EVM3695-100-BH-00A/B/C

16V, 100A/200A/400A, Scalable DC/DC Power Module Evaluation Board

DESCRIPTION

The EVM3695-100-BH-00A/B/C series evaluation boards are designed to demonstrate the capabilities of the MPM3695-100, a fully integrated, 100A, scalable power module with a PMBus interface. The device offers a complete, high-efficiency power solution that achieves up to 100A of output current (I_{OUT}) with excellent load and line regulation across a wide input voltage (V_{IN}) range. Multiple devices can be placed in parallel to deliver up to 800A of I_{OUT}.

MPS's proprietary, multi-phase constant-on-time (MCOT) control provides ultra-fast transient response and simple loop compensation.

The EVM3695-100-BH-00A/B/C series has three options that accommodate one, two, or four MPM3695GBH-100 power modules to provide up to 100A, 200A, or 400A of I_{OUT}, respectively. The MPM3695-100 is available in a BGA (15mmx30mmx5.18mm) package.

FEATURES

- 3.3V to 16V Input Voltage (V_{IN}) Range
- 0.5V to 3.3V Output Voltage (V_{OUT}) Range
- 100A of Continuous Output Current (I_{OUT}) with a Maximum 1.8V V_{OUT}
- 60A of Continuous Current with 3.3V V_{OUT}
- Parallel for Up to 800A with Active Current Balancing
- Automatic Interleaving for Parallel Operation
- V_{OUT} Remote Sense
- ±1% Reference Voltage (V_{REF}) Accuracy (-40°C to +125°C)
- PMBus 1.3 Compliant
- Telemetry Readback Including V_{IN}, V_{OUT}, I_{OUT}, Temperature, and Faults
- Configurable via the PMBus
- Available in a BGA (15mmx30mmx5.18mm) Package

APPLICATIONS

- Telecom and Networking Systems
- Industrial Equipment
- Servers and Computing
- FPGA and ASIC Core Power

EVM3695-100-BH-00A/B/C SERIES EVALUATION BOARD

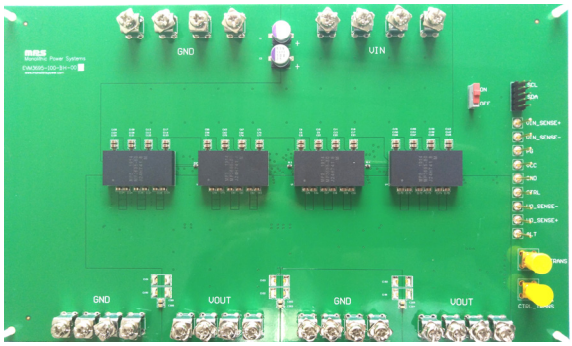
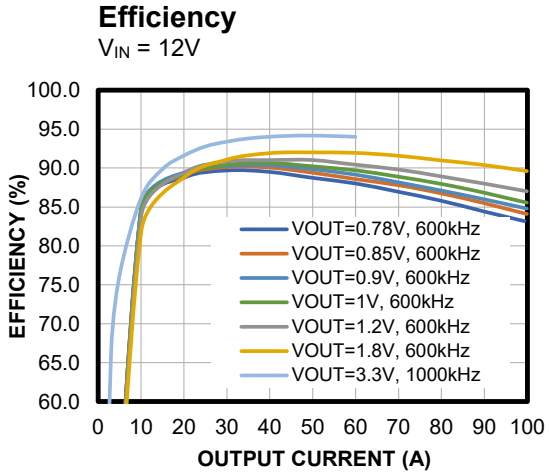


Figure 1: Four MPM3695-100 Modules and the EVM3695-100-BH-00C

Board Number	MPS IC Number
EVM3695-100-BH-00C	MPM3695GBH-100-0001



EVALUATION BOARD FEATURES

Parameter	Evaluation Board PN	Conditions	Value
Input voltage (V_{IN})	EVM3695-100-BH-00A		3.3V to 16V
	EVM3695-100-BH-00B		
	EVM3695-100-BH-00C		
Output voltage (V_{OUT})	EVM3695-100-BH-00A	V_{IN} = 4V to 16V	0.5V to 3.3V Default: 1.2V
	EVM3695-100-BH-00B		
	EVM3695-100-BH-00C		
Maximum output current (I_{OUT})	EVM3695-100-BH-00A	V_{IN} = 12V, V_{OUT} = 0.5V to 1.8V	100A
	EVM3695-100-BH-00B		200A
	EVM3695-100-BH-00C		400A
Default switching frequency (f_{SW})	EVM3695-100-BH-00A		600kHz
	EVM3695-100-BH-00B		
	EVM3695-100-BH-00C		
Number of MPM3695-100 power modules on the board	EVM3695-100-BH-00A		1
	EVM3695-100-BH-00B		2
	EVM3695-100-BH-00C		4

QUICK START GUIDE

1. Preset the DC power supply (V_{IN}) to be between 4V and 16V, then turn the power supply off.
2. Connect the power supply terminals to:
   a. Positive (+): VIN
   b. Negative (-): GND
3. Connect the load terminals to:
   a. Positive (+): VOUT
   b. Negative (-): GND
4. Turn the power supply on after making the connections. The board should automatically start up at 1.2V.
5. Set the output voltage (V_{OUT}) by using a feedback resistor divider to set the feedback gain. Calculate the feedback resistor value (R_{11}) with Equation (1):

$$R_{11}(k\Omega) = \frac{0.6}{V_{OUT} - 0.6} \times R_8(k\Omega) \quad (1)$$

   Where V_{OUT} is the output voltage. The V_{OUT} feedback gain (G_{FB}) can be estimated with Equation (2):

$$G_{FB} = \frac{R_{11}}{R_8 + R_{11}} \quad (2)$$

6. To set V_{OUT} via the PMBus, follow the steps below:
   a. Calculate G_{FB} with Equation (2). Write this value to the VOUT_SCALE_LOOP register.
   b. Write the V_{OUT} value to the VOUT_COMMAND register.

   The reference voltage (V_{REF}) is automatically updated based on the values for V_{OUT} and G_{FB}.
7. V_{REF} (0.6V by default) can be adjusted to be between 0.5V and 0.672V.

VIRTUAL BENCH PRO 3.0 GUI

Virtual Bench Pro 3.0 is a powerful graphic user interface (GUI) developed for MPS's digital, configurable power modules and ICs. The software supports a wide range of functions, including reading/writing to registers, monitoring the operation statuses, issuing diagnoses, and loading/saving configuration files. The software also supports automatic updates so users can keep the software up to date. This tool requires a USB to I²C communication interface (EVKT-USBI2C-02) to communicate between the power module/IC and a hosting computer. Follow the steps listed below to use the Virtual Bench Pro 3.0 GUI. Visit the MPS website to download Virtual Bench Pro 3.0.

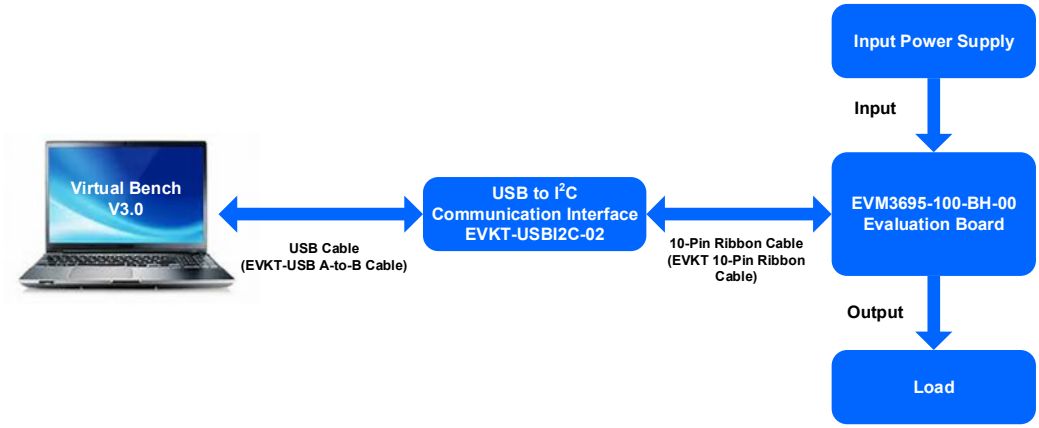


Figure 2: USB to I²C Communication Interface

The hardware must be properly configured prior to use. Follow the instructions below to set up the evaluation board.

1. Connect the PMBus cable to both the evaluation board and the EVKT-USBI2C-02. The data signal (SDA) and clock signal (SCL) are labeled on the evaluation board.
2. Connect the EVKT-USBI2C-02 to the PC using the USB cable (see Figure 3).

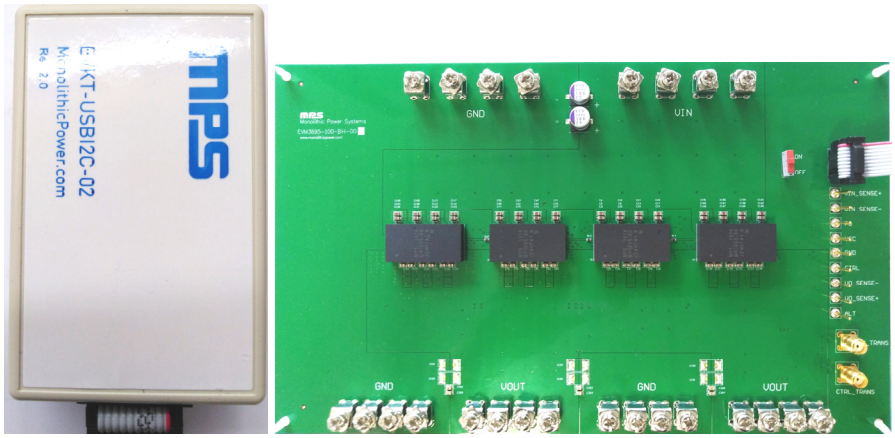


Figure 3: Connecting the I²C Communication Interface

3. Start up the evaluation board by following the Quick Start Guide section on page 3. Once the EVB is powered up, use Virtual Bench Pro 3.0 to configure and monitor the power modules.
4. Open Virtual Bench Pro 3.0. The software should automatically scan the connected power modules.

   If the GUI detects the power module, an address appears next to the "MPM3695-100" on the left panel, and the indicator turns green (see Figure 4 on page 5). See the Evaluation Board Connection Issue section on page 9 if the power module is not detected.

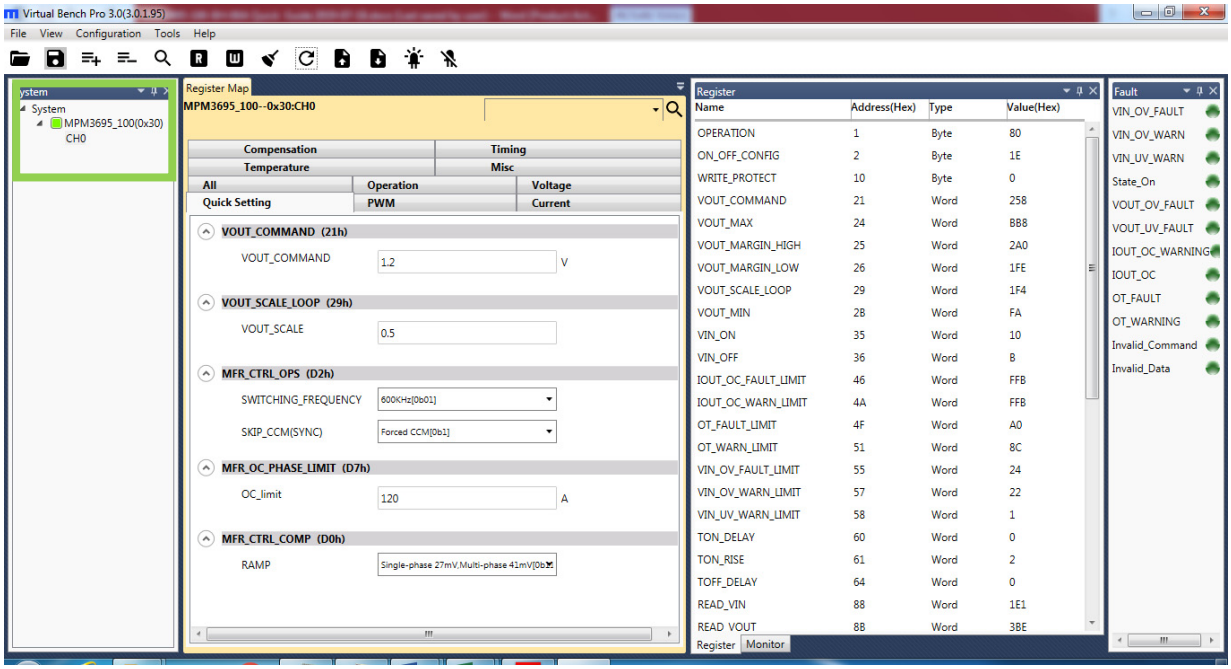


Figure 4: Successful Connection

5. The values stored in the registers of the module are read automatically (see Figure 5).

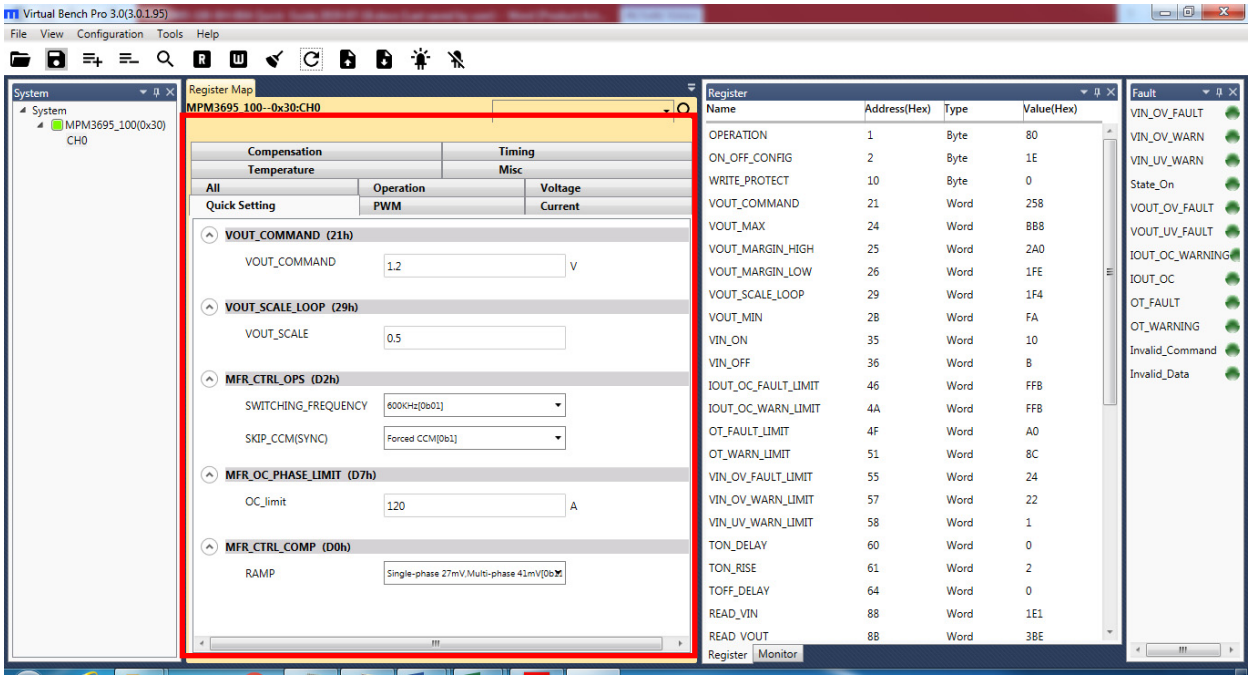


Figure 5: Reading the Register Values

6. Configure the registers using valid inputs (see Figure 6). If an invalid input is entered, an alert is issued, and the value is not accepted.

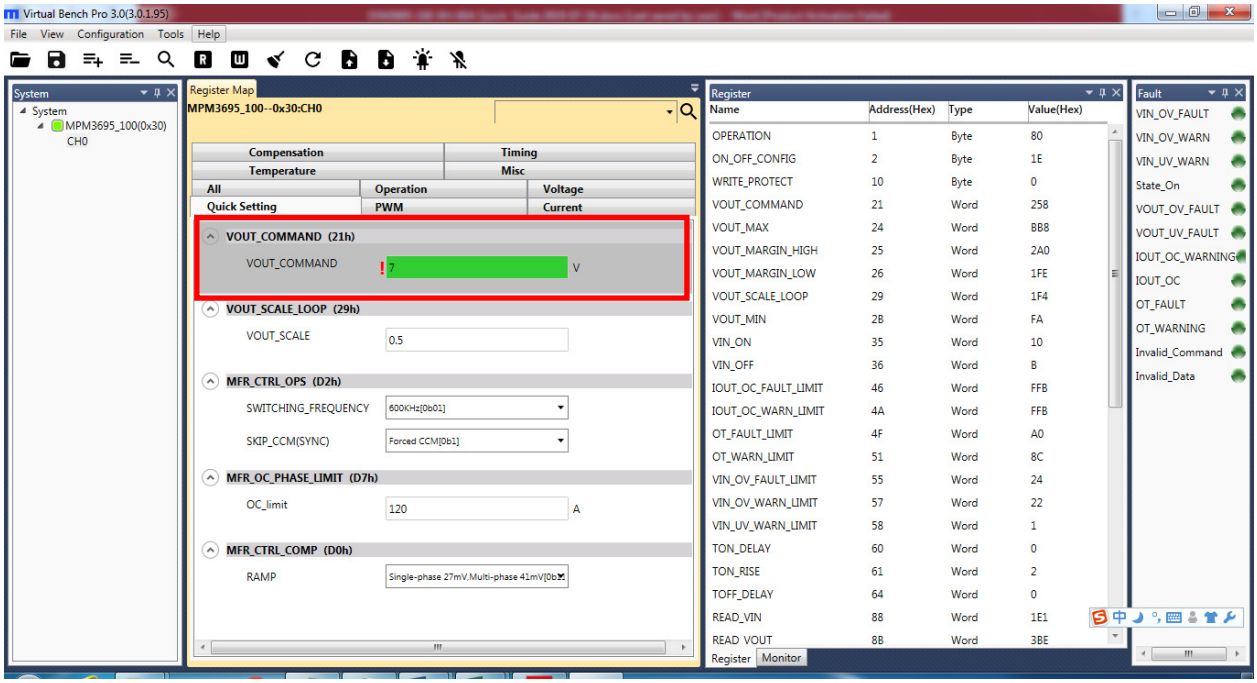


Figure 6: Inputting Values in the Register

7. Click “Write to chip” (denoted with a “W”) to write values to the register (see Figure 7).

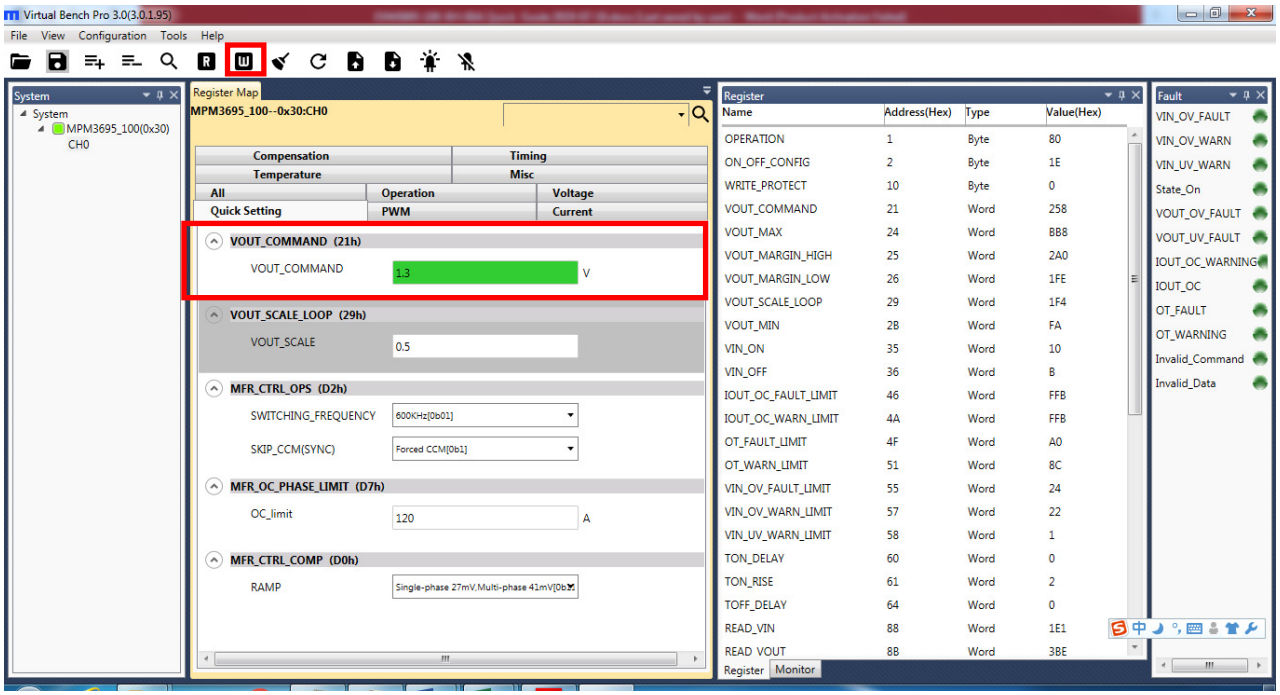


Figure 7: Writing Values to the Register

Note that if the values written to the registers are not saved in the multiple-time programmable (MTP) memory, the values are lost once the evaluation board shuts down.

8. To save the values into the MTP, click “Write to MTP” (denoted with a downward arrow) and wait until the writing action is completed (see Figure 8).

   To write to the MTP, set the input voltage to be between 8V and 16V.

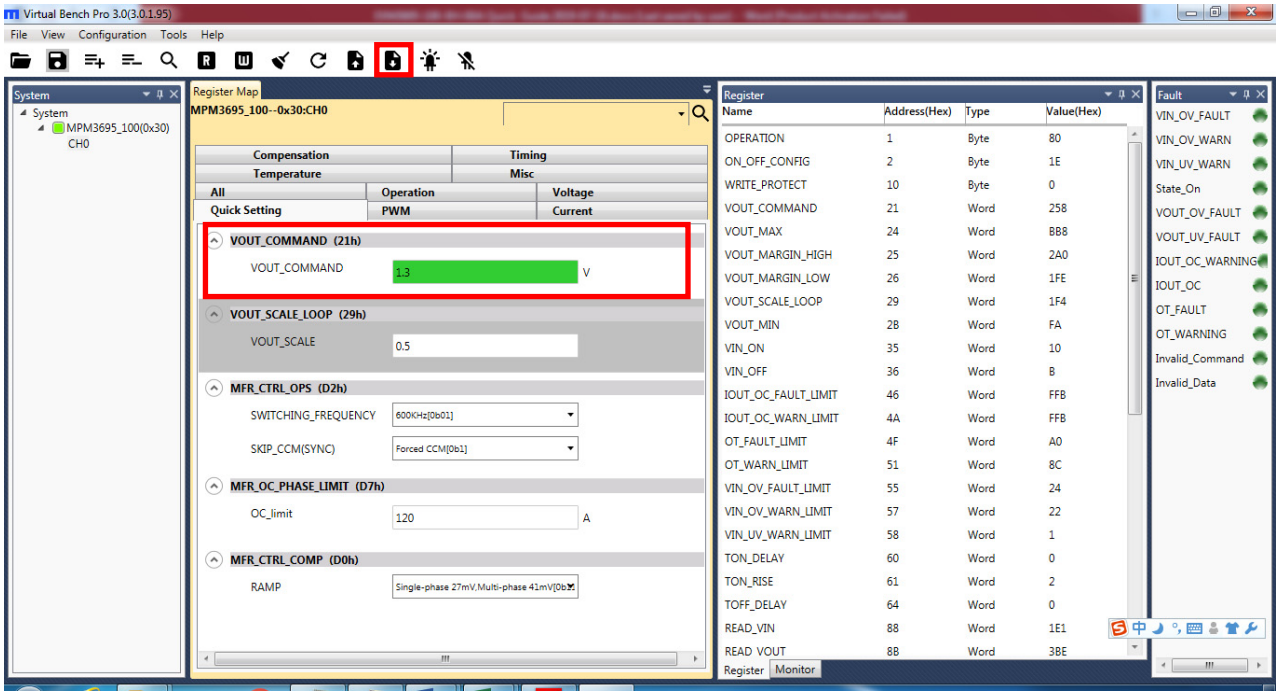


Figure 8: Writing to the MTP

9. Turn the power supply off.
10. Wait three seconds, then turn the power supply on. The new configuration should be saved.

TROUBLESHOOTING TIPS

Evaluation Board Connection Issue

If the power module cannot be automatically detected, follow the steps below:

1. Click on the icon denoted with three horizontal lines and a (+) sign (see Figure 9). Choose the MPM3695-100 from the list.
2. Click on the magnifying glass icon, then search for the I²C address (see Figure 9).

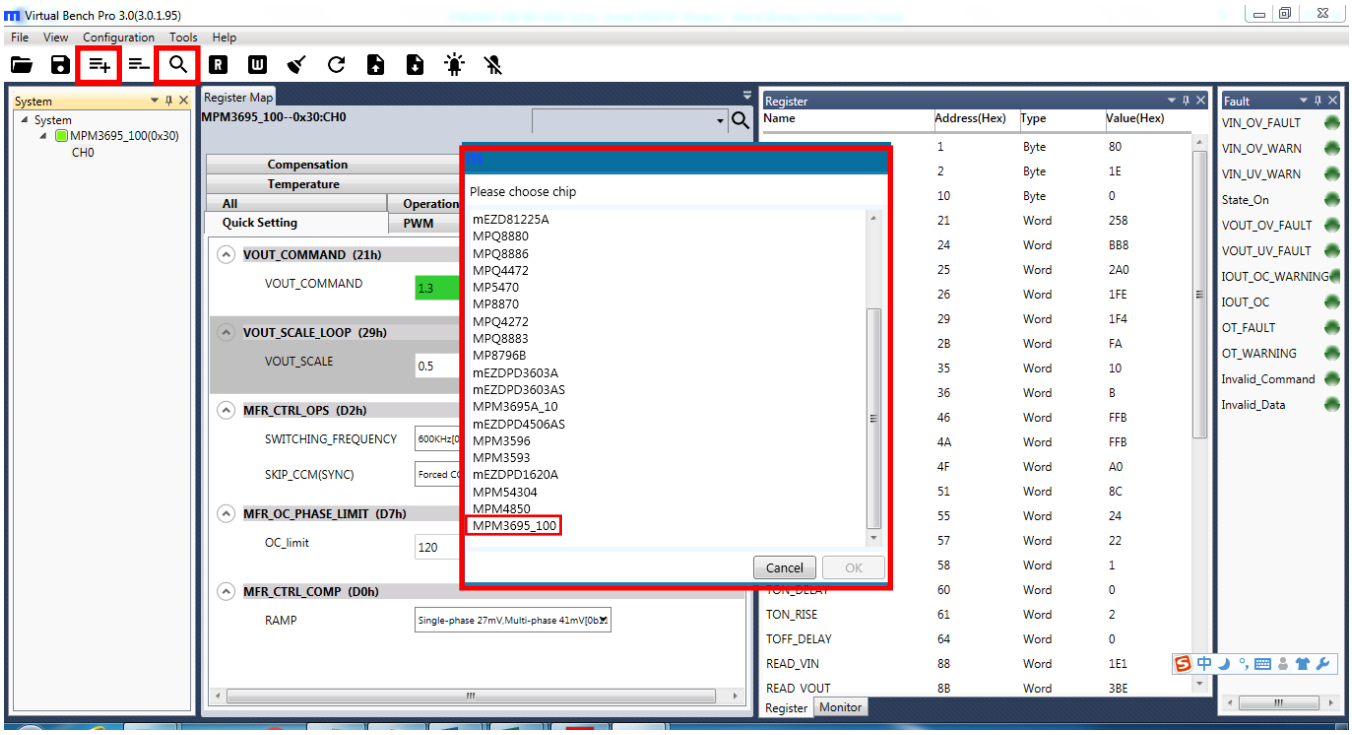


Figure 9: Selecting the MPM3695-100

3. Right click “MPM3695-100” on the left panel.
4. Click “Change chip address,” then enter the value of the slave (0x). The module should be manually added (see Figure 9).

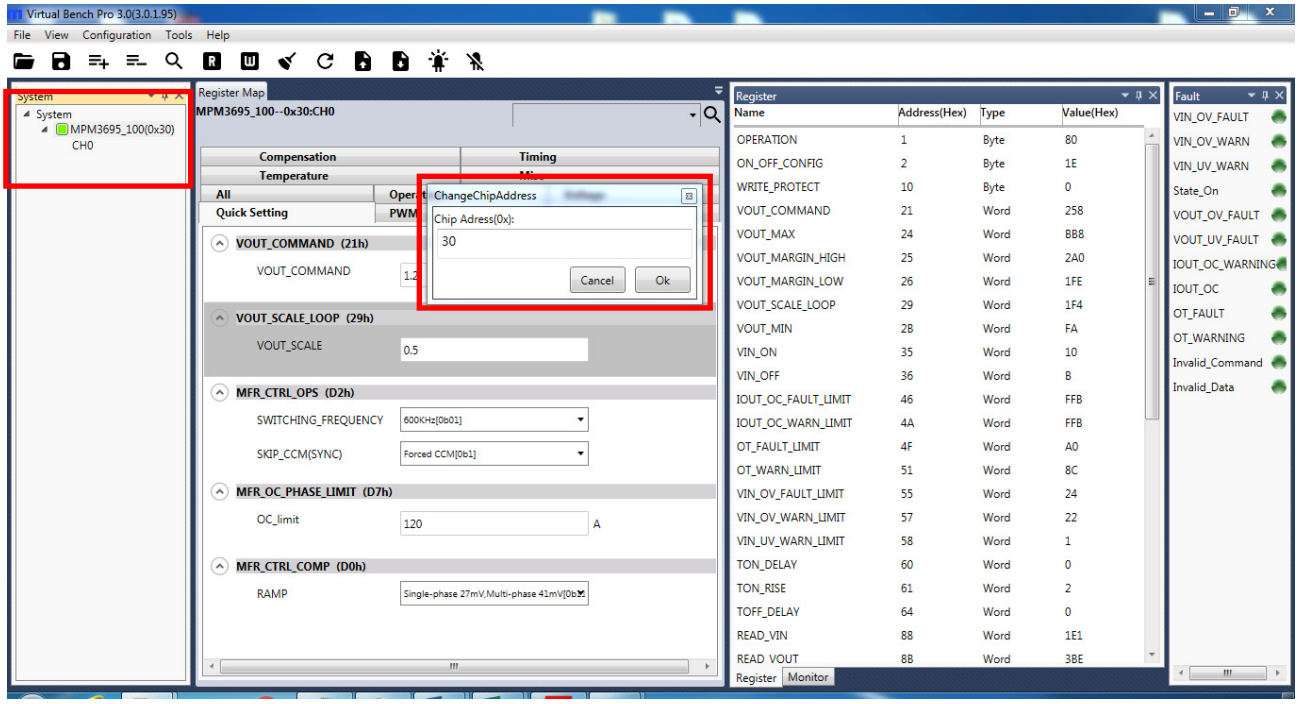


Figure 10: Changing the Chip Address

5. If the power module cannot be detected after following these steps, check the connections between the evaluation board, communication interface, and PC. Re-plug the communication interface into the computer and restart the GUI.

No Output Voltage

The MPM3695-100 provides protection features. If any of the protection functions are triggered, the power module may latch off. If a fault occurs, the indicator on the right panel indicates the specific fault by turning red (see Figure 10). For details on specific faults, refer to the MPM3695-100 datasheet.

EVALUATION BOARD SCHEMATIC

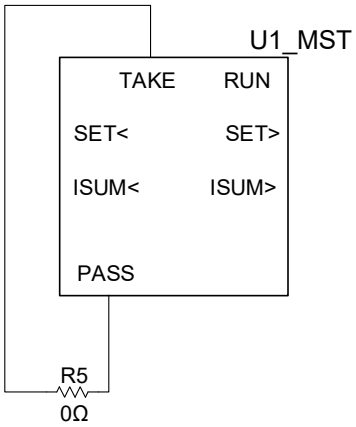


Figure 11: EVM3695-100-BH-00A Connection Diagram

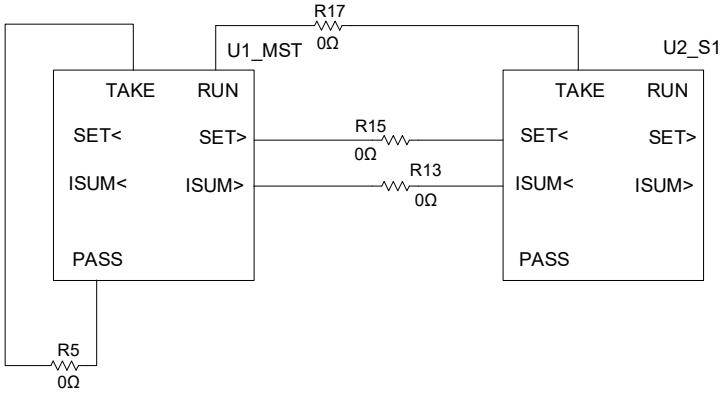


Figure 12: EVM3695-100-BH-00B Connection Diagram

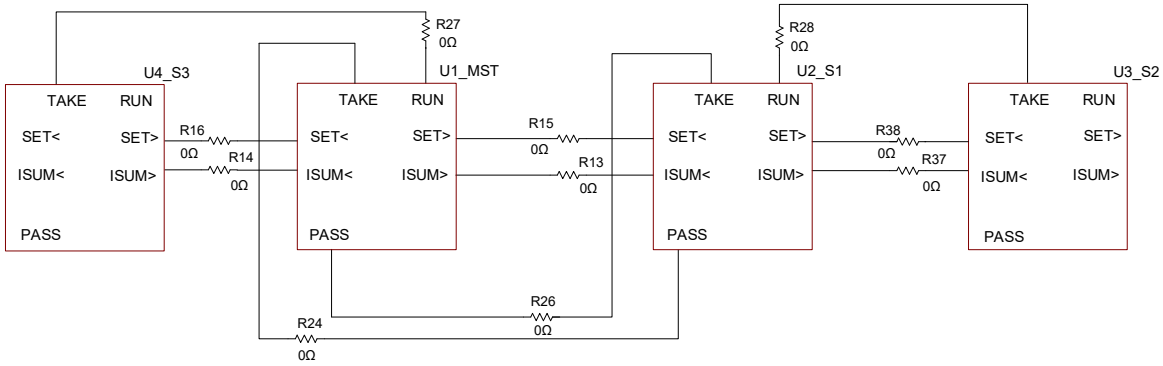


Figure 13: EVM3695-100-BH-00C Connection Diagram

EVALUATION BOARD SCHEMATIC *(continued)*

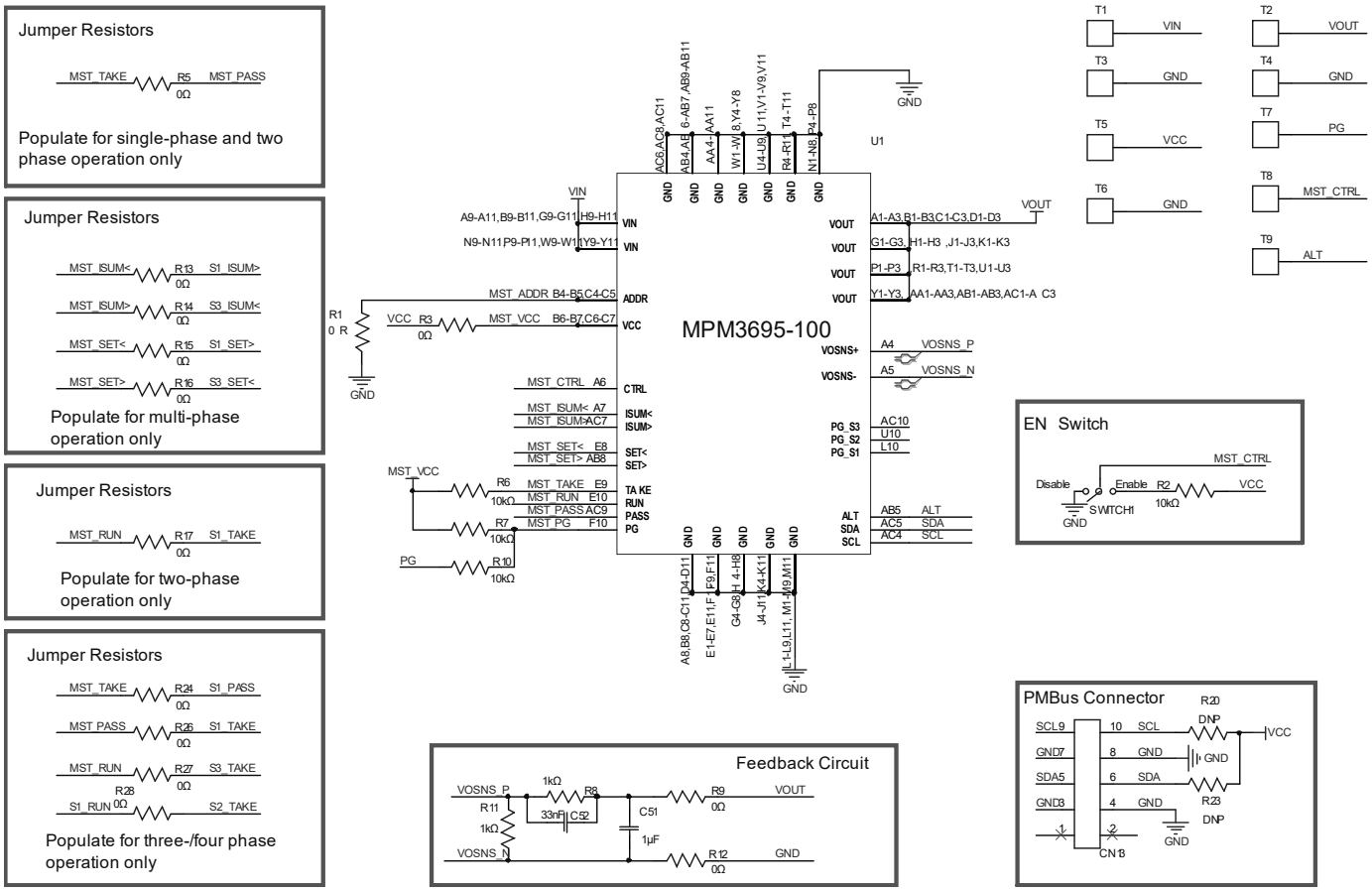


Figure 14: Schematic of the Master Device

EVALUATION BOARD SCHEMATIC *(continued)*

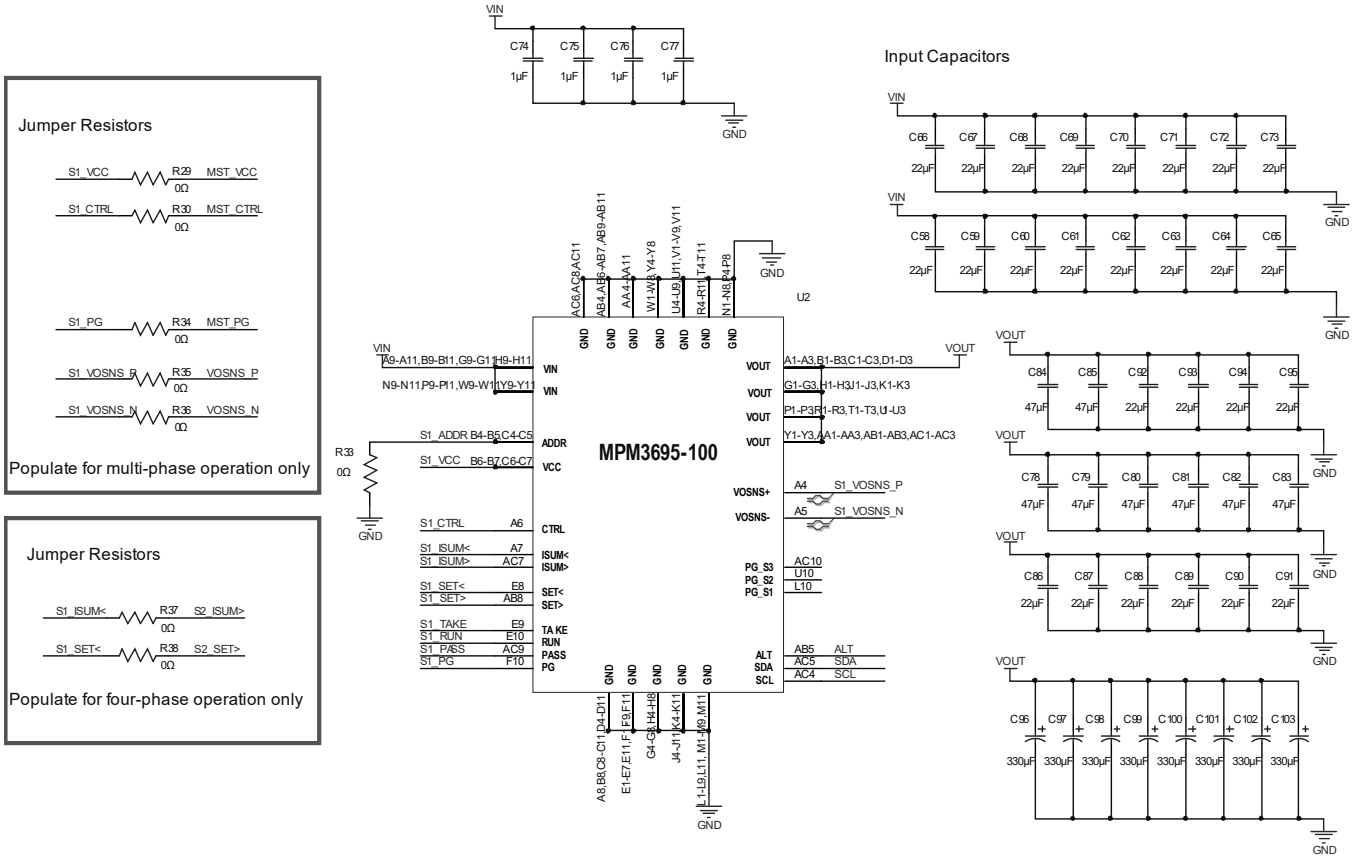


Figure 15: Schematic of Slave 1

EVALUATION BOARD SCHEMATIC *(continued)*

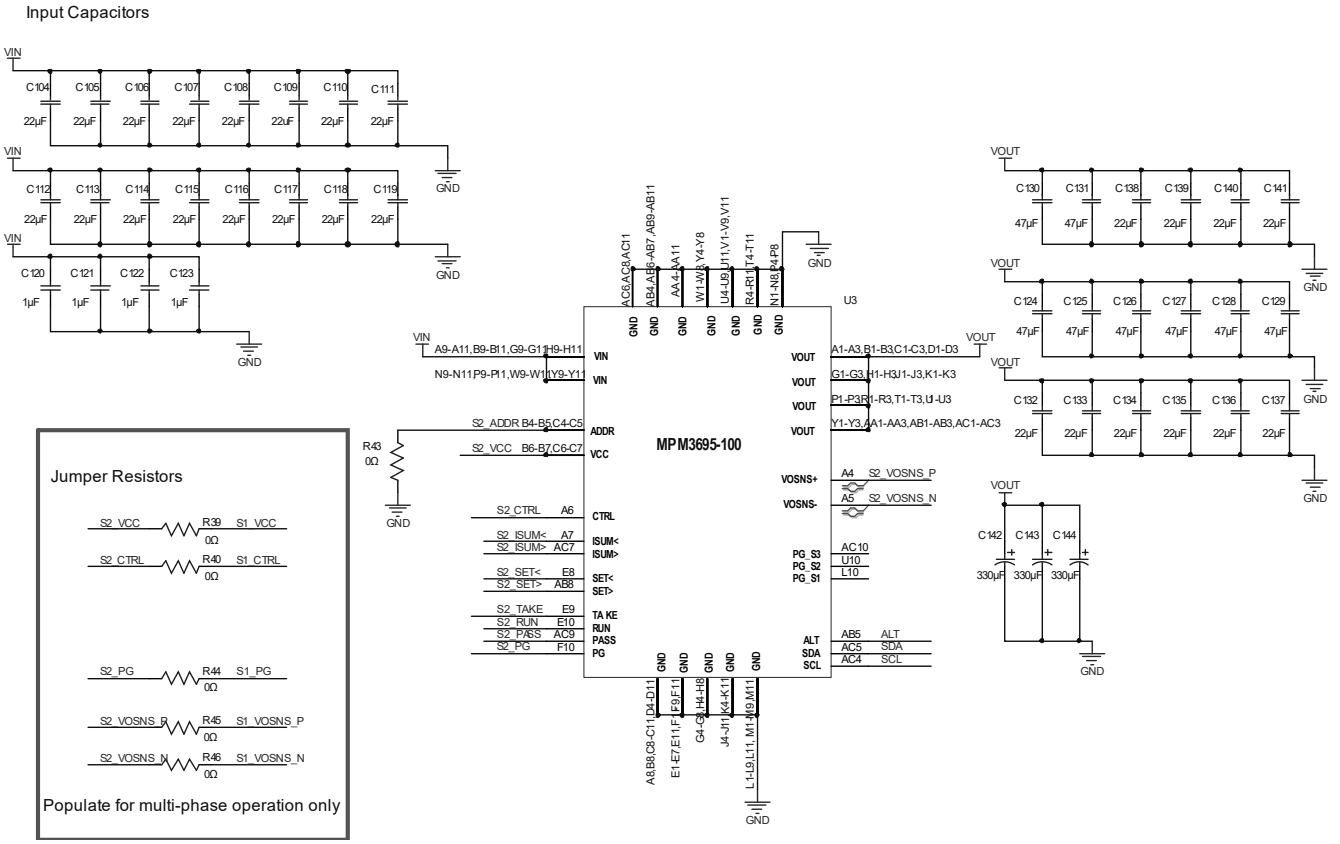


Figure 16: Schematic of Slave 2

EVALUATION BOARD SCHEMATIC *(continued)*

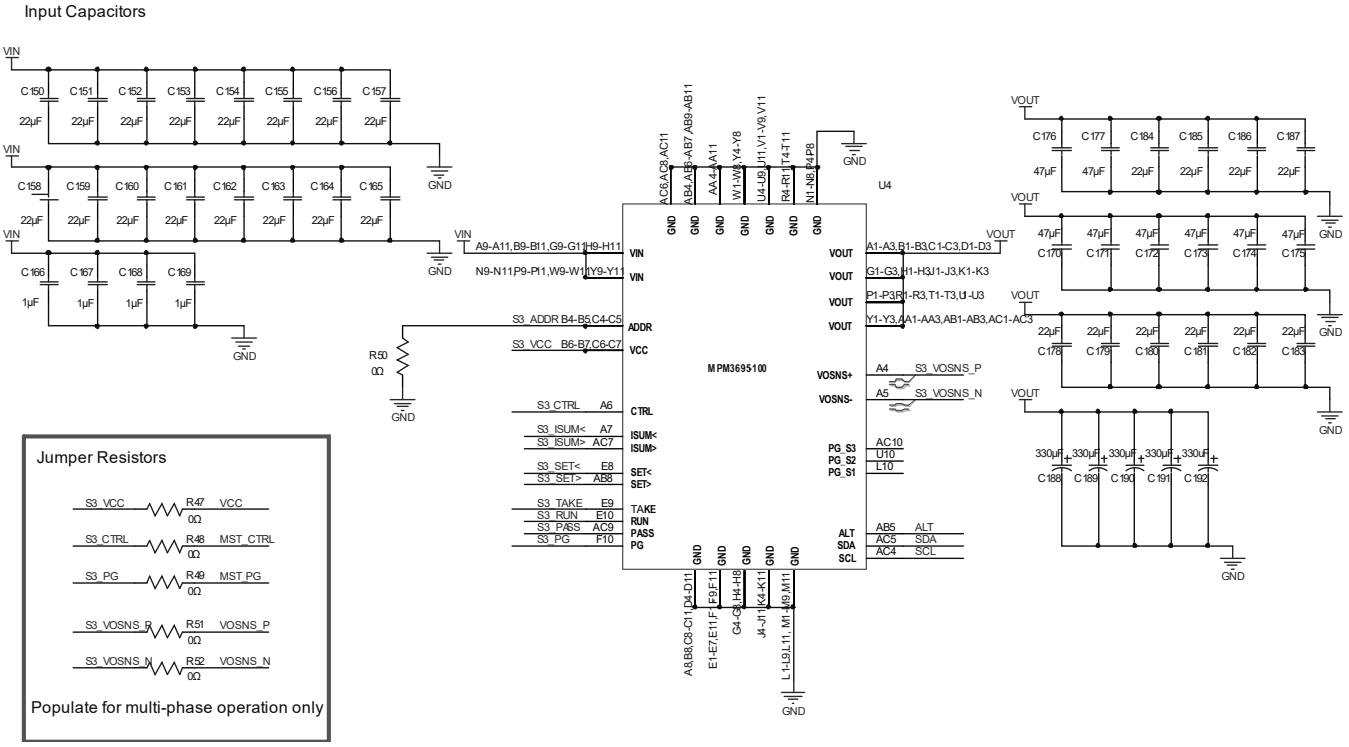


Figure 17: Schematic of Slave 3

EVALUATION BOARD SCHEMATIC *(continued)*

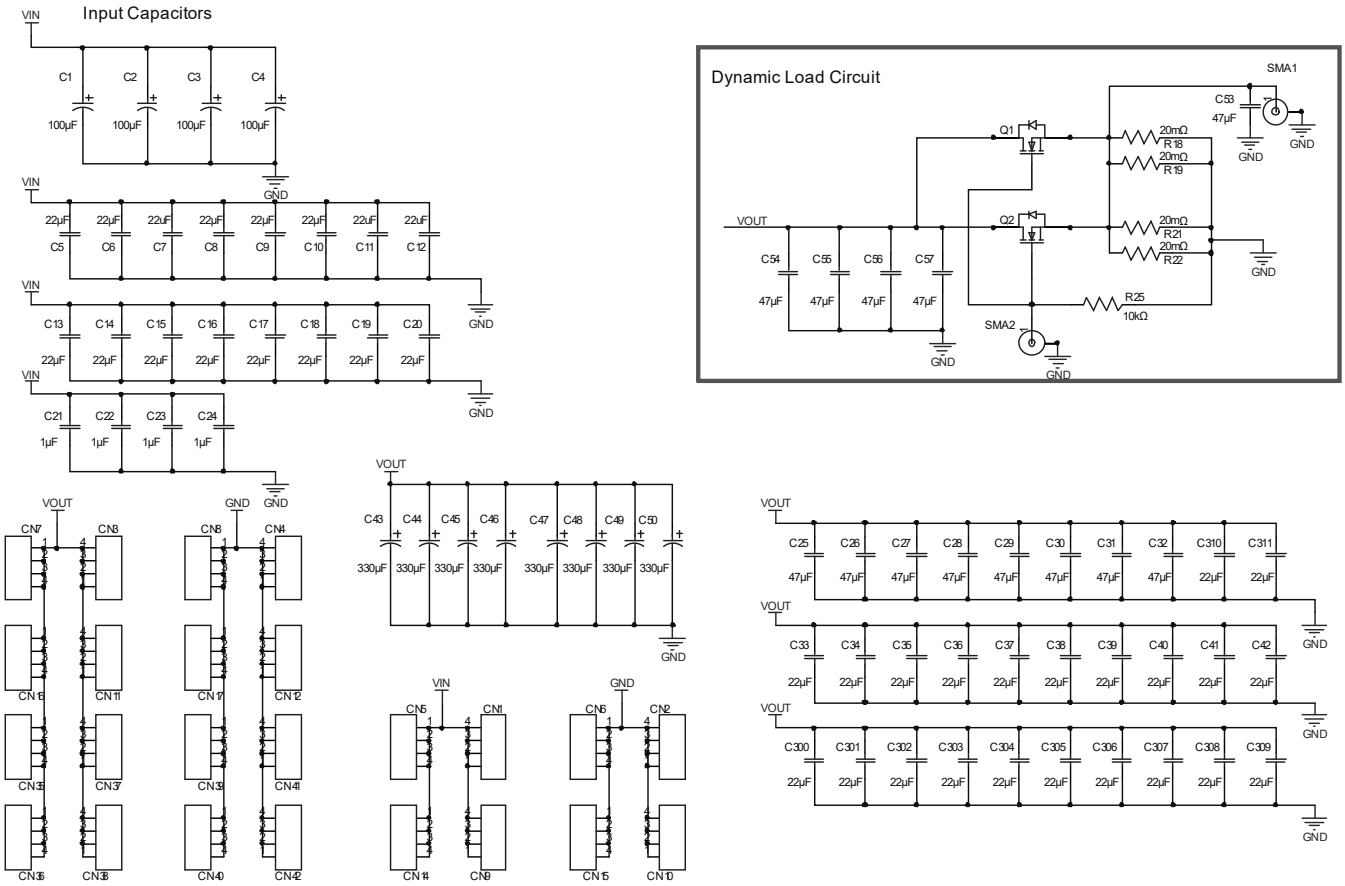


Figure 18: Schematic of Slave 4

EVM3695-100-BH-00A BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
2	C1, C2	100µF, 25V	100µF, 25V, 20% ESR, 24mΩ	SMD	Panasonic	25SVPF100M
31	C25, C26, C27, C28, C29, C30, C31, C32, C33, C34, C35, C36, C37, C38, C39, C40, C41, C42, C300, C301, C302, C303, C304, C305, C308, C309, C53, C54, C55, C56, C57	47µF, 6.3V	Ceramic capacitor, 6.3V, X5R	0805	Murata	GRM21BR60J476ME15L
16	C5, C6, C7, C8, C9, C10, C11, C12, C13, C14, C15, C16, C17, C18, C19, C20	22µF, 25V	Ceramic capacitor, 25V, X5R	0805	Murata	GRM21BR61E226ME44L
4	C21, C22, C23, C24	1µF, 25V	Ceramic capacitor, 25V, X5R	0402	Murata	GRM155R61E105KA12D
1	C51	1µF, 6.3V	Ceramic capacitor, 6.3V, X5R	0603	Murata	GRM188R60J105KA01D
1	C52	33nF	Capacitor, X7R, 50V	0603	Wurth	885012206092
7	R1, R3, R5, R9, R10, R12, R25	0Ω	Resistor, 0Ω, 0603, 1%	RES0603	Yageo	RC0603FR-070RL
3	R2, R6, R7	10kΩ	Resistor, 10kΩ, 0603, 1%	RES0603	Yageo	RC0603FR-0710KL
2	R8, R11	1kΩ	Resistor, 1kΩ, 0603, 1%	RES0603	Yageo	RC0603FR-071KL
4	R18, R19, R21, R22	0.002Ω	Film resistor, 1%, 2512	2512	Yageo	RL2512FK-070R002
2	Q1, Q2	30V, 24A	MOSFET, V_{DS} = 30V, I_{DS} = 24A, R_{DS} = 4.9mΩ	SOIC-8PP	Analog Power	AM7432N-T1-PF
5	C43, C44, C45, C48, C49,	220µF, 6.3V	Tantalum capacitor, 6.3V, 15mΩ	SMD	Panasonic	EEFCX0J221R
1	U1	MPM3695-100	16V scalable power module	BGA (15mmx 30mmx 5.18mm)	MPS	MPM3695GBH-100-0001

EVM3695-100-BH-00B BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
2	C1, C2	100µF	100µF, 25V, 20% ESR, 24mΩ	SMD	Panasonic	25SVPF100M
8	C21, C22, C23, C24, C74, C75, C76, C77,	1µF	Ceramic capacitor, 25V, X5R	0402	Murata	GRM155R61E105KA12D
32	C5, C6, C7, C8, C9, C10, C11, C12, C13, C14, C15, C16, C17, C18, C19, C20, C58, C59, C60, C61, C62, C63, C64, C65, C66, C67, C68, C69, C70, C71, C72, C73	22µF	Capacitor, 25V, X5R	0805	Murata	GRM21BR61E226ME44L
53	C25, C26, C27, C28, C29, C30, C31, C32, C33, C34, C35, C36, C37, C38, C39, C40, C41, C42,C53, C54, C55, C56, C57, C78, C79, C80, C81, C82, C83, C84, C85, C86, C87, C88, C89, C90, C91, C92, C93, C94, C95, C300, C301, C302, C303, C304, C305, C306, C307, C308, C309, C310, C311	47µF	Capacitor, 6.3V, X5R	0805	Murata	GRM21BR60J476ME15L
8	C43, C44, C45, C48, C49, C96, C97, C98,	220µF	Tantalum capacitor, 6.3V, 15mΩ	SMD	Panasonic	EEFCX0J221R
1	C51	1µF	Ceramic capacitor, 6.3V, X5R	0603	Murata	GRM188R60J105KA01D
1	C52	33nF	Capacitor, X7R, 50V	0603	Wurth	885012206092
2	R8, R11	1kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-071KL
5	R2, R6, R7, R10, R25	10kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0710KL
14	R1, R3, R5, R9, R12, R13, R15, R17, R29, R30, R33, R34, R35, R36	0Ω	Film resistor, 1%, 0Ω	0603	Yageo	RC0603FR-070RL
4	R18, R19, R21, R22	0.002Ω	Film resistor, 1%, 2512,	2512	Yageo	RL2512FK-070R002
2	Q1, Q2		MOSFET, V_{DS} = 30V, I_{DS} = 24A, R_{DS} = 4.9mΩ	SOIC-8PP	Analog Power	AM7432N-T1-PF
2	U1, U2	MPM3695-100	16V scalable power module	BGA (15mmx 30mmx 5.18mm)	MPS	MPM3695GBH-100-0001

EVM3695-100-BH-00C BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
4	C1, C2, C3, C4	100µF	100µF, 25V, 20% ESR, 24mΩ	SMD	Panasonic	25SVPF100M
16	'C21, C22, C23, C24, C74, C75, C76, C77, C120, C121, C122, C123, C166, C167, C168, C169	1µF	Ceramic capacitor, 25V, X5R	0402	Murata	GRM155R61E105KA12D
64	C5, C6, C7, C8, C9, C10, C11, C12, C13, C14, C15, C16, C17, C18, C19, C20, C58, C59, C60, C61, C62, C63, C64, C65, C66, C67, C68, C69, C70, C71, C72, C73,C104, C105, C106, C107, C108, C109, C110, C111, C112, C113, C114, C115, C116, C117, C118, C119,C150, C151, C152, C153, C154, C155, C156, C157, C158, C159, C160, C161, C162, C163, C164, C165,	22µF	Capacitor, 25V, X5R	0805	Murata	GRM21BR61E226ME44L
89	C25, C26, C27, C28, C29, C30, C31, C32, C33, C34, C35, C36, C37, C38, C39, C40, C41, C42,C53, C54, C55, C56, C57, C78, C79, C80, C81, C82, C83, C84, C85, C86, C87, C88, C89, C90, C91, C92, C93, C94, C95, C124, C125, C126, C127, C128, C129, C130, C131,C132, C133, C134, C135, C136, C137, C138, C139, C140, C141, C170, C171, C172, C173, C174, C175, C176, C177,C178, C179, C180, C181, C182, C183, C184, C185, C186, C187, C300, C301, C302, C303, C304, C305, C306, C307, C308, C309, C310, C311	47µF	Capacitor, 6.3V, X5R	0805	Murata	GRM21BR60J476ME15L
18	C43, C44, C45, C46, C47, C48, C49, C50, C96, C97, C98, C99, C142, C143, C144, C188, C189, C190	220µF	Tantalum capacitor, 6.3V, 15mΩ	SMD	Panasonic	EEFCX0J221R
1	C51	1µF	Ceramic capacitor, 6.3V, X5R	0603	Murata	GRM188R60J105KA01D
1	C52	33nF	Capacitor, 50V, X7R	0603	Wurth	885012206092
2	R8, R11	1kΩ	Film resistor, 1%, 1kΩ	0603	Yageo	RC0603FR-071KL

EVM3695-100-BH-00C BILL OF MATERIALS *(continued)*

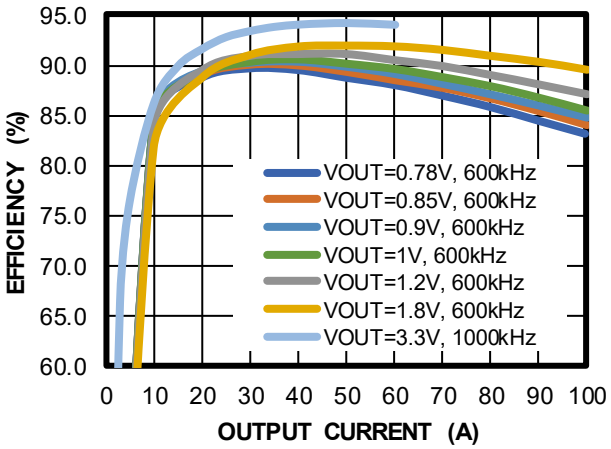
Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
7	R2, R6, R7, R10, R25	10kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0710KL
28	R1, R3, R9, R12, R13, R14, R15, R16,R24, R26, R27, R28, R29, R30, R33, R34, R35, R36, R37, R38, R39, R40, R43, R44, R45, R46, R47, R48, R49, R50, R51, R52	0Ω	Film resistor, 1%	0603	Yageo	RC0603FR-070RL
4	R18, R19, R21, R22	0.002Ω	Film resistor, 1%, 2512,	2512	Yageo	RL2512FK-070R002
2	Q1, Q2	30V, 24A, 4.9mΩ	MOSFET, V_{DS} = 30V, I_{DS} = 24A, R_{DS} = 4.9mΩ	SOIC-8PP	Analog Power	AM7432N-T1-PF
4	U1, U2, U3, U4	MPM3695-100	16V scalable power module	BGA (15mmx 30mmx 5.18mm)	MPS	MPM3695GBH-100-0001

PERFORMANCE OF EVALUATION BOARD

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 1V, T_A = 25°C, unless otherwise noted.

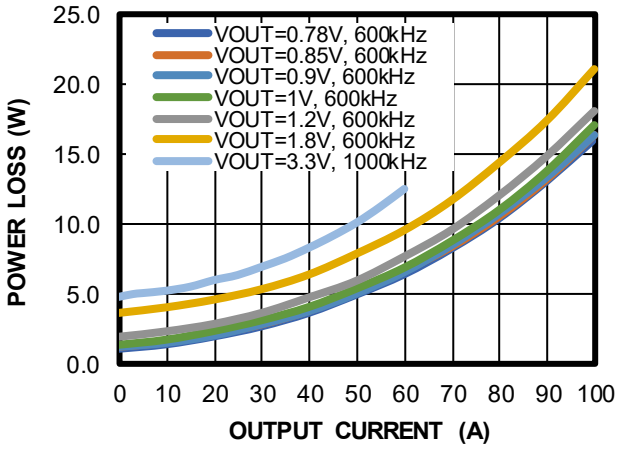
Efficiency

V_{IN} = 12V



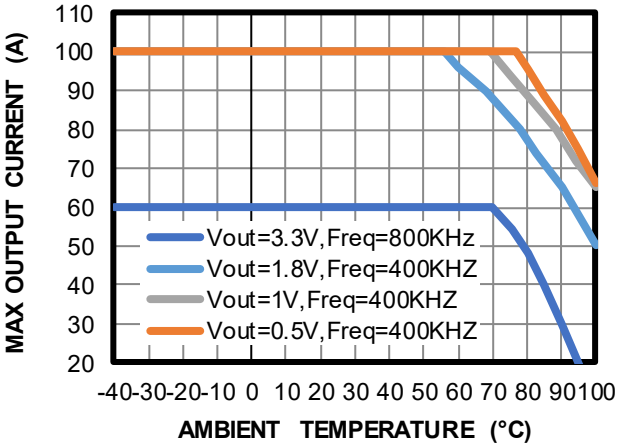
Power Loss

V_{IN} = 12V



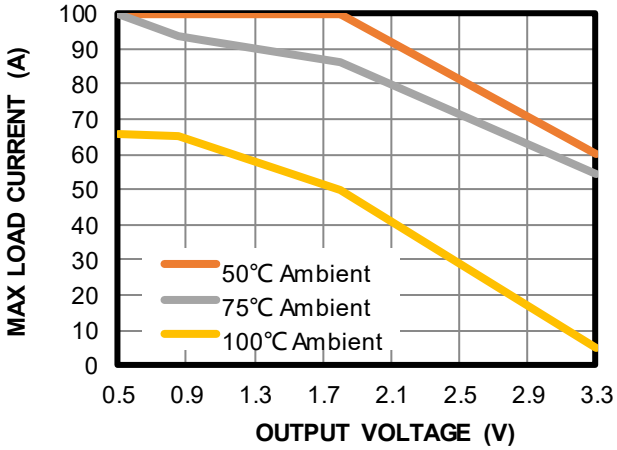
Thermal Derating

V_{IN} = 12V



Output Voltage Derating

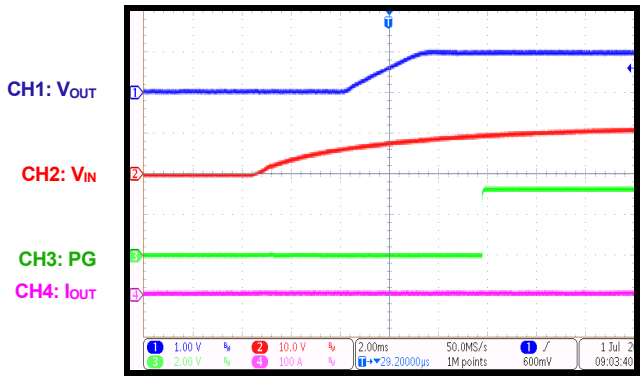
V_{IN} = 12V



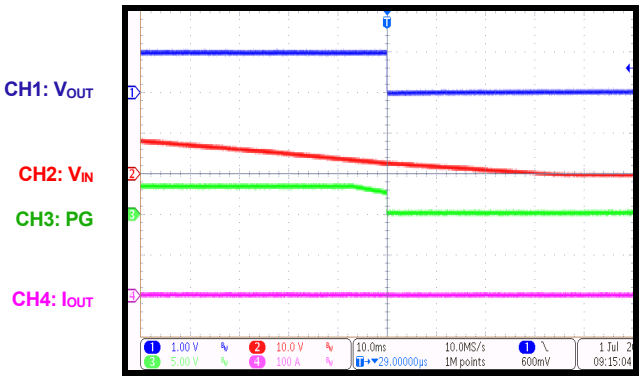
PERFORMANCE OF EVALUATION BOARD *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 1V, T_A = 25°C, unless otherwise noted.

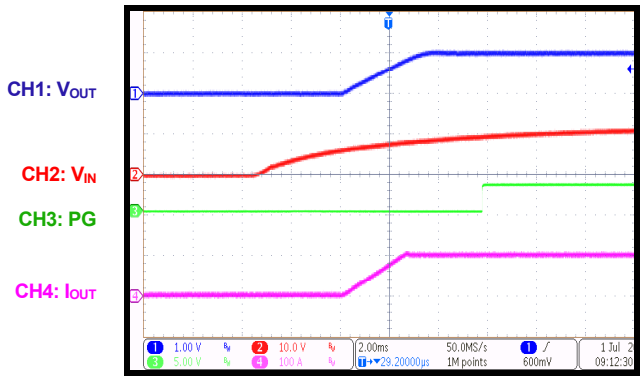
Start-Up through VIN
No load



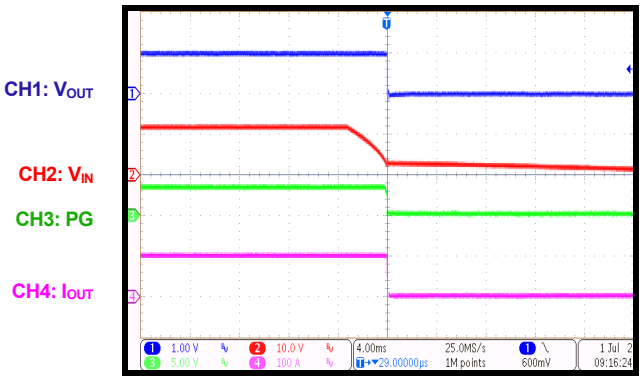
Shutdown through VIN
No load



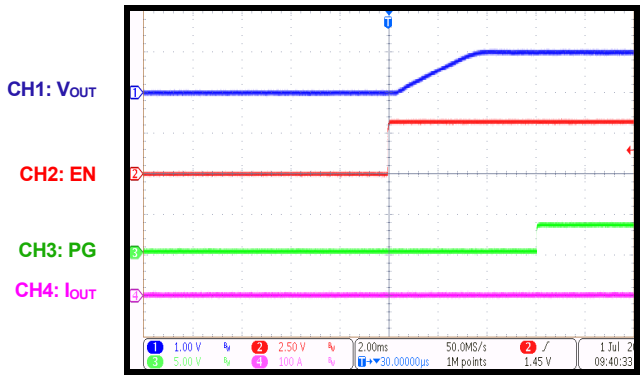
Start-Up through VIN
Full load



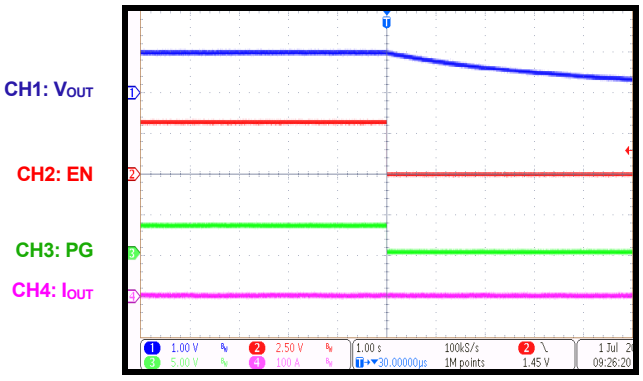
Shutdown through VIN
Full load



Start-Up through EN
No load



Shutdown through EN
No load

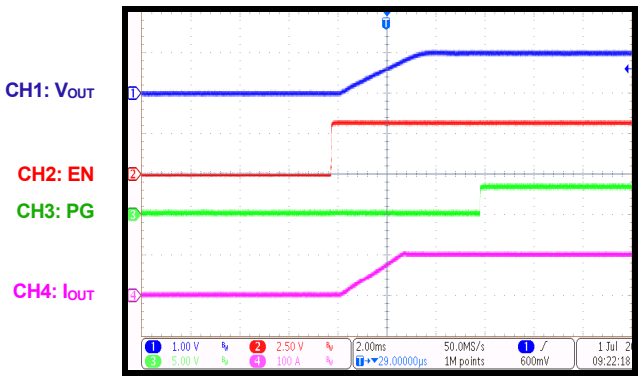


PERFORMANCE OF EVALUATION BOARD *(continued)*

V_{IN} = 12V, V_{OUT} = 1V, f_{SW} = 600kHz, T_A = 25°C, unless otherwise noted.

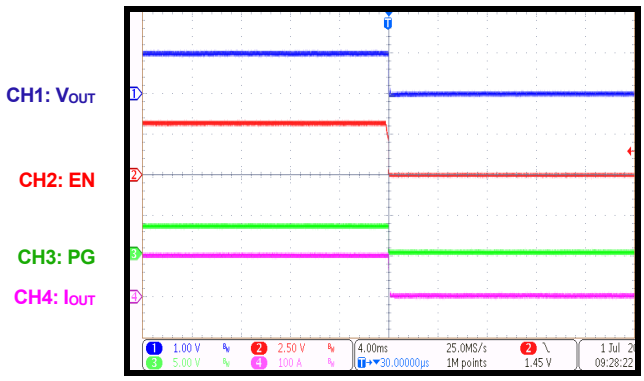
Start-Up through EN

Full load



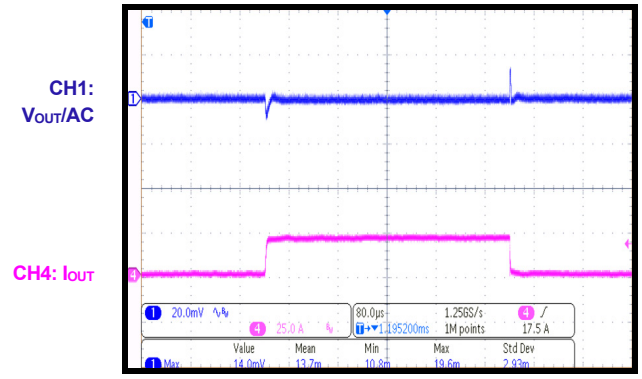
Shutdown through EN

Full load



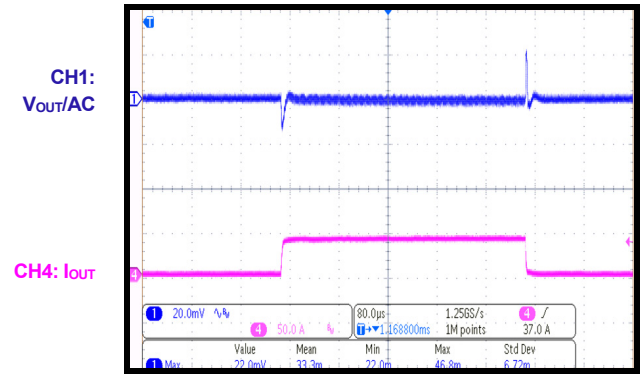
Load Transient (Single Module Operation)

V_{OUT} = 0.78V, 0A to 25A,
C_{OUT} = 20 x 47µF + 5 x 220µF



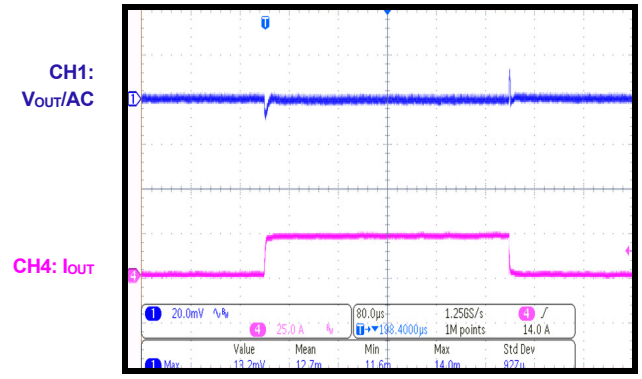
Load Transient (Single Module Operation)

V_{OUT} = 0.78V, 0A to 50A,
C_{OUT} = 20 x 47µF + 5 x 220µF



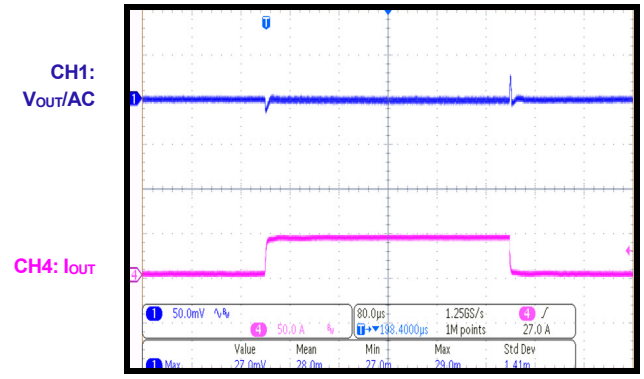
Load Transient (Single Module Operation)

V_{OUT} = 0.9V, 0A to 25A,
C_{OUT} = 20 x 47µF + 4 x 220µF



Load Transient (Single Module Operation)

V_{OUT} = 0.9V, 0A to 50A,
C_{OUT} = 20 x 47µF + 4 x 220µF



PCB LAYOUT

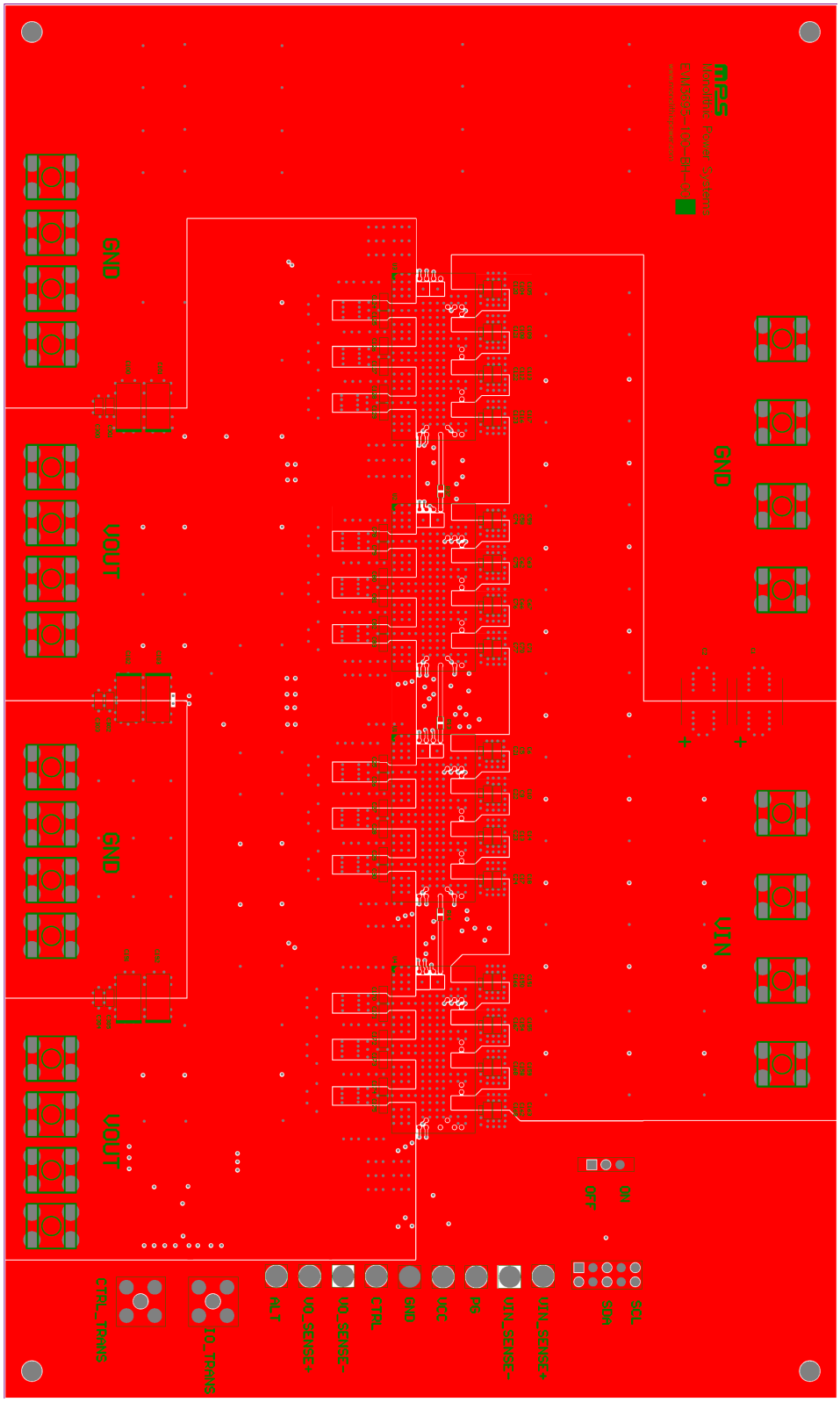


Figure 19: Top Silk

PCB LAYOUT *(continued)*

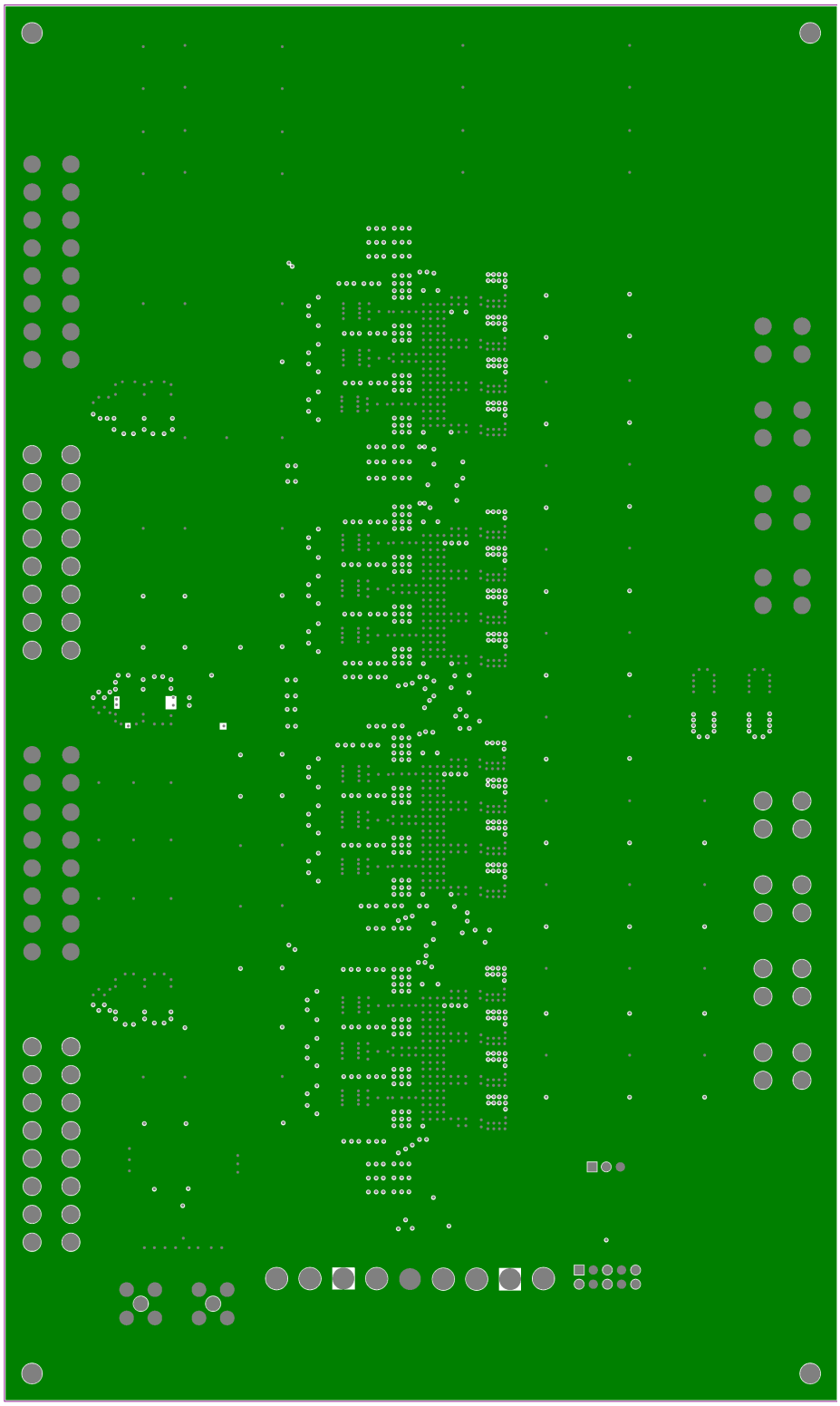


Figure 20: Mid-Layer 1

PCB LAYOUT *(continued)*

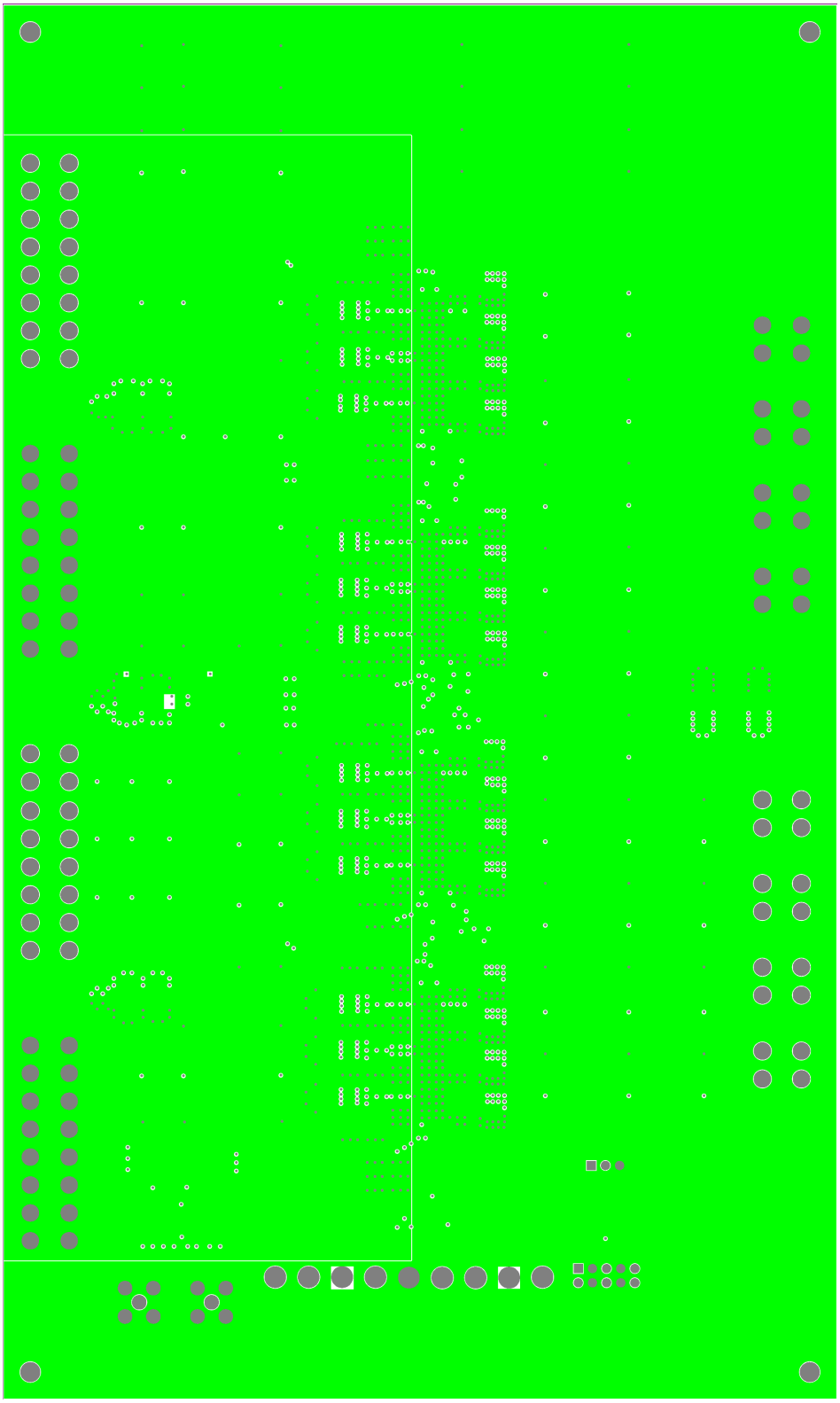


Figure 21: Mid-Layer 2

PCB LAYOUT *(continued)*

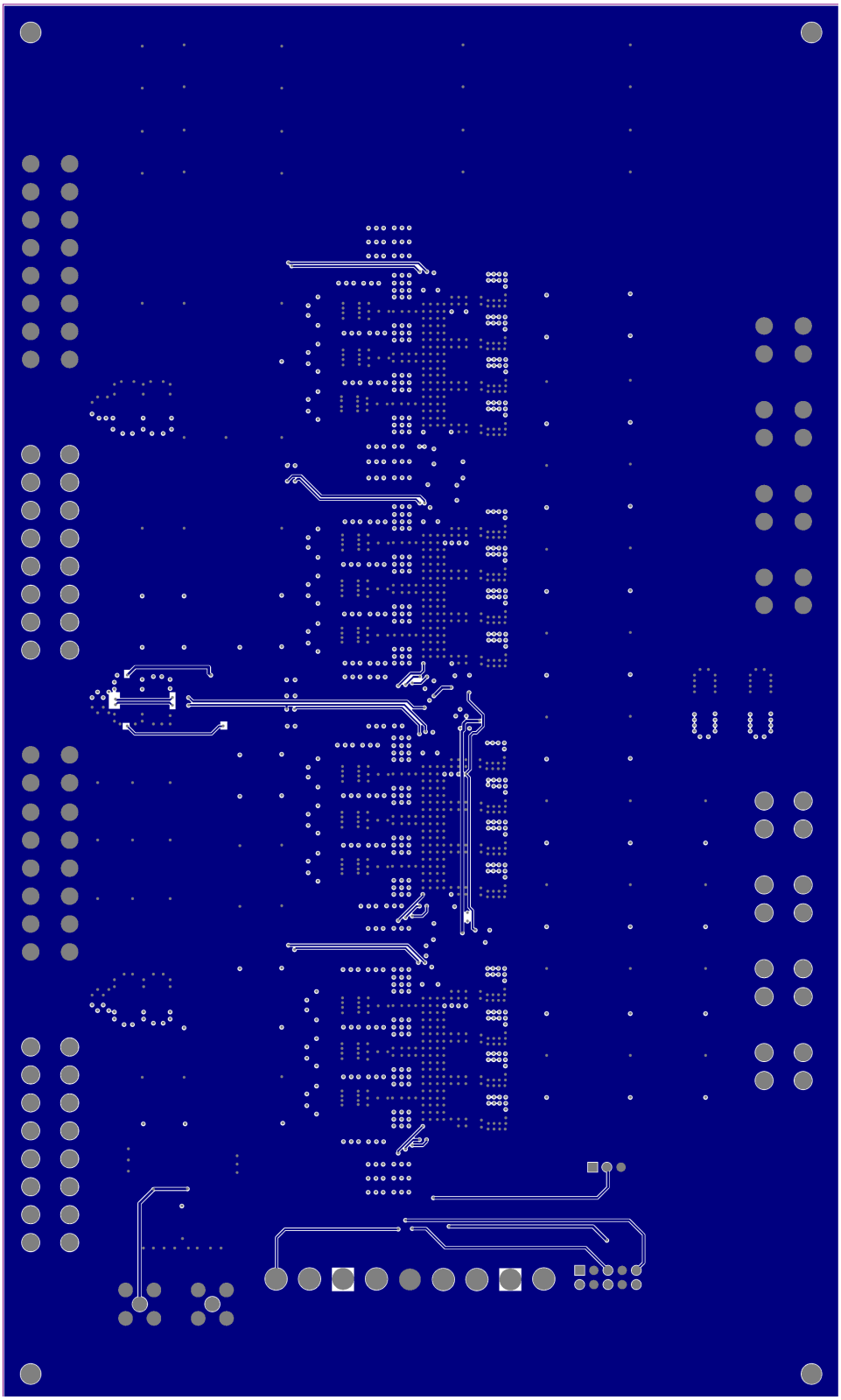


Figure 22: Mid-Layer 3

PCB LAYOUT *(continued)*

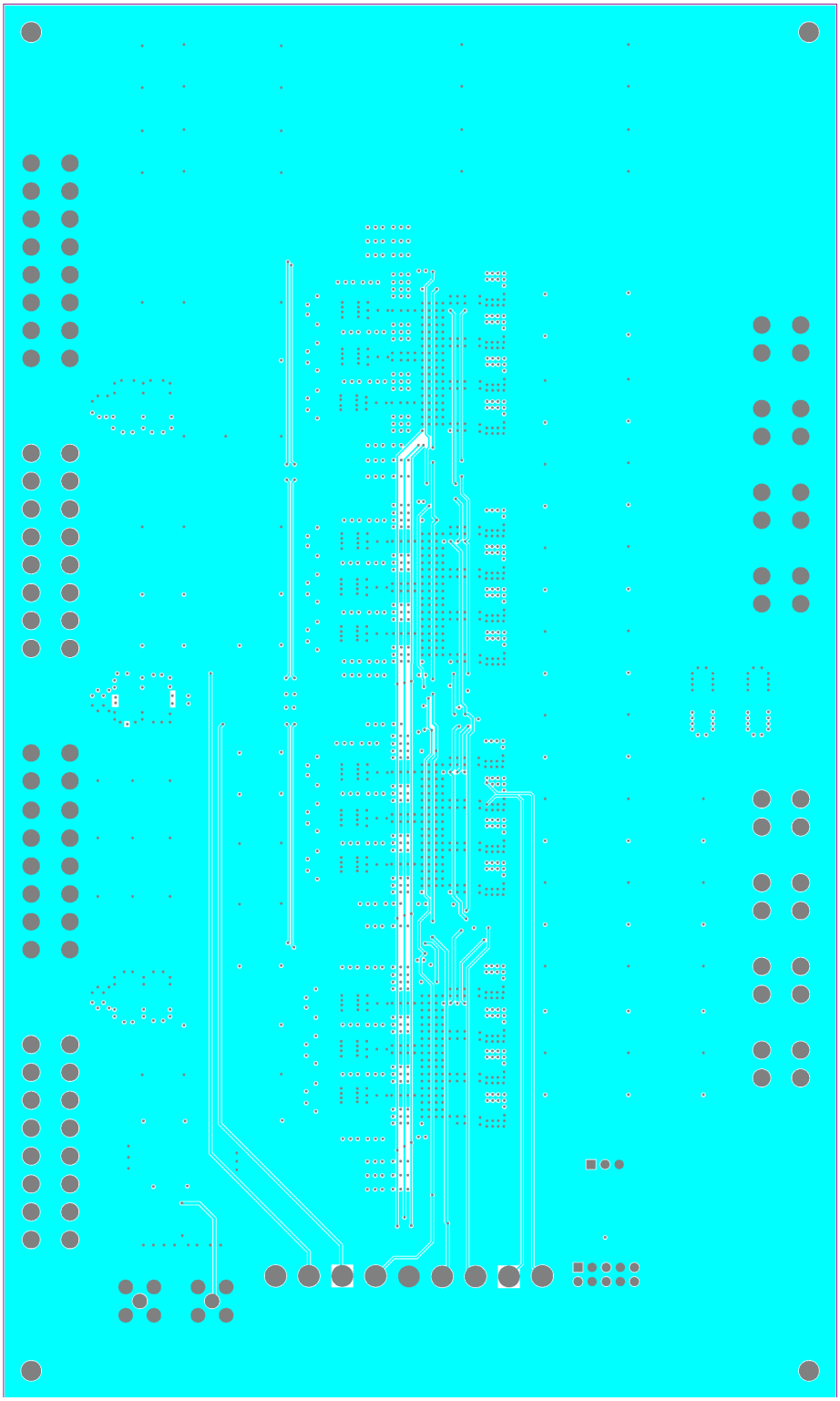


Figure 23: Mid-Layer 4

PCB LAYOUT *(continued)*

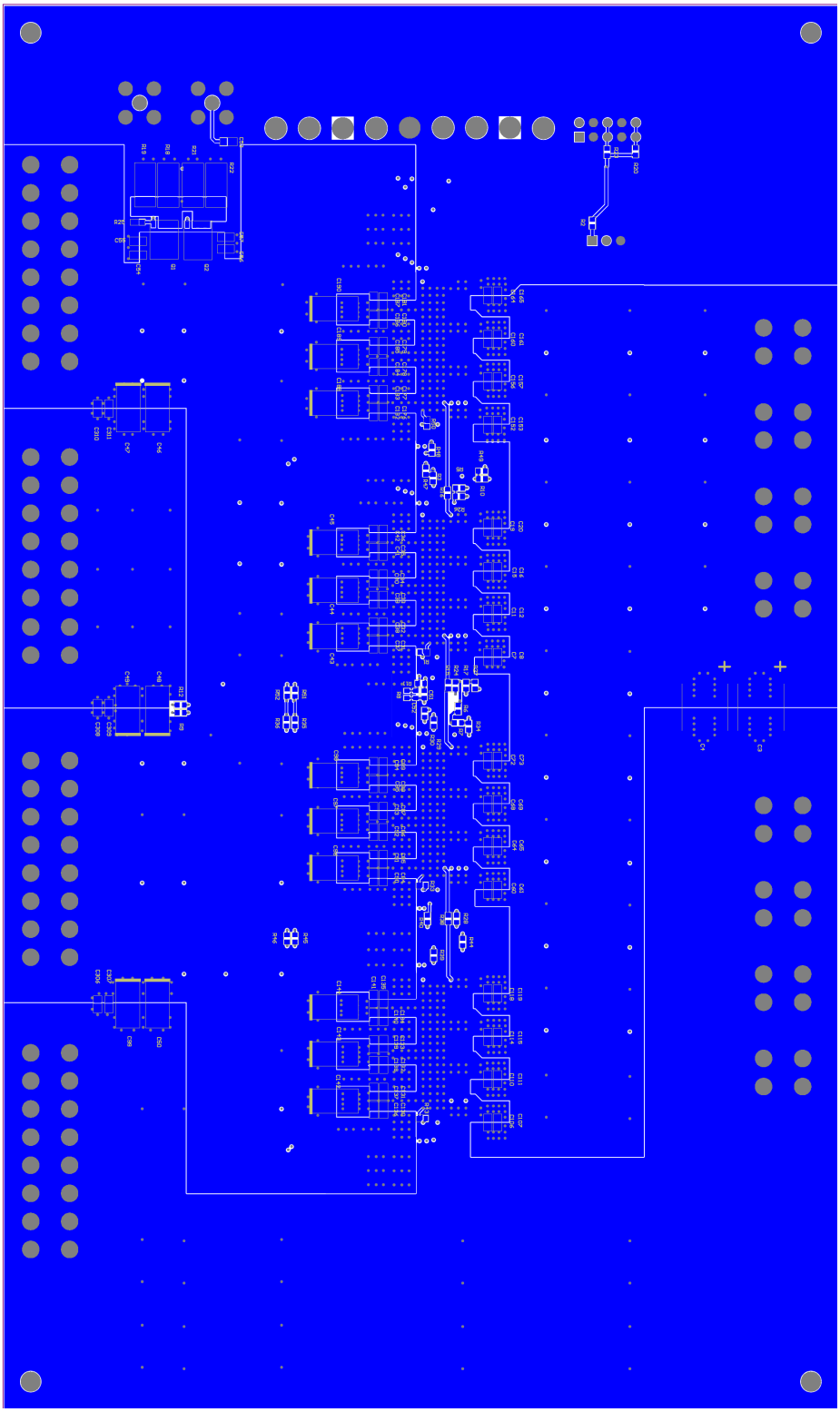


Figure 24: Bottom Silk

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	11/09/2021	Initial Release	-