



**MTD6505**  
**3-Phase BLDC**  
**Sensorless Fan Controller**  
**Demonstration Board**  
**User's Guide**

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# MTD6505 3-PHASE BLDC SENSORLESS FAN CONTROLLER DEMO BOARD USER'S GUIDE

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# MTD6505 3-PHASE BLDC SENSORLESS FAN CONTROLLER DEMO BOARD USER'S GUIDE

## 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 web site ([www.microchip.com](http://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 “DSXXXXA”, where “XXXX” 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 MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board. Items discussed in this chapter include:

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

## DOCUMENT LAYOUT

This document describes how to use the MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration 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 MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board.
- **Chapter 2. “Installation and Operation”** – Includes instructions on how to get started with MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board.
- **Appendix A. “Schematics and Layouts”** – Shows the schematic and layout diagrams for the MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board.
- **Appendix B. “Bill of Materials”** – Lists the parts used to build the MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board.

## CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

### DOCUMENTATION CONVENTIONS

Description	Represents	Examples
<b>Arial font:</b>		
Italic characters	Referenced books	<i>MPLAB<sup>®</sup> IDE User's Guide</i>
	Emphasized text	...is the <i>only</i> 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	<u><i>File&gt;Save</i></u>
Bold characters	A dialog button	Click <b>OK</b>
	A tab	Click the <b>Power</b> 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>
<b>Courier New font:</b>		
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	<i>file.o</i> , where <i>file</i> can be any valid filename
Square brackets [ ]	Optional arguments	mcc18 [options] <i>file</i> [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 MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board. Other useful documents are listed below. The following Microchip documents are available and recommended as supplemental reference resources.

- **MTD6505 Data Sheet**, “3-Phase BLDC Sinusoidal Sensorless Fan Motor Drive” (DS22281)

## THE MICROCHIP WEB SITE

Microchip provides online support via our web site at [www.microchip.com](http://www.microchip.com). This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site 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
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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 web site at: <http://www.microchip.com/support>.

## DOCUMENT REVISION HISTORY

### Revision A (December 2011)

- Initial Release of this Document.

NOTES:

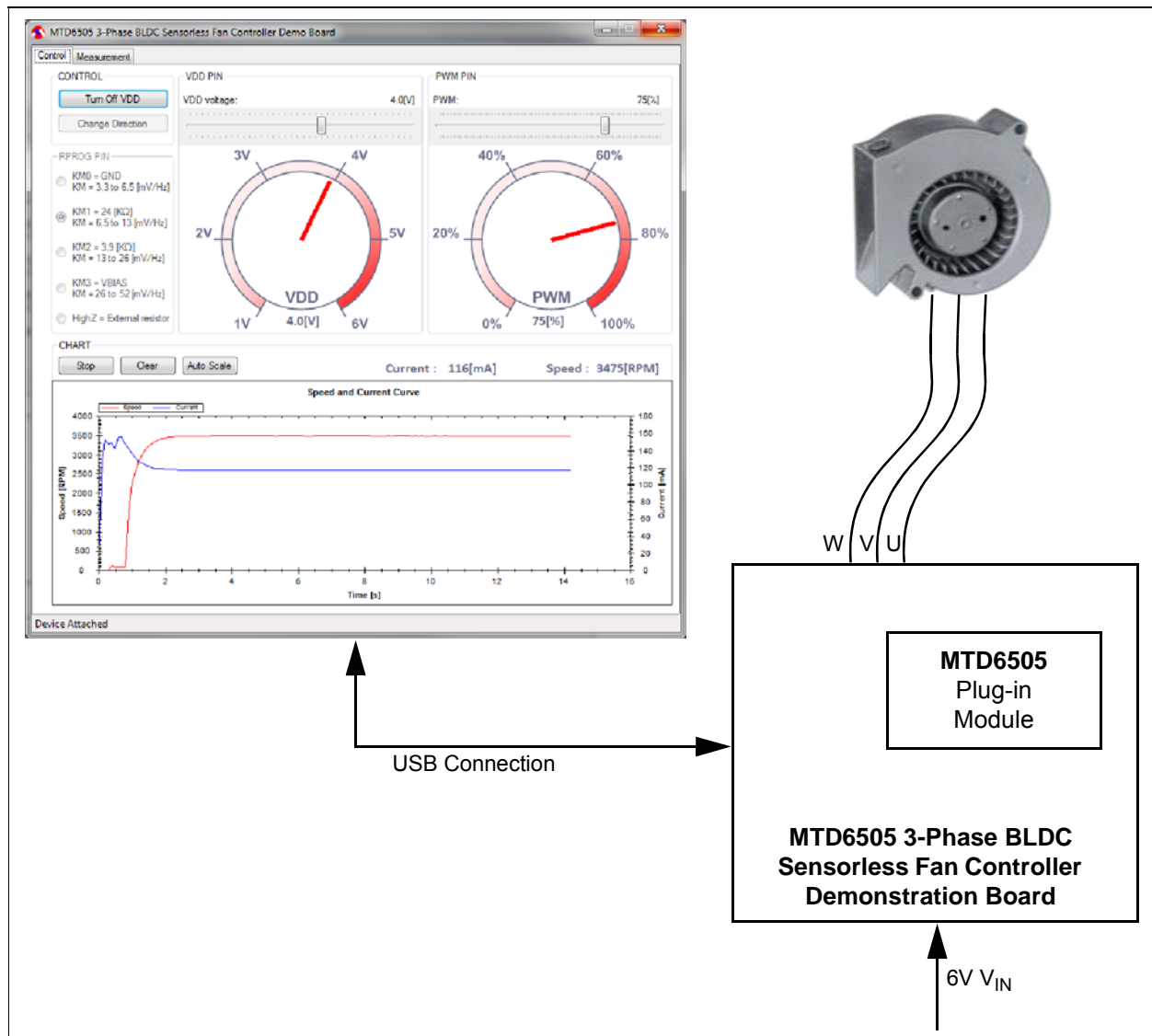


## Chapter 1. Product Overview

### 1.1 INTRODUCTION

The MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board allows the control and monitoring of the MTD6505 device, using a PC software connected to the MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board via a USB connection.

The MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board Software provides several features, such as  $V_{DD}$  control and monitoring, pulse-width modulation (PWM) control, speed and current consumption monitoring. It also allows controlling the  $R_{PROG}$  resistor value for fan fitting.



**FIGURE 1-1:** System Overview.

### 1.2 MTD6505 3-PHASE BLDC SENSORLESS FAN CONTROLLER DEMONSTRATION BOARD HARDWARE DESCRIPTION

The MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board contains several components, such as:

- A microcontroller (PIC24FJ256GB) for USB connection, PWM generation, FG frequency measurement,  $V_{DD}$  measurement, other's signal's activations and component's communication.
- An adjustable LDO (MCP1827) combined to a digital potentiometer (MCP42050) to provide the  $V_{DD}$  to the MTD6505 device. The LDO can be enabled or disabled by the microcontroller.
- The digital potentiometer is also used to set the MTD6505  $R_{PROG}$  external resistor value.
- A Delta-Sigma (MCP3421) combined to a shunt resistor for sensing the MTD6505 current consumption on the  $V_{DD}$  pin.

More details of the schematic are available in [Appendix A. "Schematics and Layouts"](#).

### 1.3 WHAT THE MTD6505 3-PHASE BLDC SENSORLESS FAN CONTROLLER DEMONSTRATION BOARD KIT INCLUDES

The MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board includes:

- MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board (ADM00345)
- 3 x MTD6505 plug-in modules with soldered on MTD6505 (3x3 UDFN-10L)
- A mini-USB cable
- A 3-Phase BLDC fan (use with  $K_M=1$ )
- Important Information Sheet

## Chapter 2. Installation and Operation

### 2.1 GETTING STARTED

The following sections describe how to use the MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board.

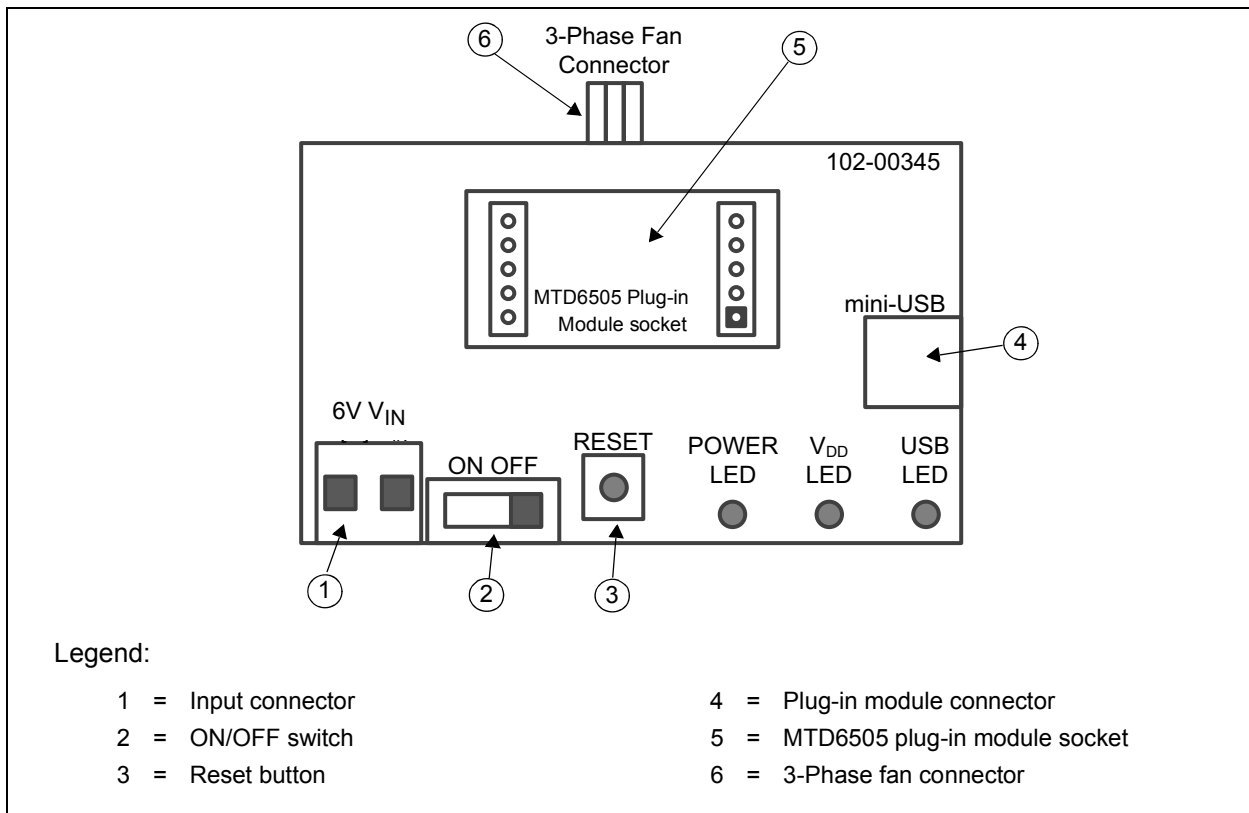
#### 2.1.1 Software Installation

Download the MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board software installer from the Microchip web site at <http://www.microchip.com>. From the web site, search for the evaluation board by part number ADM00345. The GUI can be downloaded from this web page.

**Note:** This application requires Microsoft .NET Framework 2.0 or later.

#### 2.1.2 Board installation

Figure 2-1 identifies the required points for using the MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board.



**FIGURE 2-1:** Top View - Hardware Components.

To use the MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board, follow the next steps:

1. Plug in the MTD6505 plug-in module (with an MTD6505 soldered on it) on its socket (see [Figure 2-1](#)).
2. To plug in a 3-Phase BLDC sensorless fan, choose one of these connections:
  - 3-Phase fan connector from the MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board (J5)
  - On the MTD6505 plug-in module fan connector.
3. Connect the Power Supply to the  $V_{IN}$  test point.  $V_{IN}$  value is +6V  $\pm$ 5%. The Power Supply should be able to deliver up to 1.0A.
4. Turn on the power switch. The POWER LED should be activated.
5. Plug the mini-USB cable from the USB port of a computer to the MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board connector.
6. If required, let the computer identify the MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board.
7. Restart the computer, if required.
8. Start the MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board Software.

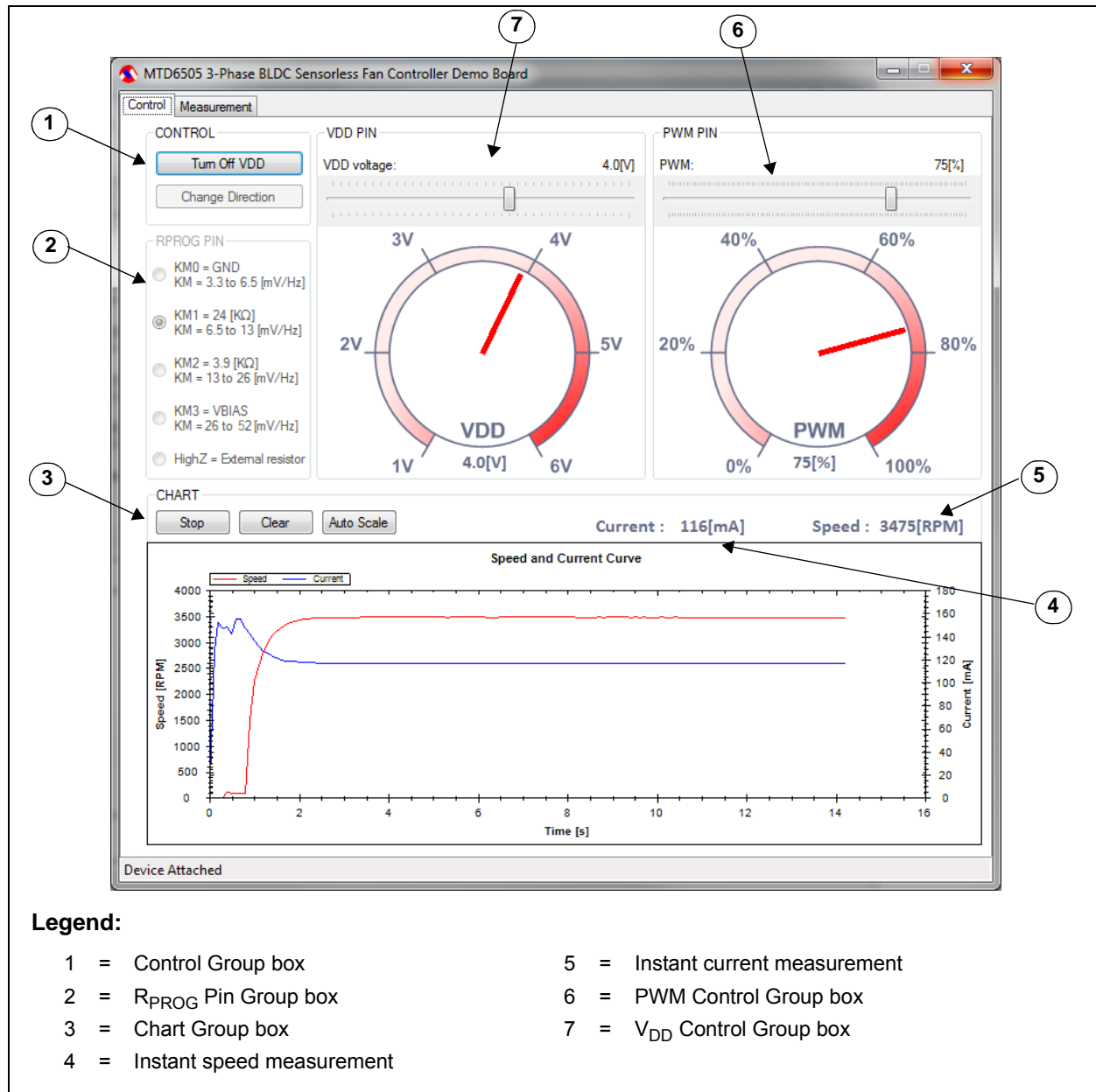
**Note:** Once the MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board Software is installed, it will automatically detect if the MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board is attached and its configuration. This means it is possible to start the MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board Software before or after enabling the board.

## 2.2 MTD6505 3-PHASE BLDC SENSORLESS FAN CONTROLLER DEMONSTRATION BOARD SOFTWARE DESCRIPTION

The MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board Software window contains two tabs. The first tab is for controlling and monitoring the MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board; the second tab is the Measurement tab.

### 2.2.1 Controlling and Monitoring Tab

Figure 2-2 shows the options and functions available to control and monitor the board.



**FIGURE 2-2:** GUI - Controlling and Monitoring Tab.

All functions presented in Figure 2-2 are enabled only when the MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board is connected to the PC via a USB connection.

### 2.2.1.1 CONTROL/MONITORING

The Control/Monitoring Group box contains two buttons:

- **Turn On/Off VDD** button enables/disables the power supply on the  $V_{DD}$  pin of the MTD6505 device.
- **Change Direction** is used to inverse the sense of the fan rotation. The **Change Direction** button is available only when  $V_{DD}$  is turned off.

### 2.2.1.2 $R_{PROG}$ PIN

The  $R_{PROG}$  Pin Group box allows the selection of the desired  $R_{PROG}$  resistor value. This value depends on the  $K_M$  (mV/Hz) of the fan. See the section [Section 2.3 “How to define the correct  \$R\_{PROG}\$  Value”](#) for more information on the  $R_{PROG}$  selection.

One particular mode, HighZ, allows the setting of an external  $R_{PROG}$  resistor value directly on the plug-in module.

In order to use the MTD6502B with the MTD6505 3-Phase BLDC Sensorless Fan Controller Demo Board, use  $K_M = 0$ .

### 2.2.1.3 CHART

This part of the GUI displays a chart of the MTD6505 current consumption (mA) on the  $V_{DD}$  pin, and the fan speed (Revolutions Per Minute - RPM) by measuring the FG frequency. The chart adds 10 values per second. The three buttons have the following functions:

- **Start/Stop** – allows the values acquisition to start or stop
- **Clear** – removes all the values added to the chart
- **Auto Scale** – allows the restoration of the default scaling. In the default scaling mode, the chart will automatically adjust the scaling to ensure the complete view of the whole added values. In addition, when selecting a part of the chart with the mouse, it is possible to zoom in the selection. The mouse wheel zoom in/out is also enabled.

### 2.2.1.4 PWM PIN

The PWM Group box provides a slide bar to set the PWM ratio on the MTD6505 PWM pin. The gauge below indicates the current PWM applied.

### 2.2.1.5 $V_{DD}$ PIN

The  $V_{DD}$  Group box also provides a slide bar to set the desired  $V_{DD}$  value. The gauge below indicates the instant  $V_{DD}$  value measured by the MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board.

### 2.2.1.6 CURRENT/SPEED FIELDS

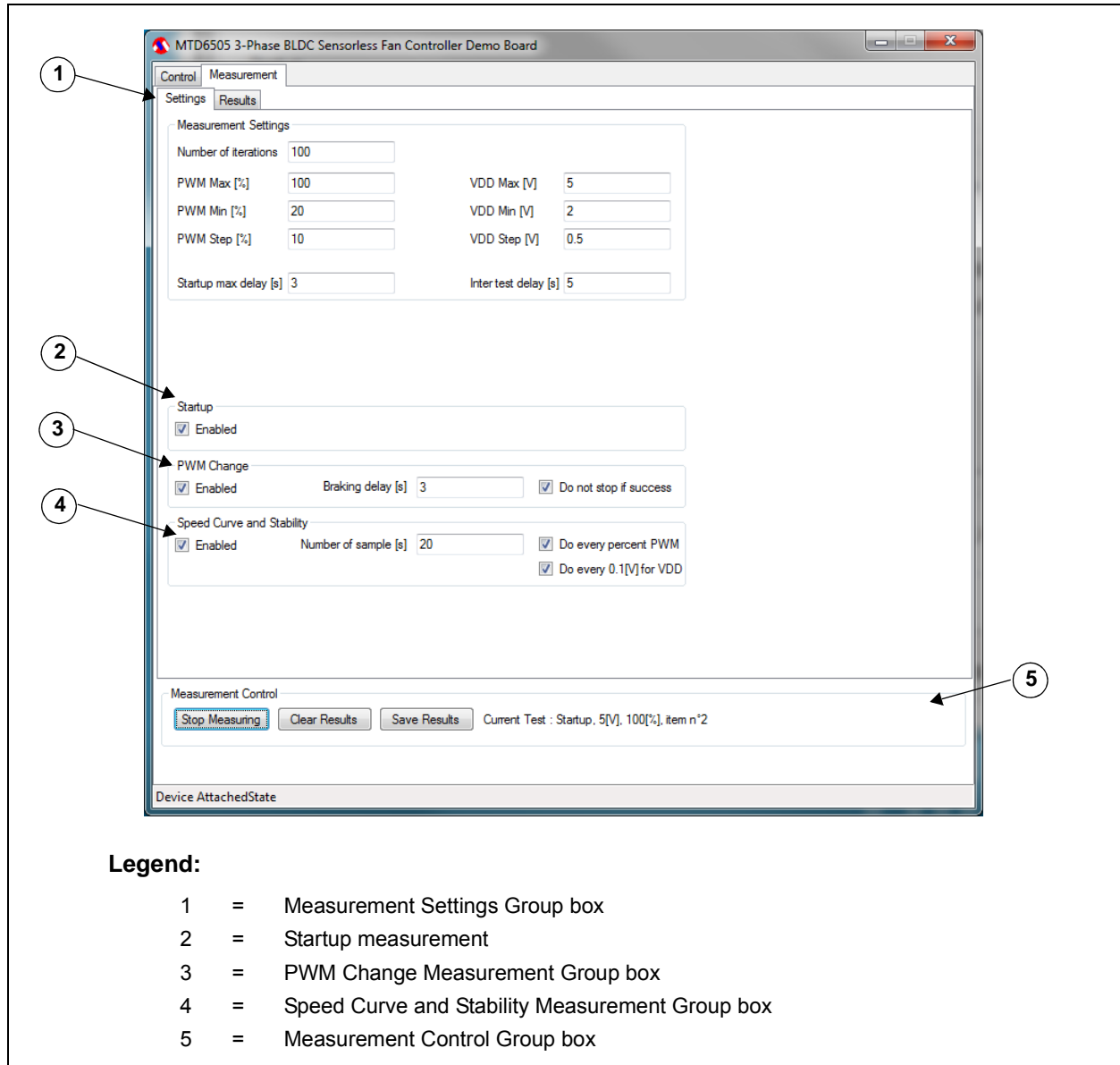
Current field shows the instant current measure (mA). Speed field shows the instant speed measure (RPM).

## 2.2.2 Measurement Tab

The **Measurement** tab is used to check if the fan is correctly adapted to the MTD6505 by testing the fan several times in different conditions. This tab contains two more tabs, for settings and results.

### 2.2.2.1 SETTINGS TAB

Figure 2-3 shows the **Setting** tab.



**FIGURE 2-3:** GUI - Measurement tab – Settings.

### 2.2.2.1.1 Measurement Settings

The **Measurement Settings** Group box is used to specify the measurement corners required:

- **Number of iterations** – for one corner
- **PWM Corners Measurement** – requires the PWM Max (%), PWM Step (%) and PWM Min (%) values setting. The software will start with the maximum value entered, and will decrease the PWM by the step value until reaches the minimum entered PWM value.
- **V<sub>DD</sub> corners** are similar to the PWM corners. A V<sub>DD</sub> corner includes all PWM corners. This means that for one V<sub>DD</sub> corner, all PWM corners are measured.
- **Startup max delay** – if the speed of the fan is measured as 0 RPM after this delay, the startup is considered a fail. The recommended value for this field is 3s.
- **Inter test delay** – specifies how many seconds are allocated to stop the fan between two tests. This value will depend on the fan lag.

### 2.2.2.1.2 Startup

When the **Startup** box is checked, the startup measurements are enabled, measuring every corner for this test. If **Startup** is not enabled, the Startup test is skipped. The other tests will be executed if they are enabled.

### 2.2.2.1.3 PWM Change

The PWM Change Measurement starts up with a PWM value of 100%. After the specified startup delay (entered in the Startup max delay field), the PWM changes depending on the PWM corner specified. The software will then verify if the fan is still running. This last check will occur after a delay value is specified in the **Braking Delay (s)** field.

### 2.2.2.1.4 Speed Curve and Stability

This measurement requires a specified number of samples in a specified condition to check speed stability. If the **Do every percent PWM** and/or **Do every 0.1(V) for V<sub>DD</sub>** are not checked, the corners are measured. For this test, the iterations numbering will always be 1. When the **Do every percent PWM** option is enabled, the software will override the specified settings, and the measurement will occur for every PWM; the same procedure will happen for V<sub>DD</sub>, if the check box **Do every 0.1[V] for V<sub>DD</sub>** is checked.

### 2.2.2.1.5 Measurement Control

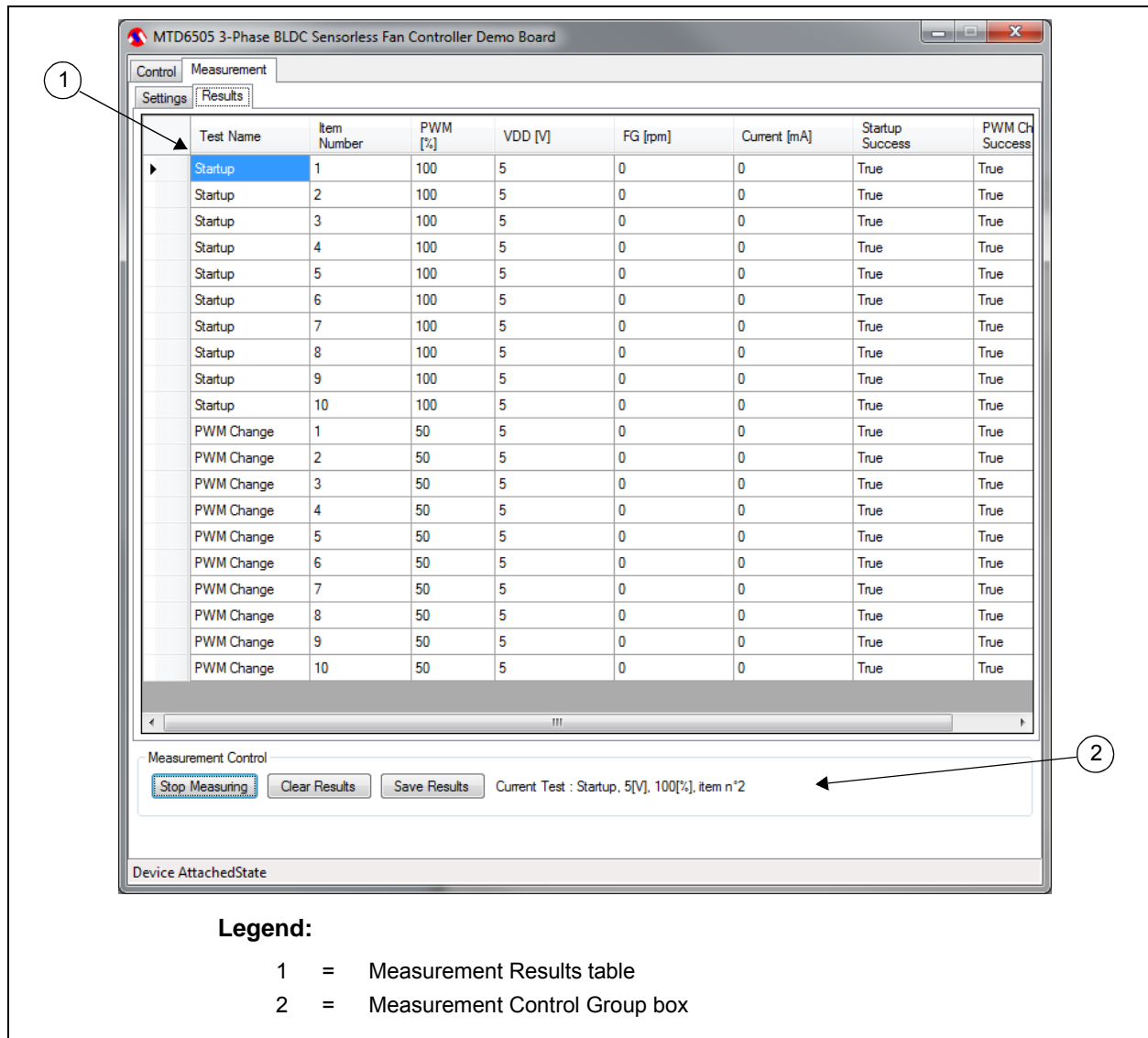
This group box contains three buttons that allows the user to control the work flow:

- **Stop Measuring** – starts and stops the required measuring
- **Clear Result** – clears the current result from the screen
- **Save Results** – stores the current measurement in an Excel file



## 2.2.2.2 MEASUREMENT RESULTS TAB

Figure 2-4 shows the Measurement Results sub-tab:



**FIGURE 2-4:** GUI - Measurement – Results Tab.

The results are stored in this table. All the tests have the first six columns in common, with the other columns being significant only for a specific test. Settings' control buttons are also visible in this tab (see description in [Section 2.2.2.1.5 “Measurement Control”](#)).

## 2.3 HOW TO DEFINE THE CORRECT $R_{\text{PROG}}$ VALUE

This section explains how to define the correct  $K_M$  value for a specific fan. The  $K_M$  is linked to the  $R_{\text{PROG}}$  (see [Table 2-1](#)). An incorrect  $K_M$  selection can create issues, or reduce the efficiency.

### 2.3.1 Operation

Follow the next steps to define the right  $R_{\text{PROG}}$  value:

1. Apply a constant stream of air to a fan that is not connected.
2. Using an oscilloscope, measure the waveform between two phases, when the fan is rotating.
3. Measure the generated peak-to-peak voltage ( $V_{p-p}$ ) value and the frequency ( $f$ ).
4. Compute  $K_M$  based on the measured  $V_{p-p}$  and  $f$  (in mV/Hz):

#### EQUATION 2-1: $K_M$ COMPUTE

$$K_m = \frac{V_{p-p}}{2f}$$

$K_M$  should be constant, for all fan rotation speeds, but for the  $K_M$  measurement, the fan rotation speed due to the air stream, should be close to the nominal fan rotation speed.

[Table 2-1](#) shows the corresponding  $K_M$  for different  $R_{\text{PROG}}$  values.

TABLE 2-1:  $R_{\text{PROG}}$  VALUE

$R_{\text{PROG}}$	$K_M$	$K_M$ Range (mV/Hz)
$V_{\text{BIAS}}$ ( $0\Omega$ )	3	26 - 52
3.9 k $\Omega$	2	13 - 26
24 k $\Omega$	1	6.5 - 13
GND	0	3.25 - 6.5



# MTD6505 3-PHASE BLDC SENSORLESS FAN CONTROLLER DEMO BOARD USER'S GUIDE

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## Appendix A. Schematics and Layouts

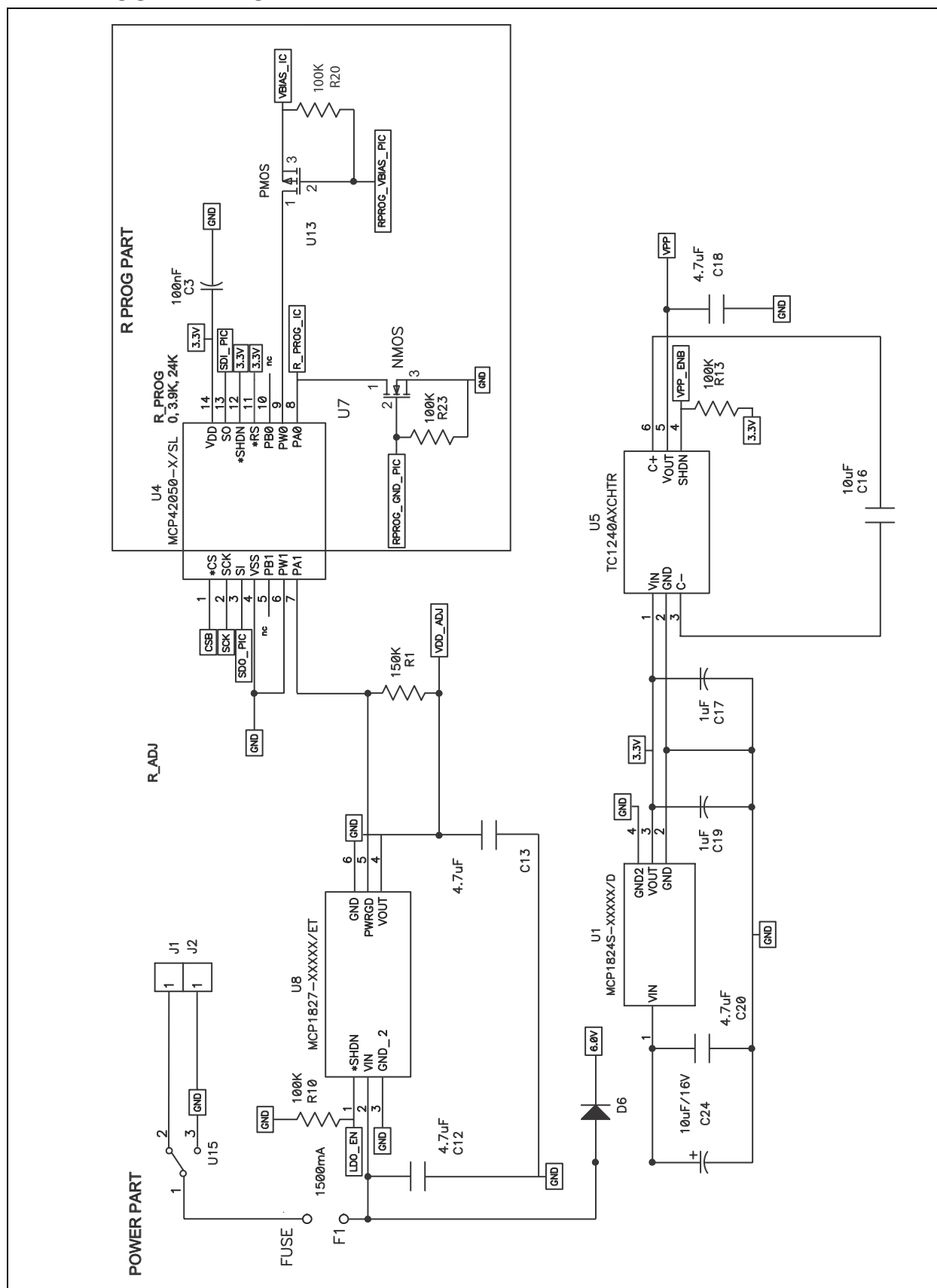
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### A.1 INTRODUCTION

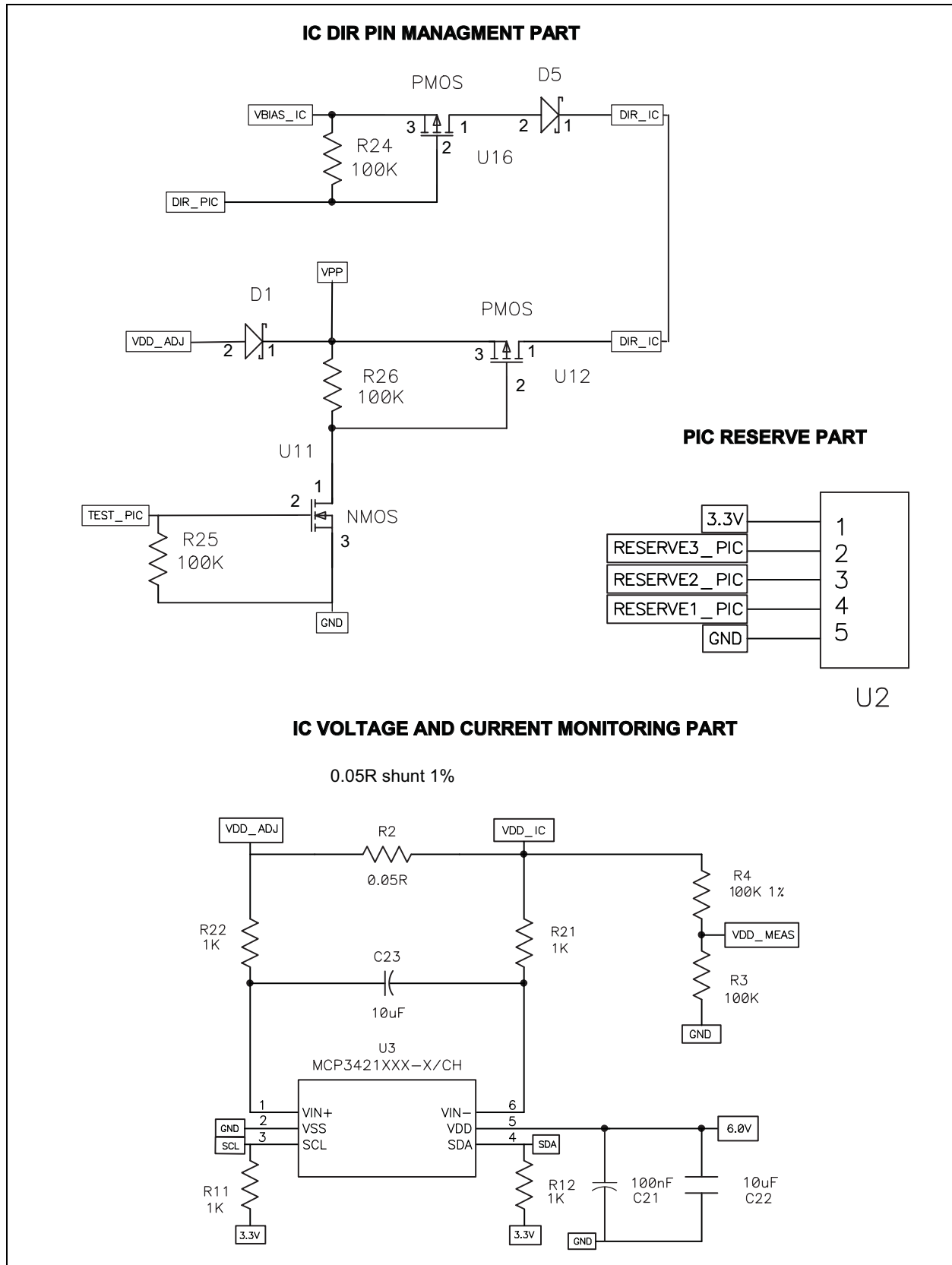
This appendix contains the following schematics and layouts for the MTD6505 3-Phase BLDC Sensorless Fan Controller Demonstration Board:

- Board - Schematic: Power Management Part and Resistor for Programming Part
- Board – Schematic: Direction Pin Management Part, PIC Reserves Part and MTD6505 Voltage and Current Monitoring Part
- Board – Schematic: PIC24FJ256GB106 Part
- Board – Schematic: IC Part/MTD6505 Plug-in Module Socket Part, USB Connection Part, LED Part and Reset Switch Part
- Board – Top Silk and Pads
- Board – Top Trace and Pads
- Board – Bottom Trace and Pads

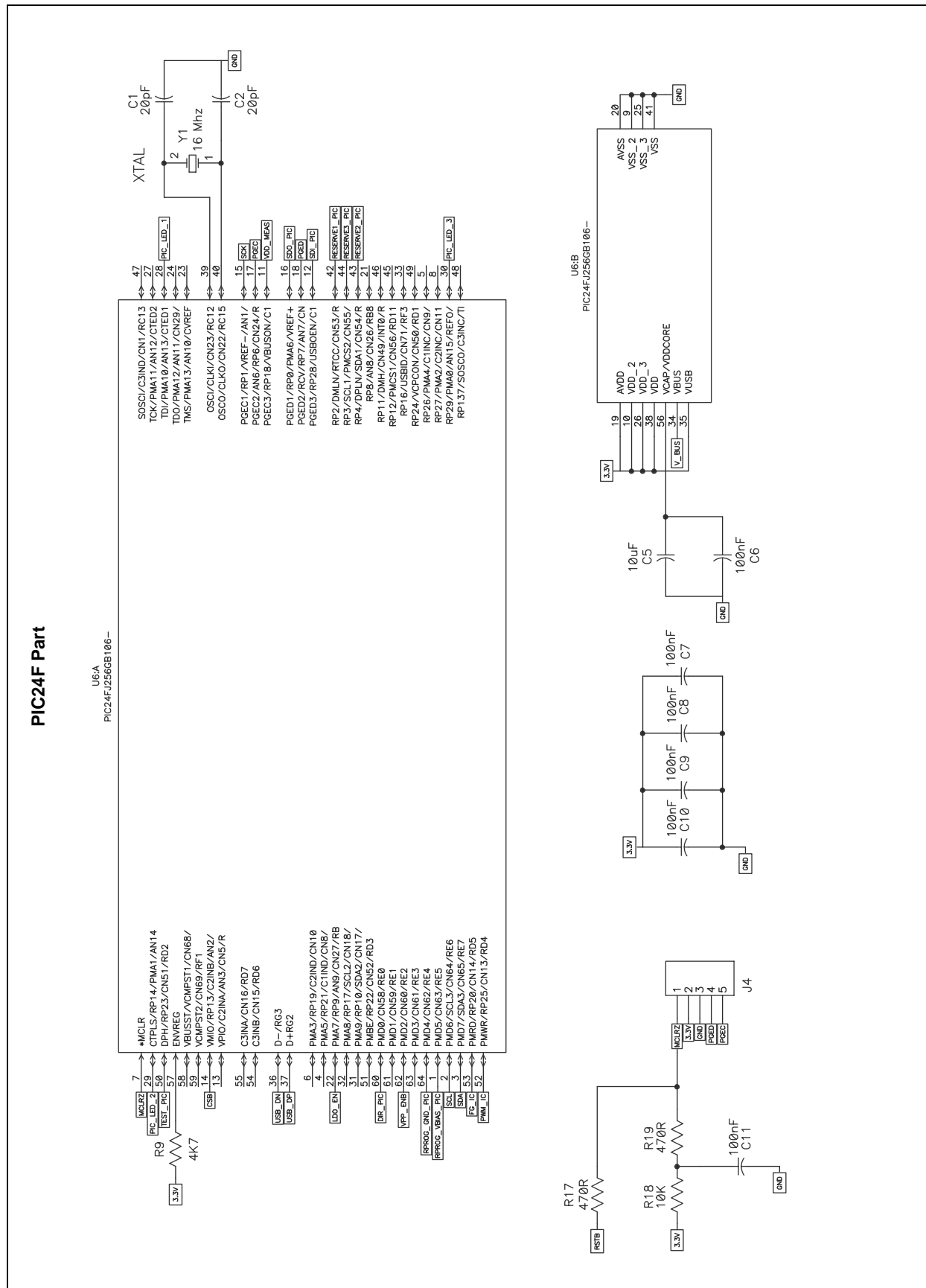
## A.2 BOARD – SCHEMATIC: POWER MANAGEMENT PART AND RESISTOR FOR PROGRAMMING PART



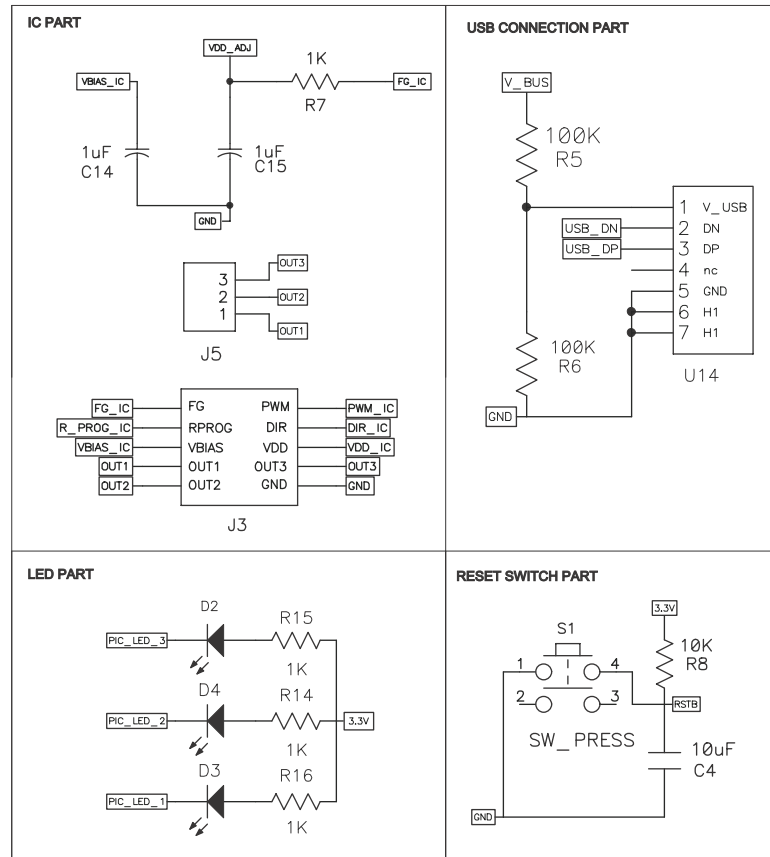
## A.3 BOARD – SCHEMATIC: DIRECTION PIN MANAGEMENT PART, PIC RESERVES PART, AND MTD6505 VOLTAGE AND CURRENT MONITORING PART



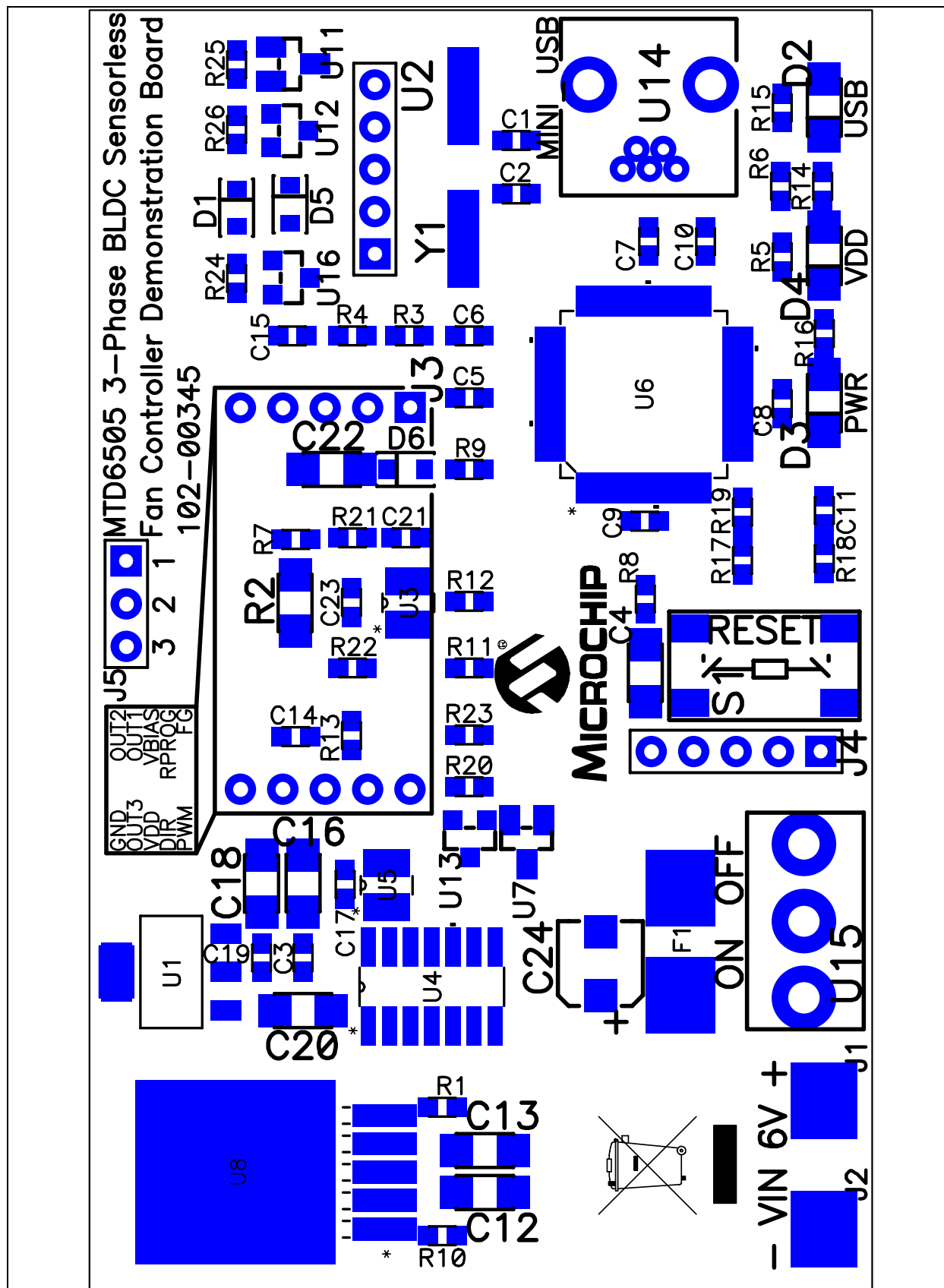
## A.4 BOARD – SCHEMATIC: PIC24FJ256GB106 PART



## A.5 BOARD – SCHEMATIC: IC PART/MTD6505 PLUG-IN MODULE SOCKET PART, USB CONNECTION PART, LED PART, AND RESET SWITCH PART

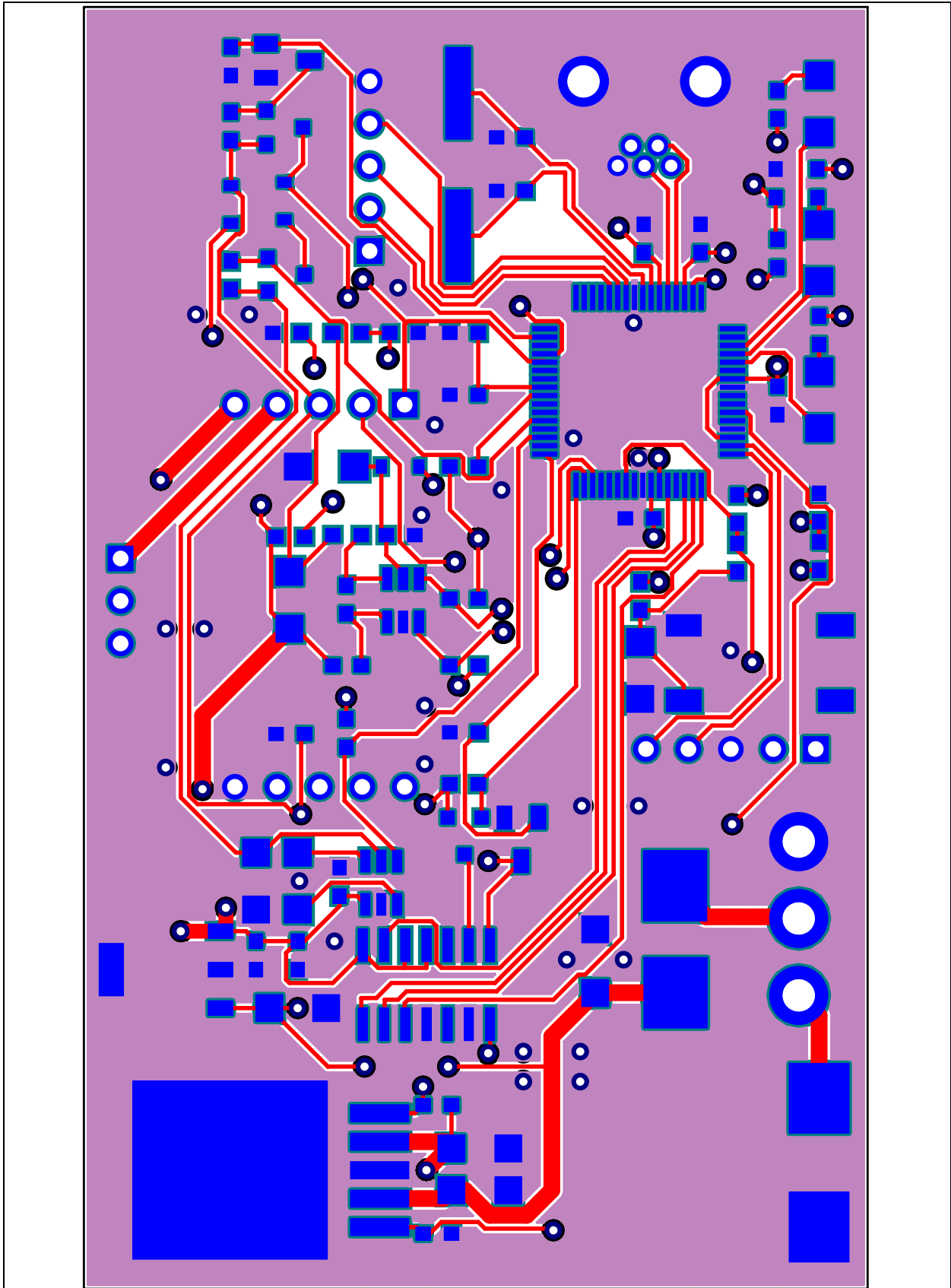


## A.6 BOARD – TOP SILK AND PADS

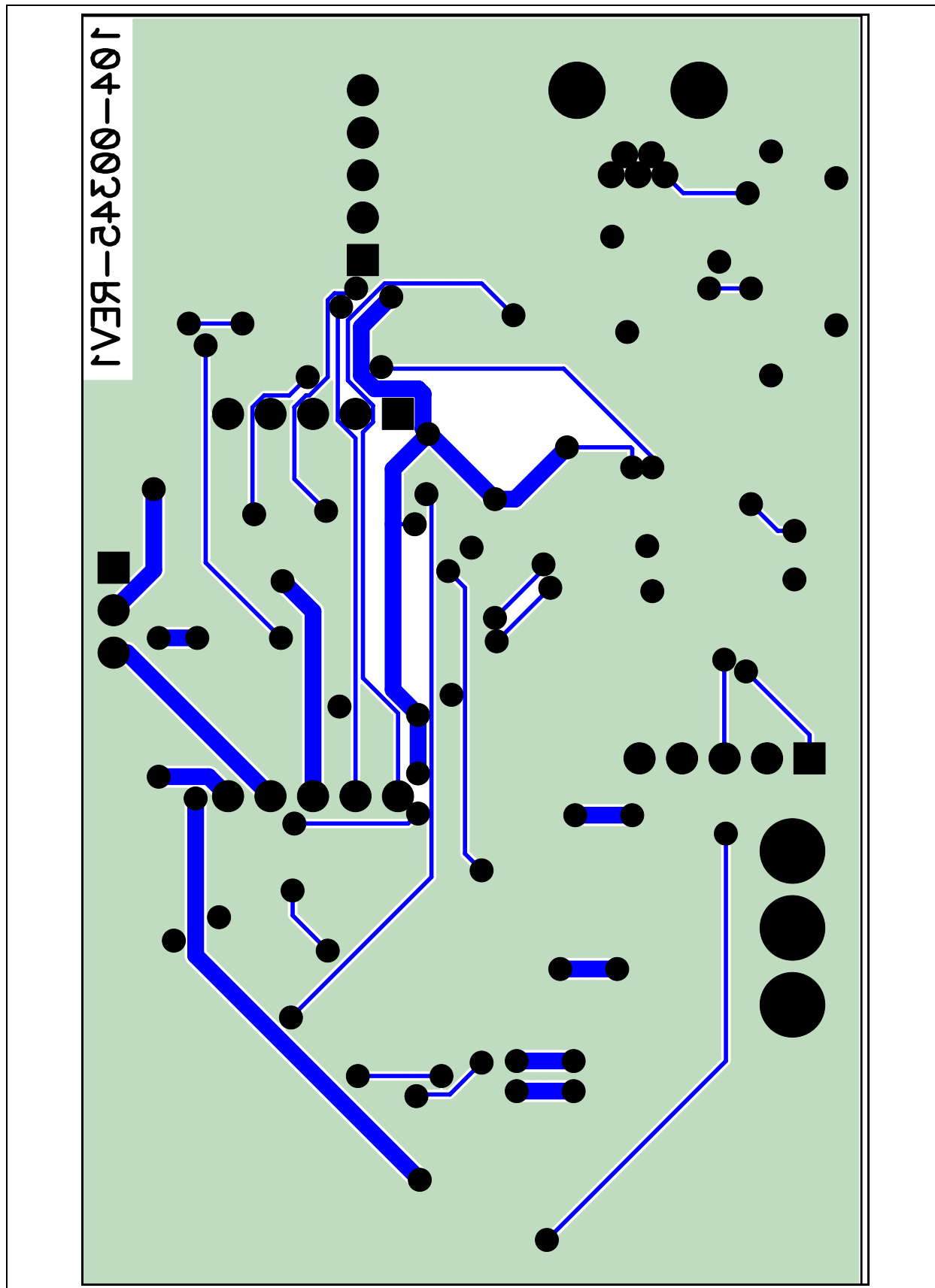




## A.7 BOARD – TOP TRACE AND PADS



A.8 BOARD – BOTTOM TRACE AND PADS



## Appendix B. Bill of Materials

**TABLE B-1: BILL OF MATERIALS (BOM)**

Qty	Reference	Description	Manufacturer	Part Number
2	C1, C2	CAP CER 20PF 50V C0G 0603	TDK <sup>®</sup> Corporation	C1608C0G1H200J
8	C3, C6, C7, C8, C9, C10, C11, C21	CAP CER .1UF 16V 10% X7R 0603	Murata Electronics <sup>®</sup>	GRM188R71C104KA01D
3	C4, C16, C22	CAP CERAMIC 10.0UF 16V X5R 1206	KEMET <sup>®</sup> Electronics Corp.	C1206C106K4PACTU
2	C5, C23	CAP CER 10UF 6.3V X5R 0603	KEMET Electronics Corp.	C0603C106M9PACTU
4	C12, C13, C18, C20	CAP CERAMIC 4.7UF 16V X7R 1206	KEMET Electronics Corp.	C1206C475K4RACTU
4	C14, C15, C17, C19	CAP CER 1.0UF 16V 10% X5R 0603	Murata Electronics	GRM188R61C105KA93D
1	C24	CAP ALUM 10UF 16V 20% SMD	Panasonic <sup>®</sup> - ECG	EEE-HC1C100R
2	D1, D5, D6	DIODE SCHOTTKY 30V 200MA SC-76	NXP Semiconductors	1PS76SB10,115
3	D2, D3, D4	LED INGAN BLUE CLEAR 1206 SMD	Dialight Corp.	598-8291-107F
1	D6	DIODE ZENER 12V 400MW SOD323	NXP Semiconductors	PDZ12B,115
1	F1 Fuse	044901.5MR - FUSE, SMD, 1.5A, TIME DELAY	Littelfuse <sup>®</sup>	044901.5MR
1	F1 Holder	0154007.DR - FUSE BLOCK W/ 7A FUSE, FAST ACTING	Littelfuse	R154007
1	J1, J2	PC TEST POINT COMPACT SMT	Keystone Electronics	5016
3	J3, J3, U2	CONN RCPT .100" 5POS SNGL TIN	Samtec, Inc.	SLW-105-01-T-S
1	J4	CONN HDR BRKWAY .100 05POS VERT	TE Connectivity	9-146282-0-05
1	J5	CONN HDR BRKWAY .100 03POS VERT	TE Connectivity	9-146282-0-03
1	R1	RES 150K OHM 1/10W 5% 0603 SMD	Panasonic - ECG	ERJ-3GEYJ154V
1	R2	RES .05 OHM 1W 1% 1206 SMD	Vishay <sup>®</sup> /Dale	WSLP1206R0500FEA
2	R3, R4	RES 100K OHM 1/10W 1% 0603 SMD	Panasonic - ECG	ERJ-3EKF1003V
9	R5, R6, R10, R13, R20, R23, R24, R25, R26	RES 100K OHM 1/10W 5% 0603 SMD	Panasonic - ECG	ERJ-3GEYJ104V
8	R7, R11, R12, R14, R15, R16, R21, R22	RES 1.0K OHM 1/10W 5% 0603 SMD	Panasonic - ECG	ERJ-3GEYJ102V

**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: BILL OF MATERIALS (BOM) (CONTINUED)**

Qty	Reference	Description	Manufacturer	Part Number
2	R8, R18	RES 10K OHM 1/10W 5% 0603 SMD	Panasonic - ECG	ERJ-3GEYJ103V
1	R9	RES 4.7K OHM 1/10W 5% 0603 SMD	Panasonic - ECG	ERJ-3GEYJ472V
2	R17, R19	RES 470 OHM 1/10W 5% 0603 SMD	Panasonic - ECG	ERJ-3GEYJ471V
1	S1	SWITCH, TACTILE SPST 50mA, SMD GULL WING	TE Connectivity Alcoswitch	FSM2JSMATR
1	U1	300 mA, Low Voltage, Low Quiescent Current LDO Regulator	Microchip Technology Inc.	MCP1824S-3302E/DB:3.3V
1	U3	18-Bit Analog-to-Digital Converter with I <sup>2</sup> C Interface and On-Board Reference	Microchip Technology Inc.	MCP3421A0T-E/CH
1	U4	Single/Dual Digital Potentiometer with SPI Interface	Microchip Technology Inc.	MCP42050-E/SL
1	U5	Positive Doubling Charge Pumps with Shutdown	Microchip Technology Inc.	TC1240AXCHTR
1	U6	64-Pin, 16-Bit Flash Microcontroller with USB On-The-Go (OTG)	Microchip Technology Inc.	PIC24FJ256GB106-I/PT
2	U7, U11	MOSFET N-CH 20V 1.2A SC59-3	Diodes Incorporated®	DMN2112SN-7
1	U8	1.5A, Low Voltage, Low Quiescent Current LDO Regulator	Microchip Technology Inc.	MCP1827-ADJE/ET
3	U12, U13, U16	MOSFET P-CH 20V 1A SSOT3	Fairchild Semiconductor®	NDS332P
1	U14	Plug-in Module connector Type B (USB 2.0)	Hsuan Mao Technology Co., Ltd	C8320-05BFRSB0R
1	U15	SLIDE SWITCH, SPDT	Knitter-Switch	MFP106D
1	Y1	CRYSTAL, HC49/SMD, 16.000MHZ	Aker Technology	CAA-16.000-18-3050-X
1	FAN	3-Phase BLDC Fan	Kunshan Kipo Technology Co., LTD	FAKL600EPA

**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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**NOTES:**

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