mc-Mod120

Product Specification

REVISION 0.2

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Contents

1. DEVICE OVERVIEW 4
2. DIMENSIONS AND PIN ASSIGNMENTS 6
2.1 PHYSICAL DIMENSIONS 6
2.2 FOOTPRINT 7
2.3 PCB Mounting 8
2.4 PIN ASSIGNMENT 9
3. PRODUCT FEATURES 10
3.1 mc-Air™ LPLAN™ 10
3.2 ARM Cortex-M4F Processor 10
3.3 Accelerometer 10
3.4 Temperature Sensor 11
3.5 Reed Switch 13
3.6 Button 13
3.7 LEDs 14
3.8 GPIOs 15
3.8.1 Digital Inputs 15
3.8.2 Digital Outputs 16
3.8.3 Analog Inputs 16
3.9 SPI Interface 18
3.10 UART Interface 19
3.11 I2C Interface 20
3.12 PWM 21
4. ELECTRICAL SPECIFICATIONS 23
4.1 Absolute Maximum Ratings 23
4.2 Recommended Operating Conditions 23
4.3 Power Consumption 23
5. Regulatory 24
5.1 FCC Notice 24
5.2 Industry Canada Notice 25

List of Figures

Figure 1-1: mcMod120 Block Diagram....4
Figure 2-1: Physical Dimensions....6
Figure 2-2: mcMod110 Footprint Dimensions....7
Figure 2-3: mcMod110 Footprint Pin Assignment....7
Figure 2-4: Board Mount Option A at edge of carrier board....8
Figure 2-5: Board Mount Option B with clearance cut-out....8
Figure 3-1: Accelerometer Schematic....11
Figure 3-2: Temperature Sensor Schematic....12
Figure 3-3: TMP102 mc-Script....12
Figure 3-4: Reed Switch Schematic....13
Figure 3-5: Reed Switch mc-Script....13
Figure 3-6: Button Schematic....14
Figure 3-7: Button mc-Script....14
Figure 3-8: LEDs Schematic....14
Figure 3-9: LED mc-Script....15
Figure 3-10: Input Pin mc-Script....16
Figure 3-11: Output Pin mc-Script....16
Figure 3-12: High Impedance Analog Inputs Schematic....17
Figure 3-13: Analog Input mc-Script....18
Figure 3-14: SPI Interface mc-Script....19
Figure 3-15: UART mc-Script....20
Figure 3-16: I2C mc-Script....21
Figure 3-17: PWM Example....22

List of Tables

Table 1-1: Key Components....4
Table 1-2: External Interfaces....5
Table 2-1: mcMod120 Pin Assignment....9
Table 3-1: GPIO Pin Modes....15
Table 3-2: Input Pin Configurations....15
Table 3-3: Analog Pins....16
Table 3-4: SPI Parameters....18
Table 3-5: UART Parameters....20
Table 3-6: I2C Parameters....21
Table 3-7: PWM Parameters....21
Table 4-1: Absolute Maximum Ratings....23
Table 4-2: Recommended Operating Conditions....23
Table 4-3: Power Consumption....23

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.

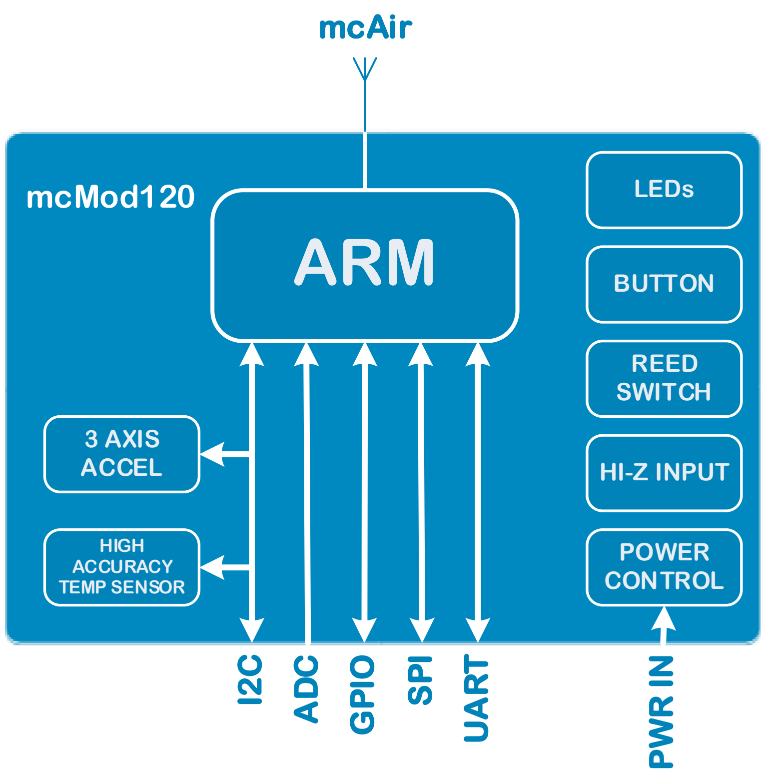

Figure 1-1: mcMod120 Block Diagram

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.
I^2C	I^2C 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.

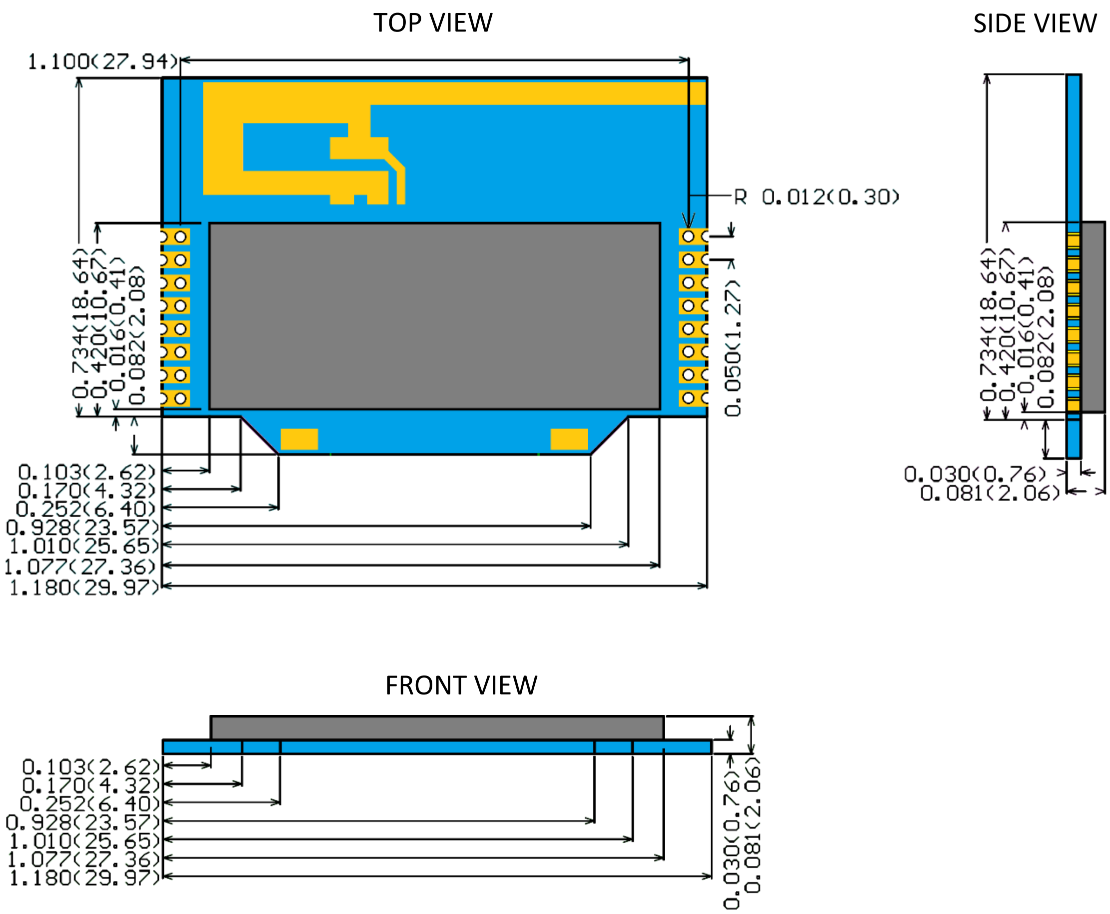

Figure 2-1: Physical Dimensions

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.

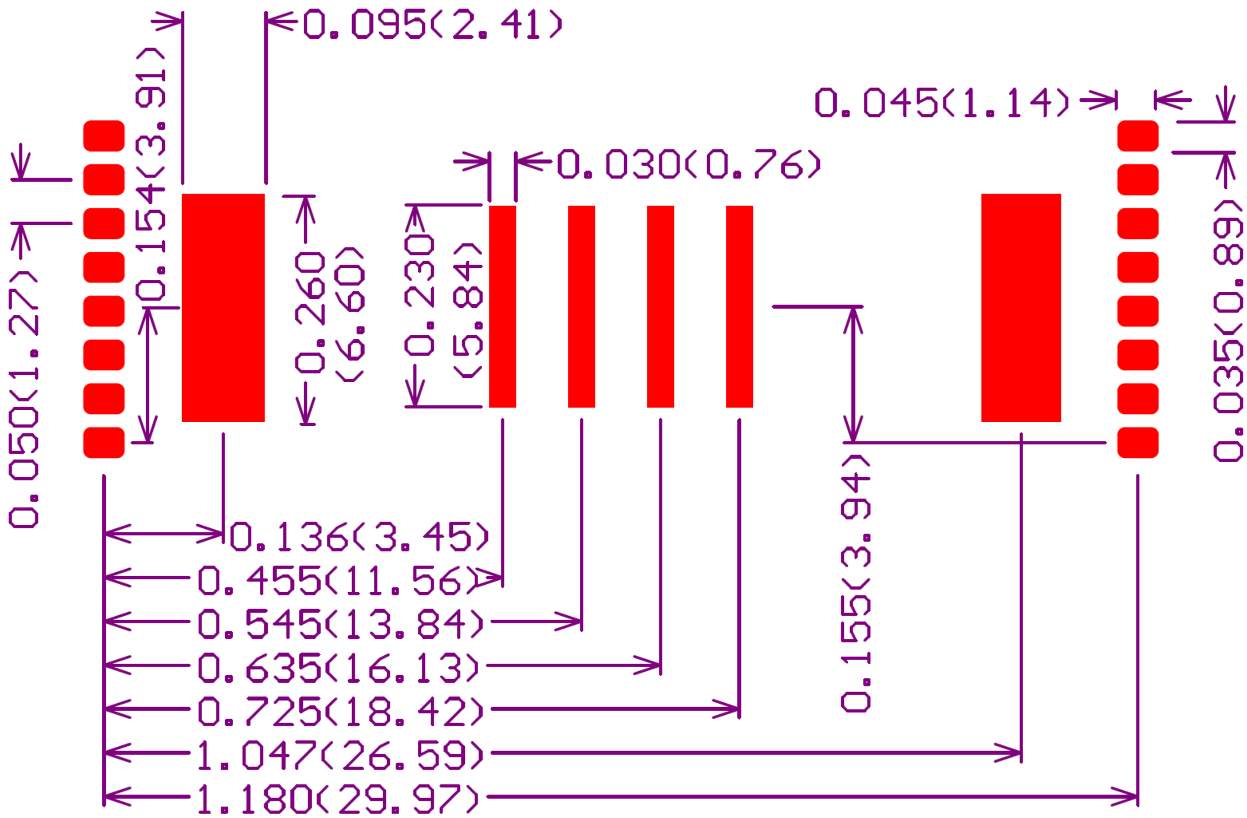

Figure 2-2: mcMod110 Footprint Dimensions

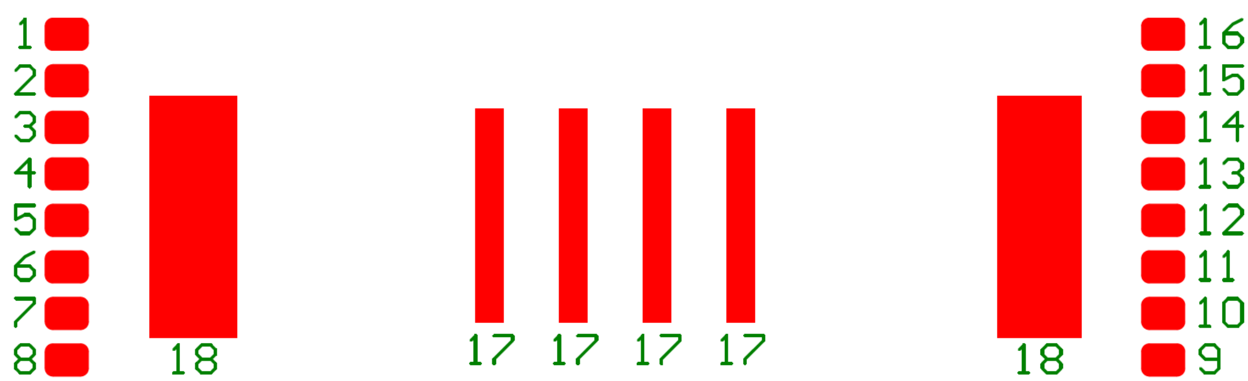

Figure 2-3: mcMod110 Footprint Pin Assignment

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).

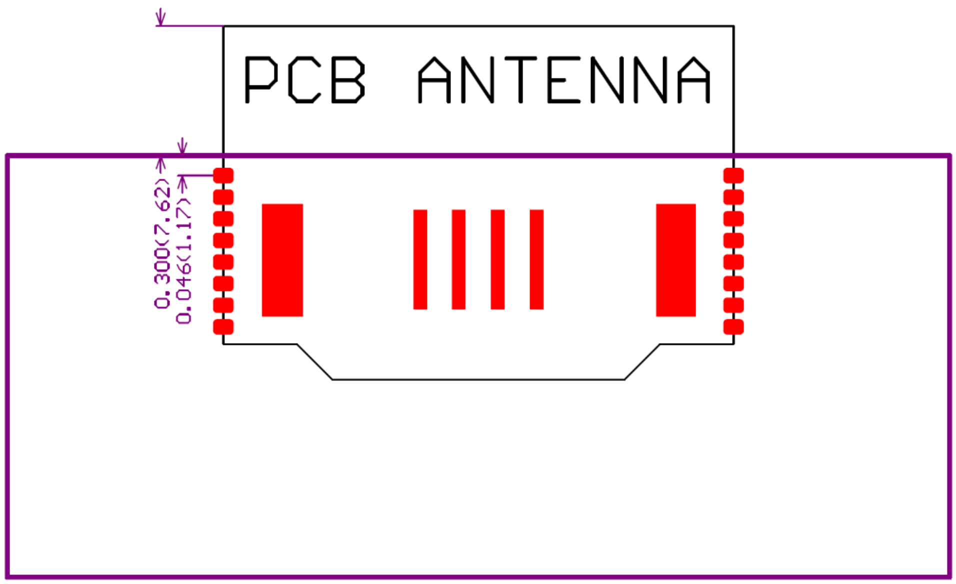

Figure 2-4: Board Mount Option A at edge of carrier board

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.

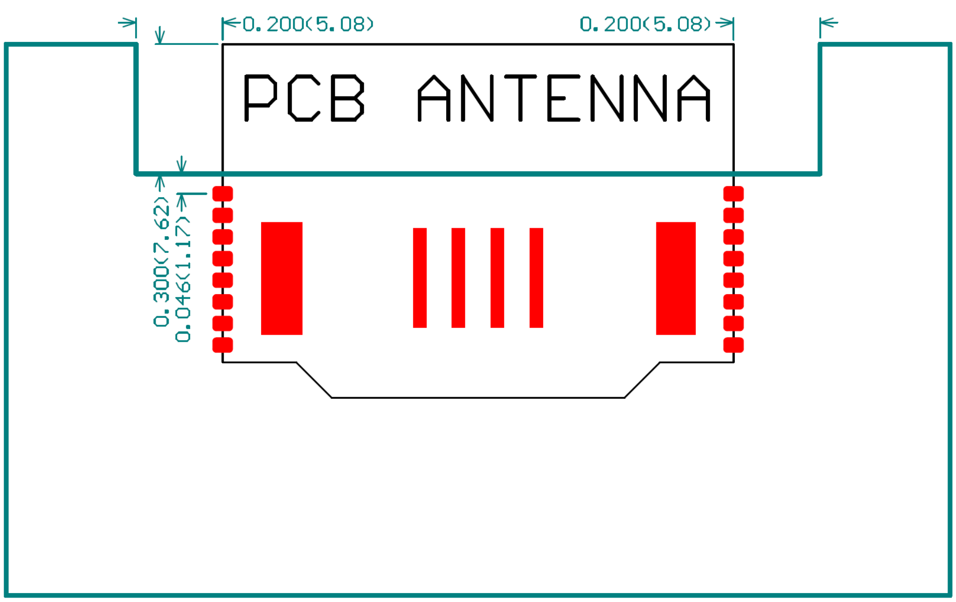

Figure 2-5: Board Mount Option B with clearance cut-out

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 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

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 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.

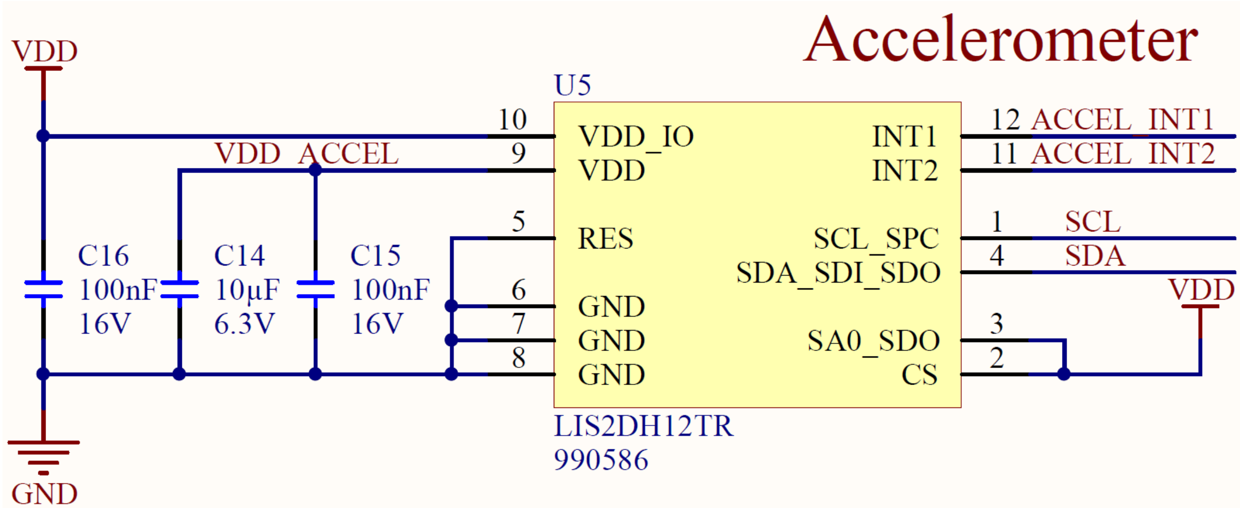

Figure 3-1: Accelerometer Schematic

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

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:
  - ±0.5°C (typical) from -25°C to +85°C
  - ±1.0° (typical) from -40°C to +125°C
- 12-bit resolution (0.0625°C)
- Very low current active current (10 µA 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.

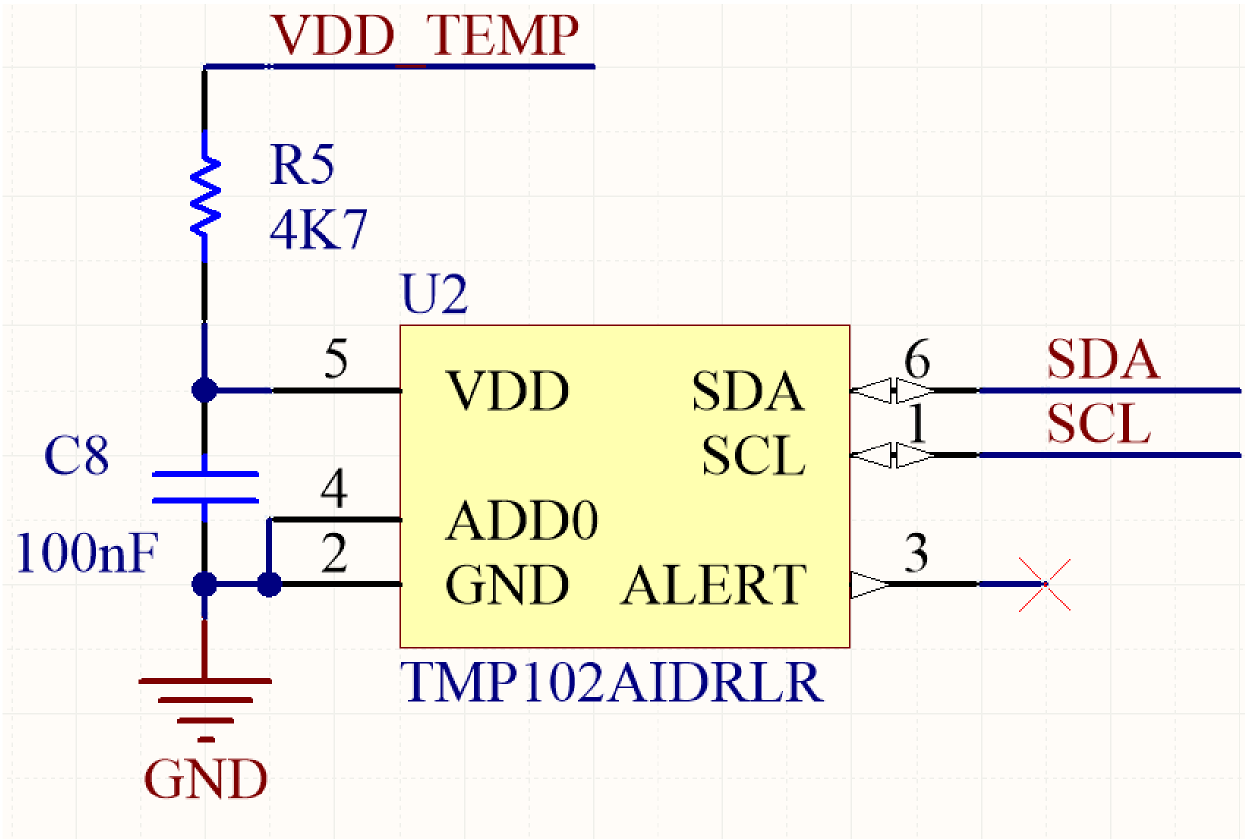

Figure 3-2: Temperature Sensor Schematic

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

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

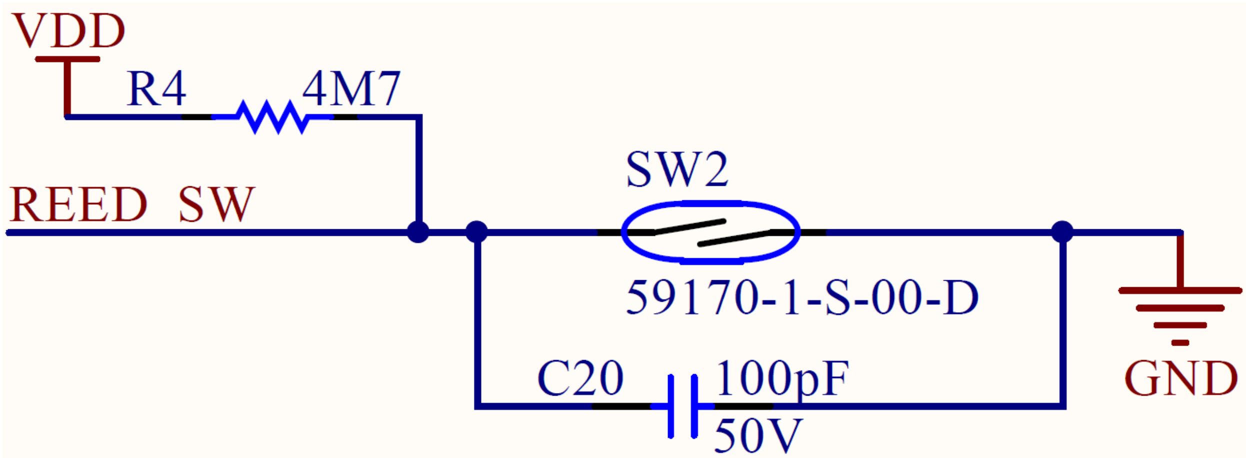

Figure 3-4: Reed Switch Schematic

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.

```
Shared Event ReedSwitchChanged()
    If ReedSwitch = True Then
        //button pressed
        LedGreen = True //turn on green LED if button pressed
    Else
        //button released
        LedGreen = False //turn off green LED if button released
    End If
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.

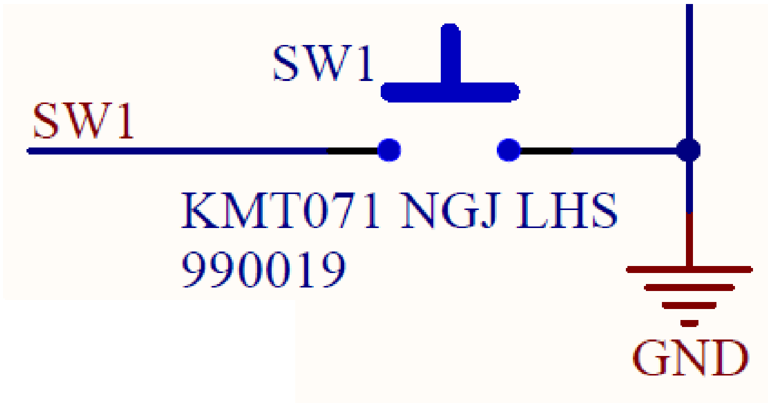

Figure 3-6: Button Schematic

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

```
Shared Event ButtonChanged()
    If Button0 = True Then
        //button pressed
        LedGreen = True //turn on green LED if button pressed
    Else
        //button released
        LedGreen = False //turn off green LED if button released
    End If
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.

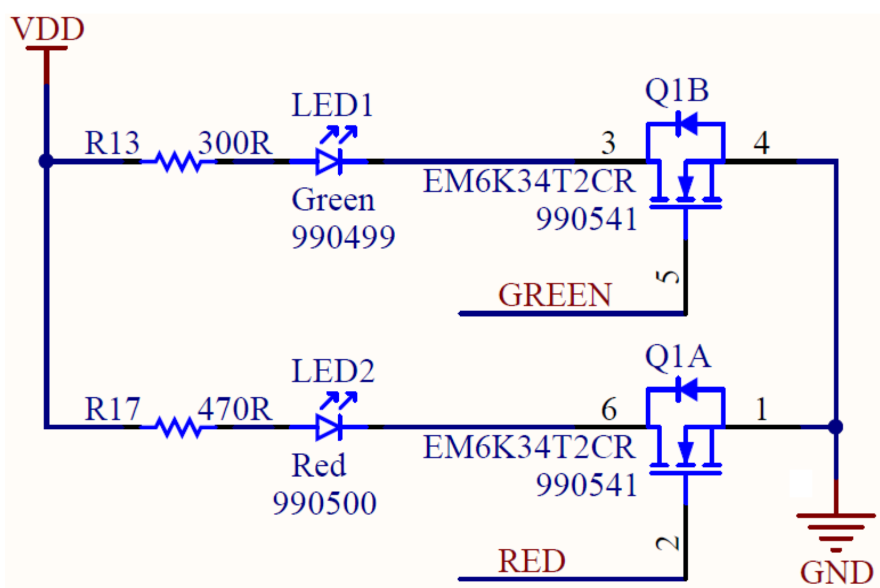

Figure 3-8: LEDs Schematic

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

```
Shared Event blinkLEDs() RaiseEvent Every 500 milliSeconds
    LedGreen = Not LedGreen //toggle green LED
    LedRed = Not LedRed //toggle red LED
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.


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

```
Define PinMode Pin1 As DigitalOutput
Class OutputPinTest()
    Shared Event TogglePin1() RaiseEvent Every 500 milliSeconds
        // toggle Pin1 every 500 milliseconds
        Pin1 = Not Pin1 // Toggle Pin1
    End Event
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.

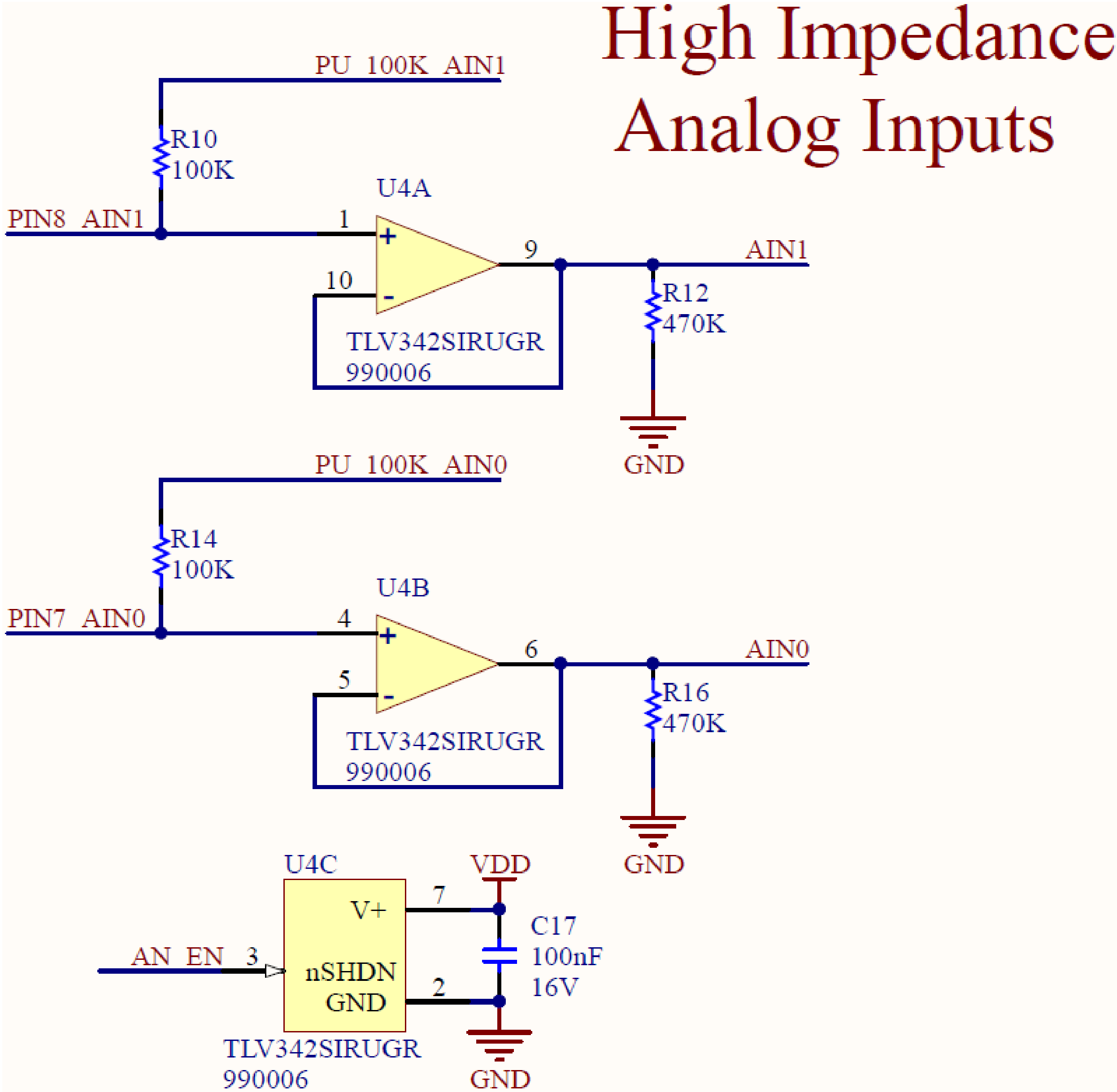

Figure 3-12: High Impedance Analog Inputs Schematic

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

```
Define PinMode Pin3 As AnalogInput
Define PinMode Pin7 As AnalogInputPullUp Alias hiZVoltage

Public Function GetPin3Analog() As Short
    Dim value As Short
    value = Pin3      // Read the pin. This activates the ADC
    Return value      // Return value in millivolts
End Function

Public Function GetPin7Analog() As Short
    Dim value As Short
    device.EnableOpamp()    // Enable opAmp for hi-Z reading
    thread.Sleep(5000)    //sleep for 5ms for opamp to power
    value = hiZVoltage      // Read the pin. This activates the ADC
    device.DisableOpamp()    // Disable Opamp
    Return value      // Return value in millivolts
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.

```
//
// See datasheet at
// http://ww1.microchip.com/downloads/en/DeviceDoc/20005119G.pdf
//
Class ExternalFlash
    Shared Mem1 As Spi
    Shared Mem2 As Spi
    Public Sub New()
        Mem1 = Spi.Create(8000000, 0, Pin.Pin0, Pin.Pin1, Pin.Pin3, Pin.Pin5)
        Mem2 = Spi.Create(8000000, 0, Pin.Pin0, Pin.Pin1, Pin.Pin3, Pin.Pin6)
    End Sub
    Public Function Read(adr As Integer, size As Integer) As ListOfByte
        Dim data As ListOfByte = New ListOfByte
        data.Add(3) ' Read command
        data.Add3Bytes(adr, Endianness.Big) ' Address
        data.AddElements(size) 'Size to read
        Dim mem As Spi
        If adr >= 0x00800000 Then
            mem = Mem2
        Else
            mem = Mem1
        End If
        data = mem.Transfer(data)
        Return data.GetRange(4)
    End Function


   Public Sub Write(adr As Integer, toWrite As ListOfByte)
        Dim data As ListOfByte = New ListOfByte
        data.Add(2) ' Write command
        data.Add3Bytes(adr, Endianness.Big) ' Address
        data.AddRange(toWrite) 'Data to write
        Dim mem As Spi
        If adr = 0x00800000 Then
            mem = Mem1
        Else
            mem = Mem2
        End If
        mem.Transfer(data)
    End Sub
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.

```
Class Display
    Shared Disp As Uart
    Public Sub New()
        Disp = Uart.Create(9600, Pin.Pin0, Pin.Pin1)
    End Sub
    Shared Event Uart0Receive()
        Dim chr As Integer = Disp.Read()
        While chr >= 0
            // Process Character and do something
            // ....
            // ....
            chr = Disp.Read()
        End While
    End Event
    Public Sub DisplayText(row As Byte, col As Byte, str As String)
        If row >= 0 Then
            Disp.Write(0xff)
            Disp.Write(row)
            Disp.Write(col)
            Disp.Write(str.Length.ToByte)
            Disp.Write(str)
        Else
            Disp.Write(0xfe)
            Disp.Write(str.Length.ToByte)
            Disp.Write(str)
        End If
    End Sub
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.

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

```
Define PinMode Pin0 As PwmOutput

Public Sub SetPwm()
    Dim pwm1kHz As Pwm
    pwm1kHz = Pwm.Create(1000)  // create PWM with 1000µs period
    pwm1kHz.SetDutyCycle(Pin0, 200) // set PWM to 20% duty cycle on Pin0
    pwm1kHz.Start() // start PWM
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

FCC ID: 2AGBO-MCMOD12Ø
Model: mcMod120

FCC STATEMENT
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.

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

ISED ID: 21Ø78-MCMOD12Ø
Model: mcMod120

ISED Statement

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 étre 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.