EV5991-V-4PHASE-00A

16V, 50A, Hot-Swap Intelli-Fuse Solution Evaluation Board

DESCRIPTION

The EV5991-V-4PHASE-00A evaluation board is designed to demonstrate the capabilities of multiple MP5991 devices operating in parallel. The evaluation board contains four phases of the MP5991, which enables it to be easily configured between one phase and four phases.

The EV5991-V-4PHASE-00A provides rich test pins and LED indications to simplify system evaluation. The pins of each paralleled MP5991 can be probed via the test pins, which makes it simple to understand the MP5991's operating principles.

The EV5991-V-4PHASE-00A is compatible with discrete power source terminals and a power supply unit (PSU) interface, which can meet different power supply verification requirements.

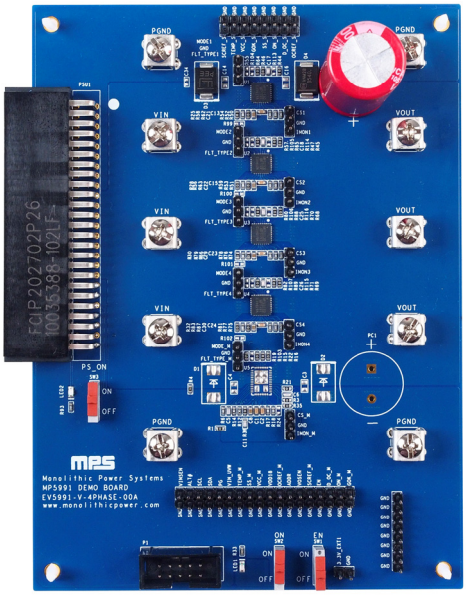
The MP5991 is available in an LGA-32 (5mmx5mm package). The EV5991-V-4PHASE-00A has 4 layers, which are each 2oz, and its total size is 11cmx15cm.

PERFORMANCE SUMMARY

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

Parameters	Conditions	Value
Input voltage (V_{IN}) range		4V to 16V
Over-current (OC) limit per device	R_{CS} = 2kΩ, R_{OCREF} = 100kΩ	50A
Short-circuit limit per device	R_{SCREF} = 200kΩ	100A
Soft-start time (t_{SS})	C_{SS} = 100nF	8.9ms
Protection mode	Pull R_{MODE} to VCC	Latch-off
Active number of MP5991 devices		4

EV5991-V-4PHASE-00A EVALUATION BOARD



LxW (11cmx15cmx1.6cm)

Board Number	MPS IC Number
EV5991-V-4PHASE-00A	MP5991GLU

GENERAL CONFIGURATIONS

Default Configuration

Table 1 lists the EV5991-V-4PHASE-00A's default configurations.

Table 1: EV5991-V-4PHASE-00A Default Configurations

Parameter	Value	Unit	Notes
Phase number	4	-	1 to 4 configurable phases (see Table 2)
Over-current protection (OCP) per phase	50	A	I_{OCP} = R_{OCREF} / R_{CS}; always maintain R_{IMON} = R_{CS}
Short-circuit protection (SCP) per phase	100	A	Change R_{SCREF} to select a different SCP current limit per phase (40A, 60A, 80A, 100A, or 120A)
Soft-start time (t_{SS})	8.9	ms	t_{SS} = C_{SS} x R_{SS} / 9; R_{SS} = 0.8MΩ
Protection mode	Latch-off	-	Change R_{MODE} to configure different protection modes, including latch-off mode or hiccup mode with a 250ms, 500ms, or 1s retry time

Phase Configuration

The EV5991-V-4PHASE-00A can be configured between 1 and 4 operating phases by adjusting the evaluation board's parameters (see Table 2).

Table 2: EV5991-V-4PHASE-00A Phase Configurations

# of Phases	Active Part	Remove Resistors				Others
1	U1	-	U2	U3	U4	Stuff R114, R115, and R116 with 0Ω; U2, U3, and U4 do not need to be removed
		D_OC	R45	R68	R69	
		ON	R47	R70	R71	
		GOK	R65	R88	R89	
		FLT_TYPE	R110	R111	R112	
		SCREF_OCWREF	R28	R30	R32	
		VTEMP	R63	R86	R87	
		SS	R61	R84	R85	
		IMON	R29	R31	R34	
		OCREF	R39	R40	R41	
2	U1, U2	-	U2	U3	U4	Stuff R115 and R116 with 0Ω; U3 and U4 do not need to be removed
		D_OC	-	R68	R69	
		ON	-	R70	R71	
		GOK	-	R88	R89	
		FLT_TYPE	-	R111	R112	
		SCREF_OCWREF	-	R30	R32	
		VTEMP	-	R86	R87	
		SS	-	R84	R85	
		IMON	-	R31	R34	
		OCREF	-	R40	R41	
3	U1, U2, U3	-	U2	U3	U4	Stuff R115 with 0Ω; U4 does not need to be removed
		D_OC	-	-	R69	
		ON	-	-	R71	
		GOK	-	-	R89	
		FLT_TYPE	-	-	R112	
		SCREF_OCWREF	-	-	R32	
		VTEMP	-	-	R87	
		SS	-	-	R85	
		IMON	-	-	R34	
		OCREF	-	-	R41	
4	U1, U2, U3, U4	The default configuration is four phases				

QUICK START GUIDE

To start up the EV5991-V-4PHASE-00A, follow the steps below:

VIN Start-Up

1. Preset the power supply between 4V and 12V, then turn the power supply off.
2. Connect the power supply terminals and load terminals to the evaluation board's corresponding terminals.
3. Turn the ON switch (SW2) on and ensure that it remains on.
4. After making the connections, turn the power supply on. The output voltage (V_{OUT}) should automatically start up.

Enable (EN) Start-Up

1. Connect the power supply terminals and load terminals to the evaluation board's corresponding terminals.
2. Turn SW2 off, then turn the power supply on. V_{OUT} remains low during this time.
3. Turn SW2 on to automatically start up V_{OUT}. If a signal generator is used to control the ON signal, SW2 must remain on.

Power Supply Unit (PSU) Start-Up

1. Connect the load terminals to the evaluation board's VOUT terminals.
2. Connect the power supply unit (PSU) to the evaluation board's PSU interface, which is compatible with the Intel PSU, G36234-013.
3. Turn the PSU switch (SW3) off, and then turn SW2 on.
4. Turn the PSU on, which should light up the PSU LED (LED2). V_{OUT} remains low during this time.
5. Turn SW3 on to automatically start up V_{OUT}.

Note:

1) If testing with a continuous input voltage (V_{IN}) exceeding 12V, remove the TVS diode (D3) and replace with the appropriate TVS according to V_{IN}.

EVALUATION BOARD SCHEMATICS

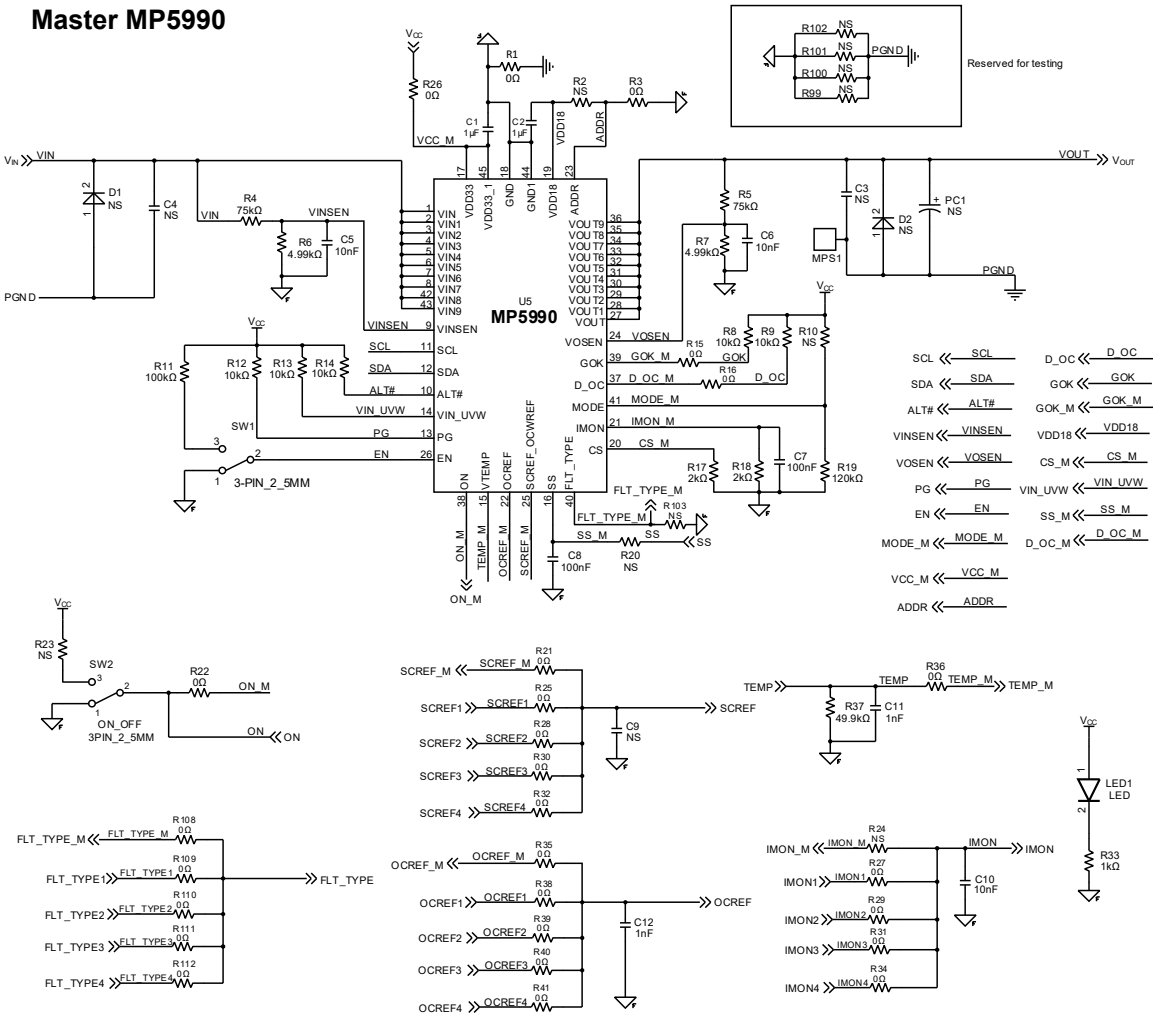


Figure 1: Evaluation Board Schematic (Master MP5990, Not Stuffed MP5990)

EVALUATION BOARD SCHEMATICS *(continued)*

Slave 4-Phase MP5991

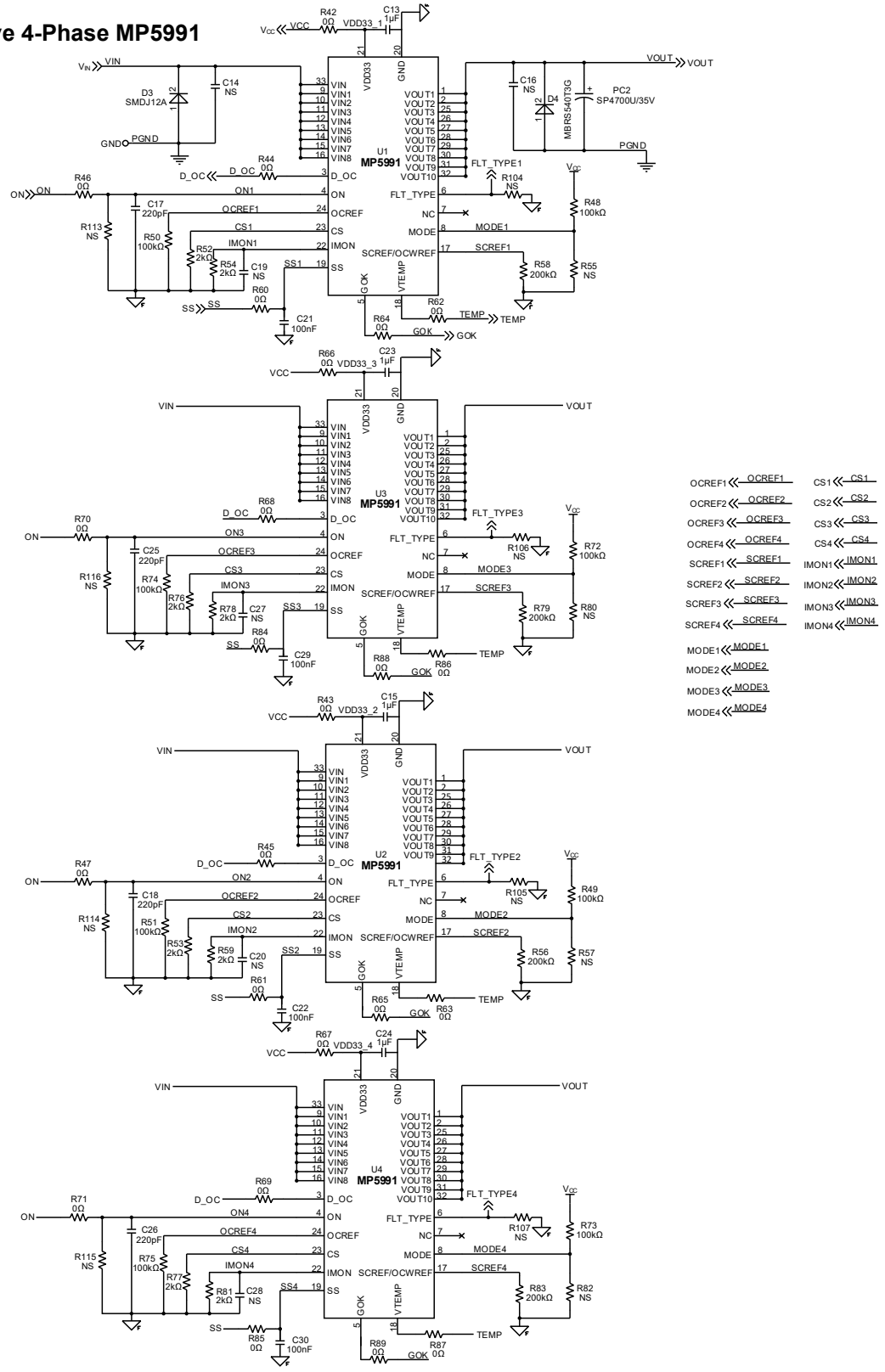


Figure 2: Evaluation Board Schematic (4-Phase MP5991s Acting as Slaves)

EVALUATION BOARD SCHEMATICS *(continued)*

Test Pins and Connectors

Figure 3: Evaluation Board Schematic (Test Pins and Connectors)

EVALUATION BOARD SCHEMATICS *(continued)*

PSU Interface

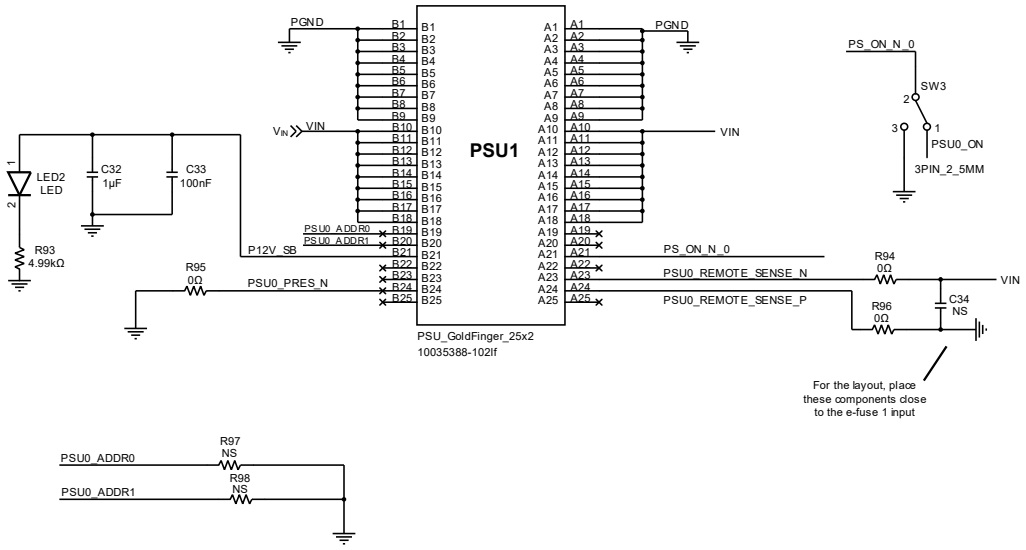


Figure 4: Evaluation Board Schematic (PSU Interface)

EV5991-V-4PHASE-00A BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
96	MODE1, IMON1, H1, FLT_TYPE1, CS1, AGND1, MODE2, IMON2, H2, FLT_TYPE2, CS2, AGND2, MODE3, IMON3, H3, FLT_TYPE3, CS3, AGND3, MODE4, IMON4, H4, FLT_TYPE4, CS4, AGND4, AGND5, AGND6, AGND7, AGND8, AGND9, AGND10, AGND11, AGND12, AGND13, AGND14, AGND15, AGND16, AGND17, VDD18, AGND18, AGND19, AGND20, AGND21, AGND22, AGND23, AGND24, AGND25, AGND26, AGND27, AGND28, AGND29, AGND30, AGND31, AGND32, AGND33, AGND34, AGND35, AGND36, AGND37, AGND38, AGND39, AGND40, AGND41, AGND42, AGND43, AGND44, AGND45, 3.3V_EXT1, VOSEN, VIN_UVW, VINSEN, VCC_S, VCC_M, TEMP_S, TEMP_M, SS_S, SS_M, SDA, SCREF_S, SCREF_M, SCL, PG, ON_S, ON_M, OCREF_S, OCREF_M, MODE_M, IMON_M, GOK_S, GOK_M, FLT_TYPE_M, EN, D_OC_S, D_OC_M, CS_M, ALT#, ADDR	3A	Connector, test point	DIP	Any	
38	D1, R2, D2, C3, C4, C9, R10, C14, C16, C19, R20, C20, R23, R24, C27, C28, C34, R55, R57, R80, R82, R92, R97, R98, R99, R100, R101, R102, R103, R104, R105, R106, R107, R113, R114, R115, R116, PC1	NS				
3	C5, C6, C10	10nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H103KA01D
7	C7, C8, C21, C22, C29, C30, C33	100nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H104KA93D
8	C1, C2, C13, C15, C23, C24, C31, C32	1µF	Ceramic capacitor, 25V, X7R	0603	Murata	GCM188R71E105KA64D

EV5991-V-4PHASE-00A BILL OF MATERIALS *(continued)*

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
1	PC2	4700µF	Electrolytic capacitor, 35V	DIP	Wurth	860020581026
4	C17, C18, C25, C26	220pF	Ceramic capacitor, 50V, COG	0603	Murata	GRM1885C1H221JA01D
2	C11, C12	1nF	Ceramic capacitor, 25V, COG	0603	Murata	GRM1885C1E102JA01D
1	D4	5A	Schottky diode, 40V	SMC	onsemi	MBRS540T3G
1	D3	12V	TVS diode	DO-214AB	Littlefuse	SMDJ12A
2	LED1, LED2	20mA	Blue LED	0805	Bright LED	HL-PSC-2012H203BC
10	VOUT1, VIN1, PGND1, VOUT2, VIN2, PGND2, VOUT3, VIN3, PGND3, PGND4	30A	Connector, test point	DIP	Keystone	8191K-ND
3	SW1, SW2, SW3	0.5A	Slide switch, 3-pin, 2.54mm	DIP	Wurth	450301014042
1	P1	3A	Header, 5-pin, dual row	DIP	Any	
1	PSU	7A	Connector, 2x25-pin	DIP	Amphenol FCI	10035388-102LF
9	R11, R48, R49, R50, R51, R72, R73, R74, R75	100kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-07100KL
7	R8, R9, R12, R13, R14, R90, R91	10kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0710KL
1	R37	49.9kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0749K9L
2	R4, R5	75kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0775KL
3	R6, R7, R93	4.99kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-074K99L
1	R33	1kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-071KL
53	R1, R3, R15, R16, R21, R22, R25, R26, R27, R28, R29, R30, R31, R32, R34, R35, R36, R38, R39, R40, R41, R42, R43, R44, R45, R46, R47, R60, R61, R62, R63, R64, R65, R66, R67, R68, R69, R70, R71, R84, R85, R86, R87, R88, R89, R94, R95, R96, R108, R109, R110, R111, R112	0Ω	Film resistor, 1%	0603	Yageo	RC0603FR-070RL

EV5991-V-4PHASE-00A BILL OF MATERIALS *(continued)*

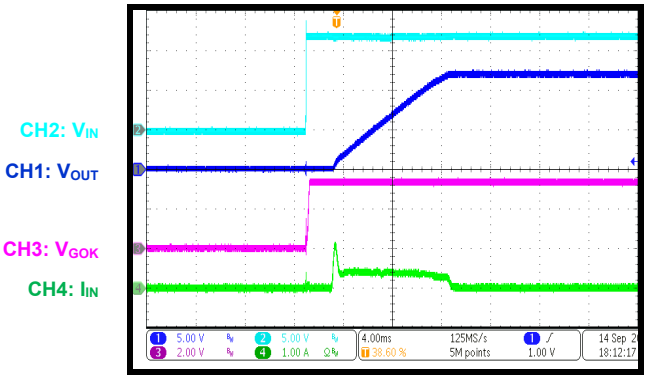
Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
1	R37	49.9kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0749K9L
2	R4, R5	75kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0775KL
3	R6, R7, R93	4.99kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-074K99L
1	R33	1kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-071KL
53	R1, R3, R15, R16, R21, R22, R25, R26, R27, R28, R29, R30, R31, R32, R34, R35, R36, R38, R39, R40, R41, R42, R43, R44, R45, R46, R47, R60, R61, R62, R63, R64, R65, R66, R67, R68, R69, R70, R71, R84, R85, R86, R87, R88, R89, R94, R95, R96, R108, R109, R110, R111, R112	0Ω	Film resistor, 1%	0603	Yageo	RC0603FR-070RL
10	R17, R18, R52, R53, R54, R59, R76, R77, R78, R81	2kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-072KL
4	R56, R58, R79, R83	200kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-07200KL
1	R19	120kΩ	Film resistor, 1%	DIP	Wurth	RC0603FR-07120KL
1	U5	NS				
4	U1, U2, U3, U4	MP5991	16V, 50A, 1mΩ $R_{DS(ON)}$, hot-swap intelli-fuse solution	LGA-32 (5mmx 5mm)	MPS	MP5991GLU

EVB TEST RESULTS

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, R_{CS} = R_{IMON} = 2kΩ, C_{OUT} = 330μF, T_J = 25°C, unless otherwise noted.

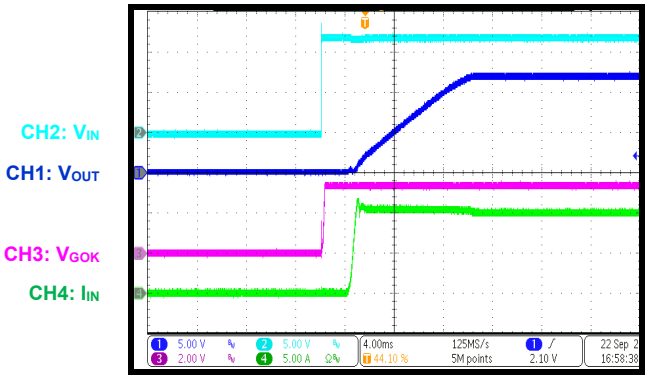
VIN Hot Plug

I_{OUT} = 0A



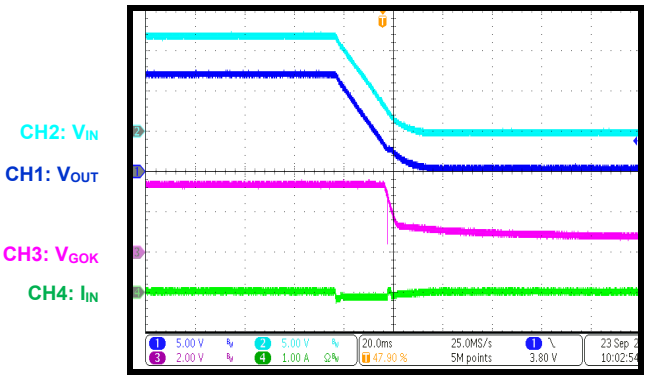
VIN Hot Plug

I_{OUT} = 10A



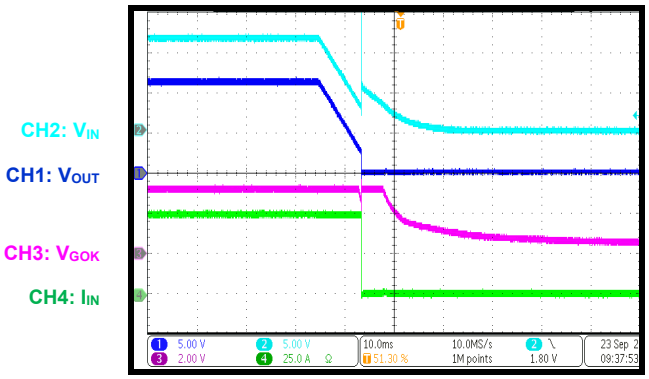
Shutdown through VIN

I_{OUT} = 0A



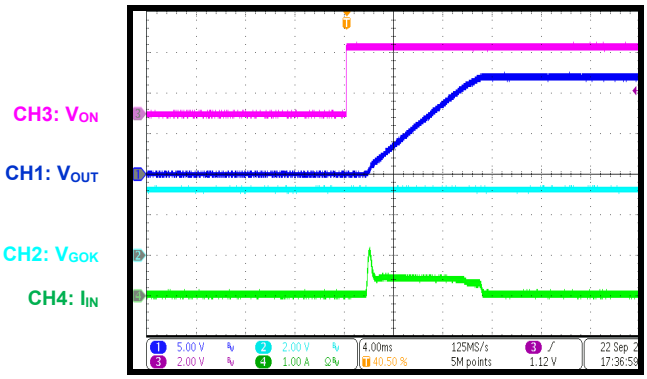
Shutdown through VIN

I_{OUT} = 50A



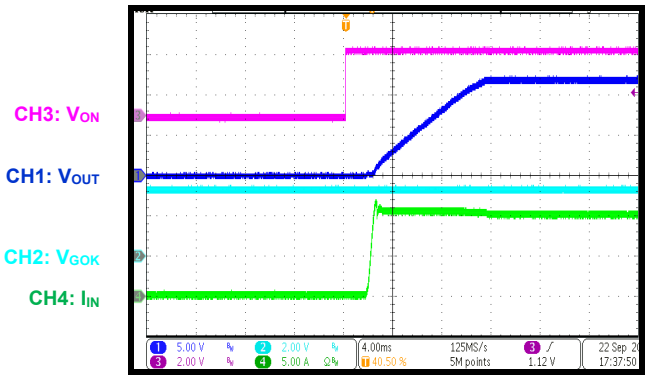
Start-Up through ON

I_{OUT} = 0A



Start-Up through ON

I_{OUT} = 10A

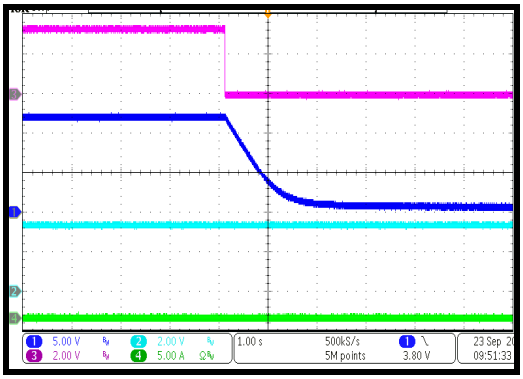


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, R_{CS} = R_{IMON} = 2kΩ, C_{OUT} = 330µF, T_J = 25°C, unless otherwise noted.

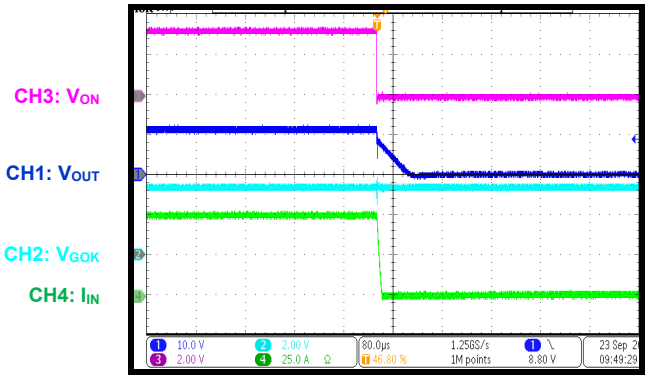
Shutdown through ON

I_{OUT} = 0A



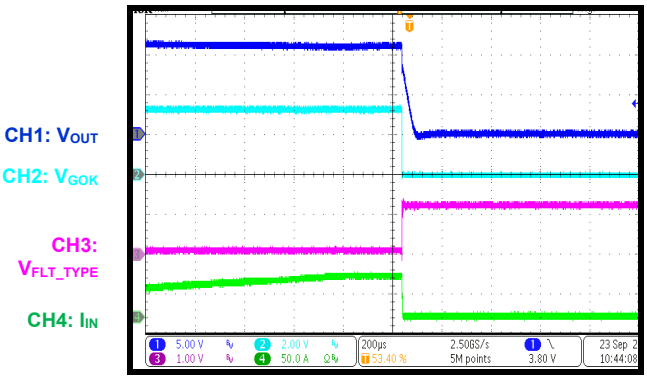
Shutdown through ON

I_{OUT} = 50A



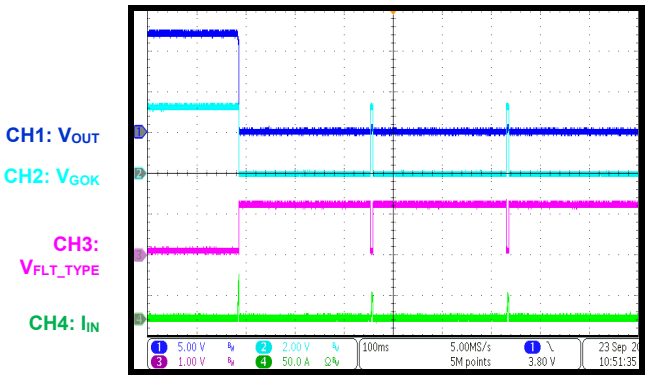
Over-Current Protection

I_{LIMIT} = 50A, latch mode



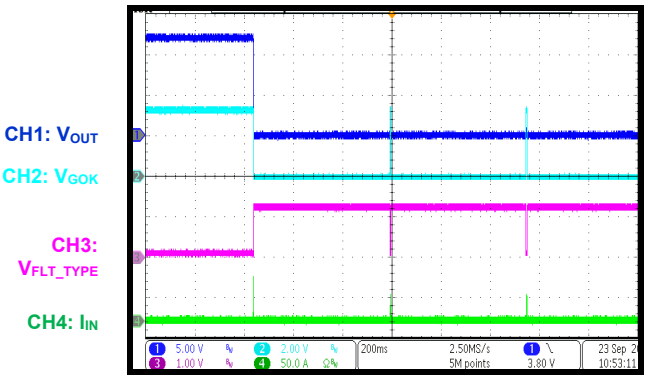
Over-Current Protection

I_{LIMIT} = 50A, hiccup mode, t_{RETRY} = 250ms



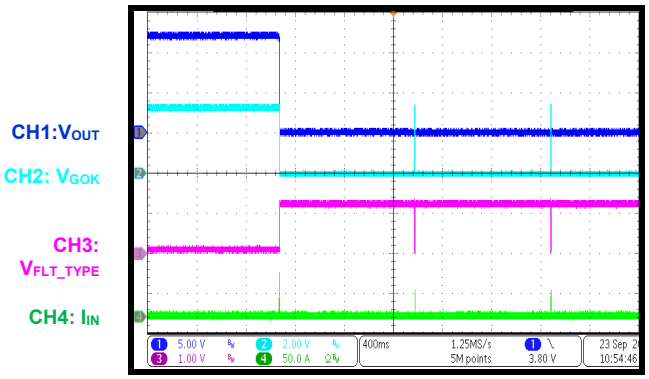
Over-Current Protection

I_{LIMIT} = 50A, hiccup mode, t_{RETRY} = 500ms



Over-Current Protection

I_{LIMIT} = 50A, hiccup mode, t_{RETRY} = 1s

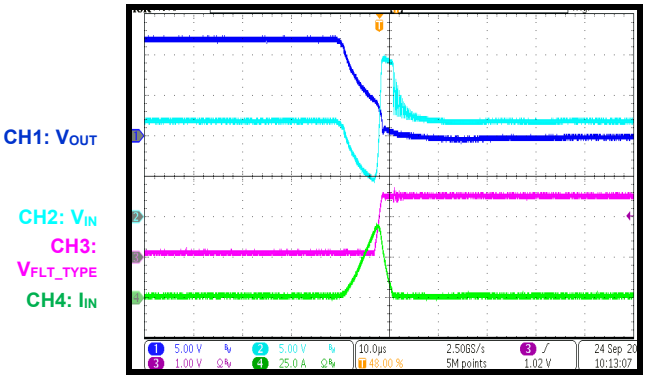


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, R_{CS} = R_{IMON} = 2kΩ, C_{OUT} = 330µF, T_J = 25°C, unless otherwise noted.

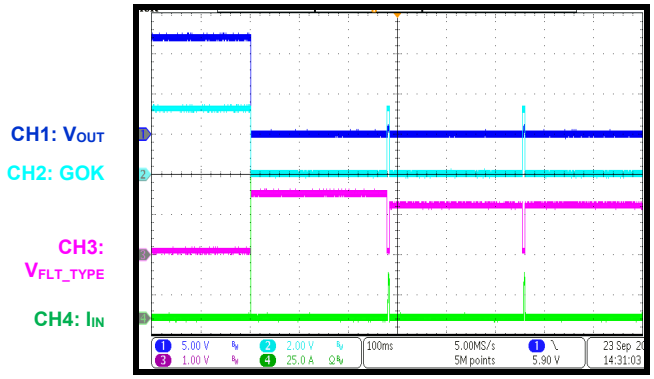
Short-Circuit Protection

I_{LIMIT} = 40A, latch mode

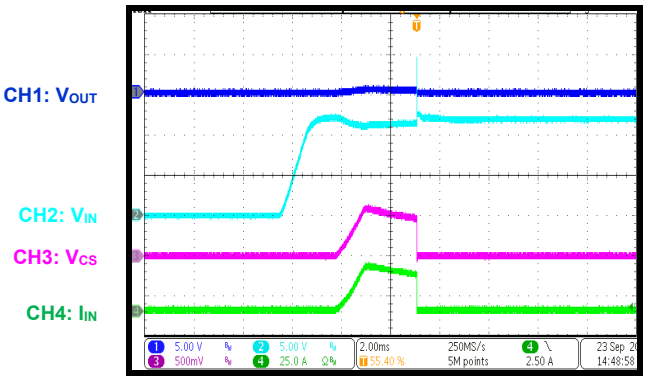


Short-Circuit Protection

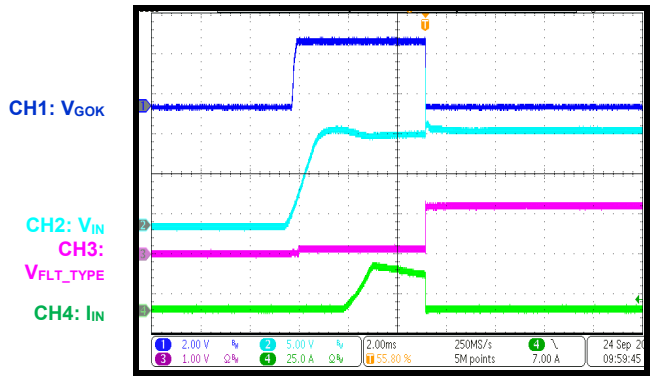
I_{LIMIT} = 100A, hiccup mode, t_{RETRY} = 250ms



Short Circuit Start-Up

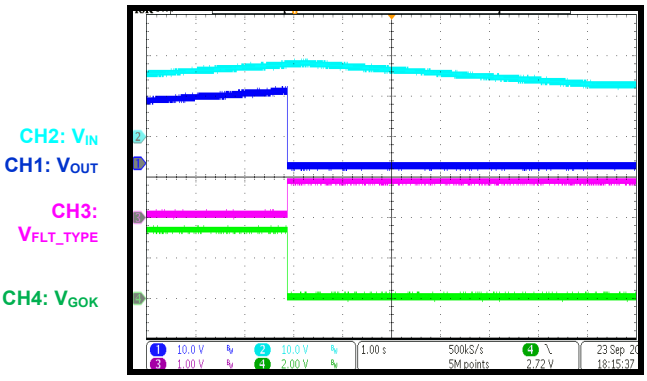


Short Circuit Start-Up



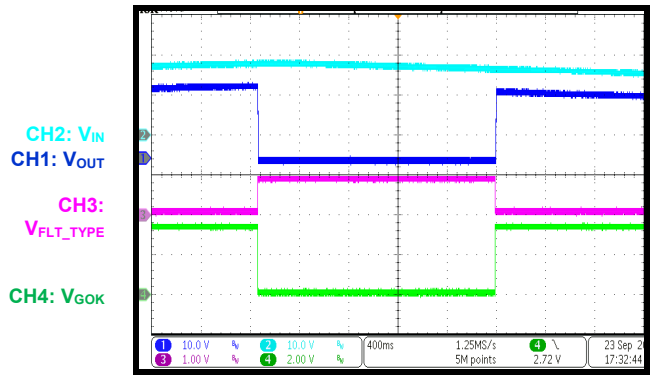
VIN OVP in Latch Mode

Latch mode, 18.5V applied to VIN, then V_{IN} is reduced



VIN OVP in Hiccup Mode

Hiccup mode, 18.5V applied to VIN, then V_{IN} is reduced

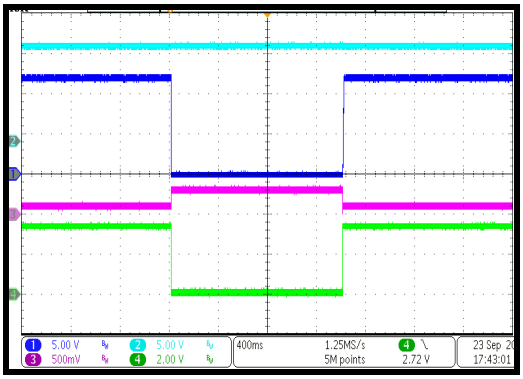


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, R_{CS} = R_{IMON} = 2kΩ, C_{OUT} = 330μF, T_J = 25°C, unless otherwise noted.

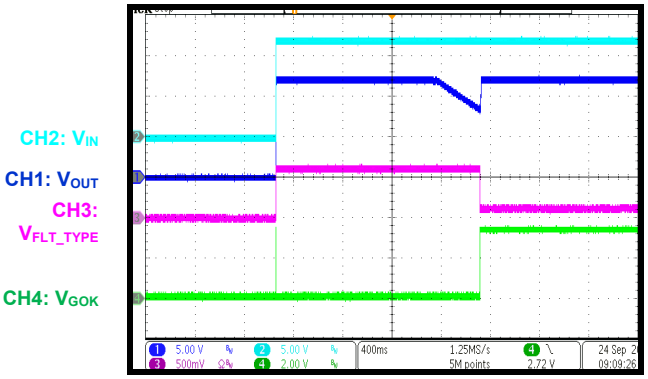
GOK Fault

GOK is pulled to GND, then GOK is pulled high



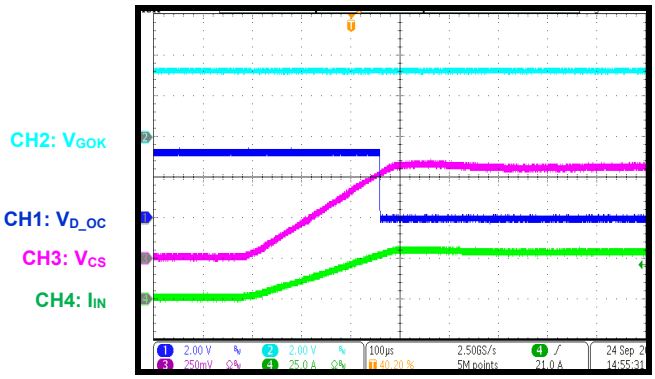
DS Short

Start-up with DS short, then DS short is removed



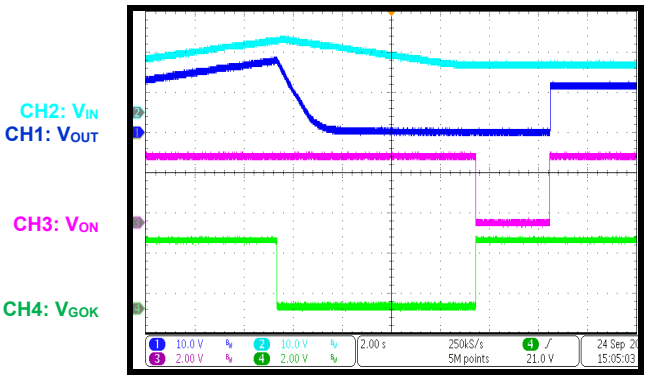
D_OC Status

Normal operation, V_{OCREF} = 0.6V, increase load, D_OC is pulled low once V_{CS} = 0.51V



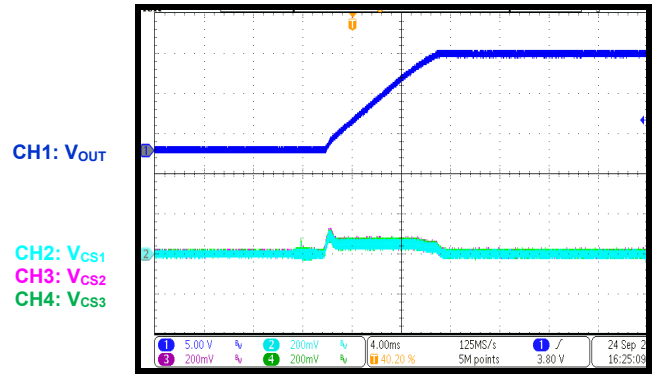
ON Signal to Clear Fault Status

Latch mode, apply V_{IN} to trigger OVP, reduce V_{IN} to 12V, then cycle the power on ON



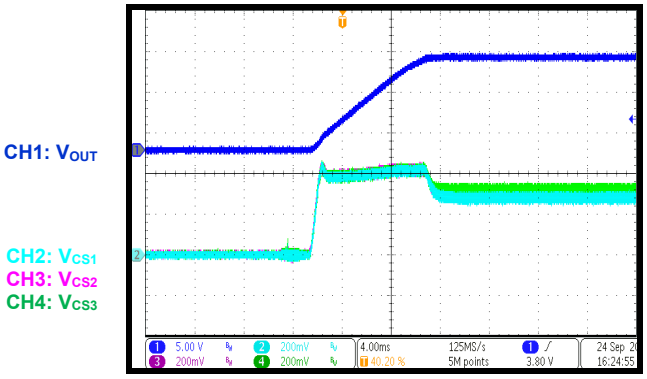
Current Balance during Start-Up

MP5991 3-phase parallel operation, R_{IMON} = R_{CS} (per MP5991), I_{OUT} = 0A



Current Balance during Start-Up

MP5991 3-phase parallel operation, R_{IMON} = R_{CS} (per MP5991), I_{OUT} = 45A



PCB LAYOUT

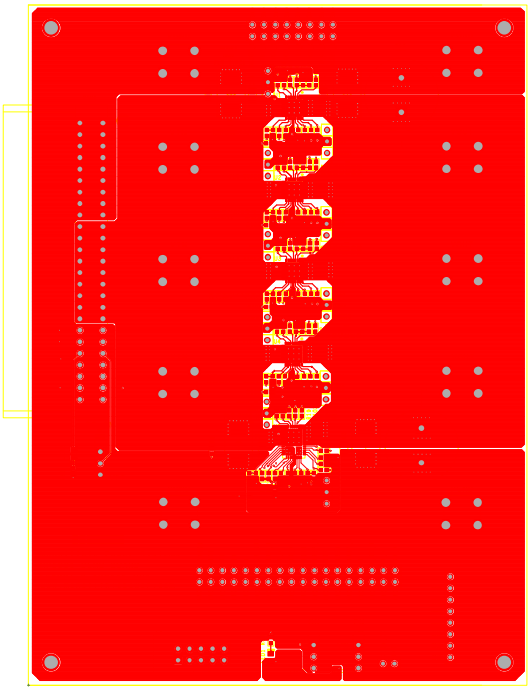


Figure 5: Top Layer

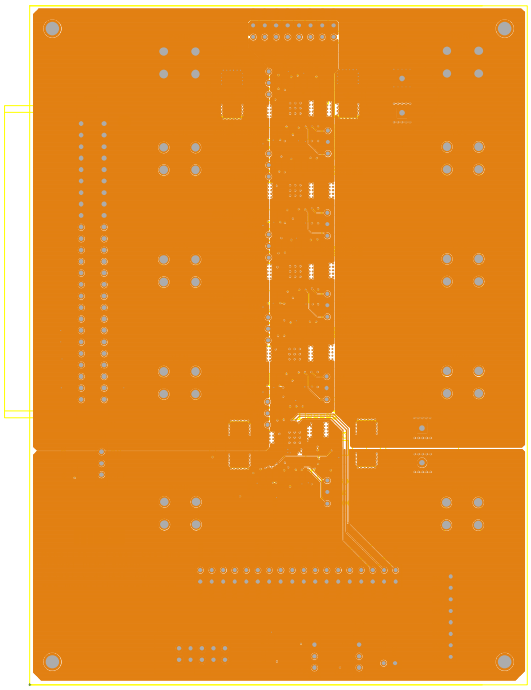


Figure 6: Mid-Layer 1

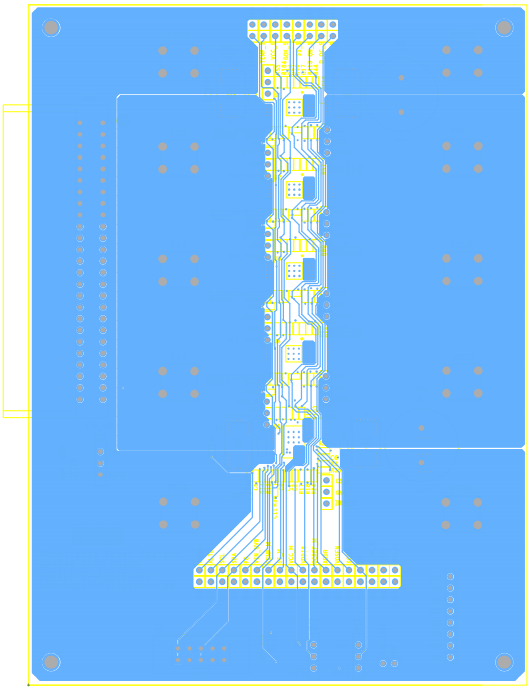


Figure 7: Mid-Layer 2

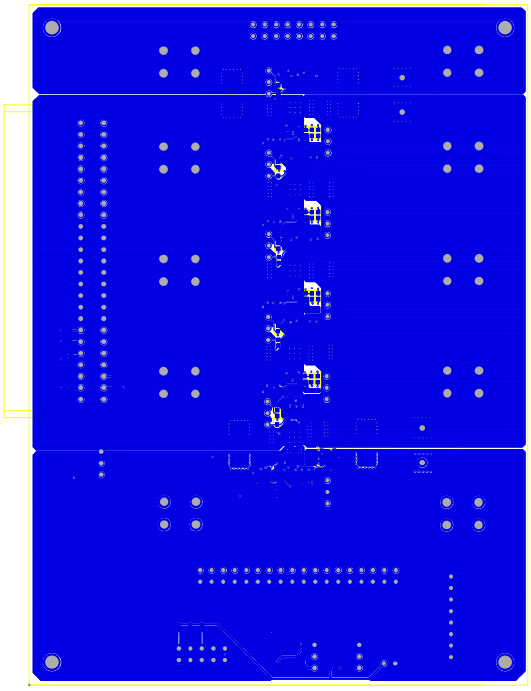


Figure 8: Bottom Layer

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	7/25/2022	Initial Release	-