PA1/AD1
PA2/AD2
PA3/AD3
PA4/AD4
PA5/AD5
PA6/AD6
PA7/AD7
AVCC
AGND
RST
PD0/I2C_CLK
PD1/I2C_DATA
PD2/RXD1
PD3/TXD1
PD4/IC1
PD5/XCK1
PD6/T1
PD7/T2
I2C_CLK
I2C_DATA
USART1_RXD
USART1_TXD
PALE
USART1_CLK
PCLK
PDATA
PC0/A8
PC1/A9
PC2/A10
PC3/A11
PC4/A12
PC5/A13
PC6/A14
PC7/A15
PE0/RXD0
PE1/TXD0
PE2/XCK0
PE3/OC3A
PE4/OC3B
PE5/OC3C
PE6/T3
PE7/IC3
UART_RXD0
UART_TXD0
AC+
AC-
INT0
INT1
INT2
INT3
INT[0..3]
ADC0
ADC1
ADC2
ADC3
ADC4
ADC5
ADC6
ADC7
ADC[0..7]
SPI_MOSI
SPI_SCK
SPI_MISO
PWM0
PWM1A
PWM1B
PB0/SS
PB1/SCK
PB2/MOSI
PB3/MISO
PB4/OC0
PB5/OC1A
PB6/OC1B
PB7/OC1C
PEN
PF0/ADC0
PF1/ADC1
PF2/ADC2
PF3/ADC3
PF4/TCK
PF5/TMS
PF6/TDO
PF7/TDI
PG0/WR
PG1/RD
PG2/ALE
WR
RD
ALE
XTAL1
XTAL2
PG4/TOSC1
PG3/TOSC2
R18
0 OHM
R20
10K
R21
10K
VCC
ATMEGA128L
Y2
7.3728MHZ
Y3
32.768KHZ
C35
13pF
C36
13pF
CROSSBOW TECHNOLOGY, INC.
Title
MICA2 MPR410CB-433MHZ
Size
B
Document Number
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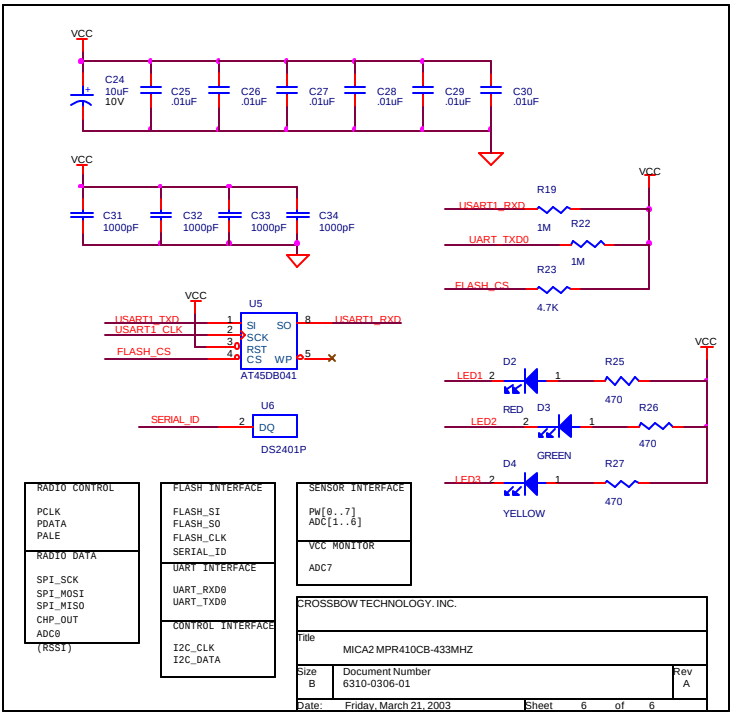
VCC
C24
10uF
10V
C25
.01uF
C26
.01uF
C27
.01uF
C28
.01uF
C29
.01uF
C30
.01uF
C31
1000pF
C32
1000pF
C33
1000pF
C34
1000pF
R19
1M
R22
1M
R23
4.7K
USART1_RXD
UART_TXD0
FLASH_CS
U5
USART1_TXD
USART1_CLK
FLASH_CS
SI
SCK
RST
CS
SO
WP
AT45DB041
U6
SERIAL_ID
DQ
DS2401P
D2
D3
D4
LED1
LED2
LED3
RED
GREEN
YELLOW
R25
R26
R27
470
RADIO CONTROL
PCLK
PDATA
PALE
RADIO DATA
SPI_SCK
SPI_MOSI
SPI_MISO
CHP_OUT
ADC0
(RSSI)
FLASH INTERFACE
FLASH_SI
FLASH_SO
FLASH_CLK
SERIAL_ID
UART INTERFACE
UART_RXD0
UART_TXD0
CONTROL INTERFACE
I2C_CLK
I2C_DATA
SENSOR INTERFACE
PW[0..7]
ADC[1..6]
VCC MONITOR
ADC7
CROSSBOW TECHNOLOGY, INC.
Title
MICA2 MPR410CB-433MHZ
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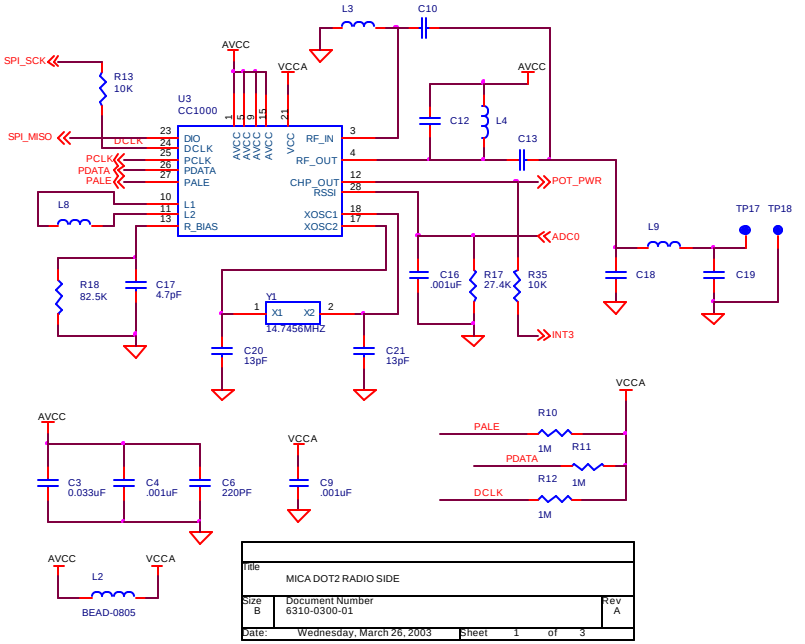
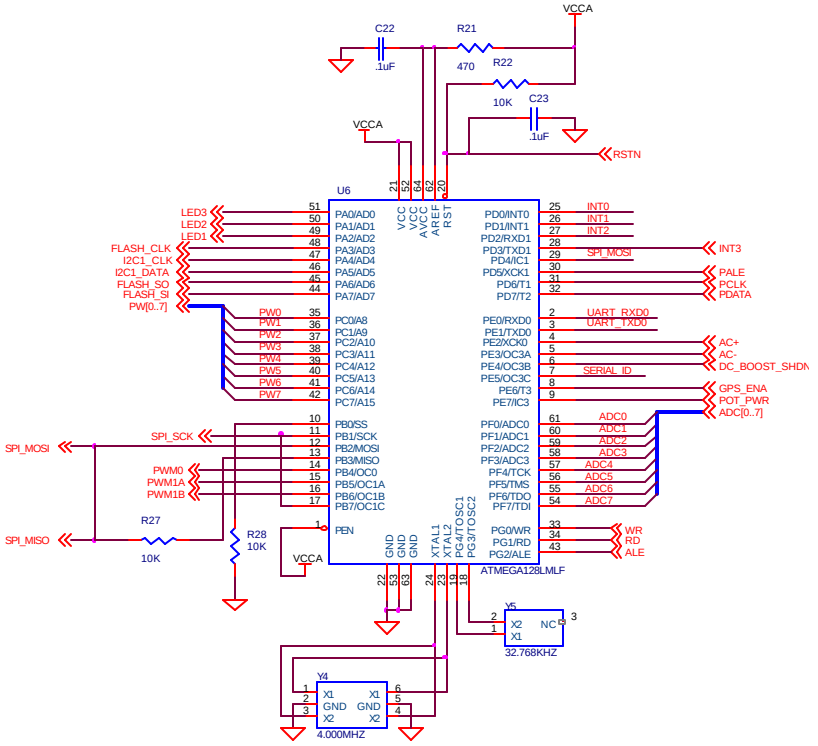
8.2 MPR500/510/520 MICA2DOT Schematics




VCCA
C22
.1uF
R21
470
R22
10K
C23
.1uF
VCCA
RSTN
U6
LED3
LED2
LED1
FLASH_CLK
I2C1_CLK
I2C1_DATA
FLASH_SO
FLASH_SI
PW[0..7]
PA0/AD0
PA1/AD1
PA2/AD2
PA3/AD3
PA4/AD4
PA5/AD5
PA6/AD6
PA7/AD7
PC0/A8
PC1/A9
PC2/A10
PC3/A11
PC4/A12
PC5/A13
PC6/A14
PC7/A15
PB0/SS
PB1/SCK
PB2/MOSI
PB3/MISO
PB4/OC0
PB5/OC1A
PB6/OC1B
PB7/OC1C
PEN
PD0/INT0
PD1/INT1
PD2/RXD1
PD3/TXD1
PD4/IC1
PD5/XCK1
PD6/T1
PD7/T2
PE0/RXD0
PE1/TXD0
PE2/XCK0
PE3/OC3A
PE4/OC3B
PE5/OC3C
PE6/T3
PE7/IC3
PF0/ADC0
PF1/ADC1
PF2/ADC2
PF3/ADC3
PF4/TCK
PF5/TMS
PF6/TDO
PF7/TDI
PG0/WR
PG1/RD
PG2/ALE
ATMEGA128LMLF
INT0
INT1
INT2
SPI_MOSI
INT3
PALE
PCLK
PDATA
UART_RXD0
UART_TXD0
AC+
AC-
DC_BOOST_SHDN
SERIAL_ID
GPS_ENA
POT_PWR
ADC[0..7]
SPI_SCK
SPI_MOSI
SPI_MISO
PWM0
PWM1A
PWM1B
R27
10K
R28
10K
VCCA
Y5
X2
X1
NC
32.768KHZ
Y4
X1
GND
X2
4.000MHZ
Title
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Size
B
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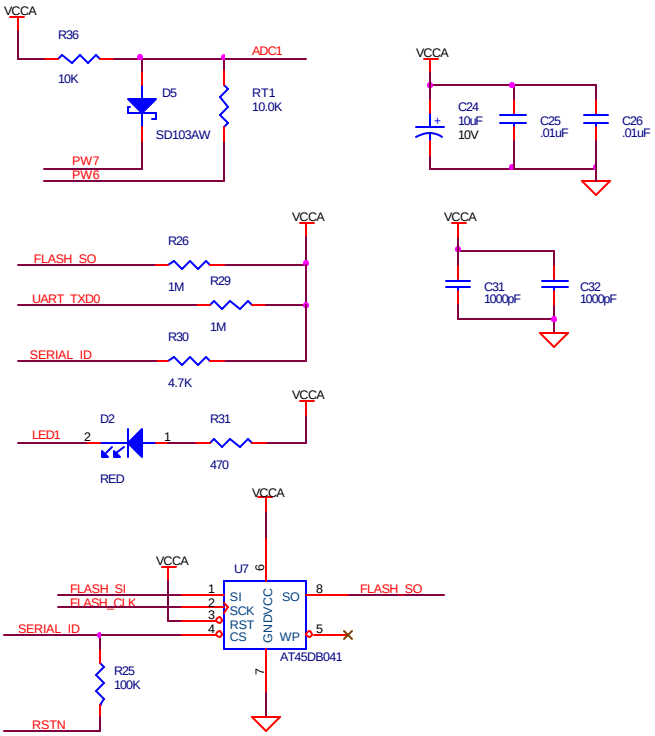

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Size: B	Document Number: 6310-0300-01	Rev: A
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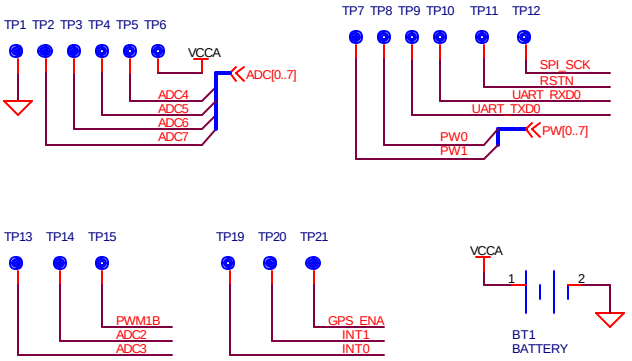
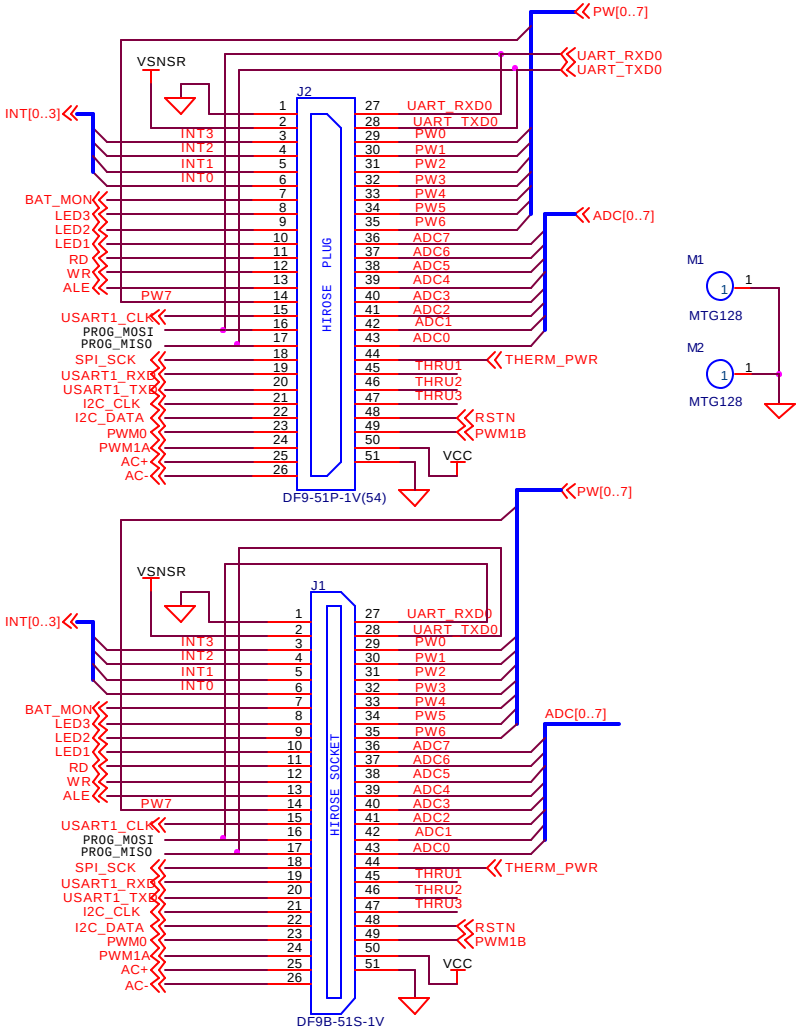
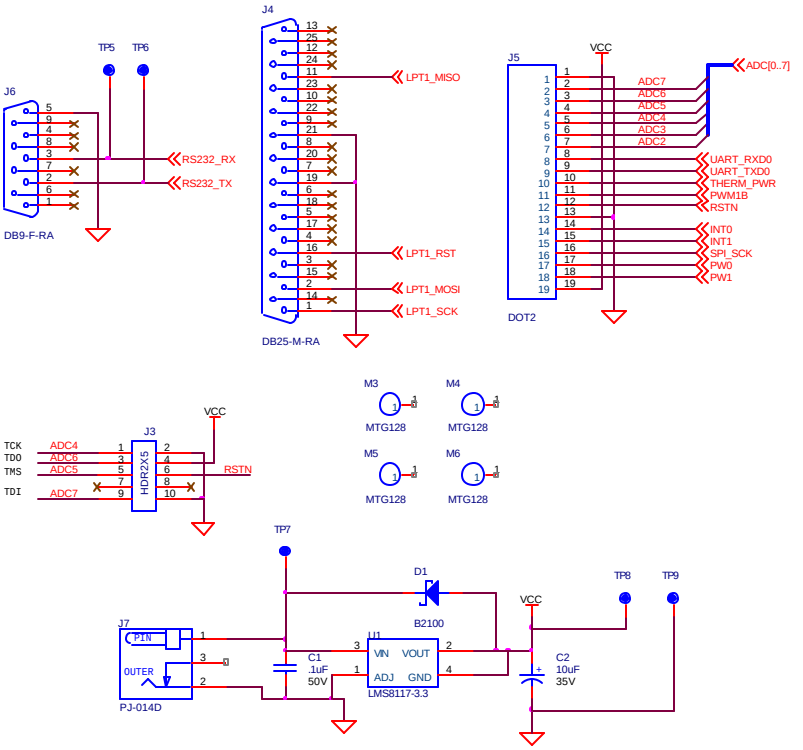

TP1 TP2 TP3 TP4 TP5 TP6
VCCA
ADC[0..7]
ADC4
ADC5
ADC6
ADC7
TP7 TP8 TP9 TP10 TP11 TP12
SPI_SCK
RSTN
UART_RXD0
UART_TXD0
PW[0..7]
PW0
PW1
TP13 TP14 TP15
PWM1B
ADC2
ADC3
TP19 TP20 TP21
GPS_ENA
INT1
INT0
VCCA
1
2
BT1
BATTERY

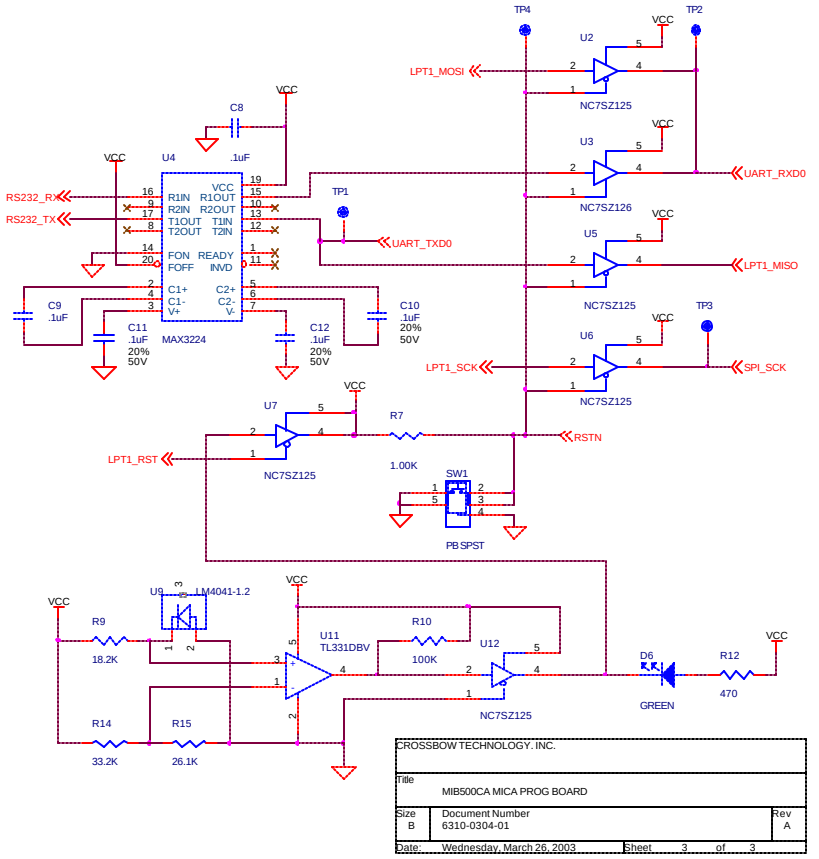
8.3 MIB500 Schematic



PIN	NAME	DESCRIPTION
1	GND	GROUND
2	VSNSR	SENSOR SUPPLY
3	INT3	GPIO
4	INT2	GPIO
5	INT1	GPIO
6	INT0	GPIO
7	BAT_MON	BATTERY VOLTAGE MONITOR ENABLE
8	LED3	LED3
9	LED2	LED2
10	LED1	LED1
11	RD	GPIO
12	WR	GPIO
13	ALE	GPIO
14	PW7	POWER CONTROL 7
15	USART1_CLK	USART1 CLOCK
16	PROG_MOSI	SERIAL PROGRAM MOSI
17	PROG_MISO	SERIAL PROGRAM MISO
18	SPI_SCK	SPI SERIAL CLOCK
19	USART1_RXD	USART1 RX DATA
20	USART1_TXD	USART1 TX DATA
21	I2C_CLK	I2C BUS CLOCK
22	I2C_DATA	I2C BUS DATA
23	PWM0	GPIO/PWM0
24	PWM1A	GPIO/PWM1A
25	AC+	GPIO/AC+
26	AC-	GPIO/AC-

PIN	NAME	DESCRIPTION
27	UART_RXD0	UART_0 RECEIVE
28	UART_TXD0	UART_0 TRANSMIT
29	PW0	POWER CONTROL 0
30	PW1	POWER CONTROL 1
31	PW2	POWER CONTROL 2
32	PW3	POWER CONTROL 3
33	PW4	POWER CONTROL 4
34	PW5	POWER CONTROL 5
35	PW6	POWER CONTROL 6
36	ADC7	ADC INPUT 7 - BATTERY MONITOR/JTAG TDI
37	ADC6	ADC INPUT 6 / JTAG TDO
38	ADC5	ADC INPUT 5 / JTAG TMS
39	ADC4	ADC INPUT 4 / JTAG TCK
40	ADC3	ADC INPUT 3
41	ADC2	ADC INPUT 2
42	ADC1	ADC INPUT 1
43	ADC0	ADC INPUT 0 / RSSI MONITOR
44	THERM_PWR	TEMP SENSOR ENABLE
45	THRU1	THRU CONNECT 1
46	THRU2	THRU CONNECT 2
47	THRU3	THRU CONNECT3
48	RSTN	RESET (NEG)
49	PWM1B	GPIO/PWM1B
50	VCC	DIGITAL SUPPLY
51	GND	GROUND


J4
TP5
TP6
J6
DB9-F-RA
RS232_RX
RS232_TX
LPT1_MISO
LPT1_RST
LPT1_MOSI
LPT1_SCK
DB25-M-RA
J5
VCC
ADC[0..7]
ADC7
ADC6
ADC5
ADC4
ADC3
ADC2
UART_RXD0
UART_TXD0
THERM_PWR
PWM1B
RSTN
INT0
INT1
SPI_SCK
PW0
PW1
DOT2
J3
HDR2X5
TCK
TDO
TMS
TDI
ADC4
ADC6
ADC5
ADC7
RSTN
M3
M4
M5
M6
MTG128
TP7
D1
B2100
TP8
TP9
J7
PIN
OUTER
PJ-014D
C1
.1uF
50V
U1
VIN
VOUT
ADJ
GND
LMS8117-3.3
C2
10uF
35V


TP4
TP2
VCC
U2
LPT1_MOSI
NC7SZ125
U3
UART_RXD0
NC7SZ126
U5
LPT1_MISO
NC7SZ125
TP3
U6
LPT1_SCK
SPI_SCK
NC7SZ125
C8
.1uF
U4
RS232_RX
RS232_TX
R1IN
R2IN
T1OUT
T2OUT
R1OUT
R2OUT
T1IN
T2IN
FON
FOFF
READY
INVD
C1+
C1-
V+
C2+
C2-
V-
MAX3224
C9
.1uF
C11
.1uF
20%
50V
C12
.1uF
20%
50V
C10
.1uF
20%
50V
TP1
UART_TXD0
U7
LPT1_RST
NC7SZ125
R7
1.00K
RSTN
SW1
PB SPST
U9
LM4041-1.2
R9
18.2K
R14
33.2K
R15
26.1K
U11
TL331DBV
R10
100K
U12
NC7SZ125
D6
GREEN
R12
470
CROSSBOW TECHNOLOGY, INC.
Title
MIB500CA MICA PROG BOARD
Size
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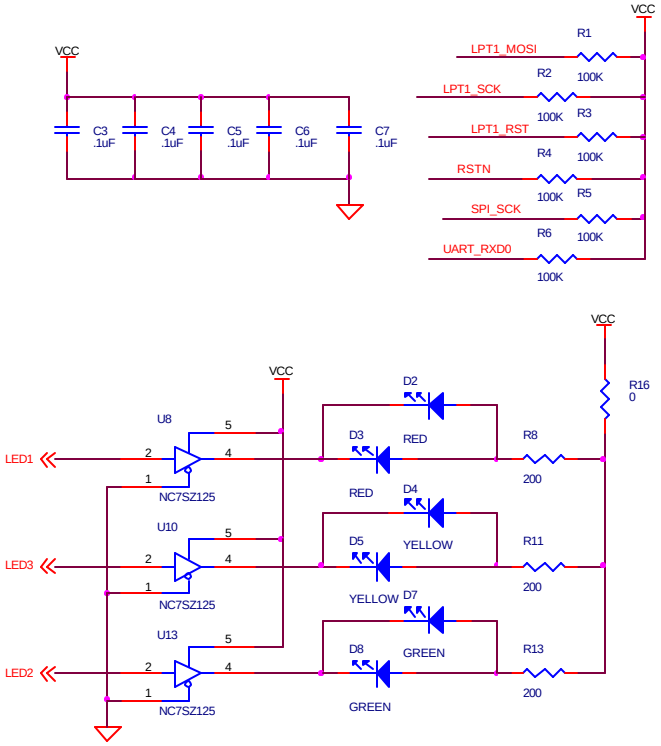

VCC
C3 .1uF
C4 .1uF
C5 .1uF
C6 .1uF
C7 .1uF
R1
LPT1_MOSI
R2 100K
LPT1_SCK
100K R3
LPT1_RST
R4 100K
RSTN
100K R5
SPI_SCK
R6 100K
UART_RXD0
100K
R16 0
D2
U8
D3 RED
R8
LED1
RED
D4
U10
D5 YELLOW
R11
LED3
YELLOW D7
U13
D8 GREEN
R13
LED2
GREEN
200
NC7SZ125

9 Warranty and Support Information

9.1 Customer Service

As a Crossbow Technology customer you have access to product support services, which include:

- Single-point return service
- Web-based support service
- Same day troubleshooting assistance
- Worldwide Crossbow representation
- Onsite and factory training available
- Preventative maintenance and repair programs
- Installation assistance available

9.2 Contact Directory

United States:	Phone:	1-408-965-3300 (7 AM to 7 PM PST)
	Fax:	1-408-324-4840 (24 hours)
	Email:	techsupport@xbow.com
Non-U.S.:	refer to website	www.xbow.com

9.3 Return Procedure

9.3.1 Authorization

Before returning any equipment, please contact Crossbow to obtain a Returned Material Authorization number (RMA).

Be ready to provide the following information when requesting a RMA:

- Name
- Address
- Telephone, Fax, Email
- Equipment Model Number
- Equipment Serial Number
- Installation Date

- Failure Date
- Fault Description

9.3.2 Identification and Protection

If the equipment is to be shipped to Crossbow for service or repair, please attach a tag TO THE EQUIPMENT, as well as the shipping container(s), identifying the owner. Also indicate the service or repair required, the problems encountered, and other information considered valuable to the service facility such as the list of information provided to request the RMA number.

Place the equipment in the original shipping container(s), making sure there is adequate packing around all sides of the equipment. If the original shipping containers were discarded, use heavy boxes with adequate padding and protection.

9.3.3 Sealing the Container

Seal the shipping container(s) with heavy tape or metal bands strong enough to handle the weight of the equipment and the container.

9.3.4 Marking

Please write the words, "***FRAGILE, DELICATE INSTRUMENT***" in several places on the outside of the shipping container(s). In all correspondence, please refer to the equipment by the model number, the serial number, and the RMA number.

9.3.5 Return Shipping Address

Use the following address for all returned products:

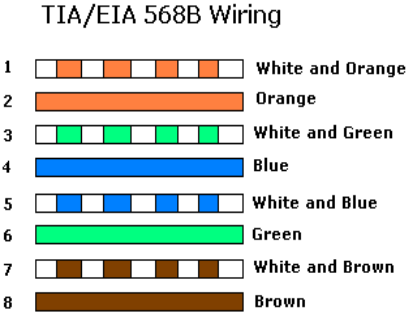
Crossbow Technology, Inc.
41 Daggett Drive
San Jose, CA 95134
Attn: RMA Number (XXXXXX)

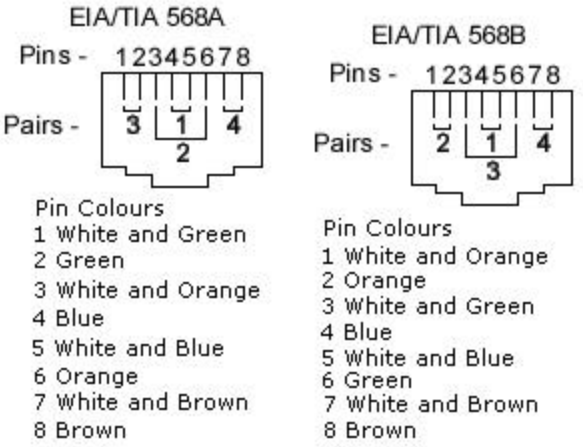
9.4 Warranty

The Crossbow product warranty is one year from date of shipment.

10 Appendix A: 10/100 Base-T Cabling Standards

Category 5(e) (UTP) color coding table





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Website: www.xbow.com