MCP3221 Evaluation Board User's Guide

Note the following details of the code protection feature on Microchip products:

- Microchip products meet the specifications contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is secure when used in the intended manner, within operating specifications, and under normal conditions.
- Microchip values and aggressively protects its intellectual property rights. Attempts to breach the code protection features of Microchip product is strictly prohibited and may violate the Digital Millennium Copyright Act.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of its code. Code protection does not mean that we are guaranteeing the product is "unbreakable" Code protection is constantly evolving. Microchip is committed to continuously improving the code protection features of our products.

Trademarks

ISBN: 978-1-6683-1542-2

For information regarding Microchip's Quality Management Systems, please visit www.microchip.com/quality.

MICROCHIP

MCP3221 EVALUATION BOARD USER'S GUIDE

Table of Contents

NOTES:

Preface

NOTICE TO CUSTOMERS

All documentation becomes dated, and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our website (www.microchip.com) to obtain the latest documentation available.

Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "DSXXXXXXXXA", where "XXXXXXXX" is the document number and "A" is the revision level of the document.

For the most up-to-date information on development tools, see the MPLAB® IDE online help. Select the Help menu, and then Topics, to open a list of available online help files.

INTRODUCTION

This chapter contains general information that will be useful to know before using the MCP3221 SAR ADC Evaluation Board. Items discussed in this chapter include:

- Document Layout
- Conventions Used in this Guide
- Recommended Reading
- The Microchip Website
- Product Change Notification Service
- Customer Support
- Document Revision History

DOCUMENT LAYOUT

This document describes how to use the MCP3221 SAR ADC Evaluation Board as a development tool to emulate and debug firmware on a target board. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the MCP3221 SAR ADC Evaluation Board and the MCP3221 device.
- **Chapter 2. "Hardware Description"** – Detailed description of the MCP3221 SAR ADC Evaluation Board.
- **Chapter 3. "Firmware"** – Information about the data acquisition process.
- **Chapter 4. "Installation and Operation"** – Describes how to use the MCP3221 SAR ADC Evaluation Board directly with the PC GUI.
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and layout diagrams for the MCP3221 SAR ADC Evaluation Board.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the MCP3221 SAR ADC Evaluation Board.

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	*MPLAB® IDE User's Guide*
	Emphasized text	...is the *only* compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, italic text with right angle bracket	A menu path	*File>Save*
Bold characters	A dialog button	Click **OK**
	A tab	Click the **Power** tab
N'Rnnnn	A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.	4'b0010, 2'hF1
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier New font:		
Plain Courier New	Sample source code	`#define START`
	Filenames	`autoexec.bat`
	File paths	`c:\mcc18\h`
	Keywords	`_asm, _endasm, static`
	Command-line options	`-Opa+, -Opa-`
	Bit values	`0, 1`
	Constants	`0xFF, 'A'`
Italic Courier New	A variable argument	*`file`*`.o`, where *`file`* can be any valid filename
Square brackets [ ]	Optional arguments	`mcc18 [options]` *`file`* `[options]`
Curly brackets and pipe character: { | }	Choice of mutually exclusive arguments; an OR selection	`errorlevel {0|1}`
Ellipses...	Replaces repeated text	`var_name [, var_name...]`
	Represents code supplied by user	`void main (void) { ... }`

RECOMMENDED READING

This user's guide describes how to use the MCP3221 SAR ADC Evaluation Board. Other useful documents are listed below. The following Microchip documents are available and recommended as a supplemental reference resources:

MCP3221 Data Sheet – *"Low-Power 12-Bit A/D Converter with I^2C Interface"* (DS20001732)

PIC32MX470 Curiosity Development Board User's Guide (DS70005283)

THE MICROCHIP WEBSITE

Microchip provides online support via our website at www.microchip.com. This website is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the website contains the following information:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

PRODUCT CHANGE NOTIFICATION SERVICE

Microchip's customer notification service helps keep customers current on Microchip products. Subscribers will receive e-mail notifications whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, access the Microchip website at www.microchip.com, click on **Product Change Notification** and follow the registration instructions.

CUSTOMER SUPPORT

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

Customers should contact their distributor, representative or field application engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

Technical support is available through the website at:
https://www.microchip.com/support.

DOCUMENT REVISION HISTORY

Revision A (November 2022)

- Initial release of this document.

NOTES:

Chapter 1. Product Overview

1.1 INTRODUCTION

This chapter provides an overview of the MCP3221 SAR ADC Evaluation Board combined with Arduino® Due and PIC32MX470 Curiosity Development Board.

1.1.1 MCP3221 Device Overview

The MCP3221 device is a successive approximation (SAR) Analog-to-Digital Converter (ADC) with 12-bit resolution in a SOT-23 package with 5 pins. This device has one single-ended input with very low power consumption. The device operates with a power supply voltage from 2.7V to 5.5V.

Communication with the MCP3221 is performed using 2-wire I^2C serial communication. Two communication modes are available: Standard mode at 100 kHz and Fast mode at 400 kHz. The converter comes with a programmable sampling speed up to 22.3 ksps in Continuous Conversion mode.

1.1.2 What is the MCP3221 SAR ADC Evaluation Board?

The MCP3221 SAR ADC Evaluation Board is a standard click board (with a micro-USB connector) that is able to acquire data and analyze the performance of the MCP3221 SAR ADC. The acquired data set is displayed in the Hi-Resolution ADC Utility GUI by using serial communication between the microcontroller unit (MCU) and the connected PC.

The Hi-Resolution ADC Utility GUI is used to analyze and display data coming from the MCP3221 SAR ADC Evaluation Board. The computer running the software must be connected to the board using a USB cable.

A download link for the GUI can be found on the Microchip web page. For instructions on how to use the Hi-Resolution ADC Utility GUI, refer to the supporting documentation within the installation package.

System and ADC performance analyses can be done through graphical interface (GUI) PC tool (Hi-Resolution ADC Utility GUI), showing noise histogram, frequency domain (FFT) plot, time domain scope plot and statistical numerical analysis.

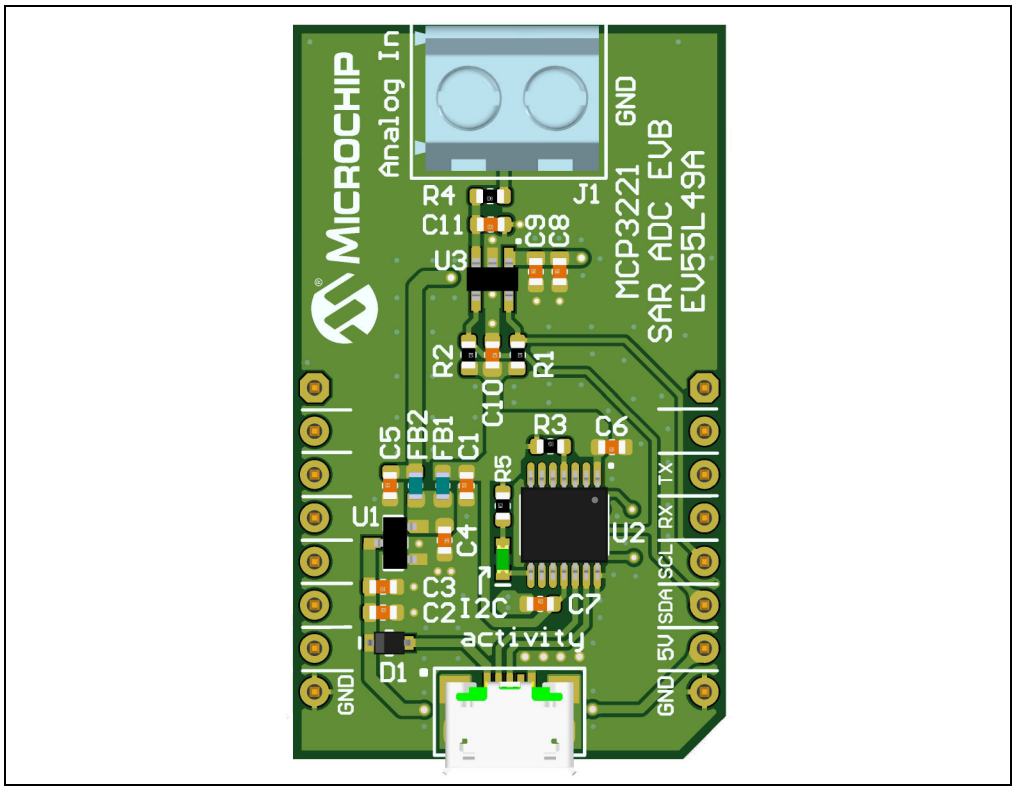


FIGURE 1-1: *MCP3221 SAR ADC Evaluation Board.*

1.1.3 MCP3221 SAR ADC Evaluation Board Kit Contents

The MCP3221 SAR ADC Evaluation Board kit includes:

- MCP3221 SAR ADC Evaluation Board (EV55L49A)
- Micro USB-B to USB-A cable
- Important Information Sheet.

Chapter 2. Hardware Description

2.1 MCP3221 SAR ADC EVALUATION BOARD HARDWARE OVERVIEW

Figure 2-1 illustrates a detailed view into the components of MCP3221 SAR ADC Evaluation Board.

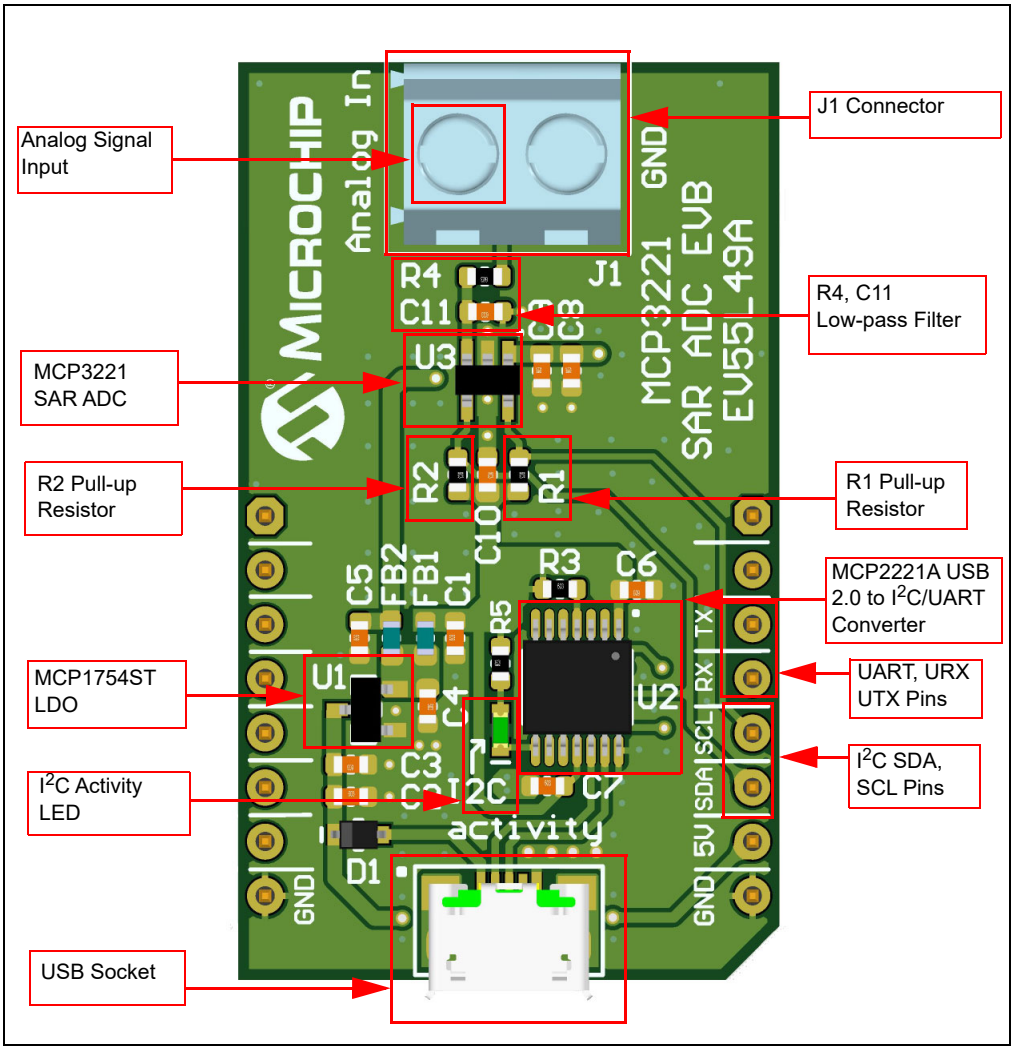


FIGURE 2-1: *MCP3221 SAR ADC Evaluation Board.*

The MCP3221 SAR ADC Evaluation Board contains four main blocks, as shown in Figure 2-2:

1. MCP3221 SAR ADC block
2. Micro-USB 2.0 and Click connector
3. USB to I^2C bridge
4. Power supply block

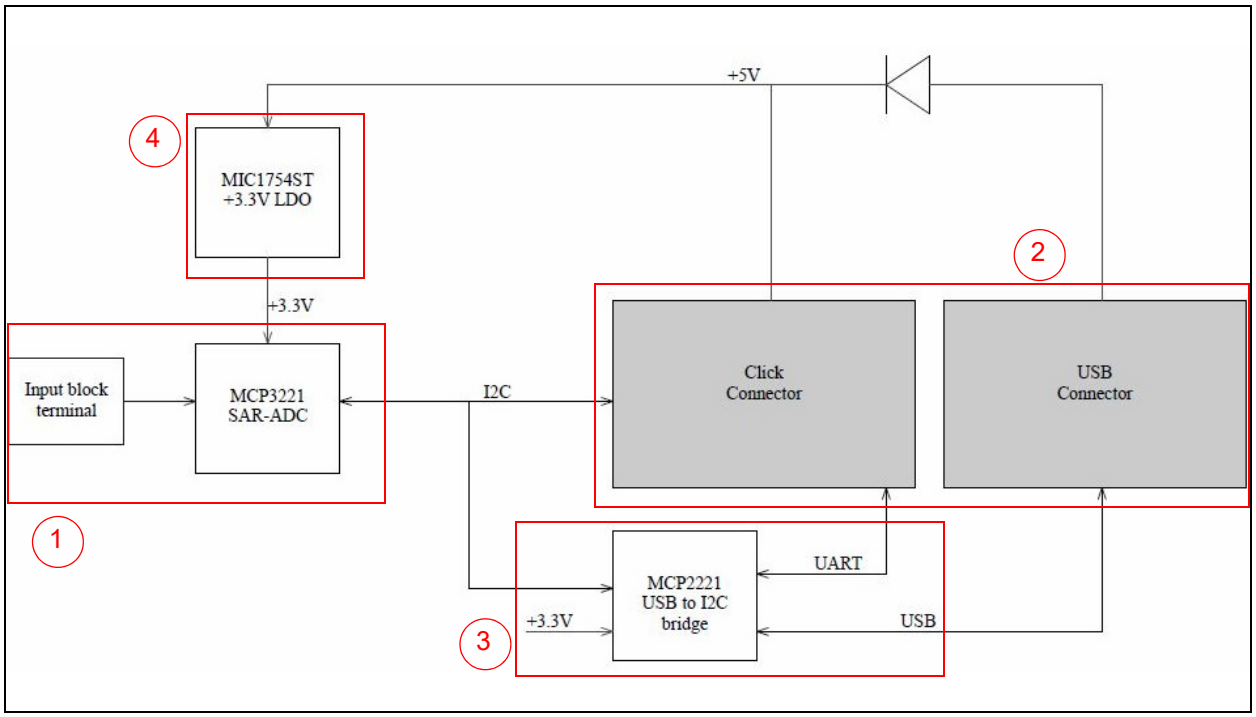


FIGURE 2-2: *MCP3221 SAR ADC Evaluation Board – Diagram Block.*

2.1.1 MCP3221 SAR ADC Block

The MCP3221 SAR ADC Evaluation Board contains the MCP3221 ADC converter, the R1 and R2 pull-up resistors, a low-pass filter consisting of an R4 resistor and C11 capacitor and the J1 connector used for analog signal input. See **Section A.3 "EV55L49A – Schematic (ADC)"**.

The communication between the MCP3221 device and the microcontroller is done through the I^2C bus, using the SDA and SCL pins. The SDA and SCL lines require a pull-up resistor (R1 and R2). A value of 2 kΩ is required for 400 kHz SCL clock speed.

The input pin (AIN) is directed at the J1 connector on the MCP3221 SAR ADC Evaluation Board. This enables the connection of the analog signal source to the ADC input channel. A low-pass filter is placed before the input pin (AIN) in order to avoid the aliasing effect.

The SCL, SDA (I^2C interface), RX and TX (UART interface) pins are connected to the Micro-USB interface.

2.1.2 Micro-USB 2.0 and Click Connector

There are two ways to connect the MCP3221 SAR ADC Evaluation Board:

a) Through Micro-USB 2.0 connector
b) Through mikroBUS connector.

The first method allows data acquisition directly from the ADC, without having another board, via an USB to I^2C bridge. The second method requires an interface with a micro-controller unit that communicates over the same I^2C bus.

2.1.3 USB to I^2C Bridge

The USB to I^2C bridge provides a solution to connect the ADC from the MCP3221 SAR ADC Evaluation Board directly to the PC. A Male USB-A to Male Micro-USB-B is required for this PC connection. The LD1 led indicates data transfer activity from MCP3221 ADC through the I^2C interface.

2.1.4 Power supply

The MCP3221 SAR ADC Evaluation Board features a high-performance LDO (MCP1754ST) to provide the supply voltage for the MCP3221.

The MCP3221 SAR ADC Evaluation Board is powered through the USB connector (from the PC) or by the micro-USB connector (from the development board). The D1 diode separates the Click and USB power supply. The LDO provides a 3.3 V for MCP3221 and MCP2221A. To avoid unwanted interface from the digital lines, analog power supply of MCP3221 is separated from the 3.3V digital power supply.

For more details, board schematics and bill of materials (BOM), see **Appendix A. “Schematic and Layouts”** and **Appendix B. “Bill of Materials (BOM)”**.

2.2 CONNECTION DIAGRAM

There are three options for data acquisition using the MCP3221 SAR ADC Evaluation Board:

1. Through a microcontroller (using the Arduino Due Board)
2. Through a microcontroller (using the PIC32MX470 Curiosity Development Board)
3. Directly through the MCP3221 SAR ADC Evaluation Board, using the USB to I^2C bridge, MCP2221A.

The microcontroller option offers two types of firmware support: PIC32MX470F512H (PIC32MX Curiosity Development Board) and Atmel SAM3X8E ARM (Arduino Due Board) microcontroller.

2.2.1 Arduino Due Board

The Arduino Due Board contains 54 digital input/output (IO) pins compatible with the Arduino Click Shield through which the Atmel SAM3X microcontroller is connected.

The MCP3221 data acquisition is achieved through the I^2C bus, SDA/PB12 (pin 20), and SCL/PB13 (pin 21) pins.

Communication with the PC is done through the USB Programming port on RX0/PA8 (pin 0), and TX0/PA9 (pin 1) pins.

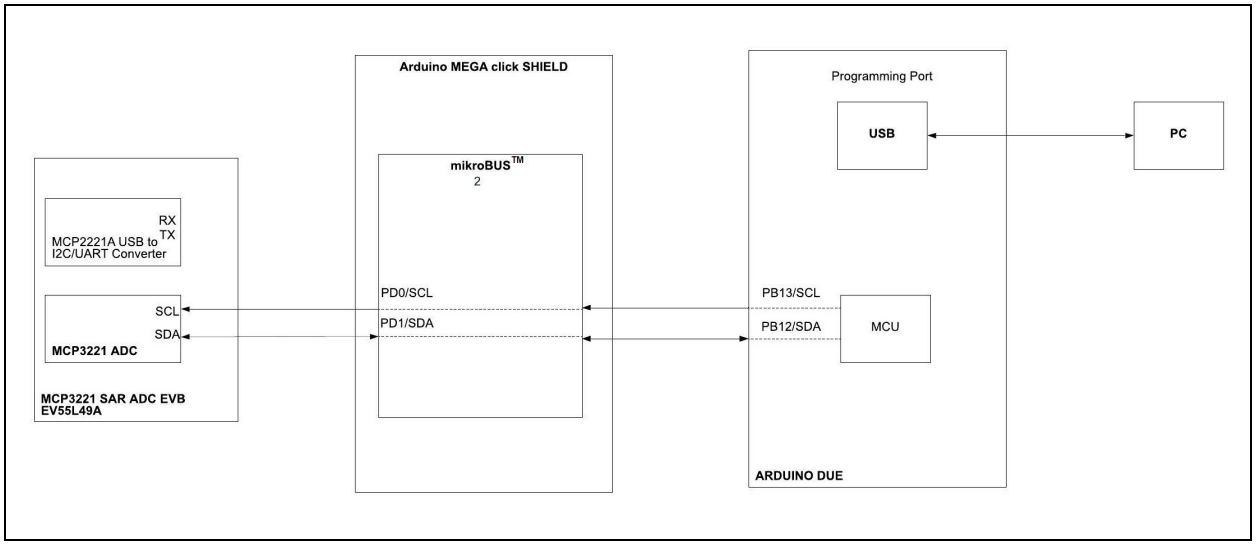


FIGURE 2-3: *Diagram Connection between the MCU and the MCP3221 – Arduino Due Board.*

2.2.2 PIC32MX470 Curiosity Development Board

The PIC32MX470 Curiosity Development Board is designed with a PIC32MX470F512H microcontroller. The board provides two mikroBUS™ sockets to expand the functionality using different Click adapter boards.

The MikroBUS 2 (J10 connector) is used to connect the MCP3221 SAR ADC Evaluation Board to the microcontroller pins. The MCP3221 data acquisition is controlled through the I^2C bus, SDA/SDA1/TPD9 (pin 11), and SCL/SCL1/RPD10 (pin 12) pins.

Communication with the PC is made through the MCP3221 SAR ADC Evaluation Board by using the MCP2221A, USB UART interface on RX/RPB9/U2RX (pin 14) and TX/RPE5/U2RX (pin 13) pins.

WARNING

Both MCP3221 SAR ADC Evaluation Board and PIC32MX470 Curiosity Development Board have pull-up resistors on the I^2C SDA and SCL lines. In order to work, the resistors must be removed from one of the boards. For example, the R76 and R77 pull-up resistors must be removed from the PIC32MX470 Curiosity Development Board. Without this change, data acquisition does not work.

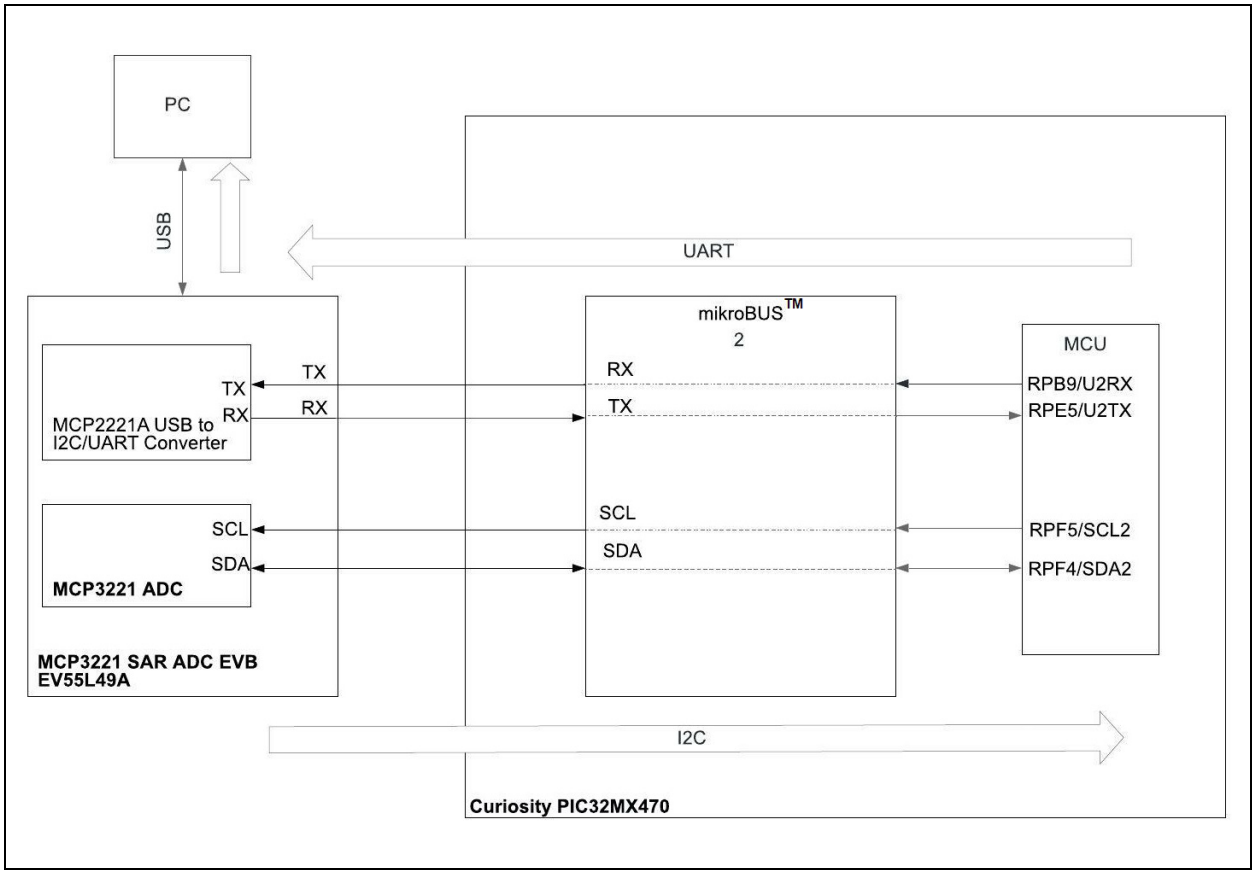


FIGURE 2-4: *Diagram Connection between the MCU and MCP3221 – PIC32MX470 Curiosity Development Board.*

2.2.3 MCP3221 ADC to MCP2221A

The MCP3221 data acquisition is carried out through the I^2C interface commands using the MCP2221A USB to the I^2C bridge.

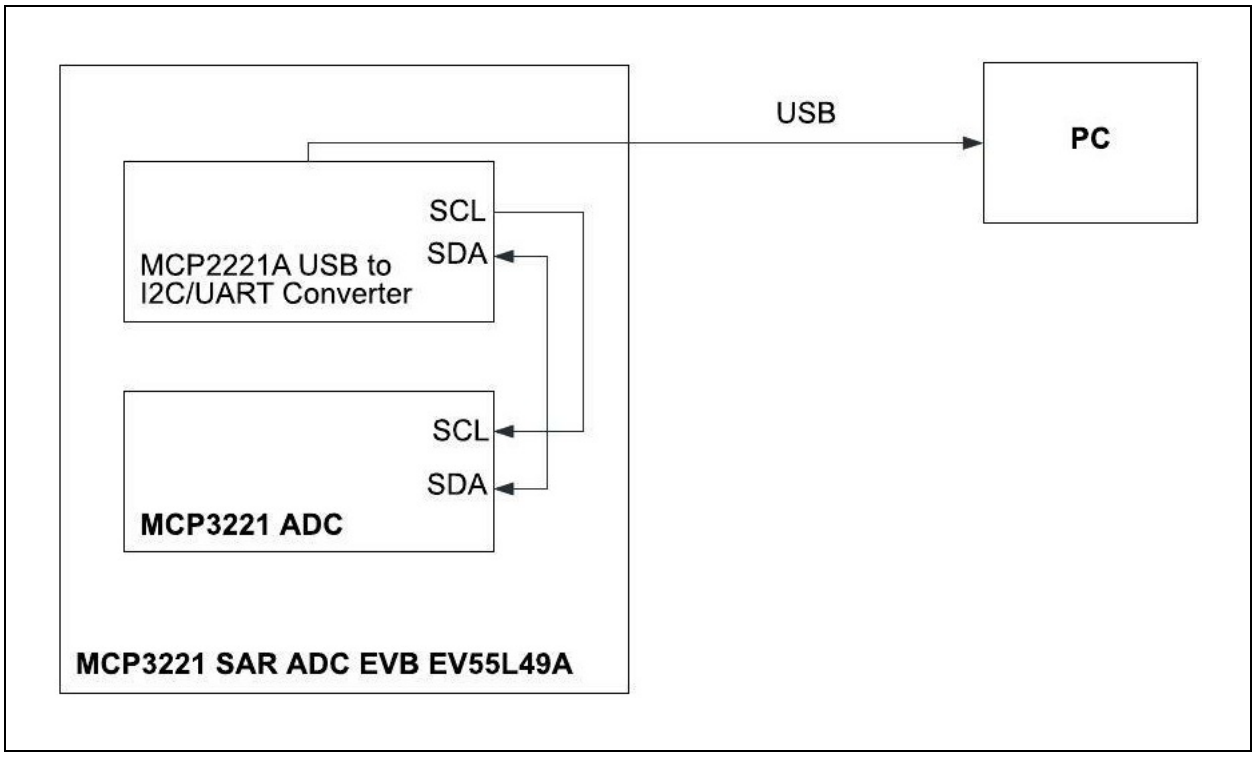


FIGURE 2-5: *Diagram Connection between MCP3221 SAR ADC Evaluation Board and the PC by using MCP2221A.*

Chapter 3. Firmware

3.1 MICROCONTROLLER UNITS

3.1.1 MCU for the PIC32MX470 Curiosity Development Board

The microcontroller unit used in the PIC32MX470 Curiosity Development Board is the PIC32MX470F512H from the PIC32MX family of devices. It is a 32-bit MCU with a 120 MHz CPU, 512 KB Flash and 128 KB RAM.

A 20 MHz crystal is connected to the on-board PIC32MX MCU; the PIC32MX470 Curiosity Development Board has additional support for an external oscillator.

The PIC32MX470 Curiosity Development Board includes on-board debugger, in addition to the option to use an external debugger by connecting to the In-Circuit Serial Programming header.

The MCP3221 SAR ADC Evaluation Board is connected to the PIC32MX470F512H MCU through the I^2C interface that uses pin 32 as SCL2 and pin 31 as SDA2.

Communication with the PC is done through the USB to serial UART interface through click interface. It used pin 22 as RX (U2RX) and pin 1 as TX (U2TX).

3.1.2 MCU for the Arduino Due Board

The Atmel SAM3X8E ARM Cortex-M3 CPU is the microcontroller used for the code examples integrated into the Arduino Due Board.

The Arduino Due Board contains everything needed to support the AT91SAM3X8E MCU. It is based on a 32-bit ARM core microcontroller. The Arduino Due Board has 54 digital input/output pins.

The MCP3221 SAR ADC Evaluation Board is connected to the AT91SAM3X8E device using an intermediary Arduino Click Shield that serves as an adapter between Arduino Due Board pinout and MikroBUS connector, specific to click boards. The MCP3221 ADC is linked to the MCU through the I^2C port as TW1 that uses pin 20 as SDA and pin 21 as SCL.

Serial data transmission is carried out through the main UART module, RX0 and TX0 pins connected to an USB-to-serial adapter chip. The same port is used for programming the Arduino Due Board.

3.2 DATA ACQUISITION

3.2.1 Data Acquisition Through MCU

The same data acquisition method applies to both the PIC32MX470 Curiosity Development Board and Arduino Due Board (Atmel SAM3X8E MCU).

Data samples are read from MCP3221 SAR ADC using the I^2C communication protocol. Communication with the MCP3221 device is accomplished in two modes: executing a single conversion, on demand (single-shot conversion) or Continuous Conversion mode, at the maximum sample rate.

Data acquisition proceeds on the Timer Interrupt regarding sequential conversion. Two bytes of data (the equivalent of a sample) are read when Timer Interrupt occurs.

The timer is used to set the period at which an ADC sample is taken. This method is used to set different sampling rate for data acquisition. The timer is controlling the acquisition speed, not the sampling speed.

In Continuous Conversion mode, the timer is stopped and a frame of 4096 bytes (the equivalent of 2048 samples) is read from ADC on the main loop.

In both cases, the connected MCU reads data from the ADC on I^2C and fills a buffer of 2048 bytes in length. After the I^2C acquisition ends and the buffer contains the 2048 samples, it is sent to the PC via the serial connection. When all data buffer content is sent, the connected MCU resumes the acquisition on I^2C.

The sampled values from MCP3221 are transmitted serially with MSB first.

Note: Timer 0 is used for the Arduino Due Board code example and Timer 2 is used for the PIC32MX470 Curiosity Development Board code example.

3.2.2 Data Acquisition through the MCP3221 SAR ADC Evaluation Board using the MCP2221A

Data samples are read from the ADC on I^2C by using the Continuous Conversion mode via MCP2221A. The data acquisition process uses the Hi-Resolution ADC Utility GUI. The GUI sends acquisition commands to MCP2221A and the bridge devices links the command further to MCP3221.

In Continuous Conversion mode, a frame of 4096 bytes (the equivalent of 2048 samples) is read from the ADC.

WARNING

Data acquisition through the MCP3221 SAR ADC Evaluation Board with the MCP2221A is not accurate for data sets larger then 30 samples because of the buffer limitation of MCP2221A. This causes a pause in the data acquisition, which leads to data reads by ADC being reproduced incorrectly.
The method of data acquisition through a microcontroller is recommended for data accuracy and maximum sampling rate.

3.3 UART COMMUNICATION PROTOCOL

The serial connection is used to send the acquired data from the MCP3221 to the PC at a transfer rate of 115200 baud.

A communication protocol is implemented to work with the Hi-Resolution ADC Utility GUI. The board does not send data to the PC unless it receives a specific command from the PC.

Received commands from PC over UART are executed on the RX interrupt service routine implemented on the connected MCU's firmware.

The data from the MCP3221 are sent on the UART in the form of 10 ASCII characters, separated by the '`;`' character.

The main implemented commands are:

- `i\r` - Identify: gets the ID of the attached board (EV55L49A);
- `v\r` - Get FW Version: gets the version of the device firmware;
- `txxx\r` - Tempo Adjustment: adjusts the sampling speed (available options are shown in Table 3-1);
- `s\r` - Start: sends the data Tx/Rx cycle;
- `p\r` - Stop: stops the data Tx/Rx cycle

TABLE 3-1: ADC SAMPLING SPEED OPTIONS

Crt. No.	Command	ADC Sampling Rate (ksps)
1	`t000\r`	1
2	`t001\r`	2
3	`t002\r`	5
4	`t003\r`	10
5	`t004\r`	22

Note: The '`txxx\r`' command is sent before the Start command. If no sampling speed is set, the acquisition starts with the default value of 1 ksps. The sampling speed can only be one of those shown in Table 3-1.

Note: The '`txxx\r`' command is not available for the method with MCP3221 SAR ADC Evaluation Board using MCP2221A.

NOTES:

Chapter 4. Installation and Operation

4.1 INTRODUCTION

The MCP3221 SAR ADC Evaluation Board is designed to demonstrate the performance of the MCP3221 device using the Hi-Resolution ADC Utility GUI for PC.

This section describes how to use the MCP3221 SAR ADC Evaluation Board directly with the PC GUI, as well as with the PIC32MX470 Curiosity Development Board and Arduino Due Board.

Contains support for:

- Using the PIC32MX470 Curiosity Development Board
- Using the Arduino Due Board
- Using the MCP3221 SAR ADC Evaluation Board through MCP2221A.

4.2 GETTING STARTED

4.2.1 PIC32MX470 Curiosity Development Board Setup

Getting started with the project requires the following items:

- PIC32MX470 Curiosity Development Board
- MCP3221 SAR ADC Evaluation Board
- Male USB-A to male mini-USB-B cable
- USB-A to micro-USB-B cable
- MPLAB® X IDE
- MPLAB XC32/32++ Compiler
- MPLAB Harmony
- Hi-Resolution ADC Utility GUI.

The MPLAB X IDE, MPLAB XC Compiler and MPLAB Harmony are available for download on the www.microchip.com web page.

Building the project requires the following packs and software versions, as shown in Figure 4-1:

- PIC32MX_DFP - 1.3.231
- XC32 - v2.50

Install the Device Family Packs (DFPs) through the IDE's pack manager:

1. Click the Tools menu
2. Select the Packs Menu option
3. Update the available DFPs.

Note: The packs must be the specified version in order for this code example to work.

Programming and debugging can be done in the following ways:

1. With the PICkit™ On-Board Debugger (PKOB), based on the PIC24FJ256GB106 General Purpose USB Microcontroller
2. With an external debugger, such as MPLAB ICD3 (or later) or MPLAB PICkit.

In order to use the second option, remove jumper J2 to disconnect the on-board debugger and connect the external debugger to the J16 header.

More details about PIC32MX470 Curiosity Development Board can be found in PIC32MX470 Curiosity Development User's Guide (DS70005283).

4.2.2 Arduino DUE Setup

Getting started with the project requires the following items:

- Arduino Due Board
- Arduino Shield (for example Arduino MEGA Click Shield)
- MCP3221 SAR ADC Evaluation Board
- Male USB-A to male micro-USB-B cable
- Eclipse IDE, with the plug-in Sloeber for Arduino boards
- Hi-Resolution ADC Utility GUI

Two options are available for the installation of the IDE:

1. Install first the Eclipse IDE for the C/C++ project, then install the Arduino Sloeber plug-in
2. Install the Sloeber product first, which contains Eclipse CTD and Sloeber in one compressed file.

After everything is installed correctly, the Arduino section appears in the toolbar of the Eclipse IDE.

Note: The firmware is tested only with the Arduino Due Board.

4.2.3 MCP3221 SAR ADC Evaluation Board to MCP2221A Setup

Getting started with the project require the following items:

- MCP3221 SAR ADC Evaluation Board
- Male USB-A to male micro-USB-B cable
- MCP2221A Utility
- Hi-Resolution ADC Utility GUI.

The MCP2221A Utility is available for download on the www.microchip.com web page.

4.3 INSTALLATION

4.3.1 PIC32MX470 Curiosity Development Board

Follow the next steps to set up the PIC32MX470 Curiosity Development Board:

1. Attach the MCP3221 SAR ADC Evaluation Board in the J10 mikroBUS socket from the PIC32MX470 Curiosity Development Board, as shown in Figure 4-1.
2. Connect the USB UART interface to the PC by using the type micro-USB cable from the MCP3221 SAR ADC Evaluation Board to the PC.

The PIC32MX470 Curiosity Development Board is powered through the USB connector, by putting the jumper in the right position to select the power source from the J8 header.

The on-board debugger is used to program the board, by leaving the jumper in the J2 position.

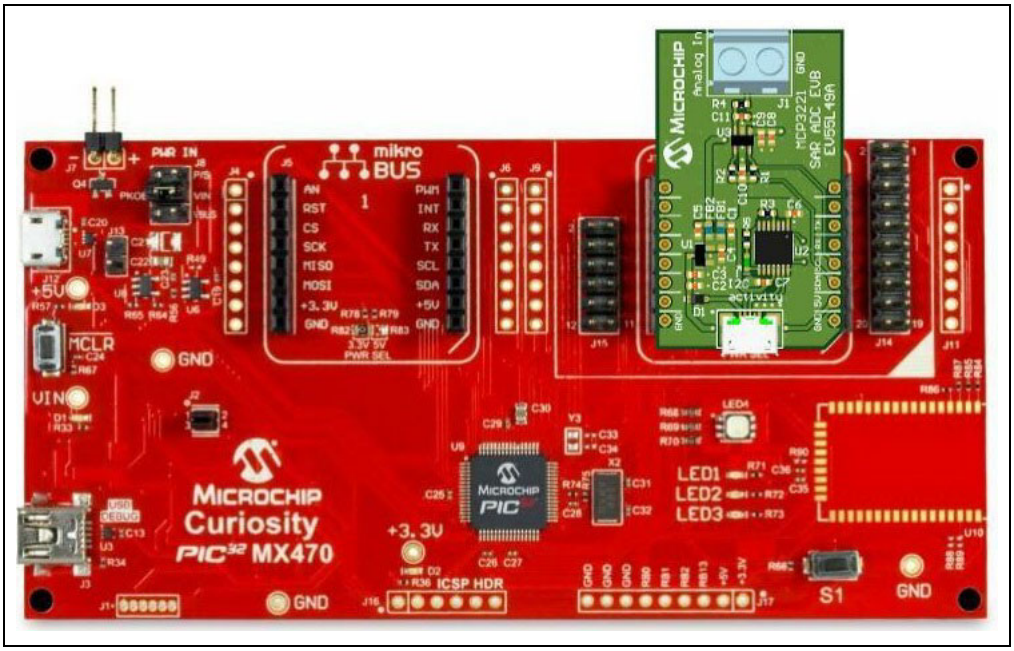


FIGURE 4-1: *Hardware Connection of the MCP3221 SAR ADC Evaluation Board into the PIC32MX470 Curiosity Development Board.*

Once the setup is complete and all the software is installed, the MPLAB IDE can be started with the project. The compiler version and the packs (DFPs) must be the ones recommended in **Section 4.2.1 "PIC32MX470 Curiosity Development Board Setup"**. To check the version, right-click the project, select Properties, then select Conf: [Curiosity_PIC32_I2C], as shown in Figure 4-2.

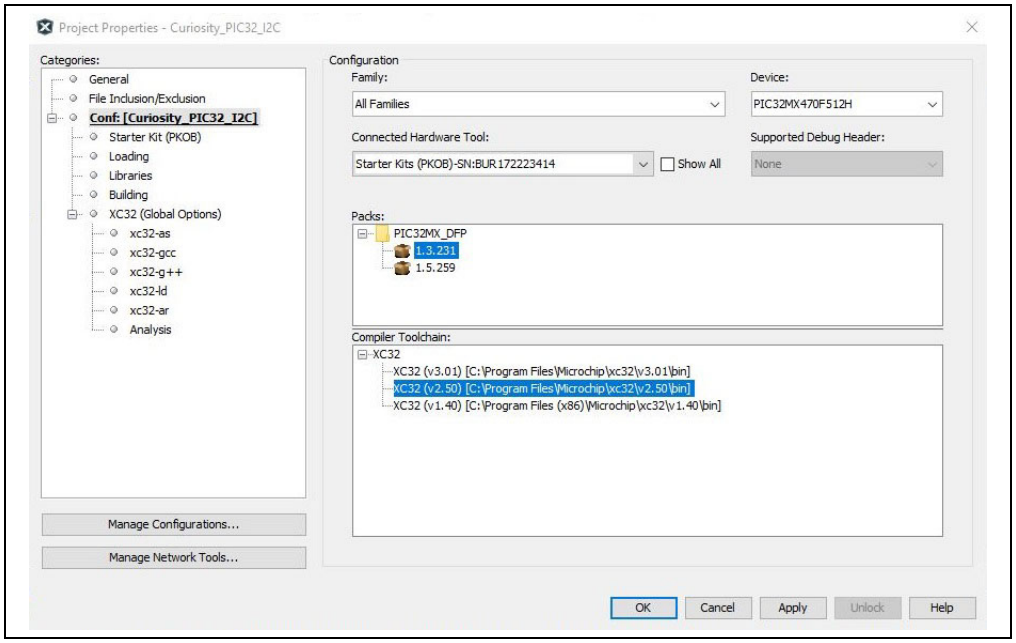


FIGURE 4-2: *MPLAB IDE Settings.*

4.3.2 Arduino Due Board

Attach the Arduino Shield over the Arduino Due Board and the Click board in socket number 2 of the Shield, as shown in Figure 4-3.

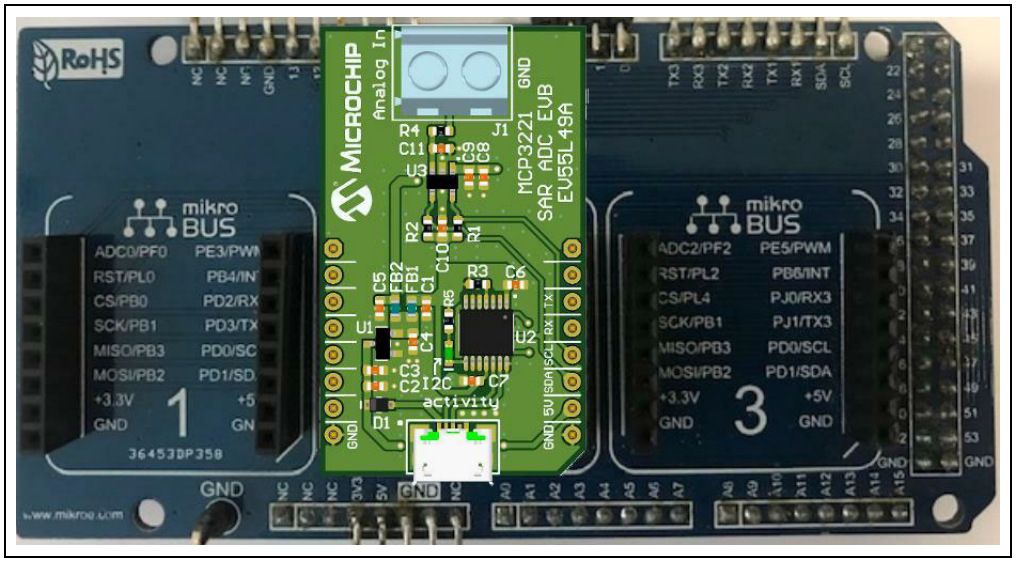


FIGURE 4-3: *Hardware Connection of the MCP3221 SAR ADC Evaluation Board into the Arduino Due Board.*

The Arduino Due Board is powered via the USB connector labeled ‘Programming’. The name of the port is visible on the bottom side of the *Arduino Due Board*. The same port is used to program the Arduino Due Board.

Once the hardware is connected and the software is installed, the Eclipse IDE can be started:

1. Launch the Eclipse IDE, then select the Workspace
2. Click the **Browser** button and select the folder with the whole project
3. Next, launch the project

A few package installations are required.

1. Select the Arduino/Sloeber section, then go to Preferences
2. Select the Platform and Boards option. Then select the ArduinoSloeber field
3. Choose Arduino SAM Boards (32-bits ARM Cortex-M3) (version 1.6.12)
4. Go back and select Library Manager -> SAMDUE_TimerInterrupt (version 1.2.0)
5. Select the Arduino/Sloeber toolbar -> Click on Add a library to the selected project -> Select SAMDUE_TimerInterrupt (the library is used for Timer Interrupt)

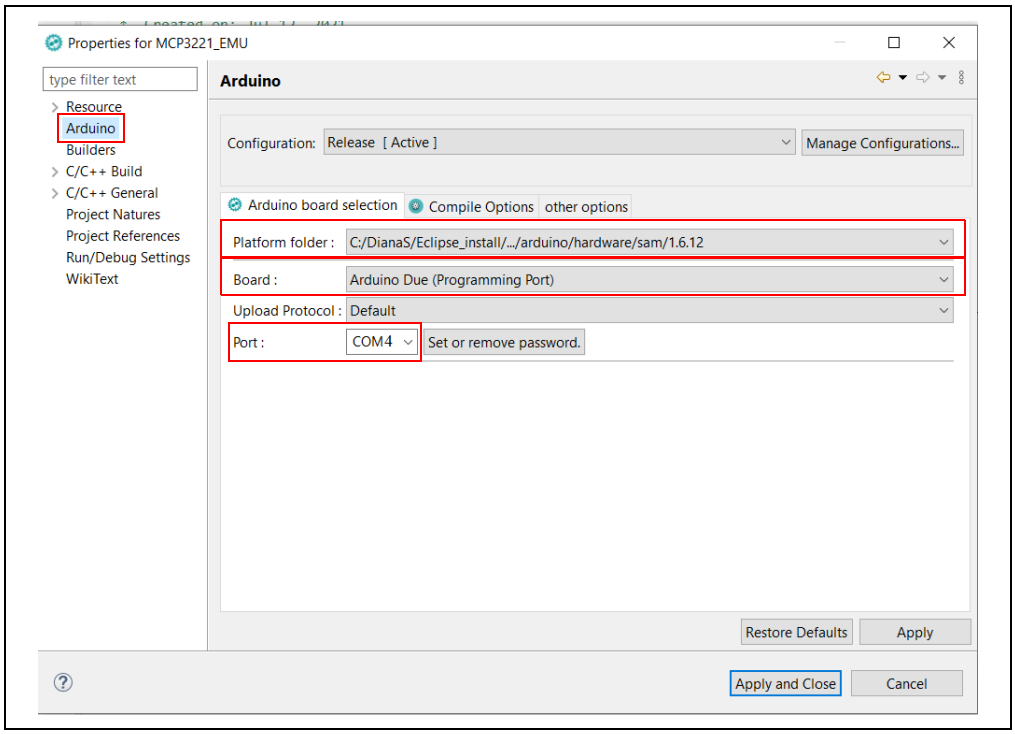


FIGURE 4-4: *Eclipse IDE – Sloeber Settings.*

To upload the firmware on the Arduino Due Board, follow the next steps:

1. Select the COM port by clicking the Project
2. Go to Properties and select the Arduino/Sloeber option
3. In the Platform folder, select the board downloaded before at “Step 3"
4. In the Board drop-down menu, select the Programming Port option, as seen in **Figure 4-4: “Eclipse IDE – Sloeber Settings.”**
5. In the Port drop-down menu, select the port used from the PC (in Figure 4-4, the example is COM4)
6. Next, click the **Apply** button.
7. The firmware can now be uploaded to the board. Select Arduino/Sloeber, then select Upload Sketch.

4.3.3 MCP3221 SAR ADC Evaluation Board using MCP2221A

Connect the MCP3221 SAR ADC Evaluation Board to the PC using the micro-USB-B cable.

Configure the MCP2221A by using MCP2221A Utility. To do so, follow the next steps:

1. Open MCP2221A Utility. If the MCP3221 SAR ADC Evaluation Board is connected, the bottom of the interface displays the message Connected
2. In the Descriptor text field, type in the part number of the board, EV55L49A. The GUI now recognizes the board when it launches
3. Click the **Configure device** button; the connection status changes to SUCCESS in the Output field
4. Close the MCP2221A Utility.

The configuration steps are exemplified in Figure 4-5.

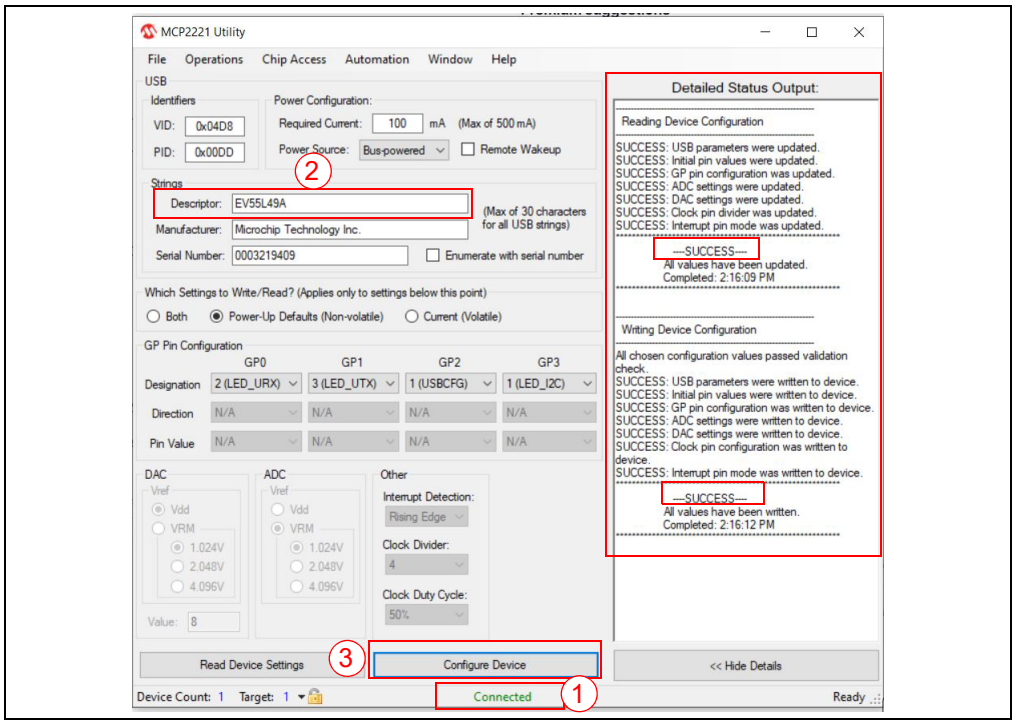


FIGURE 4-5: *MCP2221A Utility Configuration Steps.*

4.4 HI-RESOLUTION ADC UTILITY GUI LAUNCH

4.4.1 GUI Launch

The Hi-Resolution ADC Utility GUI allows the user to evaluate the features of MCP3221 device. The analog input signal of the ADC is displayed into a graph chart with the calculation of the main signal properties.

The GUI can be downloaded from the www.microchip.com web page. Once the installation is complete, the application can be launched.

4.4.2 GUI setup with PIC32MX470 Curiosity Development Board or Arduino Due Board

Before use, make sure that the PIC32MX470 Curiosity Development Board and the MCP3221 SAR ADC Evaluation Board are connected together and that the firmware is uploaded, as described in **Section 4.3.1 "PIC32MX470 Curiosity Development Board"** and **Section 4.3.2 "Arduino Due Board"**.

Once the hardware is connected, start the Hi-Resolution ADC Utility GUI. By default, the software recognizes the Serial Port case, the device ID and the main window is displayed. At the bottom of the window, a message appears with the Connection Status as shown in Figure 4-6.

FIGURE 4-6: *Connection Status.*

If the connection status is 'Not Connected', repeat the steps from **Section 4.3.1 "PIC32MX470 Curiosity Development Board"** and **Section 4.3.2 "Arduino Due Board"**.

After launching the GUI, select Communication Protocol, then choose Serial Port. Click the Operation option, then click the **Connect to a board** button. The board appears on the right side, under the **Connect** button, as shown in Figure 4-7.

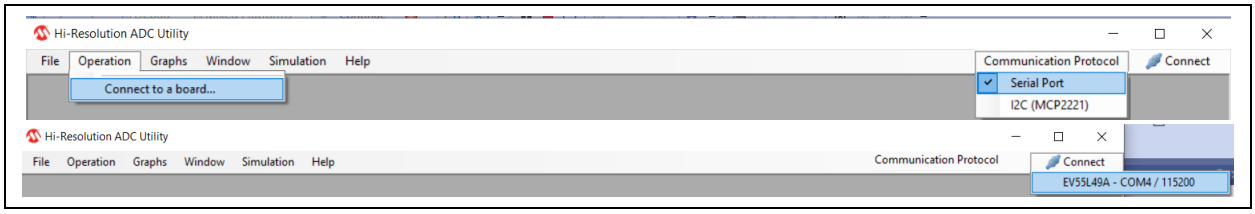


FIGURE 4-7: *Connect Procedure for PIC32MX470F512H/Arduino Due Board.*

4.4.3 GUI Setup for MCP3221 SAR ADC Evaluation Board using MCP2221A

Before use, make sure that the MCP3221 SAR ADC Evaluation Board is connected to the PC and that the MCP2221A device is configured, as described in **Section 4.3.3 "MCP3221 SAR ADC Evaluation Board using MCP2221A"**.

Once the hardware is connected, launch the Hi-Resolution ADC Utility GUI.

In the GUI, select the Communication Protocol, then select I^2C (MCP2221A). Next, select Operation, then click the **Connect to a board** button. The connected board is displayed on the right side, under the Select device drop-down menu, as shown in Figure 4-8.

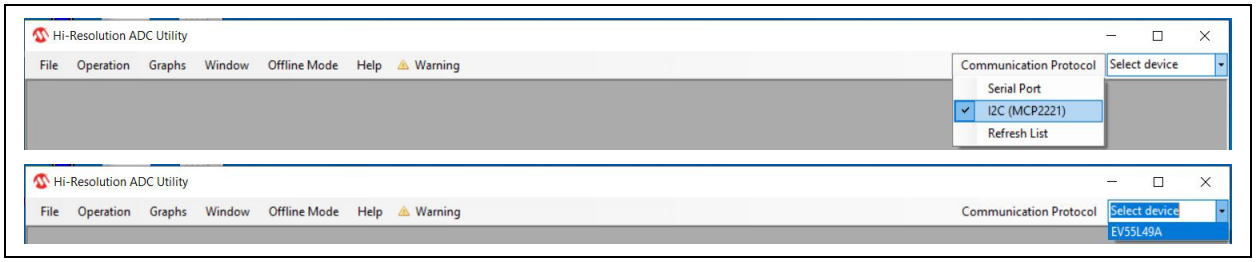


FIGURE 4-8: *Connect Procedure for MCP3221 SAR ADC Evaluation Board using MCP2221A.*

When data acquisition from the MCP3221 SAR ADC Evaluation Board is active, the I^2C activity LED on the Click board starts to blink.

WARNING

Data acquisition through the MCP3221 SAR ADC Evaluation Board with the MCP2221A device is not accurate for data sets larger then 30 samples because of the buffer limitation of MCP2221A.
This causes a pause in the data acquisition, which leads to data reads by the ADC being reproduced incorrectly.

4.4.4 System operation

The main components of the Hi-Resolution ADC Utility GUI main window are detailed in Figure .

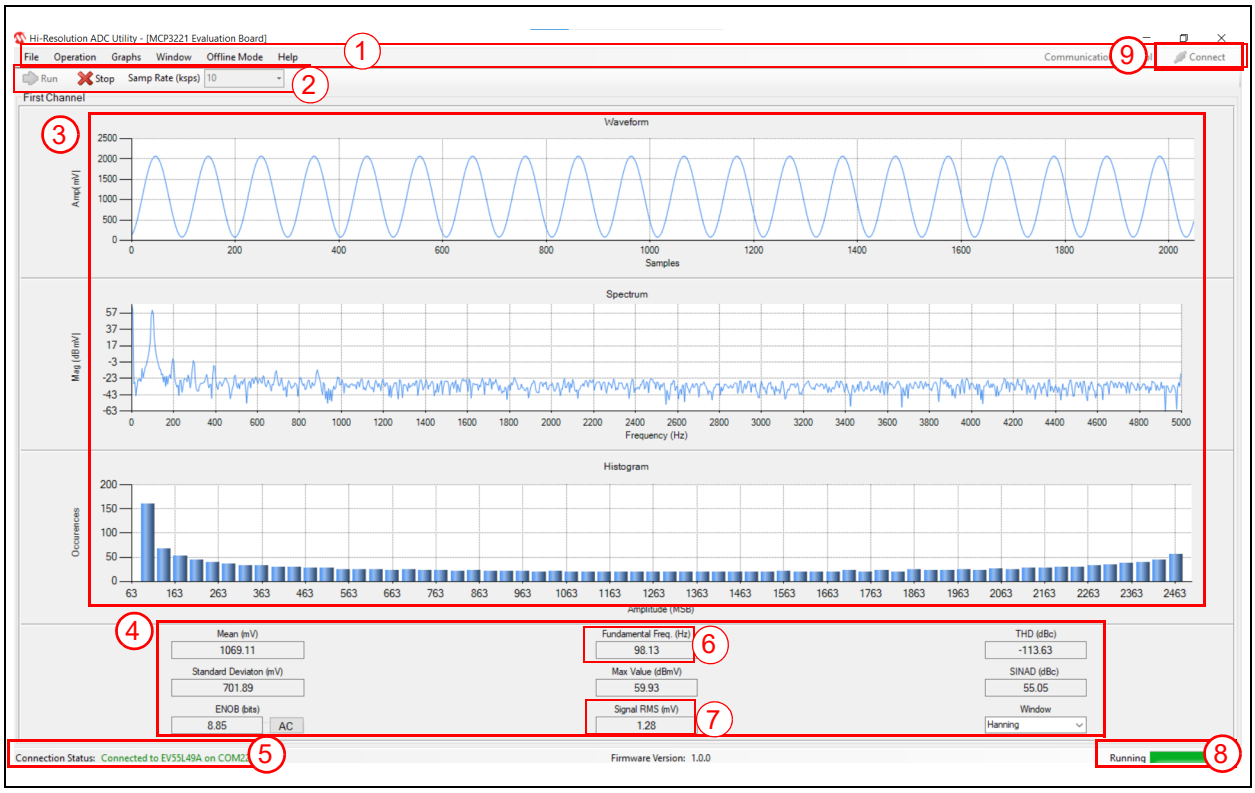


FIGURE 4-9: *Hi-Resolution ADC Utility GUI – Main Window.*

1. Control menu bar: this provides access to the File, Operation, Graph, Window, Communication Protocol, Help menus and the **Connect** button.
2. Application Control Toolbar:
   a) **Run** button: starts or resumes the data acquisition process
   b) **Stop** button: freezes all the data displayed on the main window and stops the data transmission from the MCP3221 SAR ADC Evaluation Board to the PC
   c) Sampling Rate (ksps) drop-down menu: changes the ADC sampling rate.
3. Graphs section:
   a) Waveform (Amplitude) chart
   b) FFT (Magnitude) chart
   c) Occurrences chart.
4. Info boxes: parameters normally used when analyzing electrical signals and ADC conversion performances
5. Connection Status box
6. FFT (Fast Fourier Transformation) Fundamental Frequency value
7. RMS (Root mean Square) value
8. Process Status Box
9. **Connect** button: used to reconnect the MCP3221 SAR ADC Evaluation Board.

Note: The sampling rate for the data acquisition process through MCP3221 SAR ADC Evaluation Board using MCP3221 is not configurable. The sampling rate is set to 11 ksps.

In order to show the performance of the MCP3221 SAR ADC Evaluation Board, a sine signal is applied on the input pin by using a clean signal source. In this example, the parameters of the signal are:

- Frequency: 100 Hz
- Period: 10 ms
- Amplitude: 1V
- Offset: 1V

In this example, the MCP3221 SAR ADC Evaluation Board is used with the PIC32MX470 Curiosity Development Board.

In this example, in the GUI window the sampling rate is set at 10 ksps. After clicking the **Run** button, the GUI displayed the charts with the calculated parameters, as shown in Figure 4-9.

4.4.5 Data Acquisition Process

Before starting the data acquisition process, select the sampling rate from the drop-down list (available option: 1, 2, 5, 10, 22 ksps). If no sampling rate is selected, data acquisition starts with the default value of 1 ksps. Once the sampling rate is set, click the **Run** button to begin the acquisition process.

> **Note:** The sampling rate cannot be modified during input acquisition using the MCP3221 SAR ADC Evaluation Board with the MCP2221A. The value is set at 11 ksps.

The sampling rate cannot be changed during the data acquisition process. Click the **Stop** button to stop the process, then change the sampling rate. Click the **Run** button again to resume the process.

The MCP3221 is a single-channel device with a single-ended input. Each data acquisition frame is 2048 samples per acquisition sequence.

For better visualization, there is a zoom-in option, available by clicking and dragging the mouse cursor over the desired graph. Zoom-out can be performed by using the **Zoom-out** button on each graph's axis. By default, the graphs are set to auto-scale, but that can be changed by selecting Manual Scale from the Graphs menu.

4.4.6 Conversion modes

Communication with the MCP3221 device is accomplished in two modes:

1. Executing a a single conversion (Single-Shot Conversion mode)
2. Continuous Conversion mode, with 22 ksps rate.

> **Note:** Data acquisition through MCP3221 SAR ADC Evaluation Board using MCP2221A is only available in Continuous Conversion mode.

Available sampling rates used for Single Shot Conversion are between 1 ksps and 10 ksps, from Table 3-1. In Continuous Conversion mode, the 22 ksps value must be selected.

In Single-Shot Conversion mode, the message is composed of three bytes: one with the address of the device (4D) and the next two represent the two bytes of data from the MCP3221.

Figure 4-10 shows the I^2C communication data on SCL and SDA. The decode message is above the communication waveforms.

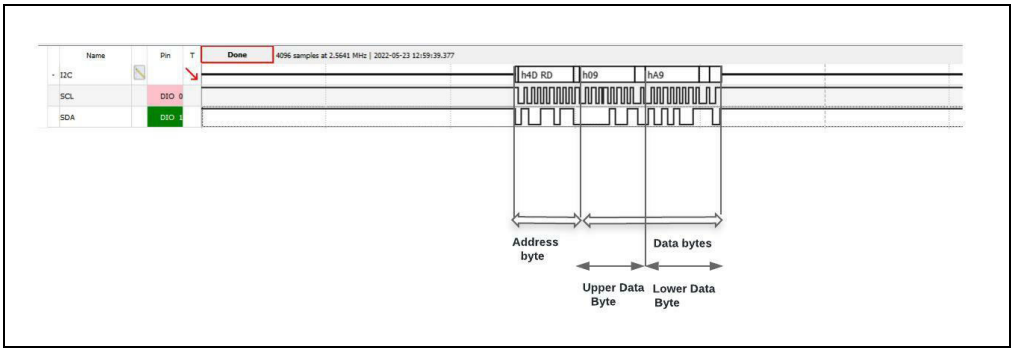


FIGURE 4-10: *Single-Shot Conversion Mode Waveforms.*

In Continuous Conversion mode, the communication consists of an address byte sent by the connected MCU, followed by the 4096 data bytes, corresponding to 2048 samples, from the MCP3221. In this situation, the sampling rate is set to maximum 22 ksps.

Figure 4-11 shows the packet format in Continuous Conversion mode.

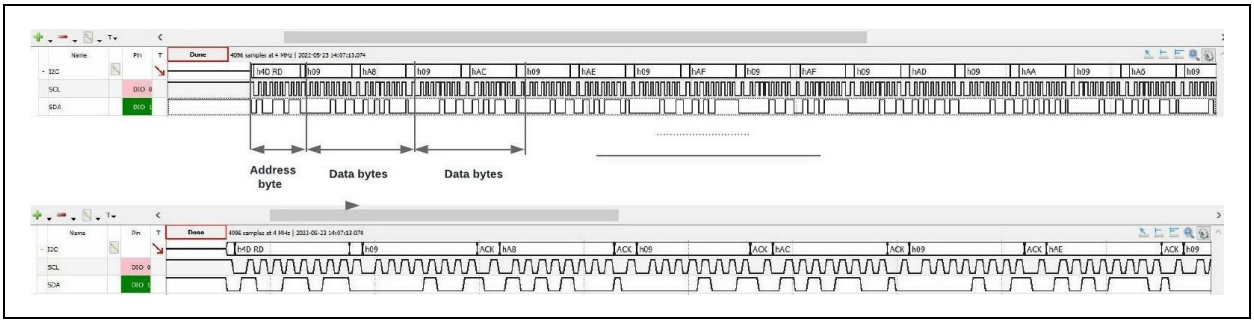


FIGURE 4-11: *Continuous Conversion Mode Waveforms.*

Note: The Figure 4-10 and Figure 4-11 are realized by the acquisition through PIC32MX470 Curiosity Development Board.

For more information about data acquisition, check the MCP3221 Data Sheet (DS20001732).

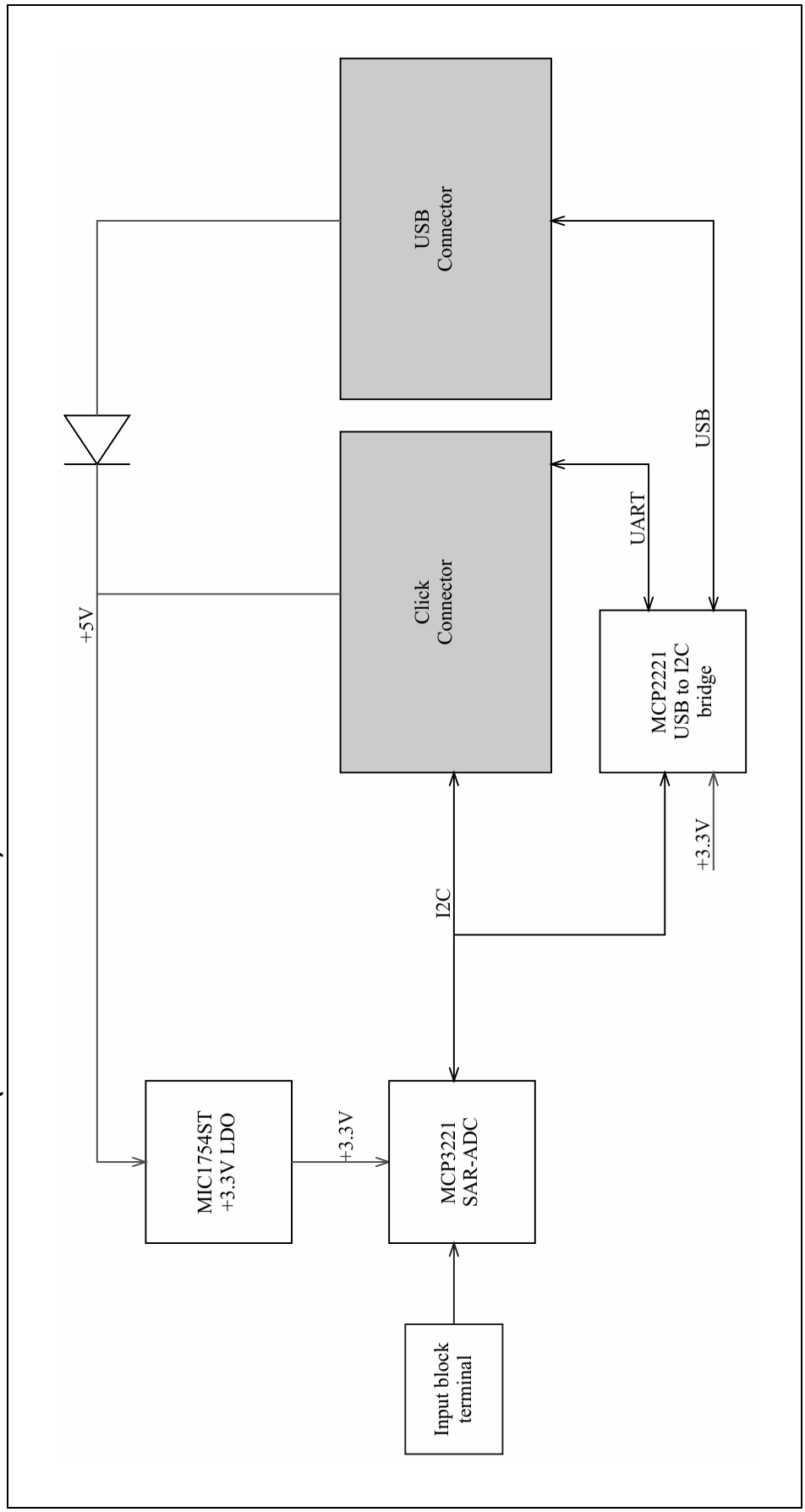
Appendix A. Schematic and Layouts

A.1 INTRODUCTION

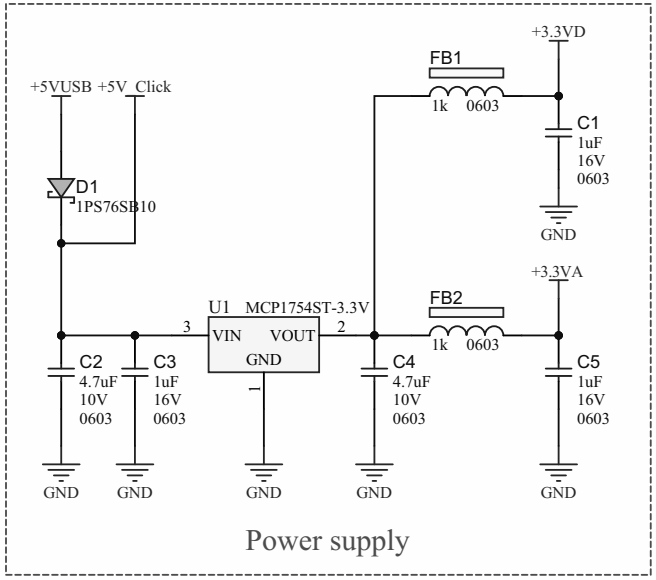
This appendix contains the following schematics and layouts for the MCP3221 SAR ADC Evaluation Board (EV55L49A):

- EV55L49A – Schematic (Block Diagram)
- EV55L49A – Schematic (ADC)
- EV55L49A – Top Silk
- EV55L49A – Top Copper and Silk
- EV55L49A – Top Copper
- EV55L49A – Bottom Copper
- EV55L49A – Bottom Copper and Silk
- EV55L49A – Bottom Silk

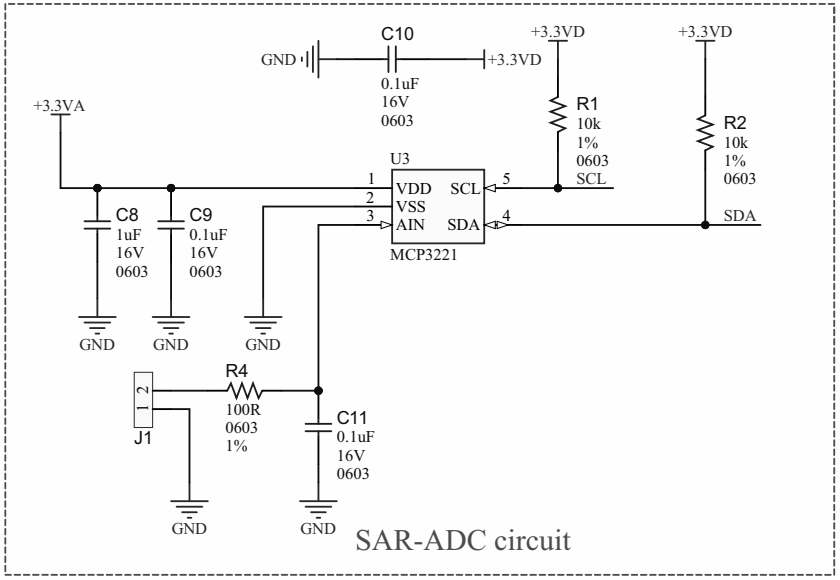
A.2 EV55L49A – SCHEMATIC (BLOCK DIAGRAM)



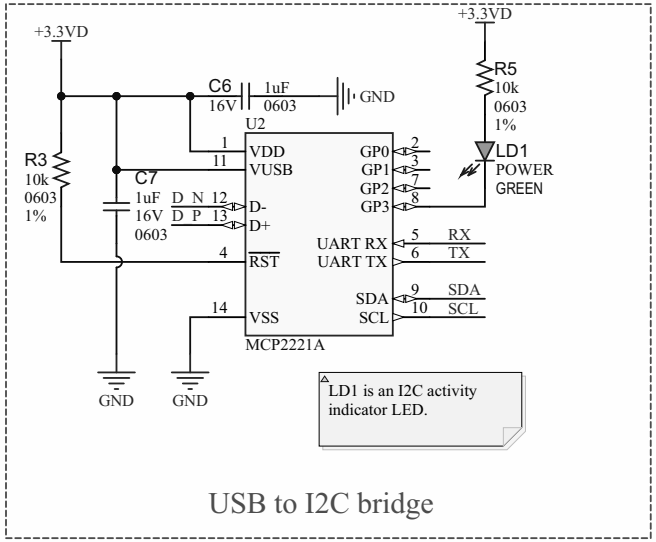
A.3 EV55L49A – SCHEMATIC (ADC)



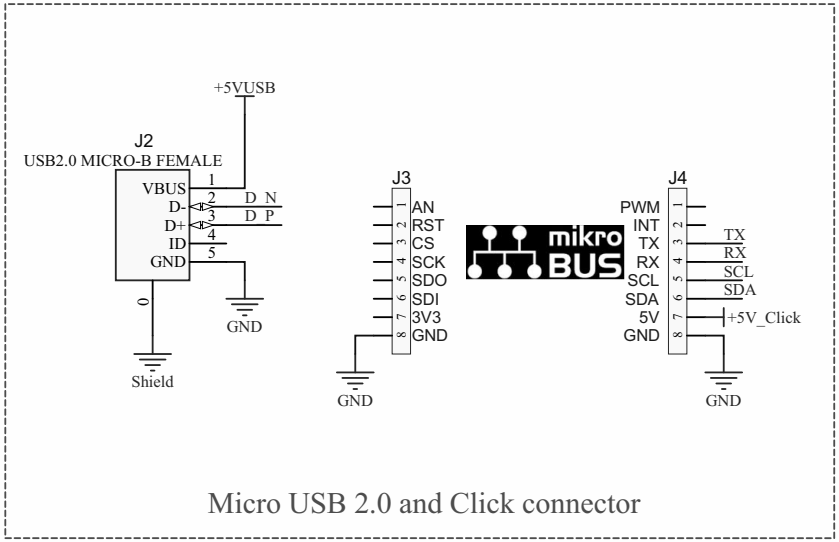
Power supply



SAR-ADC circuit

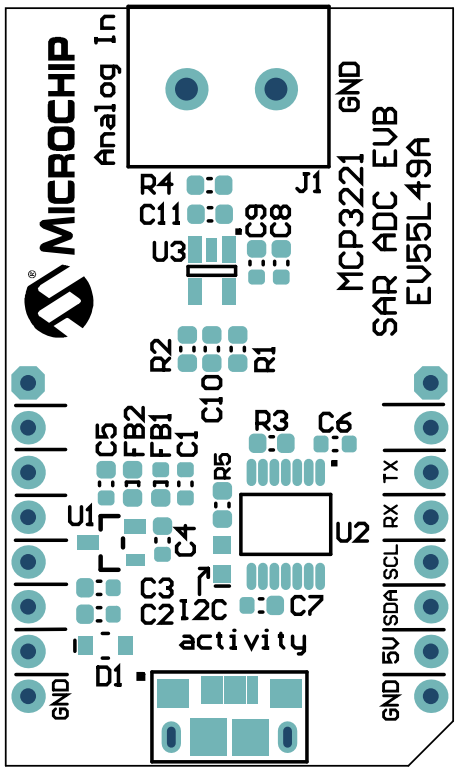


USB to I2C bridge

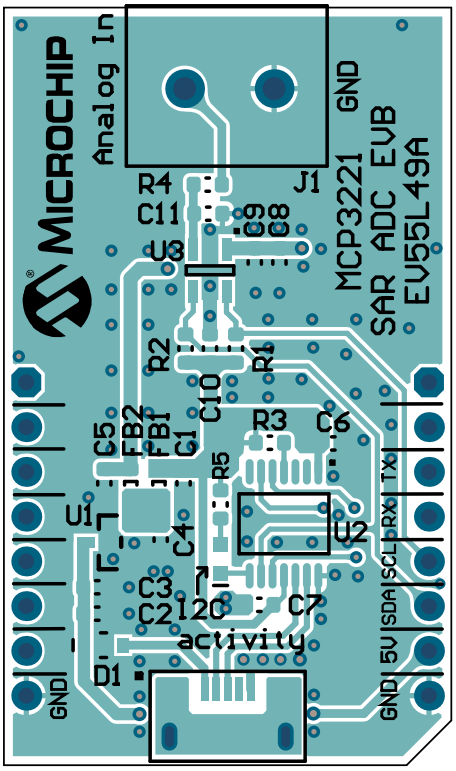


Micro USB 2.0 and Click connector

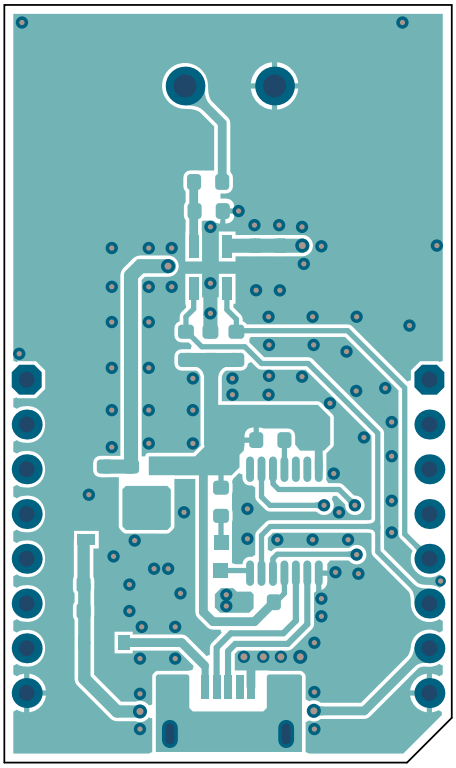
A.4 EV55L49A – TOP SILK



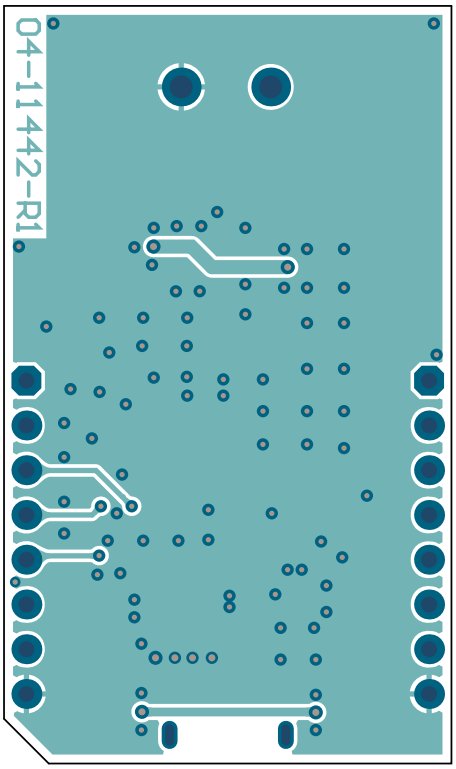
A.5 EV55L49A – TOP COPPER AND SILK



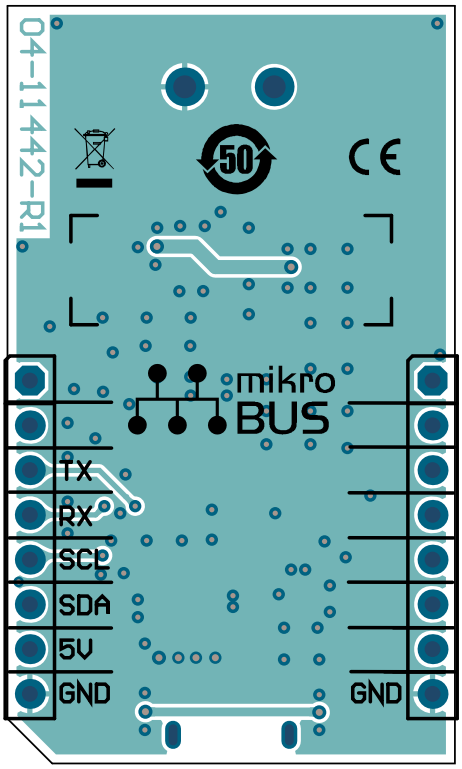
A.6 EV55L49A – TOP COPPER



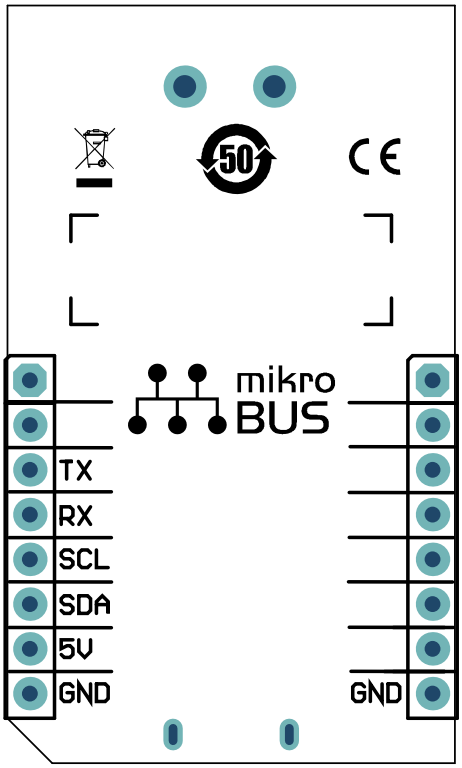
A.7 EV55L49A – BOTTOM COPPER



A.8 EV55L49A – BOTTOM COPPER AND SILK



A.9 EV55L49A – BOTTOM SILK



Appendix B. Bill of Materials (BOM)

B.1 MCP3221 SAR ADC EVALUATION BOARD - BILL OF MATERIALS (BOM)

TABLE B-1: MCP3221 SAR ADC EVALUATION BOARD - BILL OF MATERIALS (BOM)

Qty.	Reference	Description	Manufacturer	Part Number
6	C1, C3, C5, C6, C7, C8	Capacitor, Ceramic, 1 µF, 16V, 10%, X7R, Surface-Mount, 0603	Wurth Elektronik	885012206052
2	C2, C4	Capacitor, Ceramic, 4.7 µF, 10V, 10%, X5R, Surface-Mount, 0603	KEMET	C0603C475K8PACTU
3	C9, C10, C11	Capacitor, Ceramic, 0.1 µF, 16V, 10%, X7R, Surface-Mount, 0603	AVX Corporation	0603YC104KAT2A
1	CBL1	Mechanical, HW, Cable, USB Male A to USB Male Micro-B, 0.91M	Qualtek Electronics Corp.	3025030-03
1	D1	Schottky Diode, 1PS76SB10, 800 mV, 200 mA, 30V, SOD-323	NXP Semiconductors	1PS76SB10,115
2	FB1, FB2	Ferrite Bead, 1 kΩ 0603, 1LN	Wurth Elektronik	742792662
1	J1	Connector, Terminal, 5.08 mm, 1x2 Eurostyle, Through-Hole, Right Angle	Adam Tech	EB21A-02-D
1	J2	Connector, USB 2.0 Micro-B, Female, Surface-Mount, Right Angle	FCI	10118192-0001LF
2	J3, J4	Connector, HDR-2.54 Male, 1x8, Gold, 5.84 MH Through-Hole	FCI	68001-108HLF
1	LABEL1	Label, PCBA, 18x6 mm, Datamatrix, Assy#/Rev/Serial/Date	ACT Logimark AS	505462
1	LD1	Diode, LED, Green, 3.2V, 20 mA, 430 mcd, Clear, Surface-Mount, 0603	Wurth Elektronik	150060GS75000
1	PCB1	MCP3221 SAR ADC Evaluation Board – Printed Circuit Board	Microchip Technology Inc.	**04-11442-R1**
4	R1, R2, R3, R5	Resistor, Thin Film, 10 kΩ, 1%, 1/16W, Surface-Mount, 0603	TE Connectivity Alcoswitch	CPF0603F10KC1
1	R4	Resistor, Thick Film, 100R, 1%, 1/10W, Surface-Mount, 0603	Panasonic® - ECG	ERJ-3EKF1000V
1	U1	MCHP Analog, LDO, 3.3V, MCP1754ST-3302E/CB, SOT-23A-3	Microchip Technology Inc.	**MCP1754ST-3302E/CB**
1	U2	MCHP Interface, USB, I^2C, UART, MCP2221A-I/ST TSSOP-14	Microchip Technology Inc.	**MCP2221A-I/ST**
1	U3	MCHP Analog, ADC-SAR, 12-bit, MCP3221A5T-E/OT SOT-23-5	Microchip Technology Inc.	**MCP3221A5T-E/OT**

Note 1: The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

Worldwide Sales and Service

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
http://www.microchip.com/support
Web Address:
www.microchip.com

Atlanta
Duluth, GA
Tel: 678-957-9614
Fax: 678-957-1455

Austin, TX
Tel: 512-257-3370

Boston
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

Chicago
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

Dallas
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

Detroit
Novi, MI
Tel: 248-848-4000

Houston, TX
Tel: 281-894-5983

Indianapolis
Noblesville, IN
Tel: 317-773-8323
Fax: 317-773-5453
Tel: 317-536-2380

Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608
Tel: 951-273-7800

Raleigh, NC
Tel: 919-844-7510

New York, NY
Tel: 631-435-6000

San Jose, CA
Tel: 408-735-9110
Tel: 408-436-4270

Canada - Toronto
Tel: 905-695-1980
Fax: 905-695-2078

ASIA/PACIFIC

Australia - Sydney
Tel: 61-2-9868-6733

China - Beijing
Tel: 86-10-8569-7000

China - Chengdu
Tel: 86-28-8665-5511

China - Chongqing
Tel: 86-23-8980-9588

China - Dongguan
Tel: 86-769-8702-9880

China - Guangzhou
Tel: 86-20-8755-8029

China - Hangzhou
Tel: 86-571-8792-8115

China - Hong Kong SAR
Tel: 852-2943-5100

China - Nanjing
Tel: 86-25-8473-2460

China - Qingdao
Tel: 86-532-8502-7355

China - Shanghai
Tel: 86-21-3326-8000

China - Shenyang
Tel: 86-24-2334-2829

China - Shenzhen
Tel: 86-755-8864-2200

China - Suzhou
Tel: 86-186-6233-1526

China - Wuhan
Tel: 86-27-5980-5300

China - Xian
Tel: 86-29-8833-7252

China - Xiamen
Tel: 86-592-2388138

China - Zhuhai
Tel: 86-756-3210040

ASIA/PACIFIC

India - Bangalore
Tel: 91-80-3090-4444

India - New Delhi
Tel: 91-11-4160-8631

India - Pune
Tel: 91-20-4121-0141

Japan - Osaka
Tel: 81-6-6152-7160

Japan - Tokyo
Tel: 81-3-6880- 3770

Korea - Daegu
Tel: 82-53-744-4301

Korea - Seoul
Tel: 82-2-554-7200

Malaysia - Kuala Lumpur
Tel: 60-3-7651-7906

Malaysia - Penang
Tel: 60-4-227-8870

Philippines - Manila
Tel: 63-2-634-9065

Singapore
Tel: 65-6334-8870

Taiwan - Hsin Chu
Tel: 886-3-577-8366

Taiwan - Kaohsiung
Tel: 886-7-213-7830

Taiwan - Taipei
Tel: 886-2-2508-8600

Thailand - Bangkok
Tel: 66-2-694-1351

Vietnam - Ho Chi Minh
Tel: 84-28-5448-2100

EUROPE

Austria - Wels
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

Denmark - Copenhagen
Tel: 45-4485-5910
Fax: 45-4485-2829

Finland - Espoo
Tel: 358-9-4520-820

France - Paris
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

Germany - Garching
Tel: 49-8931-9700

Germany - Haan
Tel: 49-2129-3766400

Germany - Heilbronn
Tel: 49-7131-72400

Germany - Karlsruhe
Tel: 49-721-625370

Germany - Munich
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Germany - Rosenheim
Tel: 49-8031-354-560

Israel - Ra'anana
Tel: 972-9-744-7705

Italy - Milan
Tel: 39-0331-742611
Fax: 39-0331-466781

Italy - Padova
Tel: 39-049-7625286

Netherlands - Drunen
Tel: 31-416-690399
Fax: 31-416-690340

Norway - Trondheim
Tel: 47-7288-4388

Poland - Warsaw
Tel: 48-22-3325737

Romania - Bucharest
Tel: 40-21-407-87-50

Spain - Madrid
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

Sweden - Gothenberg
Tel: 46-31-704-60-40

Sweden - Stockholm
Tel: 46-8-5090-4654

UK - Wokingham
Tel: 44-118-921-5800
Fax: 44-118-921-5820