EVM3695-100-BH-D/E

16V, 600A/800A, Scalable DC/DC Power Module Evaluation Board

DESCRIPTION

The EVM3695-100-BH-00D/E evaluation board series is designed to demonstrate the capabilities of the MPM3695-100, a 100A, scalable, fully integrated digital power module. The MPM3695-100 offers a complete 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. The MPM3695-100 operates at a high efficiency across a wide load range, and can be paralleled to deliver up to 800A of current.

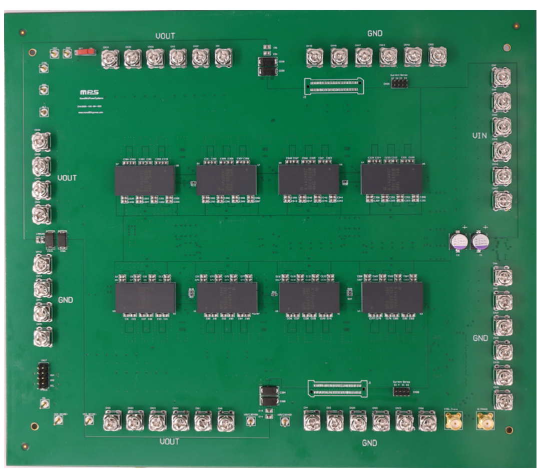
The EVM3695-100-BH-00D/E evaluation board series provides two stuffing options that accommodate six or eight MPM3695-100 power modules, which provide up to 600A and 800A of I_{OUT}, respectively. See the Performance Summary section for more details on the performance of the EVM3695-100-BH-00D/E series. The MPM3695-100 is available in a BGA (15mmx30mmx5.18mm) package.

PERFORMANCE SUMMARY

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

Parameters	Conditions	Value
Input voltage (V_{IN}) range	Internal V_{CC}	4V to 16V
Output voltage (V_{OUT})	V_{IN} = 4V to 16V, I_{OUT} = 0A to 600A/800A	V_{OUT} = 1.2V
Maximum output current (I_{OUT})	V_{IN} = 0.5V to 3.3V, EVM3695-100-BH-00D	600A
	V_{IN} = 0.5V to 3.3V, EVM3695-100-BH-00E	800A
Peak efficiency	V_{IN} = 12V, V_{OUT} = 1.2V, I_{OUT} = 50A per module	91%
Typical efficiency	V_{IN} = 12V, V_{OUT} = 1.2V, I_{OUT} = 80A per module	89%
Switching frequency (f_{SW})	Default configuration	600kHz

EVM3695-100-BH-00D/E EVALUATION BOARD



LxWxH (27cmx23cmx2cm)

Board Number	MPS IC Number
EVM3695-100-BH-00D/E	MPM3695GBH-100-0001

QUICK START GUIDE

1. Preset a DC power supply (V_{IN}) 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. After making the connections, turn the power supply on. If the CTRL pin is enabled, the board automatically starts up at 1.2V.
5. To set the output voltage (V_{OUT}), a feedback (FB) resistor divider is required to set the proper FB gain (G_{FB}). The FB resistances (R7 and R10) can be calculated with Equation (1):

$$R10 = \frac{V_{REF}}{V_{OUT} - V_{REF}} \times R7 \quad (1)$$

   Where R7 is the lower resistance of the output divider, R10 is the upper resistance of the output divider, and V_{OUT} is the output voltage. The reference voltage (V_{REF}) is set to 0.6V by default and can be adjusted between 0.5V and 0.672V. V_{REF} is the product of V_{OUT} and G_{FB}.

   G_{FB} can be calculated with Equation (2):

$$G_{FB} = \frac{R10}{R7 + R10} \quad (2)$$

6. After determining R10 and G_{FB}, set V_{OUT} via the following registers: (1)
   a. Write G_{FB} to the VOUT_SCALE_LOOP register.
   b. Write the V_{OUT} command to the VOUT_COMMAND register.
   c. Note that V_{REF} is updated automatically based on the V_{OUT} command and G_{FB}.

7. Figure 1 shows the measurement equipment set-up. (2)

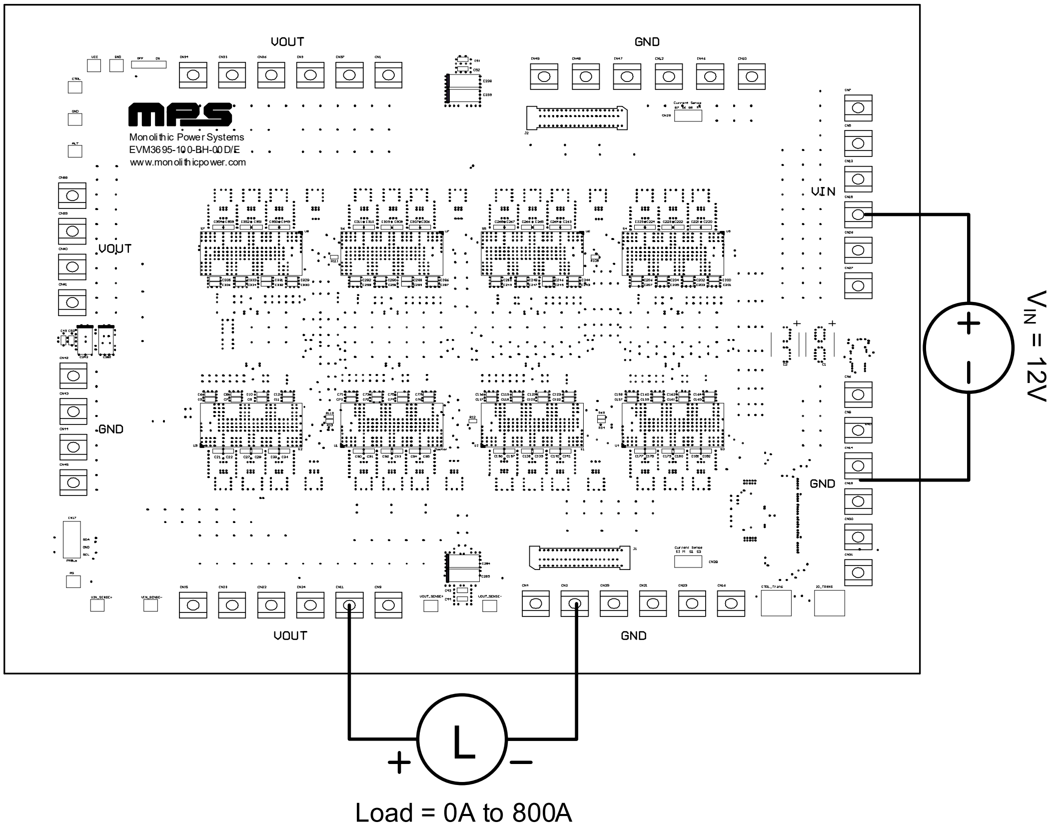


Figure 1: Measurement Equipment Set-Up

Notes:

1) Before changing the register values, shut down the evaluation board.
2) When soldering any component, be careful of static electricity.

VIRTUAL BENCH PRO 4.0 EVALUATION SOFTWARE

Virtual Bench Pro 4.0 is a powerful graphic user interface (GUI) developed for MPS configurable digital power modules and ICs. The software supports a wide range of functions, including read/write registers, operation status monitoring, issue diagnosis, and load/save configuration files. It also supports auto-update features to keep the software up to date. This tool requires the EVKT-USBI2C-02 USB to I^2C communication interface to communicate between a power module or IC and a hosting computer.

To set up Virtual Bench Pro 4.0 and the evaluation board, follow the steps below:

1. Configure the hardware properly prior to use (see Figure 2).

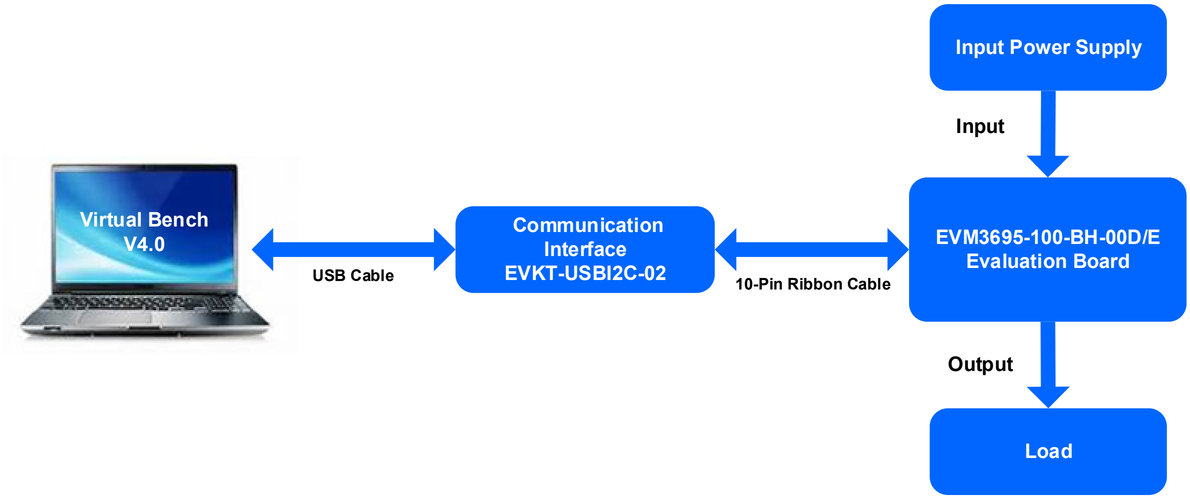


Figure 2: Hardware Set-Up

2. Connect the communication cable to the evaluation board and the EVKT-USBI2C-02 communication interface.
3. Connect the EVKT-USBI2C-02 to the computer using the USB cable (see Figure 3).

Figure 3: EVKT-USBI2C-02 Communication Interface Wire Connection

4. Start up the evaluation board (see the Quick Start Guide section on page 2), then use the GUI to configure and monitor the power modules.

5. Open Virtual Bench Pro 4.0 and click "Create New Project" (see Figure 4).

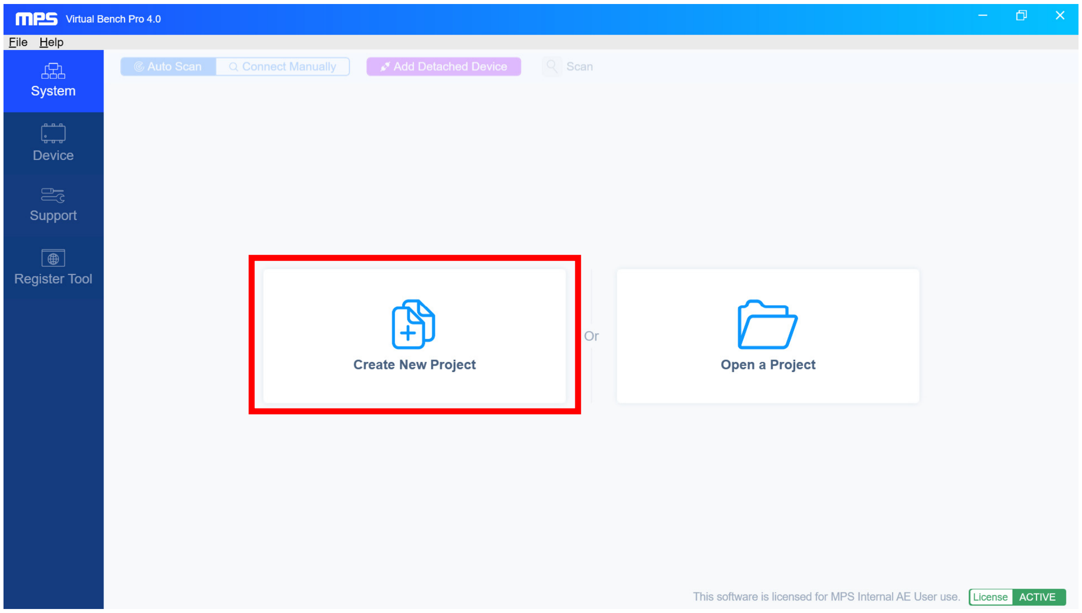


Figure 4: Create New Project

6. Click "Auto Scan" to scan the connected power modules. If the GUI detects the power module, a window appears showing the detection result. Click "Continue" (see Figure 5). If the power module cannot be detected automatically, see the Evaluation Board Connection Issues section on page 7.

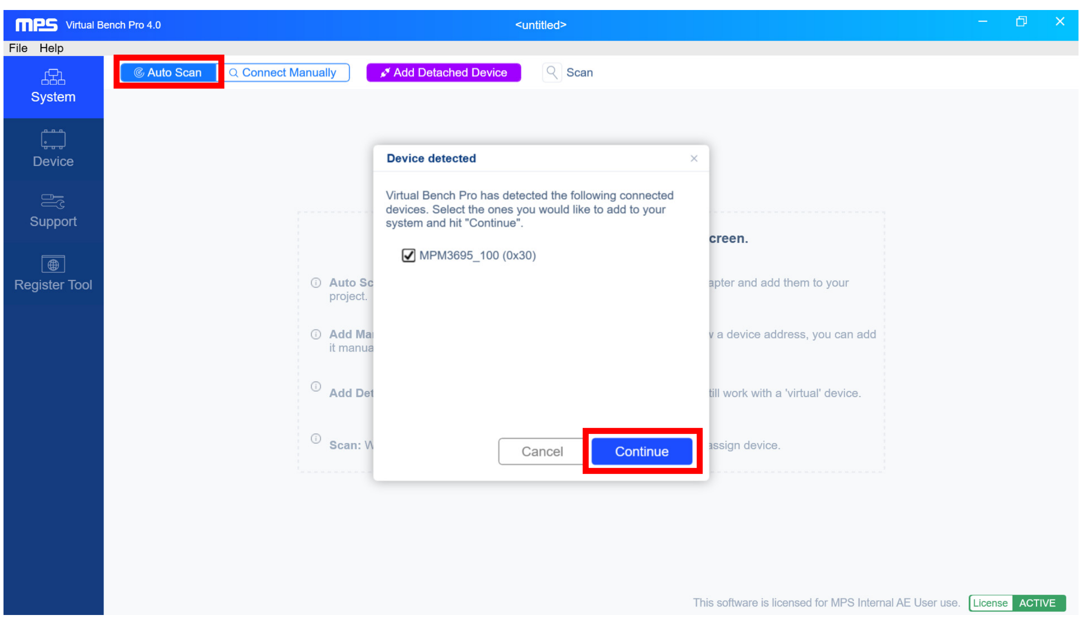


Figure 5: Auto Scan

7. Click "Device" on the left panel. The Register Control menu should appear, and the values stored in the module registers are read automatically (see Figure 6).

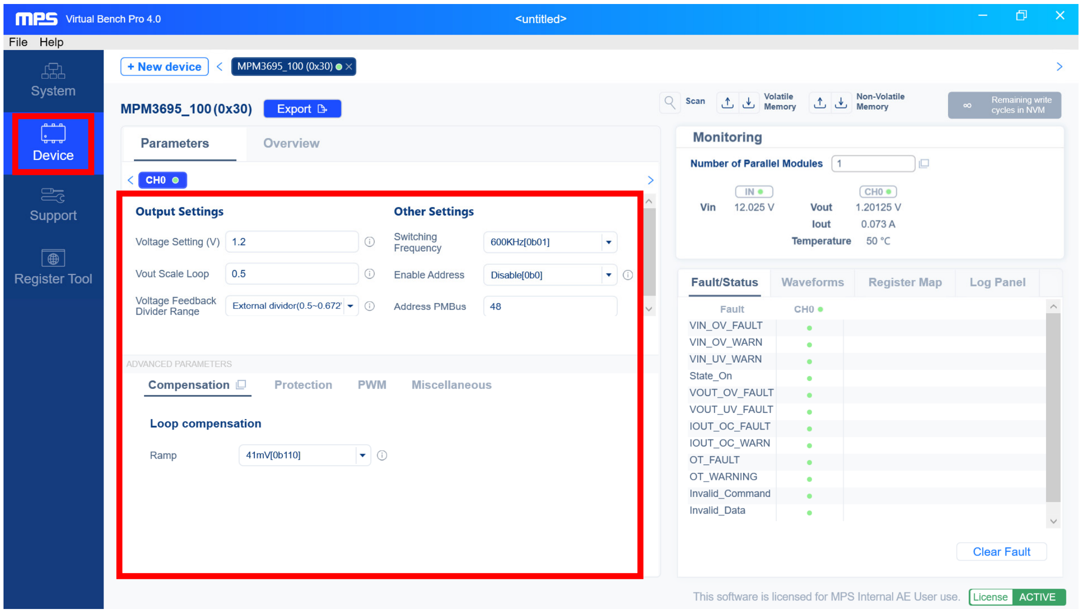


Figure 6: Register Control Menu

8. After modifying the register values, click the "Volatile Memory" button to write values to the register (see Figure 7).

⚠️ *Note that the values written to the registers are not saved when the evaluation board shuts down unless they are written into the MTP memory.*

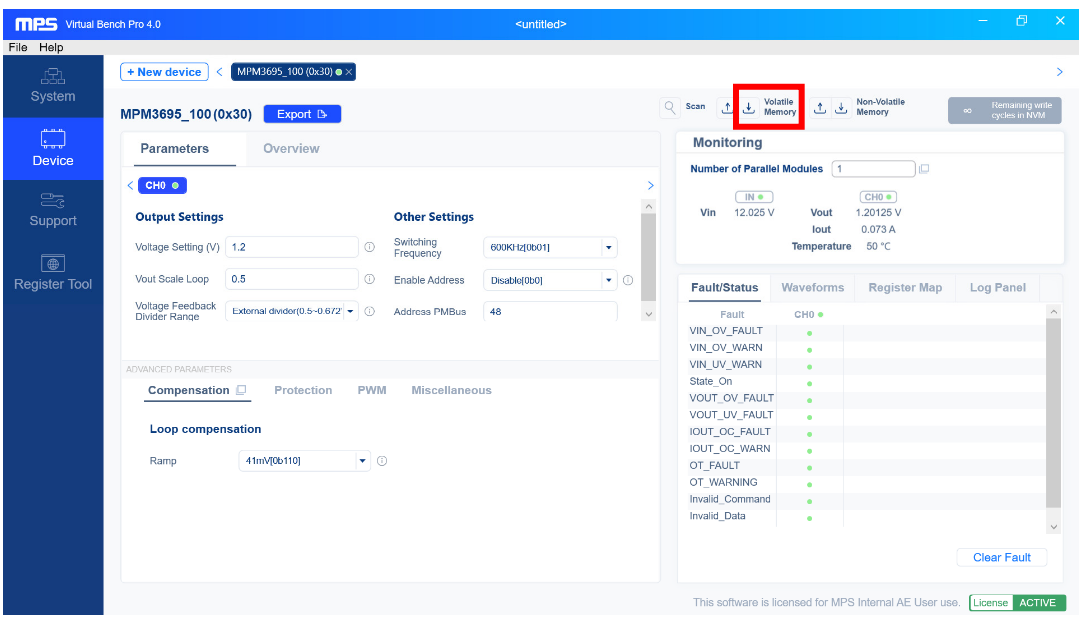


Figure 7: Write the Values Steps

9. The MPM3695-100's multiple-time programmable (MTP) memory can be custom-configured. To create and export custom configurations, follow the steps below:
    a. Connect the evaluation board to a computer (see the Quick Start Guide section on page 2).
    b. Set the register values to their required values and upload them into the registers.
    c. Pull the CTRL pin low to disable the MPM3695-100.
    d. Once V_{IN} exceeds 10V, click the "Write ROM" button and wait until the writing action completes.

Evaluation Board Connection Issues

In the case that the power module cannot be detected automatically, follow the steps below to troubleshoot:

1. Click "Device" on the left panel and then click the "Scan" button. Read the slave (0x) value.
2. Right-click on "MPM3595-100" and enter the slave (0x) value to manually add the module.
3. If the power module still cannot be detected, check the connections between the evaluation board, communication interface, and computer. Replug the USB into the computer and restart the GUI.

No Output Voltage

The MPM3695-100 offers many protection features. If any of the protections is triggered, the power module may latch off. The Fault/Status list on the right panel indicates the specific fault, where a red circle in the CH0 column indicates that a fault is triggered. Refer to the MPM3695-100 datasheet for more details regarding specific faults.

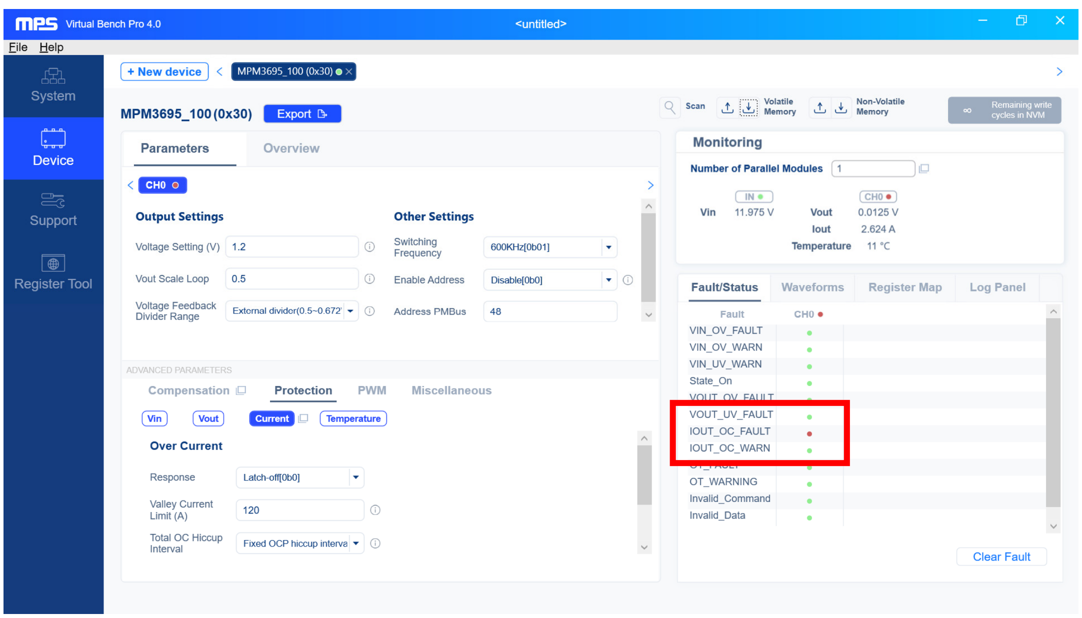


Figure 8: No Output Voltage with OC Fault

TRANSIENT CIRCUIT OF THE EVM3695-100-BH-00D/E

For large current transient tests, the EVM3695-100-BH-00D/E's transient circuit can avoid the effect of parasitic inductance on long load lines. Figure 9 shows the schematic diagram of the EVM3695-100-BH-00D/E's transient circuit.

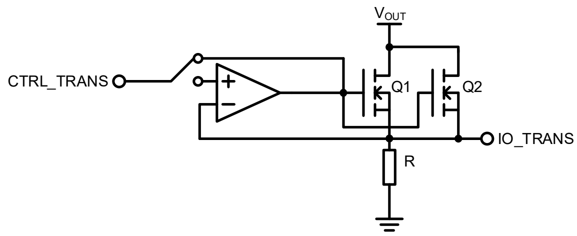


Figure 9: Functional Diagram of Transient Circuit

To set up the EVM3695-100-BH-00D/E's transient circuit, follow the steps below:

1. Use one signal generator to inject a pulse signal into the CTRL_TRANS terminal, which achieves load transients. The signal can directly turn the two MOSFETs on, or the operational amplifier (op amp) can drive the MOSFETs.
2. The voltage on the transient resistor (R) determines the transient current. Measure the transient load voltage using the IO_TRANS terminal.
3. When the signal generator is directly used to drive the MOSFETs, R must be calculated based on V_{OUT} and the required transient slew rate.
4. The on resistance ($R_{DS(ON)}$) of the MOSFETs depends on the difference between the gate voltage and source voltage of the MOSFET (V_{GS}). Therefore, adjust V_{GS} to obtain different transient steps. If V_{GS} is 5V, the MOSFET works in the saturation area.
5. Due to the limited driving capacity of the signal generator, using the op amp can achieve a faster transient slew rate. The voltage on the resistor is equivalent to the op amp's positive input voltage (V_{IN}). Figure 10 shows a detailed schematic of the transient circuit.
6. Solder R128 and R129 to drive the MOSFETs via the signal generator, and solder R130 to drive the MOSFETs via the op amp.
7. Ensure that the conduction time of the MOSFETs is small (e.g. 100μs) to meet the transient resistor's power dissipation limit.

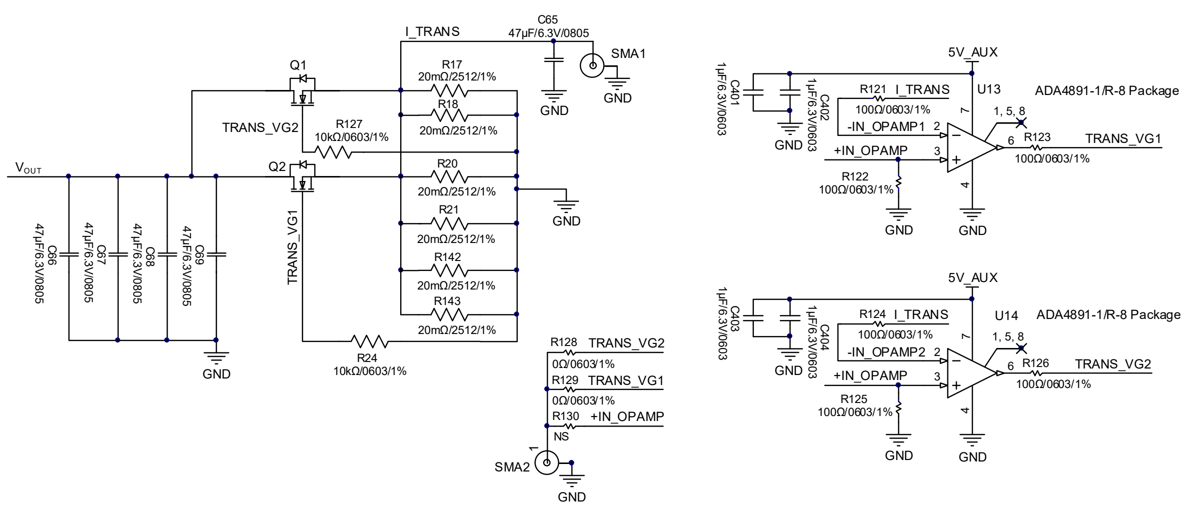


Figure 10: Schematic of Transient Circuit

EVALUATION BOARD SCHEMATIC

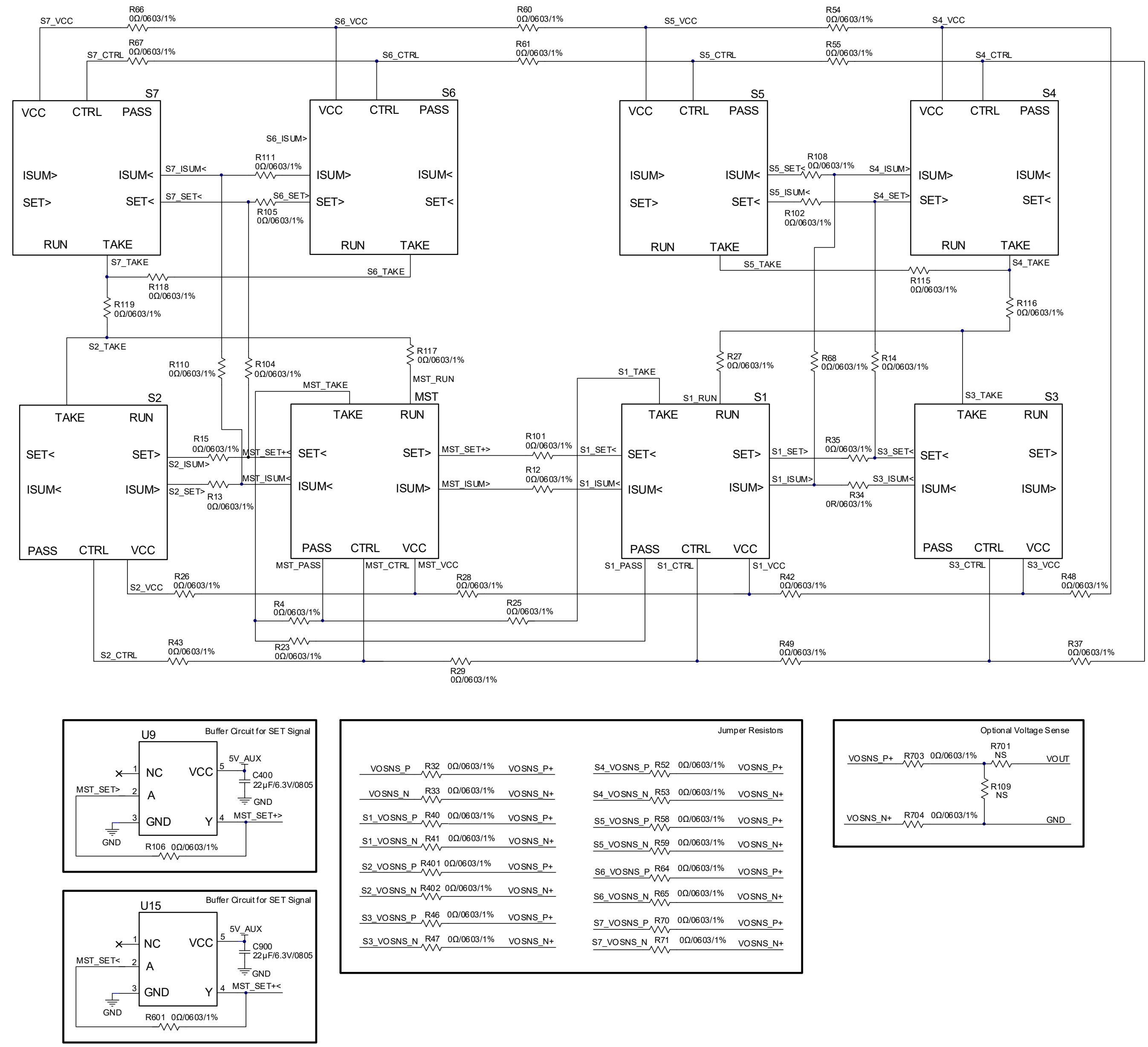


Figure 11: Evaluation Board Schematic (Part 1)

EVALUATION BOARD SCHEMATIC *(continued)*

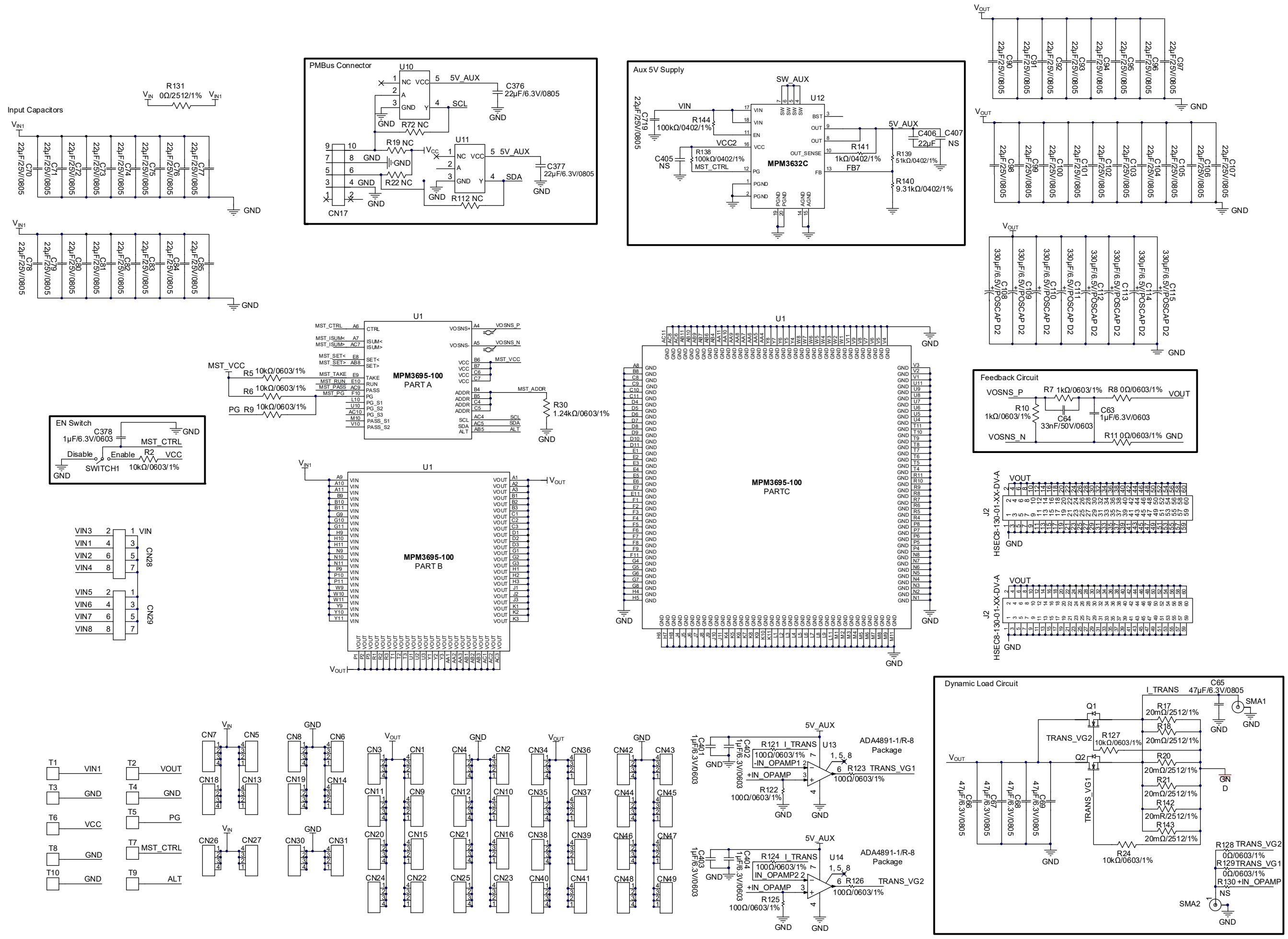


Figure 12: Evaluation Board Schematic (Part 2)

EVALUATION BOARD SCHEMATIC *(continued)*

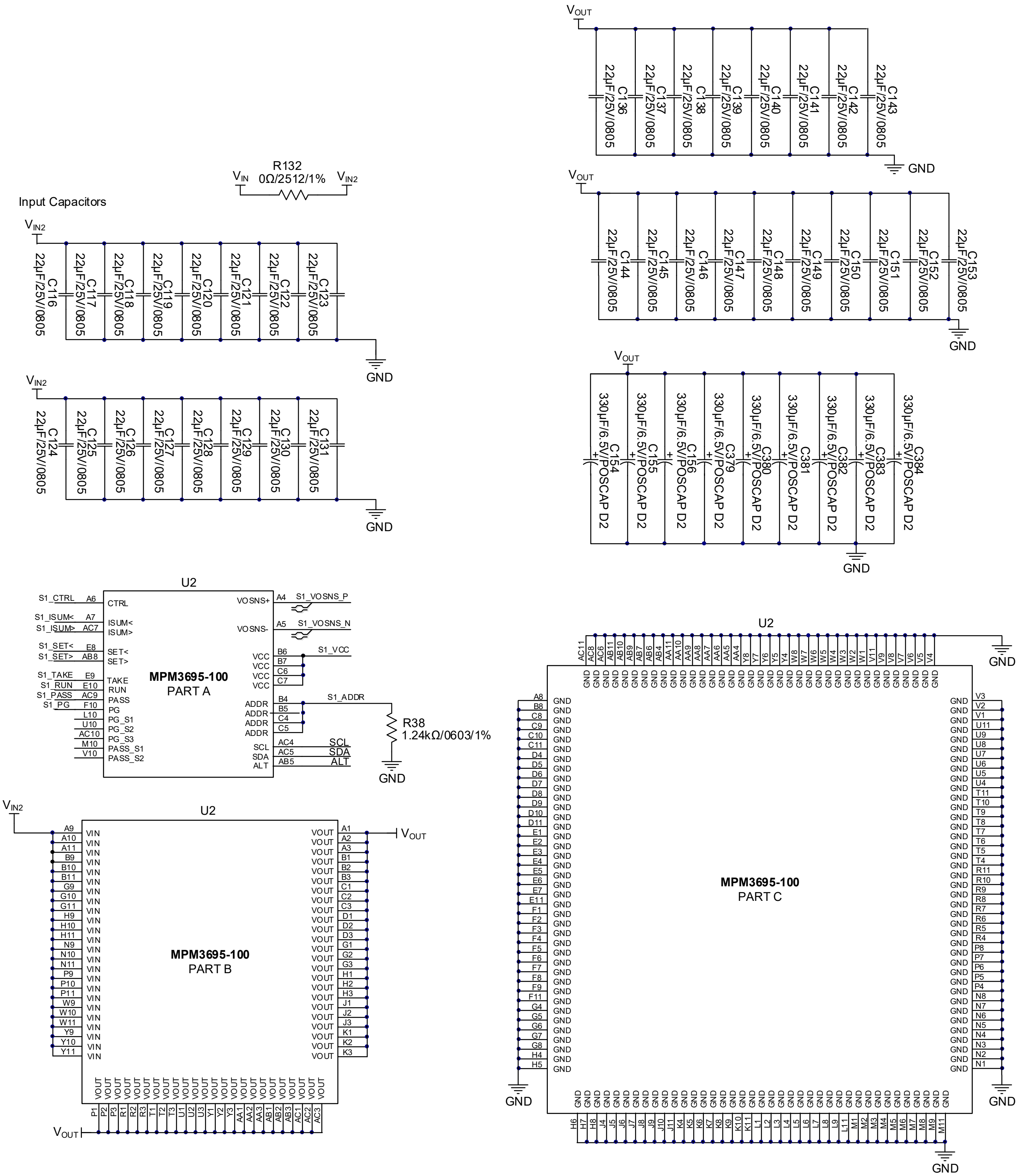


Figure 13: Evaluation Board Schematic (Part 3)

EVALUATION BOARD SCHEMATIC *(continued)*

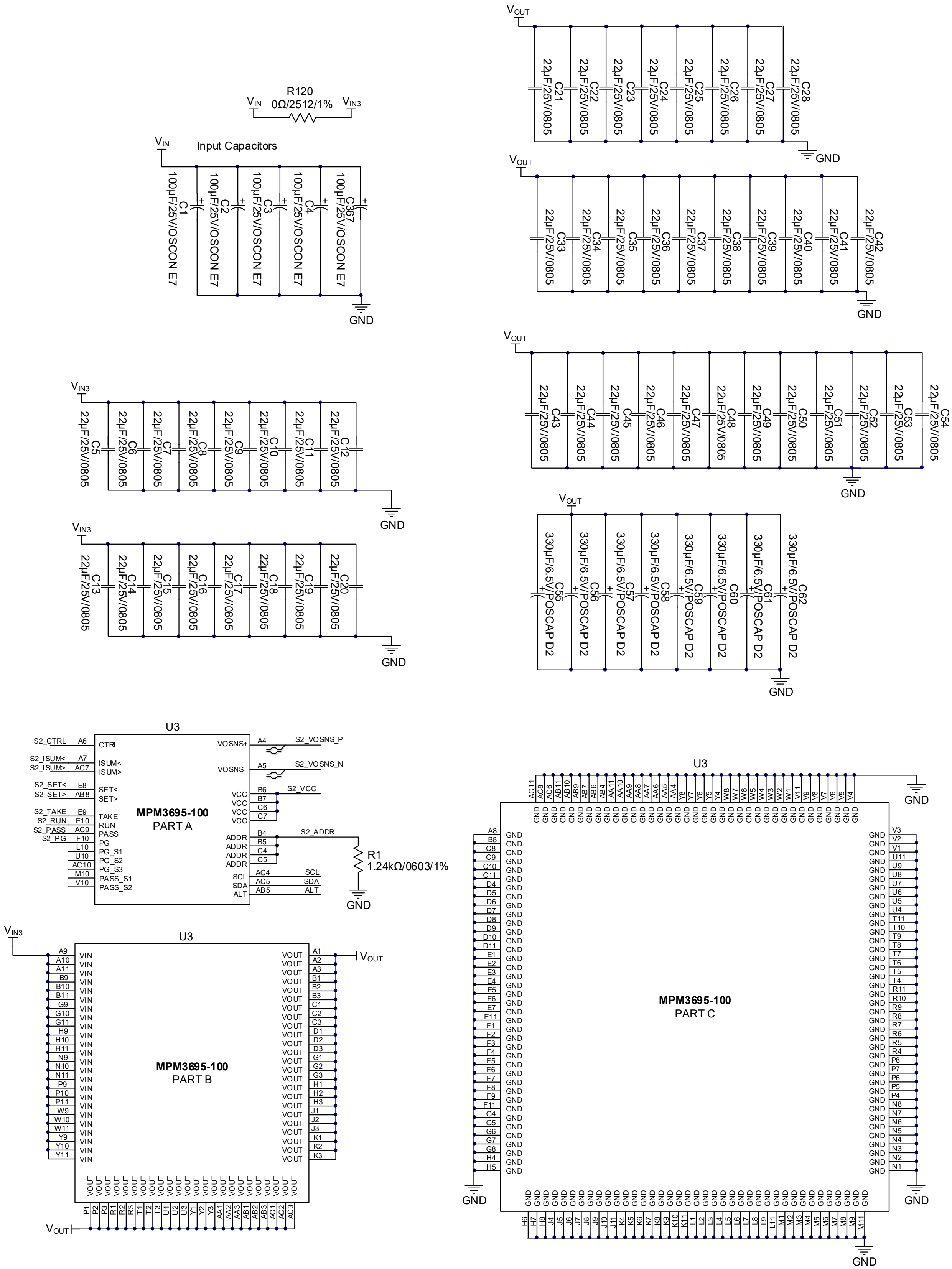


Figure 14: Evaluation Board Schematic (Part 4)

EVALUATION BOARD SCHEMATIC *(continued)*

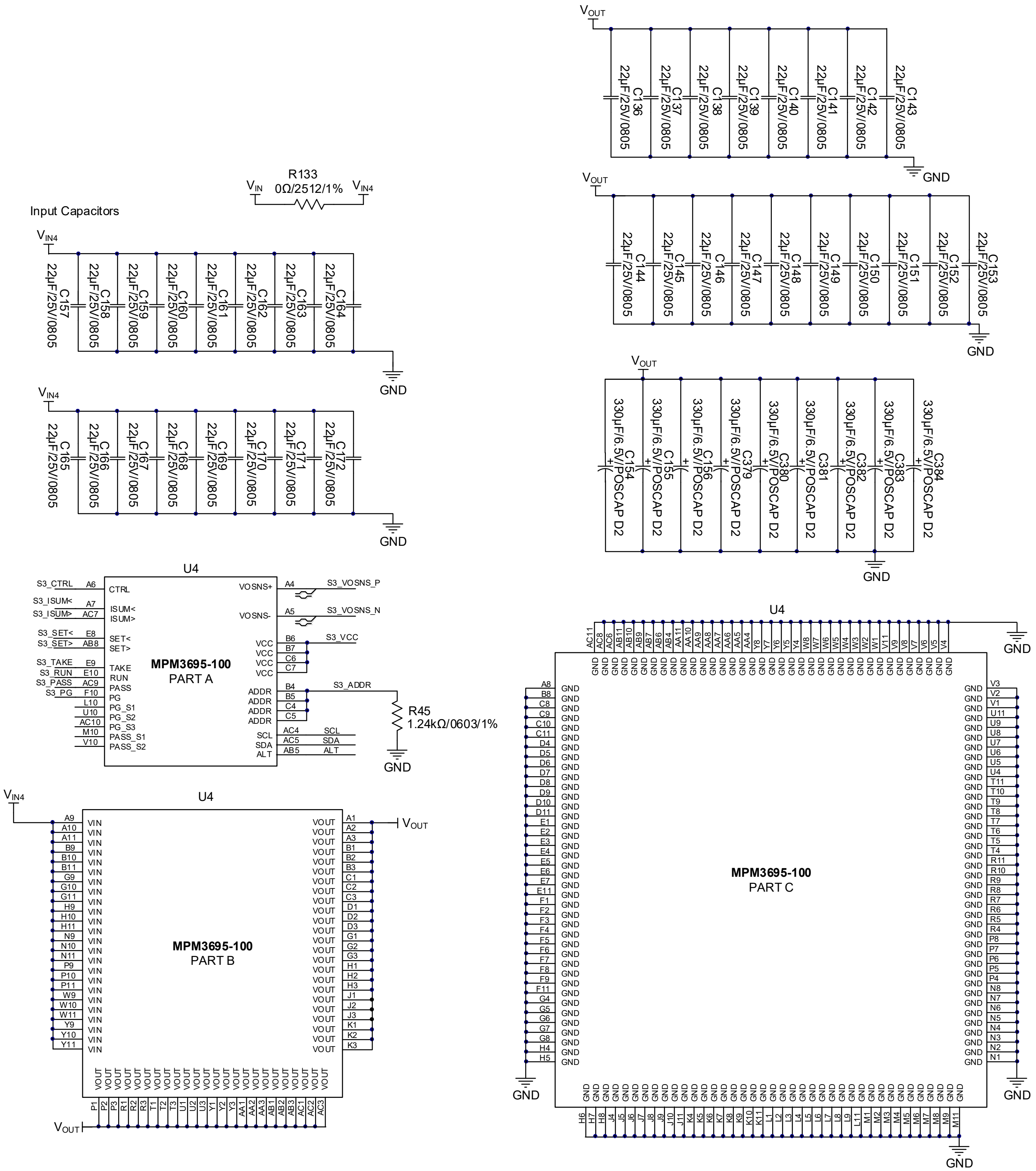


Figure 15: Evaluation Board Schematic (Part 5)

EVALUATION BOARD SCHEMATIC *(continued)*

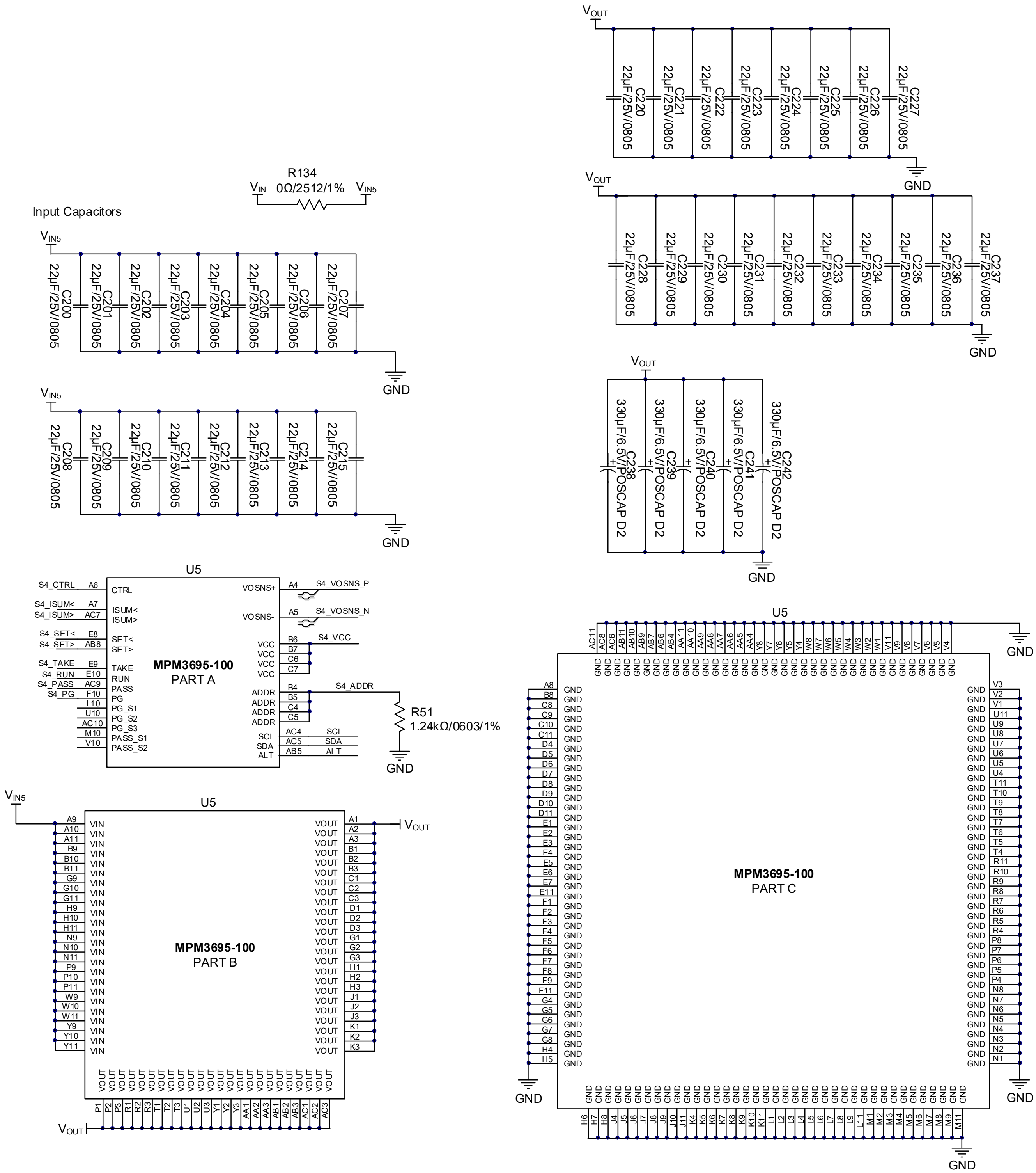


Figure 16: Evaluation Board Schematic (Part 6)

EVALUATION BOARD SCHEMATIC *(continued)*

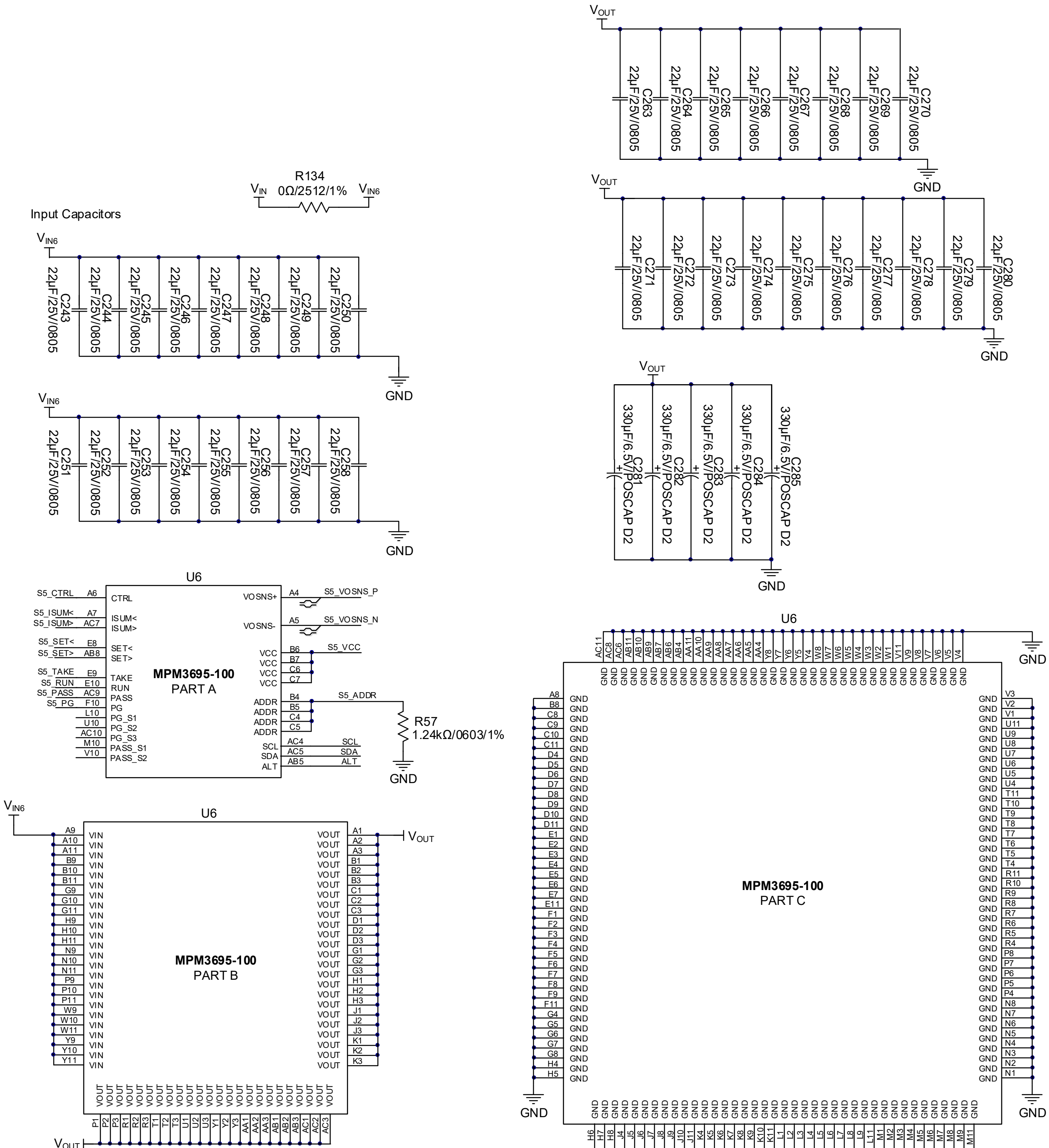


Figure 17: Evaluation Board Schematic (Part 7)

EVALUATION BOARD SCHEMATIC *(continued)*

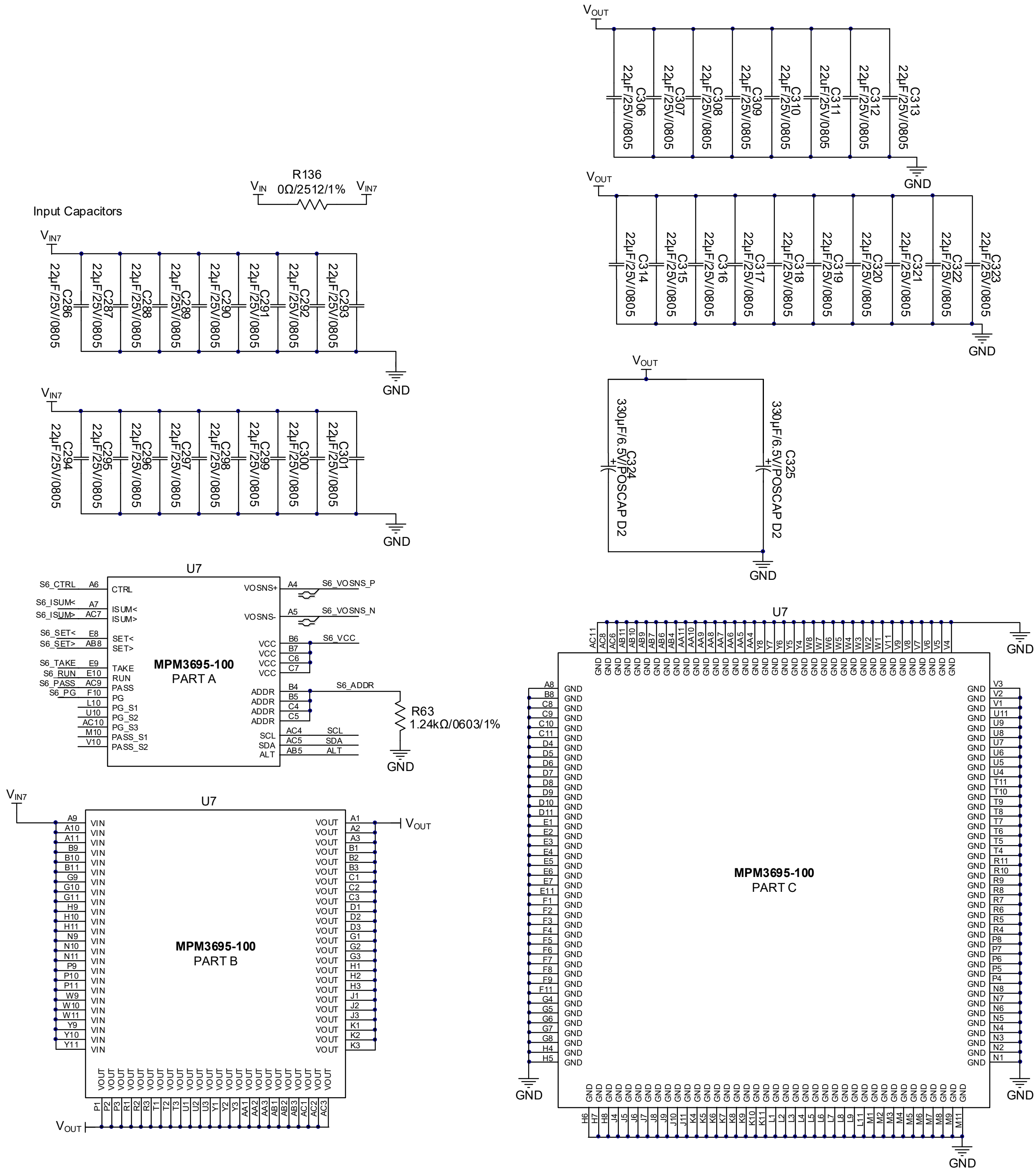


Figure 18: Evaluation Board Schematic (Part 8)

EVALUATION BOARD SCHEMATIC *(continued)*

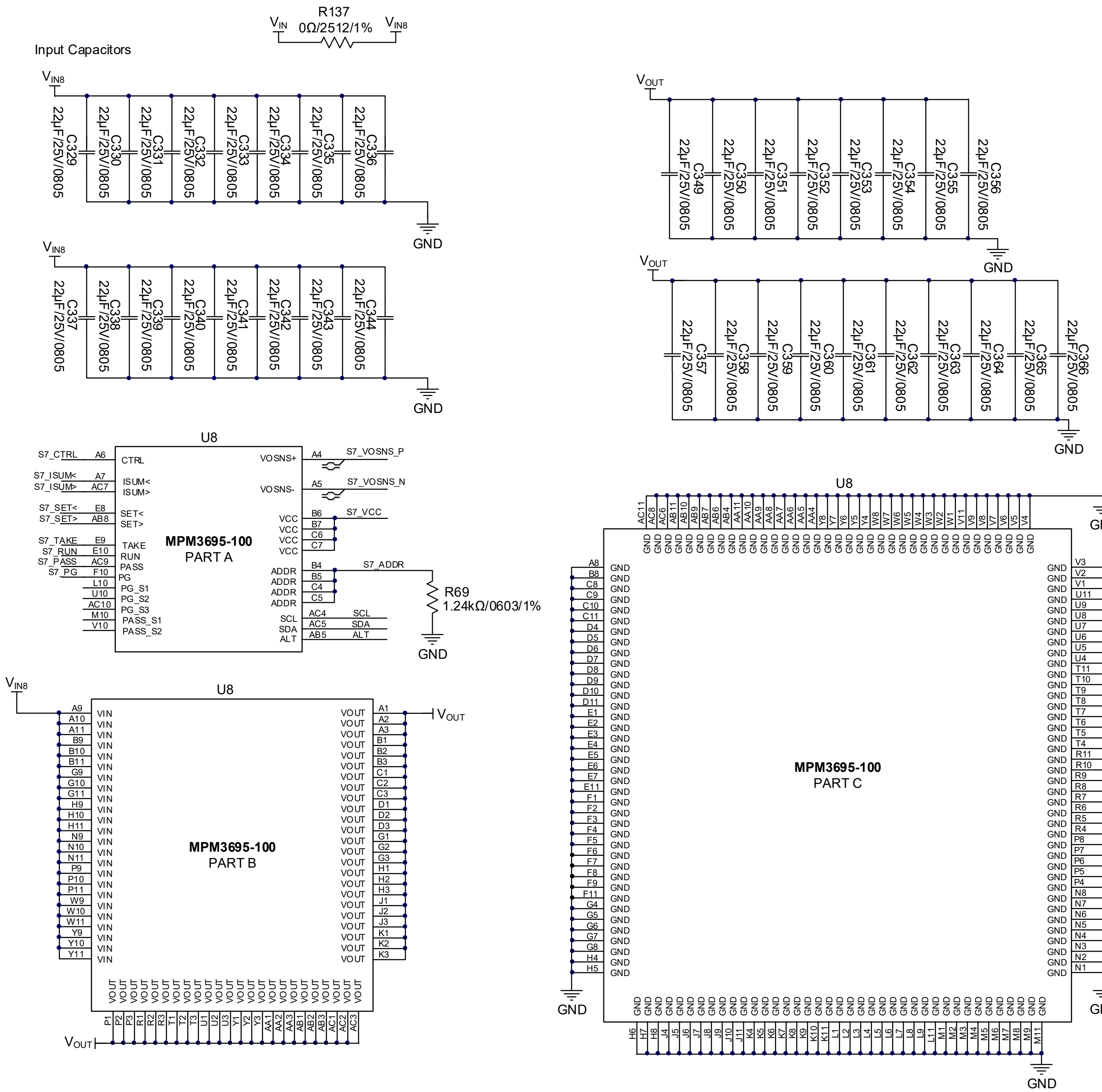


Figure 19: Evaluation Board Schematic (Part 9)

EVM3695-100-BH-00D BILL OF MATERIALS

The EVM3695-100-BH-00D is a 6-phase configuration evaluation board with a 600A output and 1.2V default V_{OUT}, unless otherwise noted.

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
5	C1, C2, C3, C4, C367	100µF	Polymer aluminum capacitor, 25V	OS-CON E7	Panasonic	25SVPF100M
53	C21-C28, C65-C69, C90-C97, C136-C143, C177-C184, C220-C227, C349-C356	47µF	Ceramic capacitor, 6.3V	0805	Murata	GRM21BR60J476ME15L
169	C5-C20, C33-C54, C70-C85, C98-C107, C116-C131, C144-C153, C157-C172, C185-C194, C200-C215, C228-C237, C329-C344, C357-C366, C719	22µF	Ceramic capacitor, 25V	0805	Murata	GRM21BR61E226ME44L
36	C55-C57, C109-C115, C154-C156, C195-C199, C238-C242, C281-C285, C324-C325, C379-C384	470µF	Polymer aluminum capacitor, 2.5V	2917	Panasonic	EEFGX0E471R
2	Q1, Q2	30V	MOSFET, I_{DS} = 24A, R_{DS} = 4.9mΩ	SOIC-8PP	Analog Power	AM7432N-T1-PF
2	IO_TRANS, CTRL_TRANS	50Ω	RF connector, WR-SMA, straight jack PCB THT	Through-hole	Wurth	60312002114503
10	VIN_SENSE+, VIN_SENSE-, PG, VCC, GND, GND, CTRL, VOUT_SENSE-, VOUT_SENSE+, ALT	1mm	Copper pin	Through-hole	Custom	Custom
1	EN SWITCH	2.54mm	Tact switch, ON-ON, vertical, THT bulk	Through-hole	Wurth	450301014042
12	R17, R18, R20, R21, R142, R143, R120, R131–R134, R137	0.002Ω	Film resistor, 1%	2512	Yageo	PA2512FKF070R002E
1	CN17	2.54mm	Connector, 2x10-pin	DIP	Wurth	612010235121

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

The EVM3695-100-BH-00D is a 6-phase configuration evaluation board with a 600A output and 1.2V default V_{OUT}, unless otherwise noted.

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
44	CN1–CN16, CN18–CN27, CN30–CN31, CN34–CN49	15A	Screw terminal, through hole	DIP	Keystone	7697-75
3	C378, C401, C403	1µF	Ceramic capacitor, 6.3V, X5R	0603	Murata	GRM188R60J105KA01D
1	C64	33nF	Ceramic capacitor, 50V, X7R	0603	Wurth	885012206092
8	C376, C377, C400, C402, C404, C900, C406, C407	22µF	Ceramic capacitor, 6.3V, X5R	0805	Wurth	885012107005
2	CN28, CN29	2mm	Straight header, 2x8-pin	DIP	Wurth	62000821121
6	R2, R5, R6, R9,	10kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0710KL
2	R7, R10	1kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-071KL
7	R111, R121, R122, R123, R124, R125, R126,	100Ω	Film resistor,1%	0603	Yageo	RC0603FR-07100RL
2	R138, R144	100kΩ	Film resistor, 1%	0402	Yageo	RC0402FR-07100KL
1	R139	51kΩ	Film resistor, 1%	0402	Yageo	RC0402FR-0751KL
1	R140	9.31kΩ	Film resistor, 1%	0402	Yageo	RC0402FR-79K31L
1	R141	1kΩ	Film resistor, 1%	0402	Yageo	RC0402FR-071KL
6	R1, R30, R38, R45, R51, R69	1.24kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-071K24L
55	R3, R8, R11, R12, R13, R14, R15, R23, R25, R26, R27, R28, R29, R32, R33, R34, R35, R37, R40, R41, R42, R43, R46, R47, R48, R49, R52, R53, R54, R55, R58, R59, R60, R61, R64, R65, 67, R68, R70, R71, R72, R101, R104, R105, R106, R110, R112, R116, R117, R119, R128, R129, R401, R402, R601	0Ω	Film resistor, 1%	0603	Yageo	RL0603FR-070RL
1	U12	MPM3632C	18V, 3A, synchronous, step-down module	QFN-20 (3mmx 5mmx 1.6mm)	MPS	MPM3632CGQV
6	U1–U4, U5, U8	MPM3695-100	16V, 10A, ultra-thin DC/DC power module with PMBus	BGA (15mmx 30mmx 5.18mm)	MPS	MPM3695GBH-100-xxxx

EVM3695-100-BH-00E BILL OF MATERIALS

The EVM3695-100-BH-00E is an 8-phase configuration evaluation board with a 600A output and default 1.2V V_{OUT}, unless otherwise noted.

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
5	C1, C2, C3, C4, C367	100µF	Polymer aluminum capacitor, 25V	OS-CON E7	Panasonic	25SVPF100M
69	C21-C28, C65-C69, C90-C97, C136-C143, C177-C184, C220-C227, C263-C270, C306-C313, C349-C356	47µF	Multilayer ceramic capacitor, 6.3V	0805	Murata	GRM21BR60J476ME15L
221	C5-C20, C33-C54, C70-C85, C116-C131, C144-C153, C157-C172, C185-C194, C200-C215, C228-C237, C243-C258, C271-C280, C286-C301, C314-C323, C329-C344, C357-C366, C719	22µF	Ceramic capacitor, 25V	0805	Murata	GRM21BR61E226ME44L
42	C55-C62, C108-C115, C154-C156, C195-C199, C238-C242, C281-C285, C324-C325, C379-C384	470µF	Polymer aluminum capacitor, 2.5V	2917	Panasonic	EEFGX0E471R
2	Q1, Q2	30V	MOSFET, I_{DS} = 24A, R_{DS} = 4.9mΩ	SOIC-8PP	Analog Power	AM7432N-T1-PF
2	IO_TRANS, CTRL_TRANS	50Ω	RF connector, WR-SMA, straight jack PCB THT	Through-hole	Wurth	60312002114503
10	VIN_SENSE+, VIN_SENSE-, PG, VCC, GND, GND, CTRL, VOUT_SENSE-, VOUT_SENSE+, ALT	1mm	Copper pin	Through-hole	Custom	Custom
1	EN SWITCH	2.54mm	Tact switch, ON-ON, vertical, THT bulk	Through-hole	Wurth	450301014042
14	R17, R18, R20, R21, R142, R143, R120, R131-R137	0.002Ω	Film resistor, 1%	2512	Yageo	PA2512FKF070R002E
1	CN17	2.54mm	Connector, 2x10-pin	DIP	Wurth	612010235121

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

The EVM3695-100-BH-00E is an 8-phase configuration evaluation board with a 600A output and default 1.2V V_{OUT}, unless otherwise noted.

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
44	CN1-CN16, CN18-CN27, CN30-CN31, CN34-CN49	15A	Screw terminal, through hole	DIP	Keystone	7697-75
3	C378, C401, C403	1µF	Ceramic capacitor, 6.3V, X5R	0603	Murata	GRM188R60J105KA01D
1	C64	33nF	Ceramic capacitor, 50V, X7R	0603	Wurth	885012206092
8	C376, C377, C400, C402, C404, C900, C406, C407	22µF	Ceramic capacitor, 6.3V, X5R	0805	Wurth	885012107005
2	CN28, CN29	2mm	Straight header, 2x8-pin	DIP	Wurth	62000821121
4	R2, R5, R6, R9, R19, R22, R24, R127	10kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0710KL
2	R7, R10	1kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-071KL
6	R121, R122, R123, R124, R125, R126,	100Ω	Film resistor, 1%	0603	Yageo	RC0603FR-07100RL
2	R138, R144	100kΩ	Film resistor, 1%	0402	Yageo	RC0402FR-07100KL
1	R139	51kΩ	Film resistor, 1%	0402	Yageo	RC0402FR-0751KL
1	R140	9.31kΩ	Film resistor, 1%	0402	Yageo	RC0402FR-79K31L
1	R141	1kΩ	Film resistor, 1%	0402	Yageo	RC0402FR-071KL
8	R1, R30, R38, R45, R51, R57, R63, R69	4.99kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-074K99L

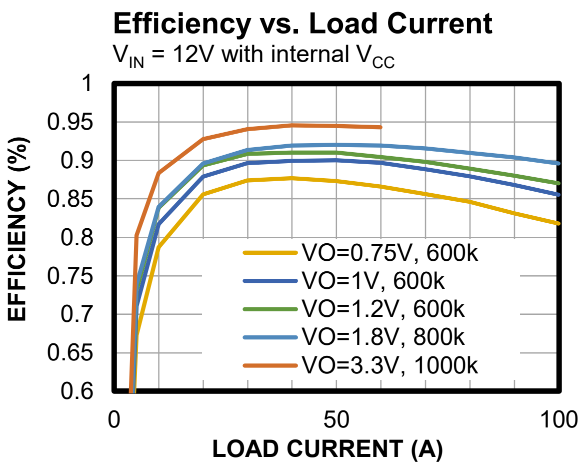
EVM3695-100-BH-00E BILL OF MATERIALS *(continued)*

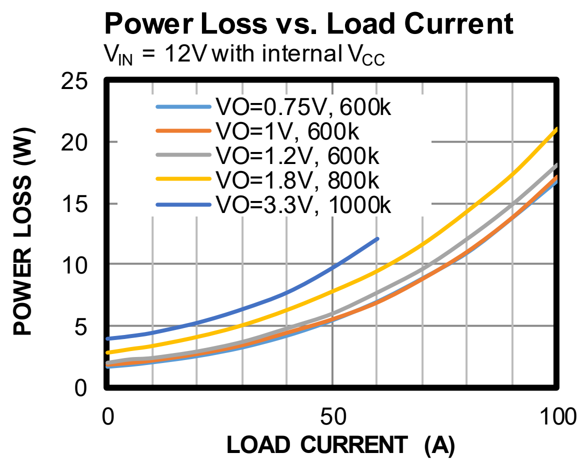
The EVM3695-100-BH-00E is an 8-phase configuration evaluation board with a 600A output and default 1.2V V_{OUT}, unless otherwise noted.

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
62	R3, R4, R8, R11, R12, R13, R14, R15, R23, R25, R26, R27, R28, R29, R32, R33, R34, R35, R37, R40, R41, R42, R43, R46, R47, R48, R49, R52, R53, R54, R55, R58, R59, R60, R61, R64, R65, R66, R68, R70, R71, R72, R101, R102, R104, R105, R106, R108, R110, R111, R112, R115, R116, R117, R118, R119, R128, R129, R401, R402, R601	0Ω	Film resistor, 1%	0603	Yageo	RL0603FR-070RL
1	U12	MPM3632C	18V, 3A, synchronous, step-down module	QFN-20 (3mmx 5mmx 1.6mm)	MPS	MPM3632CGQV
8	U1-U8	MPM3695-100	16V, 10A, ultra-thin DC/DC power module with PMBus	BGA (15mmx 30mmx 5.18mm)	MPS	MPM3695GBH-100-xxxx

EVB TEST RESULTS

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 1.2V, T_A = 25°C, unless otherwise noted.



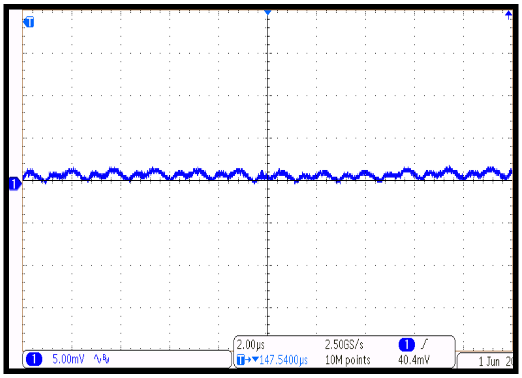


EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 12V, V_{OUT} = 1.2V, T_A = 25°C, unless otherwise noted.

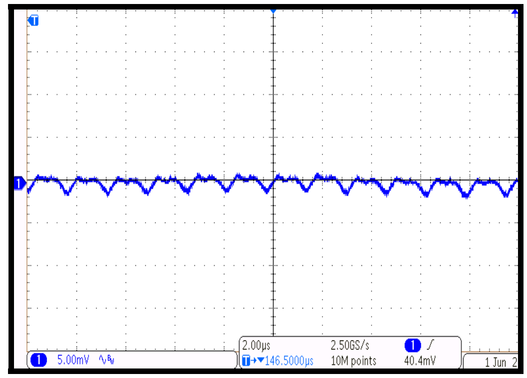
Steady Ripple

I_{OUT} = 0A, ramp = 15mV, capacitor: 42 x 470µF +128 x 47µF



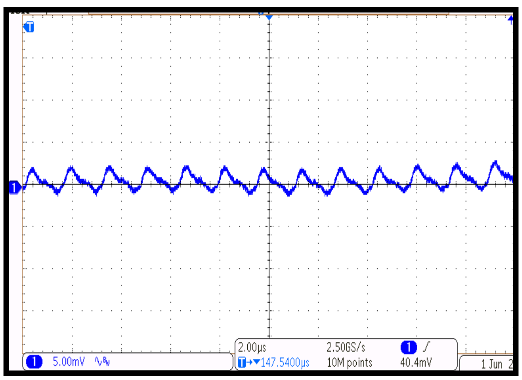
Steady Ripple

I_{OUT} = 400A, ramp = 15mV, capacitor: 42 x 470µF + 128 x 47µF



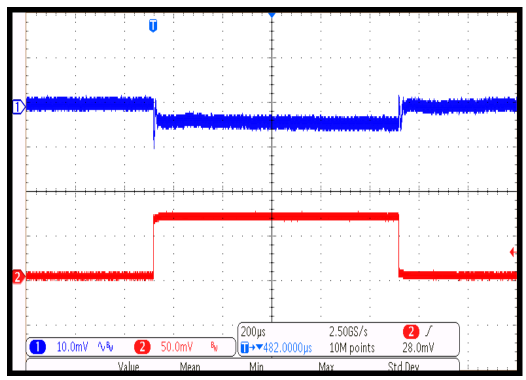
Steady Ripple

I_{OUT} = 800A, ramp = 15mV, capacitor: 42 x 470µF + 128 x 47µF



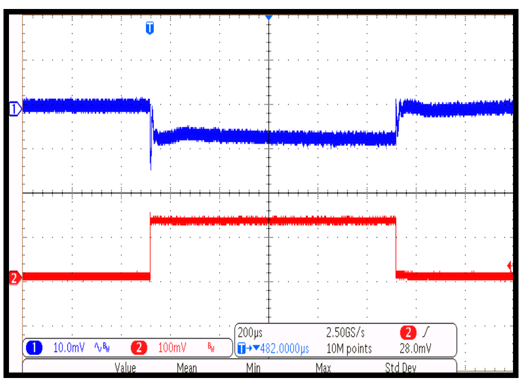
Load Transient

0A to 200A, ramp = 8.6mV, capacitor: 42 x 470µF + 128 x 47µF, transient rate = 100A/µS, R_{LOAD} = 0.32mΩ



Load Transient

0A to 400A, ramp = 8.6mV, capacitor: 42 x 470µF + 128 x 47µF, transient rate = 100A/µs, R_{LOAD} = 0.32mΩ



PCB LAYOUT

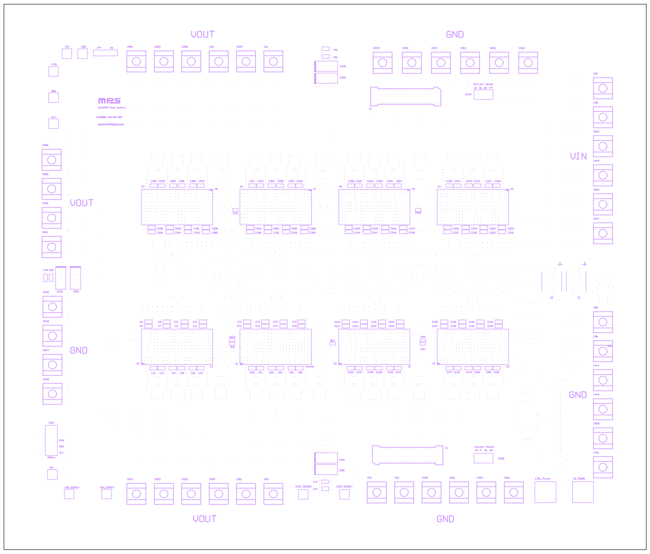


Figure 20: Top Silk

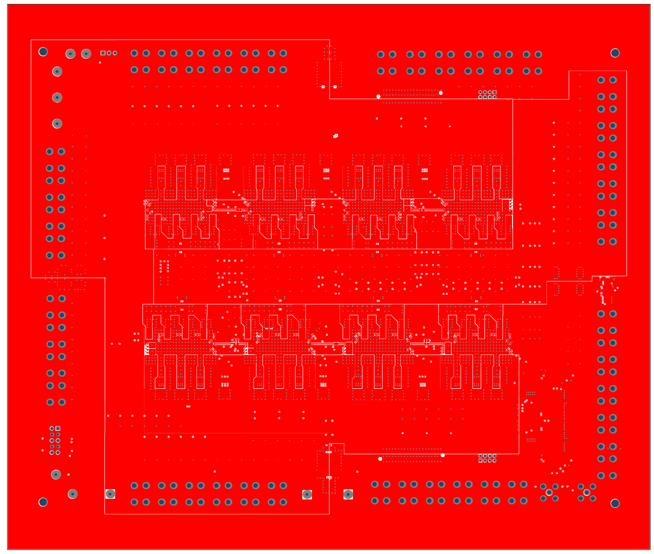


Figure 21: Top Layer

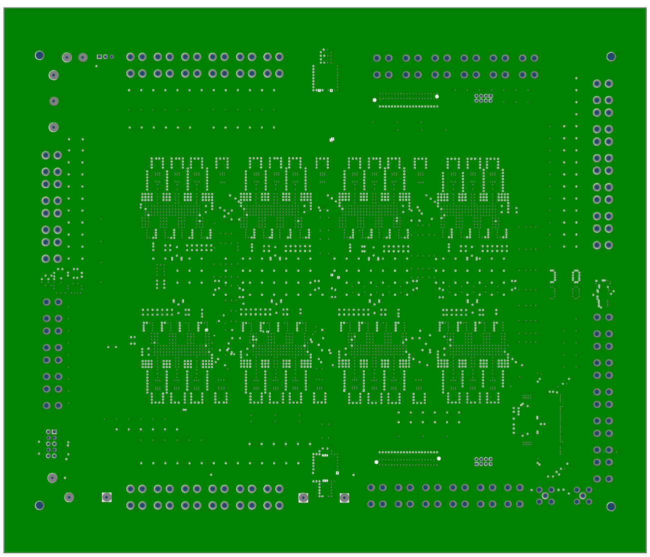


Figure 22: Mid-Layer 1

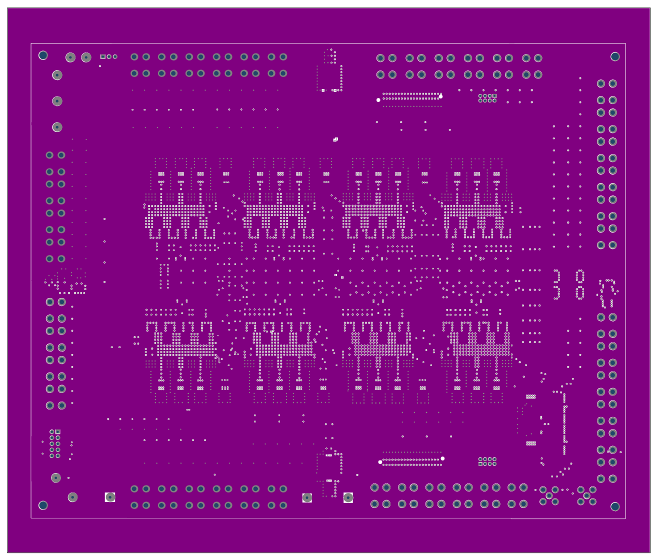


Figure 23: Mid-Layer 2

PCB LAYOUT *(continued)*

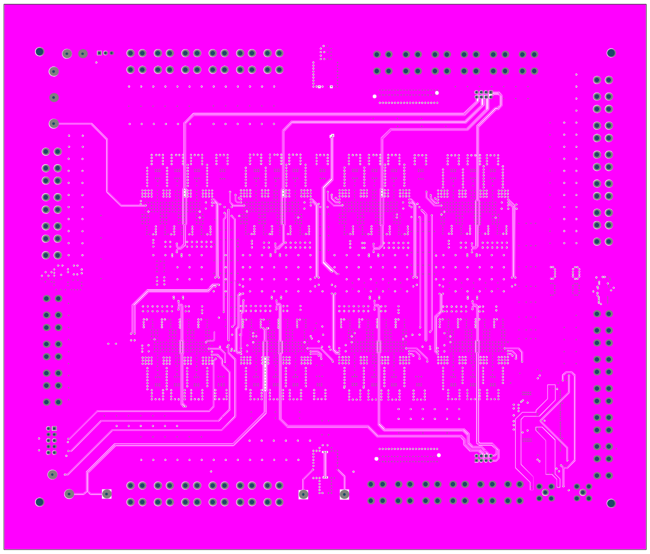


Figure 24: Mid-Layer 3

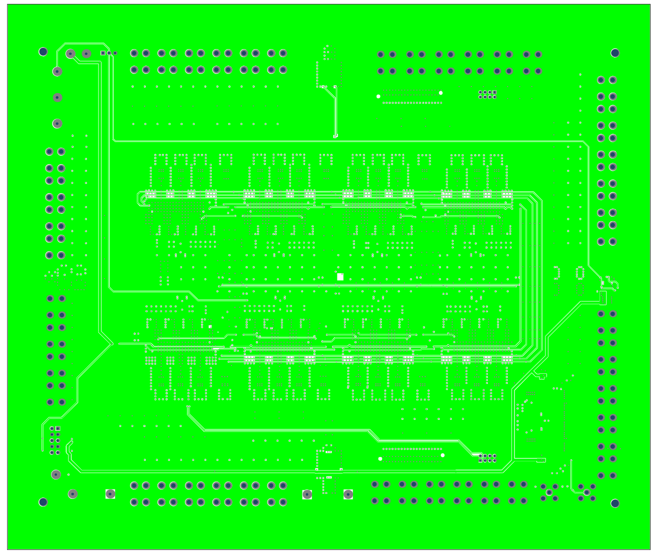


Figure 25: Mid-Layer 4

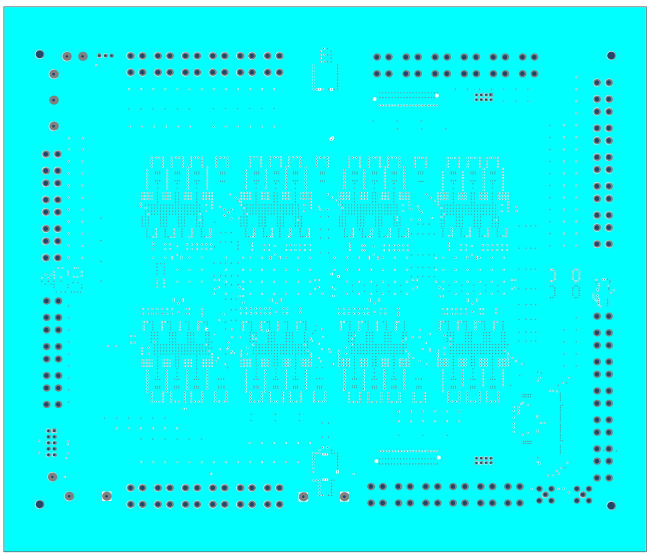


Figure 26: Mid-Layer 5

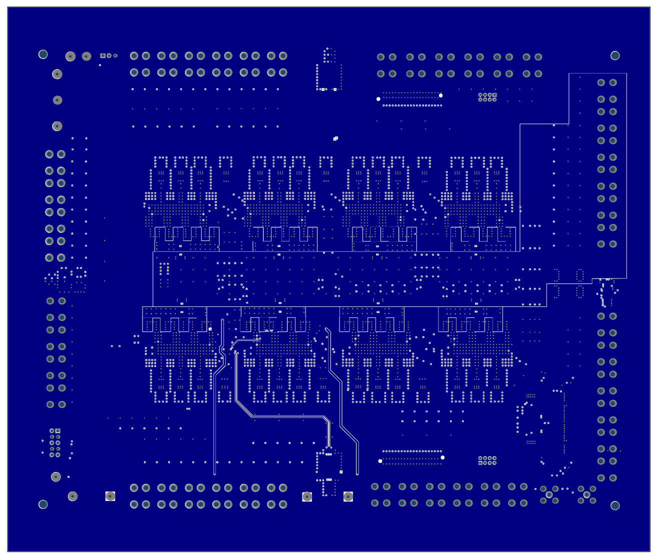


Figure 27: Mid-Layer 6

PCB LAYOUT *(continued)*

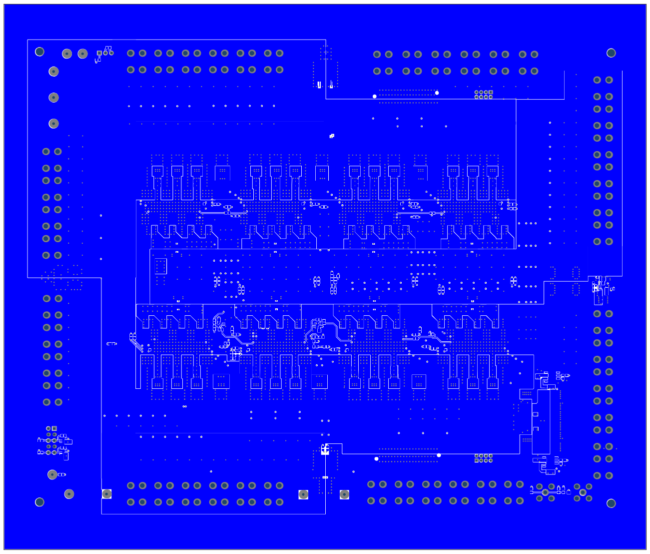


Figure 28: Bottom Layer

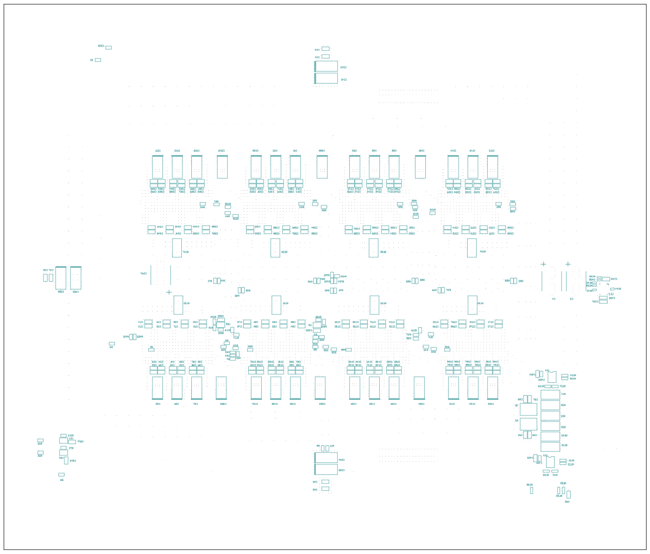


Figure 29: Bottom Silk

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	3/16/2023	Initial Release	-

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