mcSens

Product Specification

REVISION 0.2

MAY 06, 2020

Contents

1. DEVICE OVERVIEW

The mcSense is an affordable, ultra-low-power indoor/outdoor remote sensor that lets you wirelessly collect and deliver data to the cloud. This built to last, pocket-sized Internet of Things device is a fully pre-programmed (and programmable), scalable and manageable solution that lasts for up to 5 years on 2 x AA batteries.

Featuring various onboard sensors the mcSens can monitor multiple variables, from anywhere, and deliver that information to the cloud. In addition to the mcSens's onboard sensors, this device offers the versatility to interface with practically any 3rd party sensor on the market making it a fully customizable sensor solution. The device is housed in a screw mountable enclosure making it dust-tight and protected against low-pressure water jets. Size 104mm x 49mm x 26mm

The mcSens employs the long range mcAir (LPLAN) low-power communication protocol to deliver data to the cloud with a communication range of ~1km+ in optimal conditions.

mcSens edge compute applications are programmed and debugged wirelessly using the mcStudio Software without the need to open the device.

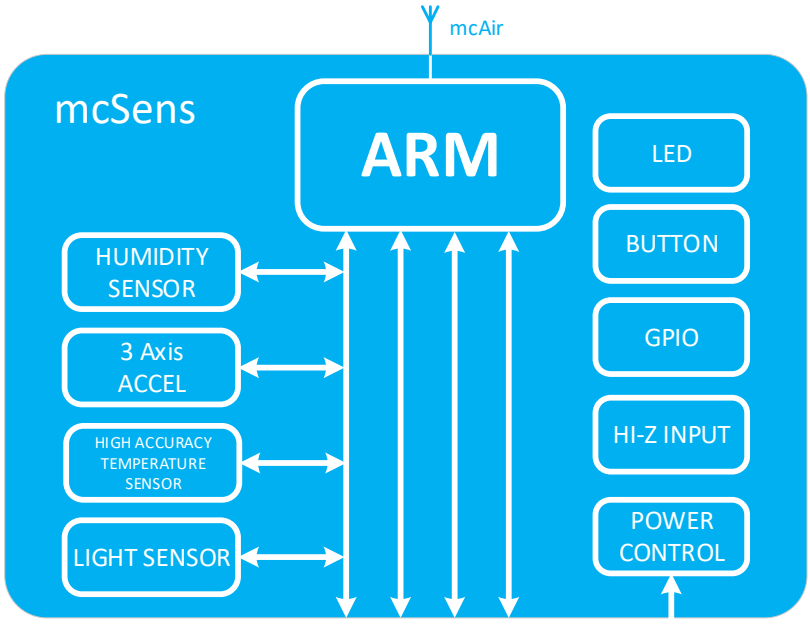


Figure 1-1: mcSens Block Diagram

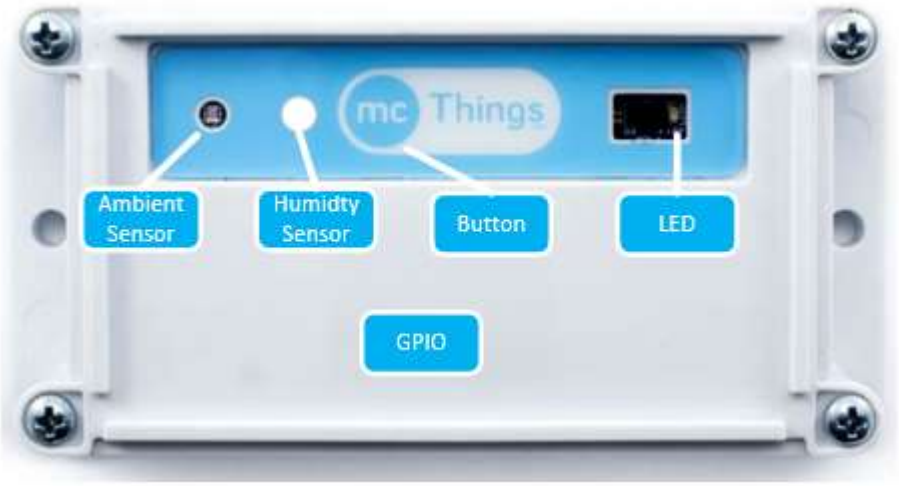
Table 1-1: Key Components

Key Components	
Application Processor	32-bit ARM Cortex M4F
mc-Air Wireless LPLAN	Ultra low power mc-Air wireless technology over 2.4GHz.
Operating System	mc-OS (specifically designed for IoT applications)
Humidity Sensor	Low power Humidity sensor measuring relative humidity, barometric pressure and ambient temperature
Accelerometer	Low power 12-bit Digital accelerometer with onboard motion processor.
Temperature sensor	Low power temperature sensor with 0.0625°C resolution over -40C to +85C
Ambient Light Sensor	Low power ambient light sensor that measures the intensity of visible light. 0.01lux to 83k lux

Table 1-2: External Interfaces

External Interfaces	
GPIO	8 GPIOs (shared with analog inputs)
ADC	4 Analog Inputs (shared with GPIO pins)
SPI	SPI Interface can be assigned to any of the GPIO pins.
UART	UART Interface can be assigned to any of the GPIO pins.
I^2C	I^2C interface
PWM	Hardware PWM

2. PRODUCT FEATURES



2.1 mc-Air™ LPLAN™

The mc-Air™ LPLAN™ (Low Power Local Area Network) is a new protocol specifically designed for the Internet of Things. Using a high performance 2.4GHz onboard PCB antenna with a gain of +3.3dB allows distances of up to 200m between the mc-Modules™ and mc-Gateway™ using very little power.

2.2 ARM Cortex-M4F Processor

The ARM Cortex-M4F Processor runs the mc-OS™ operating system. This operating system was designed to run natively on the ARM Cortex-M0 with ultra low power consumption.

Features include:

- < 2.0 µA sleep current
- 2.4 GHz transceiver
- UART, SPI, I2C, PWM

The datasheet for this device can be found here:

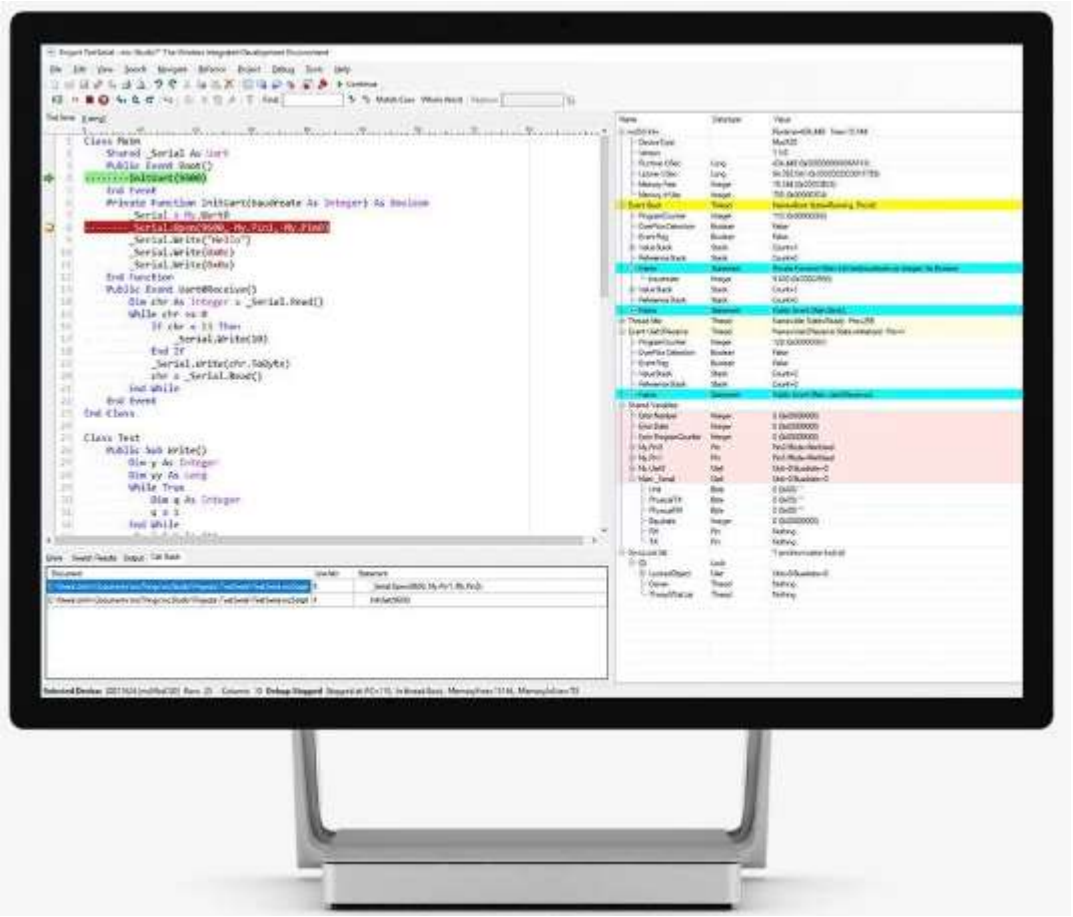
http://infocenter.nordicsemi.com/pdf/nRF52832_PS_v1.0.pdf

2.3 mcStudio

mcStudio lets you focus on the solution rather than the intricacies of firmware development. With powerful software tools creating new or updating existing use-cases is made easy. Remotely create and debug features using mcStudio makes development truly agile and accelerates implementation.

Features unclude:

- Object-Oriented Programmming using mcScript
- Local management
- Predictive Code Completion



mcScript User Guide can be found here:
https://www.mcthings.com/wp-content/uploads/files/mcScript/mcScript-User-Guide.pdf

2.4 mcCloud

mcCloud is a cloud computing service that provides “Platform as a Service” (PaaS). The service includes features for authoring, modifying, compiling, refactoring, deploying and debugging applications. The platform manages the hardware and includes authentication, security, provisioning and large scale deployment so customers can manage millions of devices on the fly. All services are provided “Over-the-air” so battery powered devices can stay where they are.

Features Include:

- Provision millions of devices with ease
- Develop and manage remotely from anywhere
- APIs for integration with existing control systems
- Security domains and permissions

Inorder to visualize or capture your data into a cloud application please contact mcThings.

2.5 Humidity Sensor

The sensor is a BME280 is a combined digital humidity, pressure and temperature sensor based on proven sensing principles. The humidity sensor communicates via 12C (address 0x77)

Features include:

- 0% to 100% relative humidity
- 300 to 1100 hPa pressure

The datasheet for this device can be found here:
https://www.bosch-sensortec.com/media/boschsensortec/downloads/datasheets/bst-bme280-ds002.pdf

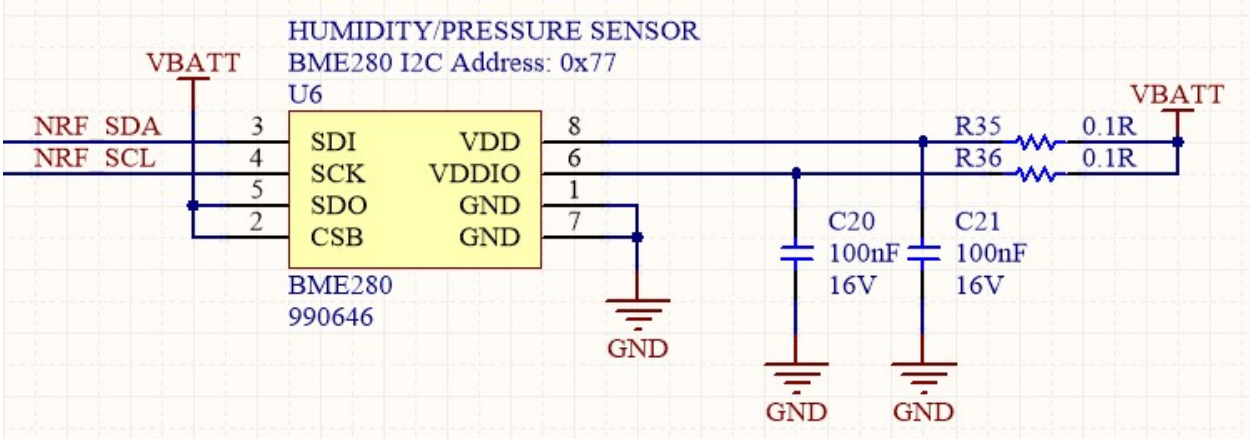


Figure 3-1: Humidity Schematic

2.6 Accelerometer

The low power I2C 12-bit 3-axis accelerometer (ST LIS2DH12) with configurable interrupt generation enables motion, freefall, and orientation detection.

Features include:

- ±2 g, ±4 g, ±8 g, and ±16 g dynamically selectable full-scale ranges
- Output Data Rates (ODR) from 1 Hz to 5.3 kHz
- 12-bit digital output
- Configurable motion detection (Freefall, Motion, Pulse, Transient)
- Ultra Low power (3 µA in 10Hz low power 8 bit mode)
- 2 programmable interrupts

The datasheet for this device can be found here:

www.**st**.com/resource/en/datasheet/**lis2dh12**.pdf

The accelerometer communicates via I2C (address 0x19) and also routes two (2) separate interrupt pins which allow the accelerometer to wake on predefined acceleration events. It is setup as shown in Figure 3-1.

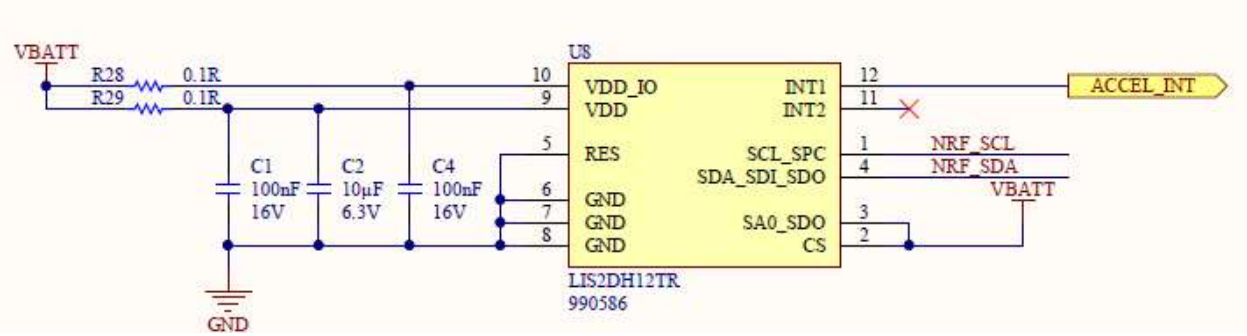


Figure 3-1: Accelerometer Schematic

Refer to the example project in mc-Studio for proper usage of the accelerometer.

2.7 Button

There is one (1) button available for user input. The button is NO (Normally Open) and the processor enables an internal pullup so the button is an active low device as shown in Figure 3-6.

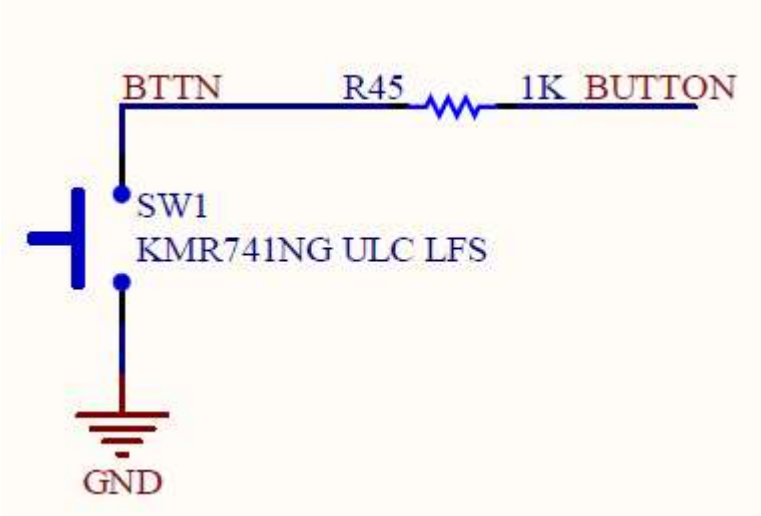


Figure 3-6: Button Schematic

Monitoring of this button is built into mc-Studio which is shown in Figure 3-7.

```
01   Shared Event ButtonChanged()
02        If Button0 = True Then
03            //button pressed
04            LedGreen = True //turn on green LED if button pressed
05        Else
06            //button released
07            LedGreen = False //turn off green LED if button released
08        End If
09   End Event
```

Figure 3-7: Button mc-Script

2.8 LED

There is on active high LEDs available for visual indication, a red LED as shown in Figure 3-8.

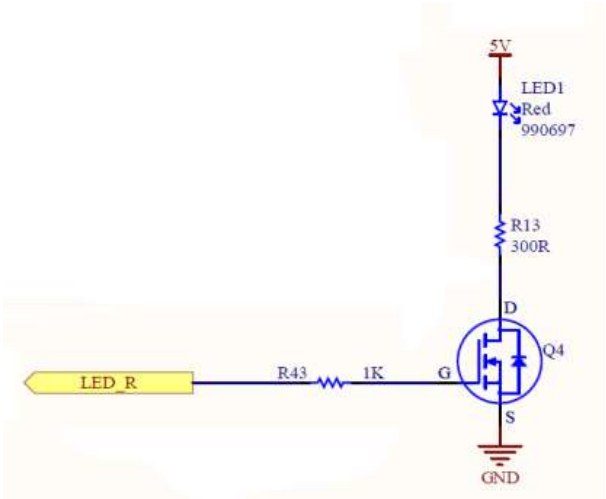


Figure 3-8: LEDs Schematic

Control of the LEDs is built into mc-Studio which is shown in Figure 3-9.

```
1     Shared Event blinkLEDs() RaiseEvent Every 500 milliSeconds
2         LedGreen = Not LedGreen //toggle green LED
3         LedRed = Not LedRed //toggle red LED
4     End Event
```

Figure 3-9: LED mc-Script

2.9 GPIOs

There are 9 General Purpose Input/Output Pins on the mcMod110. These pins are configurable as digital inputs, digital outputs, and analog inputs as shown in Table 3-1.

Table 3-1: GPIO Pin Modes

PinMode	PIN0	PIN1	PIN2	PIN3	PIN4	PIN5	PIN6	PIN7	PIN8
Not Used	Y	Y	Y	Y	Y	Y	Y	Y	Y
DigitalInput	Y	Y	Y	Y	Y	Y	Y	Y	Y
DigitalInputPullDown	Y	Y	Y	Y	Y	Y	Y	Y	Y
DigitalInputPullDownWeak	Y	Y	Y	Y	N	N	N	N	Y
DigitalInputPullUp	Y	Y	Y	Y	Y	Y	Y	Y	Y
DigitalInputPullupWeak	Y	Y	Y	Y	N	N	N	N	Y
DigitalOutput	Y	Y	Y	Y	Y	Y	Y	Y	Y
AnalogInput	Y	Y	Y	Y	N	N	N	Y	Y
AnalogInputPullDown	N	N	N	N	N	N	N	Y	Y
AnalogInputPullUp	N	N	N	N	N	N	N	Y	Y

2.9.1 Digital Inputs

Any of the 9 GPIOs may be configured as digital inputs. There are five different input configurations as shown in Table 3-2.

Table 3-2: Input Pin Configurations

Input Pin Configuration	Description
DigitalInput	Configure as high impedance (floating)
DigitalInputPullDown	Configure with internal pull-down to GND
DigitalInputPullDownWeak	Configure with external pull-down (1 MΩ) to GND
DigitalInputPullUp	Configure with internal pull-up to VDD
DigitalInputPullUpWeak	Configure with external pull-up (1 MΩ) to VDD

A GPIO digital input example is shown in Figure 3-10.

```
01 Define PinMode Pin0 As DigitalInputPullUp
02 Class InputPinTest()
3      Shared Event Pin0FallingEdge()
4          // pin0 has gone low, turn on LED for 100ms
5          LedGreen = True // Turn on LED
6          Thread.Sleep(100000) // Sleep for 100 ms
7          LedGreen = False // Turn off LED
8      End Event
9  End Class
```

Figure 3-10: Input Pin mc-Script

2.9.2 Digital Outputs

Any of the 9 GPIOs may be configured as digital outputs. A GPIO digital output example is shown in Figure 3-11.

```
01 Define PinMode Pin1 As DigitalOutput
02 Class OutputPinTest()
3      Shared Event TogglePin1() RaiseEvent Every 500 milliSeconds
4          // toggle Pin1 every 500 milliseconds
5          Pin1 = Not Pin1 // Toggle Pin1
6      End Event
7  End Class
```

Figure 3-11: Output Pin mc-Script

2.9.3 Analog Inputs

There are 6 pins that may be configured as analog inputs, 2 of which offer high impedance connections, as shown in Table 3-3.

Table 3-3: Analog Pins

Parameter	Value
ADC Pin	PIN4-PIN7
ADC Voltage Range	0V – VDD (3.6V Max)

2.10 SPI Interface

The SPI Master interface enables synchronous communication between the mcMod110 and peripheral devices. The parameters of the SPI interface are shown in Table 3-4.

Table 3-4: SPI Parameters

Parameter	Value
SCK Pin	PIN0-PIN8
MISO Pin	PIN0-PIN8
MOSI Pin	PIN0-PIN8
CS Pin	PIN0-PIN8
Data Rates	125kHz, 250kHz, 500kHz, 1Mhz, 2MHz, 4MHz, 8 MHz
SPI Modes	0, 1, 2, 3
Master/Slave	Master ONLY

```
1  //
02 // See datasheet at
03 // http://ww1.microchip.com/downloads/en/DeviceDoc/20005119G.pdf
4  //

6       Shared Mem1 As Spi
7       Shared Mem2 As Spi
8       Public Sub New()
9           Mem1 = Spi.Create(8000000, 0, Pin.Pin0, Pin.Pin1, Pin.Pin3, Pin.Pin5)
10          Mem2 = Spi.Create(8000000, 0, Pin.Pin0, Pin.Pin1, Pin.Pin3, Pin.Pin6)
11      End Sub
12      Public Function Read(adr As Integer, size As Integer) As ListOfByte
13          Dim data As ListOfByte = New ListOfByte
14          data.Add(3) ' Read command
15          data.Add3Bytes(adr, Endianness.Big) ' Address
16          data.AddElements(size) 'Size to read
17          Dim mem As Spi
18          If adr >= 0x00800000 Then
19              mem = Mem2
20          Else
21              mem = Mem1
22          End If
23          data = mem.Transfer(data)
24          Return data.GetRange(4)
25      End Function
26
27
28     Public Sub Write(adr As Integer, toWrite As ListOfByte)
29          Dim data As ListOfByte = New ListOfByte
30          data.Add(2) ' Write command
31          data.Add3Bytes(adr, Endianness.Big) ' Address
32          data.AddRange(toWrite) 'Data to write
33          Dim mem As Spi
34          If adr = 0x00800000 Then
35              mem = Mem1
36          Else
37              mem = Mem2
38          End If
39          mem.Transfer(data)
40      End Sub
41 End Class
```

2.11 UART Interface

There UART interface can be set on any of the pins (PIN0-PIN8). The parameters of the UART interface are shown in Table 3-5.

Table 3-5: UART Parameters

Parameter	Value
RX Pin	PIN0-PIN8
TX Pin	PIN0-PIN8
Flow Control	Not Supported
Supported Baud rates	1200, 2400, 4800, 9600, 14400, 19200, 28800, 38400, 57600, 76800, 115200, 230400, 250000, 460800, 921600, 1000000

An example of UART communications is shown in Figure 3-15.

```
01 Class Display
2       Shared Disp As Uart
3       Public Sub New()
4           Disp = Uart.Create(9600, Pin.Pin0, Pin.Pin1)
5       End Sub
6       Shared Event Uart0Receive()
7           Dim chr As Integer = Disp.Read()
8           While chr >= 0
 09             // Process Character and do something
 10             // ....
 11             // ....
 12             chr = Disp.Read()
13          End While
14      End Event
15      Public Sub DisplayText(row As Byte, col As Byte, str As String)
16          If row >= 0 Then
 17             Disp.Write(0xff)
 18             Disp.Write(row)
 19             Disp.Write(col)
 20             Disp.Write(str.Length.ToByte)
 21             Disp.Write(str)
22          Else
 23             Disp.Write(0xfe)
 24             Disp.Write(str.Length.ToByte)
 25             Disp.Write(str)
26          End If
27      End Sub
27  End Class
```

Figure 3-15: UART mc-Script

2.12 I2C Interface

There is a dedicated I2C communications interface on pins SCL and SDA. This interface bus is shared with the accelerometer (Address 0x19) and temperature sensor (Address 0x48). There are 10kΩ pull-ups on included on the module. The parameters of the I2C interface are shown in Table 3-6.

Table 3-6: I2C Parameters

Parameter	Value
SCL Pin	SCL
SDA PIN	SDA
Data Rates	100kHz & 400 kHz
Pull-ups (On Module)	10kΩ
Unavailable Addresses	0x19, 0x48

An example of I2C communications is shown in Figure 3-16.

```
01 Class Temperature
2       Shared Function GetTemp() As Float
3           Dim sensor As I2c
4           sensor = I2c.Create(400000, Pin.SCL, Pin.SDA, 0x48)
5           Device.EnableTempSensor()
6           Thread.Sleep(40000) // See page 13 of the datasheet
7           Dim res As ListOfByte = sensor.Read(2)
8           Dim temp As Float = Float.NaN
9           If res <> Nothing Then
 10             Dim part As Float = res(1) >> 4
 11             part = part / 16
 12             temp = res(0).SignExtend() + part
13          End If
14          Device.DisableTempSensor()
15          Return temp
16      End Function
17 End Class
```

Figure 3-16: I2C mc-Script

2.13 PWM

The module contains a hardware PWM (Pulse Width Modulation) peripheral with the parameters specified in Table 3-7. There are 3 PWM modules each with 4 channels per module. All channels using the same PWM module MUST be the same frequency but their polarity and duty cycle may be changed.

The three things that define a PWM signal are the Pin, Period and Duty cycle. The pin specifies where the PWM signal is sent to, the Period is the amount of time between the rising edges of the signal in µSec and the duty cycle is the time that the pulse is active in µSec. So to create a pulse of 1Khz and a duty cycle of 20% the user has to specify a 1000 µSec Period and a 200 µSec Duty Cycle. If the duty cycle is 0 or negative the signal is always low and if the duty cycle is equal or larger than the period, the signal is always high.

Table 3-7: PWM Parameters

Parameter	Value
PWM Pin	PIN0-PIN8
Duty Cycle	0-100% (resolution based on frequency)
Frequency	3.8Hz to 5.333 MHz
PWM Modules	3
Channels per Module	4 (each channel on same module must be same frequency)

An example using PWM is shown in Figure 3-17.

```
1     Define PinMode Pin0 As PwmOutput
2
3     Public Sub SetPwm()
4         Dim pwm1kHz As Pwm
5         pwm1kHz = Pwm.Create(1000)  // create PWM with 1000µs period
6         pwm1kHz.SetDutyCycle(Pin0, 200) // set PWM to 20% duty cycle on Pin0
7         pwm1kHz.Start() // start PWM
8     End Sub
```

Figure 3-17: PWM Example

3. ELECTRICAL SPECIFICATIONS

3.1 Absolute Maximum Ratings

Table 4-1: Absolute Maximum Ratings

Absolute Maximum Ratings	
VDD Voltage	-0.3V to +3.7V
I/O Pin Voltage	-0.3V to VDD
Storage Temperature	-40°C to +60°C

NOTE: Exposure to the absolute maximum ratings for prolonged periods of time may affect long term reliability of the device.

3.2 Recommended Operating Conditions

Table 4-2: Recommended Operating Conditions

Recommended Operating Conditions	
Input Voltage	+1.7V to +3.6V (+3.0V Typical)
Operating Temperature	-40°C to +60°C (Battery specs limited)

3.3 Power Consumption

Table 4-3: Power Consumption

Power Consumption	
Sleep Current	<2.0uA (TBD)
mc-Air Transmit Current	60 mA @ +16dBm
mc-Air Receive Current	5.4 mA

4. Regulatory

4.1 FCC Notice

Caution: Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

The grantee is not responsible for any changes or modifications not expressly approved by the party responsible for compliance. Such modifications could void the user's authority to operate the equipment.

The RF Exposure Compliance distance is 20 centimeters.

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications.

However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

4.2 Industry Canada Notice

This device complies with Innovation, Science and Economic Development Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.
CAN ICES-3(B)/NMB-3(B)
Le présent appareil est conforme aux CNR Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) il ne doit pas produire de brouillage et (2) l' utilisateur du dispositif doit être prêt à accepter tout brouillage radioélectrique reçu, même si ce brouillage est susceptible de compromettre le fomctionnement du dispositif.
CAN ICES-3(B)/NMB-3(B)

The device meets the exemption from the routine evaluation limits in section 2.5 of RSS 102 and compliance with RSS-102 RF exposure, users can obtain Canadian information on RF exposure and compliance.
Le dispositif rencontre l'exemption des limites courantes d'évaluation dans la section 2.5 de RSS 102 et la conformité à l'exposition de RSS-102 rf, utilisateurs peut obtenir l'information canadienne sur l'exposition et la conformité de rf.

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter. This equipment should be installed and operated with a minimum distance of 20 centimeters between the radiator and your body.
Cet émetteur ne doit pas être Co-placé ou ne fonctionnant en même temps qu'aucune autre antenne ou émetteur. Cet équipement devrait être installé et actionné avec une distance minimum de 20 centimètres entre le radiateur et votre corps.

Model: MCSENS
FCC ID: 2AGBO-MCSENS
IC: 21078-MCSENS