



EV5990-5991-V-5PHASE-00A

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

DESCRIPTION

The EV5990-5991-V-5PHASE-00A evaluation board is designed to demonstrate the capabilities of the MP5990 while working in parallel with multiple MP5991 devices. The MP5990 is a fully integrated, PMBus-compatible, compact hot-swap protection device. It contains a hot-swap controller and a high-side power MOSFET (HS-FET), which allow it to operate as a standalone device. The MP5990 can also operate as a hot-swap controller in parallel with the multi-phase MP5991. The evaluation board contains one phase of the MP5990 and four phases of the MP5991.

The evaluation board provides rich test pins and LED indications to simplify system evaluation. The paralleled MP5990's and MP5991's pins can be probed through the test pins, helping the user easily understand the

MP5990's operating principles.

The EV5990-5991-V-5PHASE-00A is compatible with discrete power source terminals and a power supply unit (PSU) interface, which meet different power supply verification requirements.

The MP5990 supports PMBus communication. Through the PMBus interface, the MP5990 can both monitor and report fault statuses, and set up configurations. The built-in non-volatile memory (NVM) supports storing custom configurations.

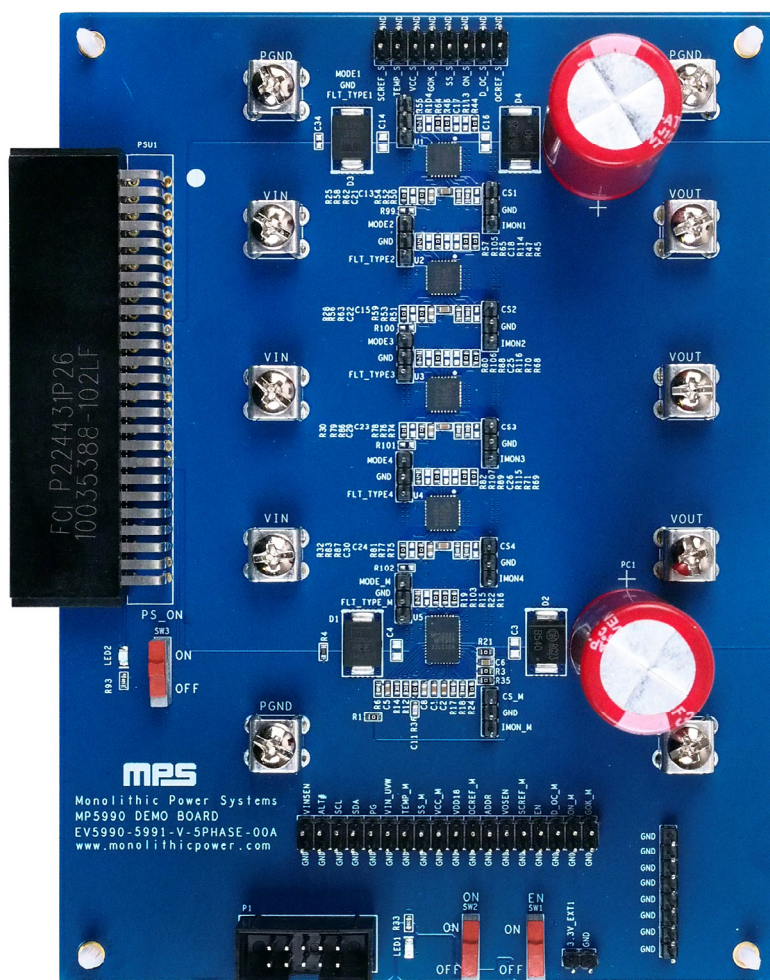
The MP5990 is available in an LGA-45 (5mmx7mm package), and the MP5991 is available in an LGA-32 (5mmx5mm package). The EV5990-5991-V-5PHASE-00A has 4 layers, which are each 2oz. The the total size of the board is 11cmx15cm.

PERFORMANCE SUMMARY ⁽¹⁾

Specifications are at $T_A = 25^{\circ}\text{C}$, unless otherwise noted.

Parameters	Conditions	Value
Input voltage (V_{IN}) range		4V to 16V
Soft-start time (t_{SS})	$C_{SS} = 100\text{nF}$	8.9ms
Active number of the MP5990 devices		1
Active number of the MP5991 devices		4
Address number	MP5990 default configuration	0x40h
Address setting		Set by pin
Power good (PG) on		8V
PG off		7V
V_{IN} on		9V
V_{IN} off		8V
V_{IN} under-voltage (UV) warning		8.5V
V_{IN} over-voltage protection (OVP) limit		18V
V_{IN} over-voltage (OV) warning		17V
Total over-current protection (OCP) limit		280A
Total OCP fault timer		2.5ms
Per phase OCP limit		60.2A
Per phase OC warning (D_{OC})		51.8A
Per phase short-circuit protection (SCP) limit		100A
Over-power (OP) warning limit		3120W
Sensed TEMP voltage (V_{TEMP}) over-temperature protection (OTP) limit		125°C
Sensed V_{TEMP} OTP warning		110°C
Protection mode		Latch-off

EVALUATION BOARD



LxWxH (11cmx15cmx1.6cm)

Board Number	MPS IC Number
EV5990-5991-V-5PHASE-00A	MP5990GMA

QUICK START GUIDE

To start up the EV5990-5991-V-5PHASE-00A, follow the steps below:

Start-Up through VIN

1. Preset the power supply between 4V and 12V ⁽¹⁾, then turn off the power supply.
2. Connect the power supply terminals to:
 - a. Positive (+): VIN
 - b. Negative (-): PGND
3. Connect the load terminals to:
 - a. Positive (+): VOUT
 - b. Negative (-): PGND
4. Turn the EN switch (SW1) and ON switch (SW2) on. Ensure these switches remain on.
5. After making the connections, turn on the power supply. The output voltage (V_{OUT}) should start up automatically.

Start-Up through EN

1. Connect the power supply terminals to:
 - a. Positive (+): VIN
 - b. Negative (-): PGND
2. Connect the load terminals to:
 - a. Positive (+): VOUT
 - b. Negative (-): PGND
3. Turn SW2 on and SW1 off, then turn on the power supply. V_{OUT} remains low during this time.
4. Turn SW1 on. V_{OUT} should start up automatically.

Start-Up through the Power Supply Unit (PSU)

1. Connect the load terminals to:
 - a. Positive (+): VOUT
 - b. Negative (-): PGND
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 SW1 and SW2 on.
4. Turn the PSU on. This should light up the PSU LED (LED2). V_{OUT} remains low during this time.
5. Turn SW3 on. V_{OUT} should start up automatically.

Note:

- 1) If testing with a continuous input voltage (V_{IN}) that exceeds 12V, remove the TVS diodes (D1 and D3), and replace with the appropriate TVS diodes according to V_{IN} .

MP5990 DEFAULT CODE

Name	Code	Type	Bytes	Default Value
OPERATION	01h	R/W	1	80h
WRITE_PROTECTION	10h	R/W	1	00h
VOUT_SCALE_LOOP	29h	R/W	2	0140h
VIN_ON	35h	R/W	2	0023h
VIN_OFF	36h	R/W	2	0020h
IOUT_CAL_GAIN	38h	R/W	2	0280h
IOUT_CAL_OFFSET	39h	R/W	2	0000h
IOUT_OC_FAULT_LIMIT	46h	R/W	2	0118h
IOUT_OC_WARN_LIMIT	4Ah	R/W	2	0104h
IOUT_GAIN_PHASE	4Dh	R/W	2	000Ah
OT_FAULT_LIMIT	4Fh	R/W	2	007Dh
OT_WARN_LIMIT	51h	R/W	2	006Eh
VIN_OV_FAULT_LIMIT	55h	R/W	2	0048h
VIN_OV_WARN_LIMIT	57h	R/W	2	0044h
VIN_UV_WARN_LIMIT	58h	R/W	2	0022h
POWER_GOOD_ON	5Eh	R/W	2	0080h
POWER_GOOD_OFF	5Fh	R/W	2	0070h
TON_DELAY	60h	R/W	2	0064h
TOFF_DELAY	64h	R/W	2	0000h
OP_WARN_LIMIT	6Ah	R/W	2	030Ch
CONFIG_ID	C0h	R/W	2	9000h
CONFIG_CODE_REV	C1h	R/W	2	0000h
PRODUCT_REV_USER	C2h	R/W	2	0000h
REV_CONST_CFG	C3h	R/W	1	00h
EFUSE_CFG	C4h	R/W	2	6888h
OCW_SC_REF	C5h	R/W	2	0FE5h
OC_REF	C6h	R/W	1	2Bh
ON_HICCUP_DLY	C7h	R/W	2	1019h
SYS_INITIAL_DELAY	D0h	R/W	2	0005h
ADDR_PMBUS	D2h	R/W	2	0040h
VIN_CFG	E3h	R/W	2	0000h
VIN_SCALE	E4h	R/W	2	0140h
TEMP_TUNE	E5h	R/W	2	CF5Ch
PROTECT_CFG	E6h	R/W	2	55EBh
VIN_PROTECT_LEVEL	E7h	R/W	2	00A0h
PRT_DELAY	E8h	R/W	2	5555h
SMBALERT_MASK	E9h	R/W	2	8000h
LEVEL_SEL	EBh	R/W	2	0401h
ADVANCE_CTRL	F1h	R/W	2	0D60h
RETRY_TIMES	F4h	R/W	2	0000h
CFG_EXT	F5h	R/W	2	0000h

PHASE CONFIGURATION

The EV5991-5991-V-5PHASE-00A can be configured between 1 and 5 operating phases by adjusting the evaluation board's parameters and configuration code (see Table 1).

Table 1: MP5990 and MP5991 Phase Configurations

Phase	Active Part	Remove Resistors					Notes
1 phase	U5	-	U1	U2	U3	U4	1. Stuff R113, R114, R115, and R116 with 0Ω. 2. U1, U2, U3, and U4 do not need to be removed. 3. Set 4Dh = 0x0002; adjust the over-current (OC) related registers.
		D_OC	R44	R45	R68	R69	
		ON	R46	R47	R70	R71	
		GOK	R64	R65	R88	R89	
		FLT_TYPE	R109	R110	R111	R112	
		SCREF_OCWREF	R25	R28	R30	R32	
		VTEMP	R62	R63	R86	R87	
		SS	R60	R61	R84	R85	
		IMON	R27	R29	R31	R34	
2 phases	U4 and U5	-	U1	U2	U3	U4	1. Stuff R113, R114, R116 with 0Ω. 2. U1, U2, and U3 do not need to be removed. 3. Set 4Dh = 0x0004; adjust the OC-related registers.
		D_OC	R44	R45	R68	-	
		ON	R46	R47	R70	-	
		GOK	R64	R65	R88	-	
		FLT_TYPE	R109	R110	R111	-	
		SCREF_OCWREF	R25	R28	R30	-	
		VTEMP	R62	R63	R86	-	
		SS	R60	R61	R84	-	
		IMON	R27	R29	R31	-	
3 phases	U3, U4, and U5	-	U1	U2	U3	U4	1. Stuff R113, R114 with 0Ω. 2. U1 and U2 do not need to be removed. 3. Set 4Dh = 0x0006; adjust the OC-related registers.
		D_OC	R44	R45	-	-	
		ON	R46	R47	-	-	
		GOK	R64	R65	-	-	
		FLT_TYPE	R109	R110	-	-	
		SCREF_OCWREF	R25	R28	-	-	
		VTEMP	R62	R63	-	-	
		SS	R60	R61	-	-	
		IMON	R27	R29	-	-	
4 phases	U2, U3, U4, and U5	-	U1	U2	U3	U4	1. Stuff R113 with 0Ω. 2. U1 does not need to be removed. 3. Set 4Dh = 0x0008; adjust the OC-related registers.
		D_OC	R44	-	-	-	
		ON	R46	-	-	-	
		GOK	R64	-	-	-	
		FLT_TYPE	R109	-	-	-	
		SCREF_OCWREF	R25	-	-	-	
		VTEMP	R62	-	-	-	
		SS	R60	-	-	-	
		IMON	R27	-	-	-	
5 phases	U1, U2, U3, U4, and U5	The default configuration is 5 phases.					

EVALUATION BOARD SCHEMATIC

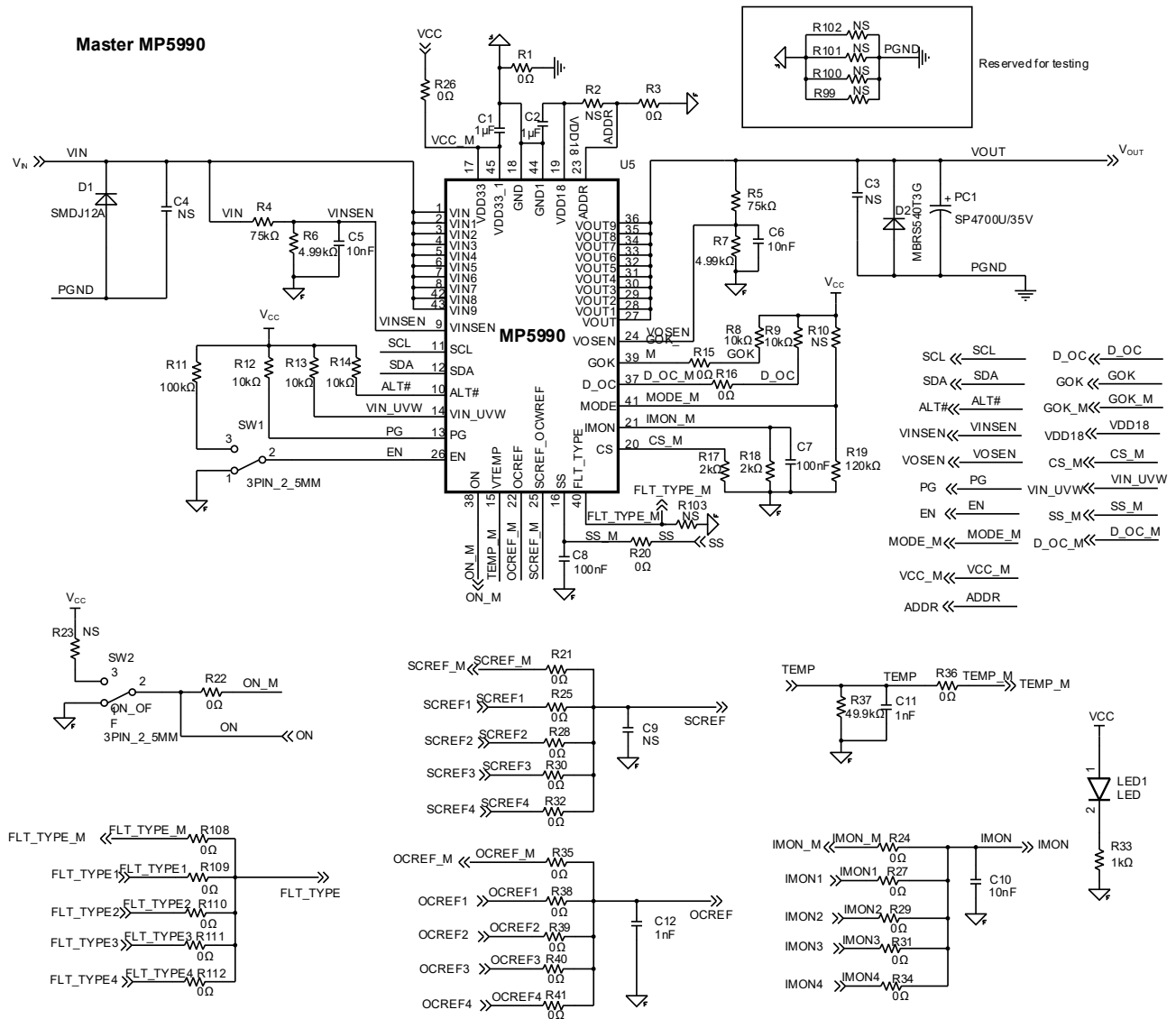


Figure 1: Evaluation Board Schematic (Master MP5990)

EVALUATION BOARD SCHEMATIC (continued)

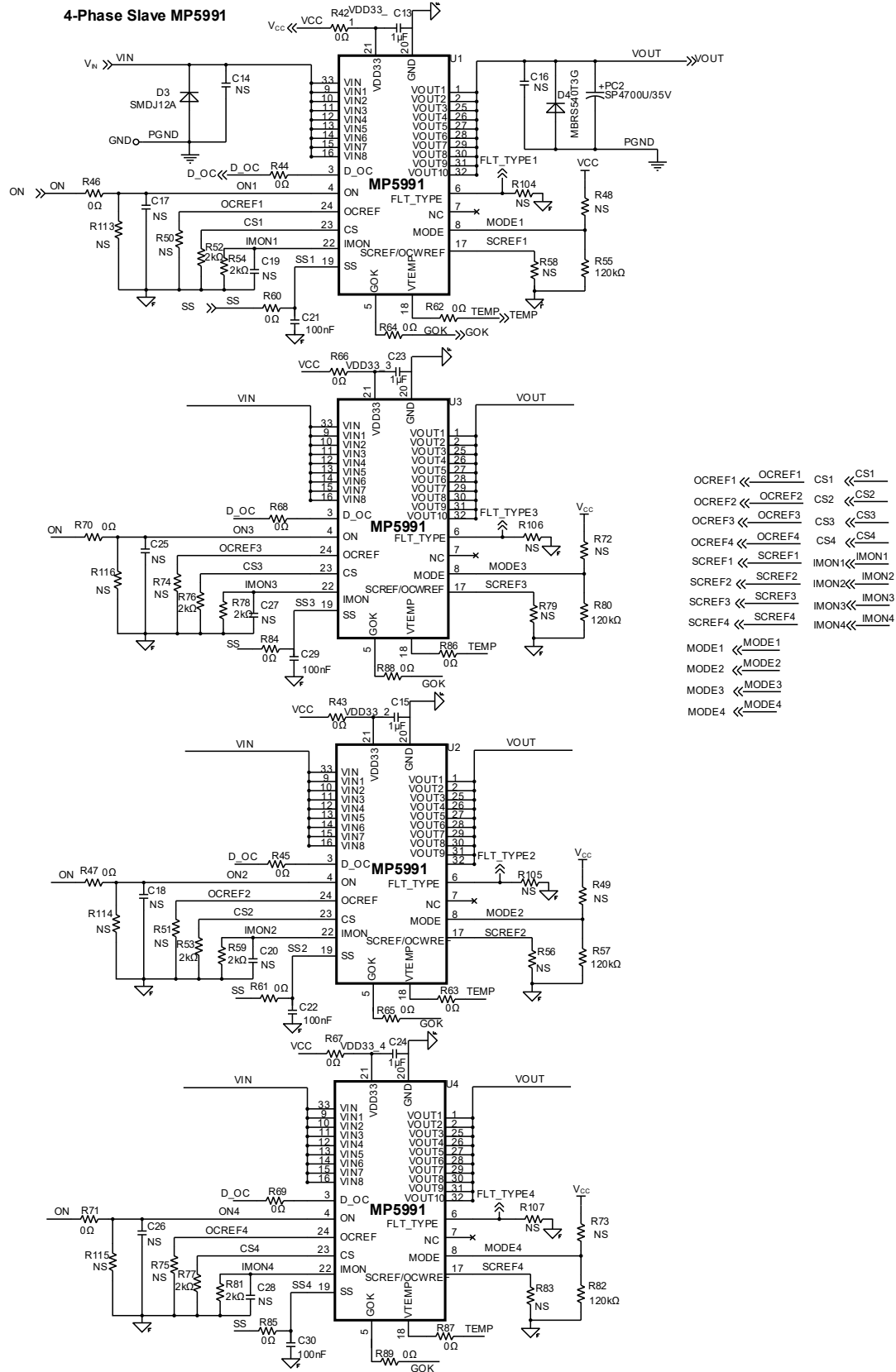


Figure 2: Evaluation Board Schematic (4-Phase Slave MP5991)

Test Pins and Connectors

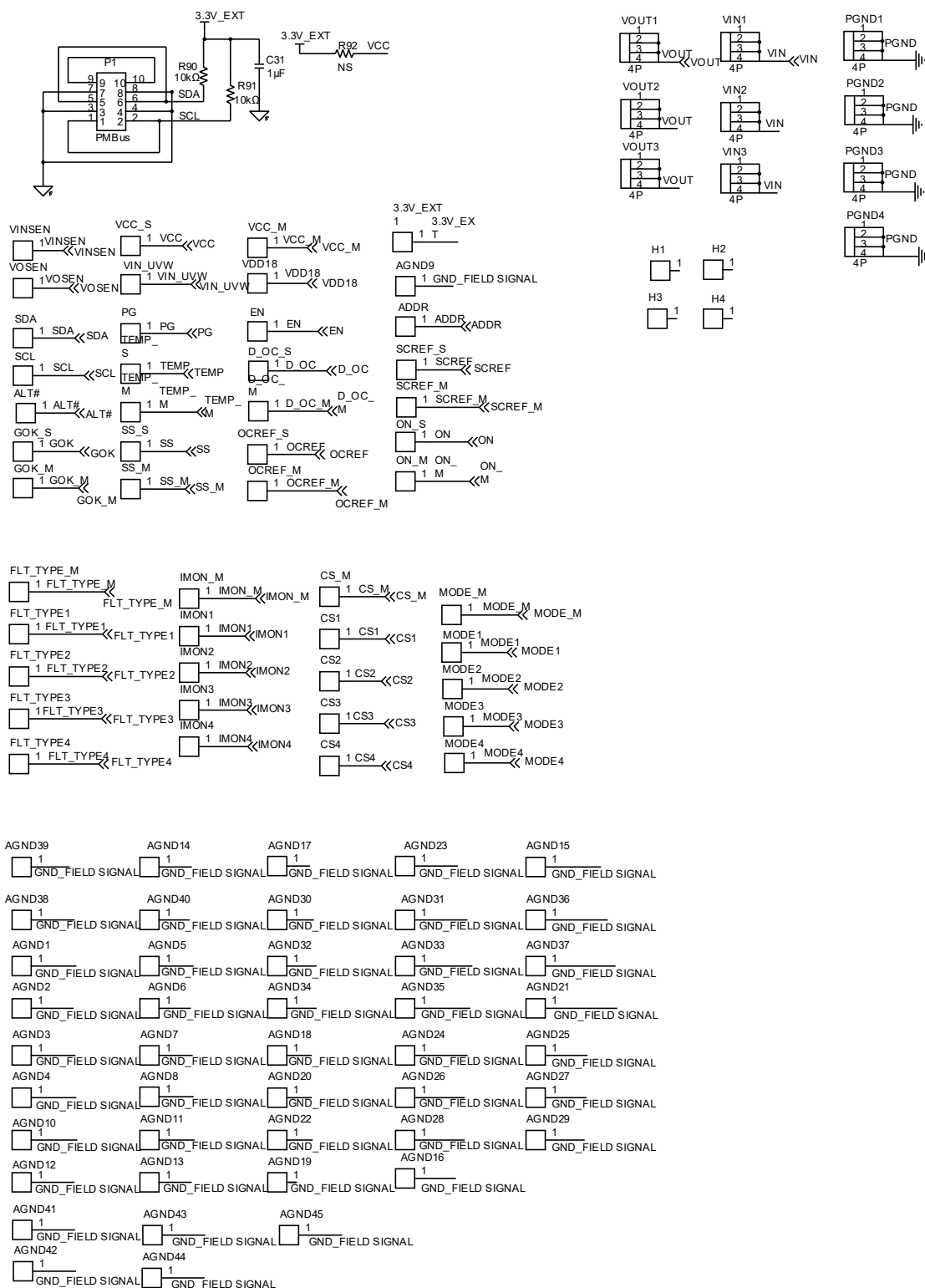


Figure 3: Evaluation Board Schematic (Test Pins and Connectors)

EVALUATION BOARD SCHEMATIC (continued)

PSU Interface

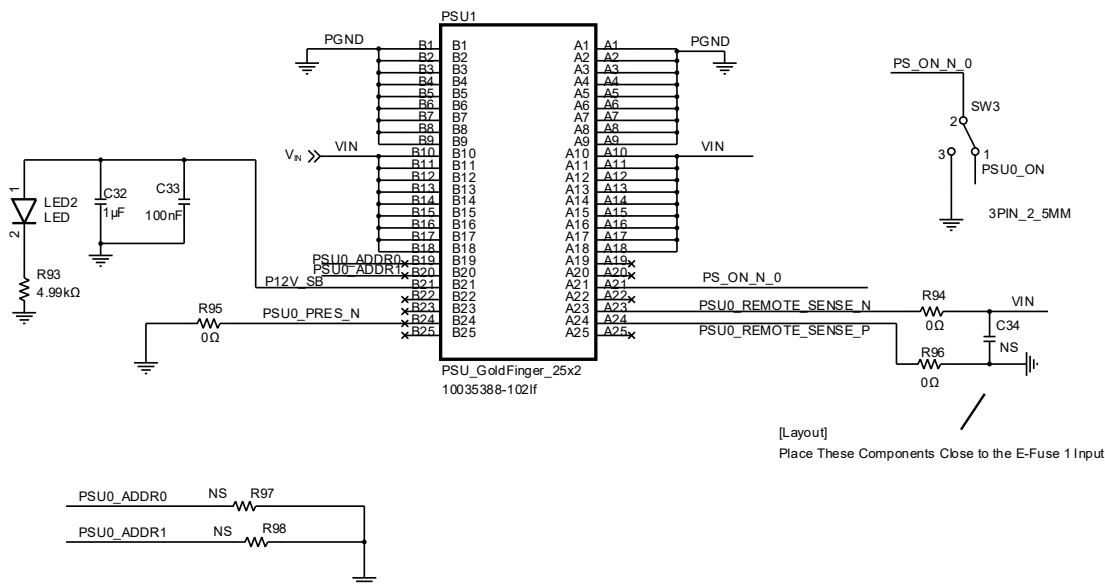


Figure 4: Evaluation Board Schematic (PSU Interface)

EV5990-5991-V-5PHASE-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	Test point	Through-hole	Any	

EV5990-5991-V-5PHASE-00A BILL OF MATERIALS (continued)

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
45	R2, C3, C4, C9, R10, C14, C16, C17, C18, C19, C20, R23, C25, C26, C27, C28, C34, R48, R49, R50, R51, R56, R58, R72, R73, R74, R75, R79, R83, R92, R97, R98, R99, R100, R101, R102, R103, R104, R105, R106, R107, R113, R114, R115, R116	NS				
3	C5, C6, C10	10nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H103 KA01D
7	C7, C8, C21, C22, C29, C30, C33	100nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R71H104 KA93D
8	C1, C2, C13, C15, C23, C24, C31, C32	1µF	Ceramic capacitor, 25V, X7R	0603	Murata	GCM188R71E105 KA64D
2	PC1, PC2	4700µF	Electrolytic capacitor, 35V	Through-hole	Wurth	860020581026(4700µF/35V)
2	C11, C12	1nF	Ceramic capacitor, 25V, COG	CAP/0603	Murata	GRM1885C1E102 JA01D
2	D2, D4	40V, 5A	SBD	SMC	onsemi	MBRS540T3G
2	D1, D3	12V	TVS diode	DO-214AB	Littelfuse	SMDJ12A
2	LED1, LED2	10mA	LED, blue	0805	Honglitronic	HL-PSC-2012H203BC
10	VOUT1, VIN1, PGND1, VOUT2, VIN2, PGND2, VOUT3, VIN3, PGND3, PGND4	30A	Connector	Through-hole	Any	
3	SW1, SW2, SW3	0.5A	Switch, 12V	Through-hole	Wurth	450301014042
1	P1	3A	Header, 5-pin, dual-row	Through-hole	Any	
1	PSU1	7A	PSU, GoldFinger, 25x2	Through-hole	FCI/Amphenol	10035388-102LF
1	R11	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%	0604	Yageo	RC0603FR-0749K9L
2	R4, R5	75kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0775KL

EV5990-5991-V-5PHASE-00A BILL OF MATERIALS *(continued)*

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
3	R6, R7, R93	4.99k Ω	Film resistor, 1%	0603	Yageo	RC0603FR-074K99L
1	R33	1k Ω	Film resistor, 1%	0603	Yageo	RC0603FR-071KL
55	R1, R3, R15, R16, R20, R21, R22, R24, 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	0 Ω	Film resistor, 1%	0603	Yageo	RC0603FR-070RL
10	R17, R18, R52, R53, R54, R59, R76, R77, R78, R81	2k Ω	Film resistor, 1%	0603	Yageo	RC0603FR-072KL
5	R19, R55, R57, R80, R82	120k Ω	Film resistor, 1%	0603	Yageo	RC0603FR-07120KL
1	U5	MP5990	Hot-swap Intelli-Fuse with PMBus, 16V, 50A, 1m Ω R _{DS(ON)}	LGA-45 (5mmx7mm)	MPS	MP5990GMA-9000
4	U1, U2, U3, U4	MP5991	Hot-swap Intelli-Fuse, 16V, 50A, 1m Ω R _{DS(ON)}	LGA-32(5mmx5mm)	MPS	MP5991GLU

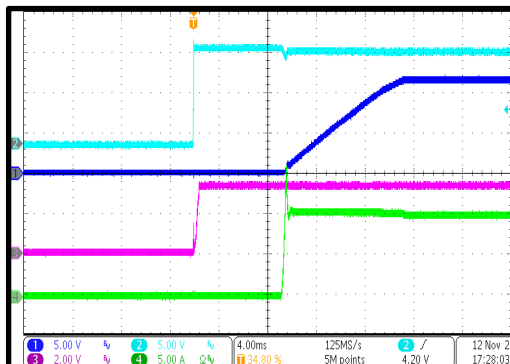
EVB TEST RESULTS

Performance curves and waveforms are tested on the evaluation board. $V_{IN} = 12V$, $R_{CS} = R_{IMON} = 2k\Omega$, $C_{OUT} = 330\mu F$, $T_J = 25^\circ C$, unless otherwise noted.

V_{IN} Hot Plug

 $I_{OUT} = 10A$

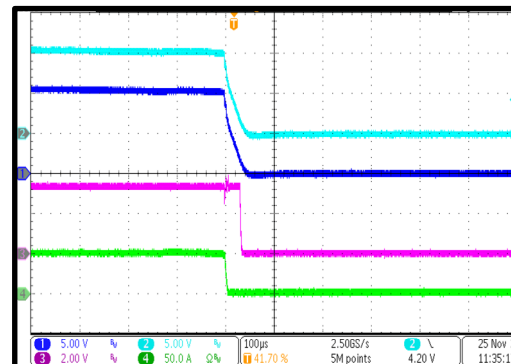
CH2: V_{IN}
CH1: V_{OUT}

CH3: GOK
CH4: I_{IN}


Shutdown through V_{IN}

 $I_{OUT} = 50A$

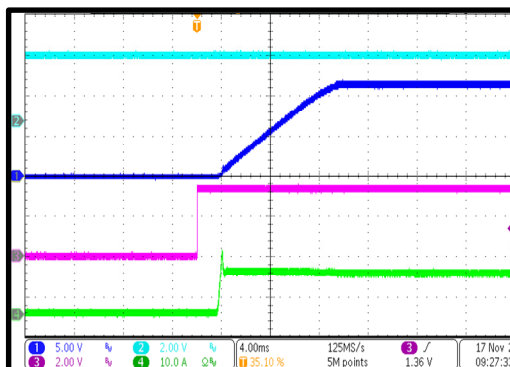
CH2: V_{IN}
CH1: V_{OUT}

CH3: SS
CH4: I_{IN}


Start-Up through EN

 $I_{OUT} = 10A$

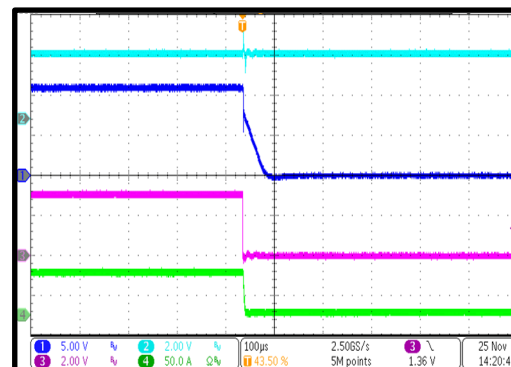
CH2: GOK
CH1: V_{OUT}

CH3: EN
CH4: I_{IN}


Shutdown through EN

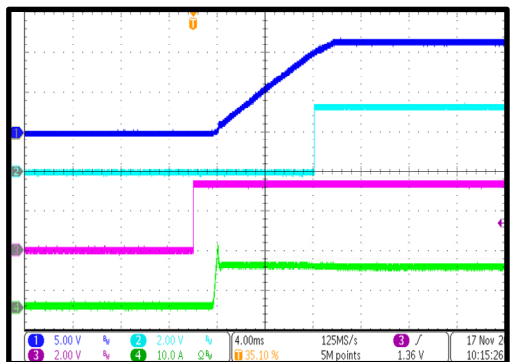
 $I_{OUT} = 50A$

CH2: GOK
CH1: V_{OUT}

CH3: EN
CH4: I_{IN}


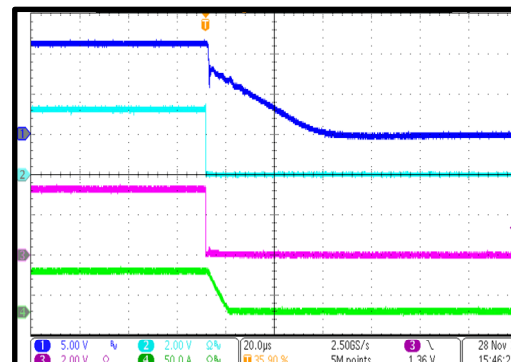
Start-Up through ON Command

 $I_{OUT} = 10A$, PG on = 10V

CH1: V_{OUT}
CH2: PG
CH3: ON
CH4: I_{IN}


Shutdown through ON Command

 $I_{OUT} = 50A$

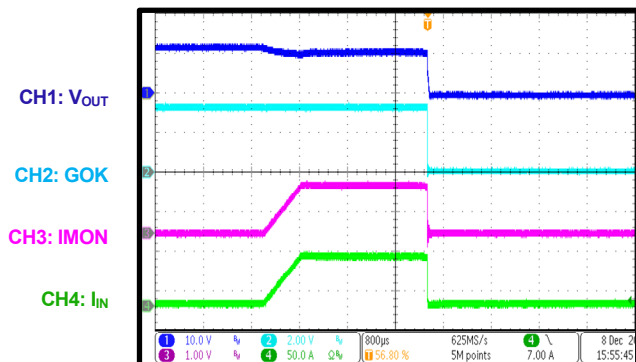
CH1: V_{OUT}
CH2: PG
CH3: ON
CH4: I_{IN}


EVB TEST RESULTS (continued)

$V_{IN} = 12V$, $C_{OUT} = 330\mu F$, $R_{CS} = R_{IMON} = 2k\Omega$, $T_A = 25^\circ C$, unless otherwise noted.

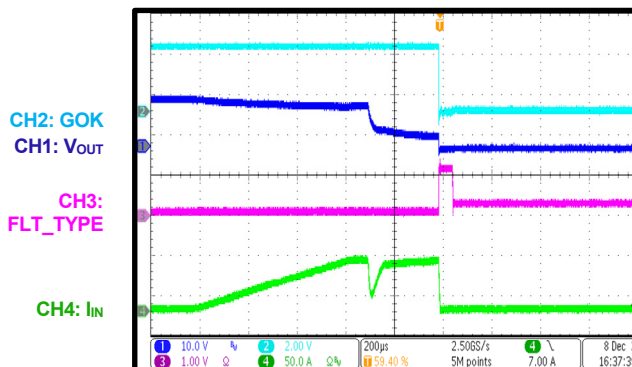
Total OCP

Total OCP limit = 55A, fault timer = 2ms, latch-off mode



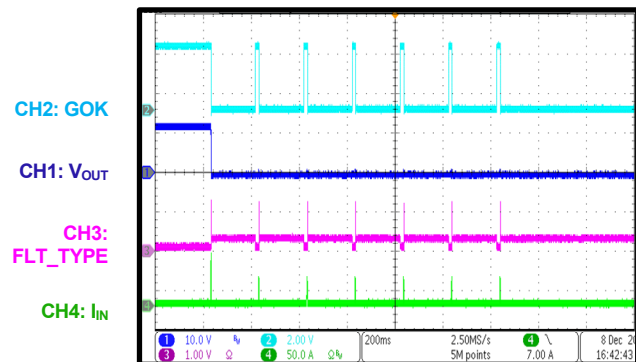
Per Phase OCP

Per phase OCP limit = 60A, latch-off mode



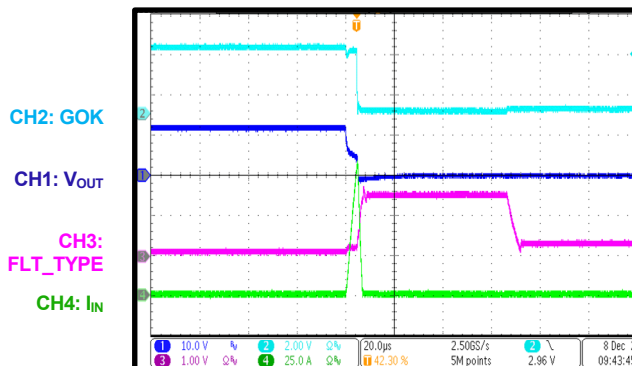
Per Phase OCP

Per phase OCP limit = 60A, set retry 6 times, auto-retry time = 200ms



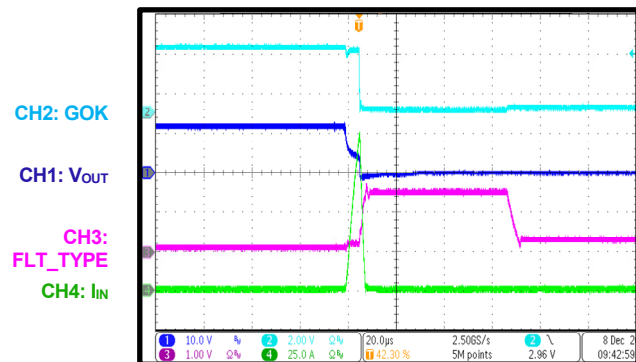
SCP

$I_{LIMIT} = 80A$, latch-off mode

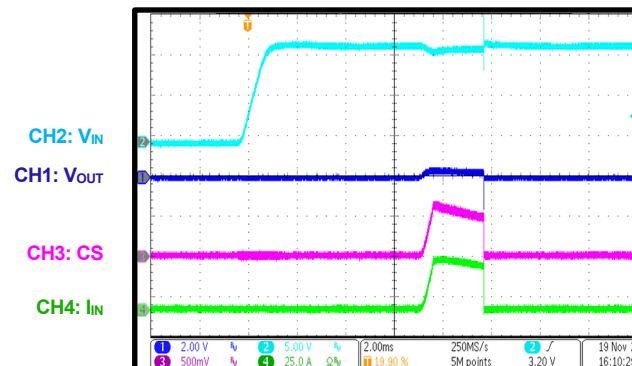


SCP

$I_{LIMIT} = 100A$, latch-off mode



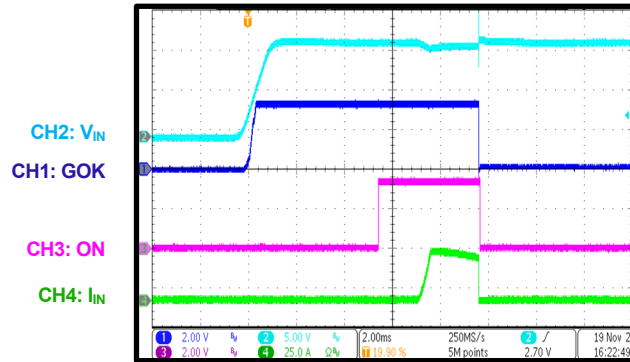
SCP Start-Up



EVB TEST RESULTS (continued)

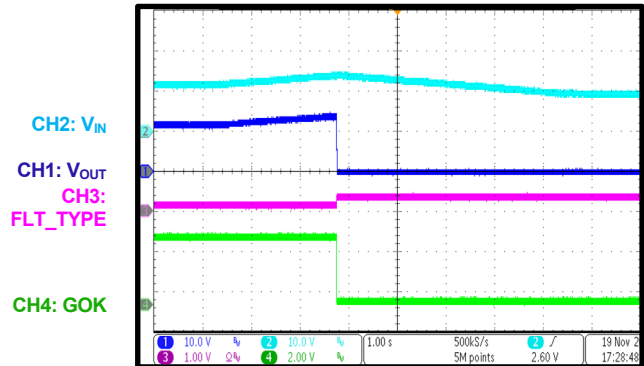
$V_{IN} = 12V$, $C_{OUT} = 330\mu F$, $R_{CS} = R_{IMON} = 2k\Omega$, $T_A = 25^\circ C$, unless otherwise noted.

SCP Start-Up



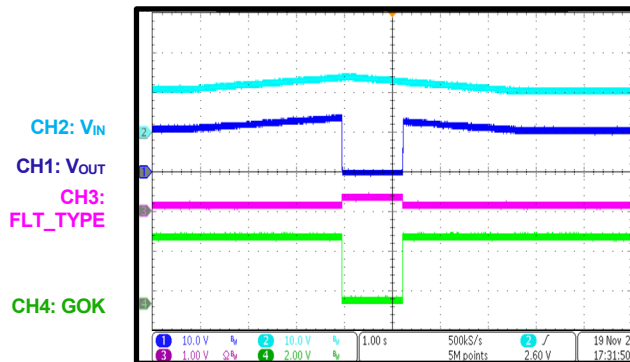
V_{IN} OVP in Latch-Off Mode

$V_{IN_RISING} = 14V$, $V_{IN_FALLING} = 13V$,
apply 14V on V_{IN} , then reduce V_{IN}



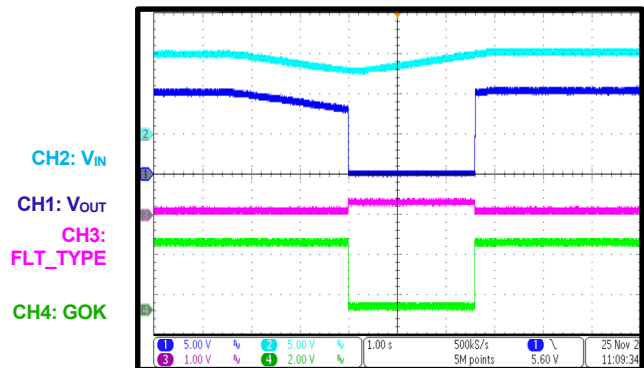
V_{IN} OVP in Hiccup Mode

$V_{IN_RISING} = 14V$, $V_{IN_FALLING} = 13V$,
apply 14V on V_{IN} , then reduce V_{IN}



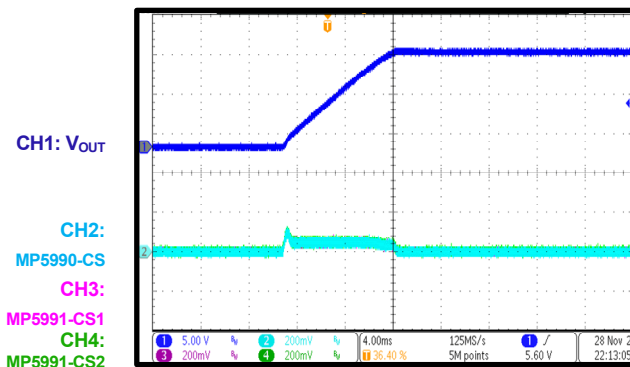
V_{IN} UVP

$V_{IN_RISING} = 10V$, $V_{IN_FALLING} = 8V$, reduce V_{IN} ,
then increase V_{IN}



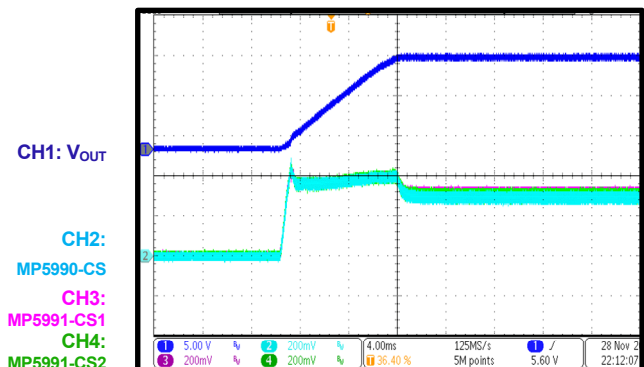
Current Balance during Start-Up at Paralleling

One MP5990 device and two MP5991 devices
operate in parallel, $R_{IMON} = R_{CS}$ per device,
 $I_{OUT} = 0A$



Current Balance during Start-Up at Paralleling

One MP5990 device and two MP5991 devices
operate in parallel, $R_{IMON} = R_{CS}$ per device,
 $I_{OUT} = 45A$



PCB LAYOUT

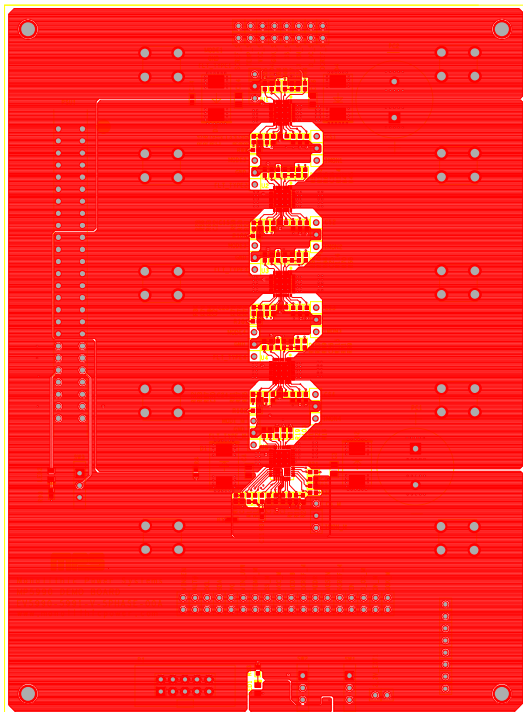


Figure 3: Top Layer

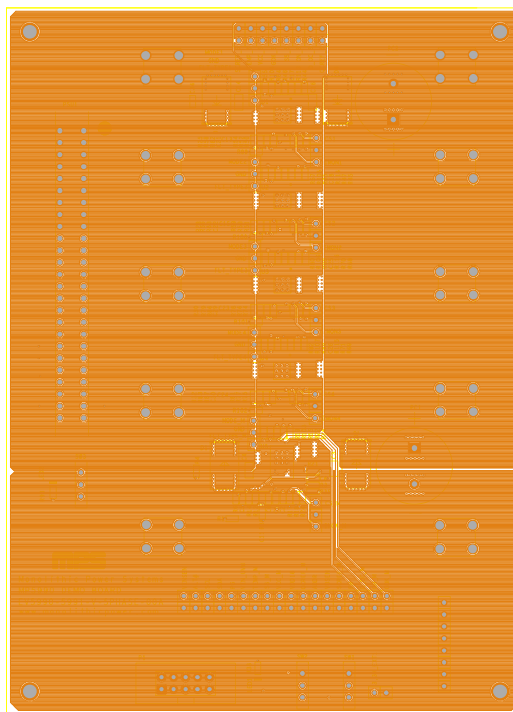


Figure 4: Mid-Layer 1

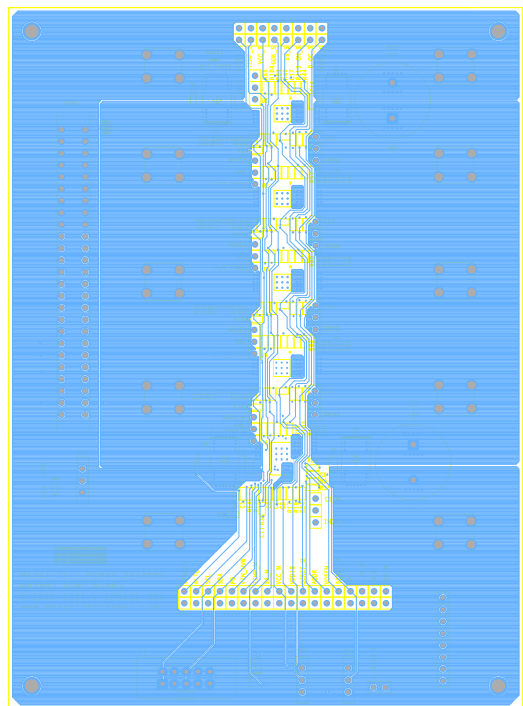


Figure 5: Mid-Layer 2

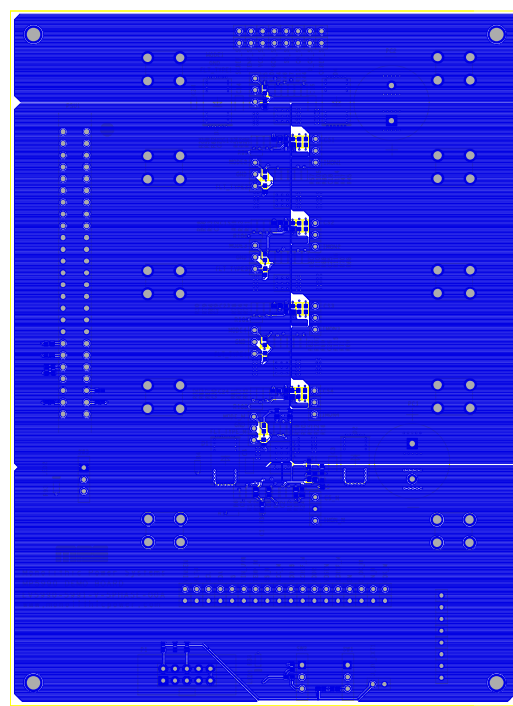


Figure 6: Bottom Layer



REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	1/31/2024	Initial Release	-

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