Crossbow

Imote2 Hardware Reference Manual

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About This Document

The following annotations have been used to provide additional information.

◂ NOTE

Note provides additional information about the topic.

☑ EXAMPLE

Examples are given throughout the manual to help the reader understand the terminology.

IMPORTANT

This symbol defines items that have significant meaning to the user

⚠ WARNING

The user should pay particular attention to this symbol. It means there is a chance that physical harm could happen to either the person or the equipment.

The following paragraph heading formatting is used in this manual:

1 Heading 1

1.1 Heading 2

1.1.1 Heading 3

This document also uses different body text fonts (listed in Table 0-1) to help you distinguish between names of files, commands to be typed, and output coming from the computer.

Table 0-1. Font types used in this document.

Font Type	Usage
`Courier New Normal`	Sample code and screen output
`Courier New Bold`	Commands to be typed by the user
Times New Roman Italic	TinyOS files names, directory names
Franklin Medium Condensed	Text labels in GUIs

1 Introduction

This *User's Manual* describes the hardware features of the Imote2 Processor Radio (IPR2400) board and basic sensor board (ITS400).

Table 1-1 below lists the models covered in this Manual.

Table 1-1. Imote2 Models covered in the Reference Manual

Model Number	Description
IPR2400	Imote2 processor radio board
ITS400	Imote2 basic sensor board

This *Manual* is **not** a software guide to programming the Imote2, nor is it a guide to pre-built software packages that run on top of the Motes. The following resources are available regarding software:

Imote2.Builder SDK Manual by Crossbow Technology, Inc.

Imote2 Yahoo Users group at

http://tech.groups.yahoo.com/group/intel-mote2-community/

Intel Imote2 resources page at

http://www.intel.com/research/sensornets/

2 Imote2 Radio Processor Board (IPR2400)

The Crossbow Imote2 is an advanced sensor network node platform designed for demanding wireless sensor network applications requiring high CPU/DSP and wireless link performance and reliability. The platform is built around Intel's XScale® processor, PXA271. It integrates an 802.15.4 radio (TI CC2420) with an on-board antenna. It exposes a "basic sensor board" interface, consisting of two connectors on one side of the board, and an "advanced sensor board" interface, consisting of two high density connectors on the other side of the board. The Imote2 is a modular stackable platform and can be stacked with sensor boards to customize the system to a specific application, along with a "battery board" to supply power to the system.

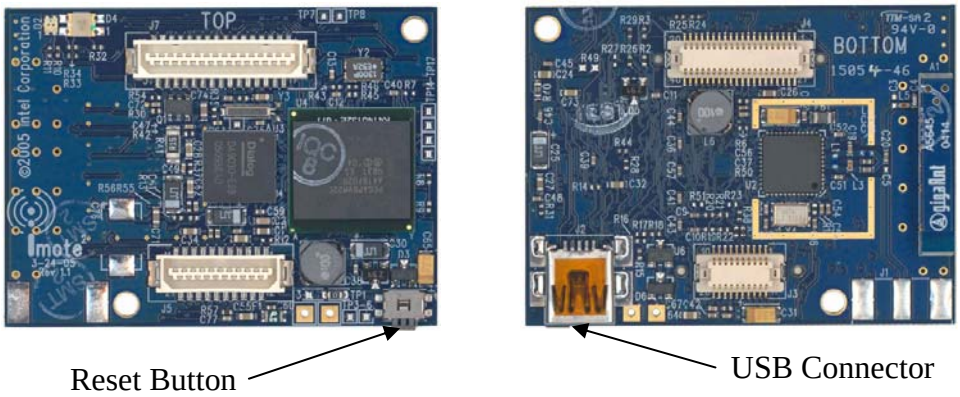


Figure 2-1. Photos of the Imote2 Board

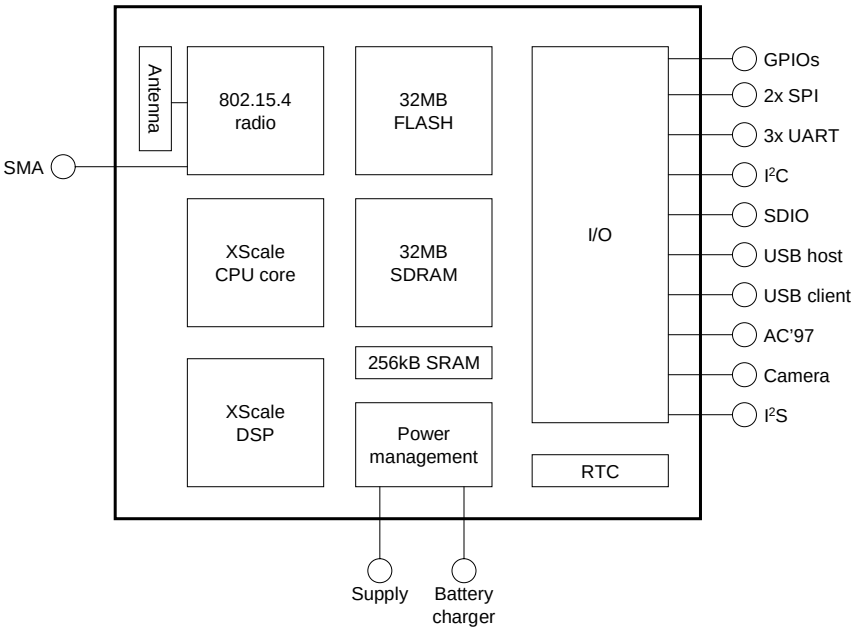


Figure 2-2. Imote2 Block diagram

2.1 Features

- PXA271 XScale® processor @ [13–416] MHz
- Wireless MMX coprocessor
- 256kB SRAM, 32MB FLASH, 32MB SDRAM
- Integrated 802.15.4 radio, support for external radios through SDIO and UART
- Integrated 2.4GHz antenna
- Multicolor status indicator LED
- Basic and advanced expansion connectors supporting : 3xUART, I2C, 2xSPI, SDIO, I2S, AC97, USB host, Camera I/F, GPIO
- Mini-USB port for direct PC connection
- Size: 48 mm x 36 mm. PCB Thickness 1.75 mm

Table 2-1. Imote2 Operating Specifications

Parameter	Operating Value
Supply Voltage (V_{bat})	5.5 V
Charger Input Voltage (V_{chg})	10 V
Input Voltage (V_{in})	$V_{CC\ io}$ ± 0.3 V
Storage Temperature	-40 to $+125^0$ C
Operating Temperature	0 to $+85^0$ C
Current in deep sleep mode	387 μA
Current in active mode (13 MHz, radio off)	31 mA
Current in active mode (13 MHz, radio Tx/Rx)	44 mA
Current in active mode (104 MHz, radio Tx/Rx)	66 mA

2.2 Mechanical Dimensions

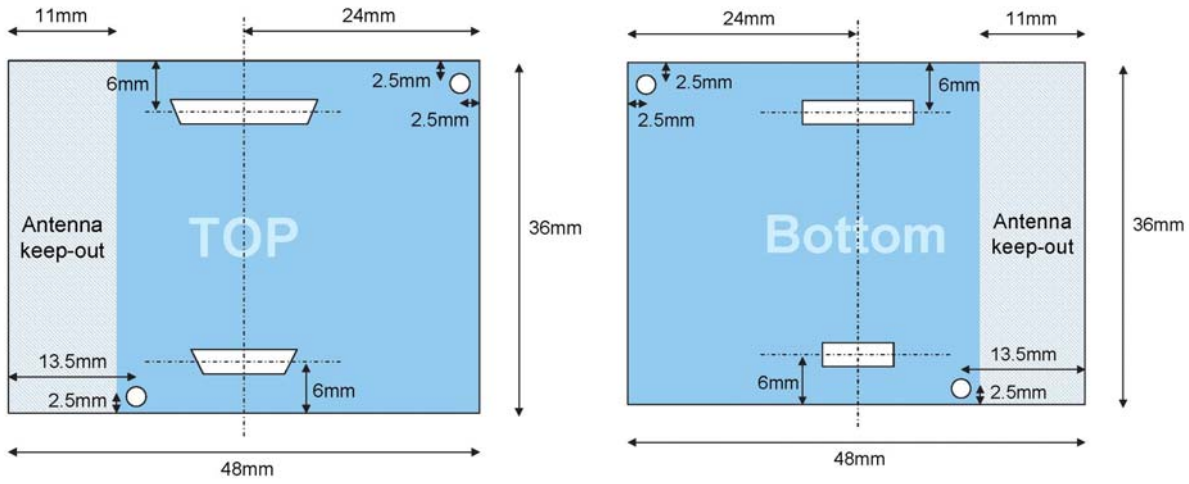


Figure 2-3. Mechanical Outline Drawing of OEM Edition Module

3 Processor

The Imote2 contains the PXA271 processor. This processor can operate in a low voltage (0.85V) and a low frequency (13 MHz) mode, hence enabling low power operation. The frequency can be scaled to 104 MHz at the lowest voltage level, and can be increased up to 416MHz with Dynamic Voltage Scaling. The processor has many low power modes, including sleep and deep sleep modes. It also integrates 256 KB of SRAM divided into 4 equal banks of 64 KB. The PXA271 is a multi-chip module that includes three chips in a single package, the processor, 32 MB SDRAM and 32 MB of flash. The processor integrates many I/O options making it extremely flexible in supporting different sensors, A/Ds, radio options, etc. These I/O options include I2C, 3 Synchronous Serial Ports one of which dedicated to the radio, 3 high speed UARTs, GPIOs, SDIO, USB client and host, AC97 and I2S audio codec interfaces, fast infrared port, PWM, Camera Interface and a high speed bus (Mobile Scaleable Link). The processor also adds many timers and a real time clock. The PXA271 also includes a wireless MMX coprocessor to accelerate multimedia operations. It adds 30 new media processor instructions, support for alignment and video operations and compatibility with Intel MMX and SSE integer instructions.

4 Radios and Antenna

4.1 Radio

The Imote2 integrates an 802.15.4 radio transceiver from ChipCon (CC2420). 802.15.4 is an IEEE standard describing the physical & MAC layers of a low power low range radio, aimed at control and monitoring applications. The CC2420 supports a 250 kb/s data rate with 16 channels in the 2.4 GHz band.

Other external radio modules such as 802.11 and Bluetooth can be enabled through the supported interfaces (SDIO, UART, SPI, etc).

4.1.1 Radio RF Channel Selection

The Imote2's CC2420 radio can be tuned within the IEEE 802.15.4 channels that are numbered from 11 (2.405 GHz) to 26 (2.480 GHz) each separated by 5 MHz.

4.1.2 Radio Transmission Power

RF transmission power is programmable from 0 dBm (1 mW) to –25dBm. Lower transmission power can be advantageous by reducing interference and dropping radio power consumption from 17.5 mA at full power to 8.5 mA at lowest power.

Table 4-1. Chipcon® CC2420 Output Power Settings and Typical Current Consumption

RF Power (dBm)	Power Register (code)	Current Consumption (mA)
0	31	17.4
-1	27	16.5
-3	23	15.2
-5	19	13.9
-7	15	12.5
-10	11	11.2
-15	7	9.9
-25	3	8.5

The RF received signal strength indication (RSSI) is read directly from the CC2420 Radio and sent with every radio packet received. Typical RSSI values for a given RF input level are shown in Figure 4-1 below.

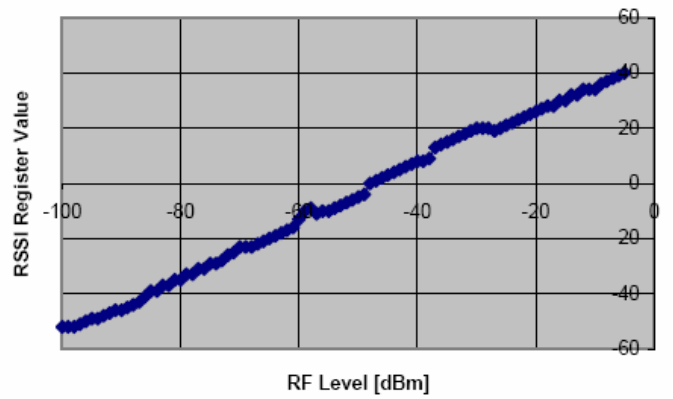


Figure 4-1. Typical RSSI value versus input RF level in dBm

4.2 Antenna

The Imote2 platform integrates a 2.4 GHz surface mount antenna which provides a nominal range of about 30 meters. If a longer range is desired, an SMA connector can be soldered directly to the board to connect to an external antenna.

There are literally hundreds of antenna options offered by different vendors and some references are provided below:

- Linx Technologies: http://www.linxtechnologies.com/
- Nearson: http://www.nearson.com/

5 Power

5.1 Power Supply Options

To supply the processor with all the required voltage domains, the Imote2 includes a Power Management IC. This PMIC supplies 9 voltage domains to the processor in addition to the Dynamic Voltage Scaling capability. It also includes a battery charging option and battery voltage monitoring. Two of the PMIC voltage regulators (1.8 V & 3.0 V) are used to supply the sensor boards with the desired regulated supplies at a maximum current of 200 mA. The processor communicates with the PMIC over a dedicated I2C bus (PWRI2C). The Imote2 platform was designed to support primary and rechargeable battery options as described below, in addition to being powered via USB. The following figure shows how the different battery boards and on board connectors can be used to power the mote.

5.1.1 Primary Battery

The Imote2 platform can be powered using primary batteries with a voltage range of 3.2 - 4.5 V (e.g. 3 AAA alkaline batteries). A battery board with a basic or advanced set of connectors can be connected to the Vbat pins of the connector. As shown in the figure below, a diode and fuse should be connected between the battery and mote board to protect the battery and the PMIC.

5.1.2 Rechargeable Battery

A rechargeable battery can be used to supply power to the Imote2 platform by connecting it directly to the Vbat pin on the connector. In this case, the PMIC battery charger can be used to recharge the batteries. The battery board should drive the nCHARGE_EN pin low to connect the USB input to the PMIC charger pin, hence allowing to recharge the battery using USB. The PMIC supports single cell Li-Ion at 4.1 and 4.2 V, in addition to a Li-Polymer pack. See the figure below for more details.

5.1.3 Mini-USB connector input

The mote can be powered directly from USB, by routing the USB power to the Vbat input of the PMIC. This is the default state when either a battery is not connected, or when a battery board drives the nCHARGE_EN input high (as the case with all primary battery boards). If a battery board pulls nCHARGE_EN low, the USB input gets routed to the Vchg pin of the PMIC, which would be the case for rechargeable batteries as mentioned above.

5.1.4 On-board pads

The On board pads can be used to connect a primary battery directly to the mote. A diode is included in this path to protect the primary battery. In addition, these pads can be used to connect any power source supplying a voltage range of 3.2 – 4.5V (after the diode drop). This connector is similar to the USB connector functionality, as it could be used to supply power to the mote or to recharge a battery based on the state of the nCHARGE_EN pin.

The PMIC is also used to enable the alarm functionality that is exposed on the basic and advanced sensor connectors. When power is supplied to the mote, the PMIC will start, however it will not start the mote until the power button is pushed (similar to a cell phone usage model).

If it is desired to have a power board automatically turn on the mote, the power board can short the alarm pin on the connector to the VRTC pin. This will cause the mote to start automatically every time power is applied to the mote. However, if a more intelligent sensor board is desired to start the mote in response to a specific sensor event, the alarm pin can be controlled by the sensor board to start/wakeup the mote selectively.

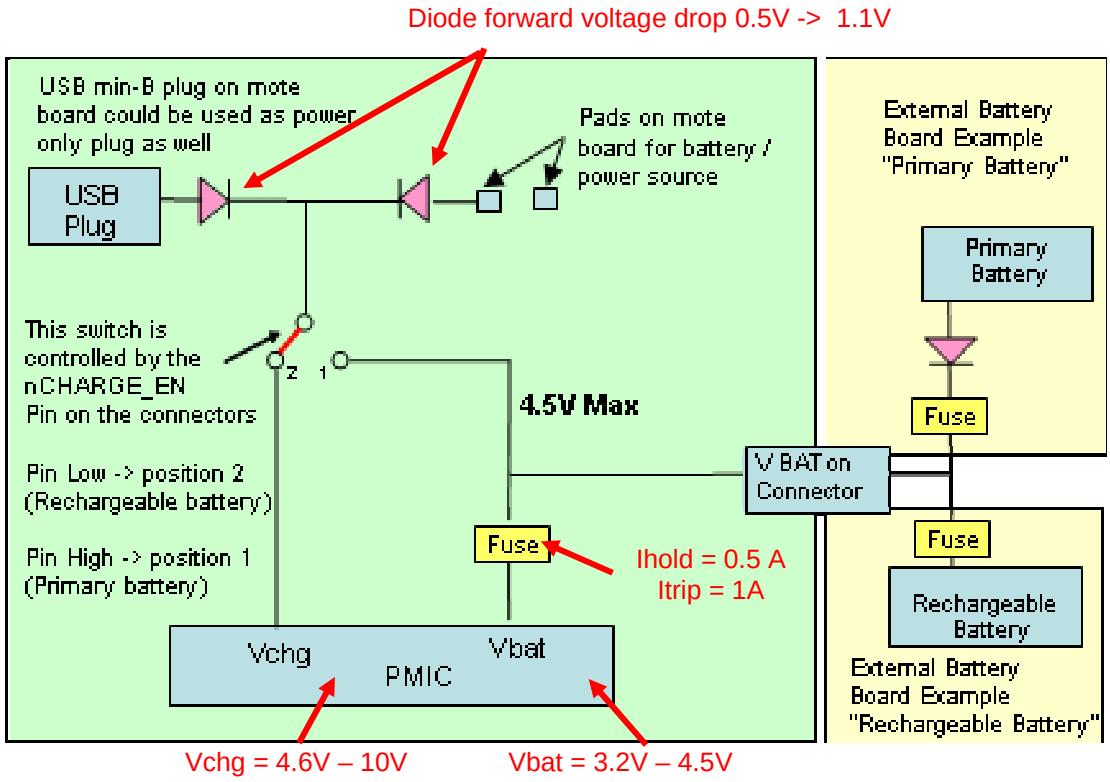


Figure 5-1. Power supply options for Imote2

6 Sensor Boards & Expansion Connectors

6.1 Sensor Board Interfaces

The Imote2 platform exposes two sets of connectors, the basic set and the advanced set. The pins on each connector set are split into two physical connectors to enhance the mechanical stability. The basic set is meant to enable low cost sensor boards (low density connectors were chosen) and support the most common sensor interfaces. This connector set is defined as the "architectural" set, and can be supported in future mote designs. The advanced connector set exposes some of the PXA271 advanced features (Camera Interface, High speed bus, Audio interfaces, etc), and is assumed to be platform specific. The details of the connector sets are described below.

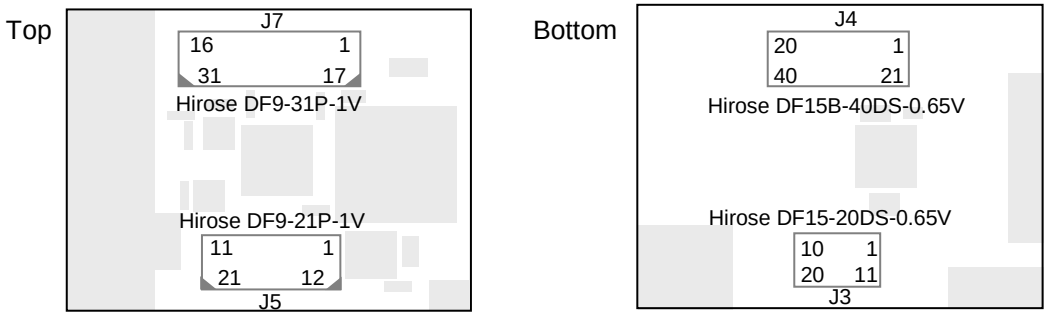


Figure 6-1. Connector information for Imote2

Table 6-1. Matching connector information

Description	Manufacturer	Part#
40 pin (J4)	Hirose	DF15B(3.2)-40DP-0.65V
20 pin (J3)	Hirose	DF15B(3.2)-20DP-0.65V
31 pin (J1)	Hirose	DF9-31S-1V
21 pin (J5)	Hirose	DF9-21S-1V

NOTE: The Hirose DF15 connector type comes in wide variety of stacking heights. Using the recommended part numbers will result in a 5mm stacking height on the bottom side. If desired, an expansion board designer can choose a different part number of the DF15 connector used in order to meet custom stacking height requirements.

6.1.1 Basic Connector Set

The basic connector set consists of 2 physical connectors from the Hirose DF9 family which has a 1 mm pitch. The connector choice simplifies the routing and soldering of sensor boards, which is useful in the prototyping stage. The pins are split between the 2 connectors (31 pin and 21 pin connectors) for mechanical stability reasons. The asymmetry of the two connectors provides a useful visual clue of sensor board orientation. All I/O pins can be programmed as GPIOs in addition to their special port function. As mentioned in the power supply section, the 1.8 and 3.0

V pins are supplied by the PMIC and can be used to power the sensor boards. The alarm pin is an input pin and can be used by the sensor boards to wake up the processor out of deep sleep mode if needed. The reset pin is an input pin to force a hardware reset of the processor. The standard UART will be used as the debug console and is exposed on the 21 pin connector. The 31 pin connector exposes 2 high speed UART ports, 2 SSP ports, an SDIO port, an I2C port and multiple GPIOs. There are 11 reserved pins to allow for future expansion and inter-board communication.

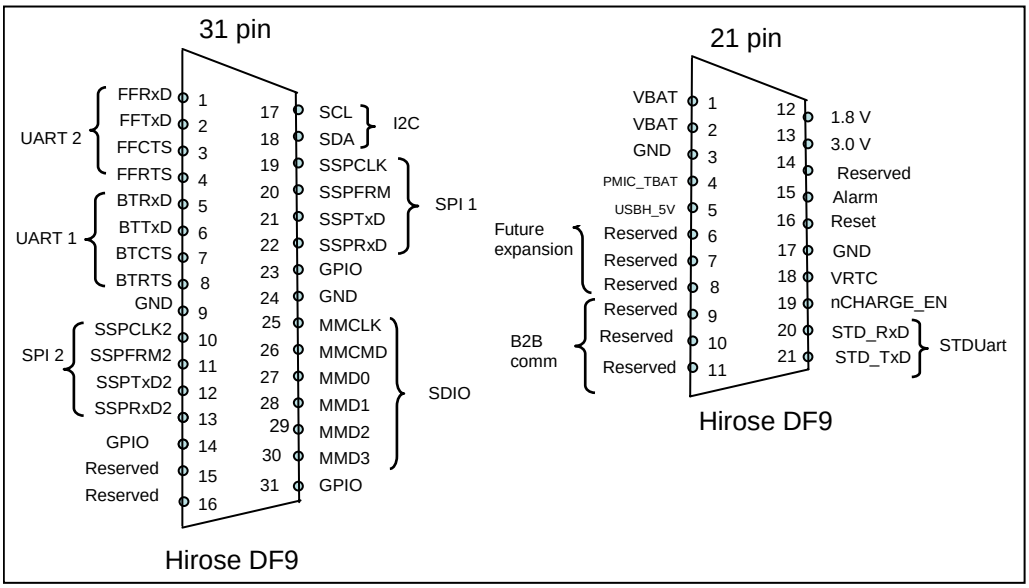


Table 6-2. Pin-out description for basic large connector (J7)

Pin#	Type	Name	GPIO#	Description
1	I/O	FF_RXD	96	UART 1 receive data
2	I/O	FF_TXD	99	UART 1 send data
3	I/O	FF_CTS	100	UART 1 clear to send
4	I/O	FF_RTS	98	UART 1 request to send
5	I/O	BT_RXD	42	UART 2 receive data
6	I/O	BT_TXD	43	UART 2 send data
7	I/O	BT_CTS	44	UART 2 clear to send
8	I/O	BT_RTS	45	UART 2 request to send
9		GND		Ground
10	I/O	SSP2_SCLK	36	Synchronous Serial Port 2 clock
11	I/O	SSP2_SFRM	37	Synchronous Serial Port 2 frame
12	I/O	SSP2_TXD	38	Synchronous Serial Port 2 transmit data
13	I/O	SSP2_RXD	11	Synchronous Serial Port 2 receive data
14	I/O	GPIO94	94	General purpose I/O
15	*R*	*Reserved*		*Do not connect*
16	*R*	*Reserved*		*Do not connect*
17	I/O	I2C_SCL	117	I2C serial clock
18	I/O	I2C_SDA	118	I2C serial data/address bus
19	I/O	SSP1_SCLK	23	Synchronous Serial Port 1 clock
20	I/O	SSP1_SFRM	24	Synchronous Serial Port 1 frame
21	I/O	SSP1_TXD	25	Synchronous Serial Port 1 transmit data
22	I/O	SSP1_RXD	26	Synchronous Serial Port 1 receive data
23	I/O	GPIO10	10	General purpose I/O
24		GND		Ground
25	I/O	MM_CLK	32	MMC and SD/SDIO bus clock

26	I/O	MM_CMD	112	MMC and SD/SDIO command
27	I/O	MM_DAT0	92	MMC and SD/SDIO read / write data 0
28	I/O	MM_DAT1	109	MMC and SD/SDIO read / write data 1
29	I/O	MM_DAT2	110	MMC chip select 0 or SD/SDIO read / write data 2
30	I/O	MM_DAT3	111	MMC chip select 1 or SD/SDIO read / write data 3
31	I/O	GPIO93	93	General purpose I/O

Table 6-3. Pin-out description for basic small connector (J5)

Pin#	Type	Name	GPIO#	Description
1		VBAT		Power Supply Rail (3.2 – 4.7 V minus Diode Drop)
2		VBAT		Power Supply Rail (3.2 – 4.7 V minus Diode Drop)
3		GND		Ground
4	I	PMIC_TBAT		Battery temperature input
5		USBH_5V		5.0 V supply rail to power sensor board (USBH)
6	*R*	*Reserved*		*Do not connect*
7	*R*	*Reserved*		*Do not connect*
8	*R*	*Reserved*		*Do not connect*
9	R	N/C		Available for communication between expansion boards
10	R	N/C		Available for communication between expansion boards
11	R	N/C		Available for communication between expansion boards
12		VCC_1P8		1.8 V supply rail to power sensor boards
13		VCC_3V		3.0 V supply rail to power sensor boards
14	*R*	*Reserved*		*Do not connect*
15	I	ALARM		Alarm input to PMIC (see power subsystem)
16	O	NRESET		Processor reset
17		GND		Ground
18		VCC_RTC		Power supply for the RTC voltage domain of the PXA
19	I	nCHARGE_EN		Battery select, 0 : rechargeable battery, 1 : primary battery
20	I/O	STD_RXD	46	UART 3 receive data
21	I/O	STD_TXD	47	UART 3 send data

6.1.2 Advanced Connector Set

The advanced connector set also consists of 2 physical connectors. We chose a higher density connector (0.65mm pitch) for the advanced set to be able to support the large pin count required without increasing the size of the connector too much. The pins are split on 2 connectors (40 pin and 20 pin connectors) for mechanical stability reasons. Note that all I/O pins (with the exception of JTAG and USB) can be programmed as GPIOs in addition to their special port function. JTAG is exposed on the 20 pin connector. The MSL interface provides two independent high speed unidirectional links. The data-channel width can be scaled from 1 to 4 bits, providing up to 192 Mbps at 48 MHz. The CIF port supports the Intel Quick Capture Camera Interface, to easily attach image sensors to the Imote2. Note that the I^2C, UART and SPI ports exposed on the 40 pin connector, are the same ports exposed on the basic side.

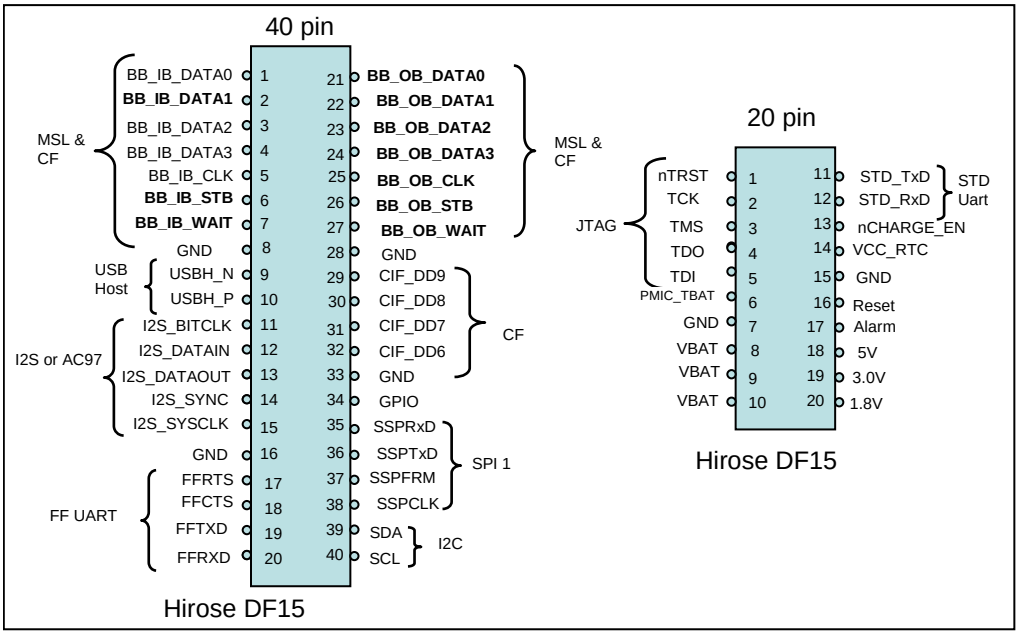


Table 6-4. Pin-out description for advanced large connector (J4)

Pin#	Type	Name	GPIO#	Description
1	I/O	BB_IB_DATA0 CIF_DD5	82	MSL inbound data bit 0 Quick capture data line 5
2	I/O	BB_IB_DATA1 CIF_DD1	55	MSL inbound data bit 1 Quick capture data line 1
3	I/O	BB_IB_DATA2	56	MSL inbound data bit 2
4	I/O	BB_IB_DATA3	57	MSL inbound data bit 3
5	I/O	BB_IB_CLK CIF_DD4	83	MSL inbound clock strobe Quick capture data line 4
6	I/O	BB_IB_STB CIF_FV	84	MSL inbound signal qualifier Quick capture frame start
7	I/O	BB_IB_WAIT CIF_LV	85	MSL wait indicator for inbound link Quick capture line start
8		GND		Ground
9	I/O	USBH_N_CONN		Data negative differential signal (USB D-)
10	I/O	USBH_P_CONN		Data positive differential signal (USB D+)
11	I/O	I2S_BITCLK AC97_BITCLK	28	I2S bit clock, supplies the serial audio bit rate AC97 12.288-MHz bit-rate clock
12	I/O	I2S_DATA_IN AC97_SDATA_IN_0	29	I2S Serial audio input data from CODEC AC97 Serial audio input data from CODEC
13	I/O	I2S_DATA_OUT AC97_SDATA_OUT	30	I2S Serial audio output data to CODEC AC97 Serial audio output data to CODEC
14	I/O	I2S_SYNC AC97_SYNC	31	I2S SYNC, BITCLCK divided by 64 AC97 48-KHz frame indicator and synchronizer
15	I/O	I2S_SYSCLK AC97_RESET_n	113	I2S system clock = BITCLK x 4 AC97 CODEC reset
16		GND		Ground
17	I/O	FF_RTS	98	UART 1 request to send
18	I/O	FF_CTS	100	UART 1 clear to send
19	I/O	FF_TXD	99	UART 1 send data
20	I/O	FF_RXD	96	UART 1 receive data
21	I/O	BB_OB_DATA0 CIF_DD0	81	MSL outbound data bit 0 Quick capture data line 0
22	I/O	BB_OB_DATA1 CIF_DD5	48	MSL outbound data bit 1 Quick capture data line 5
23	I/O	BB_OB_DATA2 CIF_DD3	50	MSL outbound data bit 2 Quick capture data line 3

24	I/O	BB_OB_DATA3 CIF_DD2	51	MSL outbound data bit 3 Quick capture data line 2
25	I/O	BB_OB_CLK CIF_DD4	52	MSL outbound clock strobe Quick capture data line 4
26	I/O	BB_OB_STB CIF_MCLK	53	MSL outbound signal qualifier Quick capture programmable output clock
27	I/O	BB_OB_WAIT CIF_PCLK	54	MSL wait indicator for outbound link Quick capture pixel clock
28		GND		Ground
29	I/O	CIF_DD9	106	Quick capture data line 9
30	I/O	CIF_DD8	107	Quick capture data line 8
31	I/O	CIF_DD7	12	Quick capture data line 7
32	I/O	CIF_DD6	17	Quick capture data line 6
33		GND		Ground
34	I/O	GPIO10	10	General purpose I/O
35	I/O	SSP1_RXD	26	Synchronous Serial Port 1 receive data
36	I/O	SSP1_TXD	25	Synchronous Serial Port 1 transmit data
37	I/O	SSP1_SFRM	24	Synchronous Serial Port 1 frame
38	I/O	SSP1_SCLK	23	Synchronous Serial Port 1 clock
39	I/O	I2C_SDA	118	I2C serial data
40	I/O	I2C_SCL	117	I2C serial clock

Table 6-5. Pin-out description for advanced small connector (J3)

Pin#	Type	Name	GPIO#	Description
1	I	JTAG_NTRST		JTAG port : Test Reset
2	I	JTAG_TCK		JTAG port : Test clock
3	I	JTAG_TMS		JTAG port : Test mode select
4	O	JTAG_TDO		JTAG port : Test data out
5	I	JTAG_TDI		JTAG port : Test data in
6	I	PMIC_TBAT		Battery temperature input
7		GND		Ground
8		VBAT		Power Supply Rail (3.2 – 4.7 V minus Diode Drop)
9		VBAT		Power Supply Rail (3.2 – 4.7 V minus Diode Drop)
10		VBAT		Power Supply Rail (3.2 – 4.7 V minus Diode Drop)
11	I	STD_RXD		UART 3 receive data
12	O	STD_TXD		UART 3 send data
13	I	nCHARGE_EN		Battery select, 0 : rechargeable battery, 1 : primary battery
14		VCC_BAT_RTC		Power supply for the RTC voltage domain of the CPU
15		GND		Ground
16	O	NRESET		Processor reset
17	I	ALARM		Alarm input to PMIC (see power subsystem)
18		VCC_5V		5.0 V supply rail to power sensor board (USBH)
19		VCC_3V		3.0 V supply rail to power sensor boards
20		VCC_1P8		1.8 V supply rail to power sensor boards

Table 6-6. Imote2 Internal I/O configuration

Component	Pin name	GPIO#
LED	Red	103
LED	Green	104
LED	Blue	105
CC2420	FIFO	114
CC2420	VREG_EN	115
CC2420	CCA	116

CC2420	FIFOP	0
CC2420	RESETN	22
CC2420	SFD	16

Table 6-7. Imote2 Test Points

Test Point Name	Signal
TP3	PWR pad for direct battery connection
TP4	GND pad for direct battery connection
TP5	STD_TXD
TP6	STD_RXD
TP7	PWR_SCL
TP8	PWR_SDA
TP9	13 MHz to PMIC
TP14	PWR_EN
TP15	SYS_EN
TP16	NVDD_FAULT
TP17	NBATT_FAULT

7 ITS400 Basic Sensor Board

The basic sensor board is designed to connect to the basic connectors on the Imote2. It contains a 3d Accelerometer, advanced temp/humidity sensor, light sensor and 4 channel A/D. It is a pass through board to allow stacking with another sensor/communication board.

Figure 7-1. Photo of the ITS400 Sensor Board

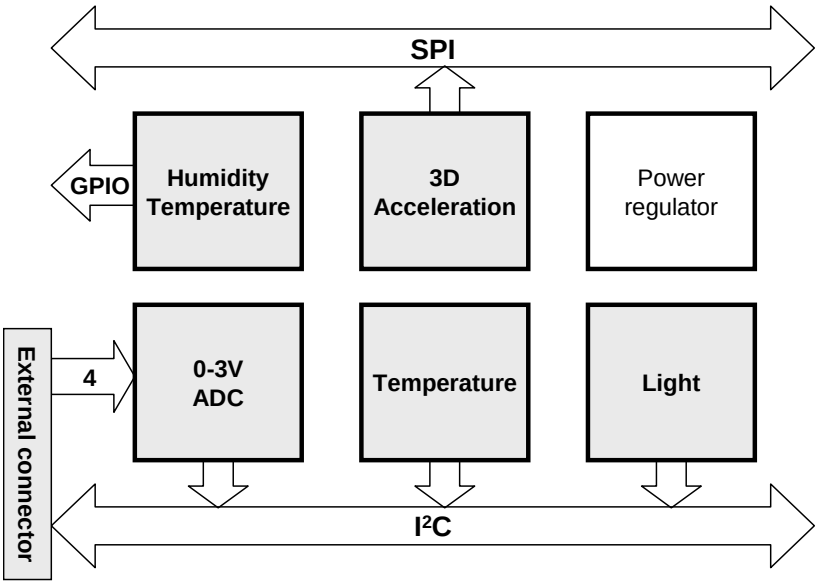


Figure 7-2. ITS400 Block diagram

Table 7-1. ITS400 Operating Specifications

Parameter	Operating Value
Operating temperature range	0 to +70 ºC
Storage temperature range	-40 to +150 ºC
Humidity (non condensing)	80 %

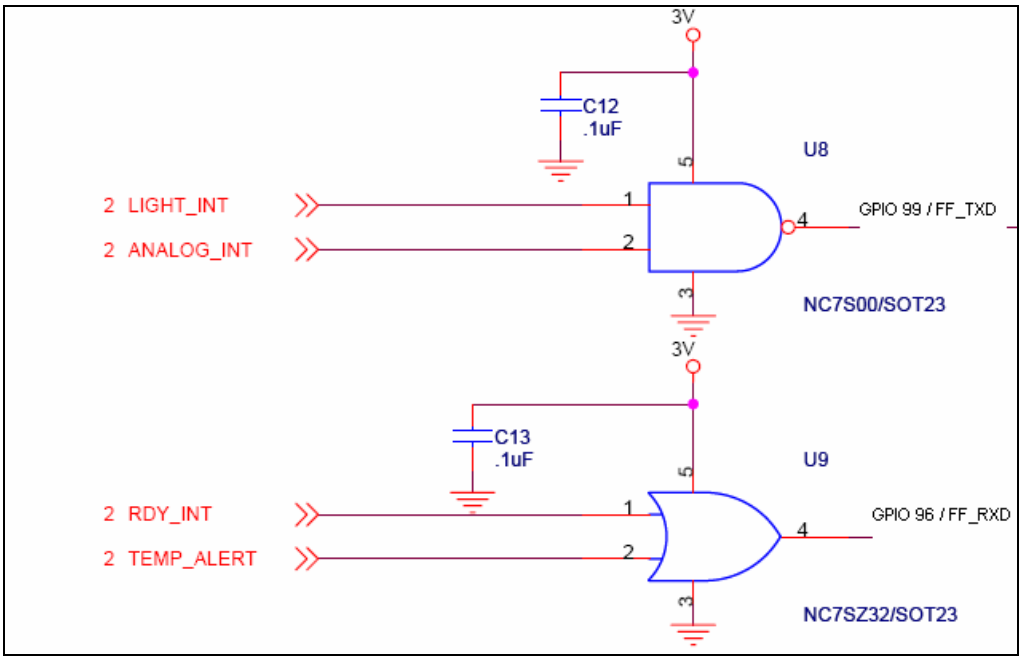
7.1 Sensor Suite

The ITS400 sensor board is multi-sensor board that combines a popular set of sensors for wireless sensor network applications, including:

- ST Micro LIS3L02DQ 3d 12 bit ±2g accelerometer
- High Accuracy, ±0.3°C Sensirion SHT15 temperature/humidity sensor
- TAOS TSL2651Light Sensor
- Maxim MAX1363 4 Channel General Purpose A/D for quick prototyping
- TI Tmp175 Digital Temperature Sensor with two-wire interface

7.1.1 3D Accelerometer

This board includes an ST Micro LIS3L02DQ 3d accelerometer. This sensor has a range of +/- 2g with 12 bit resolution. It offers two possible interfaces, SPI or I2C, either of which is selectable using 0-ohm resistors including on the board. To communicate with the sensor using the I2C interface, populate R17 and remove R21. To communicate with the sensor using SPI, populate R21 and remove R17. By default, the sensor is connected to SSP1 on the Intel Mote 2. In the event that another stacked board conflicts with the basic sensor board use of SSP1, the sensor may be disconnected from the port by removing R23, R24, R25 and R26, and connected to SSP2 instead by populating R29, R30, R31, R32 with zero ohm resistors. The sensor's data ready (RDY_INT) interrupt is connected to GPIO96 through an OR gate as shown in the schematic below. If another board conflicts with the use of GPIO 96, the BT_RXD pin can be used instead by loading R34. For more info on this sensor, the datasheet can be found at http://www.stmicro.fr/stonline/products/literature/ds/10175.pdf.



7.1.2 Temperature and Humidity Sensor

The boards include a Sensirion SHT15 sensor which can be used for applications requiring high accuracy temp reading (+/- 0.3 degC) and humidity. This sensor interfaces to the Intel Mote 2 through two GPIO pins. The data pin of the SHT11 is connected to GPIO 100, whereas the clock pin is connected to GPIO 98. Another set of connections is available by loading R36 and R37 if no conflict exists with another stacked board. For more information on the SHT11 sensor, please reference its datasheet located at: http://www.sensirion.com/images/getFile?id=25

7.1.3 Light Sensor

The board includes a TAOS TSL2651 light sensor. This sensor interfaces to the Intel Mote 2 through the I2C bus. The interrupt pin (LIGHT_INT) is connected to GPIO99 through a NAND gate as shown in the schematic above. If another board conflicts with the use of GPIO 99, the BT_TXD pin can be used instead by loading R35. The address select line is driven by R4 and R6 and is set to 1 by default (R4 in, R6 out). To set it to 0, populate R6 and remove R4. To float it, remove both R4 and R6. Refer to data sheet for address mapping. The data sheet can be found at http://www.taosinc.com/product_detail.asp?cateid=4&proid=60

7.1.4 General purpose A/D

The board includes a Maxim MAX1363, 4 channel, 12 bit resolution general purpose ADC for quick prototyping. Each channel supports 0-3 V input signals. The ADC interfaces to the Intel Mote 2 through the I2C bus. The analog pins are brought out to a Molex PN-39357-0003 connector (J5) and the pin assignment is shown below. Pin A0 which controls the I2C address of the ADC is driven to 0 by default (R7 out, R9 in). If the I2C address needs to be changed, A0 can be driven to 1 (as specified in the data sheet) by removing R9 and populating R7.

The interrupt line (ANALOG_INT) is connected to GPIO99 through a NAND gate as shown in schematic above. If another board conflicts with the use of GPIO 99, the BT_TXD pin can be used instead by loading R35. The datasheet can be found at http://pdfserv.maxim-ic.com/en/ds/MAX1363-MAX1364.pdf.

7.1.5 Digital Temperature Sensor with two wire interface

The board includes a TI TMP175, a digital temperature sensor with a two wire output serial interface. The device is capable of a ± 1.5°C accurate over the range of -25°C to +85°C. The sensor allows up to 27 I2C devices on the bus. TMP175 address can be configured via resistors R13,R14,R15,R16,R27,R28. See schematic and TMP175 datasheet for more details. The interrupt line(TEMP_ALERT) is connected to GPIO96(FF_TXD) as shown in the schematic above. The datasheet for the device can be found at http://focus.ti.com/lit/ds/symlink/tmp175.pdf

7.2 Boost Switcher and Linear Regulator

The board includes a switching voltage regulator (U11-LTC3426), followed by linear regulator (U12-LTC1962). The input to the boost regulator is provided from the battery. In order to provide a cleaner power supply the output of the switcher is regulated further with a linear regulator. Regulated voltage output is provided externally through the connector J5 pin 5. It could be used for prototyping purposes in the case where a user of the board requires a voltage that is higher than anything provided by the board. All boards are shipped with the switcher/regulator disabled. See schematic and datasheet details on how to enable the switcher and set the voltages on both the switcher and the regulator.

7.3 Communication and Addressing

The Light Sensor (U2), Simple Temp Sensor (U7) and general purpose A/D (U1) can only be accessed via the I2C bus. Resistor settings control device addressing.

Table 7-2. ITS400 Default I2C addresses

Sensor	Address
TS2561(U2)	1001001
TMP175(U7)	1001010
MAX1363(U1)	0110100

NOTE:

Temp Sensor (U6) is not I2C compatible and utilizes a proprietary serial communication protocol. Please see its datasheet for more information.
3D Accelerometer can be configured to communicate over either I2C or SPI serial buses.

7.4 Pin-out Description

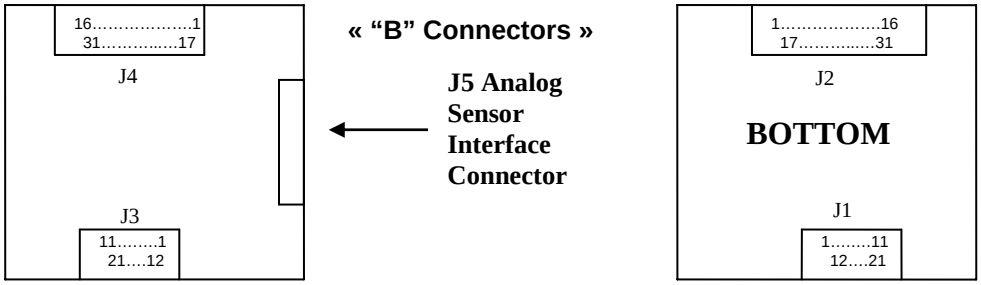


Table 7-3. ITS400 Pin-out description for Small "A" connector

Pin #	Type	Name	Description
A1[1]	PWR	VBAT	Not used by the sensor board, serves as input to the switcher
A2[1]	PWR	VBAT	Not used by the sensor board, serves as input to the switcher
A3		GND	Ground
A4[1]	PWR	PMIC_TBAT	Not used by the sensor board
A5	*R*	*Reserved*	*Do not connect*
A6	*R*	*Reserved*	*Do not connect*
A7	*R*	*Reserved*	*Do not connect*
A8	*R*	*Reserved*	*Do not connect*
A9	*R*	*Reserved*	*Do not connect*
A10	*R*	*Reserved*	*Do not connect*
A11	*R*	*Reserved*	*Do not connect*
A12[1]	PWR	1.8V	Not used by the sensor board
A13[1]	PWR	3.0V	Sensor Board Power Supply
A14[1]	*R*	*Reserved*	*Do not connect*
A15[1]		Alarm	Not used by the sensor board
A16[1]		Reset	Not used by the sensor board
A17		*GND*	*Ground*
A18[1]		VRTC	Not used by the sensor board
A19[1]		nCHARGE_EN	Not used by the sensor board
A20[1]		STD_RXD	Not used by the sensor board
A21[1]		STD_TXD	Not used by the sensor board

[1] Passed through to the bottom connectors J3 & J4 on the same pins.

Table 7-4. ITS400 Pin-out description Large "B" connector

Pin #	Type	Name	Description
B1	O	FF_RXD	Logical OR of RDY_INT and TEMP_ALERT(Note1.1)
B2	O	FF_TXD	Logical NAND of LIGHT_INT and ANALOG_INT(Note1.2)
B3	I/O	FF_CTS	Serial Data for SHT15
B4	I	FF_RTS	Serial Clock for SHT15
B5[1]		BT_RXD	An alternative connection to B1
B6[1]		BT_TXD	An alternative connection to B2
B7[1]		BT_CTS	An alternative connection to B3
B8[1]		BT_RTS	An alternative connection to B4
B9		GND	Ground
B10[1]		SSP2_SCLK	An alternative connection to B19
B11[1]		*SSP2_SFRM*	An alternative connection to B20
B12[1]		SSP2_TXD	An alternative connection to B21
B13[1]		SSP2_RXD	An alternative connection to B22
B14[1]		GPIO_94	Not used by the sensor board
B15	*R*	*RFU8*	*Do not connect*
B16	*R*	*RFU9*	*Do not connect*
B17[1]	I	I2C_SCL/SCL_SPC	I2C Clock/SPI Serial Port Clock
B18[1]	I/O	I2C_SDA/SDL_SDI_SDO	I2C Data/SPI Serial Data Input
B19[1]	I/O	SSP1_SCLK/SCL_SPC	SPI serial clock
B20[1]	I	SSP1_SFRM/SPI_CS	SPI chip select
B21[1]	I	SSP1_TXD/SDA_SDI_SDO	SPI serial data input for accelerometer
B22[1]	O	SSP1_RXD/SDO	SPI serial data output for accelerometer
B23[1]		GPIO10	Not used by the sensor board
B24		GND	Ground
B25[1]		MM_CLK	Not used by the sensor board
B26[1]		MM_CMD	Not used by the sensor board
B27[1]		MM_DATA0	Not used by the sensor board
B28[1]		MM_DATA1	Not used by the sensor board
B29[1]		MM_DATA2	Not used by the sensor board
B30[1]		MM_DATA3	Not used by the sensor board
B31		GPIO_93	Not used by the sensor board

Table 7-5. ITS400 Pin-out description J5-Analog Sensor Interface Connector

Pin #	Type	Name	Description
1	Analog Input	AIN0	Input to an ADC
2	Analog Input	AIN1	Input to an ADC
3	Analog Input	AIN2	Input to an ADC
4	Analog Input	AIN3	Input to an ADC
5	PWR	3V	Switcher/Regulator output supplied from the Sensor Board
6	GND	GND	Ground
7	I/O	I2C SDA	I2C Data
8	I/O	I2C SCL	I2C Clock

7.5 Hardware Errata (Board Rev 2.0)

U7(TMP175) TEMP_ALERT signal requires a 10Kohm pull up to 3V. It's missing in the current revision.

U2(TSL2561) LIGHT_INT signal requires a 10Kohm pull up to 3V. It's missing in the current revision.

8 IIB2400 Interface Board

The IIB2400 interface board is used for code loading and debugging through JTAG. It connects to the Imote2 through the advanced connectors, and is a pass through board to enable debugging with other power/battery boards attached to the Imote2.

Figure 8-1. Photo of the IIB2400 Interface Board

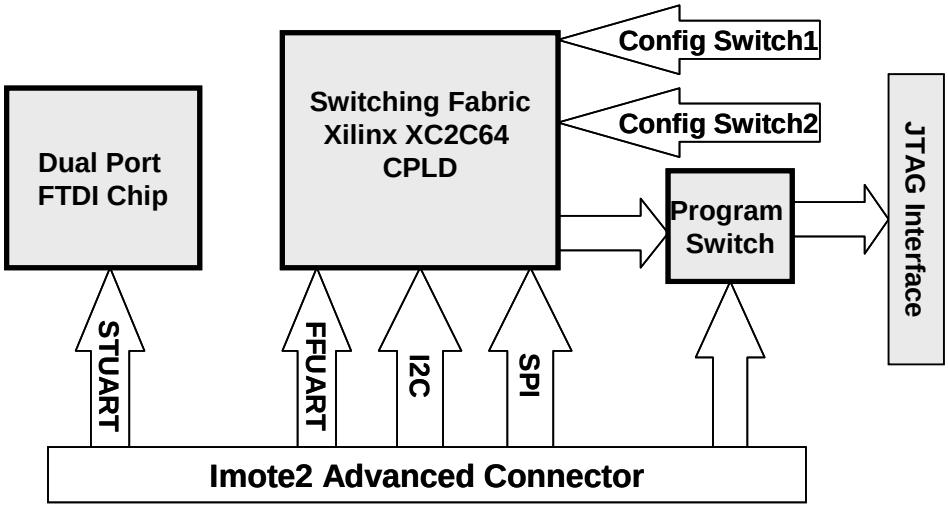


Figure 8-2. ITS400 Block diagram

It contains a dual port FTDI chip, mapping the USB input to 2 serial ports. The first serial port connects to the STDUART on the Imote2 platform and is meant to be used for the console. The second serial port can be configured to connect to FFUART regular, FFUART crossover, I2C or

SSP1 ports. This mapping is controlled by the SW5 switch on the board and is labeled accordingly.

The power supply can be controlled by the SW6 switch to select on of the following options:

- Option 1 : USB power drives VBAT to power the mote (marked as “PWR”)
- Option 2 : VBAT is not driven (marked as “No PWR”)

The debug board is designed to work with both the Intel JTAG dongle and the Macgraigor Raven dongle. It provides the ability to program the mote as well as the on-board CPLD through JTAG. The desired JTAG chain is selected via the SW3 switch.

8.1 Connector Description

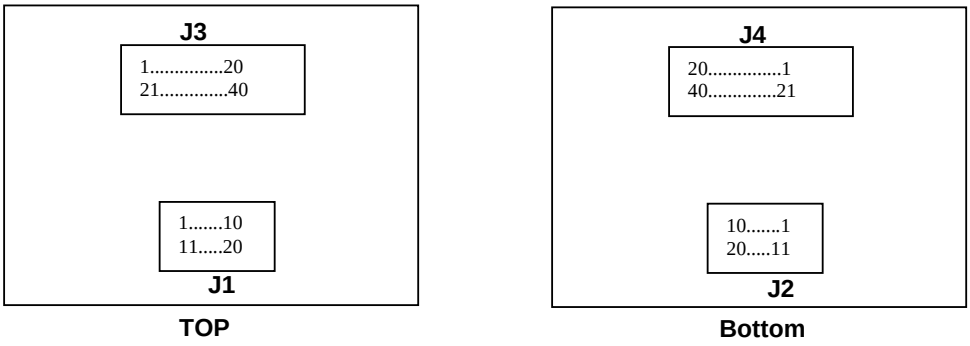


Table 8-1. Connector information

Description	Manufacturer	Part #
40 pin Advanced (J3)	Hirose	DF15B(1.8)-40DP-0.65V(50)
20 pin Advanced (J1)	Hirose	DF15B(1.8)-20DP-0.65V(50)
40 pin Advanced (J4)	Hirose	DF15B(1.8)-40DS-0.65V(50)
20 pin Advanced (J2)	Hirose	DF15B(1.8)-20DS-0.65V(50)

9 Appendix A. 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 (8 AM to 5 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.
4145 N. First Street
San Jose, CA 95134
Attn: RMA Number (XXXXXX)

9.4 Warranty

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

Crossbow Technology, Inc.
4145 N. First Street
San Jose, CA 95134
Phone: 408.965.3300
Fax: 408.324.4840
Email: info@xbow.com