EVHFC0310A-S-00A

Configurable Fixed-Frequency Flyback Controller Evaluation Board

DESCRIPTION

The EVHFC0310A-S-00A is an evaluation board designed to demonstrate the capabilities of the HFC0310A. The HFC0310A is a flyback controller that is configured to provide a 3-channel output, including a main controlled 12.5V/3A output from a $100V_{DC}$ to $1000V_{DC}$ input.

The HFC0310A uses peak current mode to provide excellent transient response and ease loop compensation. When the output power (P_{OUT}) falls below a given level, the controller enters burst mode to reduce standby power consumption.

An external capacitor connected between the FSET and GND pins configures the HFC0310A's switching frequency (f_{SW}). Otherwise, the HFC0310A uses a frequency shaping function to reduce the noise level and cost of the EMI filter.

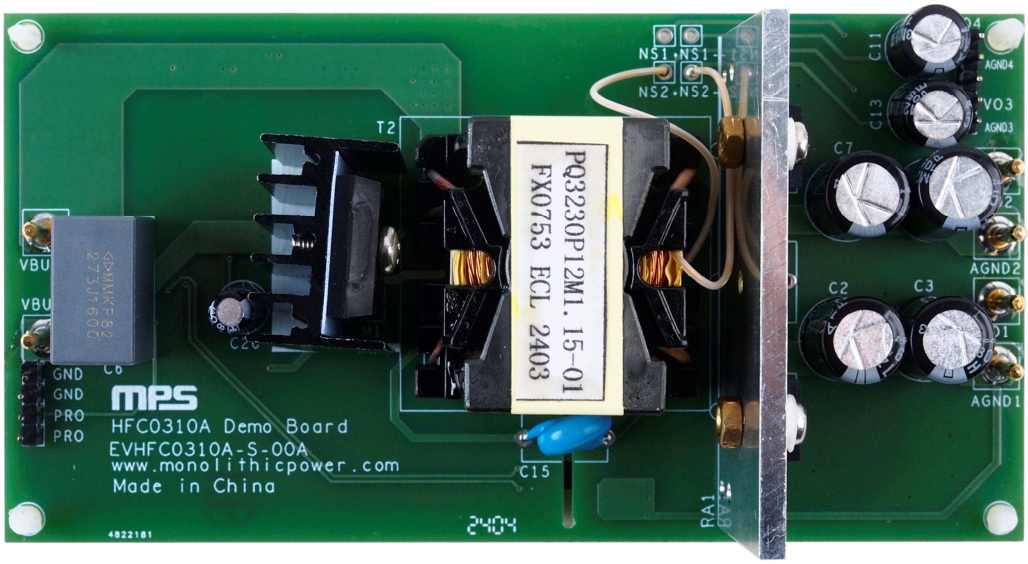
The HFC0310A is available in a SOIC-8 package.

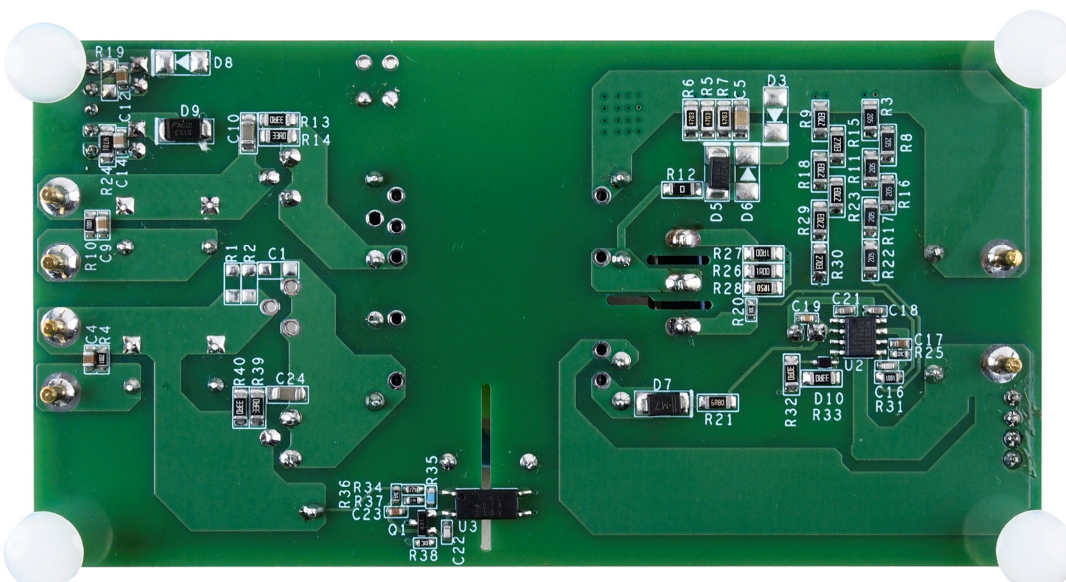
PERFORMANCE SUMMARY

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

Parameters	Conditions	Value
Input voltage (V_{IN}) range	DC input	100V to 1000V
Output voltage 1 (V_{OUT1})		V_{OUT1} = 12.5V
Maximum output current 1 (I_{OUT1})		I_{OUT1} = 3A
Output voltage 2 (V_{OUT2})		V_{OUT2} = 12.5V
Maximum output current 2 (I_{OUT2})		I_{OUT2} = 3A
Output voltage 3 (V_{OUT3})		V_{OUT3} = 24V
Maximum output current 3 (I_{OUT3})		I_{OUT3} = 100mA
Switching frequency (f_{SW})	C_{FSET} = 1nF	60kHz

EVHFC0310A-S-00A EVALUATION BOARD





LxWxH (12.5cmx6.5cmx4cm)

Board Number	MPS IC Number
EVHFC0310A-S-00A	HFC0310AGS

QUICK START GUIDE

1. Preset the power supply to $100V_{DC} \leq V_{IN} \leq 1000V_{DC}$.
2. Turn the power supply off.
3. Connect the power supply output terminals to:
    a. Positive (+): VBUS+
    b. Negative (-): VBUS-
4. Connect the load to VO1 and AGND1, VO2 and AGND2, and VO3 and AGND3, respectively.
5. If the PRO function is required, connect a DC source between the PRO and GND pins.
6. After making the connections, turn the power supply on.
7. Figure 1 shows the measurement equipment set-up.

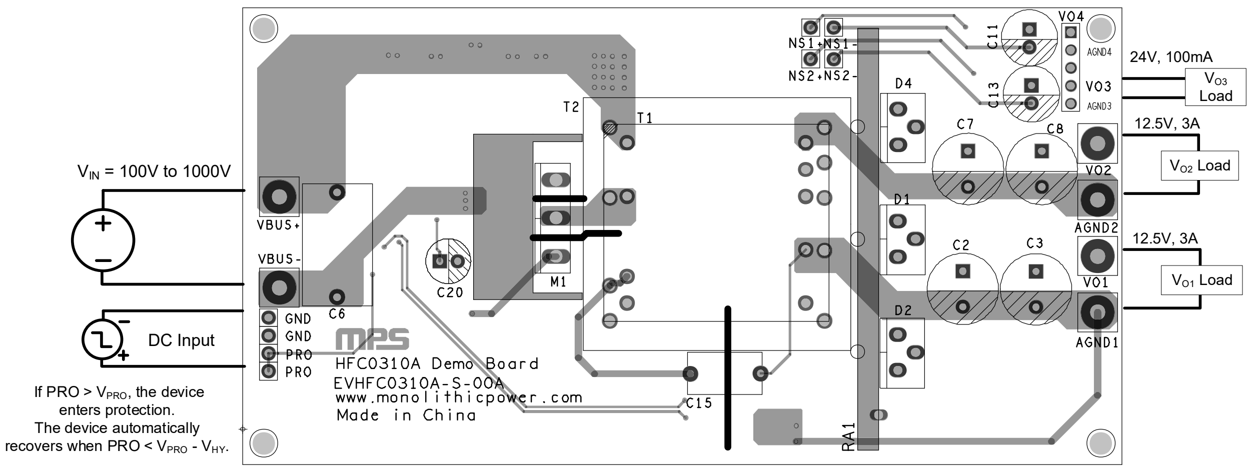


Figure 1: Measurement Equipment Set-Up

CIRCUIT DESCRIPTION

The EVHFC0310A-S-00A evaluation board can be configured in flyback applications for the HFC0310A. The HFC0310A uses secondary-side control to achieve a precise output voltage (V_{OUT}).

C6 guarantees a stable bus voltage (V_{BUS}) when the HFC0310A starts switching.

The primary-side snubber is comprised of R5, R6, R7, R12, C5, D5, and D6. When the MOSFET turns off, the primary-side snubber absorbs the leakage inductance energy to limit the high spike.

R3, R8, R11, R16, R17, R22, and R31 can be used as the feed-forward circuit. The circuit can partially compensate for the peak current difference across the wide input voltage (V_{IN}) range.

C20 is the power supply capacitor for the VCC voltage (V_{CC}). Connect C19 in parallel with C20 to decouple the voltage noise, placed as close to the IC as possible.

R9, R15, R18, R23, R29, and R30 are the start-up resistors that charge the VCC capacitor (C_{VCC}) before the HFC0310A starts switching and the transformer's auxiliary winding powers V_{CC}. D7 and R21 are used as the auxiliary power supply circuit for V_{CC}.

R26, R27, and R28 are the current-sense resistors with 1% tolerance for the peak current set-up. The RC filter for the CS pin input is comprised of R31 and C16.

R33 is the external turn-on resistance for the primary MOSFET. The external turn-off resistance is comprised of R32 and R33.

C21 is the FSET capacitor (C_{FSET}) and sets the HFC0310A's switching frequency (f_{SW}).

D1 and D2 are the output diodes for VO1, and D4 is the output diode for VO2. Schottky diodes are recommended for their fast-switching speed and low forward voltage drop (V_{FWD}) for improved efficiency. D9 is the output diode for VO3.

The secondary-side snubber is comprised of R1, R2, C1, R39, R40, C24, R13, R14, and C10. It helps suppress EMI and restrains the output diode's high spike.

T1 or T2 is the power transformer. It must be designed properly to satisfy power delivery across the wide V_{IN} range. This also ensures that the primary MOSFET and output diode's voltage stress meets the requirements.

C2, C3, C7, C8, C11, and C13 are the output capacitors. A low-ESR electrolytic capacitor is recommended to achieve improved output ripple and efficiency. C4, C9, C12, and C14 are the small ceramic capacitors that bypass the high-frequency noise on the output.

R4, R10, R19, R24 is the dummy load that regulates V_{OUT} within the designed value.

R36 and R38 are configured to set V_{OUT}. The control loop is comprised of the instantaneous feedback output voltage of U3, Q1, R34, and R35 to the FB pin. R37, C22, and C23 are configured as the compensation network. The control loop must be carefully designed to obtain good dynamic response and high system stability.

EVALUATION BOARD SCHEMATIC

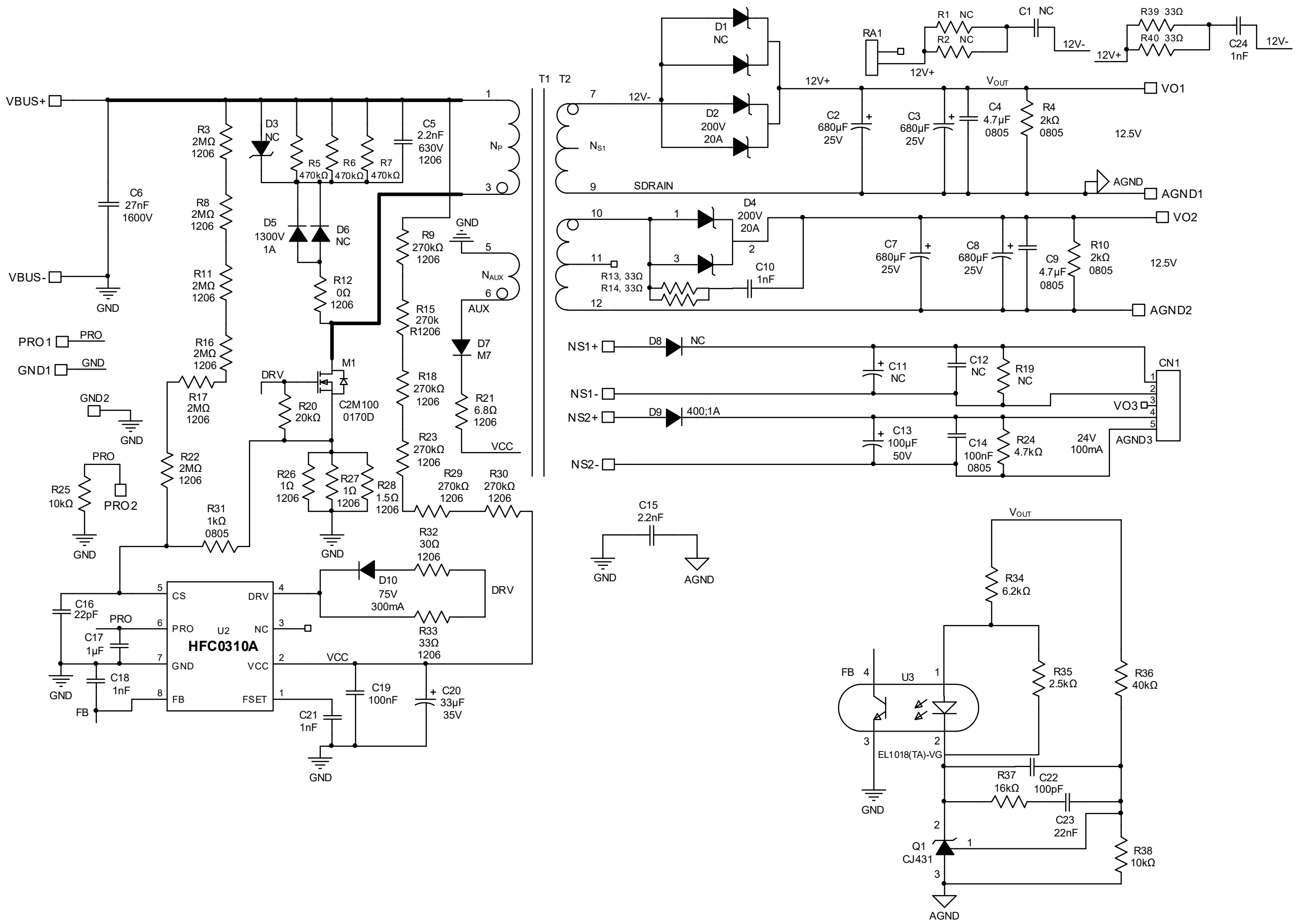


Figure 2: Evaluation Board Schematic

EVHFC0310A-S-00A BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
1	C1	NC				
2	C10, C24	1nF	Capacitor, 630V, U2J	1206	Murata	GRM31A7U2J102JW31D
4	C2, C3, C7, C8	680µF	Electrolytic capacitor, 25V	DIP	Rubycon	25ZLH680MEFC10X16
2	C4, C9	4.7µF	Capacitor, 35V, X7R	0805	TDK	C2012X7R1V475K
1	C5	2.2nF	Capacitor, 630V, X7R	1206	Murata	GRM31BR72J222KW01L
1	C6	27nF	Capacitor, 1600V, DIP	DIP	Faratronic	C5121888
1	C11	NC				
1	C12	NC				
1	C13	100µF	Electrolytic capacitor, 50V	DIP	Rubycon	50YXF100MEFC
1	C14	100nF	Capacitor, 50V, C0G	0805	Samsung	CL21B104KBCNNNC
1	C15	2.2nF	Capacitor, 275V	DIP	Hongke	JNK12E222ML02N
1	C16	22pF	Capacitor, 50V, C0G	0603	Murata	GRM1885C1H220JA01D
1	C17	1µF	Capacitor, 16V, X7R	0603	Murata	GRM188R71C105KA12D
2	C18, C21	1nF	Capacitor, 50V, X7R	0603	Murata	GRM1885C1H102JA01D
1	C19	100nF	Capacitor, 50V, X7R	0603	Murata	GRM188R71H104KA93D
1	C20	33µF	Electrolytic capacitor, 35V	DIP	Jianghai	CD281L-35V33
1	C22	100pF	Capacitor, 50V, C0G	0603	Murata	GRM1885C1H101JA01D
1	C23	22nF	Capacitor, 50V, X7R	0603	Wurth	885012206091
1	D1	NC				
2	D2, D4	200V	Diode, 20A	TO-220F	Vishay	MBR20H200CT
1	D3	NC				
1	D5	1300V	Diode, 1A	SMA	Panjit	US1R
1	D6	NC				
1	D7	1000V	Diode, 1A	SMA	MIC	M7
1	D8	NC				
1	D9	400V	Diode, 1A	SMA	Premier	ES1G
1	D10	75V	Diode, 300mA	SOD-323	Diodes, Inc.	1N4148WSQ-13-F
1	M1	1700V	N-channel MOSFET, 5A	TO-247-3	Cree	C2M1000170D
1	Q1	36V	Shunt regulator IC	SOT-23	Changdian	CJ431
2	R1, R2	NC				
4	R13, R14, R39, R40	33Ω	Film resistor, 5%	1206	Yageo	RC1206FR-0733RL

EVHFC0310A-S-00A BILL OF MATERIALS *(continued)*

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
6	R3, R8, R11, R16, R17, R22	2MΩ	Film resistor, 1%	1206	Yageo	1206J0205T5E
2	R4, R10	2kΩ	Film resistor, 1%	0805	Yageo	RC0805FR-072KL
3	R5, R6, R7	470kΩ	Film resistor, 1%	1206	Yageo	RC1206FR-07470KL
6	R9, R15, R18, R23, R29, R30	270kΩ	Film resistor, 1%	1206	Yageo	RC1206FR-07270KL
1	R12	0Ω	Film resistor, 1%	1206	Yageo	RC1206FR-070RL
1	R19	NC				
1	R20	20kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0720KL
1	R21	6.8Ω	Film resistor, 1%	1206	Yageo	1206F680KT5E
1	R24	4.7kΩ	Film resistor, 1%	1206	Yageo	RC1206JR-074K7L
2	R25, R38	10kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0710KL
2	R26, R27	1Ω	Film resistor, 1%	1206	Yageo	RC1206FR-071RL
1	R28	1.5Ω	Film resistor, 1%	1206	Yageo	RC1206FR-071R5L
1	R31	1kΩ	Film resistor, 1%	0805	Yageo	RC0805FR-071KL
1	R32	30Ω	Film resistor, 1%	1206	Yageo	RC1206FR-0730RL
1	R33	33Ω	Film resistor, 1%	1206	Yageo	RC1206FR-0733RL
1	R34	6.2kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-076K2L
1	R35	2.49kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-072K49L
1	R36	40.2kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0740K2L
1	R37	16kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0716KL
1	T1	1.15mH	PC40 transformer	PQ3230	Emei	PQ3230P12M1.15-01
1	T2	NC				
1	U3	$5000V_{RMS}$	Photocoupler	SOP-4L	Everlight	EL1018(TA)-VG
1	U2	HFC0310A	Configurable fixed-frequency flyback controller	SOIC-8	MPS	HFC0310AGS

TRANSFORMER SPECIFICATION

Electrical Diagram

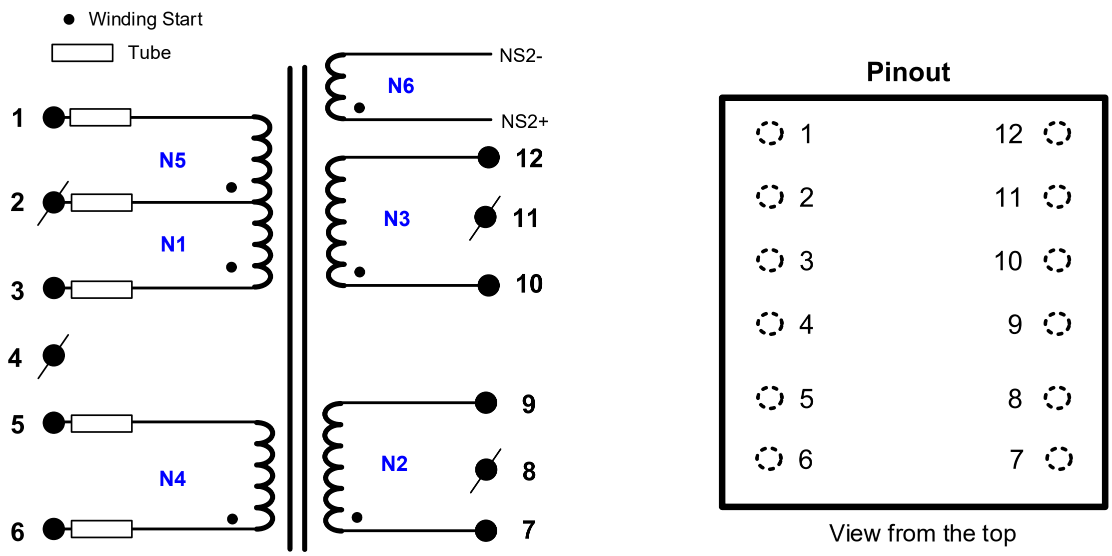


Figure 3: Transformer Electrical Diagram (1)

Note:

1) All the windings require planar layers with uniform distribution.

Winding Diagram

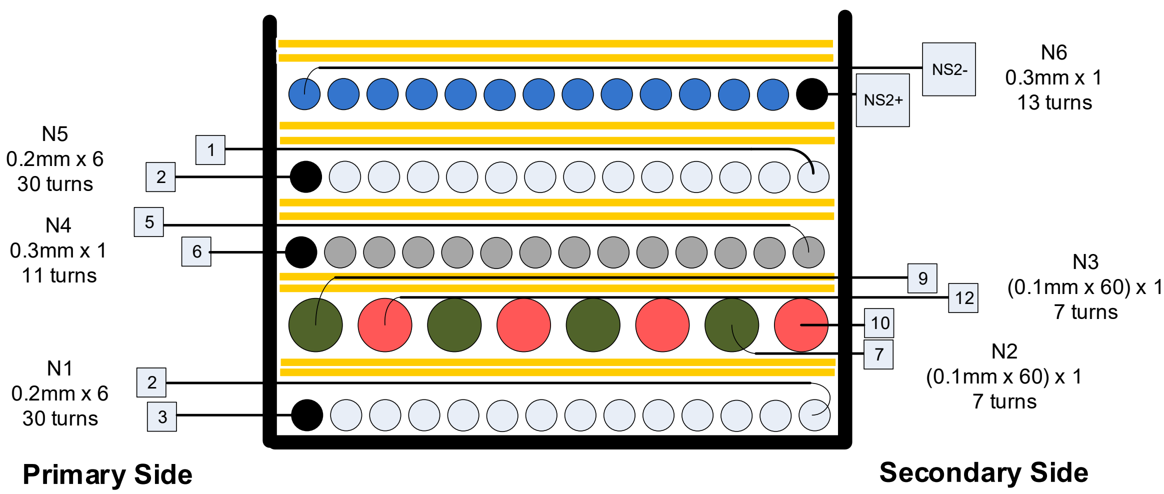


Figure 4: Winding Diagram

Winding Order

Tape Layer Number	Winding No.	Start and End	Magnet Wire	Turns	Wire Type
2	N1	3 to 2	0.2mm x 6	30	Enamel-insulated wire
2	N2 || N3	7 to 9, 10 to 12	0.1mm x 60 (TIW) x 1, (0.1mm x 60mm) (TIW) x 1	7 (1 layer, evenly)	TIW, wound in bifilar
2	N4	6 to 5	0.3mm x 1	11 (1 layer, evenly)	Enamel-insulated wire
2	N5	2 to 1	0.2mm x 6	30	Enamel-insulated wire
2	N6	NS2+ to NS2-	0.3mm (TIW) x 1	13	TIW

Electrical Specifications

No.	Item	Measuring Terminal	Value	Condition
1	Primary inductance	L_P (1 to 3)	1.15mH ± 5%	100kHz
2	Leakage inductance	L_P (1 to 3), 7, 9, 10, 12 short	15μH (max)	100kHz
3	Electrical strength	Primary side to secondary side	$3500V_{AC}$	1s, 1mA
		Primary side to core	$1500V_{AC}$	
		Secondary side to core	$3500V_{AC}$	

Materials

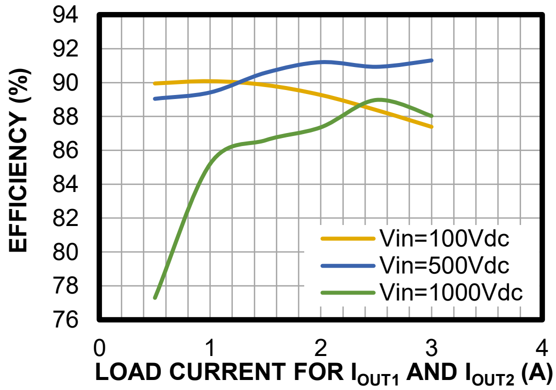
Item	Description
1	Core: PQ3230
2	Bobbin: PQ3230 vertical, 6 pins + 6 pins

EVB TEST RESULTS

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 1000V_{DC}, V_{OUT1} = 12.5V, I_{OUT1} = 3A, V_{OUT2} = 12.5V, I_{OUT2} = 3A, V_{OUT3} = 24V, I_{OUT3} = 0.1A, T_A = 25°C, unless otherwise noted.

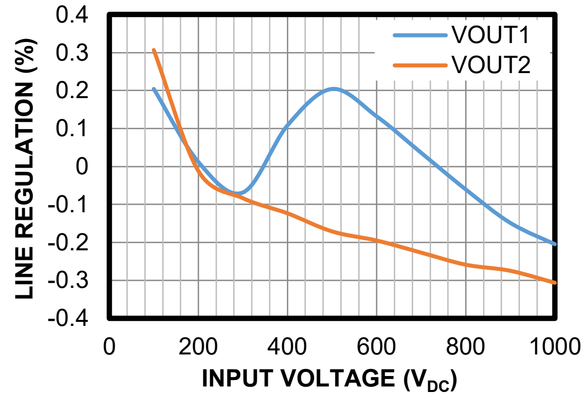
Efficiency vs. Load Current

V_{OUT1} = 12.5V, I_{OUT1} = 0.5A to 3A,
V_{OUT2} = 12.5V, I_{OUT2} = 0.5A to 3A,
V_{OUT3} = 24V, I_{OUT3} = 100mA



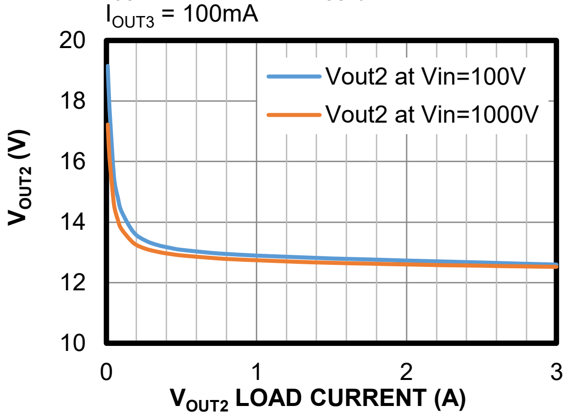
Line Regulation

V_{OUT1} = 12.5V, I_{OUT1} = 3A, V_{OUT2} = 12.5V,
I_{OUT2} = 3A, V_{OUT3} = 24V, I_{OUT3} = 100mA



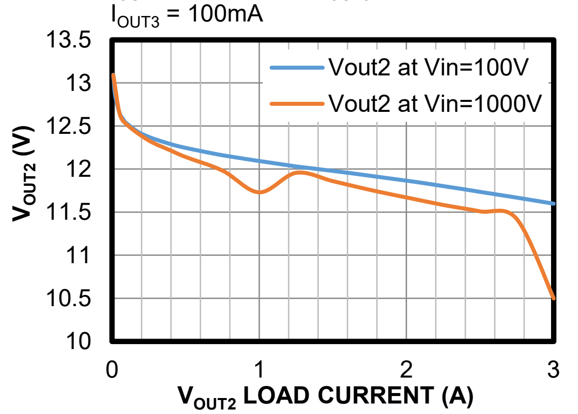
Load Regulation

V_{OUT1} = 12.5V, I_{OUT1} = 3A,
I_{OUT2} = 8mA to 3A, V_{OUT3} = 24V,
I_{OUT3} = 100mA



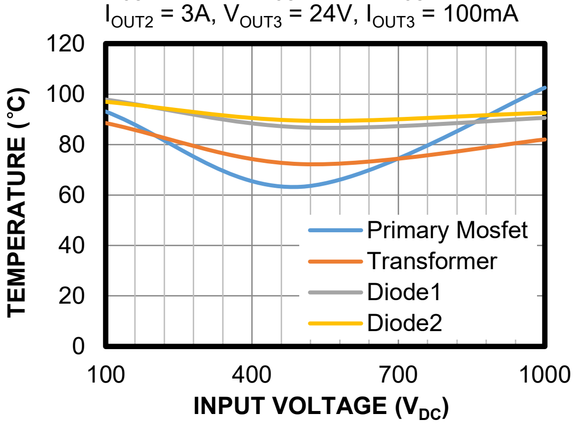
Load Regulation

V_{OUT1} = 12.5V, I_{OUT1} = 0.08A,
I_{OUT2} = 8mA to 3A, V_{OUT3} = 24V,
I_{OUT3} = 100mA



Thermal Performance

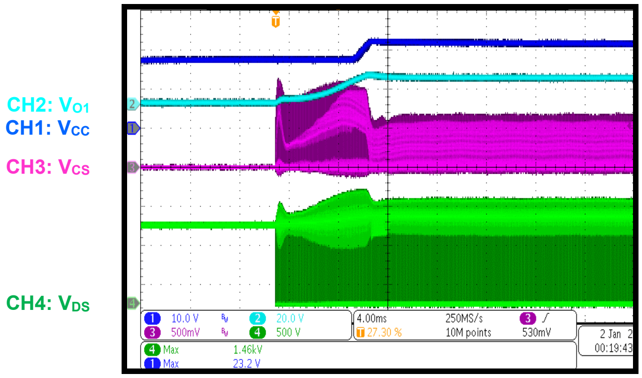
V_{OUT1} = 12.5V, I_{OUT1} = 3A, V_{OUT2} = 12.5V,
I_{OUT2} = 3A, V_{OUT3} = 24V, I_{OUT3} = 100mA



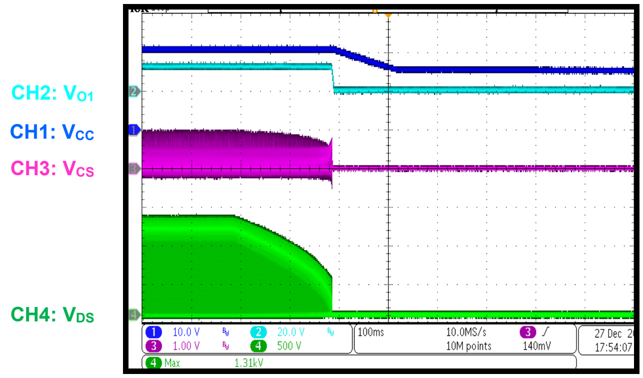
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 1000V_{DC}, V_{OUT1} = 12.5V, I_{OUT1} = 3A, V_{OUT2} = 12.5V, I_{OUT2} = 3A, V_{OUT3} = 24V, I_{OUT3} = 0.1A, T_A = 25°C, unless otherwise noted.

Start-Up

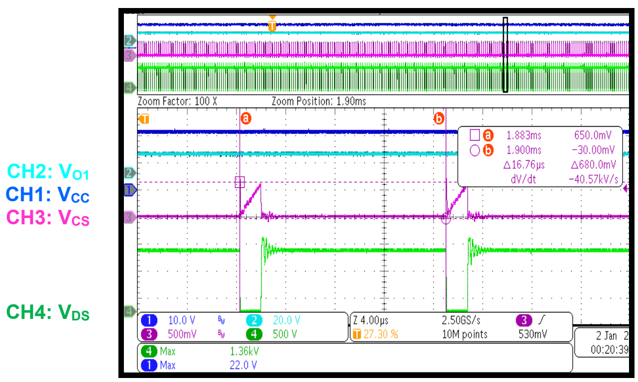


Shutdown



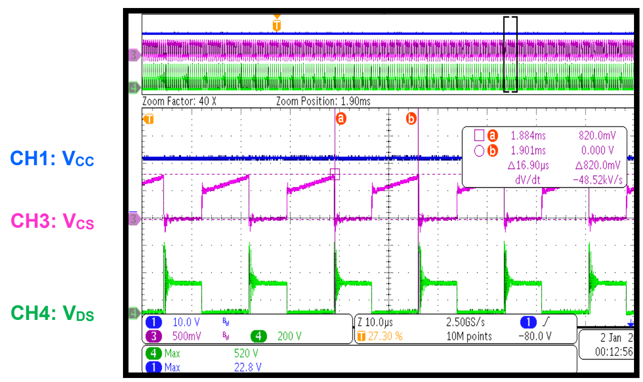
Steady State

V_{IN} = 1000V_{DC}



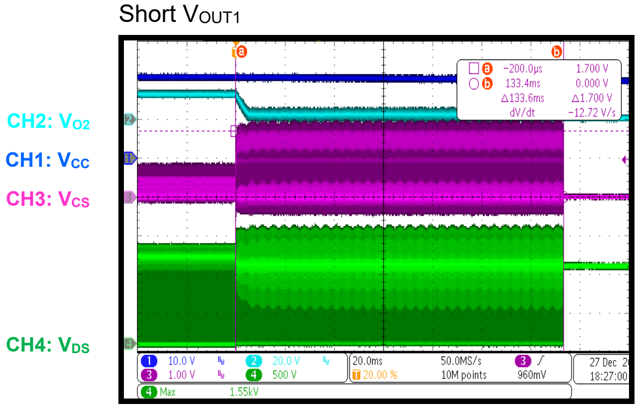
Steady State

V_{IN} = 100V_{DC}



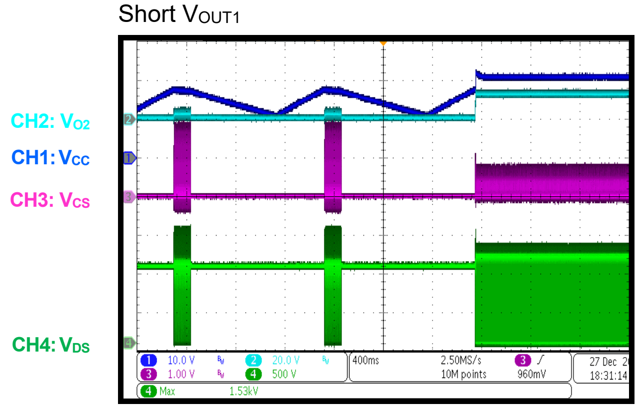
OLP Entry

Short V_{OUT1}



OLP Recovery

Short V_{OUT1}

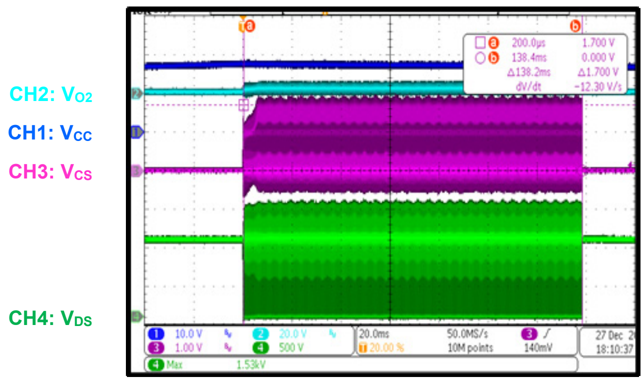


EVB TEST RESULTS *(continued)*

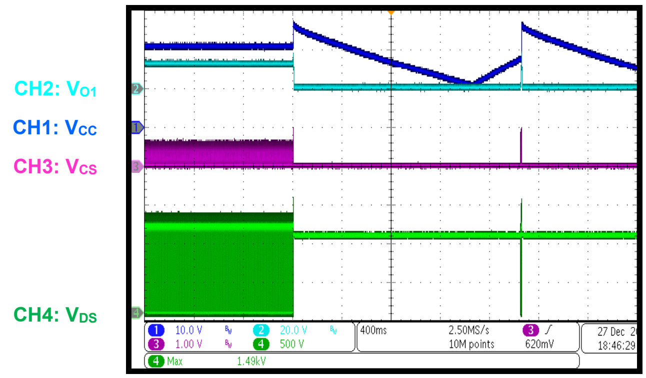
Performance curves and waveforms are tested on the evaluation board. V_{IN} = 1000V_{DC}, V_{OUT1} = 12.5V, I_{OUT1} = 3A, V_{OUT2} = 12.5V, I_{OUT2} = 3A, V_{OUT3} = 24V, I_{OUT3} = 0.1A, T_A = 25°C, unless otherwise noted.

OLP Start-Up

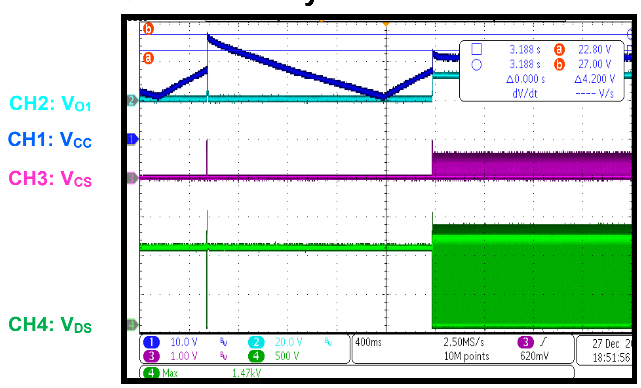
Short V_{OUT1}



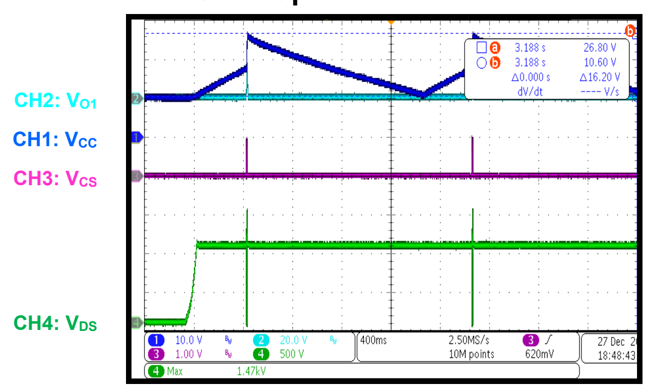
OVP Entry



OVP Recovery

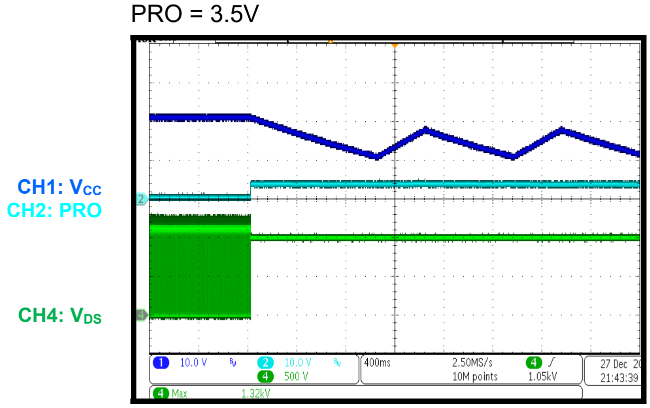


OVP Start-Up



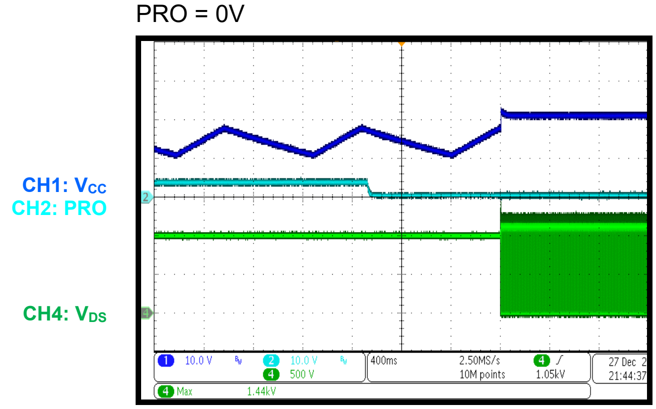
PRO Protection Entry

PRO = 3.5V



PRO Protection Recovery

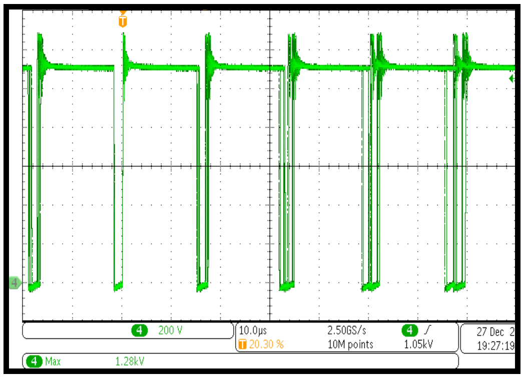
PRO = 0V



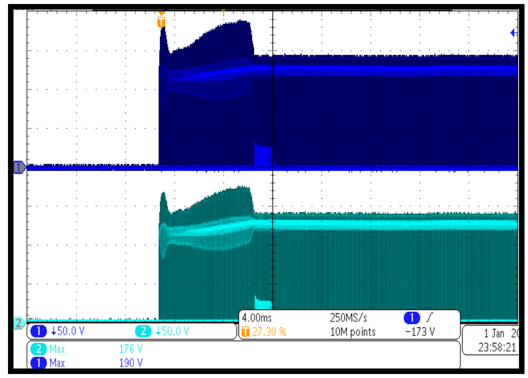
EVB TEST RESULTS *(continued)*

Performance curves and waveforms are tested on the evaluation board. V_{IN} = 1000V_{DC}, V_{OUT1} = 12.5V, I_{OUT1} = 3A, V_{OUT2} = 12.5V, I_{OUT2} = 3A, V_{OUT3} = 24V, I_{OUT3} = 0.1A, T_A = 25°C, unless otherwise noted.

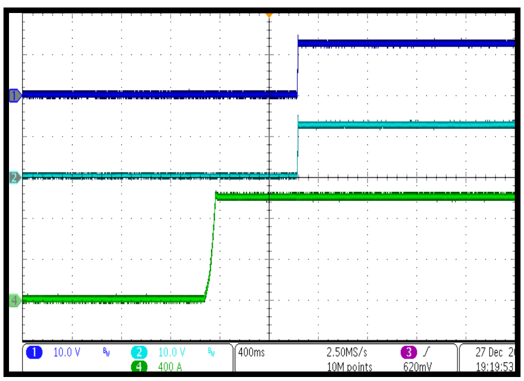
Jitter



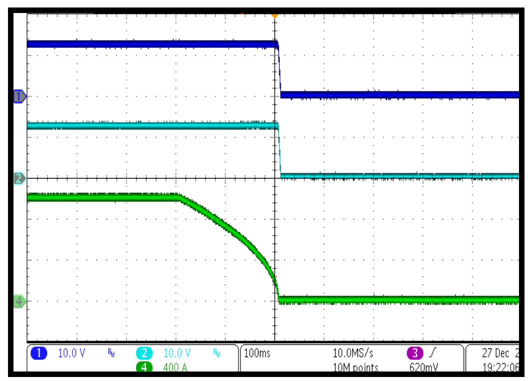
Secondary Diode Stress



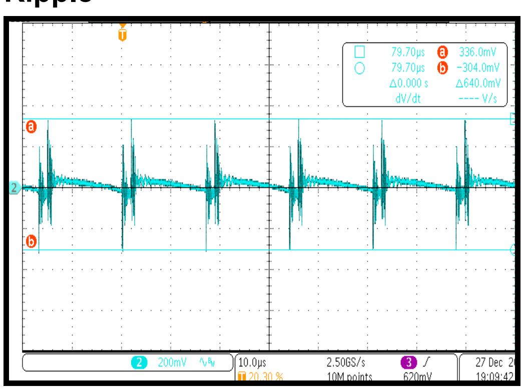
Input Power Start-Up



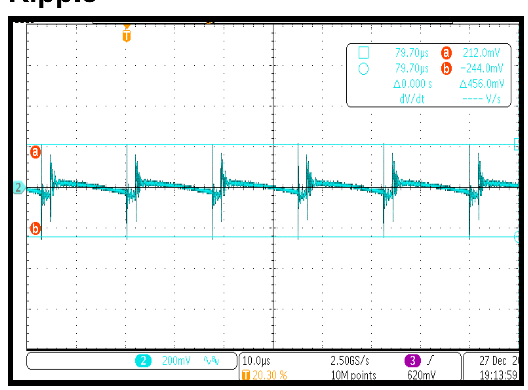
Input Power Shutdown



Ripple



Ripple



PCB LAYOUT

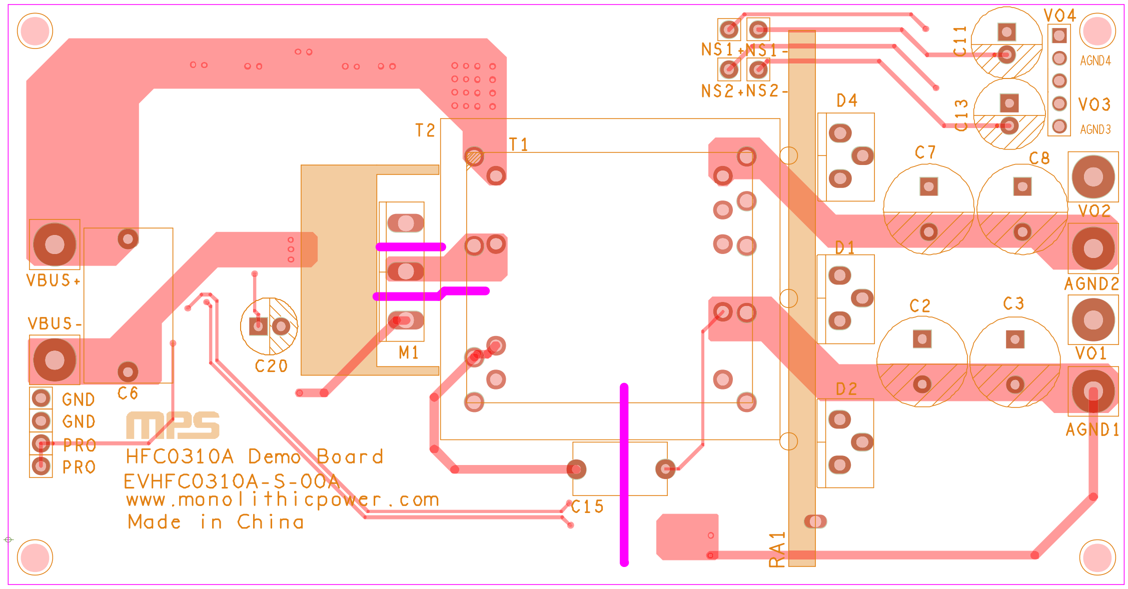


Figure 5: Top Layer

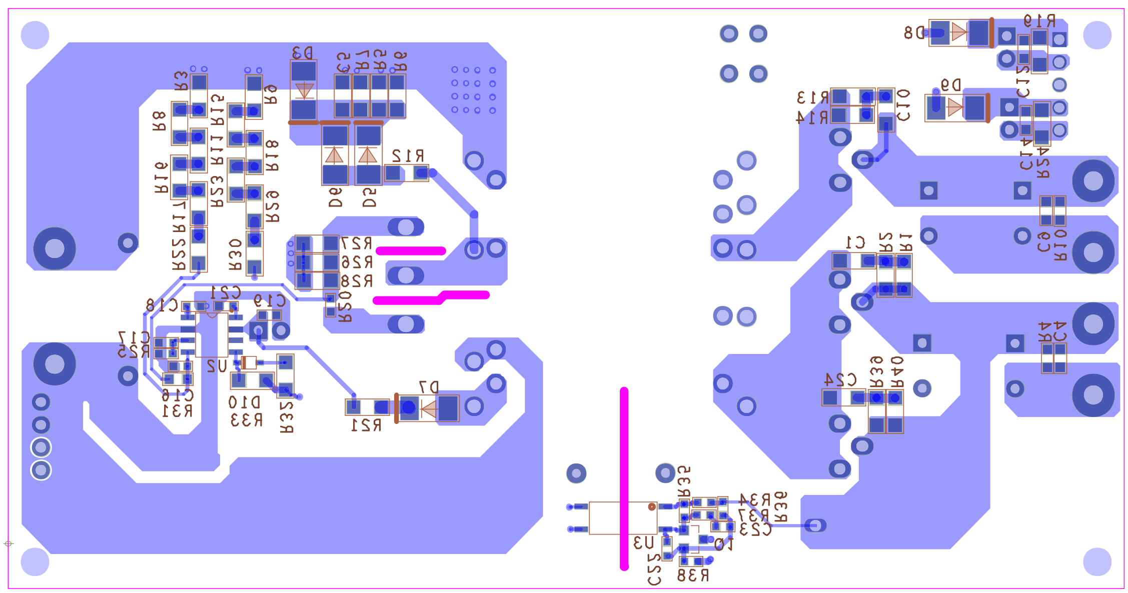


Figure 6: Bottom Layer

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	4/19/2024	Initial Release	-