EVF52000-4232-VE-00B

Dual 60W USB PD Sourcing Ports Supporting Firmware Update and PDO-Configurable Advanced PDP Mitigation for Automotive

DESCRIPTION

The EVF52000-4232-VE-00B is dual-port 60W USB power delivery (PD) evaluation board. It is designed to demonstrate the capabilities of MPS's automotive USB Type-C power delivery (PD) solution with the MPF52000 and MPQ4232. It supports firmware update and power delivery object (PDO) configurations.

The MPF52000 is a highly integrated dual-port USB PD controller for sourcing port. It integrates a 32-bit ARM Cortex-M0 microcontroller unit (MCU), 36MHz operation frequency, USB Type-C port controller, and legacy charging protocol management. A firmware update feature is supported via the CC lines.

The dual-port USB Type-C ports support USB PD Revision 3.1, and are backward compatible with DCP schemes for battery charging specification (BC1.2) and Apple divider mode without the need for outside user interaction.

Power-sharing functionality supports dynamic power budget management between the two USB PD ports. PDO capability is reduced when the car battery voltage is low or an over-temperature warning is triggered.

PERFORMANCE SUMMARY (1)

Specifications are at T_A = 25°C, unless otherwise noted.

Parameters	Conditions	Value
Input voltage (V_{IN}) range		4.3V to 22V
Output voltage (V_{OUT})	V_{IN} = 4.3V to 22V / 36V tolerant, I_{OUT} = 0A to 3A	5V to 21V
Maximum output current (I_{OUT})	V_{IN} = 4.3V to 22V / 36V tolerant	3A
Typical efficiency	V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 3A	96.75%
Switching frequency (f_{SW})		420kHz

Input Voltage (1)	Typical Value is 13.5V, 4.3V to 22V Operation Range / 36V Tolerant	
Default PDO List For Each Port	V_{OUT}	I_{OUT}
1	5V	3A
2	9V	3A
3	15V	3A
4	20V	3A
5	3.3V to 11V	3A
6	3.3V to 16V	3A
7	3.3V to 21V	3A

Note:

1) PD power is reduced when the input voltage is low. The output will be shut down if the V_{BATT} low 3 threshold is triggered.

MPL Optimized Performance with MPS Inductor MPL5030 Series

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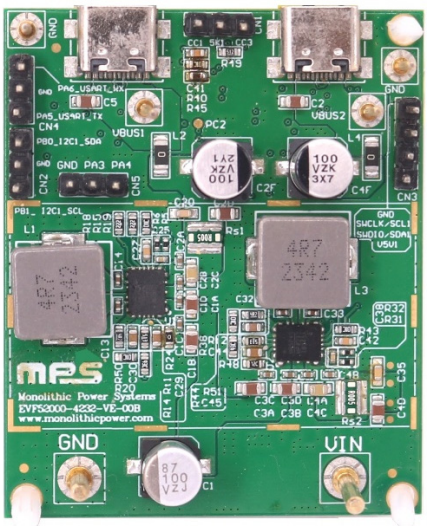
EVF52000-4232-VE-00B EVALUATION BOARD



LxWxH (5.7cmx4.7cmx2.0cm)

Board Number	MPS IC Number	Firmware Revision
EVF52000-4232-VE-00B	MPF52000GRE-0026-AEC2, MPQ4232GVE-0000-AEC1	PD firmware revision: fr1001 PDFU revision: br1001

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FIRMWARE REVISION HISTORY

1. MPF52000-0026 fr1000-initial version
2. MPF52000-0026 fr1001-Support GUI programming function. Refer to the user guide for the latest GUI version. [1]

   For GUI download: http://updates.monolithicpower.com/pd-controller-installer/PD%20Controller.zip

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QUICK START GUIDE

1. Preset the power supply (V_{IN}) to 13.5V and turn off the power supply.
2. Connect the power supply terminals to:
   a. Positive (+): VIN
   b. Negative (-): GND
3. Connect the power delivery (PD) protocol sniffer or mobile device to the USB Type-C port.
4. After making the connections, turn on the power supply.
5. VBUS should start up automatically at the default voltage set by the PD protocol sniffer or mobile device. The PD protocol sniffer can select different power delivery object (PDO) outputs.
6. The maximum PD output power should be 60W for a single port, for a shared total of 120W of output power for dual ports.
7. Over-temperature protection (OTP) function: If the voltage on PA6 (NTC function) is below 3.274V, PD power is reduced. If the voltage is below 2.447V, the MPF52000 shuts down the PD output. When the voltage exceeds 2.447V, the PD function is enabled. Table 1 shows the NTC PDP for each port.

Table 1: NTC PDP for Each Port

NTC Temperature	PD Power of Each Port
NTC_THRESHOLD > 3.274V	60W
2.906V < NTC_THRESHOLD < 3.274V	45W
2.447V < NTC_THRESHOLD < 2.906V	15W
NTC_THRESHOLD < 2.447V	PD output is shut down

8. Battery voltage sense function: If the voltage between the VIN and GND pins is below 11V, PD power is reduced. If the input voltage (V_{IN}) is below 6.6V, the PD engine shuts down. The hysteresis is 800mV. Table 2 shows the battery voltage (V_{BATT}) low PDP for each port.

Table 2: V_{BATT} Low PDP for Each Port

Battery Voltage	PD Power of Each Port
6.6V < V_{IN} <11V	30W
V_{IN} < 6.6V	PD output is shut down

9. For GUI supporting version (fr1001), the graphical user interface (GUI) can be used to configure the PD firmware's basic functions (e.g. the PDO list, VBATT_SENSE and NTC thresholds, and legacy mode selection) according to user preferences. If the user downloads the settings through the GUI, the default values are changed. Figure 1 shows the GUI interface.

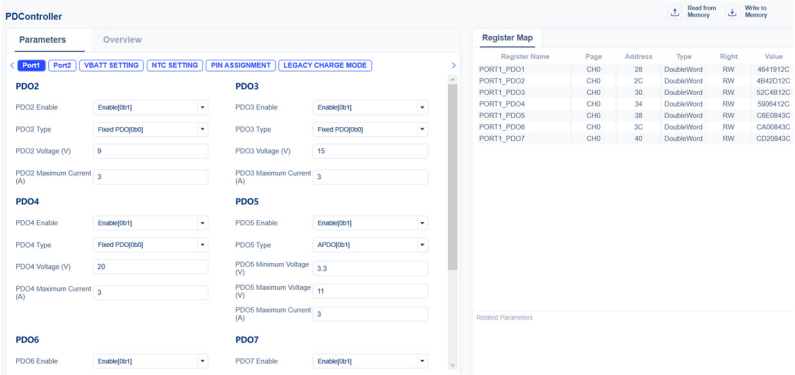

Figure 1: MPF52000 GUI

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EVALUATION BOARD SCHEMATIC

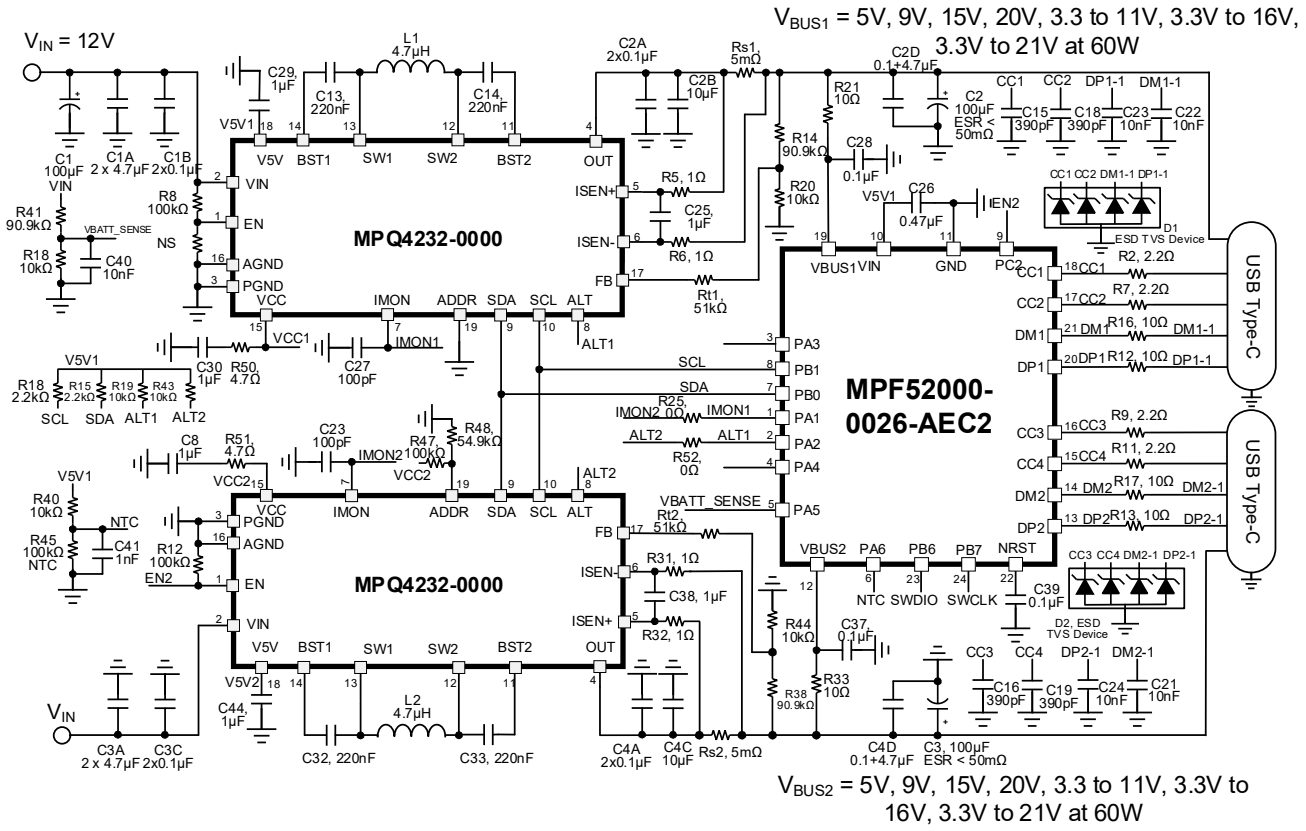

Figure 2: Evaluation Board Schematic

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EVF52000-4232-VE-00B BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
1	C1	100µF/ 35V	Aluminum polymer capacitor	SMD	Nippon Chemi-Con	EMZJ350ADA101MF80G
2	C2F, C4F	100µF	100µF, 35V, aluminum polymer capacitor	SMD	Panasonic	EEHZK1V101XP
8	C4, C6, C7, C8, C9, C10, C11, C12	2.2µF	Ceramic capacitor, 100V, X7T	0805	Murata	GRM21BD72A225KE01L
6	C20, C28, C37, C35, C39, C43	100nF	Ceramic capacitor, 50V, X7R	0603	Samsung	CL05B104KB5NNNC
8	C1C, C1D, C3C, C3D, C2A, C2B, C4A, C4B,	100nF	Ceramic capacitor, 50V, X7R	0402	Murata	GCM155R71H104KA55D
8	C1A, C1B, C3A, C3B, C2D, C4D, C2, C5	4.7µF	Ceramic capacitor, 50V, X7S	0805	Murata	GRM21BC71H475KE11L
2	C2C, C4C	10µF	Ceramic capacitor, 50V, X5R	0805	Murata	GRM21BR61H106KE43L
4	C15, C18, C16, C19	390pF	Ceramic capacitor, 50V, C0G	0402	Murata	GRM1555C1H391JA01D
1	C41	1nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H102KA01D
4	C21, C24, C22, C23	10nF	Ceramic capacitor, 50V, Y5V	0402	Murata	GCM155R71H103KA55D
1	C40	10nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H103KA01D
2	C27, C42	100pF	Ceramic capacitor, 50V, X7R	0603	Wurth	885012206077
5	C26, C29, C30, C44, C45	1µF	Ceramic capacitor, 25V, X7R	0603	Murata	GRT188R71E105KE13D
2	C25, C38	1µF	Ceramic capacitor, 10V, X5R	0402	Wurth	885012105012
4	C13, C14, C32, C33	220nF	Ceramic capacitor, 16V, X7R	0402	Murata	GRM155R71C224KA12D
2	RT1, RT2	51kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0751KL
2	R15, R18	2.2kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-072K2L
1	R47	100kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-07100KL
1	R48	54.9kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0754K9L
1	R49	5.1kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-075K1L
4	R2, R7, R9, R11	2.2Ω	Film resistor, 1%	0603	Yageo	RC0603FR-072R2L
0	D1, R1, R10, R36, R22, R37, R53, R54	NS				
3	R14, R38, R41	90.9kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0790K9L
1	R45	100kΩ	NTC resistor	0603	TDK	NTCG164KF104FTDS

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EVF52000-4232-VE-00B BILL OF MATERIALS *(continued)*

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
4	R24, R25, R27, R52	0Ω	Film resistor, 1%	0603	Yageo	RC0603FR-070RL
2	R50, R51	4.7Ω	Film resistor, 1%	0603	Yageo	RC0402FR-074R7L
6	R20, R44, R40, R46, R19, R43	10kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0710KL
6	R12, R13, R16, R17, R21, R33	10Ω	Film resistor, 1%	0603	Yageo	RC0603FR-0710RL
2	R8, R35	100kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-07100KL
2	RS1, RS2	5Ω	1%, long side, 1W, current-sensing resistor	L1508	Film Tech	RL3720W-R005-F
4	R5, R6, R31, R32	1Ω	Film resistor, 1%	0402	Yageo	RC0402FR-071RL
1	Q1	-	Short by solder			
2	L1, L3	4.7μH	Inductor, R_{DC} = 8mΩ, I_{SAT} = 13A	SMD	Super world	PIAQ1005S4R7MN
2	L2, L4	0Ω	Resistor	1206	Any	
4	CN1, CN2, CN4, CN5	3-pin	3 pins, 1 row, straight header	DIP	Wurth	61300311121
1	CN3	4-pin	4 pins, 1 row, straight header	DIP	Wurth	61300411121
2	TYPE_C1, TYPE_C2	20V	16-pin USB Type-C connector	SMD	Yue Hu	PC-071603863-R
2	D2, D3	30V	ESD diode	SOT23-6	onsemi	ESD1L001
6	VIN, GND, VBUS1, GND, VBUS2, GND	Φ2.0	φ2.0 copper pin	DIP	Any	
2	U1, U2	MPQ4232	Buck-boost controller with low-side	QFN-20 (4mmx 5mm)	MPS	MPQ4232GVE-0000-AEC1
1	U3	MPF52000	Dual USB PD controller	QFN-24 (4mmx 4mm)	MPS	MPF52000GRE-0026-AEC2
1	LEM1	470nH	Inductor, R_{DC} = 3.78mΩ, I_{SAT} = 26.5A	SMD	MPS	MPL-AL5030-R47
1	LEM2	1μH	Inductor, R_{DC} = 6.5mΩ, I_{SAT} = 16A	SMD	MPS	MPL-AL5030-1R0

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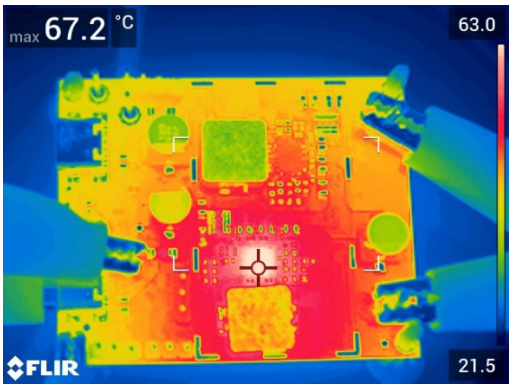
EVB TEST RESULTS

Performance curves and waveforms are tested on the evaluation board. T_A = 25°C, unless otherwise noted.

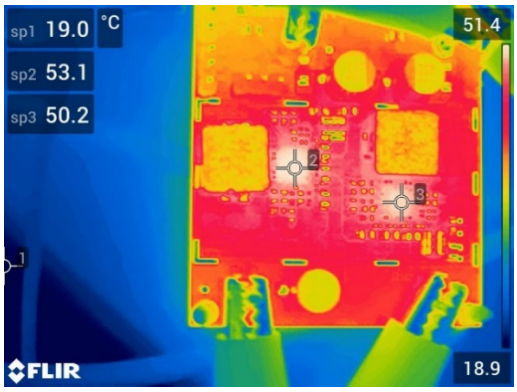
Thermal Image of the MPQ4232

V_{IN} = 12V, V_{OUT1} = 20V/3A, V_{OUT2} is disabled,
based on 4.7cmx5.7cm board, L = 4.7μH, R_{DC} = 8mΩ



Thermal Image of the MPQ4232

V_{IN} = 12V, V_{OUT1} = 20V/1.5A, V_{OUT2} =20V, 1.5A,
based on 4.7cmx5.7cm board, L = 4.7μH, R_{DC} = 8mΩ



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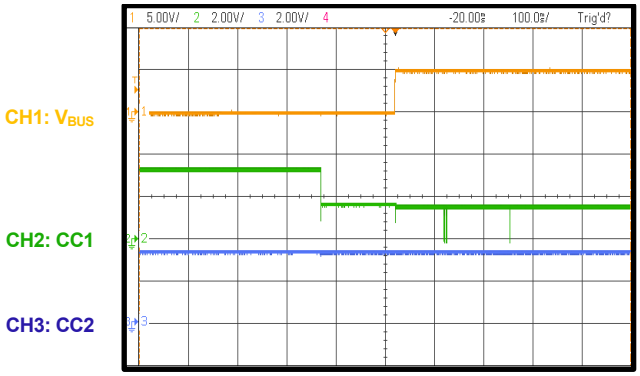
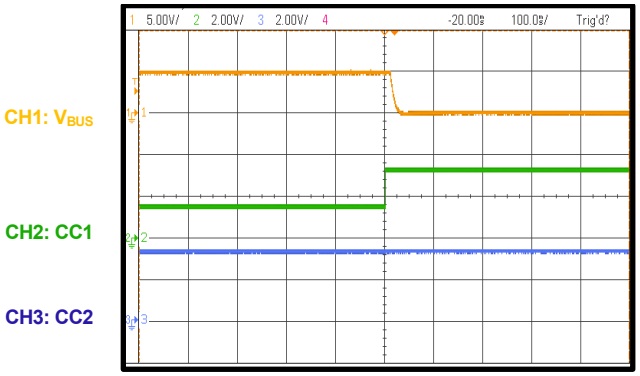
EVB TEST RESULTS

V_{IN_SYS} (DC/DC converter's V_{IN}) = 12V, MPF52000-AEC2 is supplied by an MPS DC/DC converter's V5V, V_{BUS} = 3.3V to 21V, T_A = 25°C, unless otherwise noted.

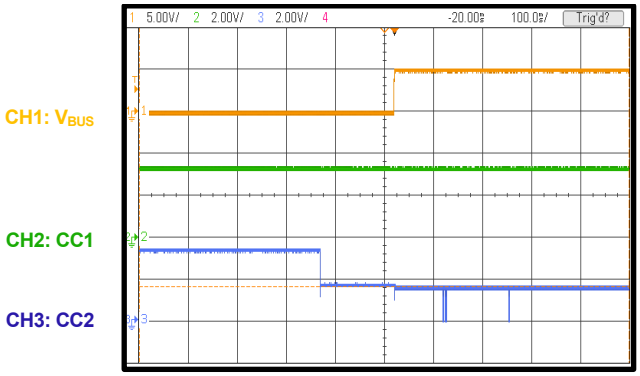
CC1 Attached R_D to Enable VBUS



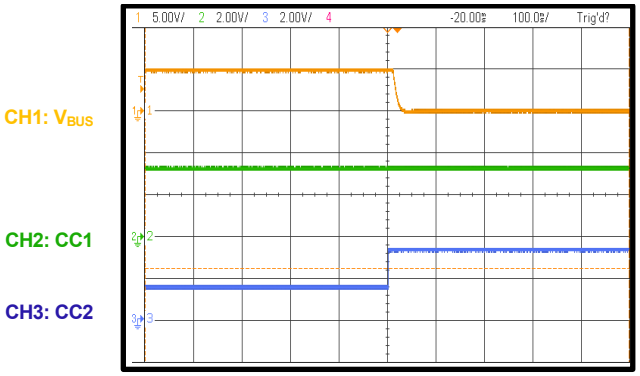
CC1 Detached R_D to Disable VBUS



CC2 Attached R_D to Enable VBUS

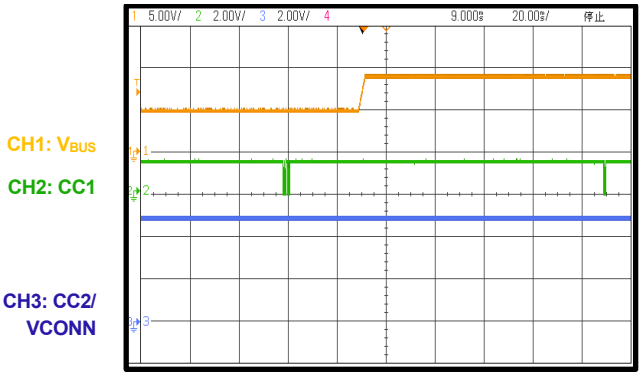


CC2 Detached R_D to Disable VBUS



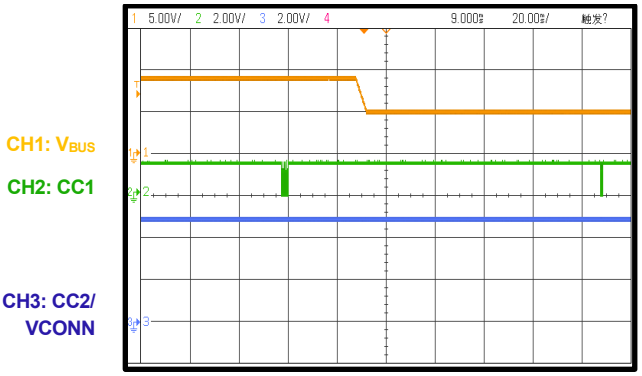
PDO Transition

5V PDO to 9V PDO



PDO Transition

9V PDO to 5V PDO



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PCB LAYOUT

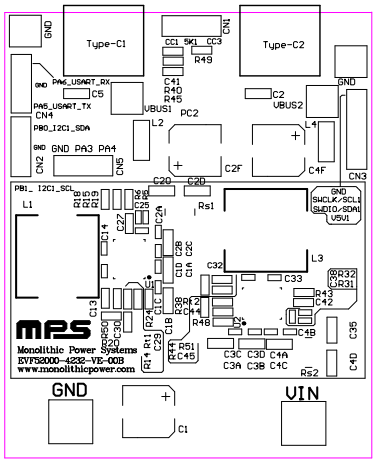

Figure 3: Top Silk

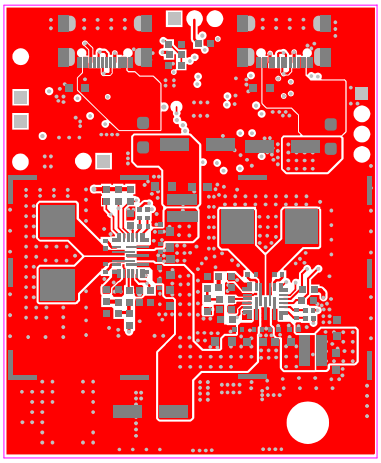

Figure 4: Top Layer

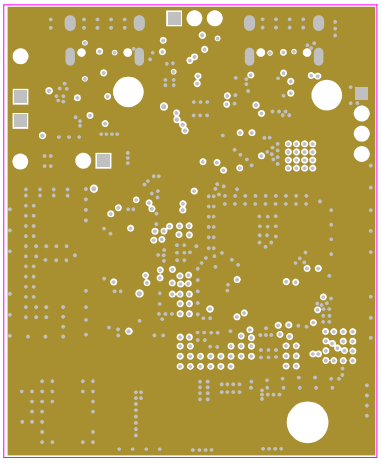

Figure 5: Mid-Layer 1

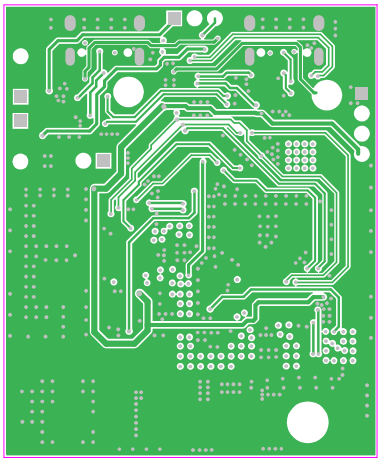

Figure 6: Mid-Layer 2

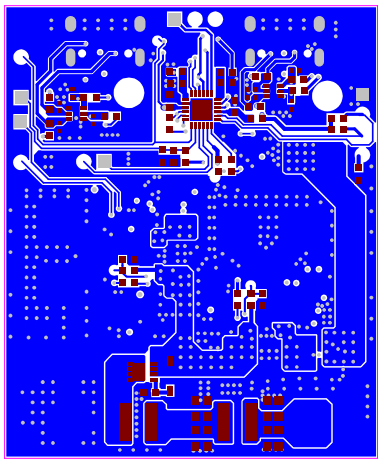

Figure 7: Bottom Layer

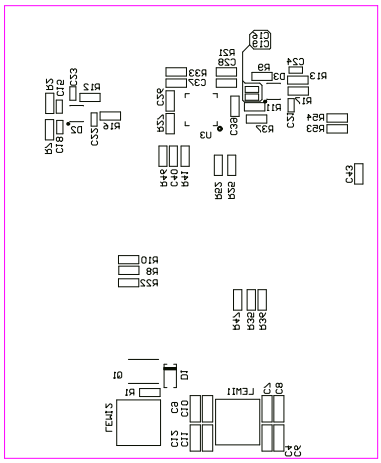

Figure 8: Bottom Silk

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MPF52000-0026 CONFIGURATION TABLE

PDO Index	Enabled/Disabled	PDO Type	Voltage Setting	Current Setting
PDO1	Enable	Fixed PDO	5V	3A
PDO2	Enable (default)	Fixed PDO (default)	9V (default)	3A
PDO3	Enable (default)	Fixed PDO (default)	15V (default)	3A
PDO4	Enable (default)	Fixed PDO (default)	20V (default)	3A
PDO5	Enable (default)	APDO (default)	3.3V to 11V	3A
PDO6	Enable (default)	APDO (default)	3.3V to 16V	3A
PDO7	Enable (default)	APDO (default)	3.3V to 21V	3A

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MPF52000-0026 OTP ITEMS (2)

OTP Items	Description	Value
PA1_FUNCTION	Configures the function of the PA1 pin.	PA1
PA2_FUNCTION	Configures the function of the PA2 pin.	ALT_IN (default)
PA3_FUNCTION	Configures the function of the PA3 pin.	PA3
PA4_FUNCTION	Configures the function of the PA4 pin.	PA4
PA5_FUNCTION	Configures the function of the PA5 pin.	VBATT_SENSE (default)
PA6_FUNCTION	Configures the function of the PA6 pin.	NTC (default)
PB0_FUNCTION	Configures the function of the PB0 pin.	I2C_SDA
PB1_FUNCTION	Configures the function of the PB1 pin.	I2C_SCL
PB6_FUNCTION	Configures the function of the PB6 pin.	SWDIO (default)
PB7_FUNCTION	Configures the function of the PB7 pin.	SWCLK (default)
PC2_FUNCTION	Configures the function of the PC2 pin.	PC2
NTC_THRESHOLD_1	Sets the NTC power derating threshold 1.	3.274V
NTC_THRESHOLD_2	Sets the NTC power derating threshold 2.	2.906V
OTP_THRESHOLD	Sets the over-temperature shutdown threshold.	2.447V
NTC1_PDP	Sets the maximum power rating when the NTC temperature exceeds the threshold.	45W
NTC1_PDO_SELECT	Selects which voltage is enabled in the PDO list.	0xBE
NTC2_PDP	Sets the maximum power rating when the NTC temperature exceeds the threshold.	15W
NTC2_PDO_SELECT	Selects which voltage is enabled in the PDO list.	0x8C
VBATT_LOW_THLD_1	Sets the first threshold for V_{IN} detection.	11.0V (default)
VBATT_LOW_THLD_2	Sets the second threshold for V_{IN} detection.	This function is disabled
VBATT_LOW_THLD_3	Sets the third threshold for V_{IN} detection. The device shuts down after the threshold is triggered.	6.6V (default)
VBATT_LOW1_PDP	Sets the maximum power rating when V_{BATT} is below the first threshold.	30W
VBATT_L1_PDO_SELECT	Selects which voltage is enabled in the PDO list.	0xBE
VBATT_LOW2_PDP	Sets the maximum power rating when V_{BATT} is below the second threshold.	-
VBATT_L2_PDO_SELECT	Selects which voltage is enabled in the PDO list.	-
LEGACY_CHARGING_MODE_SEL	Selects QC3.0/DCP short mode / Divider mode.	Apple mode and BC1.2 mode are active
MTP_SUFFIX_CODE	Sets the MTP suffix number.	0x0026

Note:

2) Refer to PD Controller GUI Firmware Update User Guide_r0.3. Contact an MPS FAE for more information.

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REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	1/27/2025	Initial Release	-

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