CM5000 DATASHEET

ADVANTIC

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1. INTRODUCTION

The CM5000 mote is IEEE 802.15.4 compliant wireless sensor node based on the original open-source "TelosB" platform design developed and published by the University of California, Berkeley (“UC Berkeley”). The mote has the following general characteristics:

- IEEE 802.15.4 WSN platform
- TI MSP430 Processor, CC2420 RF
- TinyOS 2.x & ContikiOS Compatible
- Temperature, Humidity, Light sensors
- User & Reset Buttons
- 3xLeds
- USB Interface
- 2xAA Battery Holder

This product is specially suitable not only as cots environmental wireless sensor node, but also as a very useful research platform for developers, as it includes in the same hardware module all the needed functionalities: sensor readings, processor power and wireless communication potential.

Figure 1: CM5000 Mote

2. HARDWARE CHARACTERISTICS

2.1 CM5000 DIAGRAMS

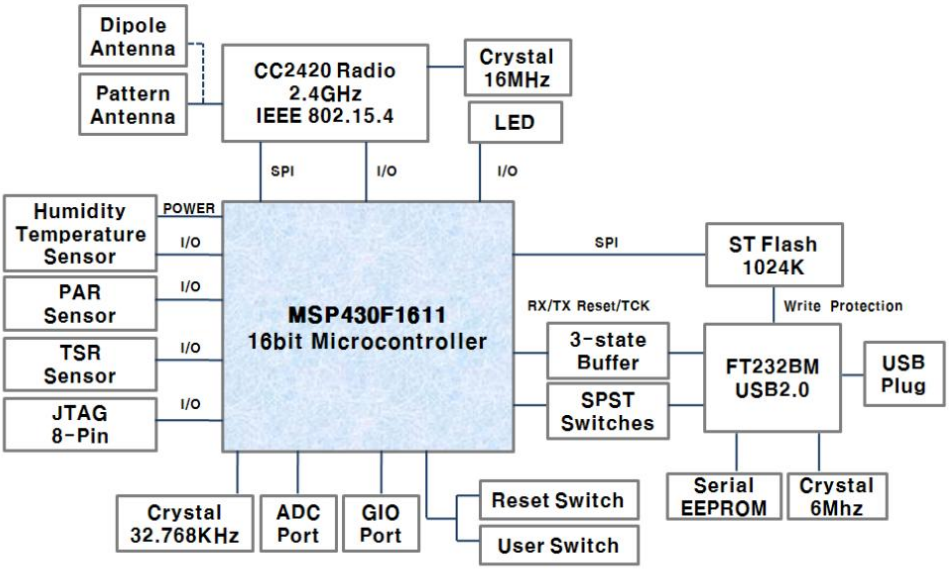

Figure 2: CM5000 Block Diagram

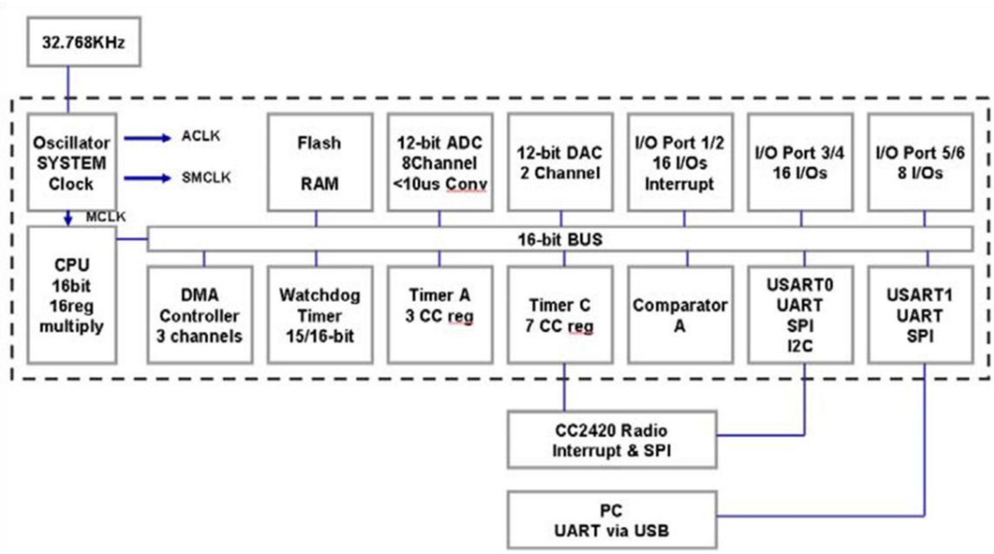

Figure 3: Interconnections between components

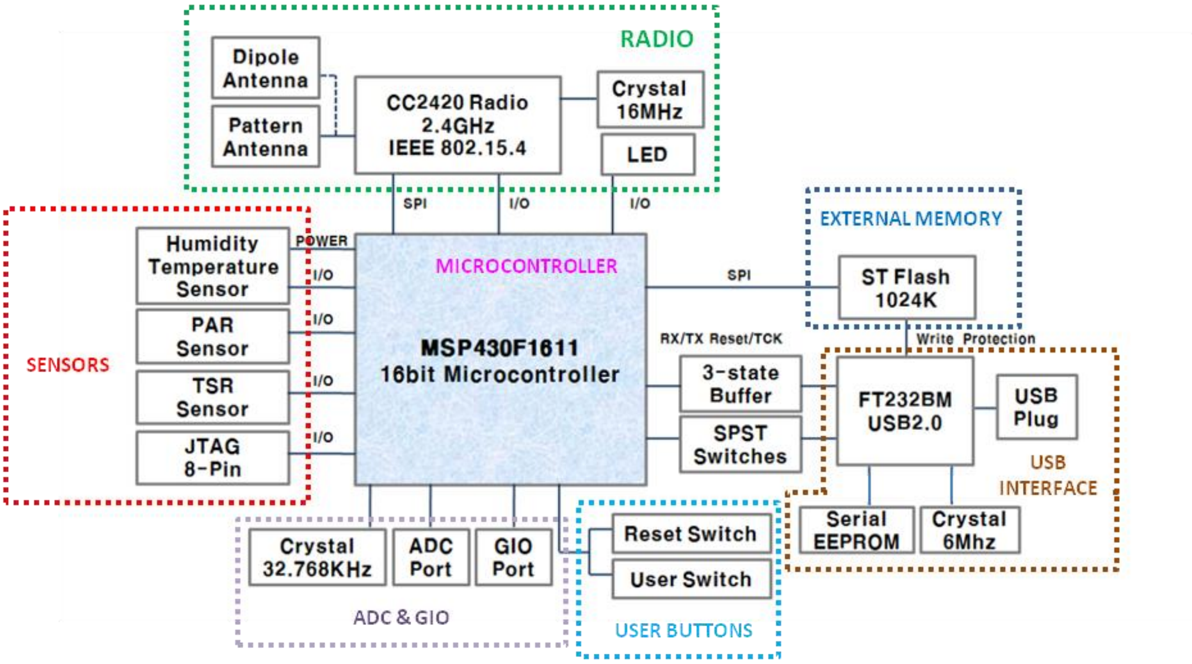

Figure 4: Sub-Component Diagram

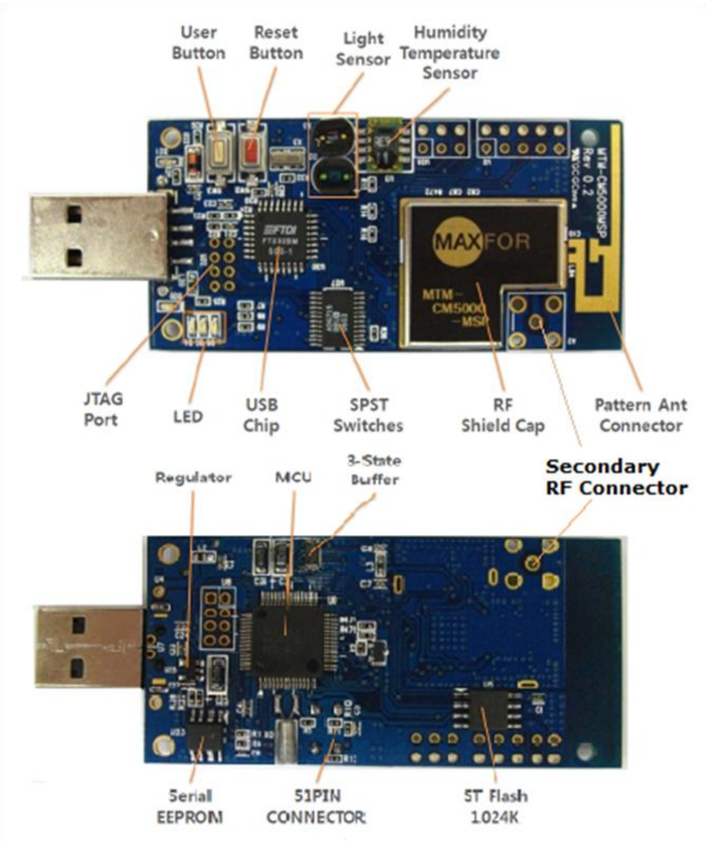

Figure 5: CM5000 Component Layout

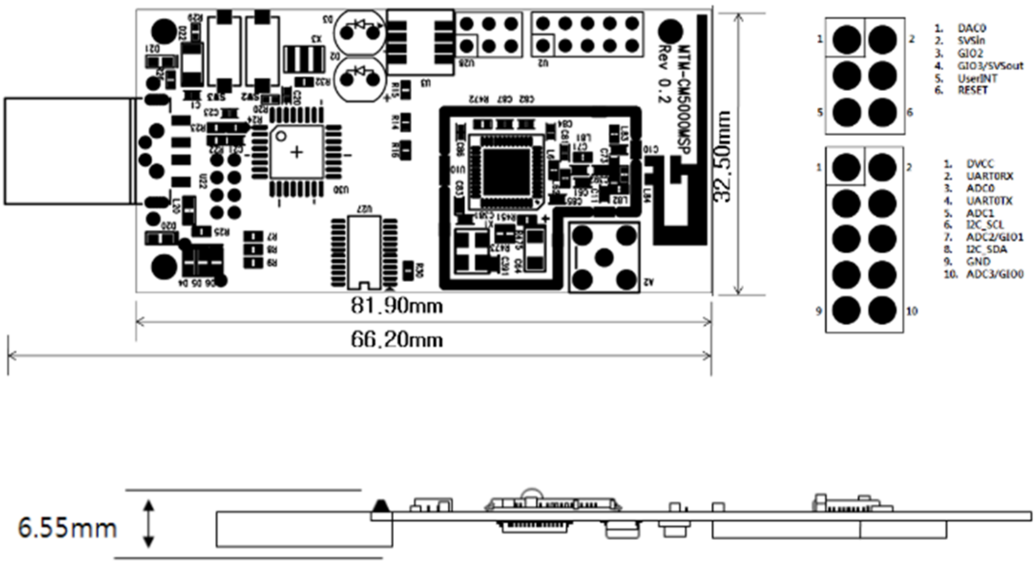

Figure 6: CM5000 Mechanical Characteristics

2.2 MICROCONTROLLER DESCRIPTION - TI MSP430F1611

At the heart of the MTM-CM5000_MSP Mote is the **MSP430F1611** microcontroller. This microcontroller belongs to the Texas Instruments MSP430 family of ultralow power microcontrollers. This architecture has five low power modes which are optimized to achieve extended battery life in portable measurement applications. The device features a powerful **16-bit RISC CPU**, **16-bit registers**, and **constant generators** that contribute to maximum code efficiency. The digitally controlled oscillator (DCO) allows wake-up from low-power modes to active mode in less than **6 µs**.

The MSP430F1611 has **two built-in 16-bit timers**, a **fast 12-bit A/D converter**, **dual 12-bit D/A converter**, **two universal serial synchronous/asynchronous communication interfaces (USART)**, **I2C**, **DMA**, and **48 I/O pins**. In addition, the MSP430F161x series offers extended RAM addressing for memory-intensive applications and large C-stack requirements.

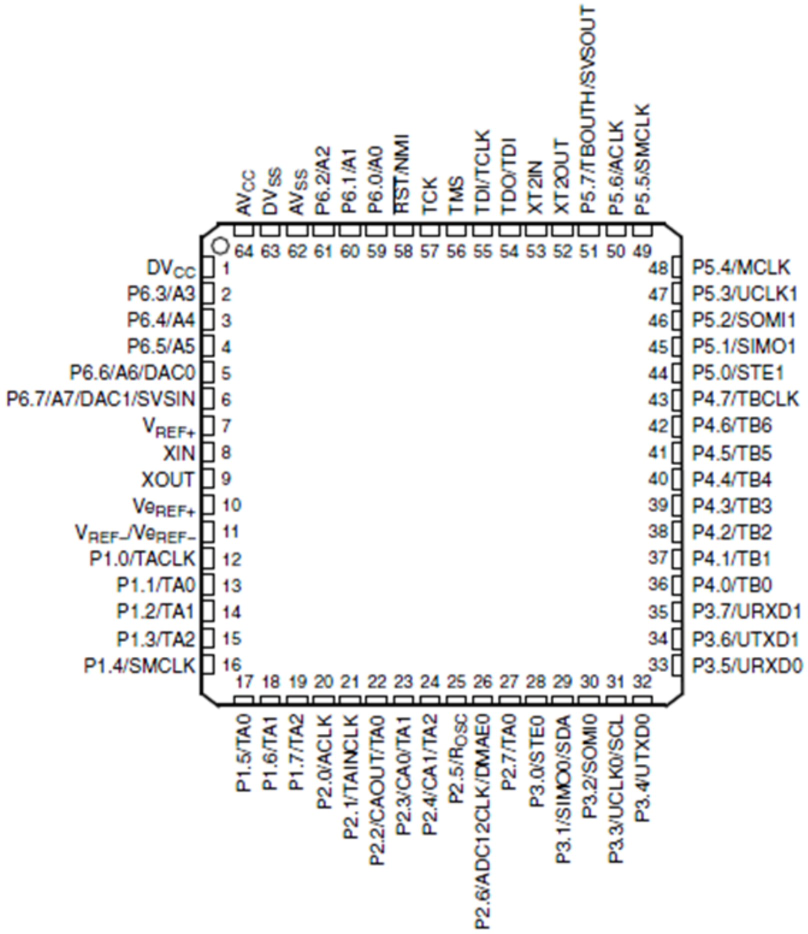

Figure 7: MSP430F1611 Microcontroller Pinout Diagram

			MIN	NOM	MAX	UNIT
Supply voltage during program execution, V_{CC} ($AV_{CC} = DV_{CC} = V_{CC}$)		MSP430F15x/16x/161x	1.8		3.6	V
Supply voltage during flash memory programming, V_{CC} ($AV_{CC} = DV_{CC} = V_{CC}$)		MSP430F15x/16x/161x	2.7		3.6	V
Supply voltage during program execution, SVS enabled (see Note 1), V_{CC} ($AV_{CC} = DV_{CC} = V_{CC}$)		MSP430F15x/16x/161x	2		3.6	V
Supply voltage, V_{SS} ($AV_{SS} = DV_{SS} = V_{SS}$)			0		0	V
Operating free-air temperature range, T_A		MSP430F15x/16x/161x	−40		85	°C
LFXT1 crystal frequency, $f_{(LFXT1)}$ (see Notes 2 and 3)	LF selected, XTS=0	Watch crystal		32.768		kHz
	XT1 selected, XTS=1	Ceramic resonator	450		8000	kHz
	XT1 selected, XTS=1	Crystal	1000		8000	kHz
XT2 crystal frequency, $f_{(XT2)}$		Ceramic resonator	450		8000	kHz
		Crystal	1000		8000	
Processor frequency (signal MCLK), $f_{(System)}$		V_{CC} = 1.8 V	DC		4.15	MHz
		V_{CC} = 3.6 V	DC		8	

NOTES:
1. The minimum operating supply voltage is defined according to the trip point where POR is going active by decreasing the supply voltage. POR is going inactive when the V_{CC} is raised above the minimum supply voltage plus the hysteresis of the SVS circuitry.
2. In LF mode, the LFXT1 oscillator requires a watch crystal. A 5.1-MΩ resistor from XOUT to V_{SS} is recommended when $V_{CC} < 2.5$ V. In XT1 mode, the LFXT1 and XT2 oscillators accept a ceramic resonator or crystal up to 4.15 MHz at $V_{CC} \geq 2.2$ V. In XT1 mode, the LFXT1 and XT2 oscillators accept a ceramic resonator or crystal up to 8 MHz at $V_{CC} \geq 2.8$ V.
3. In LF mode, the LFXT1 oscillator requires a watch crystal. In XT1 mode, LFXT1 accepts a ceramic resonator or a crystal.

Figure 8: Recommended operating conditions

The MSP430F1611 is designed for low power consumption. Depending on the mode, the approximate consumption of the component is:

- Active Mode: 330 µA at 1 MHz, 2.2 V
- Standby Mode: 1.1 µA
- Off Mode (RAM Retention): 0.2 µA

For more information on the microcontroller refer to the MSP430F1611 datasheet.

2.3 RADIO TRANSCEIVER DESCRIPTION - TI CC2420

The CC2420 is a true single-chip 2.4 GHz IEEE 802.15.4 compliant RF transceiver designed for low power and low voltage wireless applications. CC2420 includes a digital direct sequence spread spectrum baseband modem providing a spreading gain of 9 dB and an effective data rate of 250 kbps.

Figure 9: CC2420n Transceiver

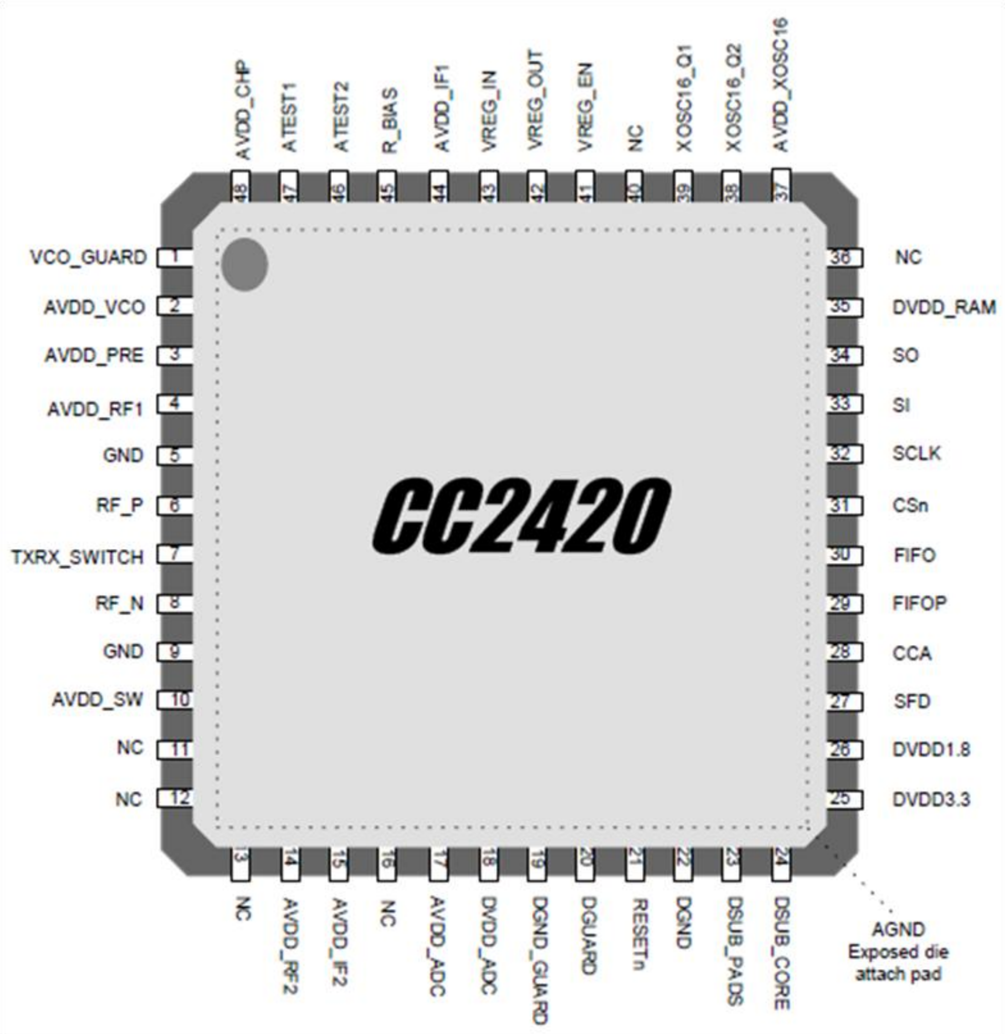

Figure 10: CC2420 Transceiver Pinout

Key Features:

- True single-chip 2.4 GHz IEEE 802.15.4 compliant RF transceiver with baseband modem and MAC support
- DSSS baseband modem with 2 MChips/s and 250 kbps effective data rate.
- Suitable for both RFD and FFD operation
- Low current consumption (RX: 18.8 mA, TX: 17.4 mA)
- Low supply voltage (2.1 – 3.6 V) with integrated voltage regulator
- Low supply voltage (1.6 – 2.0 V) with external voltage regulator
- Programmable output power
- No external RF switch / filter needed
- I/Q low-IF receiver
- I/Q direct upconversion transmitter
- Very few external components
- 128(RX) + 128(TX) byte data buffering
- Digital RSSI / LQI support
- Hardware MAC encryption (AES-128)

- Battery monitor
- QLP-48 package, 7x7 mm
- Complies with ETSI EN 300 328, EN 300 440 class 2, FCC CFR-47 part 15 and ARIB STD-T66
- Powerful and flexible development tools available

The TX power consumption of the CC2420 is dependent on the programmed output power:

Output Power [dBm]	Current Consumption [mA]
0	17.4
-1	16.5
-3	15.2
-5	13.9
-7	12.5
-10	11.2
-15	9.9
-25	8.5

Figure 11: Current Consumption vs. Output Power

In low power applications, the CC2420 should be powered down when not being active. Extremely low power consumption may be achieved when disabling also the voltage regulator, but this will require reprogramming of the register and RAM configuration.

The CM5000 mote has two antenna options—and internal antenna built into the module and an external SMA connector for connecting to external antennas. By default, CM5000 is shipped with the internal antenna enabled. If an application requires an external antenna or a different directional pattern than the internal antenna, an SMA connector may be installed and an antenna may be connected directly to CM5000's SMA female connector.

2.4 SENSOR DESCRIPTION

The CM5000 has integrated temperature, humidity and light sensors.

2.4.1 Temperature & Humidity Sensor - Sensirion® SHT11

The CM5000 uses the well known **Sensirion® SHT11** sensor, which is specially suitable for low power consumption air temperature & humidity measurements. This sensor is managed by the mote using a two wire interface. For more information

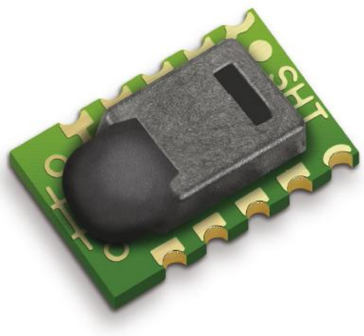

Figure 12: Sensirion® SHT11 Sensor

regarding the electrical characteristics and communication specifics check the sensor's datasheet.

Key features:

- 14-bit internal ADC temperature conversion
- 12-bit internal ADC humidity conversion
- Temperature Resolution: 0.01 (typical)
- Temperature Accuracy: ± 0.5 ^{o}C (typical)
- Humidity Resolution: 0.05 (typical)
- Humidity Accuracy: ± 4.5 %RH (typical)

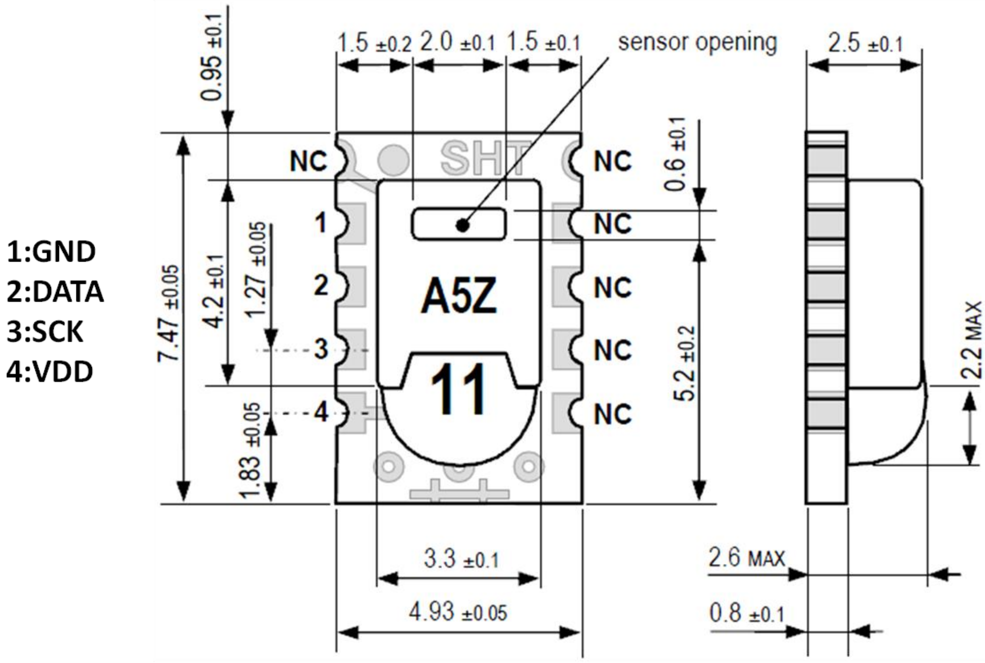

Figure 13: SHT11 Dimensions

Conversion formulas:

Sensor readings are received as 2-byte values from the internal ADC. They have to be converted using the following formulas:

Temperature(Tc) = -39.60 + 0.01 * adc_temperature_value

Humidity(%) = -4 + 0.0405 * adc_humidity_value + (-2.8 * 10^{-6}) * (adc_humidity_value^2)

Humidity_True(%) = (Tc -25) * (0.01 + 0.00008 * adc_humidity_value) + Humidity

Humidity_True corrects the humidity value for those situations where the temperature is far from 25 ^{o}C.

These conversion formulas assume a stable voltage of 3V. When the voltage is reduced, as it can happen with some batteries when they are being used up, it may be necessary to correct them. See SHT11 datasheet for more details.

2.4.2 Light Sensor - Hamamatsu® S1087 / S1087-01

The CM5000 provides two light sensors, the Hamamatsu® S1087 for visible range measurements and the S1087-01 for visible to infrared range. Both of them give their measurements in lx.

These analogue sensors are connected to the mote's microcontroller ADC4 and ADC5 pins.

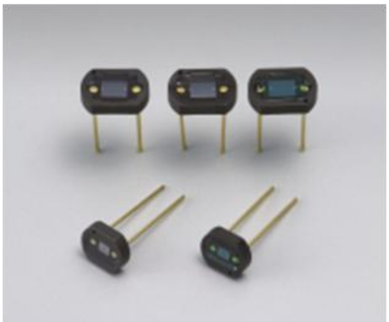

Figure 14: Hamamatsu® S1087

Key features:

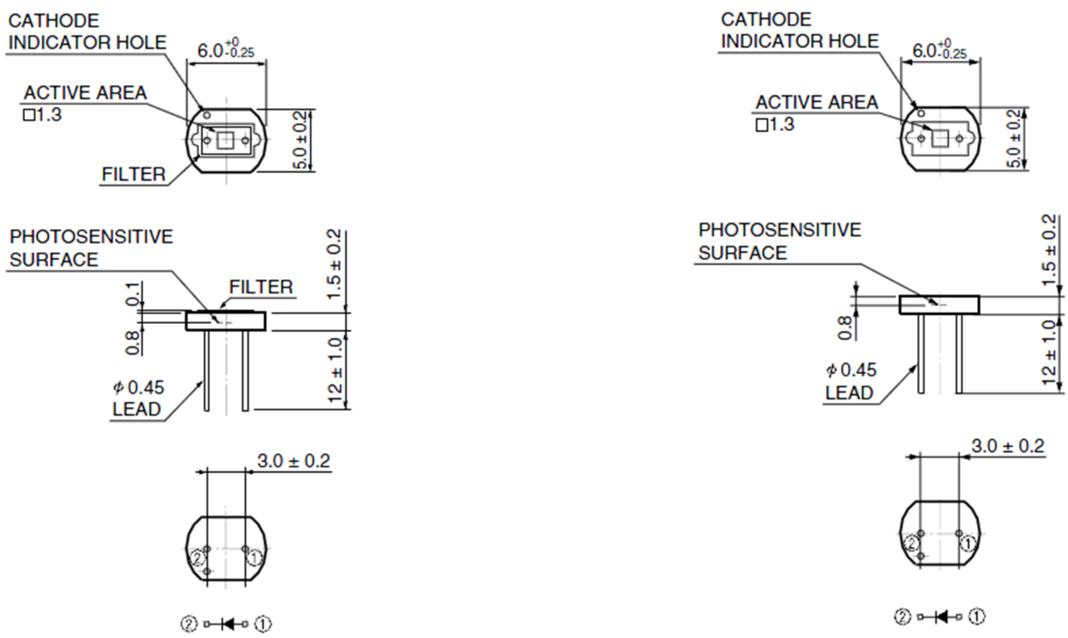

Figure 15: Hamamatsu S1087 Mechanical Characteristics

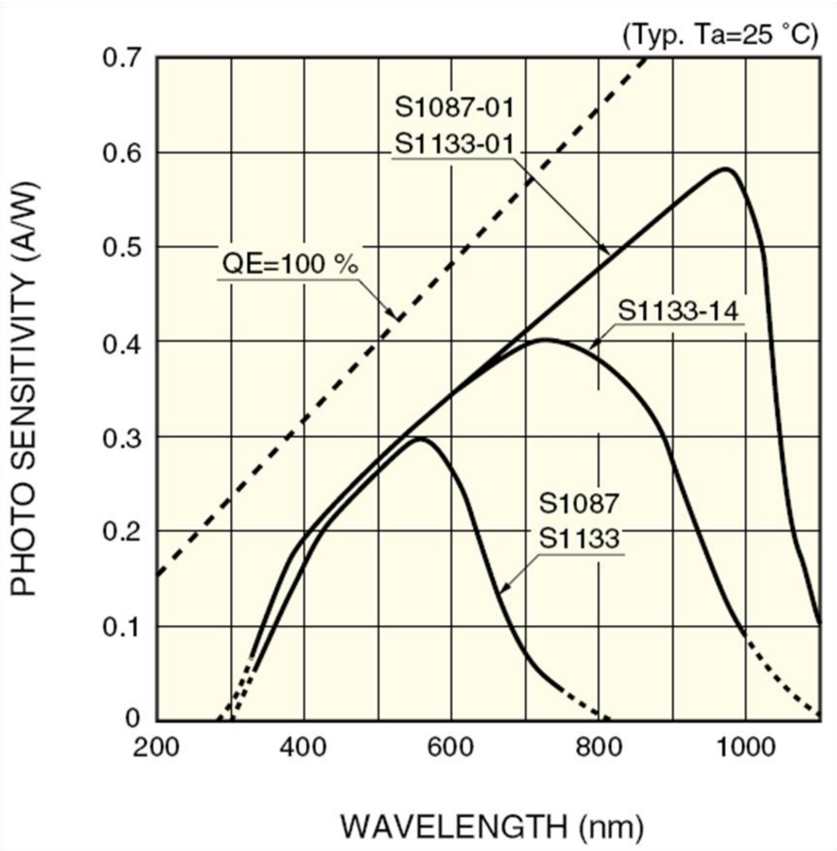

Figure 16: S1087/S1087-01 Photosensitivity vs. Wavelength

Type No.	Spectral response range λ (nm)	Peak sensitivity wavelength λp (nm)	Photo sensitivity S (A/W) λp	Photo sensitivity S (A/W) GaP LED 560 nm	Photo sensitivity S (A/W) He-Ne laser 633 nm	Infrared sensitivity ratio (%)	Short circuit current Isc 100 lx (µA)	Temp. coefficient of Isc (%/°C)	Dark current ID VR=1 V Max. (pA)	Temp. coefficient of ID TCID (times/°C)	Rise time tr VR=0 V RL=1 kΩ (µs)	Terminal capacitance Ct VR=0 V f=10 kHz (pF)	Shunt resistance Rsh VR=10 mV Min. (GΩ)	Shunt resistance Rsh VR=10 mV Typ. (GΩ)
S1087	320 to 730	560	0.3	0.3	0.19	10	0.16	-0.01	10		0.5	200		250
S1087-01	320 to 1100	960	0.58	0.33	0.38	-	1.3	0.1						
S1133	320 to 730	560	0.3	0.3	0.19	10	0.65	-0.01		1.12	2.5	700	10	100
S1133-01	320 to 1100	960	0.58	0.33	0.38	-	5.6	0.1						
S1133-14	320 to 1000	720	0.4		0.37	-	3.4		20		0.5	200		50

Figure 17: S1087/S1087-01 Properties

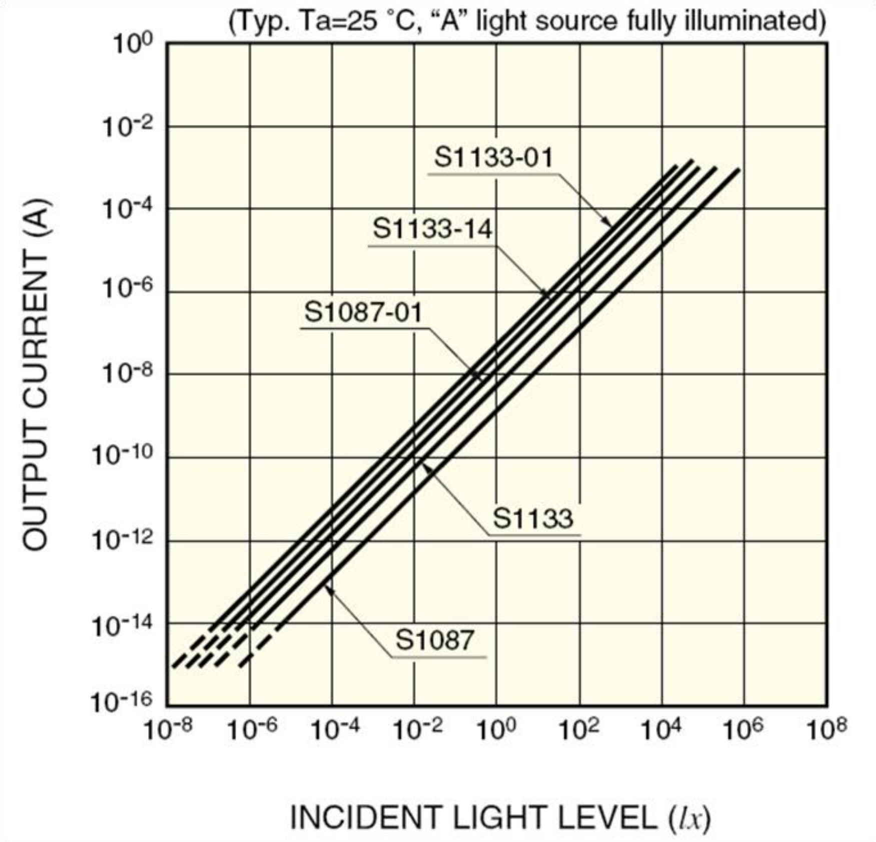

Figure 18: S1087/S1087-01 Output Current vs. Incident Light Level

Conversion formulas:

S1087 Light(lx) = 2.5 * (adc_Light_value) / 4096) * 6250

S1087-01 Light(lx) = 1.5 * (adc_TSR_value) / 4096) * 1000

2.5 USB INTERFACE DESCRIPTION - FTDI® FT232BM

The CM5000 has a USB interface attached. This allows transmitting the information from the mote to a PC or similar device. It is also used to reprogram the mote's hardware with new firmware.

At the heart of the USB interface lies a **FTDI® FT232BM** which provides USB to UART compatibility.

Figure 19: FTDI® FT232BM

Key features:

The FT232BM chip provides:

- Single chip USB <=> asynchronous serial data transfer
- Full handshaking & modem interface signals
- UART interface supports 7/8 data bits, 1/2 stop bits and Odd/Even/Mark/Space/No Parity
- Data transfer rate of 300 Baud => 3M Baud (TTL)
- Data transfer rate of 300 Baud => 1M Baud (RS232)
- Data transfer rate of 300 Baud => 3M Baud (RS422/RS485)
- 384 Byte Rx buffer/128 Byte Tx buffer for high data throughput
- Adjustable Rx buffer timeout
- Fully assisted hardware or X-On/X-Off handshaking
- Built-in support for event characters and line break condition
- Auto transmit buffer control for RS485
- Support for USB suspend/resume through SLEEP# and RI# pins
- Support for high power USB bus powered devices through PWREN# pin
- Integrated level converter on UART and control signals for interfacing to 5V and 3.3V logic
- Integrated 3.3V regulator for USB IO
- Integrated Power-On-Reset circuit
- Integrated 6MHz - 48Mhz clock multiplier PLL
- USB Bulk or Isochronous data transfer modes
- 4.35V to 5.25V single supply operation
- UHCI/OHCI/EHCI host controller compatible
- USB 1.1 and USB 2.0 compatible
- USB VID, PID, serial number and product description strings in external EEPROM
- EEPROM programmable on-board via USB
- Compact 32-LD LQFP or QFN-32 package
- Available as a Lead-free device (FT232BL and FT232BQ) compliant to EU directive 2002/95/EG RoHS

2.6 EXTERNAL MEMORY DESCRIPTION - ST® M25P80

The CM5000 mote has a 1MB external flash memory for use.

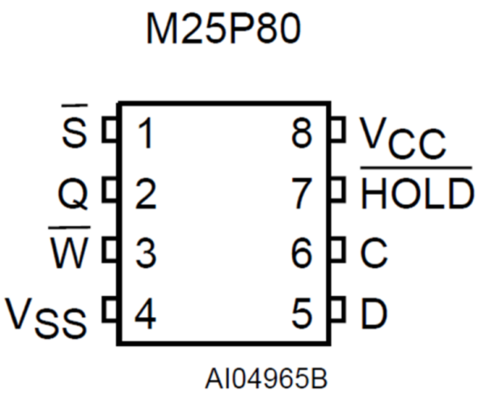

Figure 20: ST® M25P80

2.7 USER BUTTONS DESCRIPTION

Two buttons are available on the mote, one provides a hardware reset that reboots the device, and the other can be programmed as it is directly wired to the microcontroller.

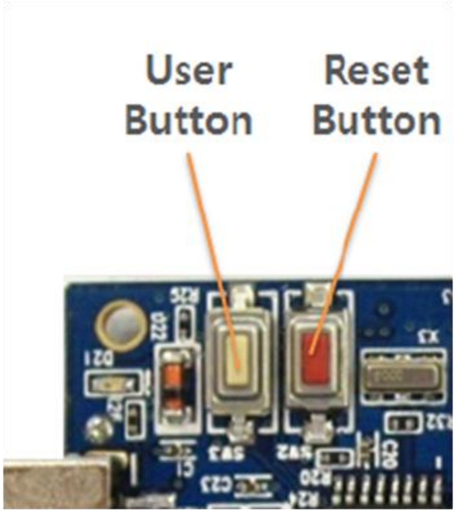

Figure 21: User & Reset Buttons

2.8 ADC & GIO PIN DESCRIPTION

The mote has several pins available to connect external peripherals.

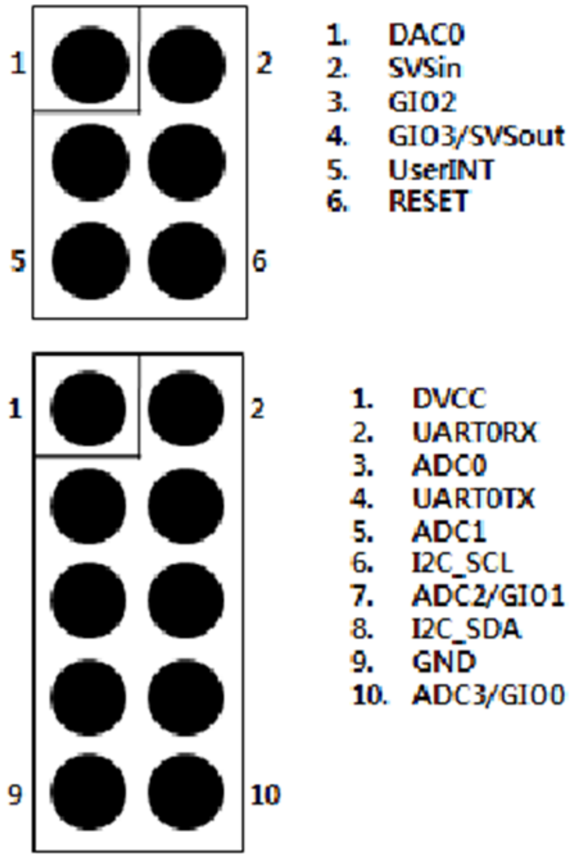

Figure 22: ADC & GIO PIN

2.9 POWER CHARACTERISTICS

The CM5000 mote can be powered either by plugging the USB to a host computer, or by using batteries. The provided battery holder allows using 2xAA batteries, but the mote itself can be powered by a wide variety of ways, since it internally has a voltage regulator that adapts the power input to the needed voltage. The regulator is a

MICREL MIC5207, and it is recommended to refer to its datasheet before using alternative power sources.

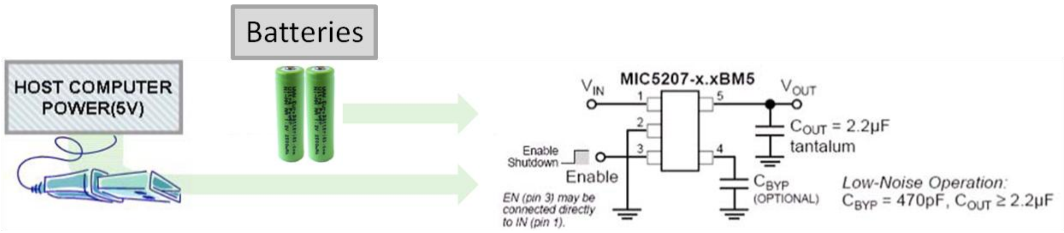

Figure 23: Power Feed Schema

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