Mica2 Data Acquisition Board

FEATURS

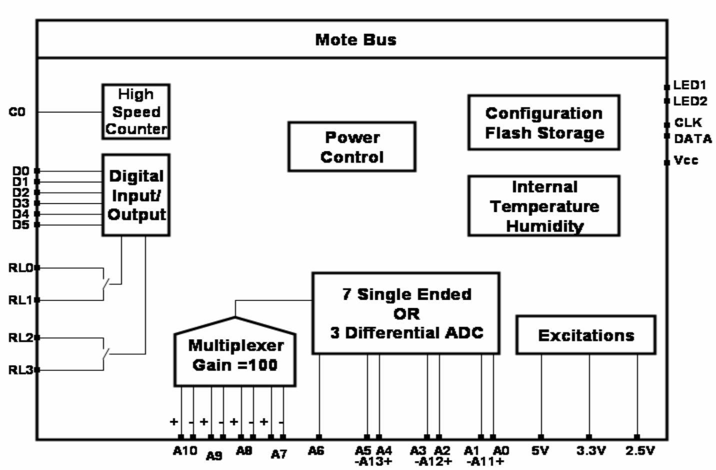
- **Mica2 daughter Board**
- **7 single ended 12bit ADC channels**
  Range 0-2.5V, precision 0.6mV
- **3 differential 12bit ADC channels**
  Range 0-2.5V, precision 0.6mV
- **4 differential 12bit ADC channels with high gain**
  Range ±12.5mV, precision 6μV
- **3 Excitation**
  2.5V, 3.3V, 5.0V
- **6 Interrupt driven digital Input**
- **6 Digital output**
- **One relay normally closed**
- **One relay normally open**
- **One high speed counter channel**
- **Low power sleep**
- **On board temperature and humidity sensor**
- **On-board E2PROM for channel configuration**
- **Miniature terminals for easy sensor connection**
- **Software driver for TinyOS**

APPLICATIONS

- **Wireless Low power instrumentation**
- **Weather measurement systems**
- **Precision Agriculture and irrigation control**
- **Habitat monitoring**
- **Soil analysis**
- **Remote process control**

Description

MDA300CA is designed as a general measurement platform for Mica2. Analog sensors can be attached to different channels based on the expected precision and dynamic range. Digital sensors can be attached to the provided digital or counter channels. Mote samples analog, digital or counter channels and can actuate via digital outputs or relays. The combination of the Mote (MPR400CB) and MDA300CA can be used as a low power wireless Data acquisition device or process control machine.



Absolute Maximum Ratings:
+VDD to GND..............................–0.3V to +5.5V
Operating Temperature Range ...40°C to +105°C
Digital Lines:
Input voltage range*............-0.5 V to V_{DD}+ 0.5 V
Continuous output low current................50 mA
Continuous output high current..............–4 mA
Analog Lines:
Input voltage range. ....-0.2 V to V_{CC} + 0.5 V
Counter Line:
Input voltage range ....0 V to 5.5V
Relays:
Maximum Contact Voltage......................100V
Maximum Contact Current...................150mA

*The input negative-voltage ratings may be exceeded if the input and output current ratings are observed.

This board can be damaged by ESD. ESD damage can range from subtle performance degradation to complete device failure.

Parts in yellow are not in current implementation.

Electrical Characteristics: +2.7V

Analog channels

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
ANALOG INPUT (A0-A6;A11-A13)					
Full-Scale Input Scan	Positive Input - Negative Input	0		2.5V	V
Absolute Input Range	Positive Input	-0.2		VDD+0.2	V
	Negative Input	-0.2		+0.2	V
Capacitance			25		pF
Leakage Current			±1		µA
SYSTEM PERFORMANCE					
No Missing Codes		12			Bits
Integral Linearity Error			±0.5	±1	LSB*
Differential Linearity Error			±0.5	-1,+2	LSB
Offset Error			±0.75	±2	LSB
Offset Error Match			±0.2	±1	LSB
Gain Error			±0.75	±3	LSB
Gain Error Match			±0.2	±1	LSB
Noise			33		µVrms
Power-Supply Rejection			82		dB
Precision Differential Channels (A7-A10)					
Offset Error	Software Calibration		±1		LSB
Gain Error				±0.2	%
Input Impedance			1.0		MΩ

*LSB means Least Significant Bit. For channels A0-A6 and A11-A13 it is 0.6mv and for A7-A10 it is 6µv.

Internal channels

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
TEMPRATURE INPUT					
Range		-40		85	°C
Accuracy	@ 5-40°C		±0.4		°C
	@ <5°C or >40°C			±1.5	°C
HIMIDITY INPUT					
Range		0		100	%
Accuracy	@ 10-90% non-condensing		±2		%
	@ >10% or <90%		±4		%
Hystersis					%
BATTERY VOLTAGE INPUT					
Accuracy*	Using Internal Mica2 circuit			5	mV

*For correct voltage reading Mica2' JTAG should be disabled. Consult the "BatteryM.nc" inside tos/sensorboards/mda300ca for instruction or consult with manufacturer at Xbow (http://www.xbow.com).

Digital channels

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
VIH High-level input voltage		0.7×VCC		VCC + 0.5V	V
VIL Low-level input voltage		–0.5		0.3 ×VCC	V
IOH High-level output current				–1	mA
IOL Low-level output current				25	mA

Counter channel

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Recommended Range	It also depend on the mote working load			200	Hz
VT+ Positive-going input threshold voltage		1.2		2.2	V
VT- Negative-going input threshold voltage		0.9		1.9	V

Excitation

PARAMETER	COMPONENT	MIN	TYP	MAX	UNITS
5.0V*					
Output drive**			±22		mA
Short circuit current			±59		mA
Accuracy			±2		%
3.325V*					
Output drive**			±22		mA
Short circuit current			±59		mA
Accuracy			±2		%
2.5*					
Output drive**			±22		mA
Short circuit current			±59		mA
Accuracy			±2		%

*Excitations are proportional to the ADC reference for maximum accuracy.
**Driving Capacitive Load needs special consideration for prevention from oscillation. Refer to excitation section.

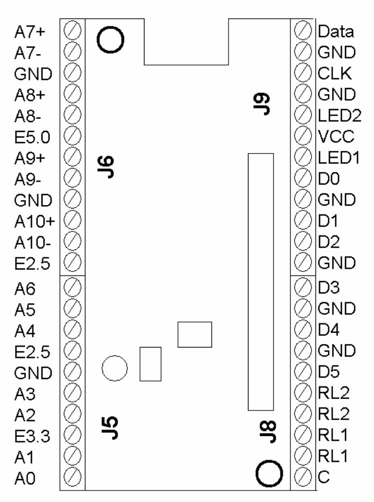
Power Consumption

PARAMETER	COMPONENT	ACTIVE (TYP)	POWER DOWN(TYP)	UNITS
Part Break-down				
TLV2473IDGQR	U11	1100	1	µA
TLV2473IDGQR	U12	1100	1	µA
MAX1795EUA	U10		0.1	µA
SN74AHC1G86DBVR	U6	1	1	µA
PCF8574APWR	U8	40	2.5	µA
PS7112L-1A	RL1	2500-3500	0	µA
PS7141L-1B	RL2	2500-3500	0	µA
ADS7828EB	U1	150-300	0.4	µA
INA321E	U2	40	0.01	µA
TLV2370IDBVR	U3	470	25	µA
SHT15	U5	550	0.3	µA
ADG715BRU	U4	10	10	µA
24LC64-I/SN	U9	1000-3000	30	µA
SN74AHC1G14DBVR	U7	1	1	µA
MDA300CA	Complete Board		73	µA

Timing Parameters

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
I2C Clock	Hardware I2C		80		KHz
ADC Conversion Time			6		µSec
ADC Throughput Frequency			2		KHz
Digital Lines delay (Input/Output)			4		MSec
Relay ON/OFF time				0.4	mSec

PIN CONFIGURATION



TOP VIEW

PIN DESCRIPTION

A0	Single-ended analog channel 0 or analog channel 11 positive side
A1	Single-ended analog channel 1 or analog channel 11 negative side
A2	Single-ended analog channel 2 or analog channel 11 positive side
A3	Single-ended analog channel 3 or analog channel 11 negative side
A4	Single-ended analog channel 4 or analog channel 11 positive side
A5	Single-ended analog channel 5 or analog channel 11 negative side
A6	Single-ended analog channel 6
A7+ A7-	Differential analog channels 7
A8+ A8-	Differential analog channels 8
A9+ A9-	Differential analog channels 9
A10+ A10-	Differential analog channels 10
DATA	I2C Data
CLK	I2C Clock
D0 - D6	Digital Lines D0 to D6
C	Counter Channel
LED1	RED LED
LED2	GREEN LED
E5.0	5.0 V excitation
E3.3	5.0 V excitation
E2.5	5.0 V excitation
Vcc	Vcc of the Mote
RL1	Relay one sides (Normally-Open)
RL2	Relay two sides (Normally-Closed)

Theory of Operation:

Single Ended Analog Channels

Channels A0-A6 are single ended successive approximation A/D converters. The reference of the ADC is 2.5V. Signals with dynamic range of 0-2.5V can be plugged to these channels. The least significant bit value is 0.6mV. The result of ADC can be converted to voltage knowing that Voltage = 2.5 × ADC-READING / 4096.

Note that these channels are shared with differential channels A11-A13 and both of them cannot be used at the same time.

Differential Analog Channels

Channels A11-A13 can be used for differential signals. Dynamic range and conversion formula is the same as single ended channels.

Differential Precision Analog Channels

Channels A7-A10 are precision differential channels. They have a sensor front end with gain of 100. Dynamic range of these channels is ±12.5mV. The offset is cancelled by measurement of the constant offset and writing it to the E2PROM for software cancellation. The result of the ADC can be converted to voltage (in mv) knowing that Voltage = 12.5 (ADC_READING /2048 -1)

Digital Channels

Channels D0-D5 are Digital channels that can be used for digital input or output. They can be used for counting external phenomena, triggering based on external events or for actuating external signal.

The result of these channels can be saved to the E2PROM for totalizing sensors to avoid losing count in case of power reset. These channels can be protected against switch bouncing. When they set as input they have internal pull-up resistance so that they can be plugged to switch (close-open) sensors.

Counter Channel

This channel is appropriate for high-speed counting or frequency measurement. It has a Schmitt triggered front end.

Internal Channels

There is an internal sensor for temperature and humidity. This can be used for monitoring the health of the system. It can also be used for “cold junction compensation” in thermocouple measurement applications. The Voltage of the device also can be read using the Mica2’s internal monitor to have lifetime information.

Relay Channels

There are two relay channels that can be used for actuation of external phenomena. Both relays are optical solid state for maximum isolation and minimum power consumption. One relay is normally open and the other one is normally closed type.

External Sensors Excitation

There are three excitation of 5.0V, 3.3V, and 2.5V available for exciting external sensors. They can be used for turning on active external sensors or they can be used in half bridge or full bridge sensors such as strain gauge, force or pressure measurement.

LEDs

LED signals are brought out for applications that use motes inside enclosures and want to bring the LEDs to the case.

Power Supply (Vcc)

It can be used for external Battery attachment.

SOFTWARE ARCHITECTURE

Architecture

The software driver is written in nesC under tinyOs-1.x. There is only one component (SamplerC.nc) that user needs to include and that component abstracts all components of the MDA300A underneath.

The Sample interface (provided by SamplerC.nc) lets the application to call all the channels periodically (or one-shot) with necessary parameters. Application will continuously receives the corresponding event based on the time interval setting. It will receive the event only once in the case of ONE_SHOT an in the case of digital or counter channels it receives the event asynchronously if EVENT parameter has been set. On call for the sample a record number is returned that can be used for reconfiguration or retaking of that sampling. Note that multiple calls in different intervals can be used for one channel.

Digital channels can be set to output and the corresponding channels can be set to high, low or toggle. Relay channels are output by default and can be set

If sampling of different records collides on a shared resource like ADC the underlying software holds the sampling until the shared resource is free.

Sampling of internal temperature and humidity channels faster than on second interval may lead to internal sensor self heating and is not recommended.

The data that returns in the event is the raw value of ADC in case of ANALOG channels. It is the counter value in the case of COUNTER and DIGITAL channels. It is battery voltage in mili-volt in VOLTAGE channel, is humidity in 0-100% ranges in HUMIDITY channel and temperature in 0.1 Fahrenheit resolutions in TEMPRATURE channel.

Sampler leaves all underneath hardware in sleep when no sampling in progress. All external interrupts including digital and counter channels are active at that time.

Sample.nc Interface

Sampling Channels Synchronously or Asynchronously
command int8_t[5] **getSample**(uint8_t **channel**[1],uint8_t **channelType**[2],uint16_t **interval**[3],uint8_t **param**[4]);
event result_t **dataReady**(uint8_t **channel**[1],uint8_t **channelType**[2],uint16_t **data**[6]);
command result_t **reTask**(int8_t **record**[5],uint16_t **interval**[3]);
command result_t **reParam**(int8_t **record**[5],uint16_t **param**[4]);
command result_t **stop**(int8_t **record**[5]);
Digital Outputs
command result_t **set_digital_output**(uint8_t **channel**[7]);
command result_t **High**(uint8_t **channel**[8]);
command result_t **Low**(uint8_t **channel**[9]);
command result_t **Toggle**(uint8_t **channel**[8]);

1 it can be 0-13 in case of ANALOG; 0-6 in case of DIGITAL and it is irrelevant in case of COUNTER, VOLTAGE, TEMPRATURE and HUMIDITY.
2 it can be ANALOG, DIGITAL, COUNTER, TEMPRATURE, HUMIDITY or VOLTAGE.
3 **Interval in the order of 0.1 second.** **It can also be set to ONE_SHOT.**
4 parameters that are described in the following tables.
5 The record number that getSample returns for later operations like reTasking or reParametring or stopping that record.
6 raw data from ADC or Counters.
7 channels 0-6.
8 channels 0-6, NORMALLY_OPEN_RELAY, NORMALLY_CLOSE_RELAY

Channel Parameters; ANALOG*

SAMPLER_DEFAULT	No Excitation, No Averaging, Sample Immediately
AVERAGE_FOUR	Return the result average of four sample
AVERAGE_EIGHT	Return the result average of eight sample
AVERAGE_SIXTEEN	Return the result average of sixteen sample
EXCITATION_25	Turn 2.5V excitation before sampling
EXCITATION_33	Turn 3.3V excitation before sampling
EXCITATION_50	Turn 5.0V excitation before sampling
EXCITATION_ALWAYS_ON	Leave excitation always ON. Default is only ON before sampling of the specified channels.
DELAY_BEFORE_MEASUREMENT	After turning excitation ON insert delay before sampling. Default is immediate sampling. This is specifically important in capacitive sensors. Delay is fixed and it is equal to 50ms.

* Channels 0-13

Channel Parameters; DIGITAL*

SAMPLER_DEFAULT	No Excitation, Action based on rising edge, Synchronously based on the interval
RISING_EDGE**	Action based on rising edge
FALLING_EDGE**	Action based on falling edge
EVENT	The event fired asynchronously at the edge, interval is irrelevant
EEPROM_TOTALIZER	Keeps the last reading in EPROM. Continue at power ON from last reading. Always update EEPROM.
EXCITATION_33	Turn 3.3V excitation ON (always)
EXCITATION_50	Turn 5.0V excitation ON (always)
RESET_ZERO_AFTER_READ	Reset variable to zero for measurement of frequency. Default is accumulative.
DEBOUNCER	Turn on de-bouncer filter

*Channels 0-6
** if both RISING_EDGE and FALLING_EDGE action happens on both edge.

Channel Parameters; COUNTER*

SAMPLER_DEFAULT	No Excitation, Action based on rising edge, Synchronously based on the interval
RISING_EDGE**	Action based on rising edge
FALLING_EDGE**	Action based on falling edge
EVENT	The event fired asynchronously at the edge , interval is irrelevant
EEPROM_TOTALIZER	Keeps the last reading in EPROM. Continue at power ON from last reading. Always update EEPROM.
EXCITATION_33	Turn 3.3V excitation ON (always)
EXCITATION_50	Turn 5.0V excitation ON (always)
RESET_ZERO_AFTER_READ	Reset variable to zero for measurement of frequency. Default is accumulative.

*Channel is irrelevant
** if both RISING_EDGE and FALLING_EDGE action happens on both edge.

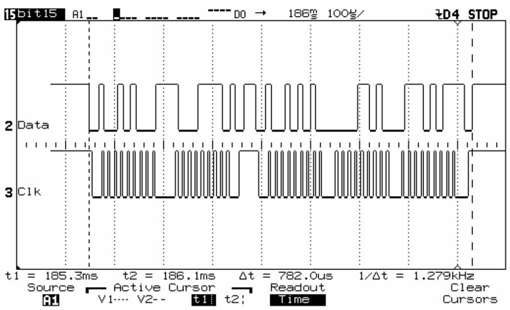
Channel Parameters; VOLTAGE, TEMPRATURE, HUMIDITY*

SAMPLER_DEFAULT	No effect

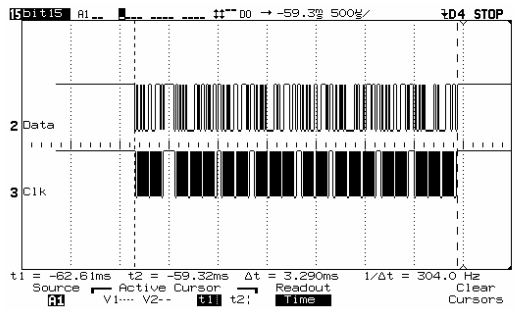
*Channel is irrelevant

Timing Diagram and Parameters

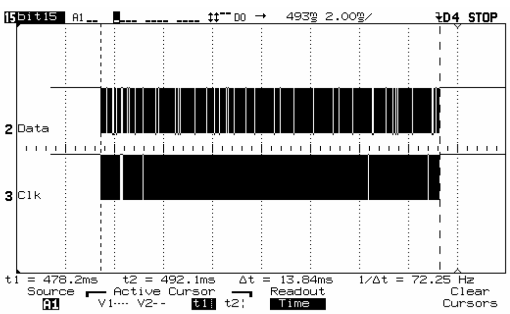
ADC sampling time is 782µSec and the effective throughput is 1.279KHz. I2C Clock is 80KHz.



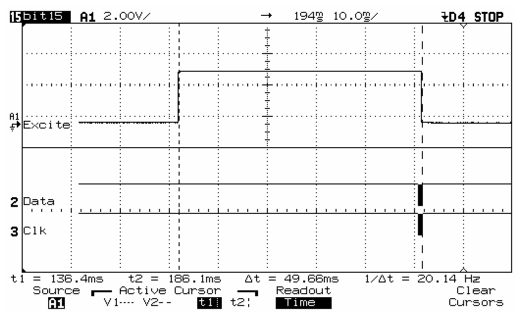
ADC sampling time increases with AVERAGE_FOUR option to 3.29ms and the effective throughput is reduced to 304Hz.



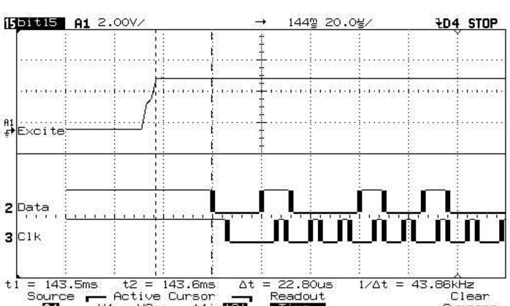
ADC sampling time increases with AVERAGE_SIXTEEN option to 13.84ms and the effective throughput is reduced to 72.25Hz.



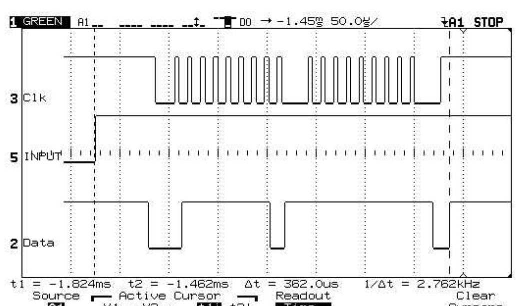
DELAY_BEFORE_MEASUREMENT turns excitation immediately but delays sampling 50ms so that the sensor gets stable. This has effect on the maximum sampling throughput, which will be reduced to 20Hz.



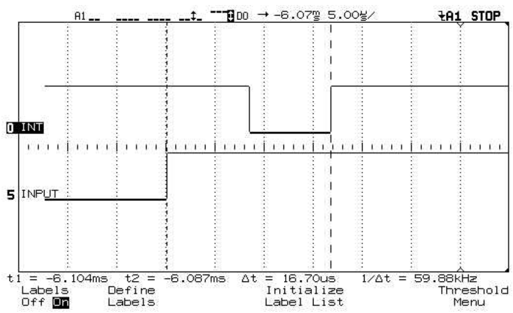
The delay time between stability of excitation and start of sampling is 22.8µSec in no load condition. If the sensor is not stable by that time, then the option DELAY_BEFORE_MEASURMENT should be called for the sensor to be stable. This is specially may be important in the case of capacitive sensors.



Delay of Digital line is 362µSec. This picture shows the time from the edge of the input to the end of reading of the status of digital lines.

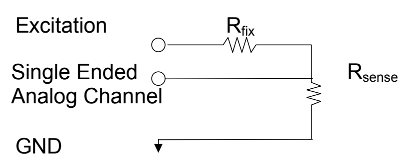


Delay of Counter line is 16.7µSec.



Example Application

Measurement of External temperature (air, soil, water) using NTC or PTC thermistor:
NTC is "Negative Coefficient" and PTC is "positive Coefficient" temperature sensor. They are very precise and are widely used in industry. They are used as below:



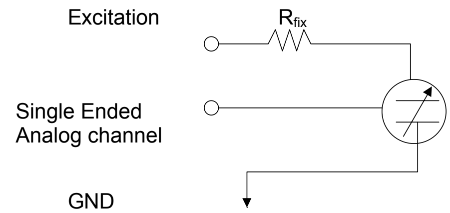
Sensor*	THERMISTOR 10K OHM NTC From "BC Components" part number "2322 640 55103"
Rfix**	13K0.1%
Excitation	2.5V
Sample Code***	record = call Sample.getSample(1,ANALOG,600,EXCITATION_25);
Conversion****	result = (int)(0.5 + 10 * (110.2149 - 1.138253e-1 * adc + 7.509040e-5* adc * adc - 3.188276e-8* adc* adc * adc + 7.069376e-12* adc * adc * adc * adc - 6.502949e-16* adc *adc *adc * adc * adc));

*It can be purchased from digikey, www.digikey.com ; BC1489-ND
**13K 0.1% resistors from Mouser Electronics, www.mouser.com part 66-RC55-D-13K
***In the sample code channel one called each 60 second as example and it can be any of the channels 0-6.
****This polynomial gives less than 0.1°C error over -25 to 60 results in tenths of a degree.

Sensor	Water and Soil Temperature Sensors probe 108 from Campbell Scientific, http://www.campbellsci.com/
Rfix	None, internal inside the sensor.
Excitation*	5.0V
Sample Code**	record = call Sample.getSample(1,ANALOG,600,EXCITATION_25);
Conversion	To be determined

*5.0V excitation gives 125mV range which can be resolved to 125mV/0.6mV or 0.48%. Note to turn off channels not to let channels be always on to avoid self heating which may lead to calibration error in measurement.
**In the sample code channel one called as example and it can be any of the channels 0-6.
***For air temperature a sun shield needed for maximum accuracy.

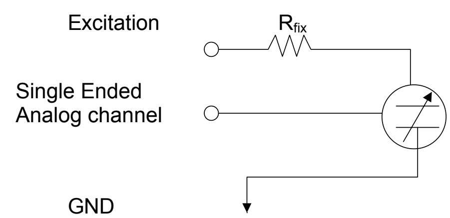
Measurement of Humidity:
Humidity sensors are usually capacitive sensor.



Sensor*	HumiRel HM1500; immersion OK, with NTC temperature compensation
Rfix**	10Ω
Excitation	3.3V
Sample Code***	record = call Sample.getSample(1,ANALOG,600,EXCITATION_33 | DELAY_BEFORE_MEASUREMENT | AVERAGE_FOUR);
Conversion****	result= (int) ((-3.9559e-6*adc * adc + 6.1797e-2*res-67.681) +0.5);

*can be purchased from Digikey, www.digikey.com ; HM1500-ND
**Only in beta release of the board to avoid oscillation of excitation with capacitive loads. It can be purchased from Digikey, www.digikey.com ; 10.0XBK-ND
***In the sample code channel one called as example and it can be any of the channels 0-6. Delay before excitation is necessary in driving capacitive loads for sensor stability.
****in 0-100% humidity

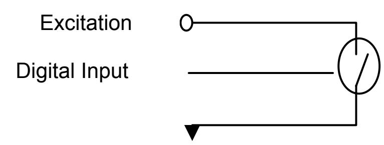
Measurement of Soil Moisture:
Soil Moisture sensors are usually capacitive sensor. EC-10 and EC-20 are particularly good at measurement of soil moisture in wet conditions. In dry conditions needs carefull calibration for specific soil type. Also in the presence of the contamination may need extra calibration. Consult manufacturer for further information.



Sensor	Decagon Echo ECHO10 and EC-20; http://www.decagon.com/
Rfix*	10Ω
Excitation	2.5V
Sample Code**	record = call Sample.getSample(1,ANALOG,600,EXCITATION_33 | DELAY_BEFORE_MEASUREMENT | AVERAGE_FOUR);
ECHO-10 Conversion***	`conv= ((float)adc) *2.5 /4096;` `result = (int)(100*(0.000936 * (conv * 1000) - 0.376) + 0.5);`
ECHO-20 Conversion***	`conv= ((float)adc) *2.5 /4096;` `result = (int)(100*(0.000695 * (conv * 1000) - 0.29) + 0.5);`

*Only in beta release of the board to avoid oscillation of excitation with capacitive loads. It can be purchased from Digikey, www.digikey.com ; 10.0XBK-ND
**In the sample code channel one called, as example and it can be any of the channels 0-6. Delay before excitation is necessary in driving capacitive loads for sensor stability.
*** Result is volumetric % water content. According to Manual Theta = 0.000936*mVout - 0.376 where Theta is the volumetric water content fraction (1=100%)

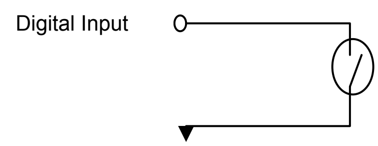
Motion Detector:
Motion detector can be turned ON using one of the excitations and expect event to happen when they observe a moving object. Motion detectors usually have Normally-Open or Normally-Closed output.



Sensor	Any Motion detector with 5V supply.
Sample Code*	record = call Sample.getSample(1,DIGITAL,3000, EVENT | EXCITATION_50);
Motion Detector	`result = dig;`

*In the sample code channel one called, as example and it can be any of the channels 0-5. RISING_EDGE or FALLING_EDGE can be set depending on the sensor. The event happens asynchronously (sampling time is irrelevant) and the application can do the action accordingly.

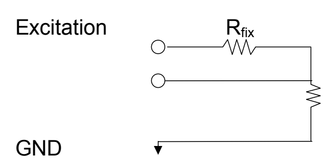
Rain Gauge:
Rain gauges are usually ON/OFF connections. Each connection represents certain amount of rain. The accumulative value represents total amount of rain sensor visited since installation. Digital inputs have internal pull-up resistor and the sensor can be directly connected to a digital channel.



Sensor	Rain Collector from Davis Weather; http://www.davisnet.com/weather
Sample Code*	record = call Sample.getSample(1,DIGITAL,3000,EEPROM_TOTALIZER);
Rain Sensor from Davis**	`result = dig;`

*In the sample code channel one called, as example and it can be any of the channels 0-5.
** In some rain sensor DEBOUNCER may be needed for some rain sensors.
***Dig is the result of the event. It can be used directly and it is hundred times rainfall per inch

Leaf Wetness:
Leaf wetness sensors are resistive sensors that change their resistance based on the wetness they experience. The end result is usually a discrete value between 0-10 (Or 0-15 depending on the model).

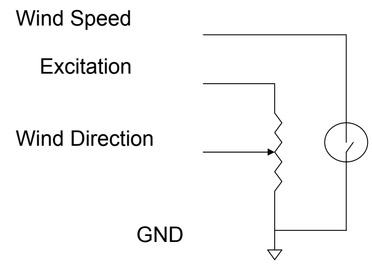


Sensor	Leaf wetness from Davis Weather; http://www.davisnet.com/weather
Rfix**	510K0.1%
Excitation	2.5V
Sample Code***	record = call Sample.getSample(1,ANALOG,600,EXCITATION_25);

Conversion****	`conv= ((float)adc) *2.5 /4096;`
	result = (int)((10*(conv-1.66)/(0.51-1.66))+0.5);
	result = result > 10 ? 10 : result < 0 ? 0 : result;

* The output is resistance to ground >1Meg dry, <130K wet So Dry is >1.66V, Wet is <0.51V
** It can be purchased from Digikey, www.digikey.com ; P510KBBCT-ND
***In the sample code channel one called each 60 second as example and it can be any of the channels 0-6.

Wind Speed (Average and Gust) and Wind Direction:
Wind speed sensor anemometer is measuring number of wind speed pulses per second and translates them into gust wind and average wind speed. Wind direction measures a rotational potentiometer resistance and converts that value to an offset from north.



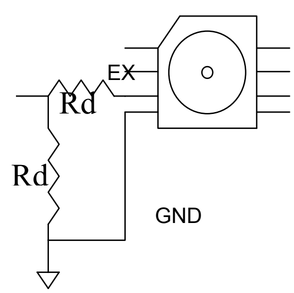
Sensor	Wind Speed and Direction Sensors, 034B set from Campbell Scientific, http://www.campbellsci.com/ OR Wind Speed and Direction Sensors from Davis Weather , http://www.davisnet.com/weather
Excitation	2.5V
Sample Code*	record = call Sample.getSample(1,ANALOG,600,EXCITATION_25); record = call Sample.getSample(1,COUNTER,20, RESET_ZERO_AFTER_READ);

Conversion
Davis-Set
	`// KPH = freq*3.62  We count for 30 seconds (1/10 KPH)`
	`// KPH = freq*2*1.810  We count for 2 seconds (KPH)`
	`// Linear voltage to angle. 0V = North. 4 degree dead zone`
	`gust = (int)((float)counter * 1.81 + 0.5);`
	`wind = (int)((float)counter * 3.62/3 + 0.5);`
	`direction = (int)((float)adc*356.0/4096+0.5);`

Conversion
Campbell Scientific
	`// KPH = freq*2.879  We count for 30 seconds (1/10 KPH)`
	`// KPH = freq*2*1.4395  We count for 2 seconds`
	`// Linear V to Angle, 1/2 excitation.`
	`gust = (int)((float)val*1.4395 + 0.5);`
	`wind = (int)((float)val*2.879/3 + 0.5);`
	`direction = (int)((float)val*356.0/2048+0.5);`

*In the sample code analog channel one called each 60 second as example and it can be any of the channels 0-6 and counter channel is called for 2 second for gust wind and it is averaged for 30 second for wind speed. The addition of the values that are read in the 2 second interval for 15 times to measure the 30Second periode should be done in the application software.

Pressure:
Pressure can be measured with any analog pressure sensor. Example of that is MPXA6115A from Motorola.

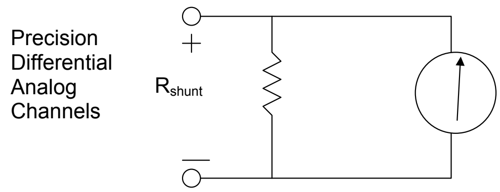


Sensor	MPXA6115A from Motorola
Rd*	270K,1%
Excitation	2.5V
Sample Code**	record = call Sample.getSample(1,ANALOG,600,EXCITATION_50 | DELAY_BEFORE_MEASUREMENT);

Conversion	`// ADC is 1/2 chip Vout  Result is in mBar/10`
	`// Sensor output: PmBar = (Vo/Vs)*1111.11+105.555`
	`result = (int)(((float)adc/4096)*11111.1 + 1055.55 + 0.5);`

* It can be purchased from Digikey, http://www.digikey.com/ , P270KBBCT-ND
**In the sample code analog channel one called each 60 second as example and it can be any of the channels 0-6.

Radiation Sensors:
Radiation sensors are very important for environmental studies. They mainly include Quantum Sensors for measure PAR in the 400 to 700 nm waveband and are available in terrestrial and underwater configurations. LI-COR Pyranometer Sensors measure solar radiation received from a whole hemisphere. They are suitable for measuring global sun plus sky radiation. LI-COR's Photometric Sensors measure illumination in terms of lux (1 footcandle = 10.764 lux). This is radiation as the human eye sees it. They all can be connected to the board using a shunt resistance. Rhunt resitance should be very precise for maximum accuracy. In addition each sensor has a separate calibration factor that is shipped with that from the company. All these radiation sensors can be purchased from Campbell Scientific and LI-COR.



Sensor	LI-190SA Quantum Sensor, LI-200SA Pyranometers, LI-210SA Photometric Sensor
R_{shunt}*	Rshunt = 182Ω, 0.1%
Sample Code**	record = call Sample.getSample(7,ANALOG,600,EXCITATION_50 | AVERAGE_EIGHT);

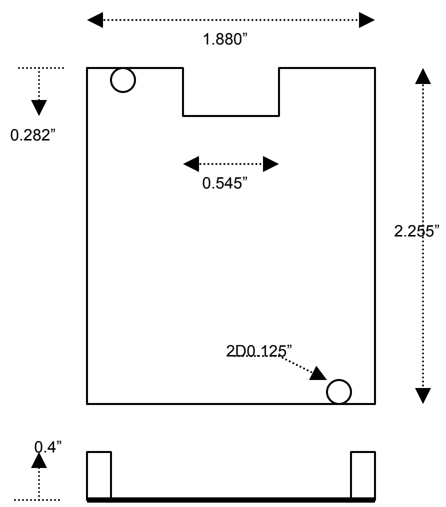
Conversion***	//Calibration Coefficient from factory
	CC = 12.28 // in (μA/1000μmol $s^{-1}m^{-2}$)
	I = adc * 6.1 / Rshunt // current (μA)
	L = 1000* I / CC // Light Intensity (μmol $s^{-1}m^{-2}$)

* 182Ω 0.1% resistors from Mouser Electronics, www.mouser.com part 66-RC55-D-182
**In the sample code analog channel seven called each 60 second as example and it can be any of the channels 7-10.
***Note that calibration coefficient depends on individual sensor and is shipped via sensor.

Other Sensors:

List of other sensors will be added soon. This includes thermocouple, IR temperature sensor, thermopile, Strain gauge Bridge, force.

DIMENTIONS:



All Dimensions in Inch

PACKAGING:

Packaging component are for connection of main Mica board to the MDA300CA and the enclosure are as below:

Screws	* Note1	Qty. 2
Nuts	* Note1	Qty. 1
Spacers	* Note1	Qty. 2
Enclosure	* Note1	Qty. 1
Battery	* Note1	Qty. 1

*consult with manufacturer at Xbow (http://www.xbow.com).

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Web Information: http://www.cens.ucla.edu/~mhr/daq/

Source Code: http://cvs.cens.ucla.edu/viewcvs/viewcvs.cgi/tos-contrib/sensorIB/
Instruction at http://cvs.cens.ucla.edu/
Source Code: http://sourceforge.net/projects/tinyos/