ADM00902 Demonstration Board for EMC2103 User's Guide

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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 "XXXXXXX" 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 ADM00902 Demonstration Board for EMC2103. Items discussed in this chapter include:

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

DOCUMENT LAYOUT

This document describes how to use the ADM00902 Demonstration Board for EMC2103 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 ADM00902 Demonstration Board for EMC2103.
- **Chapter 2. "Installation and Operation"** – Includes instructions on installing and starting the Microchip Thermal Management Utility.
- **Chapter 3. "Microchip Thermal Management Utility"** – Includes instructions on operating the Thermal Management Utility.
- **Chapter 4. "Hardware Description"** – Contains a detailed description of the ADM00902 Demonstration Board for EMC2103.
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and layout diagrams for the ADM00902 Demonstration Board for EMC2103.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the ADM00902 Demonstration Board for EMC2103.

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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 ADM00902 Demonstration Board for EMC2103. Other useful documents are listed below. The following Microchip document is available and recommended as a supplemental reference resource:

EMC2103 Data Sheet – *"RPM-Based Fan Controller with Hardware Thermal Shutdown"* **(DS20005250)**

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

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CUSTOMER SUPPORT

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- 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: http://www.microchip.com/support.

DOCUMENT REVISION HISTORY

Revision A (November 2019)

- Initial Release of this Document.

NOTES:

Chapter 1. Product Overview

1.1   INTRODUCTION

This chapter provides an overview of the ADM00902 Demonstration Board for EMC2103 and covers the following topics:

- EMC2103-4 Device Short Overview
- What is the ADM00902 Demonstration Board?
- ADM00902 Demonstration Board Kit Contents

1.2   EMC2103-4 DEVICE SHORT OVERVIEW

EMC2103 is an SMBus/I^2C-compliant fan controller with up to three external and one internal temperature channels. The fan driver can be operated using two methods, each with two modes. The methods include an RPM-based fan speed control algorithm and a direct PWM drive setting. The modes include manually programming the desired settings or using the internal programmable temperature look-up table, to select the desired setting based on measured temperature.

The temperature monitors offer ±0.5°C accuracy (for external diodes). The monitors include sophisticated features to reduce errors introduced by series resistance and beta variation of substrate thermal diode transistors commonly found in processors.

The EMC2103 device also includes hardware-programmable temperature limit and dedicated system shutdown output for thermal protection of critical circuitry.

1.3   WHAT IS THE ADM00902 DEMONSTRATION BOARD?

The ADM00902 Demonstration Board for EMC2103 provides an example of a fan control application using the EMC2103-4 fan controller. There is one fan channel, one internal temperature sensor and three remote temperature sensor inputs available. An on-board heat source is connected to Ext 1 temperature channel.

The board is powered from either the Micro-USB connector (boosted to 12V for powering the fan and the heat source) or the 2.1 mm jack for 12V input (power adapter not included), making it possible to drive low-power fans without the need for an external power supply. Test points for the 12V input are also available.

I^2C communication is provided over USB by using the on-board MCP2221A USB to the I^2C bridge. The Thermal Management Utility Graphic User Interface (GUI) automatically detects the board and loads the appropriate interface.

An on-board heat source with ten heat levels is provided for demonstrative purposes.

The demonstration GUI is equipped with options to manually set up all the parameters for the thermal sensor and the fan controller. The GUI also provides a fully automatic temperature control interface, where the fan channel can be linked to any temperature channel.

1.4   ADM00902 DEMONSTRATION BOARD KIT CONTENTS

The ADM00902 Demonstration Board kit includes the following:

- One ADM00902 Demonstration Board for EMC2103
- Important Information Sheet
- USB cable
- Two NPN transistors in TO-92 package to be used as remote temperature diodes

Chapter 2. Installation and Operation

2.1 INTRODUCTION

This section describes how to install the Microchip Thermal Management Utility GUI required in order to interact with the ADM00902 Demonstration Board.

2.2 SYSTEM REQUIREMENTS

The ADM00902 Demonstration Board is designed to be used with a personal computer (desktop or laptop) running Microsoft® Windows® 7 or later. For USB connectivity, the minimal physical requirement for the PC is a standard type-A USB 2.0 port.

2.3 MICROCHIP THERMAL MANAGEMENT UTILITY GUI INSTALLATION

Go to www.microchip.com, search for EMC2103-4 and download the Thermal Management Utility (Version 1.5.7 or newer).

If an older version of the software is already installed, you must remove it before installing the new one.

Follow the next steps to proceed with the installation.
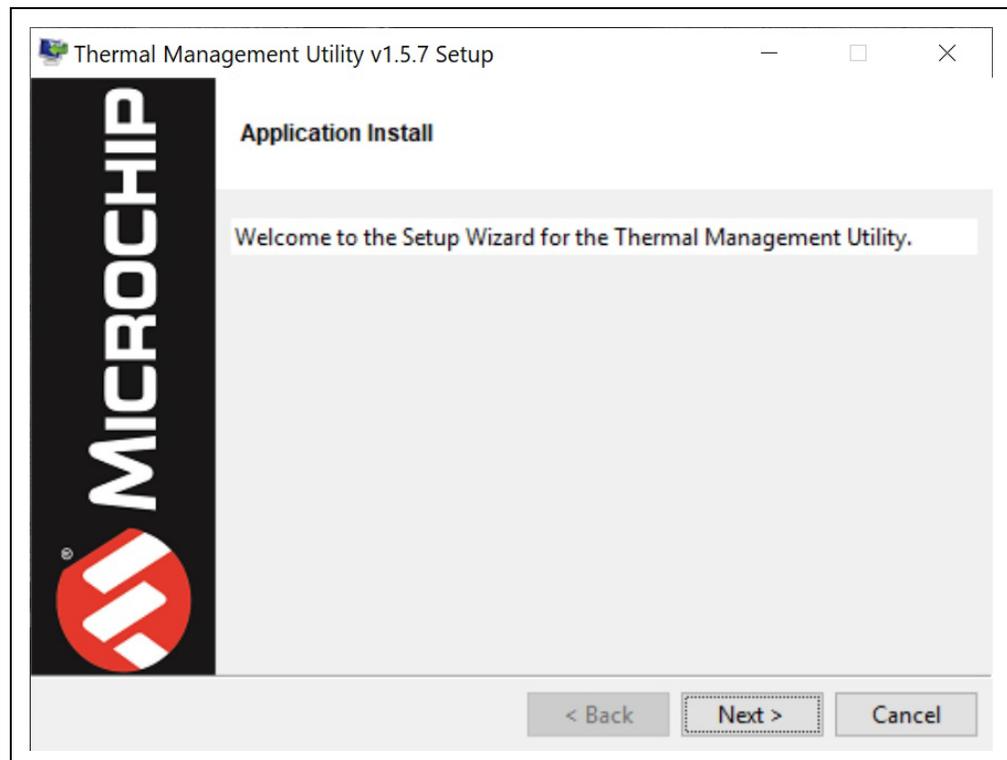
FIGURE 2-1:   Thermal Management Utility – Setup Window.

Click the **Next** button to continue.
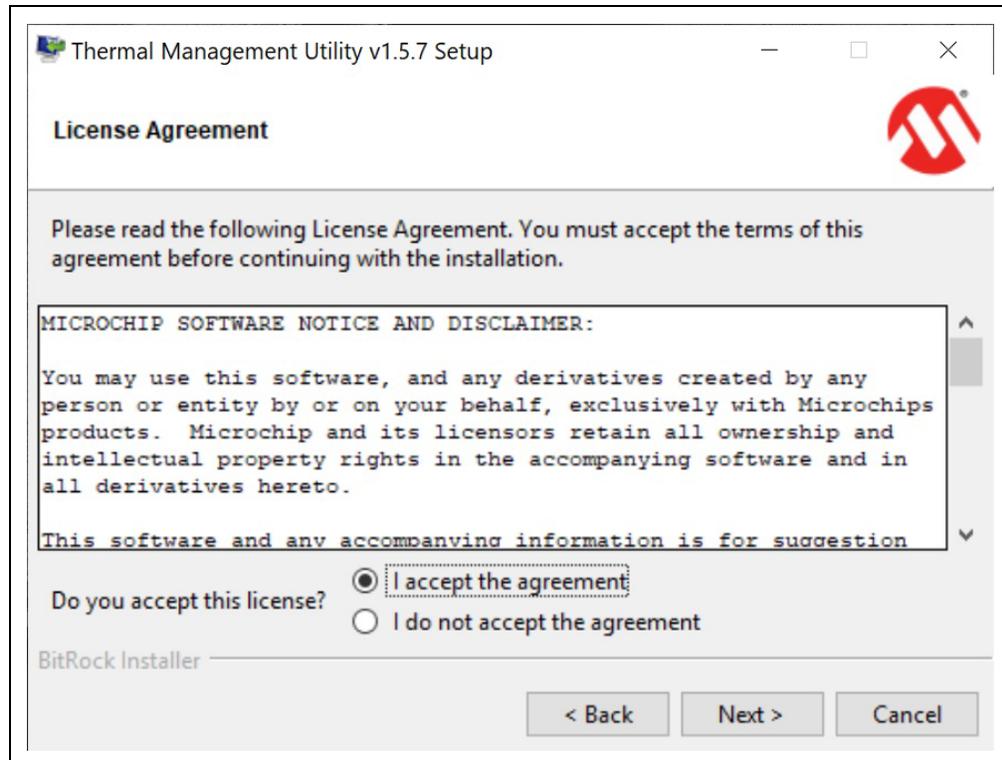
FIGURE 2-2:   *Thermal Management Utility – License Agreement Window.*

Read and accept the License Agreement. Click the **Next** button to proceed.
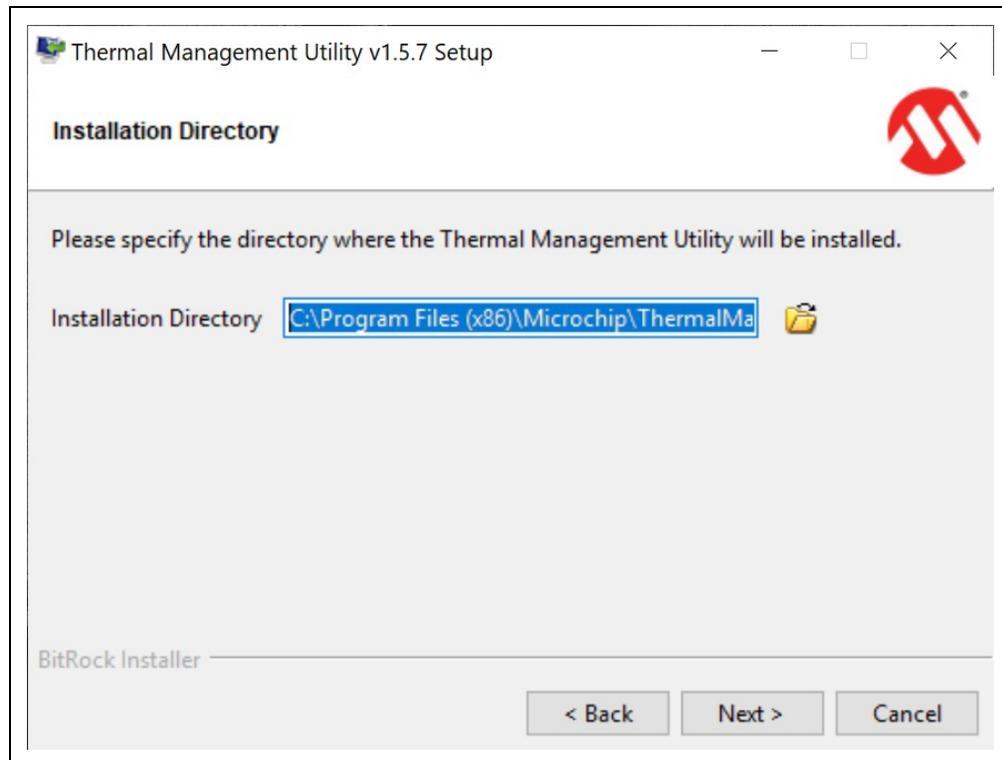
FIGURE 2-3:   *Thermal Management Utility – Installation Directory Window.*

Choose the desired installation directory and click **Next**.
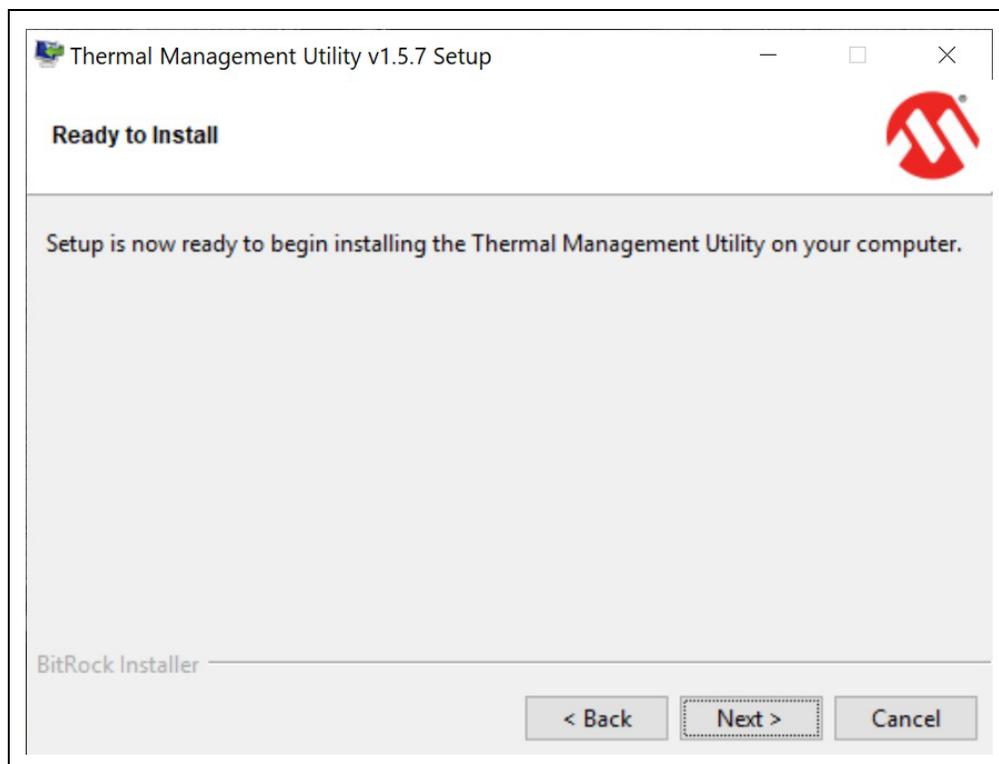
FIGURE 2-4: *Thermal Management Utility – Ready to Install Window.*

Once the installation directory has been chosen, click **Next** to begin the installation.
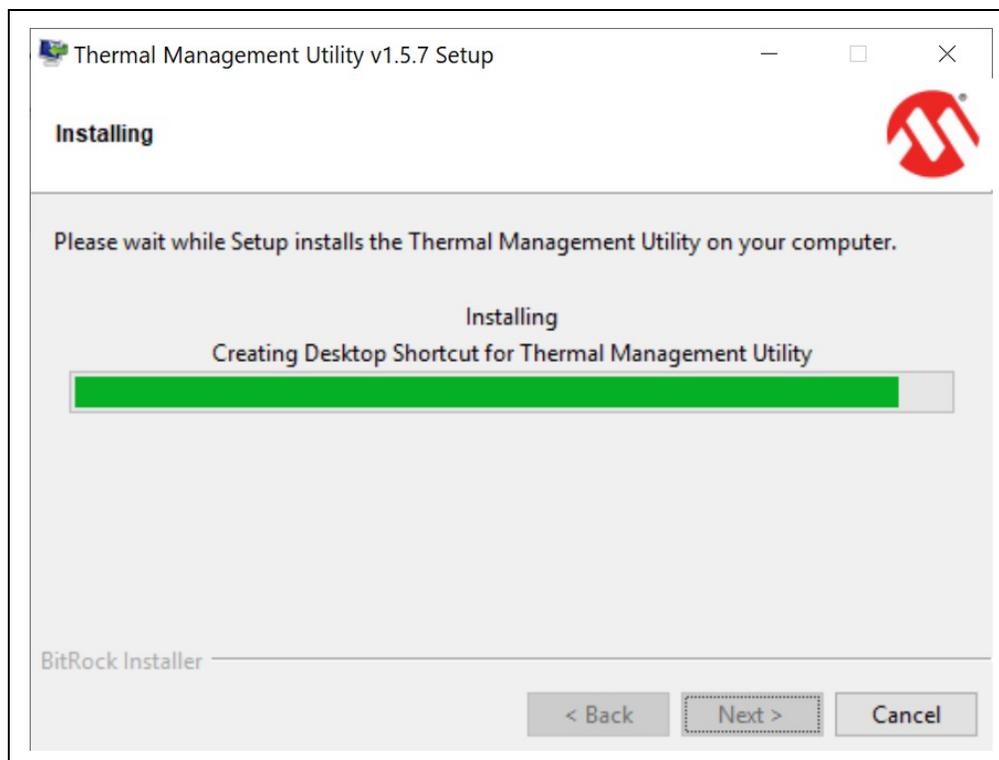
FIGURE 2-5: *Thermal Management Utility – Installing Window.*

Wait for the setup wizard to finish the installation.
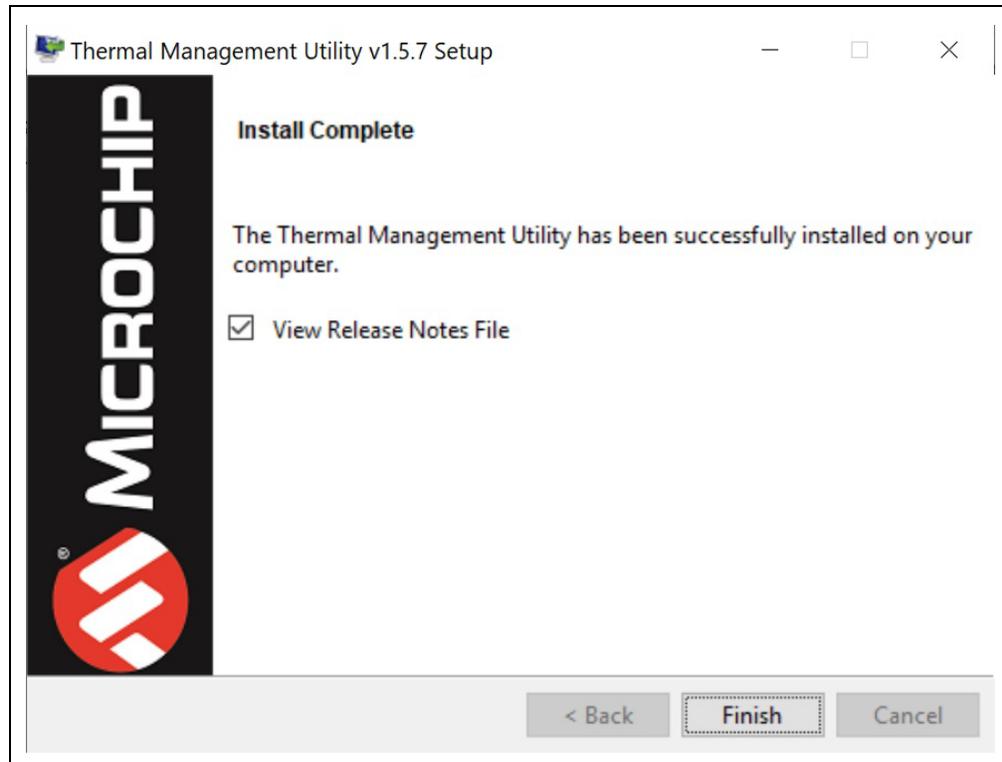
FIGURE 2-6: *Thermal Management Utility – Install Complete Window.*

Once the installation is complete, click **Finish** to exit the setup wizard.

Chapter 3. Microchip Thermal Management Utility

3.1 INTRODUCTION

The Microchip Thermal Management Utility GUI allows the user to evaluate the EMC2103-4 device for temperature and fan control applications.

3.2 FIRST LAUNCH

The ADM00902 Demonstration Board for EMC2103 is required in order to start the Graphical User Interface.

When the GUI is launched for the first time after the installation, or a new board is connected, it reads and displays the current settings of the fan driver. To use the Demo mode, as described in **Section 3.4 "Demo Tab"**, the proper settings must be loaded. The installer automatically adds the `ADM00902_Default_Settings.bin` file in the `C:\Users\Public\Documents\ThermalManagementUtility\Board Settings` folder. The user must click the **Load** button from the top menu to open the file and apply these settings to the board.

Once the hardware is connected, the software recognizes the device ID and displays the corresponding GUI for the ADM00902 Fan Controller with Look-up Table Demonstration Board. When a board is connected, its fan driver and temperature sensor settings are read and displayed in the GUI.

Disconnecting the USB closes the GUI and displays a Hardware Not Detected dialog box, as pictured in Figure 3-1.
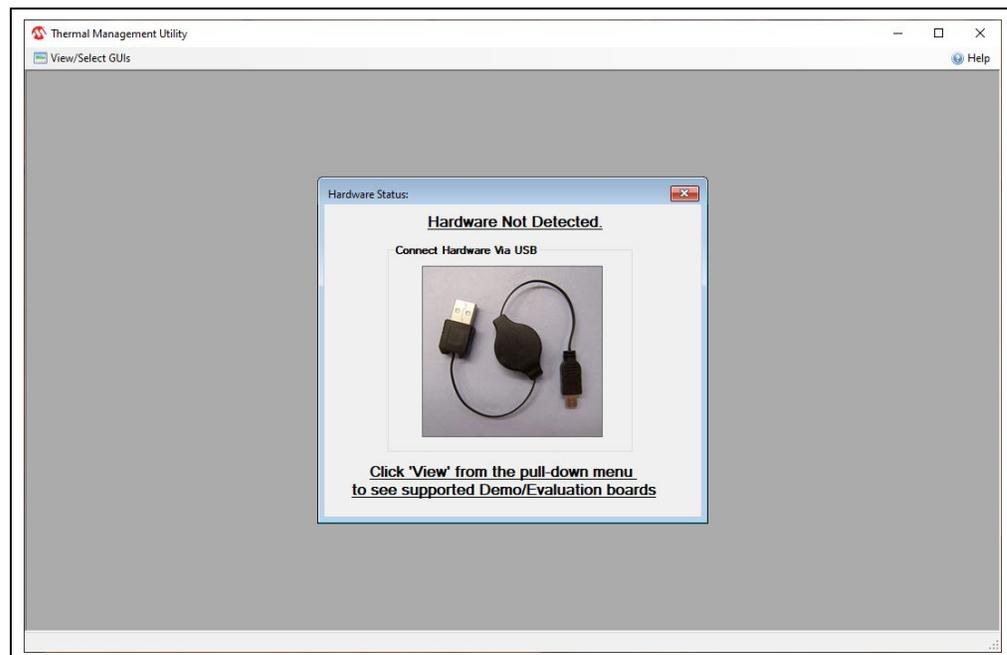
FIGURE 3-1:   Hardware Not Connected Dialog Box.

The Thermal Management Utility main window (Figure 3-2) consists of a Control Toolbar (marked in Figure 3-2 with the number **1**), a View Selection section (marked with the number **2**), a Demo Options section (**3**) and a Temperature/RPM Plots section (**4**).
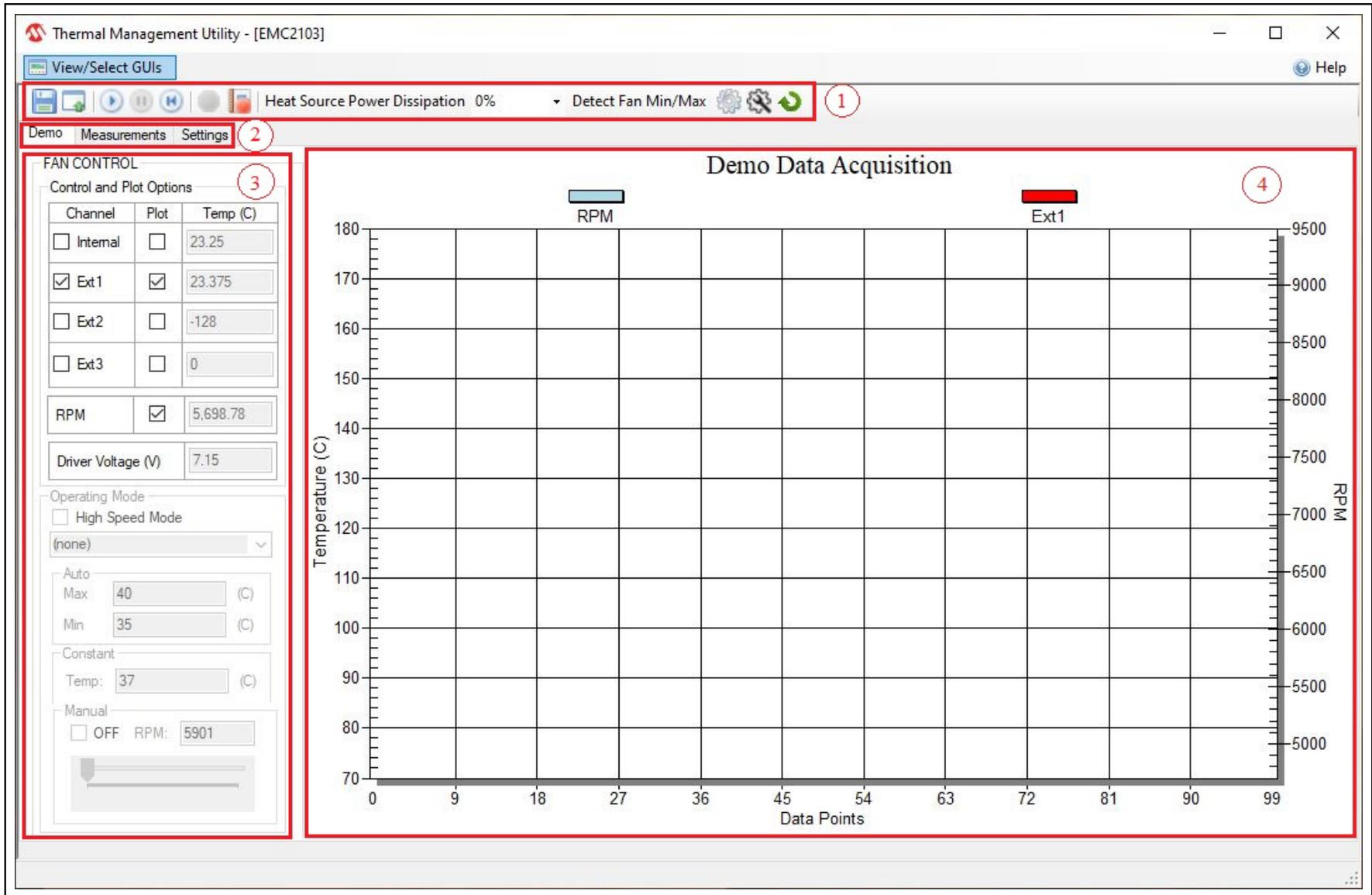
FIGURE 3-2: *Thermal Management Utility Main Window.*

3.3 CONTROL TOOLBAR
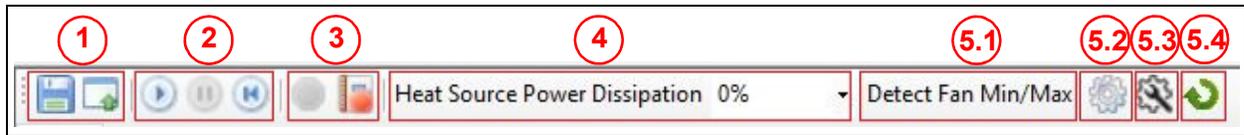
FIGURE 3-3: *Control Toolbar Section.*

3.3.1 Save/Load Settings

The Save/Load Settings section is noted in Figure 3-3 with the number **1**. This section allows the saving of all the currently configured GUI settings. The settings are stored in a `file.bin` file and can be reloaded to reconfigure the board. The loading process repopulates all the available fields and writes the settings into the connected ADM00902 Demonstration Board. This process takes up to 30 seconds to complete.

3.3.2 Data Acquisition

The Data Acquisition section (marked in Figure 3-3 with the number **2**) provides controls for starting, stopping and resetting the chart data.

Starting the data capture provides continuous reading of data from the temperature channels and fan driver, updates the charts and activates the Demo Operating modes. The Auto and Constant Operating modes need to have valid temperature target fields in order to work. When data capture is stopped, the four Demonstration modes (Auto, Constant, Manual and Look-up Table) are not operational.

The **Reset Plot Data** button clears the data from any visible chart in the currently selected view.

3.3.3 Data Logging

The Data Logging section (number **3**) enables or disables the data logging. Clicking the **Record Acquisition** button opens a file selection window in which the destination of the log file can be set. The logs are saved as `file.txt` files and contain the temperature readings for all four channels, and the fan RPM value that is reported in the **Measurements** tab. Note that the log contains only the values that are reported in the **Measurements** tab.

3.3.4   Temperature Related Options

The Temperature Related Options section is marked in Figure 3-3 with the number **4**.

The Heat Source Power Dissipation controls the on-board heat source connected to Channel 1 of the temperature sensor. Table 3-1 shows the approximate temperatures that can be reached when heating is enabled, considering an ambient temperature of approximatively +25°C.

TABLE 3-1:   HEAT SOURCE TEMPERATURES

Heat %	Temperature (°C)	
	Fan – OFF	**Fan – 100%**
0	25 (ambient temperature)	25
10	34.125	27.5
20	40-40.47	29.5-30
30	46.56	32.1
40	49.5	32.75
50	59.5	35.5
60	63.25	37.5
70	72.75	41.5
80	78.75	44.2
90	88.25	46.5
100	104	56.75

3.3.5 Fan Related Options

The Fan Related Options section is marked by the number **5**.

3.3.5.1 DETECT FAN MIN/MAX BUTTON

The **Detect Fan Min/Max** button opens a dialog box (Figure 3-4), which allows the detection of the minimum and maximum RPM (Revolutions Per Minute) values for the fan. It is initially set to the minimum drive value (configured in the **Fan Driver** tab under the "Min Drive" percentage field), the RPM being measured subsequently. If the fan doesn't start, then the Min Drive percentage is increased with the selected PWM step until the fan starts. After the minimum RPM, Valid Tachometer Count and Minimum Drive values are determined, they are stored. In order to determine the maximum RPM value, the fan drive is set to 100% and the RPM is measured. Note that the maximum RPM value detected can be slightly lower than the fan specification.

Note that the IC does not automatically determine the Min and Max values. This is done by software and is automated for the user's convenience.
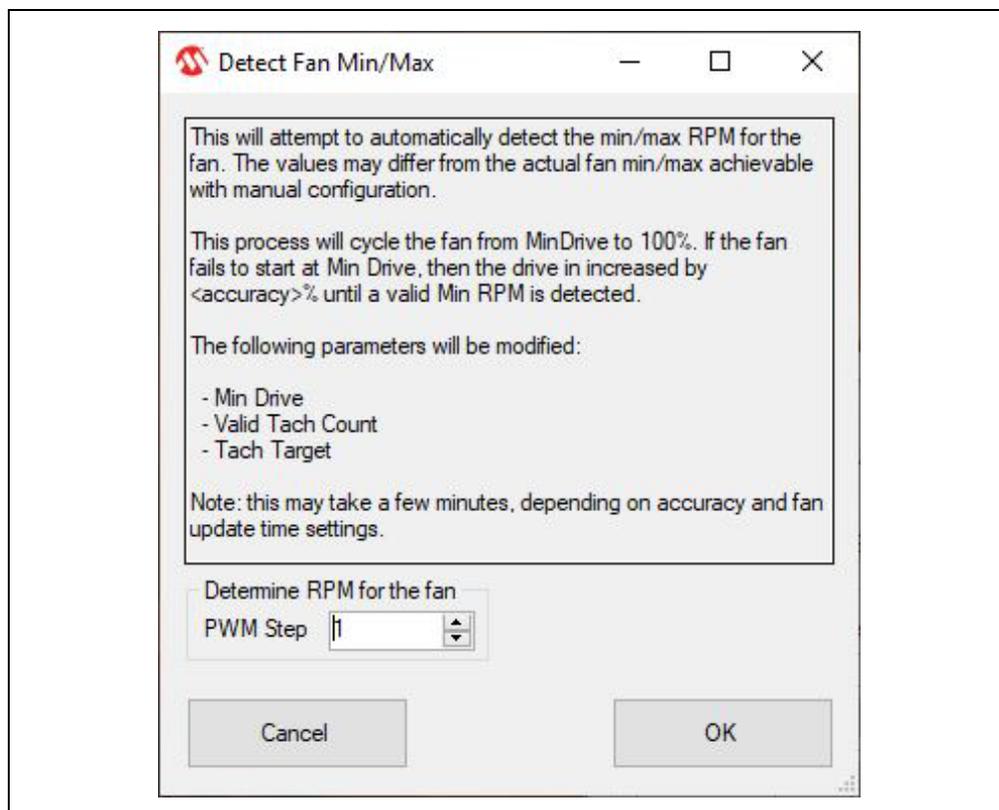
FIGURE 3-4:　　*Determine Fan Min/Max RPM Dialog Box.*

3.3.5.2 DEMO RPM OFFSET BUTTON

The **Demo RPM Offset** button (marked as **5.2** in Figure 3-3) opens a dialog box (Figure 3-5) in which the Min RPM offset values can be configured. This relates only to the fan control algorithm implemented in software for the demo application example. For the Auto and Constant Demo modes, the algorithm uses a minimum RPM target that consists of the minimum RPM value, specified in the **Fan Configuration** tab (Figure 3-19, number **4**), summed with the offset value.

Due to the RPM jitter, if the fan target is set to the Min RPM value, a false fan Stall detection can occur, causing the fan to be sped up unnecessarily, as the drive level used for the initial spin-up (Figure 3-19, number **3**) has a minimum value of 30% (which is larger than the Min Drive setting for this particular application).

Setting the RPM offset to 0 allows the demo to use the full RPM range.
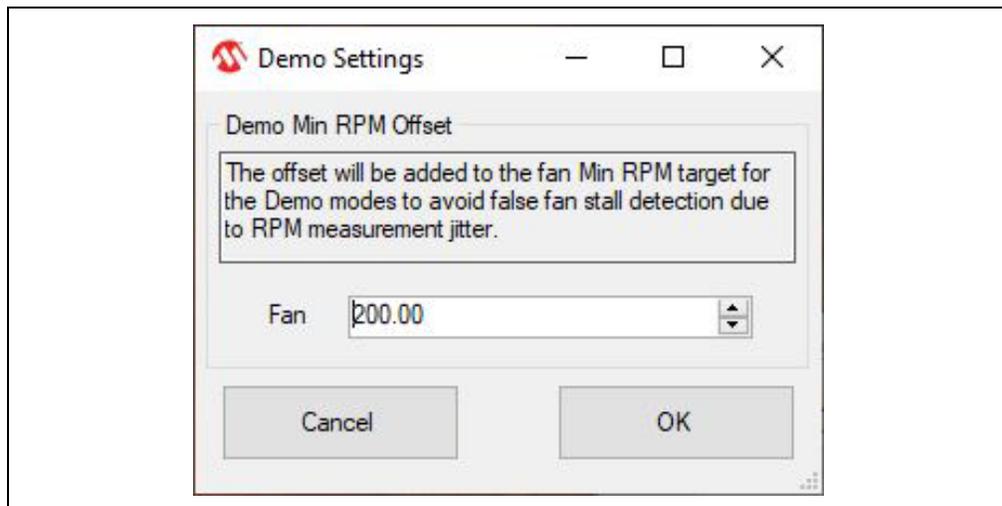
FIGURE 3-5: *Demo Settings Dialog Box.*

3.3.5.3   ADVANCED SETTINGS BUTTON

The **Advanced Settings** button (marked as **5.3** in Figure 3-3) opens a dialog box (Figure 3-6) where the PID values can be adjusted. This relates only to the target RPM adjustment algorithm implemented in software for the demo application example. It is used for the Auto and Constant Demo modes as the RPM value must adjust in order to either reach the target temperature established as a parameter in the two modes, or keep it constant, depending on which mode is used.
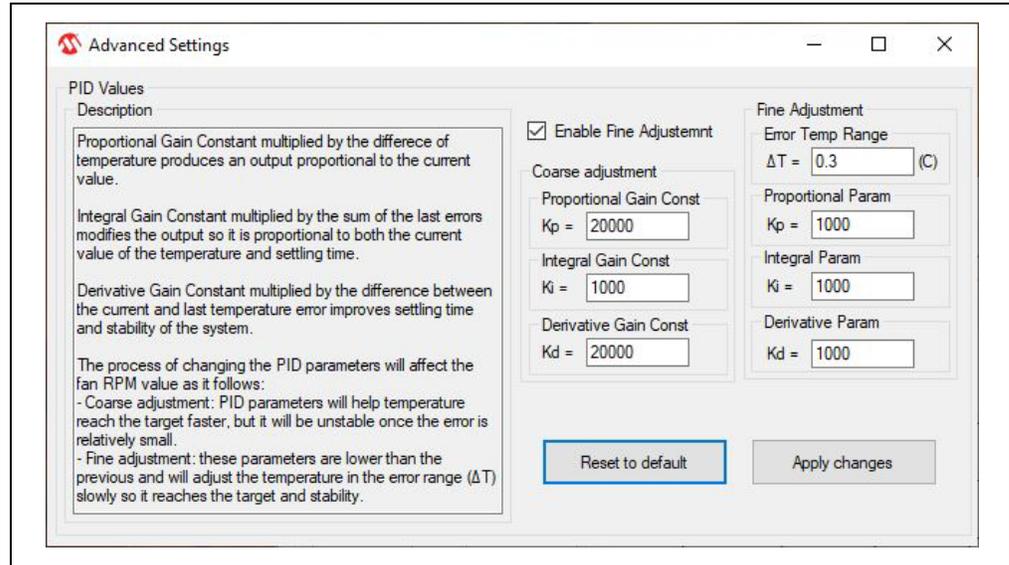
FIGURE 3-6:   *Advanced Settings Dialog Box.*

3.3.5.4   UPDATE BUTTON

The **Update** button (marked as **5.4** in Figure 3-3) refreshes the GUI fields with the values read from the chip.

3.4   DEMO TAB

The Demo View section (Figure 3-7) consists of a Demo Options area (**1**) and a Temp/RPM Charts area (**2**).
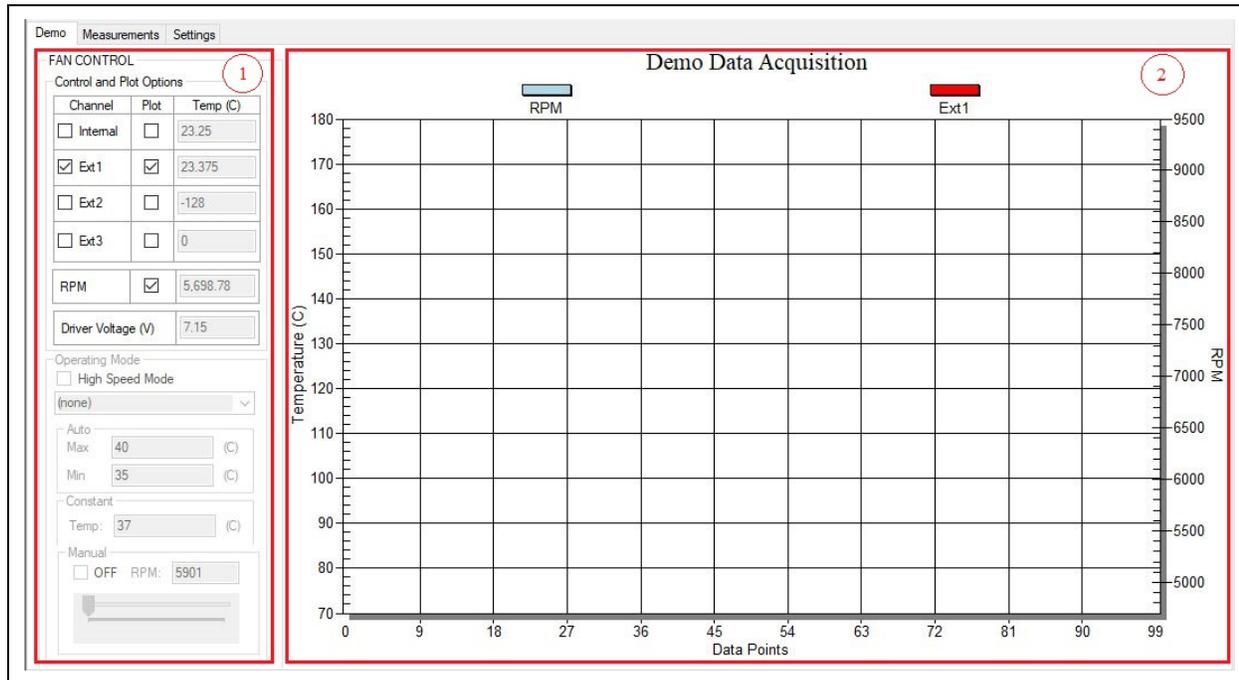
FIGURE 3-7:   *Demo View Section.*

3.4.1   Demo Options

This section provides control over the operating mode of the fan and its associated temperature source; it also displays the measured values and selects which data can be plotted.
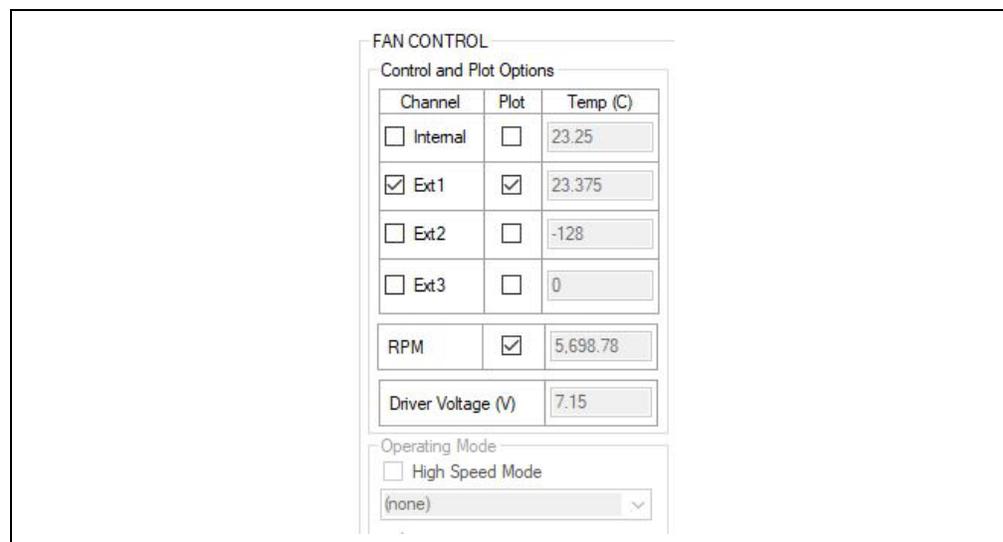
FIGURE 3-8:   *Demo Options Fan.*

3.4.1.1   CONTROL AND PLOT OPTIONS

In the demo, all available temperature channels of the EMC2103-4 can be monitored, depending on which mode is used, along with the RPM value. The Ext 1 channel is tied to the on-board heat source.

Any of the four available temperature channels, and the RPM value, can be plotted if their corresponding plot checkbox is marked.

3.4.1.2   OPERATING MODE

This demonstration offers four main operating modes: Auto, Constant, Manual and Look-up Table. The Auto and Constant modes are implemented in software by reading the temperature from the EMC2103-4 device and adjusting the fan speed based on this input.

The High-Speed mode allows the acquisition of more data per second than the normal operating mode. When the normal speed for the acquisition is used, more data are read from the chip, which includes the demo and measurements values that are displayed. In High-Speed mode, only the values selected from the Control and Plot Options of the **Demo** tab are read and displayed, with no updates reported in the **Measurements** tab. Consequently, the log file does not receive any new data.

In Auto mode, the user can select multiple temperature channels for monitoring. The fan RPM is adjusted based on the highest measured temperature, out of the selected channels, by ticking the corresponding channel checkboxes from the control region. The speed is adjusted as follows:

- The Max parameter is set as the target temperature and the Min parameter works as a threshold.
- If the temperature is below the minimum temperature value, the fan is turned off.
- If the temperature is between the minimum and maximum values, the fan runs at the minimum RPM value summed with the offset value.
- When the temperature exceeds the maximum value, the fan speed is adjusted in order to keep the temperature at the maximum limit, with a hysteresis of ±0.3°C value, which can be modified from the Advanced Settings menu (Figure 3-6). This outcome is dependent on the cooling solution (appropriate heat sink to dissipate the heat).
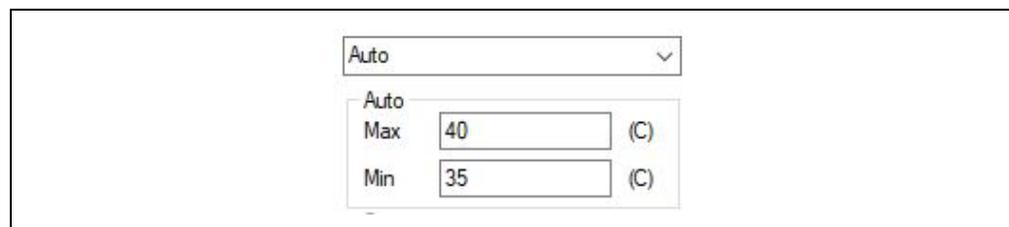
FIGURE 3-9:   *Demo Options Fan – Auto Mode.*

In Constant mode, the user can select only one temperature channel for monitoring and the fan speed will be adjusted as follows:

• If the temperature is below the target temperature value, the fan is running at the minimum RPM value summed with the offset value.

• When the temperature exceeds the target value, the fan speed is adjusted, in order to keep the temperature at the target limit, with a hysteresis of ±0.3°C value, which can be modified from the Advanced Settings menu (Figure 3-6). This outcome is dependent on the cooling solution (appropriate heat sink to dissipate the heat).
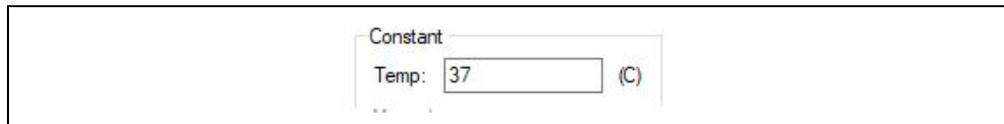
FIGURE 3-10:   *Demo Options Fan – Constant Mode.*

In Manual mode, if the user switches from another operating mode, the algorithm takes the fan's RPM last value from the previous operating mode and adjusts the fields in the Manual mode accordingly. If the fan is in the OFF state, the **Off** button will be checked and the other fields will be disabled. If the fan is in the ON state, the **Off** button will be unchecked and the other two fields will adjust to the RPM value. The fan RPM value can then be adjusted, from minimum to maximum, by using the slider or by directly writing in the designated "RPM" field. The fan can be stopped by checking the Fan Off checkbox.
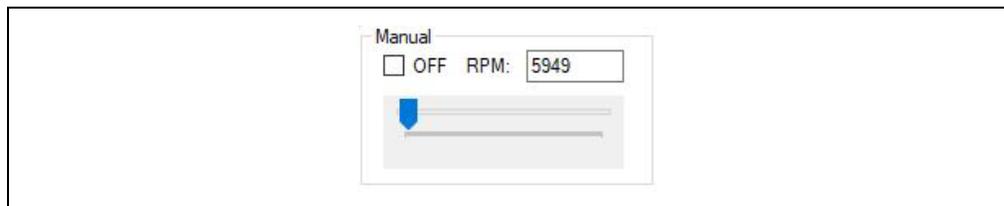
FIGURE 3-11:   *Demo Options Fan – Manual Mode.*

In Look-up Table mode, all the other demo options are disabled and LUT registers are locked. In this mode, the fan RPM value will be changed according to the temperatures set in the look-up table.
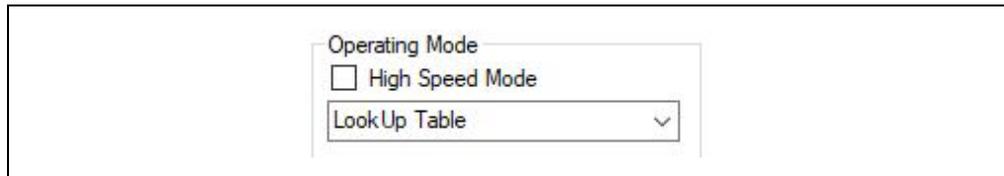
FIGURE 3-12:   *Demo Options Fan – Look-up Table.*

3.4.2 Temperature Charts

This section displays the fan RPM and its corresponding heat source value (°C). The data plots from the temperature channels and the RPM value can be toggled on/off from the corresponding fan Plot On checkbox, located in the Demo Options section. (Figure 3-7).

For better visibility of the plotted values, a data table can be enabled from the chart's context menu. The user must right-click the plot in order to trigger this menu and select the Both Graph and Table option, as displayed in Figure 3-13.
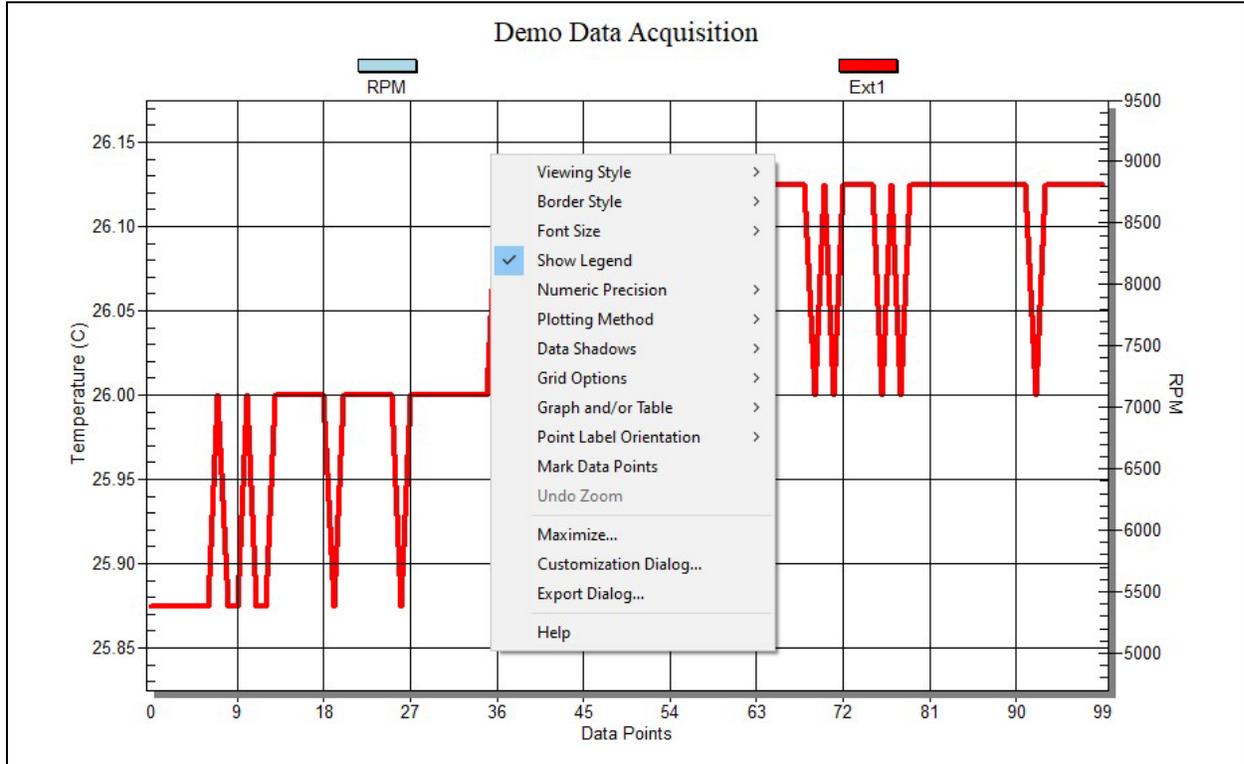
FIGURE 3-13: *Chart Options.*

3.5   MEASUREMENTS TAB

This view contains all the values related to the temperature channels, fan parameters and status of the device features.
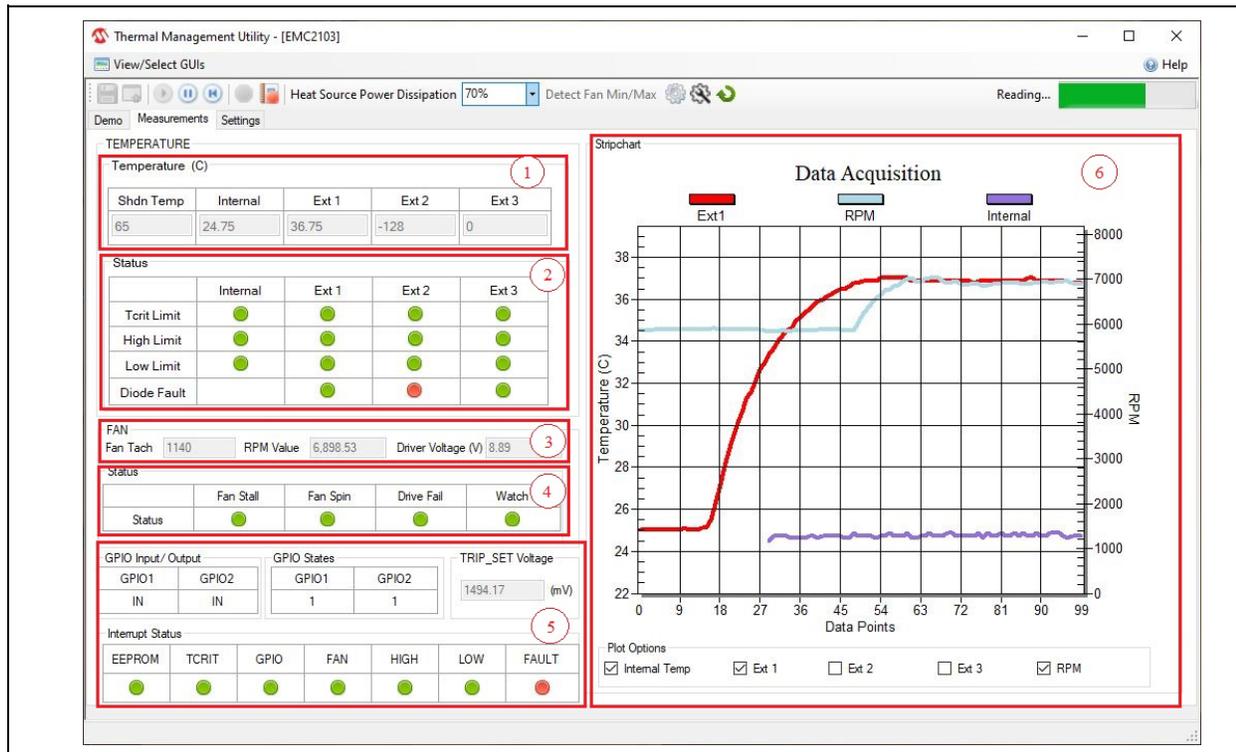
FIGURE 3-14:   *Temperature Sensor View – **Measurements** Tab.*

The **Measurements** tab provides an overview of all the temperature, fan speed and state-related readings from the EMC2103-4 device:

- The temperature values are presented in both the Temperature table (marked in Figure 3-14 with (**1**) and in the Data Acquisition chart (**6**). The chart can be configured to display any combination of the device channels by enabling the corresponding channel checkbox from the Plot Options section.
- The temperature channels' status is displayed in the Status section (marked in Figure 3-14 with (**2**), where a green icon represents normal operation and a red icon signals that the limit or the Fault condition named on the row title has been reached.
- The fan values are displayed in the Fan section (**3**) and the RPM value can also be presented in the Data Acquisition chart. The fan driver output voltage is measured using the MCP2221A ADC and calculated using the following formula: (first channel for ADC) * 2(mV per bit)/1000 * 11(voltage divider)
- The device's status is displayed in the Status section (**4**), where a green icon represents normal operation (limit not exceeded, no Fault condition) and a red icon signals that a limit has been reached or a Fault condition has been detected.
- The GPIO and Interrupt states are monitored in the section marked by (**5**) in Figure 3-14. The GPIO Input/Output section monitors the pin direction of each GPIO pin. The GPIO States section indicates the state of the corresponding GPIO pin. The Interrupt Status reports the operating condition of the device. The TRIP_SET Voltage register value is displayed. This value is proportional to the TRIP_SET Resistor value.
- The device data can be read continuously by clicking the **Start** button from the toolbar or manually sampled by clicking the **Update Registers** button. The chart is only updated during continuous sampling.

3.6   SETTINGS TAB

The **Settings** tab provides access to all of the device's settings, limit configuration and alert options.

3.6.1   GPIO Settings

The GPIO section allows for independent configuration of the two GPIO pins. Checking the mask for input options enables the ALERT pin indication of the GPIO status change (the on-board ALERT LED will turn on for every high-to-low or low-to-high transition detected on the GPIO pin).
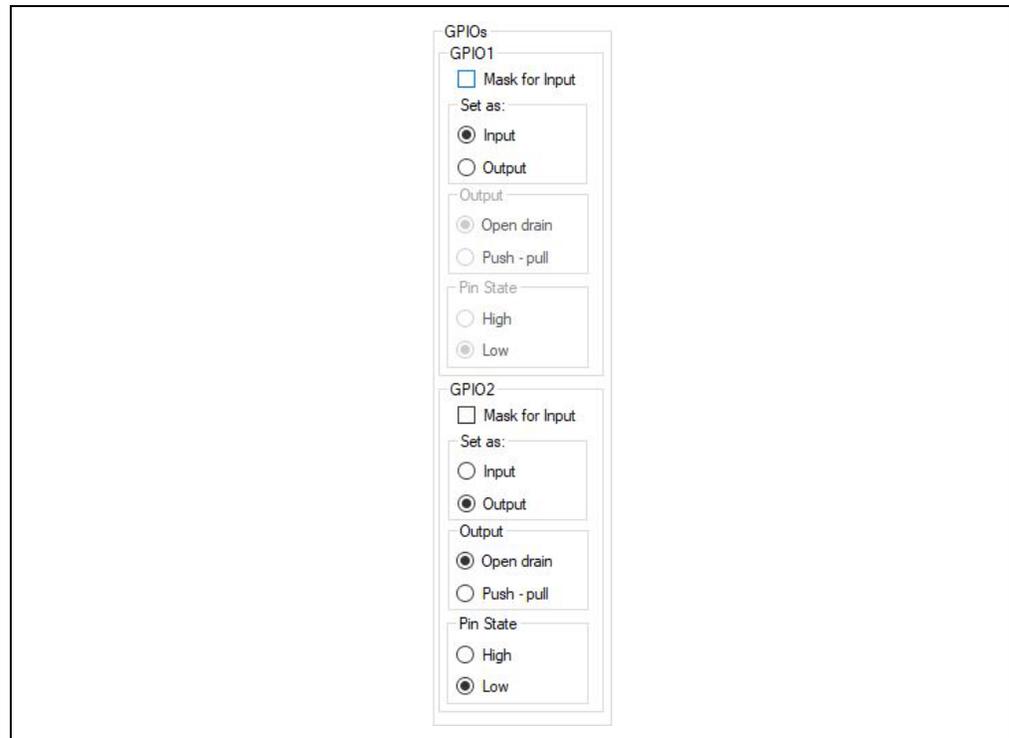
FIGURE 3-15:   *GPIO Settings.*

3.6.2 Look-up Table

In this section, the user can set up the configuration for the look-up table and set the parameters for the Drive and Temperature registers.
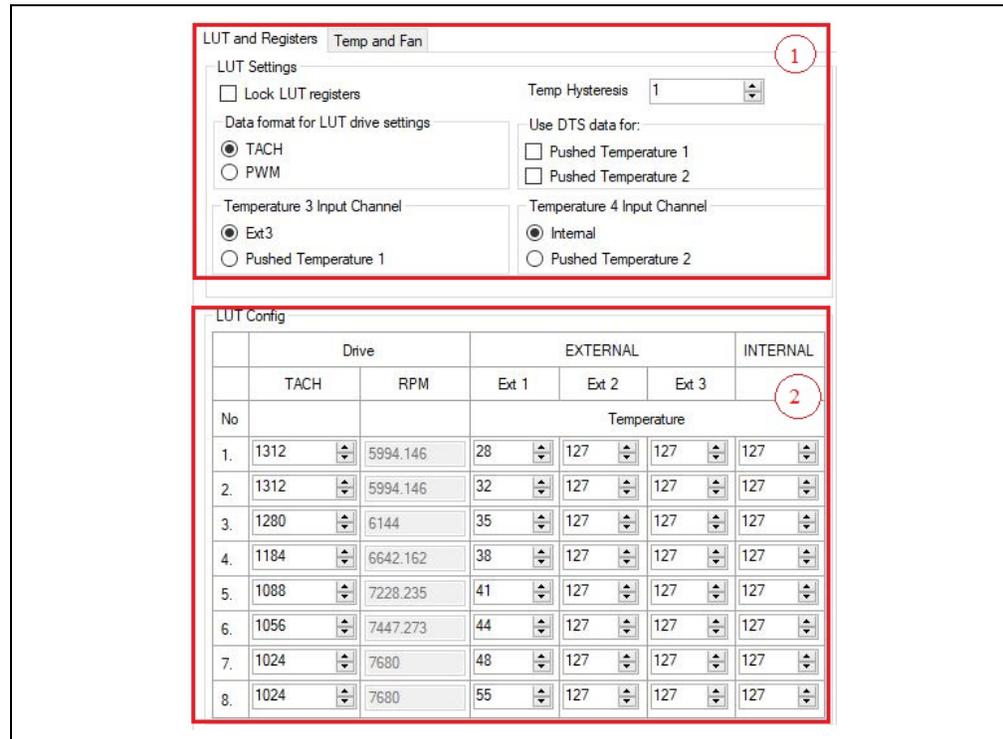
FIGURE 3-16: *Look-up Table.*

The Look-up Table Settings section (marked in Figure 3-16 with the number (**1**) provides a list of features that can be selected and changed.

The LUT Config section (**2**) contains the correlation between the Drive registers' values and the temperatures from all available channels that are to be encountered during the usage of the Look-up Table Functioning mode. This mode can be enabled from the LUT Settings section by checking the Lock LUT registers box. The drive values are read from eight registers, each of them being common for a TACH value and a PWM value. If PWM is used, the registers can take values from 0 to 255. When used in the GUI, these values are scaled and shown in percentages. The values from the TACH column can be replaced with the PWM values from the same registers if the data format for the LUT drive settings is changed. The user can set a correlation between the temperatures for each channel and the fan TACH values, so the fan will change its speed according to what temperature value is encountered. The user is constrained to set TACH/PWM values between a specific range. For the TACH, the range is defined by the minimum and maximum RPM values set in the Fan Configuration section, and for the PWM values, the range is determined by the fan minimum drive setting and the value of 100%. When switching from TACH to PWM and from PWM to TACH, the values from the registers may change due to the limit constraints from each format.

3.6.3   Register List

The **Register List** tab gives an overview of all the device registers, their addresses and their values. The values are updated after clicking the **Update Registers** button from the **Settings** tab. Each register can also be individually read by selecting the register and right-clicking, then selecting Read.

FIGURE 3-17:   *Registers List Tab.*

3.6.4   Temperature Sensor Settings

The Temperature Sensor Settings provides access to all of the sensor's settings and limit configurations.
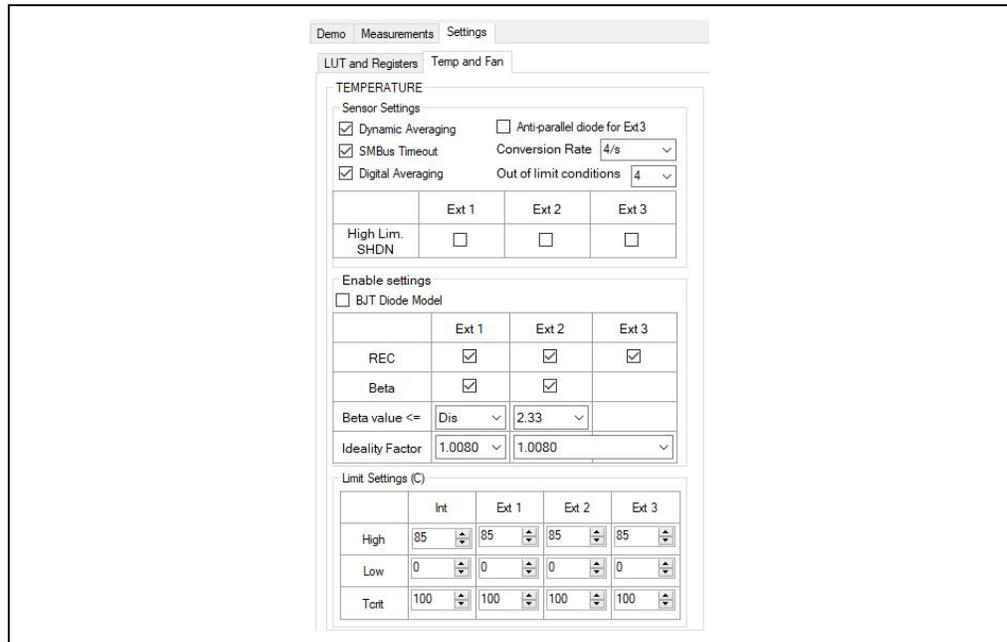
FIGURE 3-18:   *Temperature Sensor.*

Note that the TCRIT values can only be changed once after power-up.
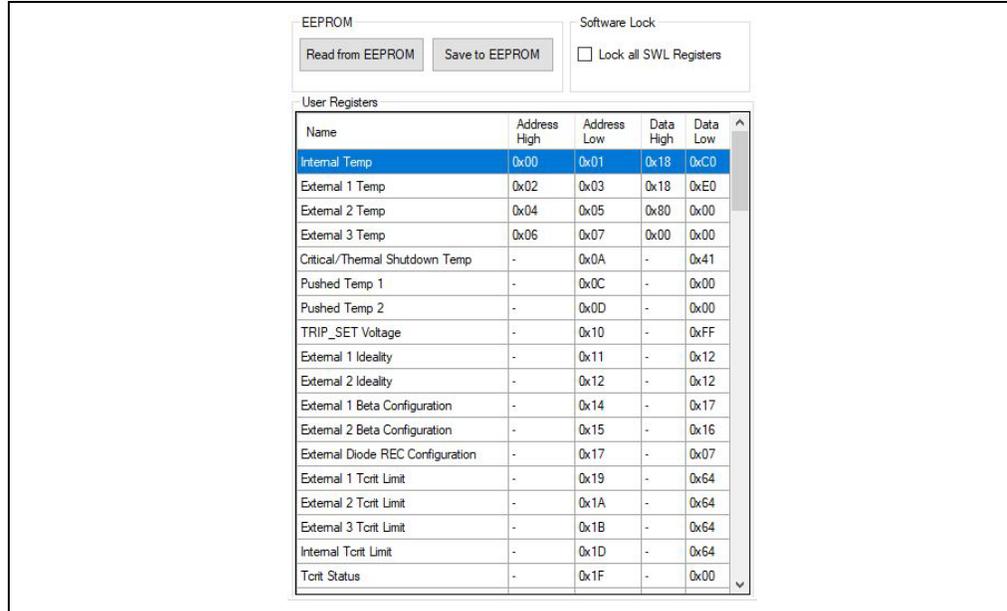
When starting the board with the SHDN_SEL jumper on a position that loads the settings from EEPROM (15k, 22k, 33k and open positions), this one-time TCRIT write operation will automatically be exhausted and the GUI will not update the values any more, nor be able to write other values to the EEPROM.

When starting the board with the SHDN_SEL jumper on a position that doesn't load the settings from EEPROM (4.7k, 6.8k, 10k positions), the first TCRIT update from the GUI will be successful and only that value will be able to be saved to the EEPROM. Using the Load Settings command from the GUI will not replace the TCRIT values, allowing for the one-time manual write operation (any entered value that is different from the default of 100 will use up the one-time write).

3.6.5 Fan Driver Settings

The **Fan Driver** tab (Figure 3-19) provides easy access to the EMC2103-4 device's settings and readings.

Each section of the **Fan Driver** tab is highlighted in Figure 3-19 by a red rectangle and a number, with each corresponding number being described below.
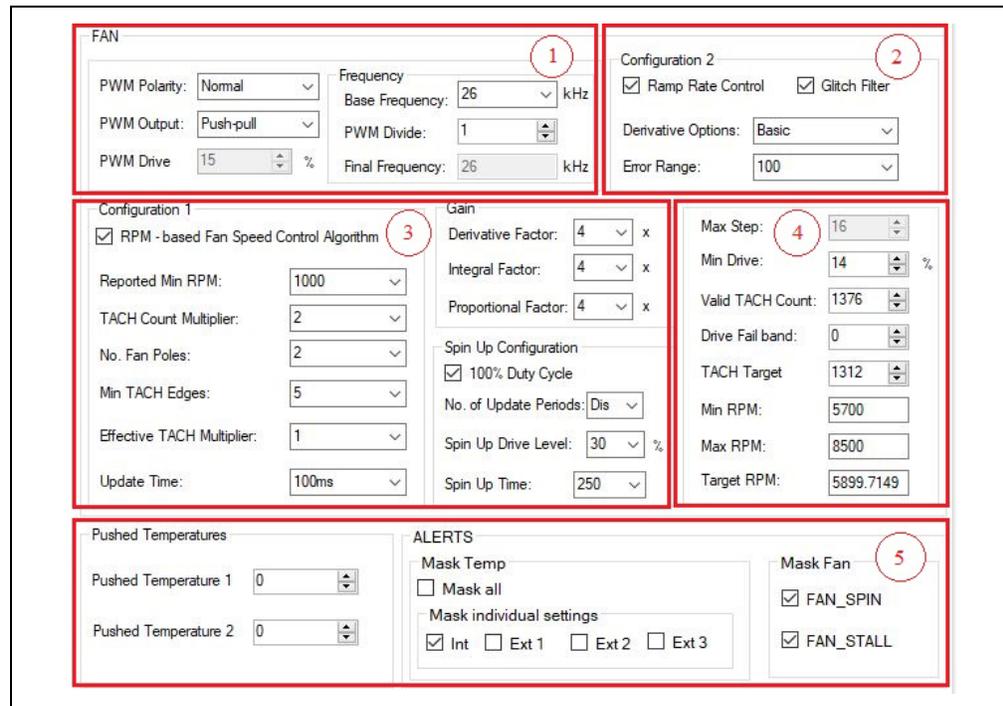
FIGURE 3-19: *Fan Driver Tab.*

- The PWM Settings section (**1**) contains all PWM-related settings for the fan driver channel.
- The General Configuration sections (**2** and **3**) give access to the rest of the driver's settings.
- The Fan Related Settings section (**4**) contains the drive and RPM/TACH options needed to properly drive the connected fan. The "Min RPM" field is connected to the "Valid TACH Count" field; if either value is changed, the other is updated as well. The same is true for the "Target RPM" field and the "TACH Target" field.
- The General Settings section (**5**) allows setting the pushed temperatures, toggling the alert settings and mask fan options for the fan spin and stall.

3.7   DEMO EXERCISES

3.7.1   Auto-Mode Example

Steps:

1. From the taskbar, select the **Load Settings** button and load the
    configuration file named, `ADM00902_Default_Settings.bin`, to make sure
    the out of box operating settings are set correctly.

2. An alert can be configured for Ext 1 in the **Settings** tab. Select the **Temp and
    Fan** subtab and in the "Limit Settings (C)", modify the Ext 1 "High" temperature
    to 45.
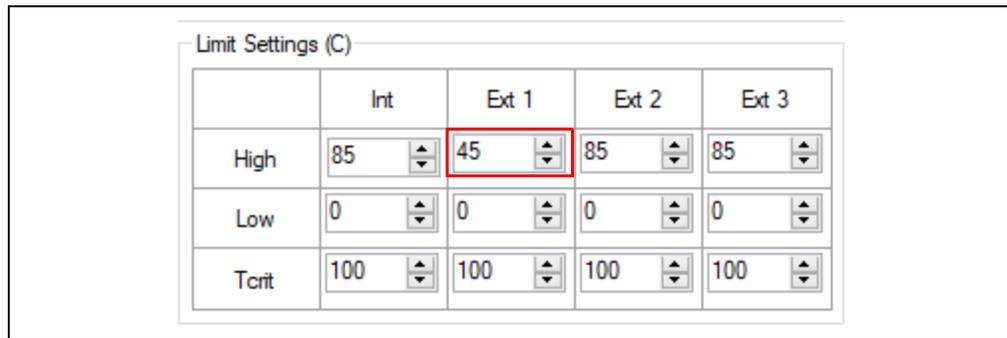
3. In the "ALERTS" section, in the "Mask individual settings", check the corresponding
    box to "Ext 1".
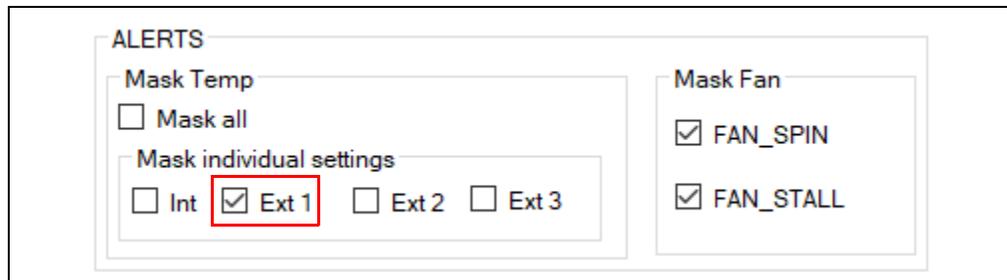
4. In the **Demo** tab, in the "Control and Plot Options" section, check the "Ext 1" box from the "Channel" column, and from the "Plot" column, check the boxes corresponding to "Ext 1" and "RPM".

   This will enable the fan speed control based on the External 1 temperature channel and plot the related values.
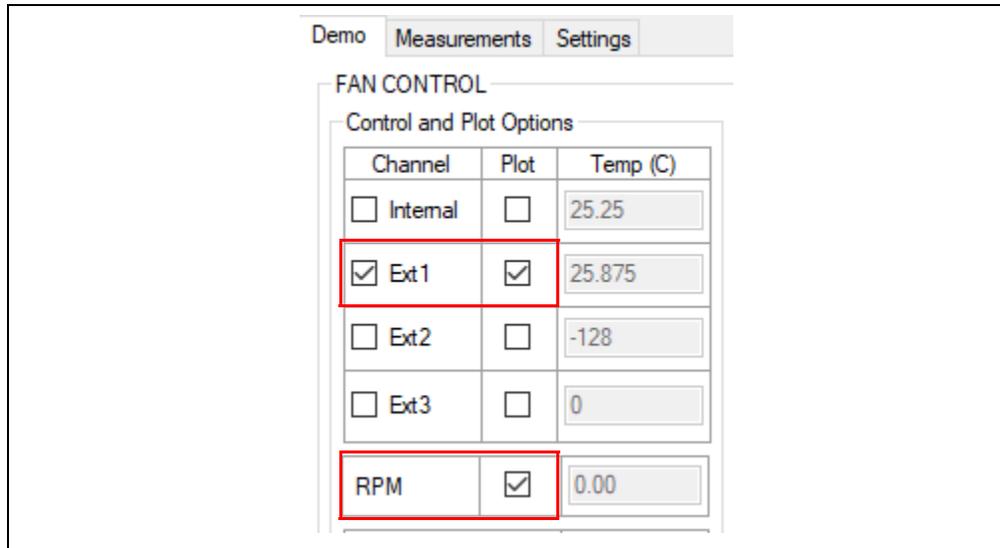
5. From the taskbar, press the **Start Acquisition** button in order to start the demo.
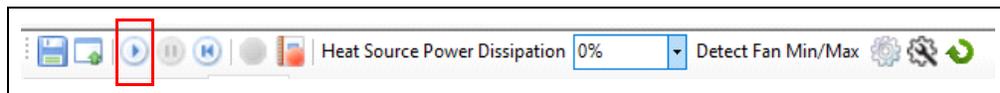
6. In the "Auto" section, set the "Max" parameter to 40°C and the "Min" parameter to 35°C. When the Ext 1 temperature is below 35°C, the fan will be off.
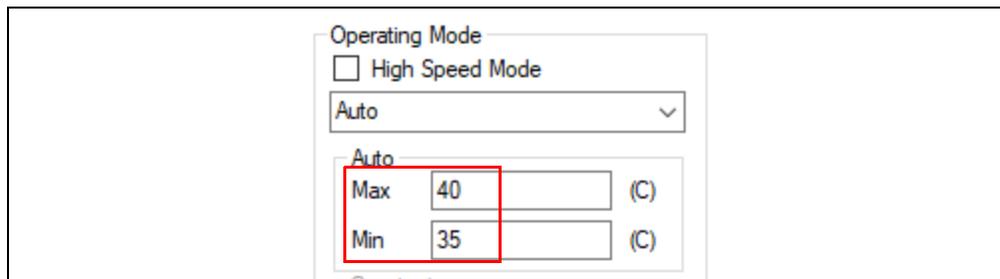
7. From the taskbar, set the "Heat Source Power Dissipation" to 80%. Note here that the exact temperature varies and 80% may result in different temperatures for your board. The fan will start spinning at the minimum RPM when the temperature has reached the "Min" target and increases the RPM once the temperature has exceeded the "Max" target.
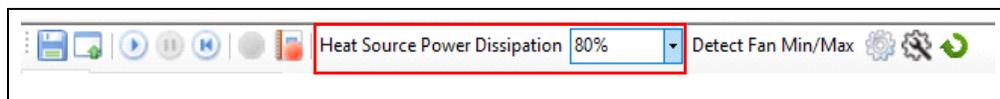
8. After the temperature has settled around 40 degrees, increase the "Heat Source Power Dissipation" to 100% (note the exact temperature for 100% because your board may be different than the resulting plot due to heat source component variation and ambient temperature) to force the temperature to exceed the 45-degree target that was set for the alert threshold on the Ext 1 channel. Notice the ALERT LED on the board turn on. When lowering the "Heat Source Power Dissipation" back to 80%, the LED will turn off after the temperature falls below the set target.
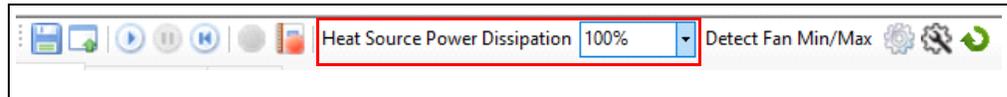
The plot from the "Demo Data Acquisition" chart should look like the picture below.
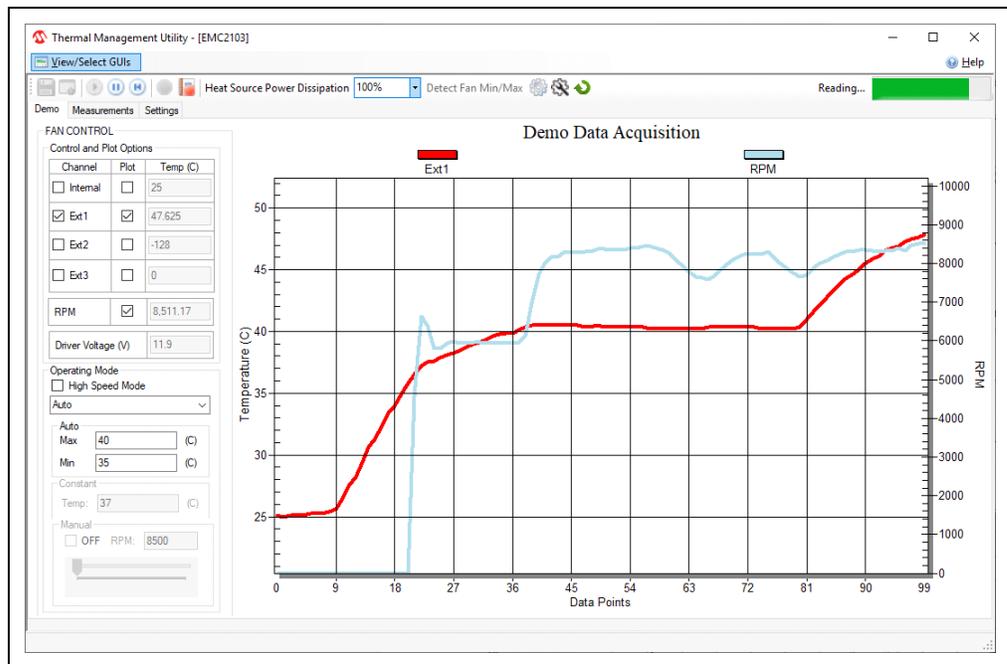
3.7.2 Look-up Table (LUT) Mode Example

Steps:

1. From the taskbar, select the **Load Settings** button and load the configuration file named, 'ADM00902_Default_Settings.bin'.
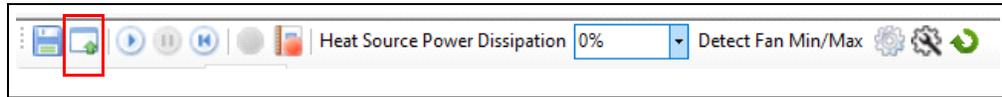
2. In the **Demo** tab, in the "Control and Plot Options", check the "Ext 1" box from the "Channel" column, and from the "Plot" column, check the boxes corresponding to "Ext1" and "RPM".
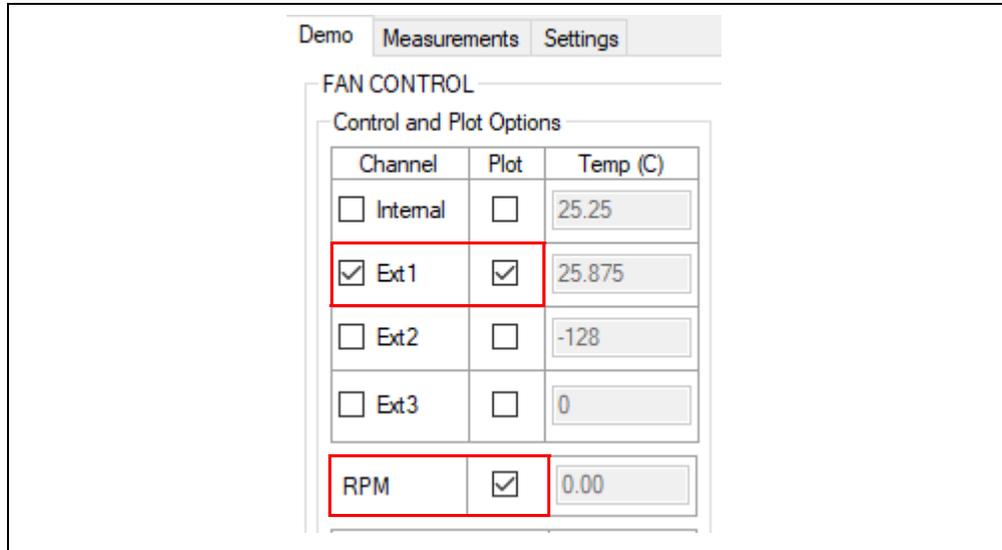
3. In the **Settings** tab, **LUT and Registers** subtab, the "LUT Settings" can be config-
    ured. The default settings come with the LUT drive configured for TACH mode, so
    the corresponding RPM values (grayed out) can be calculated based on the fan
    settings (the RPM value is calculated when selecting a different cell). Use the
    up/down arrows for each of the TACH values in the table to define a different speed
    setting for the corresponding target temperature (lower TACH value = higher RPM).

    The Ext 1 temperature channel is used in this case as this is the channel that is
    affected by the on-board heat source.

4. From the taskbar, press the **Start Acquisition** button in order to start the demo.

5. In the "Operating Mode" section, select from the drop-down menu, the LookUp Table option.
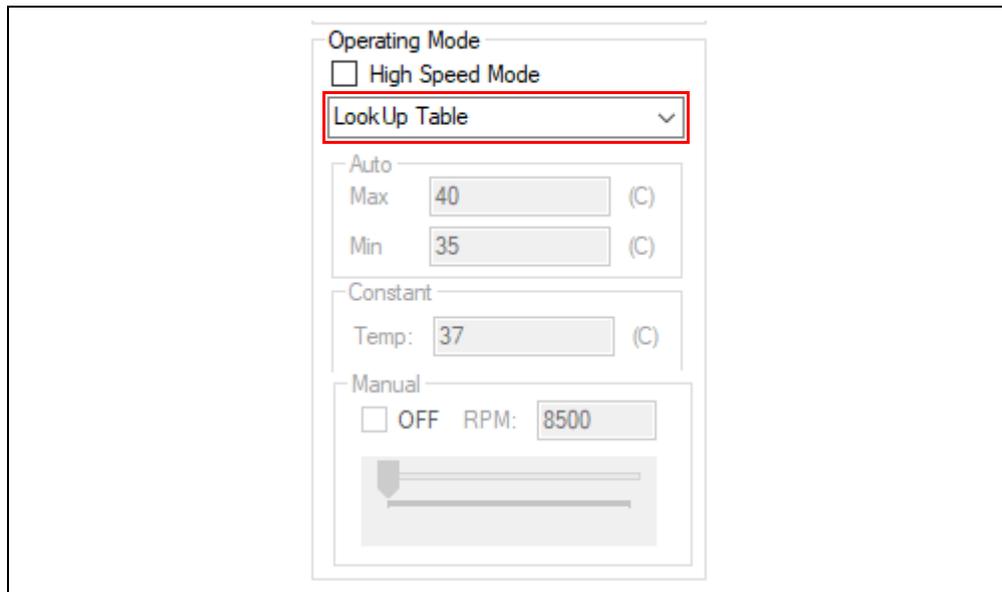
6. From the taskbar, set the "Heat Source Power Dissipation" to 80%.

    The fan speed will change to set to the defined RPM setting from the "LUT Config" at each target temperature.
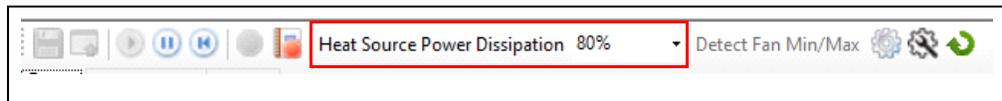
7. The plot from the Demo Data Acquisition chart should look like the picture below. Notice the fan speed increasing when the 28°C, 35°C and 41°C LUT targets are crossed.
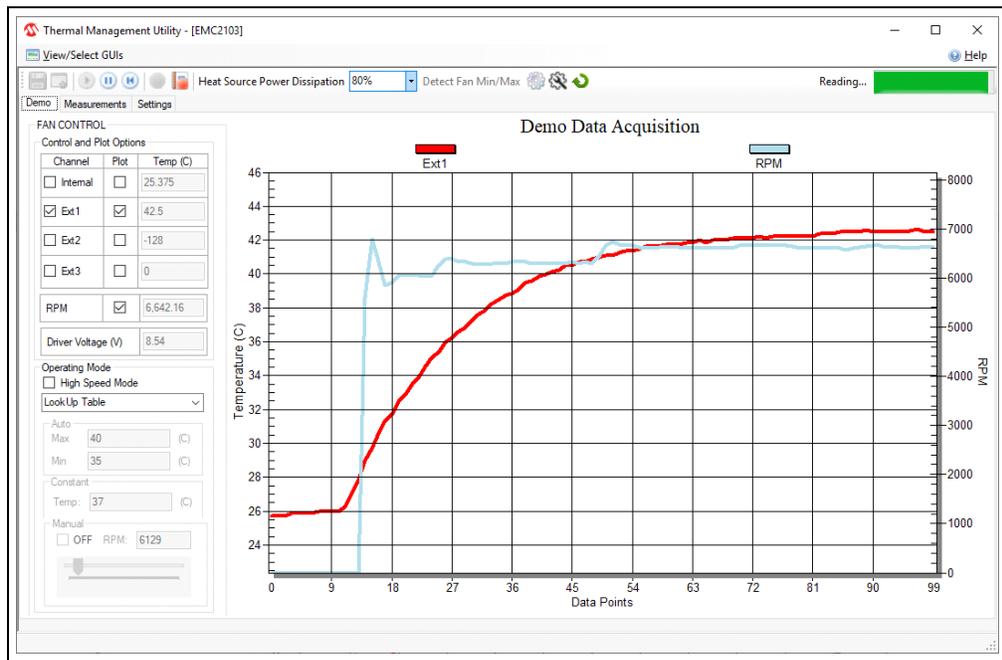
Chapter 4. Hardware Description

4.1 ADM00902 DEMONSTRATION BOARD FOR EMC2103 DESCRIPTION

The ADM00902 Demonstration Board for EMC2103 becomes fully functional when it is powered through the USB connector and the 12V BOOST for the V_{FAN} supply is selected. The total power consumption of the board is slightly below the 2.5W that the USB port can supply. The external 12V jack (J2) or test points (TP1 and TP2) are needed when using another fan with a higher power consumption.

The maximum voltage supported by the jack and the power test point connections is 16V, limited by the 3.3V regulator that is powering the low-voltage circuits.

The communication with the PC is provided through the MCP2221A device, a USB to I^2C/SMBus bridge.

There is one fan channel available which uses a Switch mode PWM driver for higher efficiency and three remote diode channels accessible through the J11 connector.

The on-board EEPROM (U4) holds the device configuration and can be used to load the settings at power-up by setting the appropriate SHDN_SEL jumper (J6).
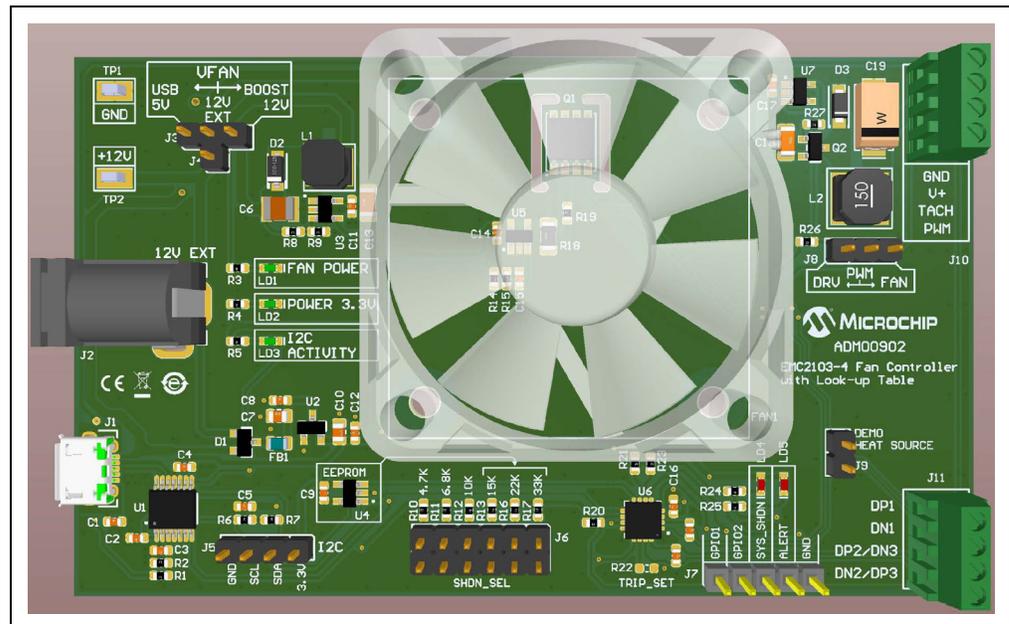
FIGURE 4-1: *ADM00902 Demonstration Board for EMC2103 Top View.*

4.1.1 Power Selection

The fan and heat source power input (V_{FAN}) is selectable through a 3-way jumper assembly comprised of J3 and J4 with the following options:

- 5V USB (direct 5V option for 5V fans)
- 12V EXT (for an external power supply option)
- 12V BOOST (on-board boost switcher that is powered from the 5V USB input)

4.1.2 SHDN_SEL Pin Pull-up Selection

The J6 header provides easy access to all of the available pull-up values for the SHDN_SEL pin. For the 15 kΩ, 22 kΩ, 33 kΩ and no jumper selection, the power-on settings are loaded from the on-board EEPROM. See **Section 5.1.1** of the *"EMC2103 Data Sheet"* (DS20005250) for more mode/shutdown channel details.

4.1.3 Fan Connection and PWM Fan Driver

The fan is connected via a four contacts wire-to-board connector. The 3-pin jumper, J8, is used to route the PWM output from the EMC2103-4 towards the switching driver for a 3-wire fan (DRV option) or directly to the PWM pin of a 4-wire fan (FAN option). The fan wiring color code for the 3-wire fan supplied in the kit is: Red = 12V, Black = GND, Yellow = TACH. Depending on market availability, the provided fan can change in time.

If no jumper selection is made, the fan driver provides an unregulated output voltage equal to the V_{FAN} selection voltage.

The high-side DC/DC drive topology used (Figure 4-2) helps maintain the GND connection for the tachometer output when driving 3-wire fans.

While the EMC2103-4 device can provide multiple frequency values for the PWM output (ranging from 9.57 Hz to 26 kHz), the on-board Switch mode driver needs the maximum frequency setting to operate properly without large ripple and audible noise.
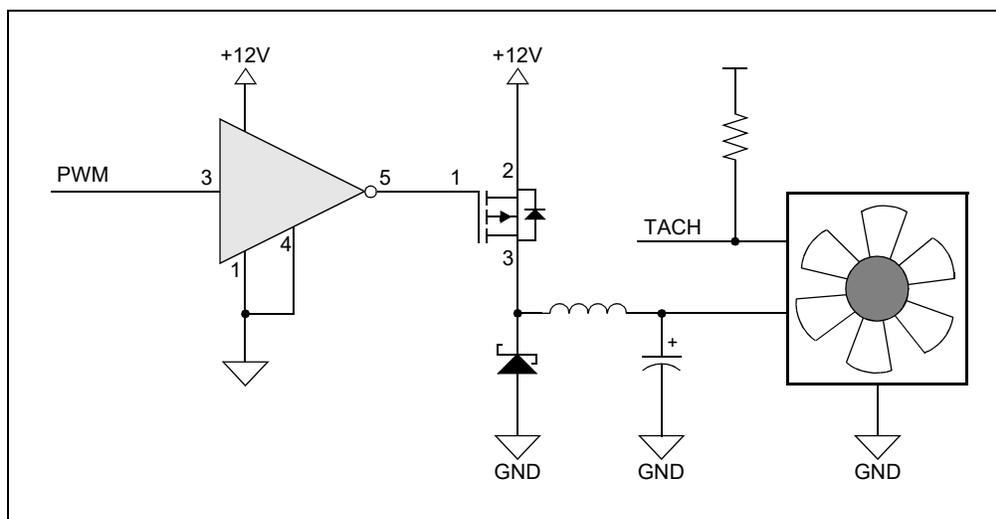
FIGURE 4-2:　　　*PWM Fan Drive.*

Figure 4-3 displays the output voltage versus the PWM duty cycle for the fan provided in the kit.
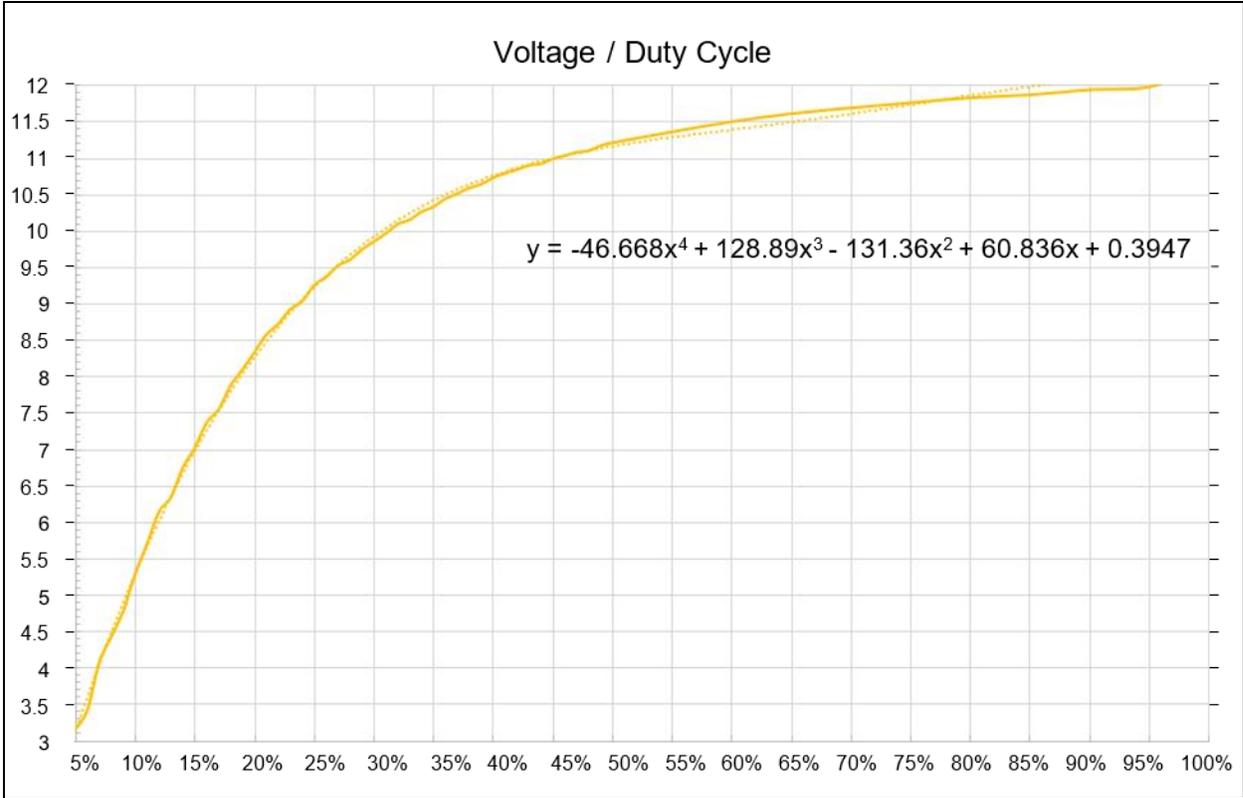
FIGURE 4-3: *PWM Duty Cycle to Voltage Correspondence.*

The equation shown in the figure is:

$$y = -46.668x^4 + 128.89x^3 - 131.36x^2 + 60.836x + 0.3947$$

Considering that the minimum specified voltage for the provided fan is 7V, the minimum drive setting needs to be set at 16 in order to ensure a reliable fan operation and tachometer reading.

This minimum drive setting and voltage per duty cycle behavior is dependent on the drawn current and varies from fan to fan. Figure 4-3 is provided only for reference on how this combination of driver and fan behave and to help with understanding the relationship between the output voltage and the PWM duty cycle.

Note that by setting the PWM duty cycle at 50%, the fan RPM won't be set at 50%. This is where the EMC2103-4 RPM-based Fan Speed Control Algorithm solves the problem, by automatically adjusting the PWM duty cycle to achieve a target RPM.

4.1.4   On-Board Demonstration Heat Source and Remote Diode

The Q1 dual NPN transistor is used both as a heat source and as a remote diode, in order to help provide an out-of-the-box demonstration of the implemented PID (proportional-integral-derivative) controller in the Thermal Management Utility GUI.
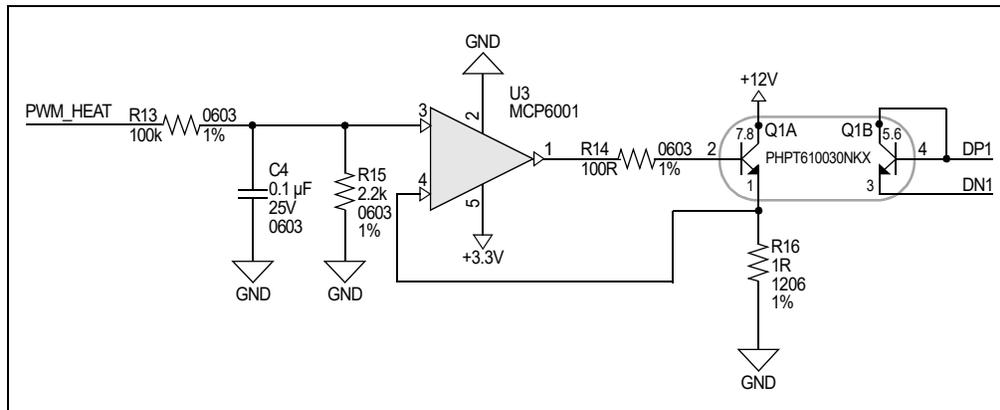
FIGURE 4-4:   *Heat Source Schematic.*

4.1.5   External Temperature Remote Diode Connections

The External Diode 1 channel can support a diode connected transistor (such as a 2N3904) or a substrate transistor requiring the BJT or transistor model (such as those found in a CPU or GPU), as shown in Figure 4-5.

The External Diode 2 channel supports any diode connection shown or it can be configured to operate in Anti-Parallel Diode (APD) mode. When configured in APD mode, a third temperature channel is available that shares the DP2 and DN2 pins. When in this mode, both the External Diode 2 channel and External Diode 3 channel thermal diodes must be connected as diodes.
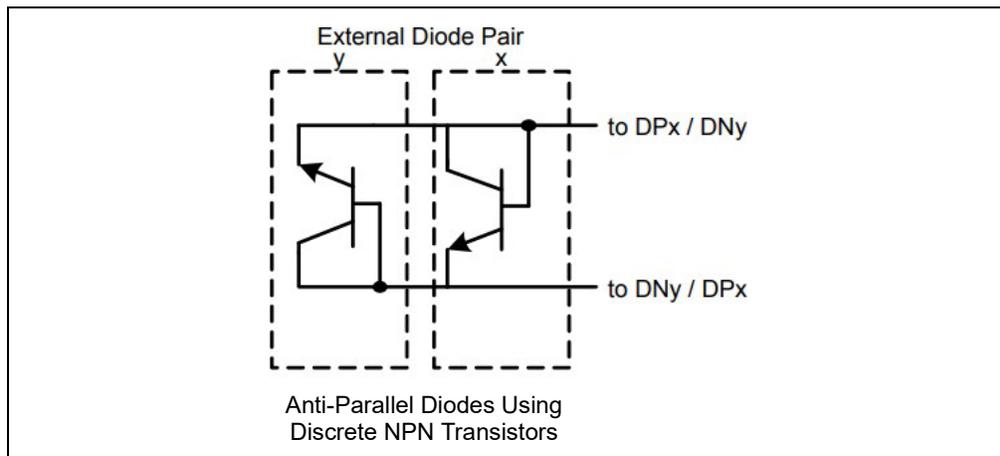
FIGURE 4-5:   *Remote Diode Connection Diagram.*

4.1.6   On-Board LEDs

There are three Green LEDs on the left side of the board that indicate the ON/OFF state of the fan power (LD1), 3.3V digital power (LD2) and I^2C communication (LD3).

Two more Red LEDs are present on the right side of the board, corresponding to the SYS_SHDN (LD4) and ALERT (LD5) pins of the device. In depth details on these alert pins' operation can be found in the *"EMC2103 Data Sheet"* (DS20005250).

Appendix A. Schematic and Layouts

A.1 INTRODUCTION

This appendix contains the following schematics and layouts for the ADM00902 Demonstration Board for EMC2103:

- Board – Schematic – EMC2103-4
- Board – Schematic – Fan Drive
- Board – Schematic – Interface and Power
- Board – Schematic – Mechanical
- Board – Top Silk
- Board – Top Copper and Silk
- Board – Top Copper
- Board – Bottom Copper
- Board – Bottom Copper and Silk
- Board – Bottom Silk

A.2   BOARD – SCHEMATIC – EMC2103-4

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A.3   BOARD – SCHEMATIC – FAN DRIVE

+VFan

+3.3V

C17   25V
0.1 µF   0603

GND

+VFan

C18

10 µF
25V
1206

GND

R26
10k
0603
1%

PWM_FAN

PWM

PWM_DRV

J8

U7
MCP1401

2

V$_{DD}$

3   IN   OUT   5

GND

1   4

GND

R27
22R
0603
1%

1   2

Q2
DMP3099

3

L2
68 µH

V_DRV

PWM_FAN

TACH

J10

TERMINAL 1x4

D3
MBR230LSFT1G

C19
47 µF
25V
E

GND   GND   GND

Schematic and Layouts

A.4   BOARD – SCHEMATIC – INTERFACE AND POWER

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A.5   BOARD – SCHEMATIC – MECHANICAL

PAD1

RUBBER PAD D9.4 H4.8

PAD3

RUBBER PAD D9.4 H4.8

PAD4

RUBBER PAD D9.4 H4.8

PAD2

RUBBER PAD D9.4 H4.8

SCR1

Screw M3x16 mm Nylon

STANDOFF1

Standoff M3 Nylon 10 mm

NUT1

Nut M3 Nylon

SCR2

Screw M3x16 mm Nylon

STANDOFF2

Standoff M3 Nylon 10 mm

NUT2

Nut M3 Nylon

SCR3

Screw M3x16 mm Nylon

STANDOFF3

Standoff M3 Nylon 10 mm

NUT3

Nut M3 Nylon

SCR4

Screw M3x16 mm Nylon

STANDOFF4

Standoff M3 Nylon 10 mm

NUT4

Nut M3 Nylon

CBL1

USB Male-A to Male Micro-B

JP1   JP2   JP3   JP4

Shunt 2.54 mm 1x2 Handle

FAN1

FAN 40x10 mm 3-Wire

DPx   DNy

3   1
2   Q3   2   Q4
   2N3904TA   2N3904TA
1   MECH   3   MECH

DNx   DPy

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A.6   BOARD – TOP SILK
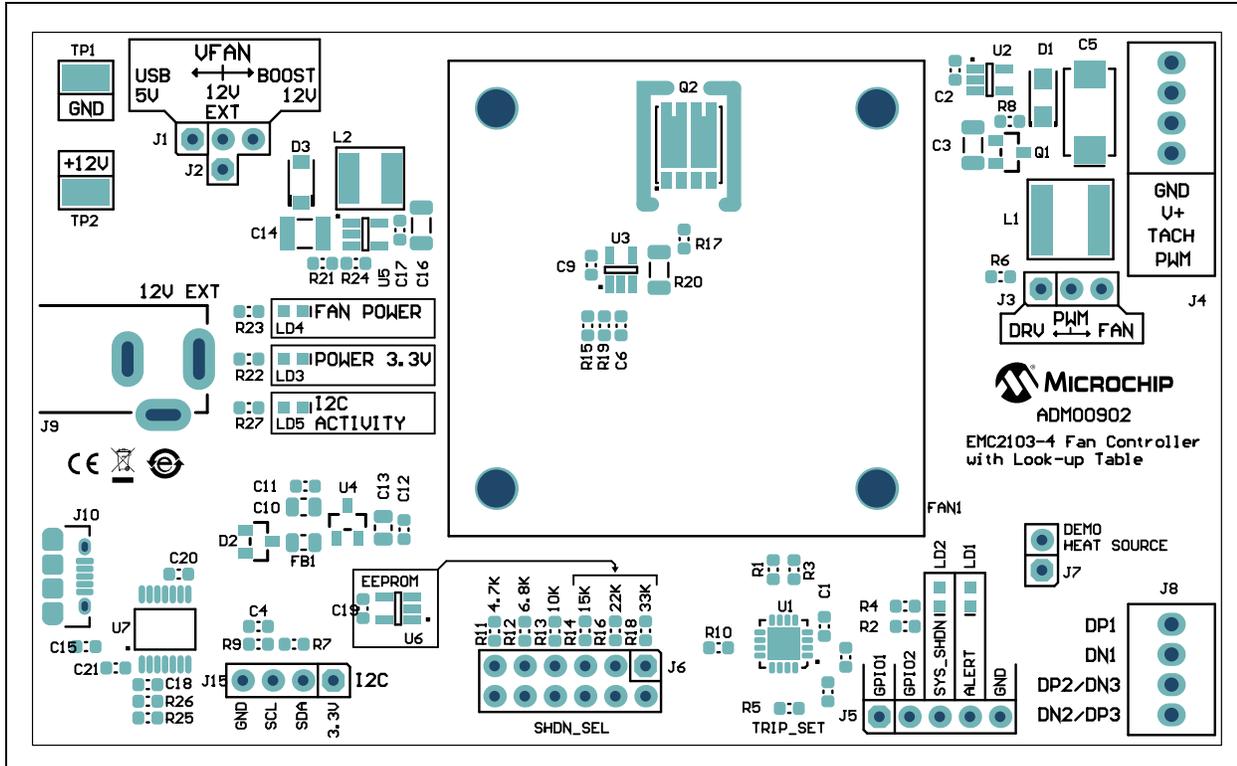
A.7   BOARD – TOP COPPER AND SILK

A.8   BOARD – TOP COPPER
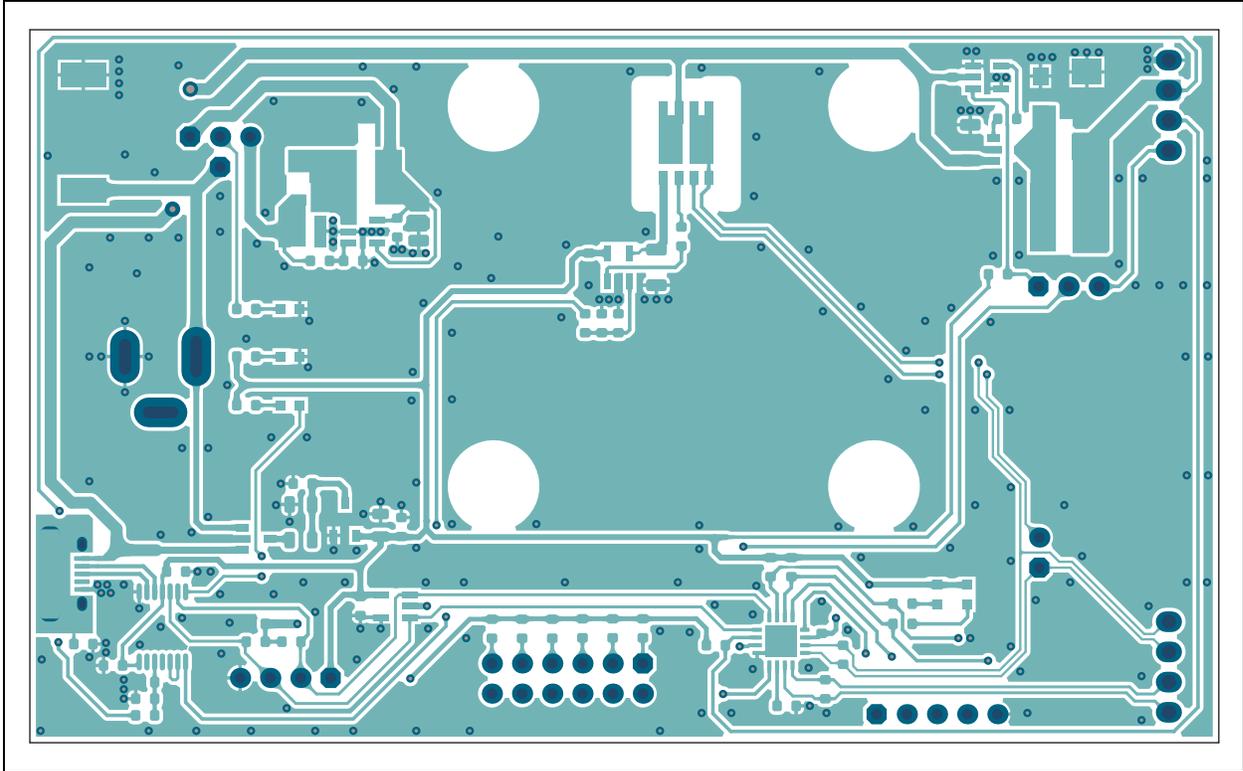
A.9   BOARD – BOTTOM COPPER

04-10801-R3
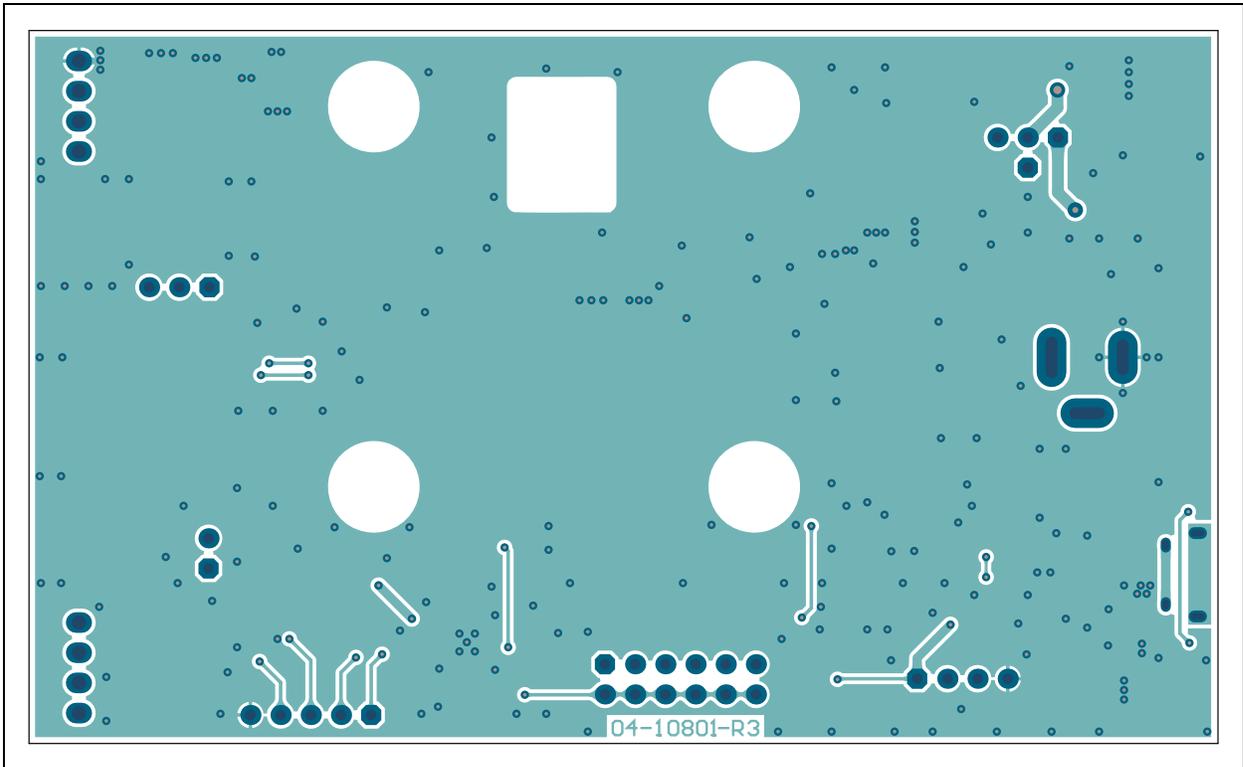
A.10   BOARD – BOTTOM COPPER AND SILK
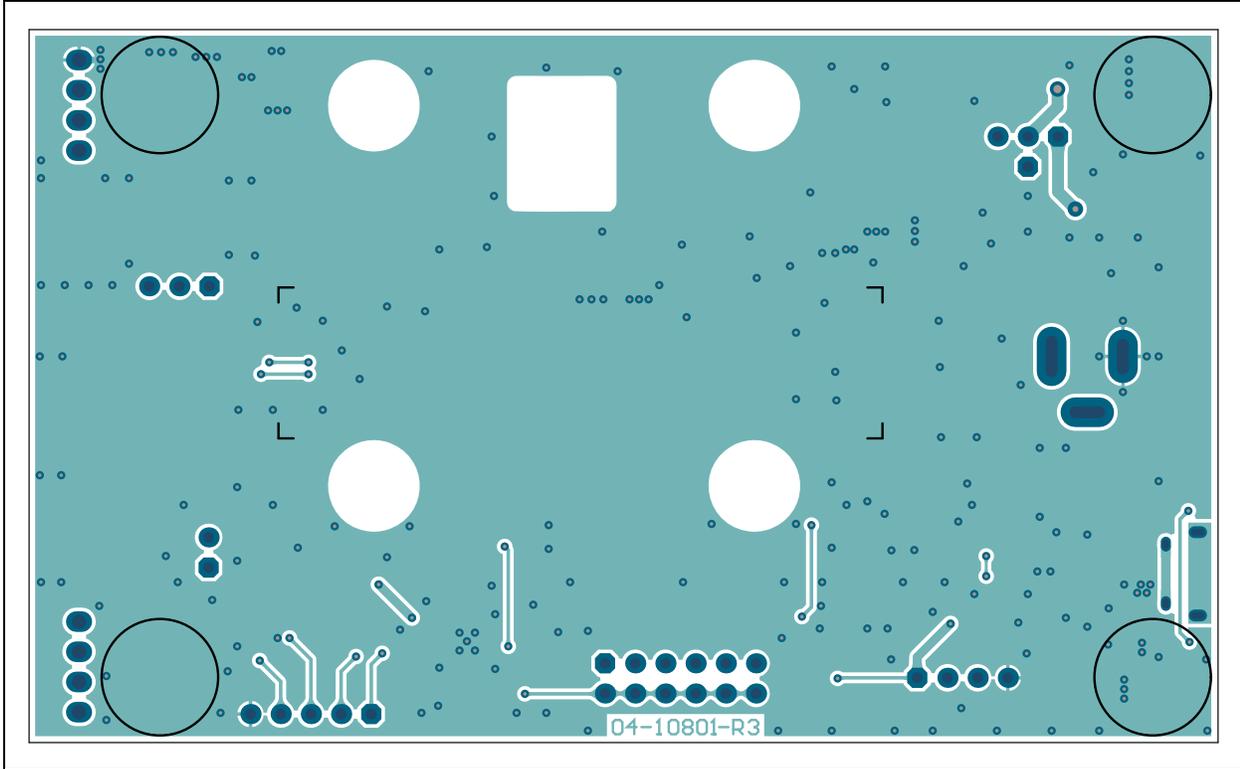
A.11   BOARD – BOTTOM SILK
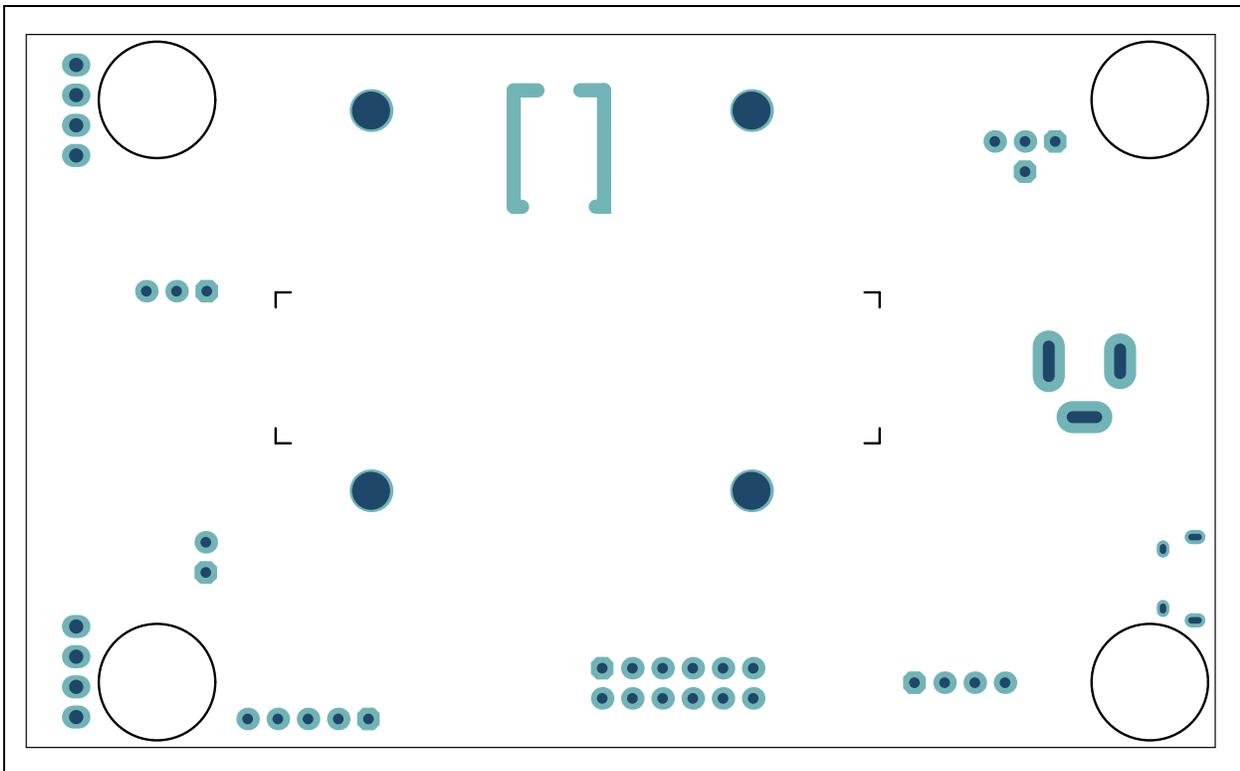
Appendix B. Bill of Materials (BOM)

B.1 ADM00902 DEMONSTRATION BOARD FOR EMC2103 – BILL OF MATERIALS (BOM)

TABLE B-1: ADM00902 DEMONSTRATION BOARD FOR EMC2103 – BILL OF MATERIALS (BOM)[1]

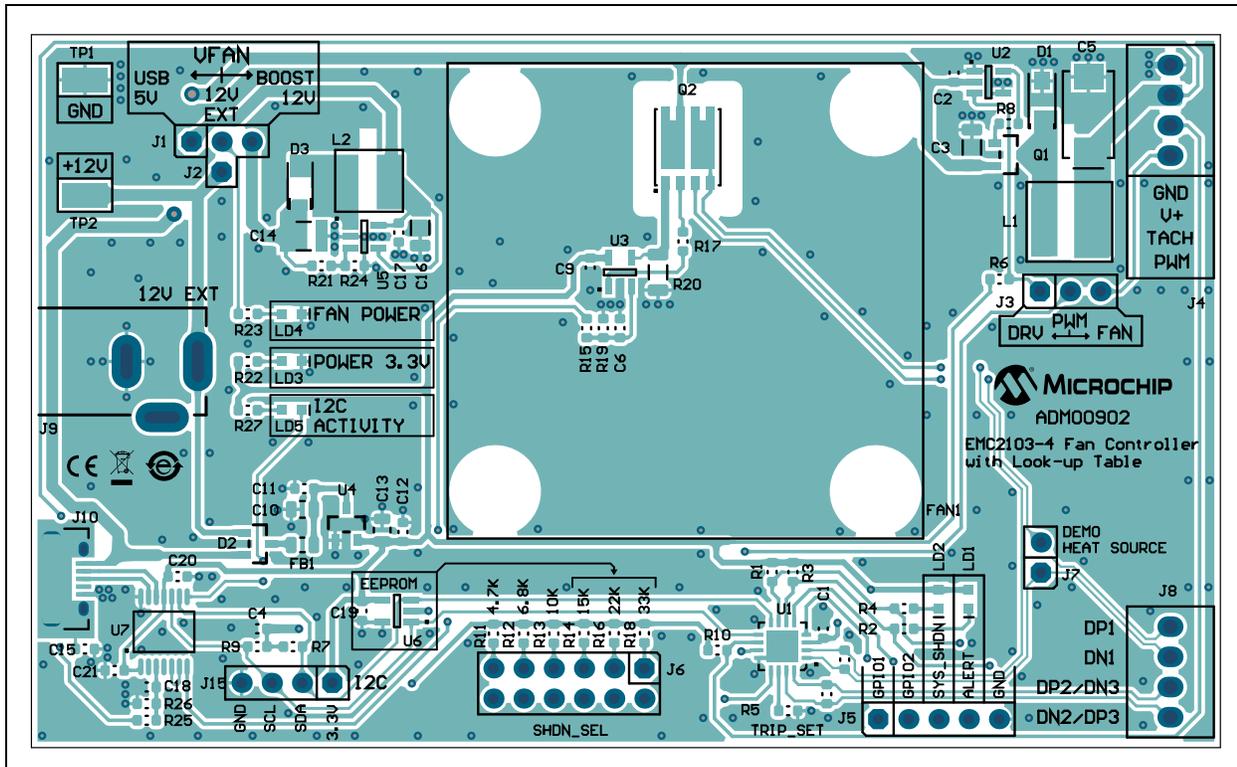| Qty.	Reference	Description	Manufacturer	Part Number
13	C1, C2, C3, C4, C5, C8, C9, C11, C12, C14, C15, C16, C17	Ceramic Capacitor, 0.1 µF, 25V, 10%, X7R, Surface Mount, 0603	Murata Electronics North America, Inc.	GRM188R71E104KA01D
1	C13	Ceramic Capacitor, 10 µF, 16V, 10%, X7R, Surface Mount, 1206	TDK Corporation	C3216X7R1C106K
1	C18	Ceramic Capacitor, 10 µF, 25V, 10%, X7R, Surface Mount, 1206	Murata Electronics North America, Inc.	GRM31CR71E106KA12L
1	C19	Tantalum Capacitor, 47 µF, 25V, 10%, 0.6R, Surface Mount, E	Vishay Sprague	293D476X9025E2TE3
2	C20, C21	Ceramic Capacitor, 2200 pF (2.2 nF), 50V, 10%, X7R, Surface Mount, 0603	KEMET	C0603C222K5RACTU
1	C6	Ceramic Capacitor, 10 µF, 25V, 10%, X7R, Surface Mount, 1210	TDK Corporation	C3225X7R1E106K250AC
2	C7, C10	Ceramic Capacitor, 4.7 µF, 10V, 10%, X5R, Surface Mount, 0805	Samsung Electro-Mechanics America, Inc.	CL21A475KPFNNNE
1	D1	Diode, Array, Schottky, BAT54C, 530 mV, 200 mA, 30V, SOT-23-3	Diodes Incorporated®	BAT54CTA
1	D2	Diode, Schottky, MBR0540T1G, 510 mV, 500 mA, 40V, Surface Mount, SOD-123	ON Semiconductor®	MBR0540T1G
1	D3	Diode, Schottky, MBR230LSFT1G, 430 mV, 2A, 30V, Surface Mount, SOD-123FL	ON Semiconductor	MBR230LSFT1G
1	FB1	Ferrite Bead, 2A, 220R, Surface Mount, 0805	Murata Electronics North America, Inc.	BLM21PG221SN1D
1	J1	Connector, USB 2.0, Micro-B, Female, Surface Mount, Right Angle, Through-Hole	FCI	10118194-0001LF
2	J10, J11	Terminal Connector, 2.54 mm, 1x4, Female, 20-30AWG, 6A, Right Angle, Through-Hole	On-Shore Technology, Inc.	OSTVN04A150
1	J2	Power Connector, 2.1 mm, 5.5 mm, Switch Slotted, Right Angle, Through-Hole	MPD – Memory Protection Devices, Inc.	EJ508A
1	J3	Connector, Header-2.54, Male, 1x3, Tin, 5.84 MH, Through-Hole, Vertical	Samtec, Inc.	TSW-103-07-T-S

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.

TABLE B-1: **ADM00902 DEMONSTRATION BOARD FOR EMC2103 – BILL OF MATERIALS (BOM)[1] (CONTINUED)**

Qty.	Reference	Description	Manufacturer	Part Number
1	J4	Connector Header-2.54, Male, 1x1, Gold, 5.84 MH, Through-Hole, Vertical	Samtec, Inc.	TSW-101-07-S-S
1	J5	Connector Header-2.54, Male, 1x4, Gold, 5.84 MH, Through-Hole, Vertical	Wurth Elektronik	61300411121
1	J6	Connector Header-2.54, Male, 2x6, Tin, 5.84 MH, Through-Hole, Vertical	Samtec, Inc.	TSW-106-05-T-D
1	J7	Connector Header-2.54, Male, 1x5, Gold, 5.84 MH, Through-Hole, Vertical	FCI	68000-105HLF
1	J8	Connector Header-2.54, Male, 1x3, Gold, 5.84 MH, Through-Hole, Vertical	FCI	68000-103HLF
1	J9	Connector Header-2.54, Male, 1x2, Gold, 5.84 MH, Through-Hole, Vertical	FCI	77311-118-02LF
1	L1	Fixed Inductors, 4.7 μH, 20%, Surface Mount, 5040	Bourns®, Inc.	SRN5040-4R7M
1	L2	Inductor, 68 μH, 0.95A, 20%, Surface Mount, L6W6H4.5	Taiyo Yuden Co., Ltd.	NRS6045T680MMGK
3	LD1, LD2, LD3	Diode, LED, Green, 3.2V, 20 mA, 430 mcd, Clear, Surface Mount, 0603	Wurth Elektronik	150060GS75000
2	LD4, LD5	Diode, LED, Red, 2V, 20 mA, 250 mcd, Clear, Surface Mount, 0603	Wurth Elektronik	150060RS75000
1	PCB1	ADM00902 Demonstration Board for EMC2103 – Printed Circuit Board	Microchip Technology Inc.	**04-10801-R3**
1	Q1	Transistor, Bipolar (BJT), Dual NPN+NPN, PHPT610030NKX, 100V, 3A, 1.25W, LFPAK56D-8	Nexperia	PHPT610030NKX
1	Q2	Transistor, P-Channel, DMP3099L-7, -30V, -3.8A, 1.08W, SOT-23-3	Diodes Incorporated®	DMP3099L-7
1	R1	Resistor, Thin Film, 100 kΩ, 1%, 1/8W, Surface Mount, 0603	Vishay Beyschlang	MCT06030C1003FP500
1	R13	Resistor, Thick Film, 115 kΩ, 1%, 1/10W, Surface Mount, 0603	Stackpole Electronics, Inc.	RMCF0603FT15K0
1	R14	Resistor, Thick Film, 100 kΩ, 1%, 1/10W, Surface Mount, 0603	TE Connectivity, Ltd.	1622827-1
1	R15	Resistor, Thick Film, 2.2 kΩ, 1%, 1/10W, Surface Mount, 0603	Panasonic® - ECG	ERJ-3EKF2201V
1	R16	Resistor, Thick Film, 22 kΩ, 1%, 1/8W, Surface Mount, 0603	Multicomp Inc.	MCHP03W8F2202T5E
1	R17	Resistor, Thick Film, 33 kΩ, 1%, 1/10W, Surface Mount, 0603	Panasonic - ECG	ERJ-3EKF3302V
1	R18	Resistor, Thick Film, 1R, 1%, 1/4W, Surface Mount, 1206	ROHM Semiconductor	MCR18EZHFL1R00
1	R19	Resistor, Thick Film, 100R, 1%, 1/10W, Surface Mount, 0603	Panasonic - ECG	ERJ-3EKF1000V
1	R2	Resistor, Thin Film, 10 kΩ, 1%, 1/16W, Surface Mount, 0603	TE Connectivity, Ltd.	5-1879337-9
1	R22	**NOT POPULATED**	Yageo Corporation	9T06031A7871FBHFT
1	R27	Resistor, Thick Film, 22R, 1%, 1/10W, Surface Mount, 0603	Panasonic - ECG	ERJ-3EKF22R0V

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.

TABLE B-1: ADM00902 DEMONSTRATION BOARD FOR EMC2103 –
BILL OF MATERIALS (BOM)[1] (CONTINUED)

Qty.	Reference	Description	Manufacturer	Part Number
1	R3	Resistor, Thick Film, 30 kΩ, 1%, 1/10W, Surface Mount, 0603	Stackpole Electronics, Inc.	RMCF0603FT30K0
6	R4, R12, R20, R21, R23, R26	Resistor, Thick Film, 10 kΩ, 1%, 1/10W, Surface Mount, 0603	Panasonic® - ECG	ERJ-3EKF1002V
4	R5, R11, R24, R25	Resistor, Thick Film, 6.8 kΩ, 1%, 1/10W, Surface Mount, 0603	Panasonic - ECG	ERJ-3EKF6801V
3	R6, R7, R10	Resistor, Thick Film, 4.7 kΩ, 1%, 1/10W, Surface Mount, 0603	Vishay/Dale	CRCW06034K70FKEA
1	R8	Resistor, Thick Film, 1.05M, 1%, 1/10W, Surface Mount, 0603	Vishay/Dale	CRCW06031M05FKEA
1	R9	Resistor, Thick Film, 120 kΩ, 1%, 1/10W, Surface Mount, 0603	Panasonic - ECG	ERJ-3EKF1203V
2	TP1, TP2	Connector, Test Point, TAB, Silver, Mini, 3.8x2.03, Surface Mount	Keystone Electronics Corp.	5019
1	U1	MCHP Interface, USB, I^{2}C, UART, MCP2221A-I/ST, TSSOP-14	Microchip Technology Inc.	**MCP2221A-I/ST**
1	U2	MCHP Analog, LDO, 3.3V, MCP1703AT-5002E/CB, SOT-23A-3	Microchip Technology Inc.	**MCP1703AT-3302E/CB**
1	U3	MCHP Analog Switcher Boost, 32V, MCP1663T-E/OT, SOT-23-5	Microchip Technology Inc.	**MCP1663T-E/OT**
1	U4	MCHP Memory Serial EEPROM, 2k, I^{2}C, 24LC02BT-E/OT, SOT-23-5	Microchip Technology Inc.	**24LC02BT-E/OT**
1	U5	MCHP Analog Op Amp, 1-Ch, 1 MHz, MCP6001T-I/OT, SOT-23-5	Microchip Technology Inc.	**MCP6001T-I/OT**
1	U6	MCHP Analog Fan Controller, 3-Channel, EMC2103-4-AP-TR, QFN-16	Microchip Technology Inc.	**EMC2103-4-AP-TR**
1	U7	MCHP Analog FET Driver, Single Inverting, MCP1401T-E/OT, SOT-23-5	Microchip Technology Inc.	**MCP1401T-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.

TABLE B-2: BILL OF MATERIALS – MECHANICAL PARTS[1]

Qty.	Reference	Description	Manufacturer	Part Number
1	CBL1	Mechanical Headers & Wires Cable, USB Male-A to Male Micro-B, Clear, 4	DongGuan ZhanXin	A006ZX027
1	FAN1	Mechanical Headers & Wires Fan, 12V, DC, 40x10 mm, 8500 RPM, TACH, 3-Wire	Sunon® Fans	MF40101VX-1000U-G99
4	JP1, JP2, JP3, JP4	Mechanical Headers & Wires Jumper, 2.54 mm, 1x2, w/Handle	TE Connectivity, Ltd.	880584-4
4	NUT1, NUT2, NUT3, NUT4	Mechanical Headers & Wires Nut, M3, Nylon	Keystone Electronics Corp.	4688
4	PAD1, PAD2, PAD3, PAD4	Mechanical Headers & Wires Rubber Pad, Cylindrical, D9.4, H4.8, Clear	Multicomp Inc.	2565
2	Q3, Q4	Transistor, BJT, NPN, 2N3904TA, 40V, 0.2A, 0.625W, TO-92-3	Fairchild Semiconductor®	2N3904TA
4	SCR1, SCR2, SCR3, SCR4	Mechanical Headers & Wires Screw, M3x16 mm, Pan, Slotted, Nylon	Keystone Electronics Corp.	29346
4	STANDOFF1, STANDOFF2, STANDOFF3, STANDOFF4	Mechanical Headers & Wires Stand-off, M3x10 mm, M/F, HEX, Nylon	Essentra Components	NTS-10

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.

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