

mcMod120

Product Specification

REVISION 0.3

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1. DEVICE OVERVIEW

The mc-Mod120 is an integrated IoT module containing an ARM processor, accelerometer, temperature sensor, 2.4Ghz antenna, reed switch, button, LEDs, and various I/Os. It can operate as a standalone device or surface mounted module. Communication using the mc-Air™ Low Power LAN protocol allows distances up to 200m* to the mc-Gateway™. A high level block diagram is shown in Figure 1-1.

Integration with mc-Studio™ ensures the fastest and most reliable IoT application development and deployment. Multiple sensors, interfaces, and I/Os provide measurement and control capabilities to solve any IoT problem.

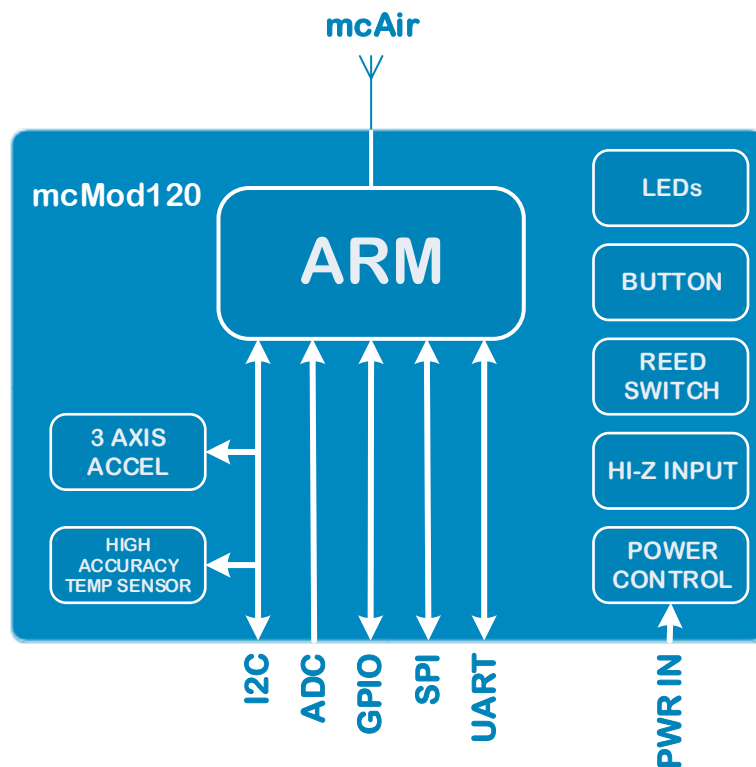


Figure 1-1: mcMod120 Block Diagram

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)
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

Table 1-2: External Interfaces

External Interfaces	
GPIO	9 GPIOs (shared with analog inputs)
ADC	6 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.
I²C	I ² C interface
PWM	Hardware PWM

2. DIMENSIONS AND PIN ASSIGNMENTS

2.1 PHYSICAL DIMENSIONS

The module size is 1.180" (29.97mm) x 0.816" (20.73mm) x 0.08" (2.06mm) with detailed dimensions shown in Figure 2-1.

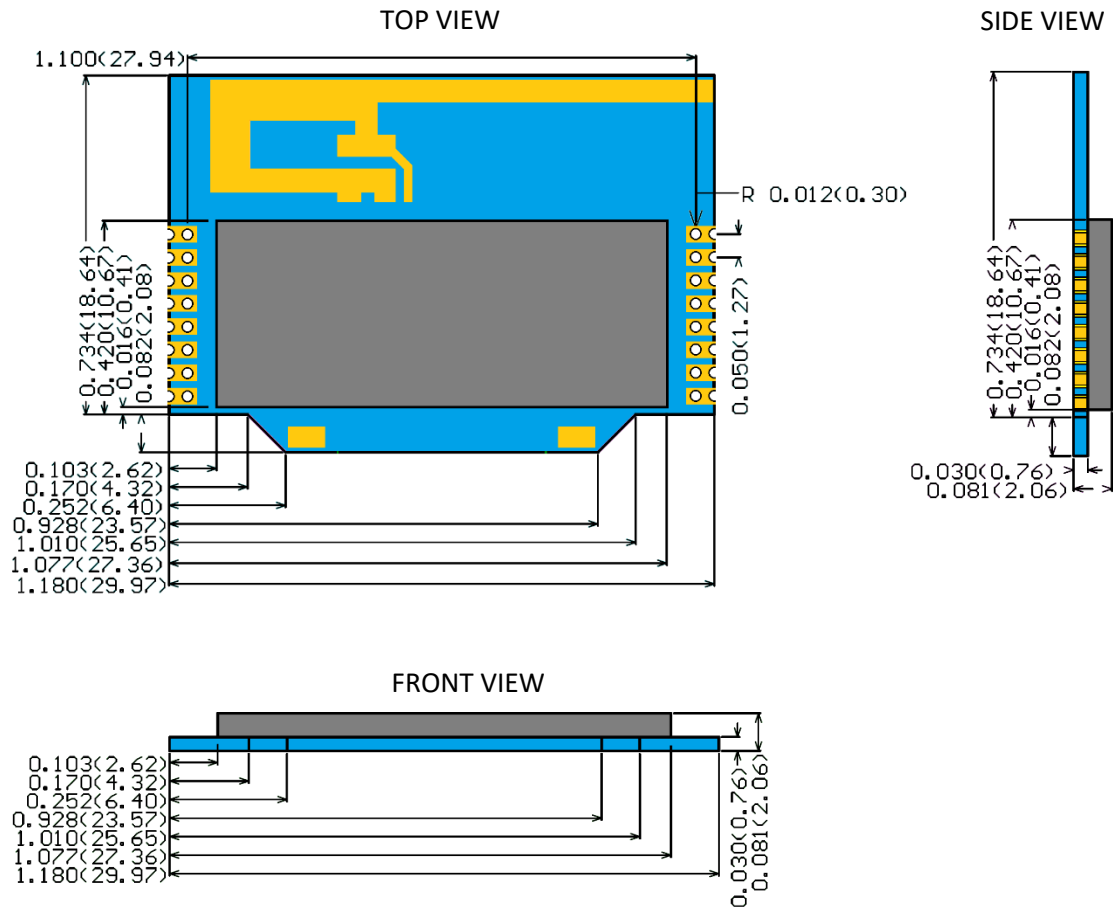


Figure 2-1: Physical Dimensions

2.2 FOOTPRINT

The recommended footprint for mounting of the module is shown in Figure 2-2 and the pin assignment is shown in Figure 2-3.

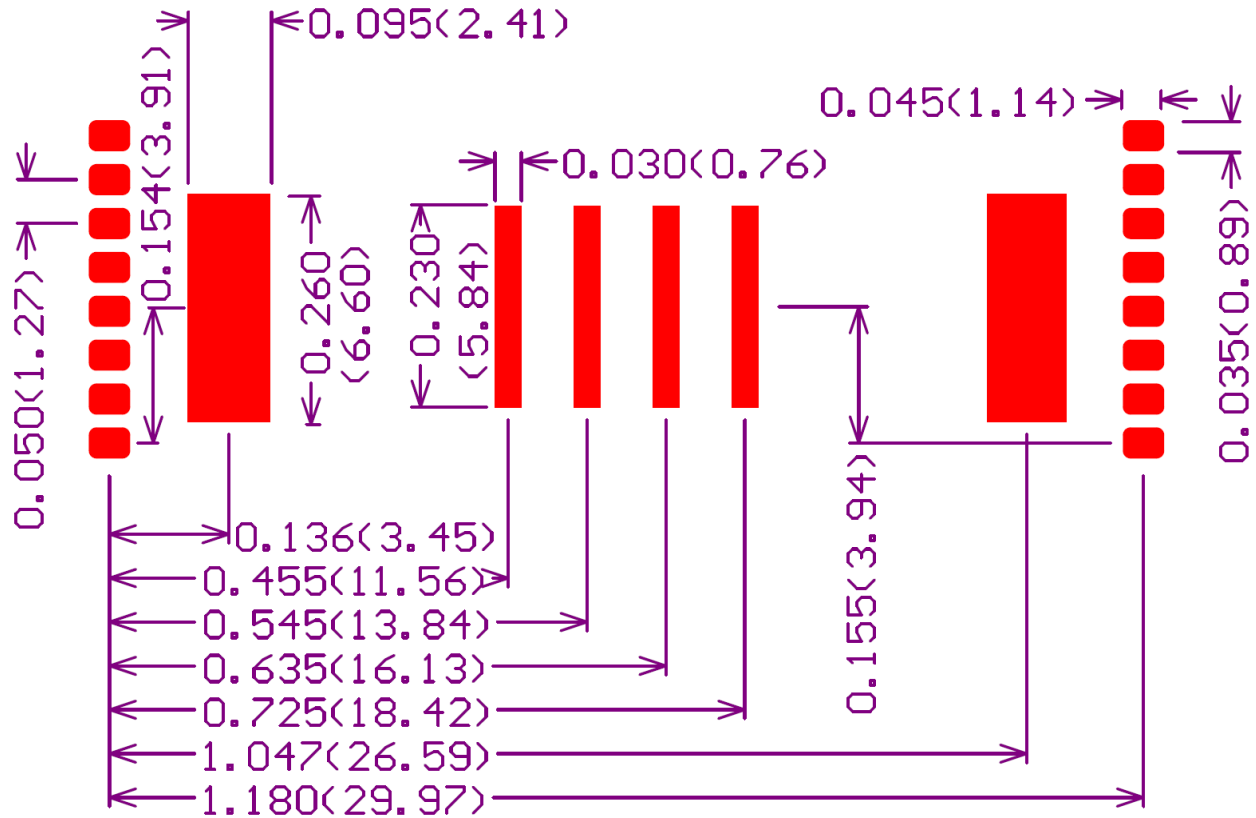


Figure 2-2: mcMod110 Footprint Dimensions

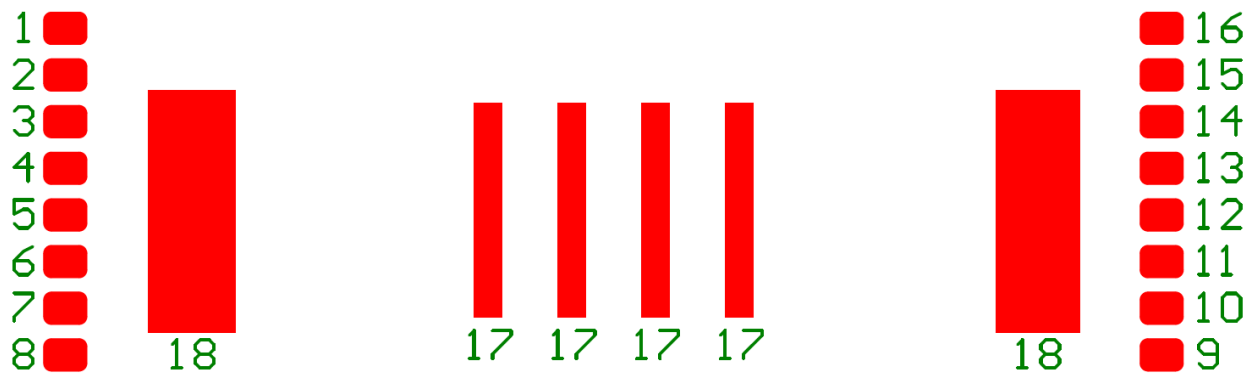


Figure 2-3: mcMod110 Footprint Pin Assignment

2.3 PCB Mounting

There are two recommended options for mounting the module to the carrier PCB. In both mounting options it is recommended to have at least one large uninterrupted ground plane on a full layer of the carrier PCB. Option A (Figure 2-4) is the best option which has the module overhanging the carrier board by 0.300" (7.62mm).

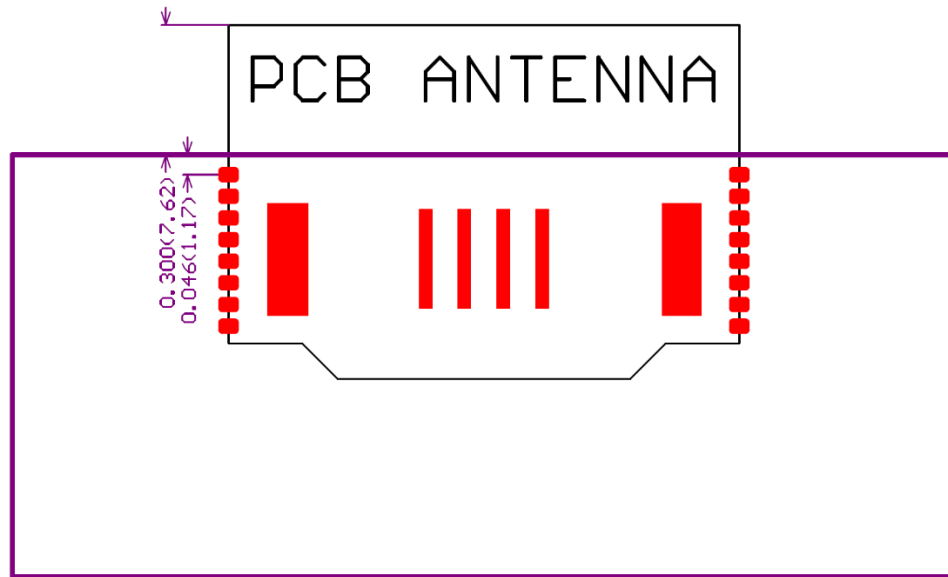


Figure 2-4: Board Mount Option A at edge of carrier board

If it is not feasible for the module to overhang the carrier PCB then Option B (Figure 2-5) with a clearance cut-out may be used. It is recommended to have at least 0.200" (5.08mm) clearance on either side of the antenna.

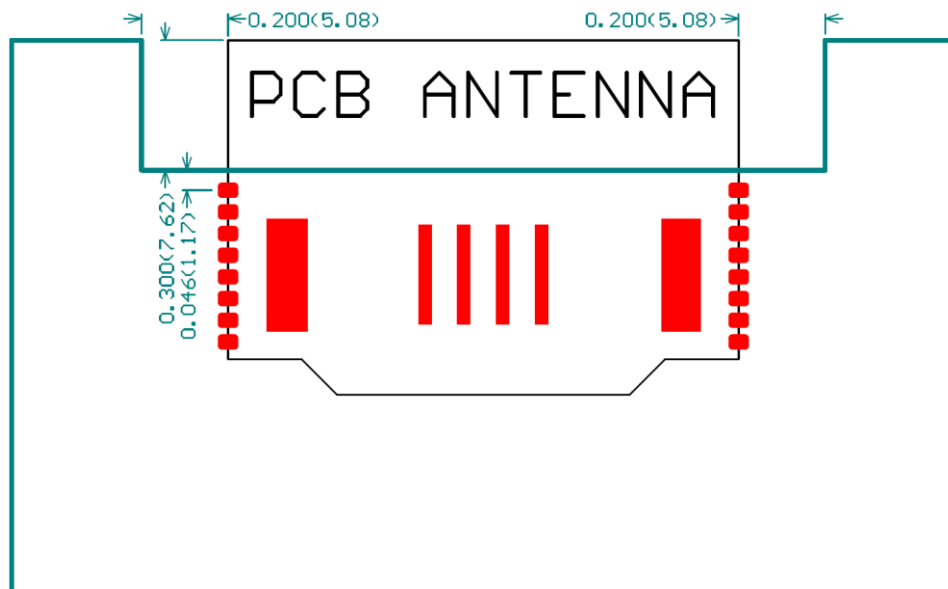


Figure 2-5: Board Mount Option B with clearance cut-out

2.4 PIN ASSIGNMENT

The pin assignment of the module is shown in Table 2-1.

Table 2-1: mcMod120 Pin Assignment

Pin	Name	Type	Function
1	PIN6_D6	I/O	General Purpose I/O 6
2	PIN5_D5	I/O	General Purpose I/O 5
3	PIN4_D4	I/O	General Purpose I/O 4
4	GND	G	Ground
5	PIN3_D3_A3	I/O	General Purpose I/O 3 (Analog Input)
6	PIN2_D2_A2	I/O	General Purpose I/O 2 (Analog Input)
7	PIN1_D1_A1	I/O	General Purpose I/O 1 (Analog Input)
8	PIN0_D0_A0	I/O	General Purpose I/O 0 (Analog Input)
9	PIN7_D7_A7	I/O	General Purpose I/O 7 (Analog Input through OpAmp)
10	PIN8_D8_A8	I/O	General Purpose I/O 8 (Analog Input through OpAmp)
11	nRESET	I	Programming Reset
12	VDD	P	1.7V ~ 3.6V Power Input
13	SCL	O	I2C Clock
14	SDA	I/O	I2C Data
15	SWDIO	I/O	Programming Data I/O
16	SWDCLK	I	Programming Clock
17	GND	G	Ground
18	VDD	P	1.7V ~ 3.6V Power Input

3. PRODUCT FEATURES

3.1 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.

3.2 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 μ A 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

3.3 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 μ A 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.

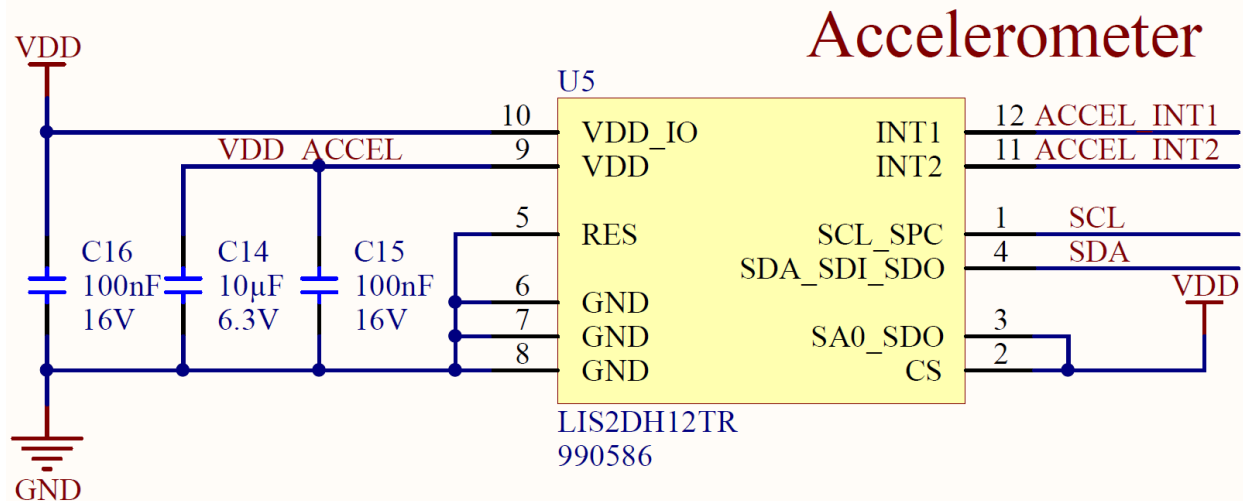


Figure 3-1: Accelerometer Schematic

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

3.4 Temperature Sensor

The low power I2C digital temperature sensor (Texas Instruments TMP102) is ideal where high accuracy is required.

Features include:

- Accuracy Without Calibration:
 - $\pm 0.5^{\circ}\text{C}$ (typical) from -25°C to $+85^{\circ}\text{C}$
 - $\pm 1.0^{\circ}$ (typical) from -40°C to $+125^{\circ}\text{C}$
- 12-bit resolution (0.0625°C)
- Very low current active current ($10\text{ }\mu\text{A}$ max)
- NIST Traceable

The datasheet for this device can be found here: <http://www.ti.com/lit/ds/symlink/tmp102.pdf>

The temperature sensor communicates via I2C (address 0x48) and is setup as shown in Figure 3-2.

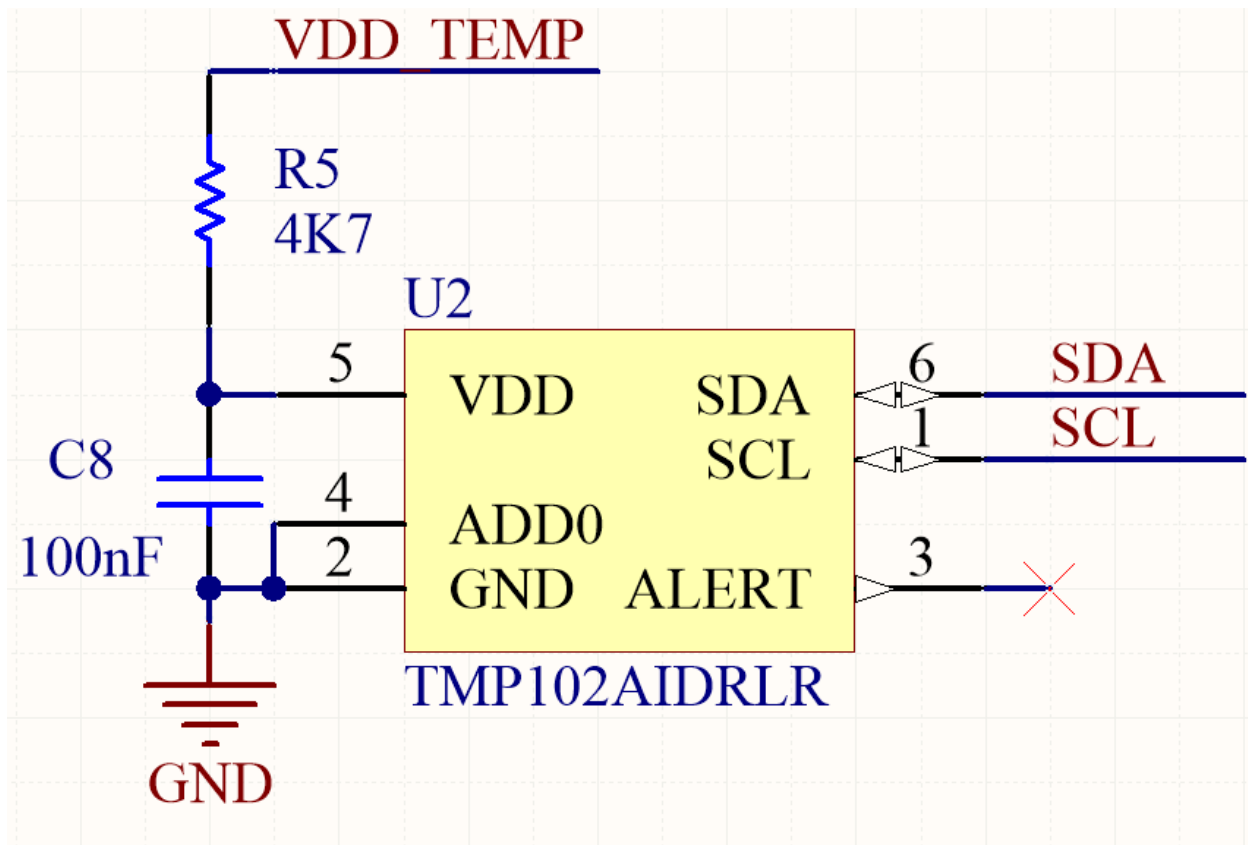


Figure 3-2: Temperature Sensor Schematic

An example of reading the temperature from the TMP102 is shown in Figure 3-3.

```

01 Class Temperature
02     Shared Function GetTemp() As Float
03         Dim sensor As I2c
04         sensor = I2c.Create(400000, Pin.SCL, Pin.SDA, 0x48)
05         Device.EnableTempSensor()
06         Thread.Sleep(40000) // See page 13 of the datasheet
07         Dim res As ListOfByte = sensor.Read(2)
08         Dim temp As Float = Float.NaN
09         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 3-3: TMP102 mc-Script

3.5 Reed Switch

There is one (1) reed switch available for user input. The reed switch is NO (Normally Open) and contains a very weak (4.7 MΩ) pull-up so the reed switch is an active low device as shown in Figure 3-4.

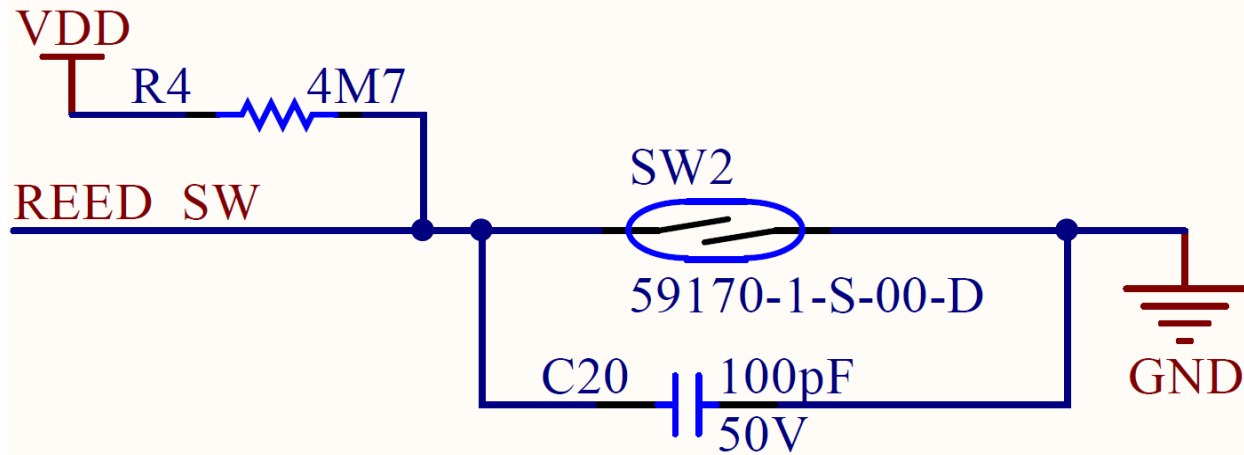


Figure 3-4: Reed Switch Schematic

In order to activate the reed switch a magnet must be in close proximity. Neodymium magnets are recommended for best performance. The reed switch is very useful for window and door open/close detection.

Monitoring of the reed switch is built into mc-Studio which is shown in Figure 3-5.

```

01 Shared Event ReedSwitchChanged()
02   If ReedSwitch = 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 3-5: Reed Switch mc-Script

3.6 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.

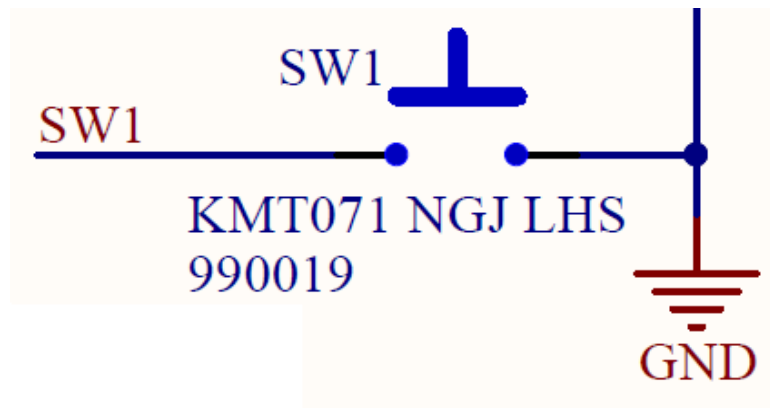


Figure 3-6: Button Schematic

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

3.7 LEDs

There are two (2) active high LEDs available for visual indication, a green LED and red LED as shown in Figure 3-8.

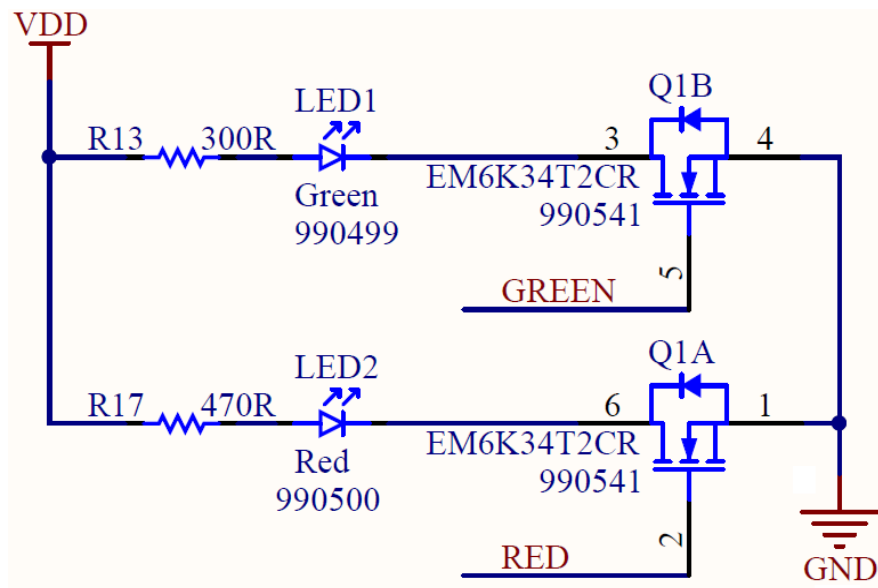


Figure 3-8: LEDs Schematic

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

```

01  Shared Event blinkLEDs() RaiseEvent Every 500 milliseconds
02      LedGreen = Not LedGreen //toggle green LED
03      LedRed = Not LedRed //toggle red LED
04  End Event

```

Figure 3-9: LED mc-Script

3.8 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

3.8.1 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()
03     Shared Event Pin0FallingEdge()
04         // pin0 has gone low, turn on LED for 100ms
05         LedGreen = True // Turn on LED
06         Thread.Sleep(100000) // Sleep for 100 ms
07         LedGreen = False // Turn off LED
08     End Event
09 End Class

```

Figure 3-10: Input Pin mc-Script

3.8.2 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()
03     Shared Event TogglePin1() RaiseEvent Every 500 milliseconds
04         // toggle Pin1 every 500 milliseconds
05         Pin1 = Not Pin1 // Toggle Pin1
06     End Event
07 End Class

```

Figure 3-11: Output Pin mc-Script

3.8.3 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	PIN0-PIN3
HI-Z ADC Pin	PIN7-PIN8
ADC Voltage Range	0V – VDD (3.6V Max)

The high impedance analog input circuitry is shown in Figure 3-12.

High Impedance Analog Inputs

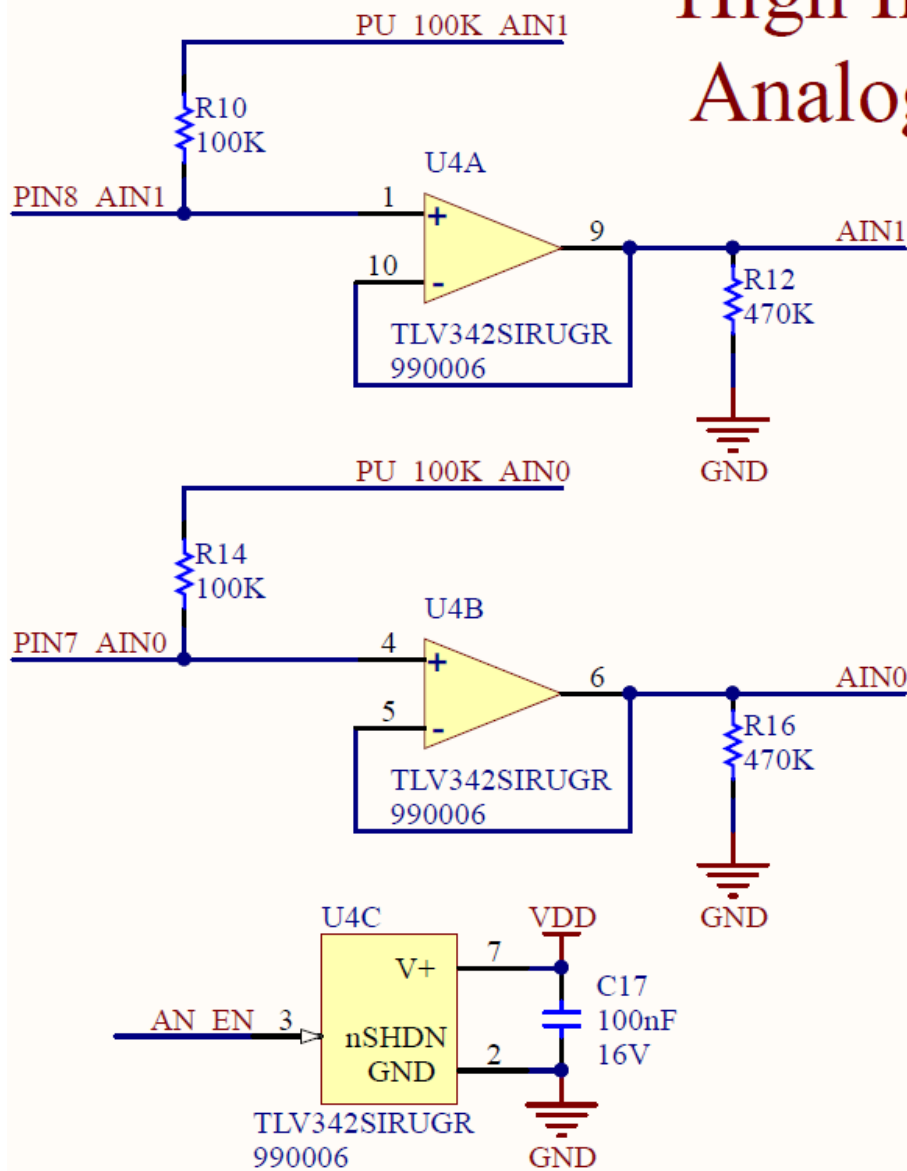


Figure 3-12: High Impedance Analog Inputs Schematic

Figure 3-13 shows examples of reading both standard and high impedance analog inputs.

```

01 Define PinMode Pin3 As AnalogInput
02 Define PinMode Pin7 As AnalogInputPullUp Alias hiZVoltage
03
04 Public Function GetPin3Analog() As Short
05     Dim value As Short
06     value = Pin3      // Read the pin. This activates the ADC
07     Return value      // Return value in millivolts
08 End Function
09
10 Public Function GetPin7Analog() As Short
11     Dim value As Short
12     device.EnableOpamp() // Enable opAmp for hi-Z reading
13     thread.Sleep(5000)  //sleep for 5ms for opamp to power
14     value = hiZVoltage   // Read the pin. This activates the ADC
15     device.DisableOpamp() // Disable Opamp
16     Return value        // Return value in millivolts
17 End Function

```

Figure 3-13: Analog Input mc-Script

3.9 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

An example of SPI communications is shown in Figure 3-14.

```

01 //
02 // See datasheet at
03 // http://ww1.microchip.com/downloads/en/DeviceDoc/20005119G.pdf
04 //
05 Class ExternalFlash
06     Shared Mem1 As Spi
07     Shared Mem2 As Spi
08     Public Sub New()
09         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

```

Figure 3-14: SPI Interface mc-Script

3.10 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
02     Shared Disp As Uart
03     Public Sub New()
04         Disp = Uart.Create(9600, Pin.Pin0, Pin.Pin1)
05     End Sub
06     Shared Event Uart0Receive()
07         Dim chr As Integer = Disp.Read()
08         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

3.11 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
02     Shared Function GetTemp() As Float
03         Dim sensor As I2c
04         sensor = I2c.Create(400000, Pin.SCL, Pin.SDA, 0x48)
05         Device.EnableTempSensor()
06         Thread.Sleep(40000) // See page 13 of the datasheet
07         Dim res As ListOfByte = sensor.Read(2)
08         Dim temp As Float = Float.NaN
09         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

3.12 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.

```
01 Define PinMode Pin0 As PwmOutput
02
03 Public Sub SetPwm()
04     Dim pwm1kHz As Pwm
05     pwm1kHz = Pwm.Create(1000) // create PWM with 1000µs period
06     pwm1kHz.SetDutyCycle(Pin0, 200) // set PWM to 20% duty cycle on Pin0
07     pwm1kHz.Start() // start PWM
08 End Sub
```

Figure 3-17: PWM Example

4. ELECTRICAL SPECIFICATIONS

4.1 Absolute Maximum Ratings

Table 4-1: Absolute Maximum Ratings

Absolute Maximum Ratings	
VDD Voltage	-0.3V to +3.6V
I/O Pin Voltage	-0.3V to VDD
Storage Temperature	-40°C to +125°C

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

4.2 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 +85°C

4.3 Power Consumption

Table 4-3: Power Consumption

Power Consumption	
Sleep Current	<2.0uA (TBD)
mc-Air Transmit Current	7.5 mA @ +4dBm
mc-Air Receive Current	5.4 mA

5. Regulatory

5.1 FCC Notice

This device complies with Part 15 of the FCC Rules. Operation is subject to the condition that this device does not cause harmful interference. 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 transmitter must not be co-located or operated in conjunction with any other antenna or transmitter.

NOTE: 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.

Warning: 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.

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.

5.2 Industry Canada Notice

This device complies with Industry 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.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement

Model: mcMod120
FCC ID: 2AGBO-MCMOD120
IC: 21078-MCMOD120

