EVX2003-Y-00D

65W, High-Frequency, USB Type-C PD Adapter Evaluation Board

DESCRIPTION

The EVX2003-Y-00D is an evaluation board designed for the MPX2003, a 65W USB Type-C power delivery 3.0 (PD 3.0) adapter. The board is designed in a very small form factor with a high power density. Its electrical specifications are well-suited for cellphone and computer power adapters. The board provides very low, no-load power consumption (<40mW), and its high overall efficiency meets DOE Level VI and CoC Tier2.

The MPX2003 is an all-in-one flyback controller solution. It integrates a primary driving circuit, secondary controller, synchronous rectification driver, and safety-compliant feedback in one chip. The device offers the benefits of both primary-side regulation (PSR) and secondary-side regulation (SSR).

No feedback circuit is required, as a synchronous rectifier (SR) can be matched with the driving signal of the primary-side MOSFET. With this feature, the SR can operate safely in continuous conduction mode (CCM), which helps increase overall efficiency and provides the design more flexibility.

The MPX2003 adopts novel quasi-resonant mode switching when it runs in discontinuous conduction mode (DCM). Due to this feature, the power supply has improved efficiency. Under very light loads, the controller enters burst mode to achieve very low standby power consumption. The MPX2003 offers frequency jittering to help dissipate the energy generated by conducted noise.

The EVX2003-Y-00D evaluation board provides a reference design for a universal offline isolated power supply with a 20V/3.25A, 15V/3A, 12V/3A, 9V/3A, or 5V/3A output. This datasheet contains the complete specification of the power supply, a detailed circuit diagram, the entire bill of materials required to build the power supply, a drawing of the transformers, and performance testing.

PERFORMANCE SUMMARY

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

Parameters	Conditions	Value
AC input voltage (V_{IN})		90V_{AC} to 264V_{AC}
AC input frequency		47Hz to 63Hz
Output voltage (V_{OUT}) / output current (I_{OUT})	Power delivery 3.0 (PD 3.0)	20V/3.25A, 15V/3A, 12V/3A, 9V/3A, 5V/3A
Maximum efficiency	V_{IN} = 230V_{AC}, V_{OUT} = 20V, I_{OUT} = 3.25A	93.4%
No-load power consumption	V_{IN} = 264V_{AC}	<40mW

EVX2003-Y-00D EVALUATION BOARD

LxWxH (40mmx40mmx25mm)

Board Number	MPS IC Number
EVX2003-Y-00D	MPX2003GY

QUICK START GUIDE

1. Preset the AC input voltage (V_{AC}) between $90V_{AC}$ and $264V_{AC}$.
2. Turn the AC power supply off.
3. Connect the load to the USB Type-C connector.
4. Connect the power supply's line and neutral terminals to the AC input.
5. Turn the power supply on. The board should start up automatically.

EVALUATION BOARD SCHEMATICS

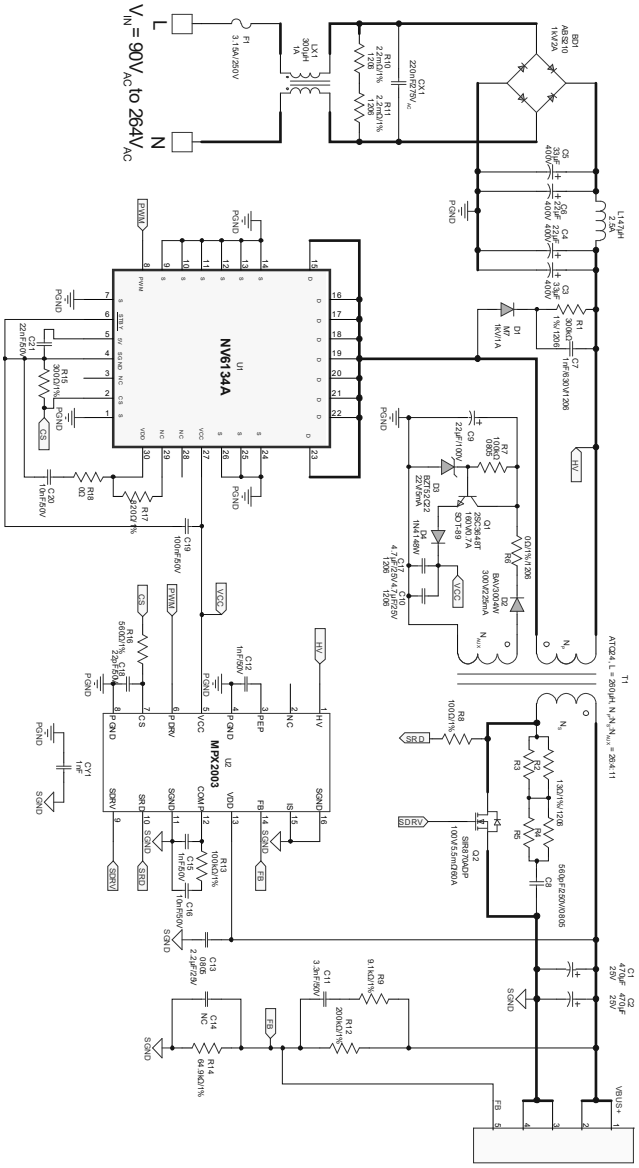


Figure 1: Main Board Power

EVALUATION BOARD SCHEMATICS *(continued)*

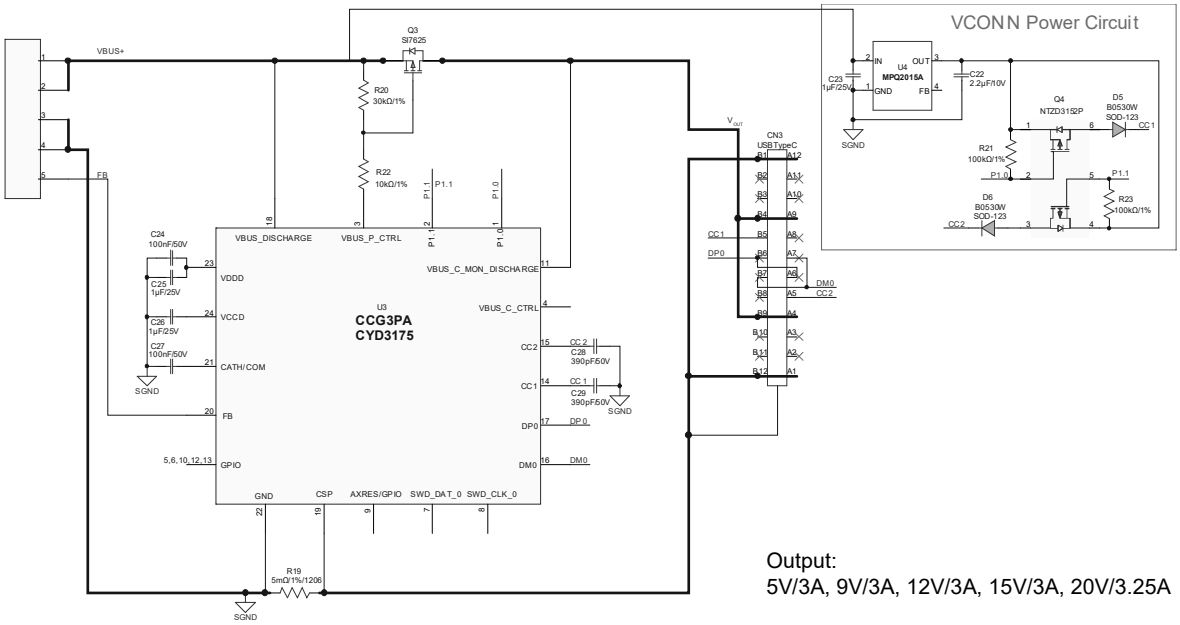


Figure 2: Daughter Board/PD Controller

EVX2003-Y-00D BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
Main Board/Power Stage						
2	BD1, BD2	1000V	Diode, 2A	SOPA-4	Diodes, Inc.	ABS210-13
2	C1, C2	470µF	Electrolytic capacitor, 25V	DIP	Zhongyuan	RQ471M025E150
2	C3, C5	22µF	Electrolytic capacitor, 400V	DIP	Ymin	KCXD1802G220MF
2	C4, C6	33µF	Electrolytic capacitor, 400V	DIP	Ymin	KCXE1802G330MF
1	C7	1nF	Ceramic capacitor, 630V, U2J	1206	Murata	GRM31A7U2J102JW31D
1	C8	560pF	Ceramic capacitor, 250V, U2J	0805	Murata	GRM21A7U2E561JW31D
1	C9	22µF	Electrolytic capacitor, 100V	DIP	Aishi	ERJ1KM220E12OT
2	C10, C17	4.7µF	Ceramic capacitor, 25V, X7R	1206	Murata	GCM31CR71E475KA55L
1	C11	3.3nF	Ceramic capacitor, 50V, X7R	0603	Murata	CC0603KRX7R9BB332
2	C12, C15	1nF	Ceramic capacitor, 50V, X7R	0603	Murata	GRM188R72A102KA01D
1	C13	2.2µF	Ceramic capacitor, 25V, X7R	0805	Murata	GCM21BR71E225KA73L
1	C14	NC				
2	C16, C20	10nF	Ceramic capacitor, 50V, C0G	0603	Murata	GRM1885C1H103JA01D
1	C18	22pF	Ceramic capacitor, 50V, C0G	0603	Murata	GRM1885C1H220JA01D
1	C19	100nF	Ceramic capacitor, 50V, X7R	0603	Murata	GCM188R71H104KA57D
1	C21	22nF	Ceramic capacitor, 50V, X7R	0603	Murata	GCM188R71H223KA37D
1	CY1	1nF	Capacitor, 250V	DIP	Murata	DE2E3KY102MA3BM02
1	CX1	220nF	Capacitor, 275V_{AC}, 10%	DIP	DGCX	MPX224275VP10T4.5G
1	D1	1000V	Diode, 1A	SMA	MIC	M7
1	D2	300V	Diode, 225mA	SOD-123	Diodes, Inc.	BAV3004W
1	D3	22V	Zener diode, 5mA	SOD-123	JCET	BZT52C22
1	D4	75V	Diode, 0.15A	SOD-123	JCET	1N4148W
1	F1	250V	Fuse, 3.15A	DIP	Cooper Bussman	SS-5-3.15A
1	LX1	300µH	Common choke, 1A	DIP	Emei	TP4U300-00
1	L1	47uH	Inductor	DIP	Wurth	744772470
1	Q1	160V	Transistor	SOT-89	ON Semiconductor	2SC3648T

EVX2003-Y-00D BILL OF MATERIALS *(continued)*

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
1	Q2	100V	N-channel MOSFET	SO-8	Vishay	SIR104DP-T1-RE3
1	R1	300kΩ	Film resistor, 1%	1206	Yageo	RC1206FR-07300KL
4	R2, R3, R4, R5	10Ω	Film resistor, 1%	1206	Yageo	RC1206FR-0710RL
2	R6, B1	0Ω	Film resistor, 1%	1206	Yageo	RC1206FR-070RL
1	R7	100kΩ	Film resistor, 1%	0805	Yageo	RC0805JR-07100KL
1	R8	100Ω	Film resistor, 1%	0603	Yageo	RC0603FR-07100RL
1	R9	9.1kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-079K1L
2	R10, R11	2.2MΩ	Film resistor, 1%	1206	Yageo	RC1206JR-072M2L
1	R12	200kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-07200KL
1	R13	100kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-07100KL
1	R14	64.9kΩ	Film resistor, 1%	0603	Yageo	RC0603FR-0764K9L
1	R15	300Ω	Film resistor, 1%	0603	Yageo	RC0603FR-07300RL
1	R16	560Ω	Film resistor, 1%	0603	Yageo	RC0603FR-07560RL
1	R17	820Ω	Film resistor, 1%	0603	Yageo	RC0603FR-07820RL
1	R18	0Ω	Film resistor, 1%	0603	Royal Ohm	0603WAF0000T5E
1	T1	260μH	ATQ23 transformer, L_P = 0.26mH, N_P:N_S:N_{AUX} = 24:4:11	DIP	ZYD	FX0633-1
1	U1	650V	GaN, 260mΩ	QFN-31 (6mmx 8mm)	Navitas	NV6134A
1	U2	MPX2003	All-in-one flyback controller	SOICW-16	MPS	MPX2003GY-Z

EVX2003-Y-00D BILL OF MATERIALS *(continued)*

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
Daughter Board/PD Controller Stage						
1	C22	2.2µF	Ceramic capacitor, 25V, X7R	0603	Murata	GRM188R71A225KE15D
3	C23, C25, C26	1µF	Ceramic capacitor, 25V, X7R	0603	Murata	GCM188R71E105KA64D
2	C24, C27	100nF	Ceramic capacitor, 50V, X7R	0402	Murata	GRM155R71H104KE14D
2	C28, C29	390pF	Ceramic capacitor, 50V, C0G	0603	Murata	GRM1885C1H391JA01D
2	D5, D6	30V	Schottky diode, 0.5A	SOD-123	Diodes, Inc.	B0530W
2	R21, R23	100kΩ	Film resistor, 1%	0402	Yageo	RC0402FR-07100KL
1	R19	5mΩ	Film resistor, 1%	1206	Yageo	PA1206FRF070R005L
1	R20	30kΩ	Film resistor, 1%	0402	Yageo	RC0402FR-0730KL
1	U3	30V	USB PD controller	QFN-24 (4mmx 4mm)	Cypress	CYPD3175
1	Q3	-30V	P-channel MOSFET, 5.6mΩ	PowerPAK-1212-8	Vishay	SI7625DN
1	Q4	-20V	Dual P-channel MOSFET	SOT563-6	ON Semiconductor	NTZD3152Pt1g
1	USB-C	30V	Type-C connecter	DIP	Yalian	93551001
1	U4	MP2015A	3.3V low-I_Q current linear regulator	QFN-8 (3mmx 3mm)	MPS	MP2015AGQ-33-Z

EVB TEST RESULTS

Performance waveforms are tested on the evaluation board. Note that the board efficiency is measured at C_{OUT} (C2).

Table 1: Efficiency (V_{OUT} = 5V)

V_{OUT} = 5V							CoC Tier 2 Requirement
V_{IN} (V_{AC}/Hz)	Load	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	P_{OUT} (W)	Eff. (%)	
115/60	100%	16.471	5.01	3.002	15.040	91.31%	
	75%	12.313	5.02	2.250	11.295	91.73%	
	50%	8.212	5.02	1.500	7.530	91.70%	
	25%	4.127	5.03	0.750	3.773	91.41%	
	Average Efficiency (%)					91.54%	81.84%
	10%	1.868	5.03	0.301	1.514	81.05%	72.48%
230/50	100%	16.537	5.01	3.002	15.040	90.95%	
	75%	12.443	5.02	2.250	11.295	90.77%	
	50%	8.340	5.02	1.500	7.530	90.29%	
	25%	4.511	5.02	0.751	3.770	83.57%	
	Average Efficiency (%)					88.90%	81.84%
	10%	1.948	5.05	0.301	1.520	78.03%	72.48%

Table 2: Efficiency (V_{OUT} = 9V)

V_{OUT} = 9V							CoC Tier 2 Requirement
V_{IN} (V_{AC}/Hz)	Load	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	P_{OUT} (W)	Eff. (%)	
115/60	100%	29.397	9.04	3.002	27.138	92.32%	
	75%	21.992	9.04	2.251	20.349	92.53%	
	50%	14.641	9.05	1.500	13.575	92.72%	
	25%	7.369	9.05	0.751	6.797	92.23%	
	Average Efficiency (%)					92.45%	87.30%
	10%	3.076	9.06	0.301	2.727	88.66%	77.30%
230/50	100%	29.282	9.04	3.002	27.138	92.68%	
	75%	22.007	9.04	2.251	20.349	92.47%	
	50%	14.726	9.05	1.500	13.575	92.18%	
	25%	7.460	9.05	0.751	6.797	91.11%	
	Average Efficiency (%)					92.11%	87.30%
	10%	3.214	9.06	0.301	2.727	84.85%	77.30%

EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

Table 3: Efficiency (V_{OUT} = 12V)

V_{OUT} = 12V							CoC Tier 2 Requirement
V_{IN} (V_{AC}/Hz)	Load	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	P_{OUT} (W)	Eff. (%)	
115/60	100%	38.920	11.99	3.002	35.994	92.48%	
	75%	29.091	11.99	2.250	26.978	92.73%	
	50%	19.393	12.00	1.500	18.000	92.82%	
	25%	9.763	12.00	0.751	9.012	92.31%	
	Average Efficiency (%)					92.59%	88.30%
	10%	4.013	12.01	0.301	3.615	90.08%	78.30%
230/50	100%	38.730	11.99	3.002	35.994	92.94%	
	75%	29.038	11.99	2.250	26.978	92.90%	
	50%	19.432	12.00	1.500	18.000	92.63%	
	25%	9.869	12.00	0.751	9.012	91.32%	
	Average Efficiency (%)					92.45%	88.30%
	10%	4.170	12.01	0.301	3.615	86.69%	78.30%

Table 4: Efficiency (V_{OUT} = 15V)

V_{OUT} = 15V							CoC Tier 2 Requirement
V_{IN} (V_{AC}/Hz)	Load	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	P_{OUT} (W)	Eff. (%)	
115/60	100%	48.429	14.92	3.002	44.790	92.49%	
	75%	36.242	14.92	2.250	33.570	92.63%	
	50%	24.143	14.93	1.500	22.395	92.76%	
	25%	12.142	14.94	0.751	11.220	92.41%	
	Average Efficiency (%)					92.57%	88.85%
	10%	5.006	14.95	0.300	4.485	89.59%	78.85%
230/50	100%	48.040	14.92	3.002	44.790	93.23%	
	75%	36.006	14.92	2.250	33.570	93.23%	
	50%	24.115	14.92	1.500	22.380	92.81%	
	25%	12.245	14.94	0.751	11.220	91.63%	
	Average Efficiency (%)					92.73%	88.85%
	10%	5.085	14.95	0.300	4.485	88.20%	78.85%

EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

Table 5: Efficiency (V_{OUT} = 20V)

V_{OUT} = 20V							CoC Tier 2 Requirement
V_{IN} (V_{AC}/Hz)	Load	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	P_{OUT} (W)	Eff. (%)	
115/60	100%	69.866	19.92	3.253	64.800	92.75%	
	75%	52.477	19.94	2.437	48.594	92.60%	
	50%	34.983	19.95	1.625	32.419	92.67%	
	25%	17.604	19.98	0.813	16.244	92.27%	
	Average Efficiency (%)					92.57%	89%
	10%	7.235	19.98	0.325	6.494	89.75%	79%
230/50	100%	68.969	19.91	3.253	64.767	93.91%	
	75%	51.798	19.92	2.437	48.545	93.72%	
	50%	34.778	19.95	1.625	32.419	93.22%	
	25%	17.643	19.96	0.813	16.227	91.98%	
	Average Efficiency (%)					93.21%	89%
	10%	7.303	19.99	0.325	6.497	88.96%	79%

Table 6: Efficiency (V_{OUT} = 20V)

V_{OUT} = 20V (Full Load)						
V_{IN} (V_{AC}/Hz)	Load	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	P_{OUT} (W)	Eff. (%)
90/60	100%	71.128	19.93	3.253	64.832	91.15%
115/60	100%	69.866	19.92	3.253	64.800	92.75%
230/50	100%	68.969	19.91	3.253	64.767	93.91%
264/50	100%	69.100	19.91	3.253	64.767	93.73%

Table 7: No-Load Consumption

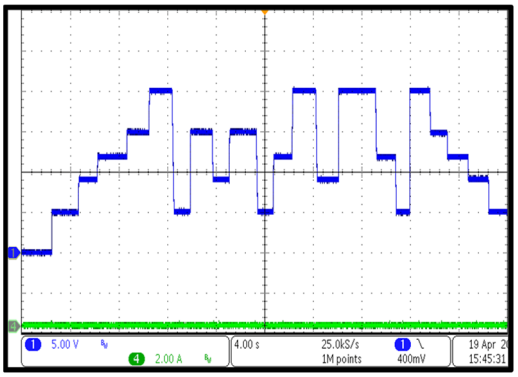
No Load Consumption				
V_{IN} (V_{AC})	90	115	230	264
P_{IN} (mW)	19.8	21.6	32.5	37.3

EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

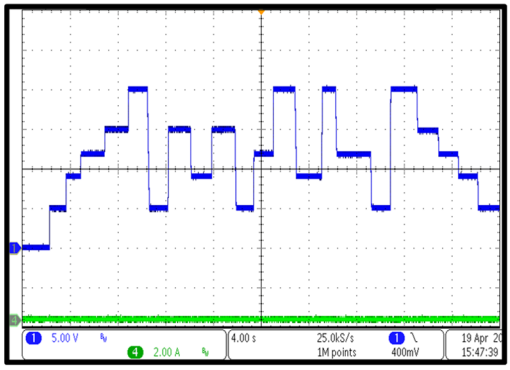
Output Voltage Transient Response

V_{IN} = 115V_{AC}/60Hz, I_{OUT} = 0A



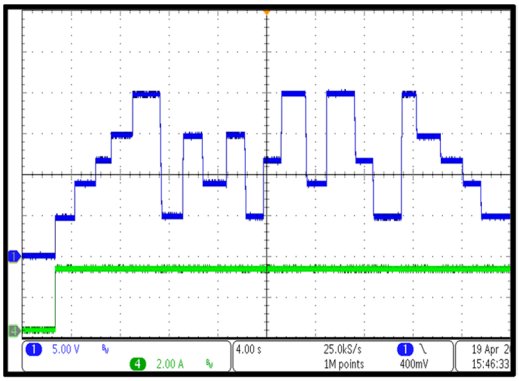
Output Voltage Transient Response

V_{IN} = 230V_{AC}/50Hz, I_{OUT} = 0A



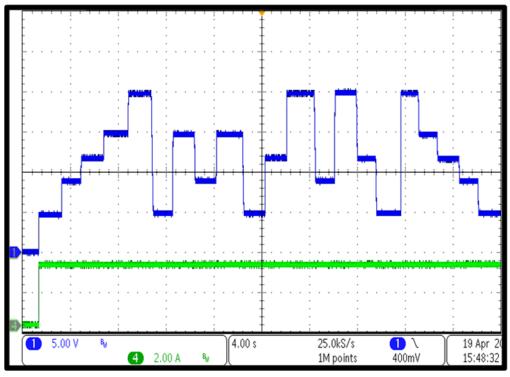
Output Voltage Transient Response

V_{IN} = 115V_{AC}/60Hz, I_{OUT} = 3A



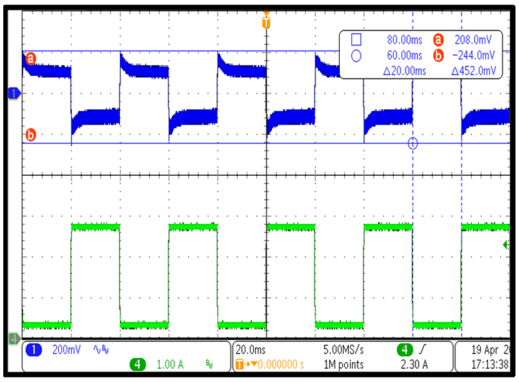
Output Voltage Transient Response

V_{IN} = 230V_{AC}/50Hz, I_{OUT} = 3A



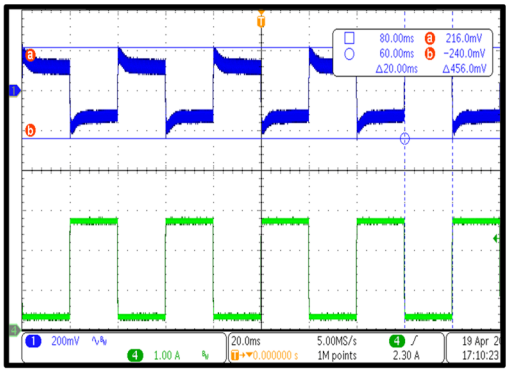
Load Transient Response

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 5V, V_{PP} = 452mV,
load: 10% to 90%, 20ms, 150mA/µs



Load Transient Response

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 5V, V_{PP} = 456mV,
load: 10% to 90%, 20ms, 150mA/µs

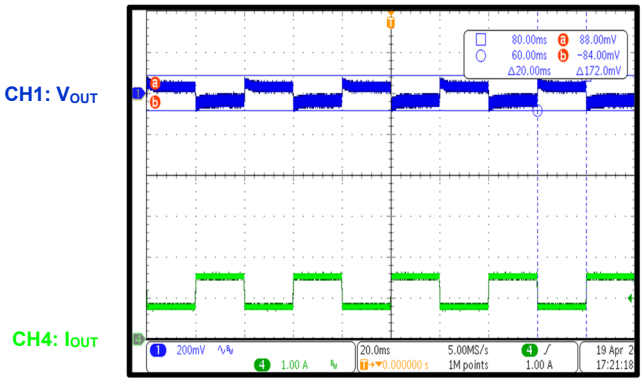


EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

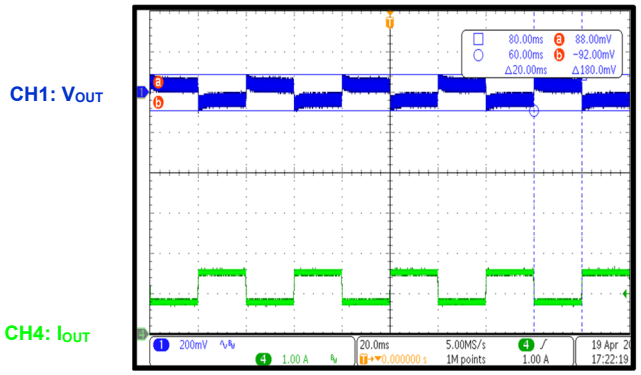
Load Transient Response

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 5V, V_{PP} = 172mV,
load: 25% to 50%, 20ms, 150mA/μs



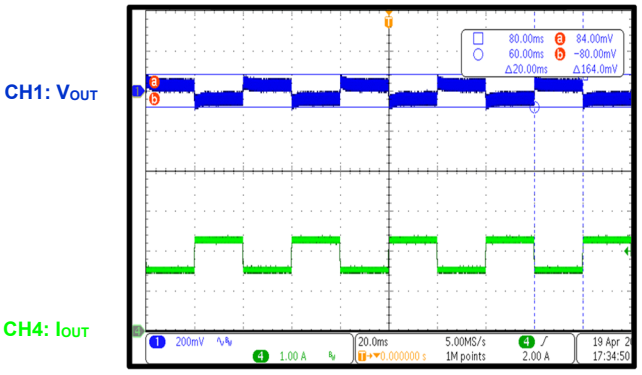
Load Transient Response

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 5V, V_{PP} = 180mV,
load: 25% to 50%, 20ms, 150mA/μs



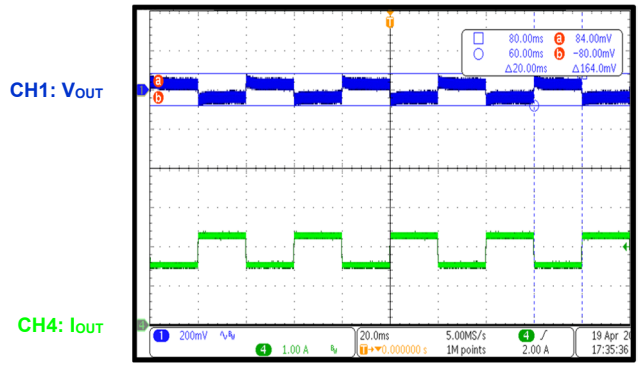
Load Transient Response

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 5V, V_{PP} = 164mV,
load: 50% to 75%, 20ms, 150mA/μs



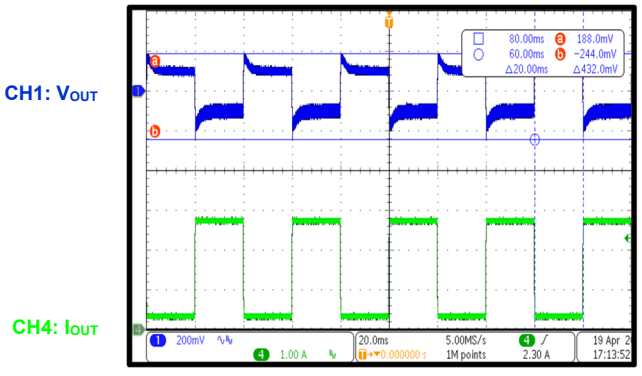
Load Transient Response

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 5V, V_{PP} = 164mV,
load: 50% to 75%, 20ms, 150mA/μs



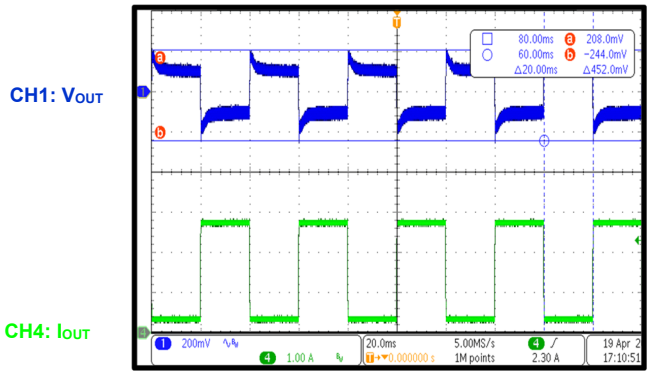
Load Transient Response

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 9V, V_{PP} = 432mV,
load: 10% to 90%, 20ms, 150mA/μs



Load Transient Response

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 9V, V_{PP} = 452mV,
load: 10% to 90%, 20ms, 150mA/μs

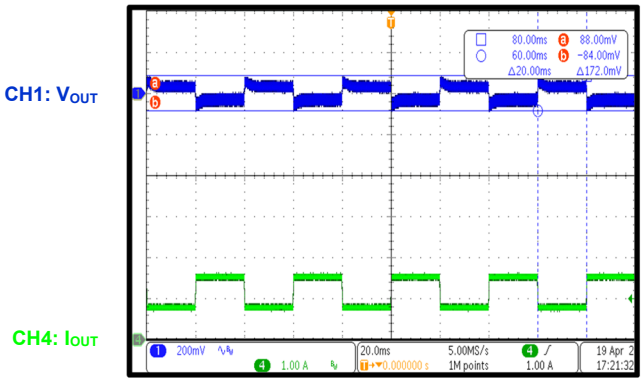


EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

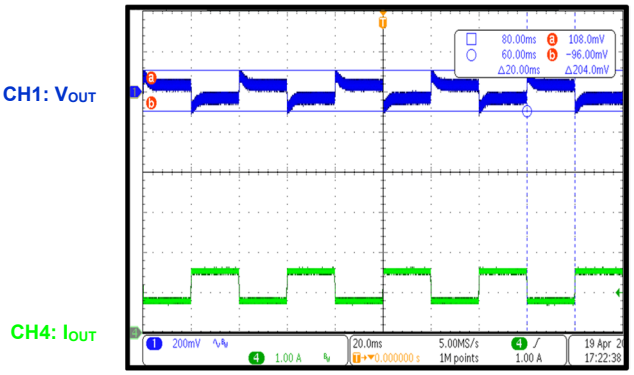
Load Transient Response

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 9V, V_{PP} = 172mV,
load: 25% to 50%, 20ms, 150mA/μs



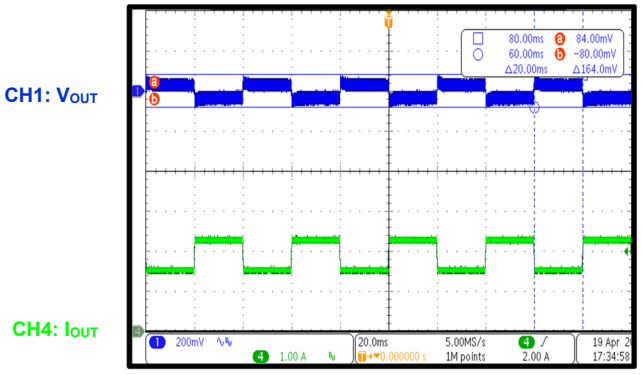
Load Transient Response

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 9V, V_{PP} = 204mV,
load: 25% to 50%, 20ms, 150mA/μs



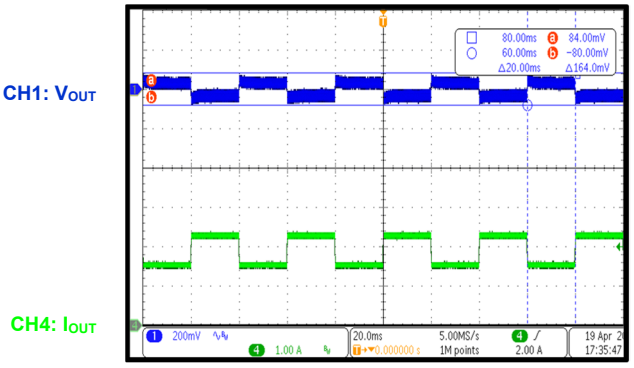
Load Transient Response

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 9V, V_{PP} = 164mV,
load: 50% to 75%, 20ms, 150mA/μs



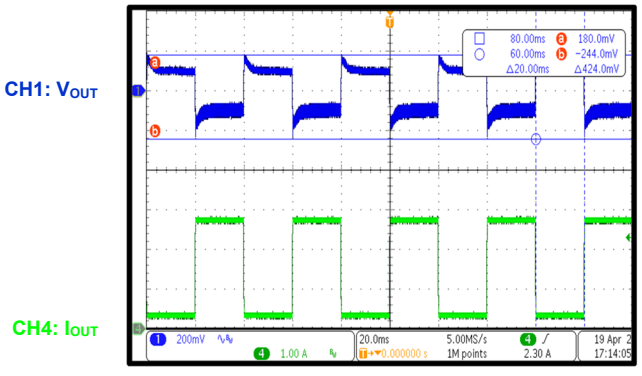
Load Transient Response

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 9V, V_{PP} = 164mV,
load: 50% to 75%, 20ms, 150mA/μs



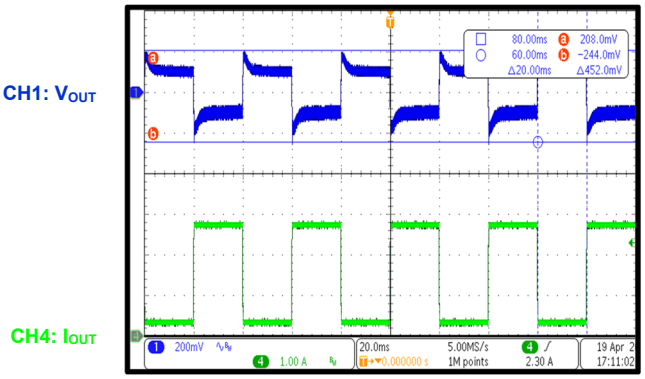
Load Transient Response

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 12V, V_{PP} = 424mV,
load: 10% to 90%, 20ms, 150mA/μs



Load Transient Response

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 12V, V_{PP} = 452mV,
load: 10% to 90%, 20ms, 150mA/μs

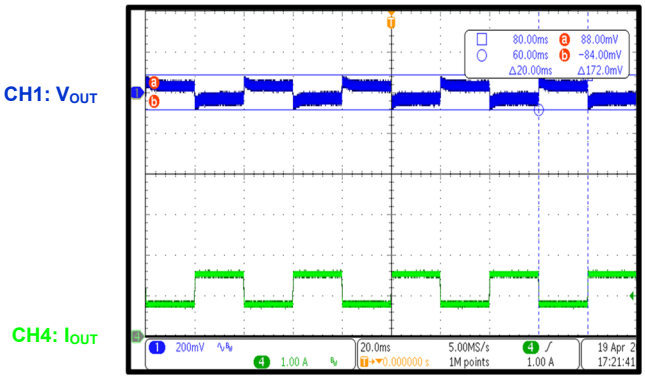


EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

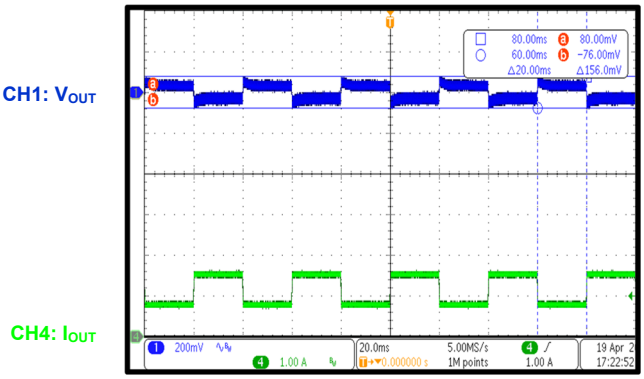
Load Transient Response

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 12V, V_{PP} = 172mV,
load: 25% to 50%, 20ms, 150mA/μs



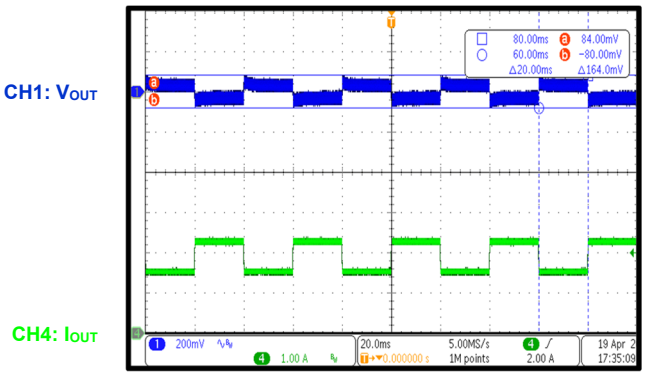
Load Transient Response

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 12V, V_{PP} = 156mV,
load: 25% to 50%, 20ms, 150mA/μs



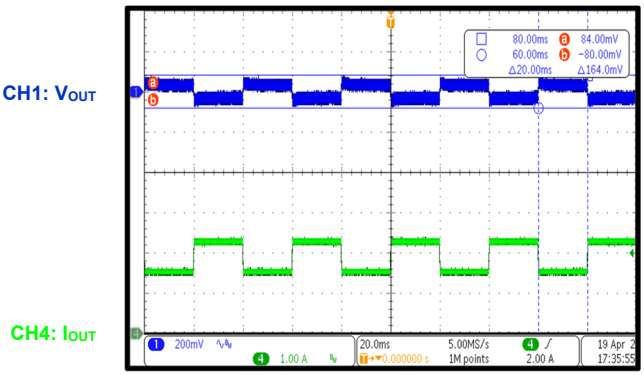
Load Transient Response

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 12V, V_{PP} = 164mV,
load: 50% to 75%, 20ms, 150mA/μs



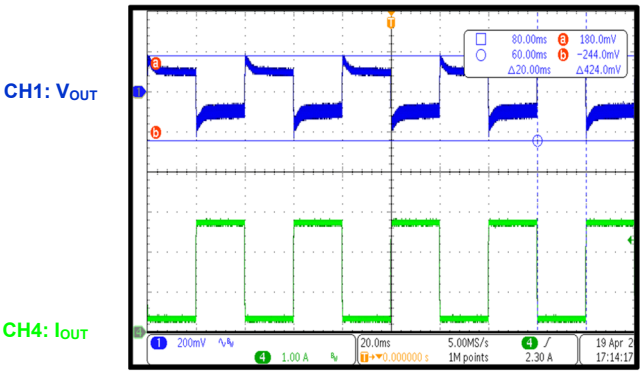
Load Transient Response

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 12V, V_{PP} = 164mV,
load: 50% to 75%, 20ms, 150mA/μs



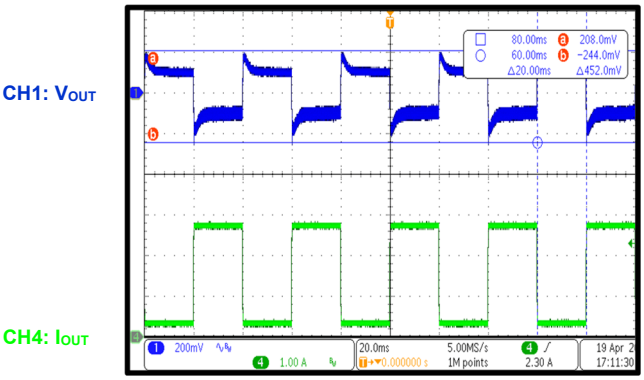
Load Transient Response

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 15V, V_{PP} = 424mV,
load: 10% to 90%, 20ms, 150mA/μs



Load Transient Response

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 15V, V_{PP} = 452mV,
load: 10% to 90%, 20ms, 150mA/μs

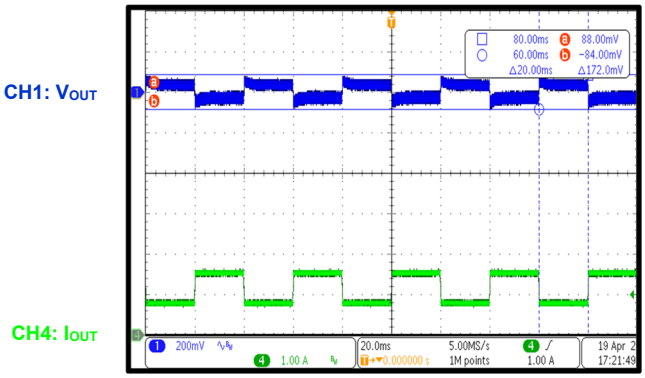


EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

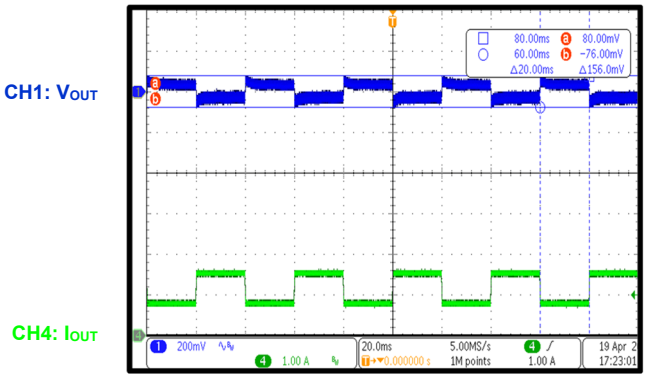
Load Transient Response

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 15V, V_{PP} = 172mV,
load: 25% to 50%, 20ms, 150mA/μs



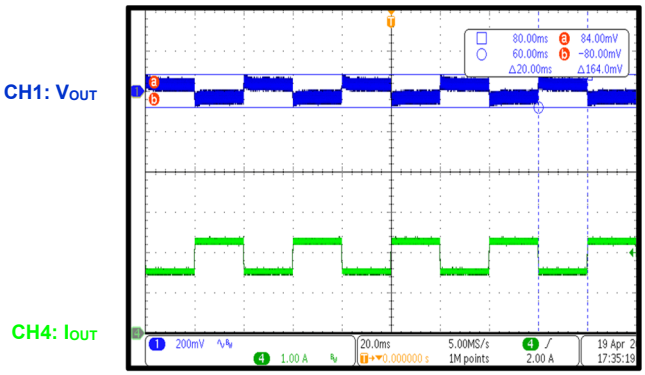
Load Transient Response

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 15V, V_{PP} = 156mV,
load: 25% to 50%, 20ms, 150mA/μs



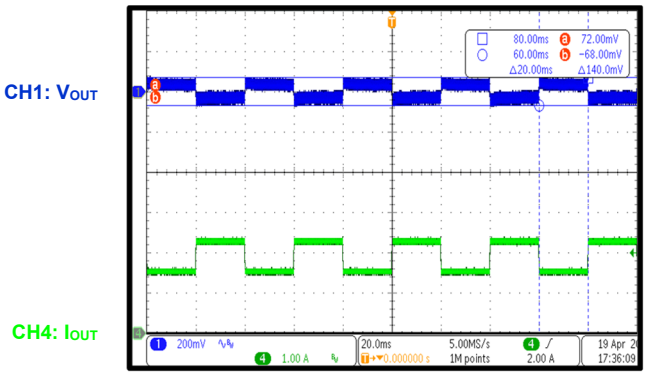
Load Transient Response

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 15V, V_{PP} = 164mV,
load: 50% to 75%, 20ms, 150mA/μs



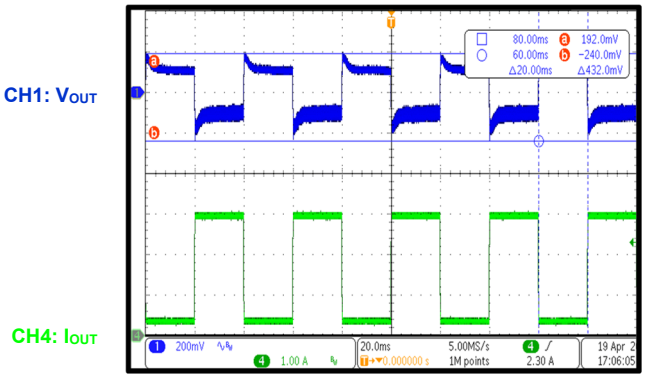
Load Transient Response

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 15V, V_{PP} = 140mV,
load: 50% to 75%, 20ms, 150mA/μs



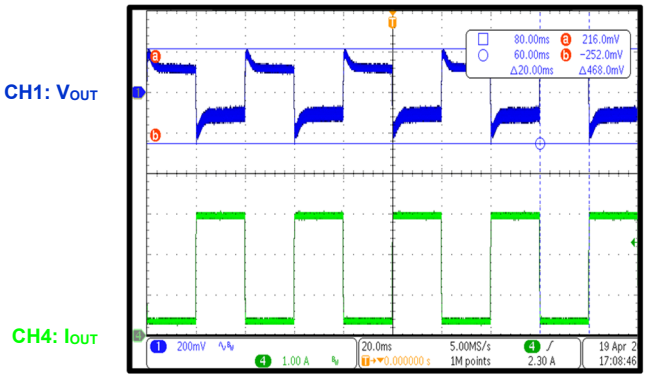
Load Transient Response

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 20V, V_{PP} = 432mV,
load: 10% to 90%, 20ms, 150mA/μs



Load Transient Response

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 20V, V_{PP} = 468mV,
load: 10% to 90%, 20ms, 150mA/μs

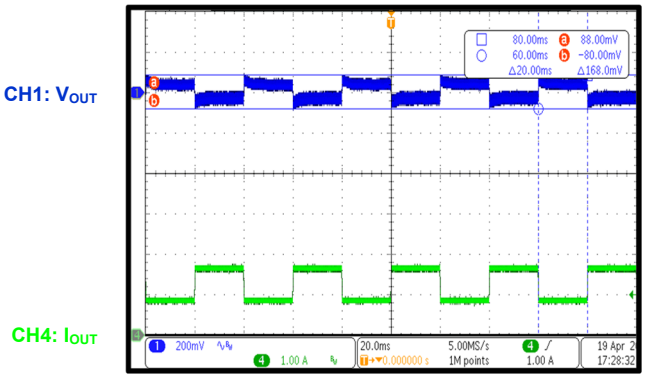


EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

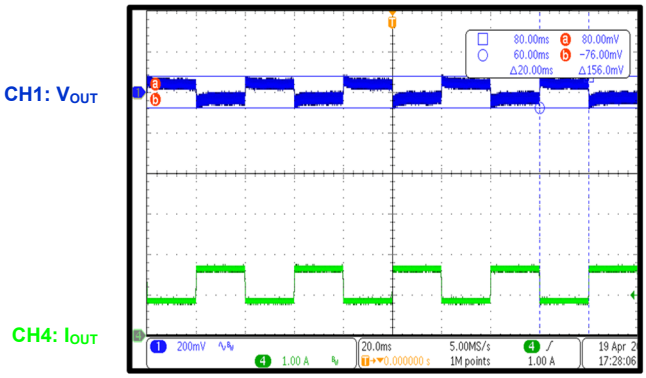
Load Transient Response

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 20V, V_{PP} = 168mV,
load: 25% to 50%, 20ms, 150mA/μs



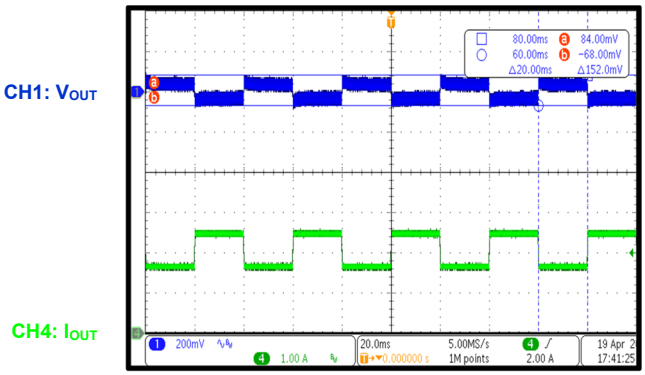
Load Transient Response

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 20V, V_{PP} = 156mV,
load: 25% to 50%, 20ms, 150mA/μs



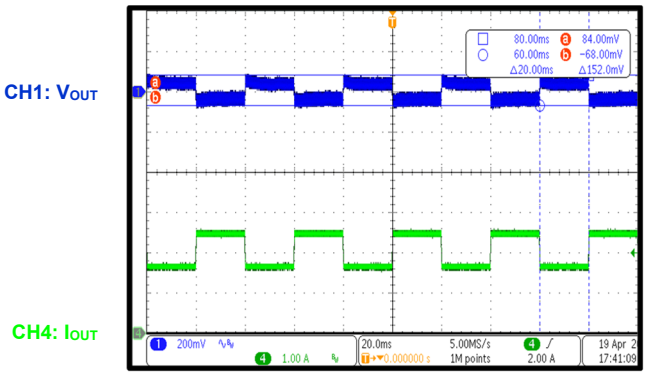
Load Transient Response

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 20V, V_{PP} = 152mV,
load: 50% to 75%, 20ms, 150mA/μs



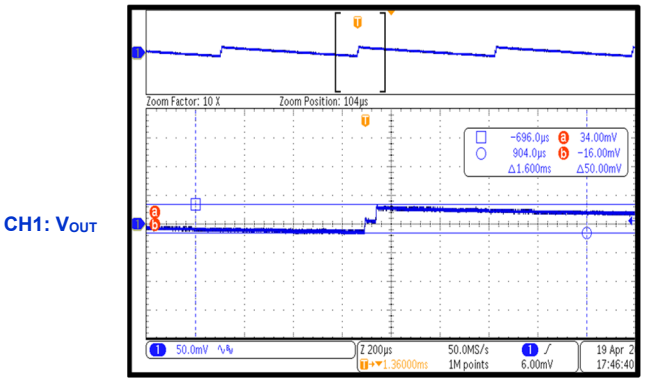
Load Transient Response

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 20V, V_{PP} = 152mV,
load: 50% to 75%, 20ms, 150mA/μs



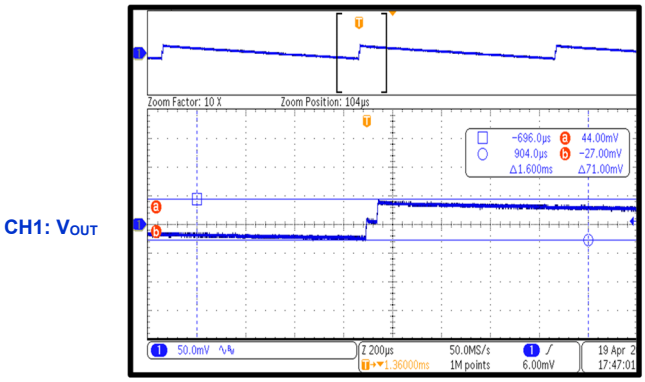
Output Voltage Ripple

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 5V, I_{OUT} = 0A,
V_{PP} = 50mV



Output Voltage Ripple

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 5V, I_{OUT} = 0A,
V_{PP} = 71mV



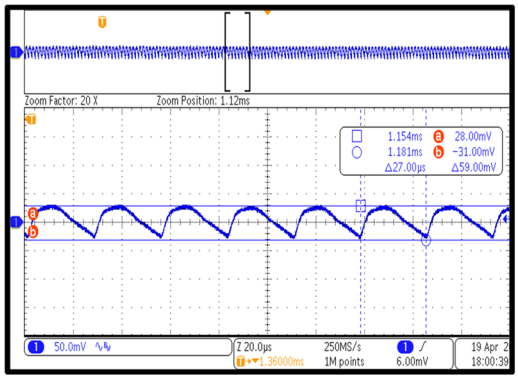
EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

Output Voltage Ripple

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 5V, I_{OUT} = 3A,
V_{PP} = 59mV

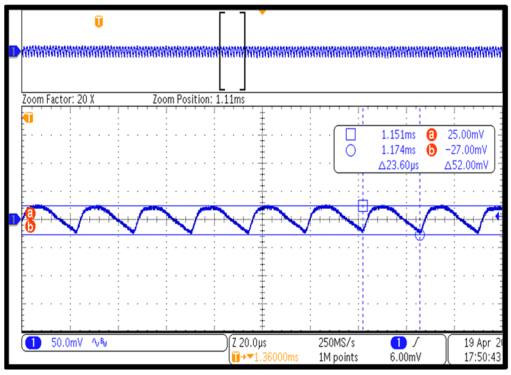
CH1: V_{OUT}



Output Voltage Ripple

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 5V, I_{OUT} = 3A,
V_{PP} = 52mV

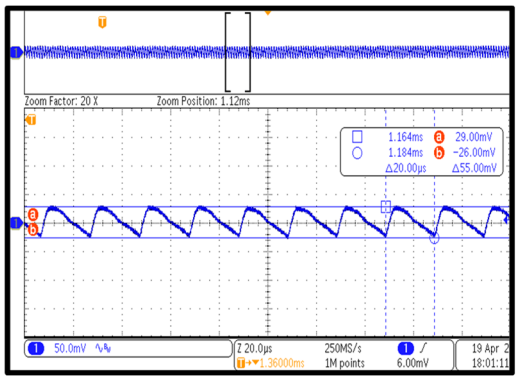
CH1: V_{OUT}



Output Voltage Ripple

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 9V, I_{OUT} = 3A,
V_{PP} = 55mV

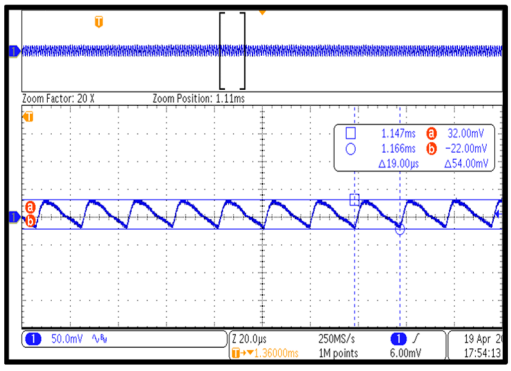
CH1: V_{OUT}



Output Voltage Ripple

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 9V, I_{OUT} = 3A,
V_{PP} = 54mV

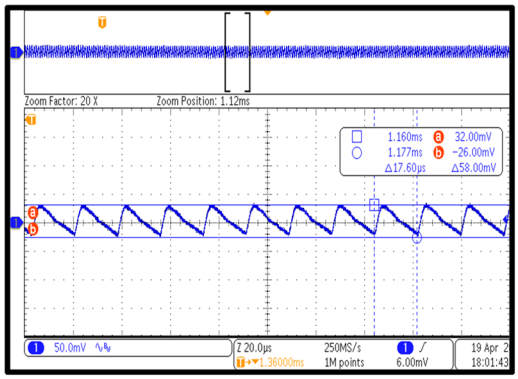
CH1: V_{OUT}



Output Voltage Ripple

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 12V, I_{OUT} = 3A,
V_{PP} = 58mV

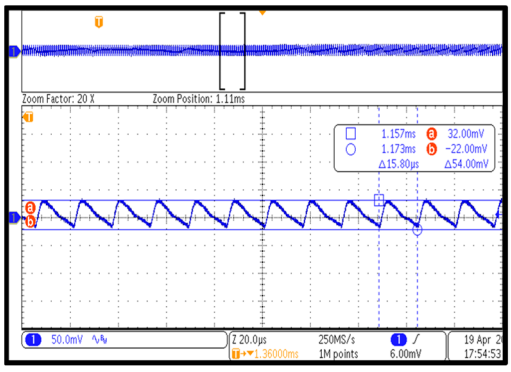
CH1: V_{OUT}



Output Voltage Ripple

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 12V, I_{OUT} = 3A,
V_{PP} = 54mV

CH1: V_{OUT}

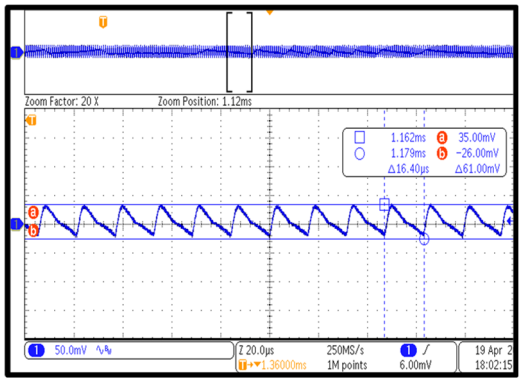


EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

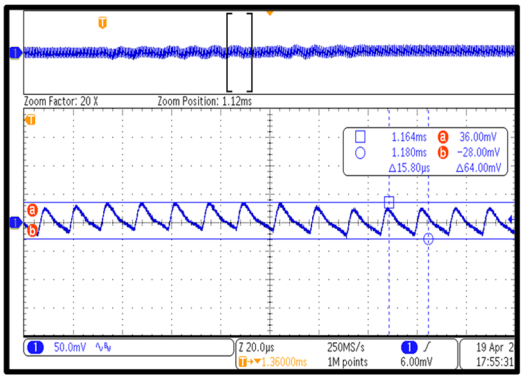
Output Voltage Ripple

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 15V, I_{OUT} = 3A,
V_{PP} = 61mV



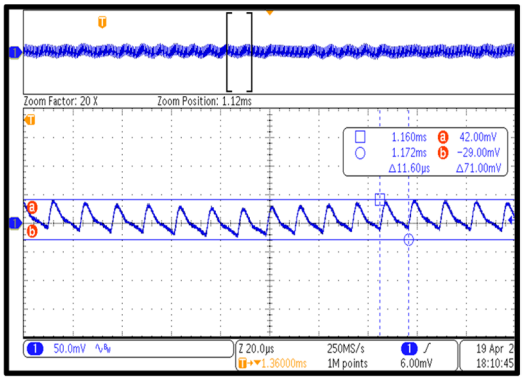
Output Voltage Ripple

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 15V, I_{OUT} = 3A,
V_{PP} = 64mV



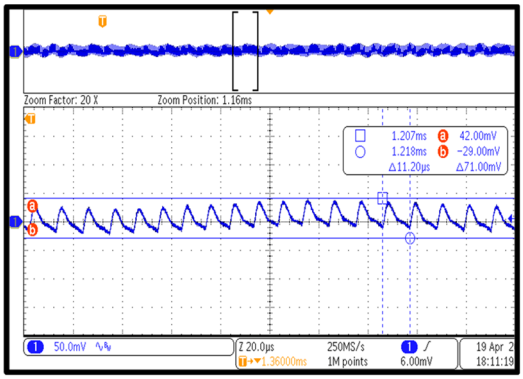
Output Voltage Ripple

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 20V, I_{OUT} = 3.25A,
V_{PP} = 71mV



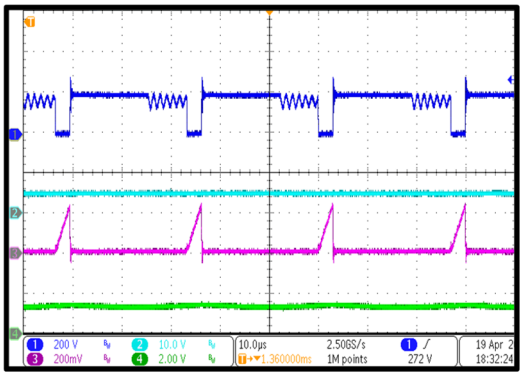
Output Voltage Ripple

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 20V, I_{OUT} = 3.25A,
V_{PP} = 71mV



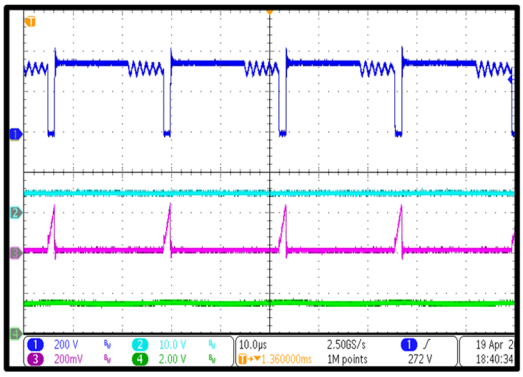
Steady State

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 5V, I_{OUT} = 3A



Steady State

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 5V, I_{OUT} = 3A

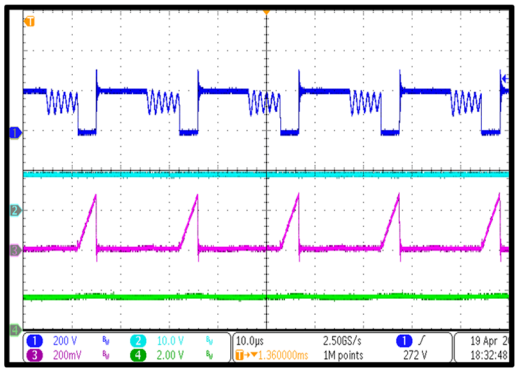


EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

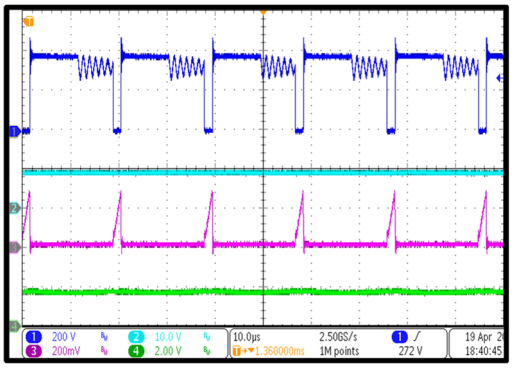
Steady State

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 9V, I_{OUT} = 3A



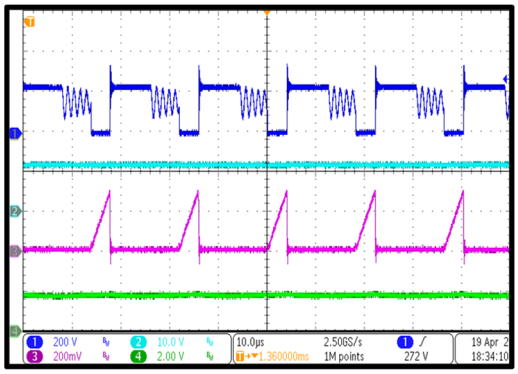
Steady State

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 9V, I_{OUT} = 3A



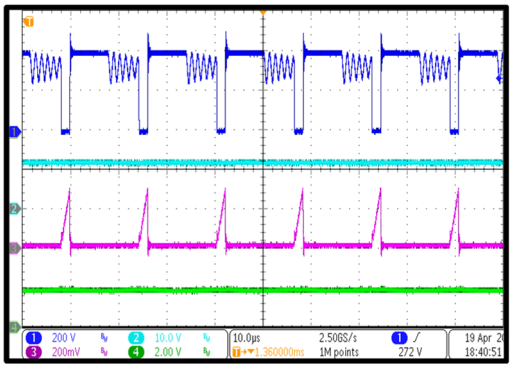
Steady State

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 12V, I_{OUT} = 3A



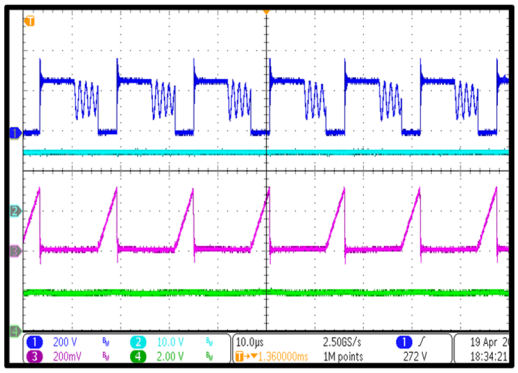
Steady State

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 12V, I_{OUT} = 3A



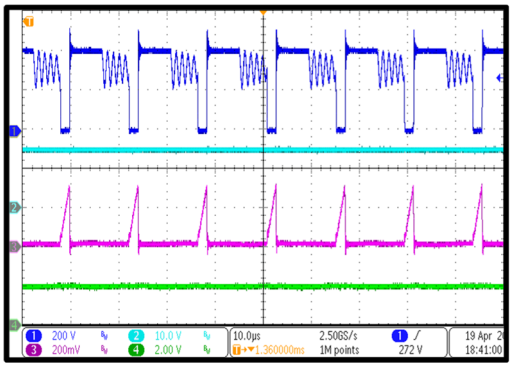
Steady State

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 15V, I_{OUT} = 3A



Steady State

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 15V, I_{OUT} = 3A

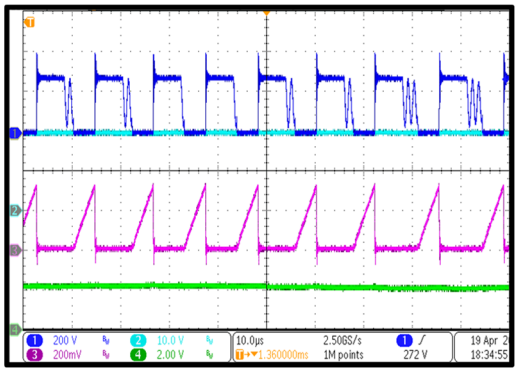


EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

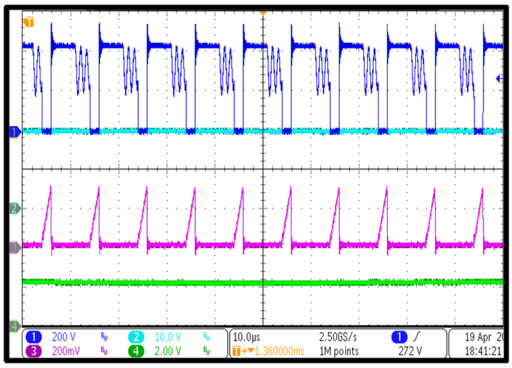
Steady State

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 20V, I_{OUT} = 3.25A



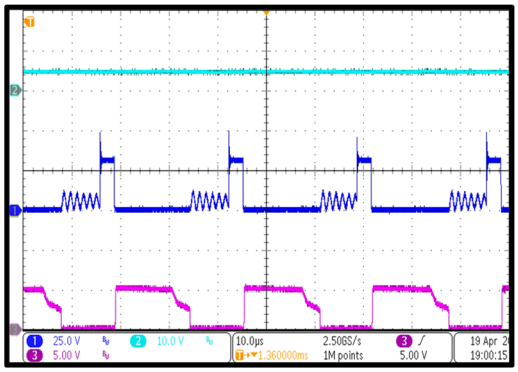
Steady State

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 20V, I_{OUT} = 3.25A



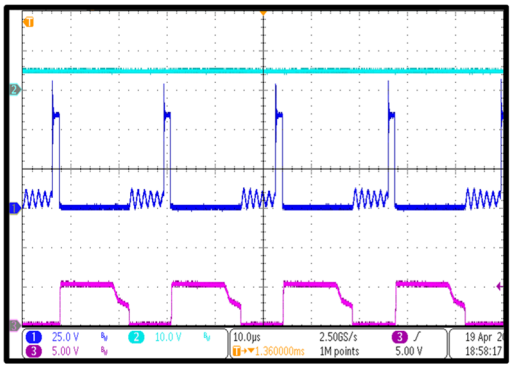
SR Steady State

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 5V, I_{OUT} = 3A



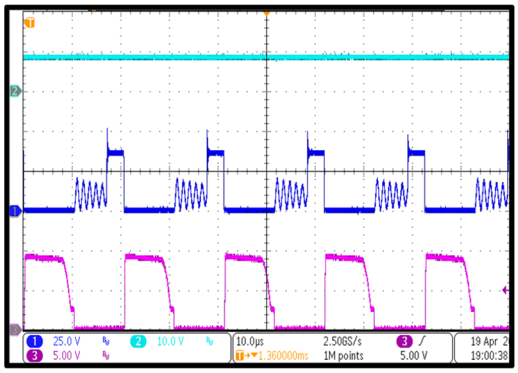
SR Steady State

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 5V, I_{OUT} = 3A



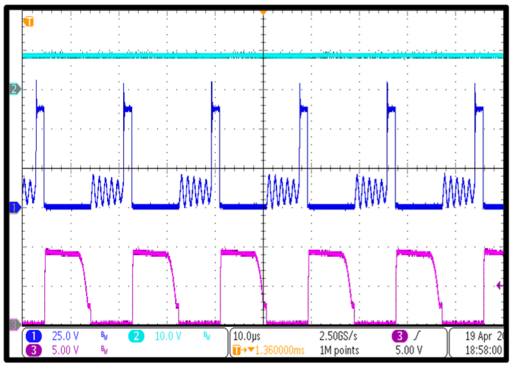
SR Steady State

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 9V, I_{OUT} = 3A



SR Steady State

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 9V, I_{OUT} = 3A

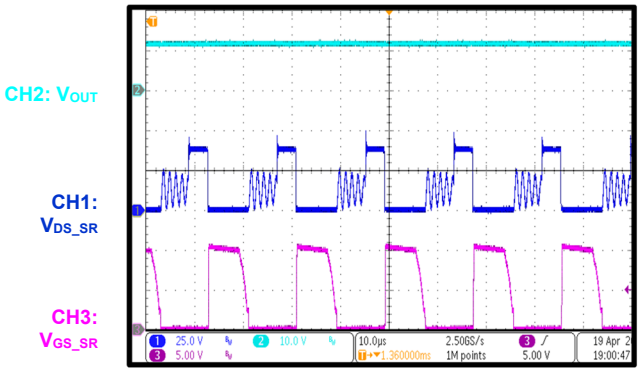


EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

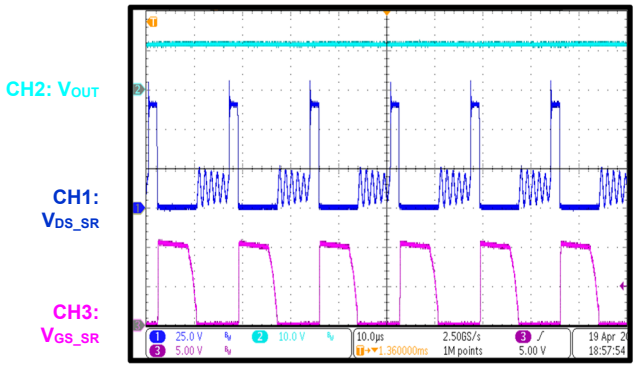
SR Steady State

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 12V, I_{OUT} = 3A



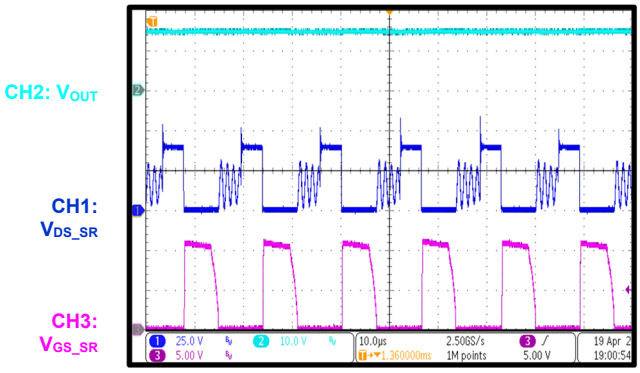
SR Steady State

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 12V, I_{OUT} = 3A



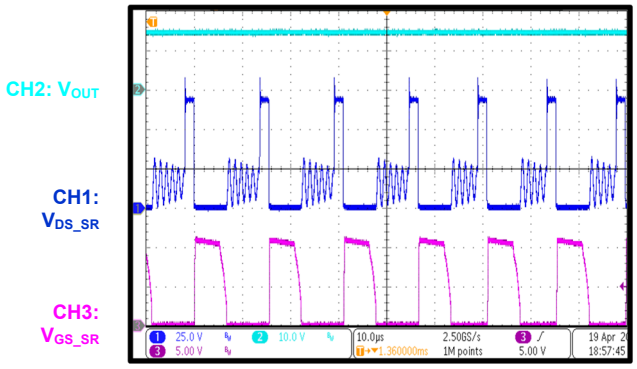
SR Steady State

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 15V, I_{OUT} = 3A



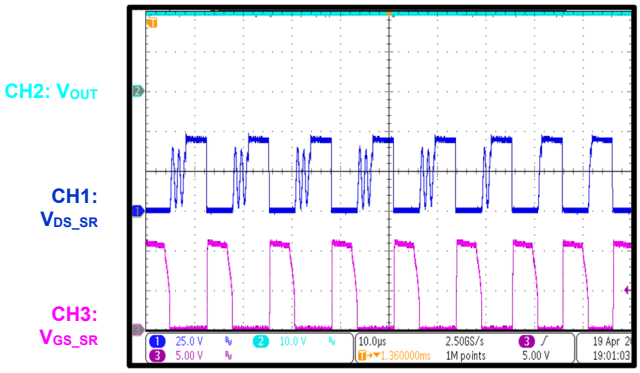
SR Steady State

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 15V, I_{OUT} = 3A



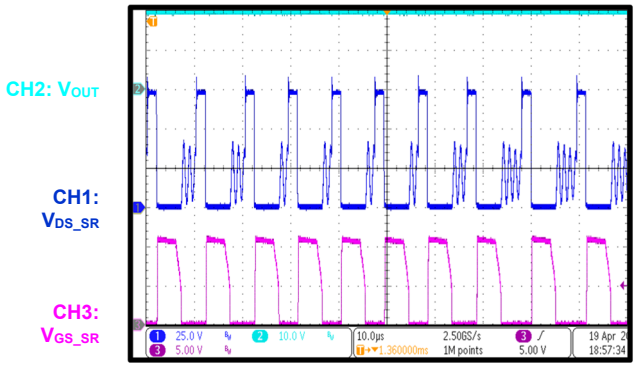
SR Steady State

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 20V, I_{OUT} = 3.25A



SR Steady State

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 20V, I_{OUT} = 3.25A

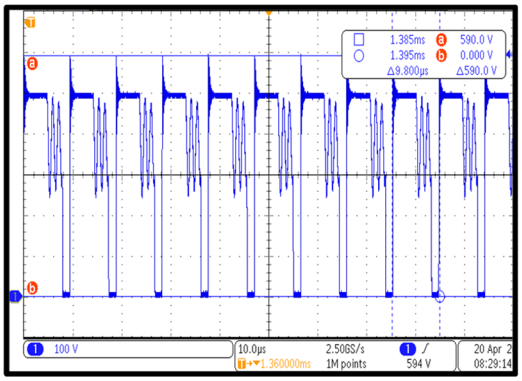


EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

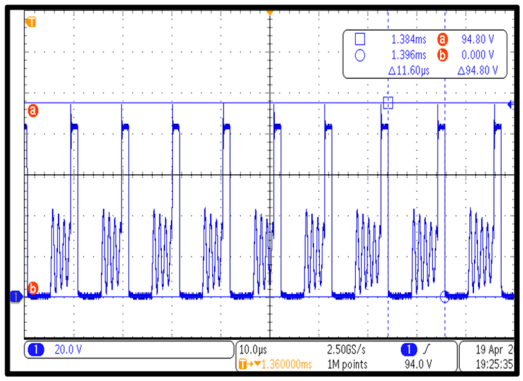
Primary MOSFET Stress

V_{IN} = 264V_{AC}, V_{OUT} = 20V, I_{OUT} = 3.25A,
V_{MAX} = 590V



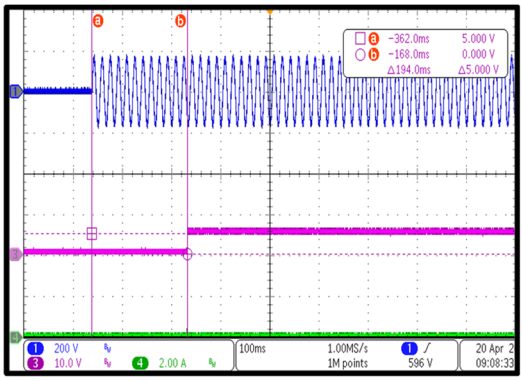
Secondary MOSFET Stress

V_{IN} = 264V_{AC}, V_{OUT} = 20V, I_{OUT} = 2.23A,
V_{MAX} = 94.8V



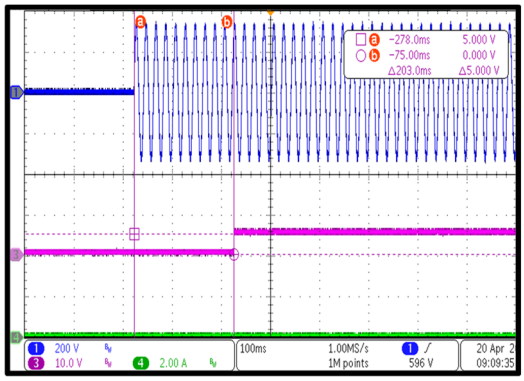
AC Input Start-Up

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 5V, I_{OUT} = 0A,
t_{RISE} = 194ms



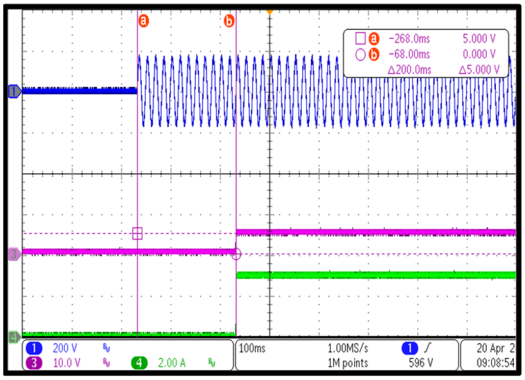
AC Input Start-Up

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 5V, I_{OUT} = 0A,
t_{RISE} = 203ms



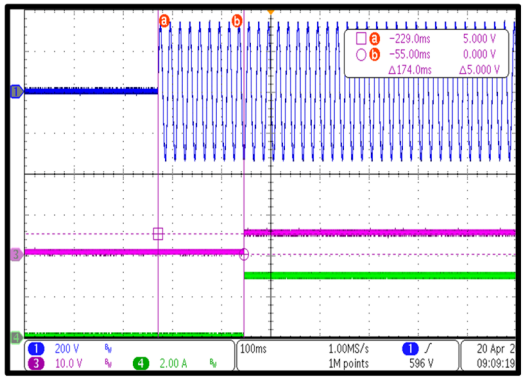
AC Input Start-Up

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 5V, I_{OUT} = 3A,
t_{RISE} = 200ms



AC Input Start-Up

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 5V, I_{OUT} = 3A,
t_{RISE} = 174ms

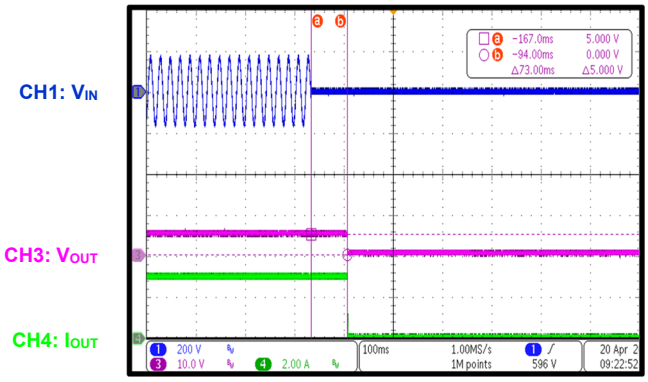


EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

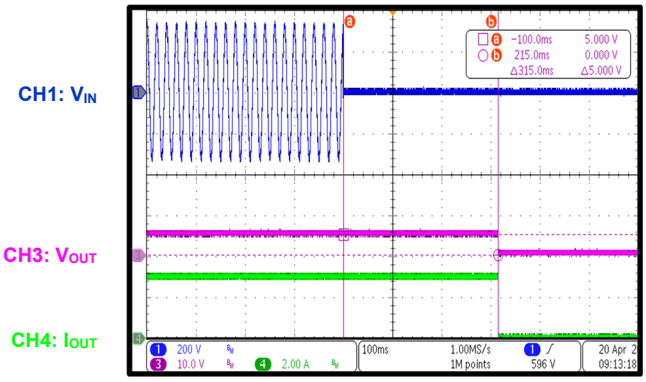
AC Input Shutdown

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 5V, I_{OUT} = 3A,
t_{HOLD} = 73ms



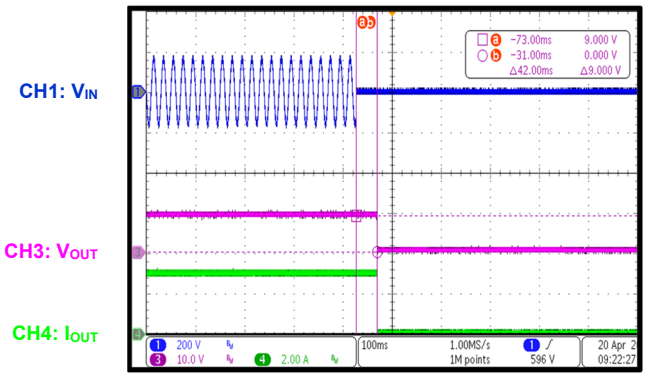
AC Input Shutdown

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 5V, I_{OUT} = 3A,
t_{HOLD} = 315ms



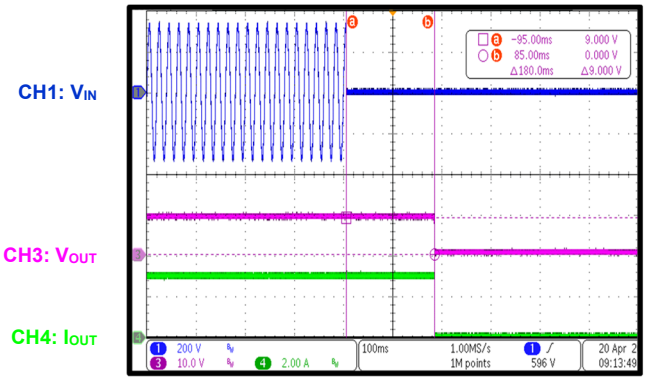
AC Input Shutdown

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 9V, I_{OUT} = 3A,
t_{HOLD} = 42ms



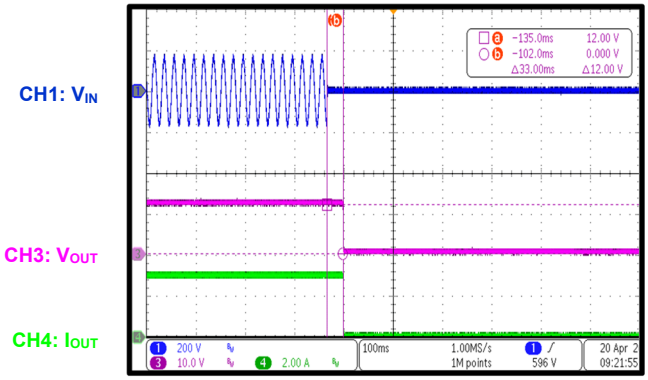
AC Input Shutdown

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 9V, I_{OUT} = 3A,
t_{HOLD} = 180ms



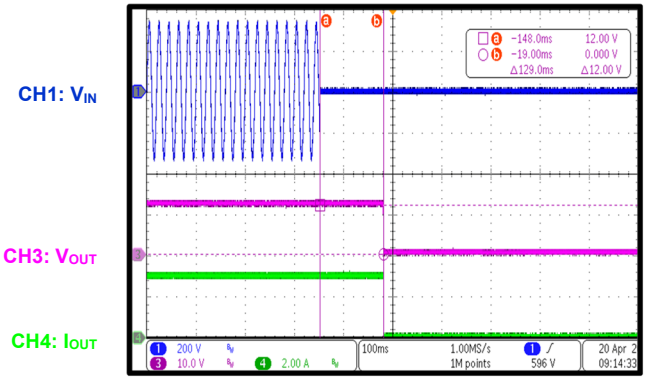
AC Input Shutdown

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 12V, I_{OUT} = 3A,
t_{HOLD} = 33ms



AC Input Shutdown

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 12V, I_{OUT} = 3A,
t_{HOLD} = 129ms

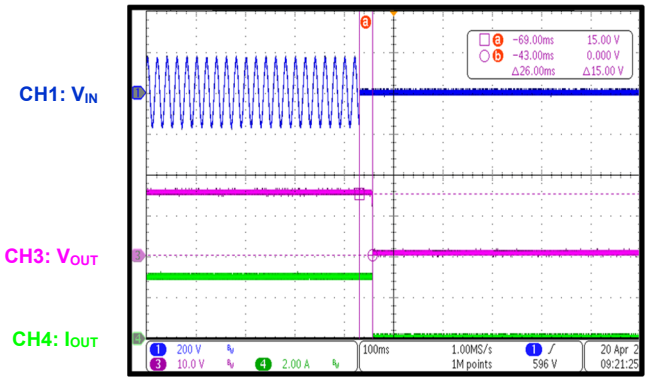


EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

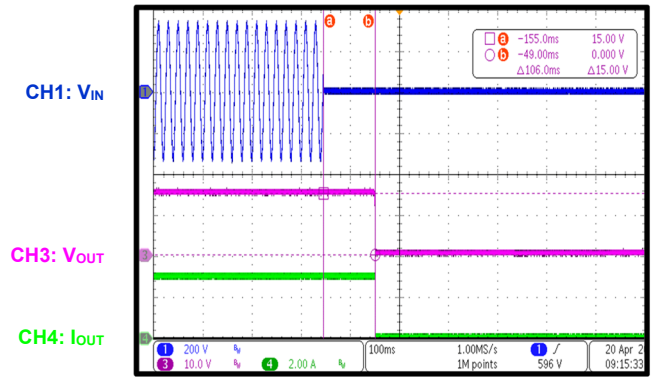
AC Input Shutdown

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 15V, I_{OUT} = 3A, t_{HOLD} = 26ms



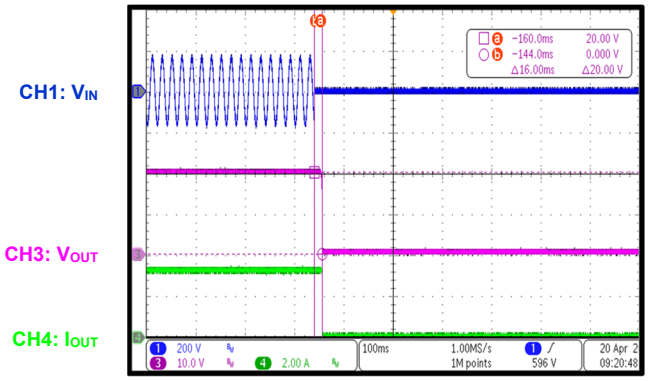
AC Input Shutdown

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 15V, I_{OUT} = 3A, t_{HOLD} = 106ms



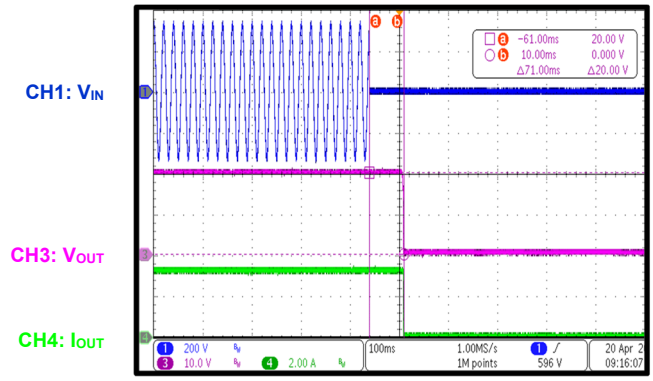
AC Input Shutdown

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 20V, I_{OUT} = 3.25A, t_{HOLD} = 16ms



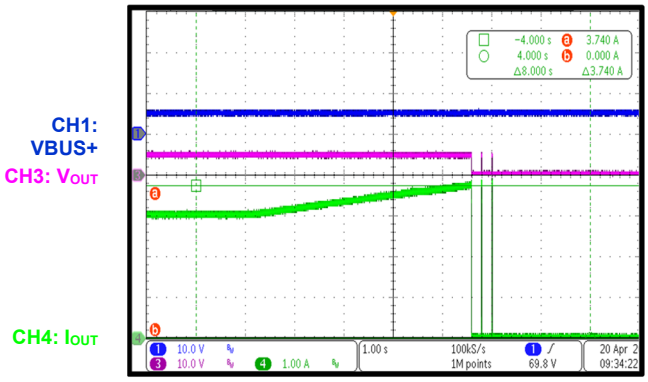
AC Input Shutdown

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 20V, I_{OUT} = 3.25A, t_{HOLD} = 71ms



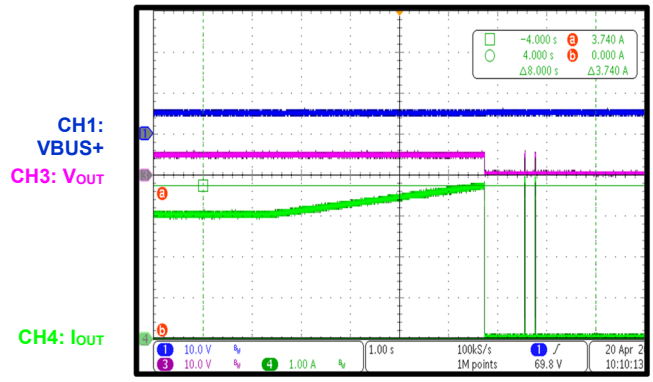
Output OCP

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 5V, I_{OCP} = 3.74A



Output OCP

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 5V, I_{OCP} = 3.74A

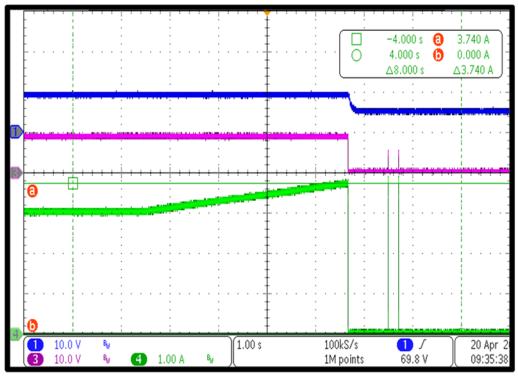


EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

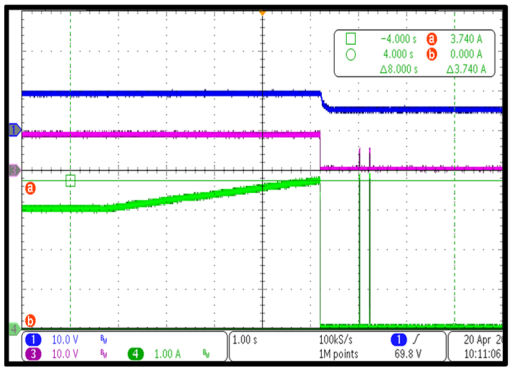
Output OCP

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 9V, I_{OCP} = 3.74A



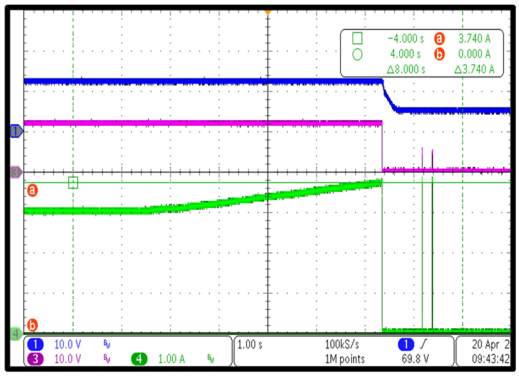
Output OCP

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 9V, I_{OCP} = 3.74A



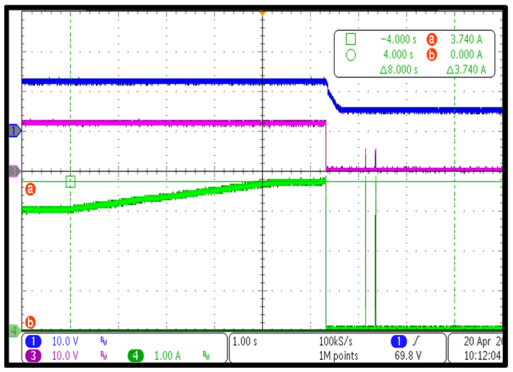
Output OCP

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 12V, I_{OCP} = 3.74A



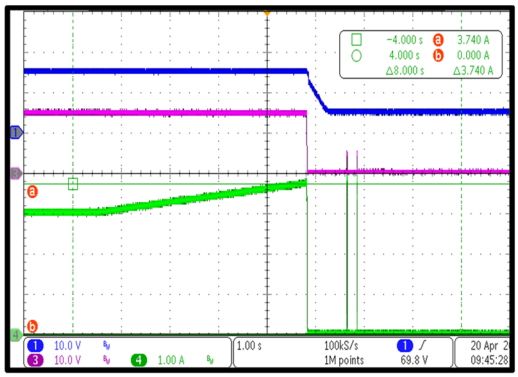
Output OCP

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 12V, I_{OCP} = 3.74A



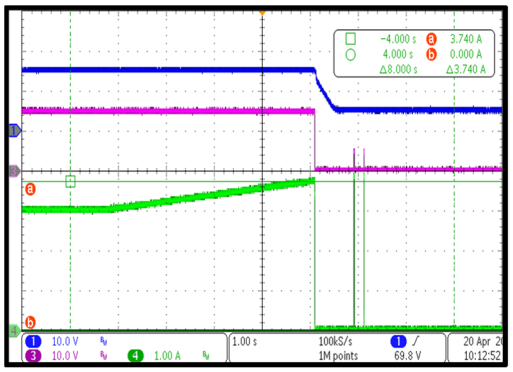
Output OCP

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 15V, I_{OCP} = 3.74A



Output OCP

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 15V, I_{OCP} = 3.74A

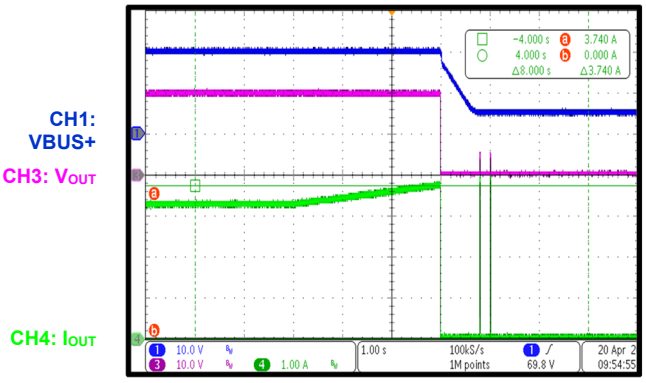


EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

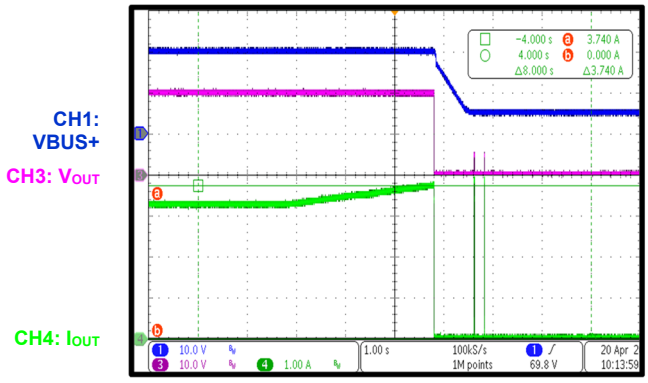
Output OCP

V_{IN} = 115V_{AC}/60Hz, V_{OUT} = 20V, I_{OCP} = 3.740A



Output OCP

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 20V, I_{OCP} = 3.740A

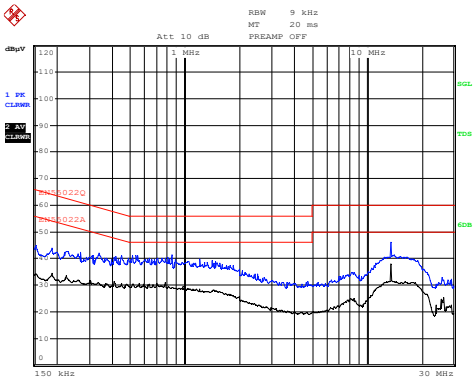


EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

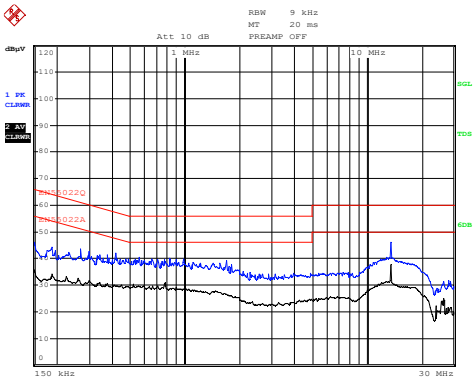
Conducted EMI

V_{IN} = 115V_{AC}/50Hz, V_{OUT} = 5V, I_{OUT} = 3A, line L



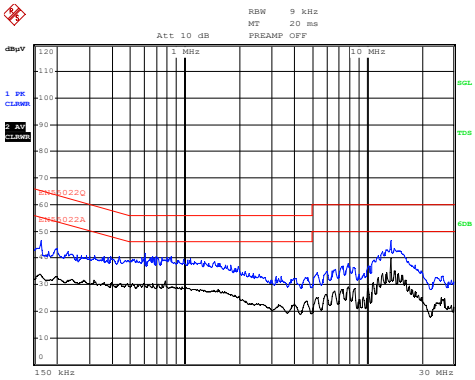
Conducted EMI

V_{IN} = 115V_{AC}/50Hz, V_{OUT} = 5V, I_{OUT} = 3A, line N



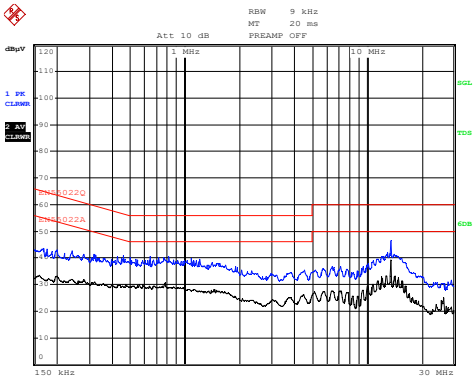
Conducted EMI

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 5V, I_{OUT} = 3A, line L



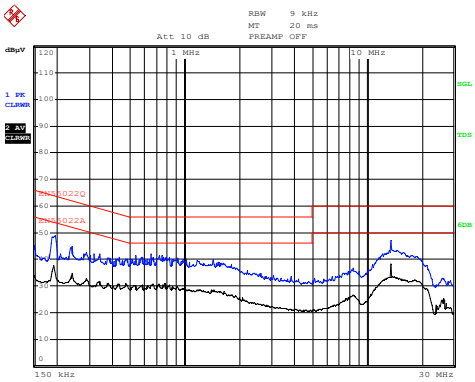
Conducted EMI

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 5V, I_{OUT} = 3A, line N



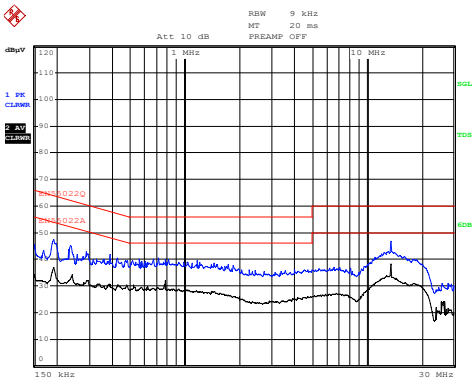
Conducted EMI

V_{IN} = 115V_{AC}/50Hz, V_{OUT} = 9V, I_{OUT} = 3A, line L



Conducted EMI

V_{IN} = 115V_{AC}/50Hz, V_{OUT} = 9V, I_{OUT} = 3A, line N

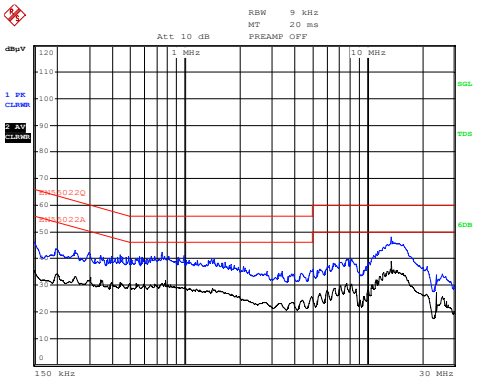


EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

Conducted EMI

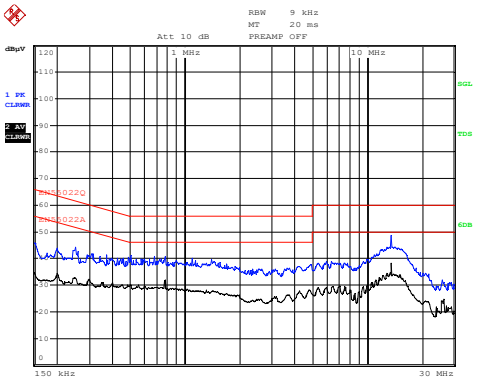
V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 9V, I_{OUT} = 3A, line L



Date: 3.NOV.2021 09:09:02

Conducted EMI

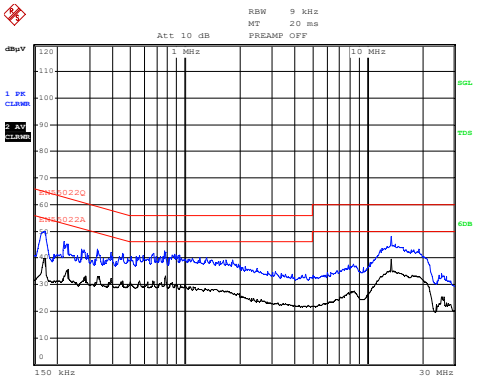
V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 9V, I_{OUT} = 3A, line N



Date: 3.NOV.2021 09:12:02

Conducted EMI

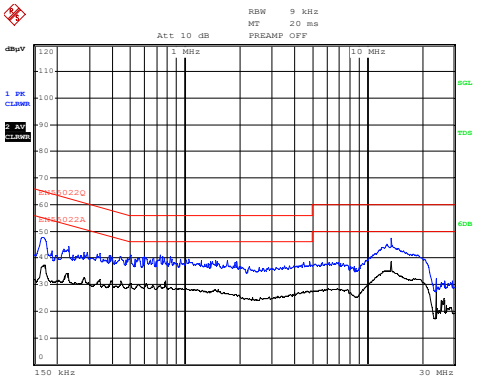
V_{IN} = 115V_{AC}/50Hz, V_{OUT} = 12V, I_{OUT} = 3A, line L



Date: 3.NOV.2021 09:15:40

Conducted EMI

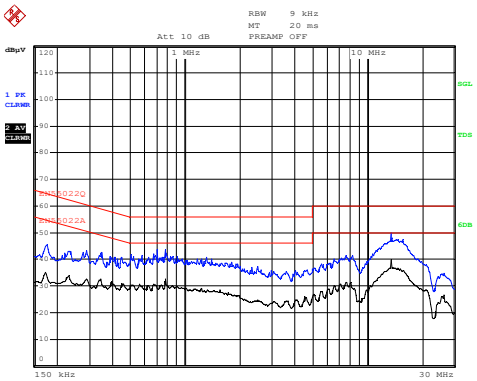
V_{IN} = 115V_{AC}/50Hz, V_{OUT} = 12V, I_{OUT} = 3A, line N



Date: 3.NOV.2021 09:19:03

Conducted EMI

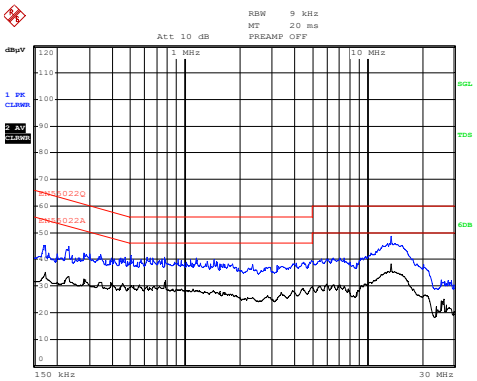
V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 12V, I_{OUT} = 3A, line L



Date: 3.NOV.2021 09:22:21

Conducted EMI

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 12V, I_{OUT} = 3A, line N



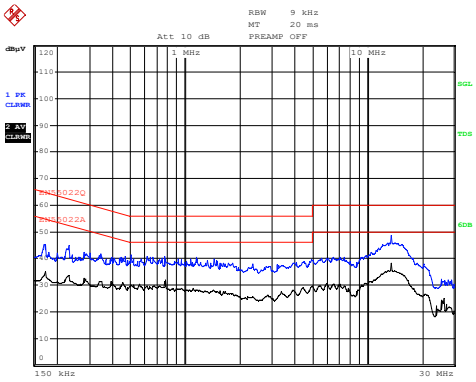
Date: 3.NOV.2021 09:25:30

EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

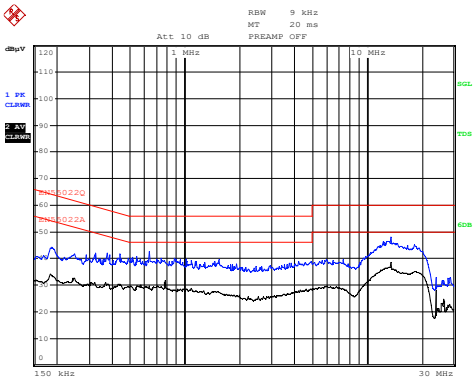
Conducted EMI

V_{IN} = 115V_{AC}/50Hz, V_{OUT} = 15V, I_{OUT} = 3A, line L



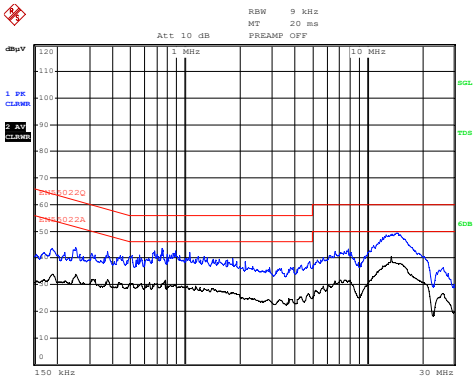
Conducted EMI

V_{IN} = 115V_{AC}/50Hz, V_{OUT} = 15V, I_{OUT} = 3A, line N



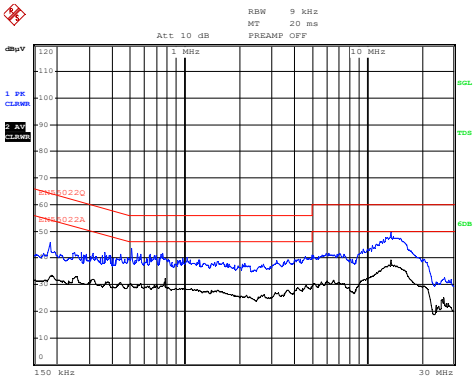
Conducted EMI

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 15V, I_{OUT} = 3A, line L



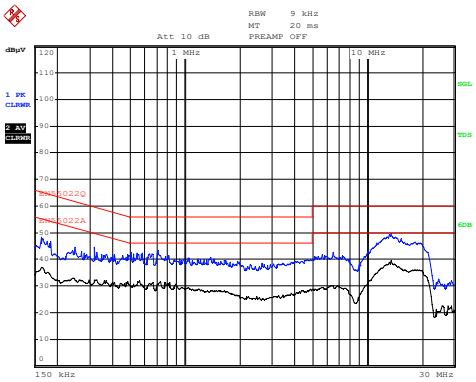
Conducted EMI

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 15V, I_{OUT} = 3A, line N



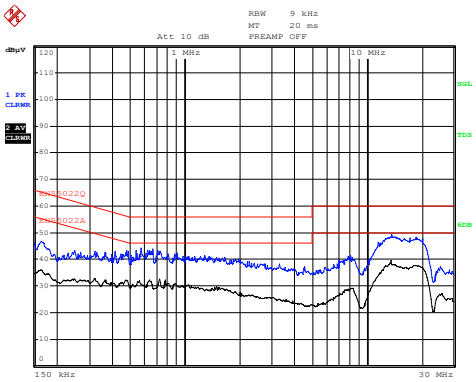
Conducted EMI

V_{IN} = 115V_{AC}/50Hz, V_{OUT} = 20V, I_{OUT} = 3.25A, line L



Conducted EMI

V_{IN} = 115V_{AC}/50Hz, V_{OUT} = 20V, I_{OUT} = 3.25A, line N

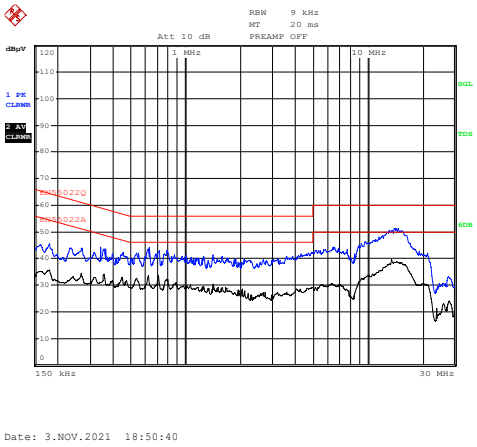


EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

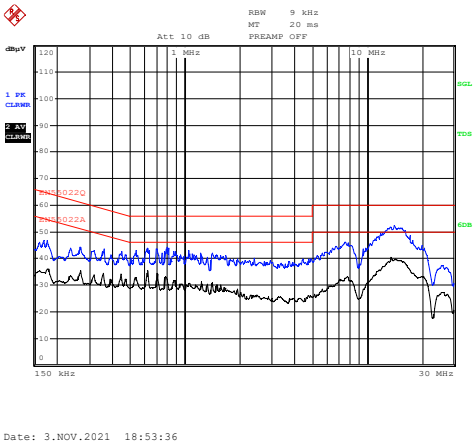
Conducted EMI

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 20V, I_{OUT} = 3.25A, line L



Conducted EMI

V_{IN} = 230V_{AC}/50Hz, V_{OUT} = 20V, I_{OUT} = 3.25A, line N

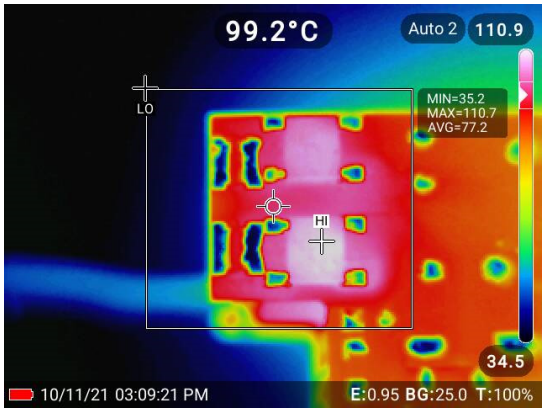


EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

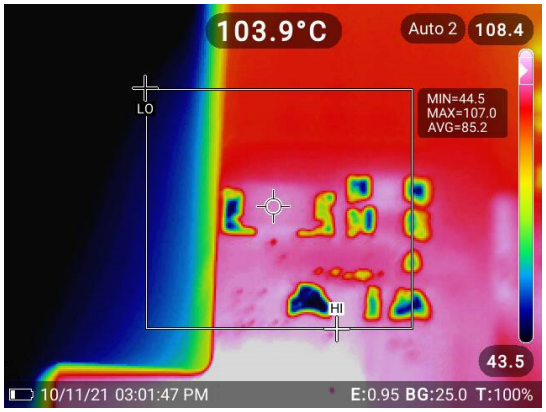
Thermal Measurements

V_{IN} = 90V_{AC}/60Hz, V_{OUT} = 20V, I_{OUT} = 3.25A,
BD1: 110.7°C



Thermal Measurements

V_{IN} = 90V_{AC}/60Hz, V_{OUT} = 20V, I_{OUT} = 3.25A,
D1: 107°C

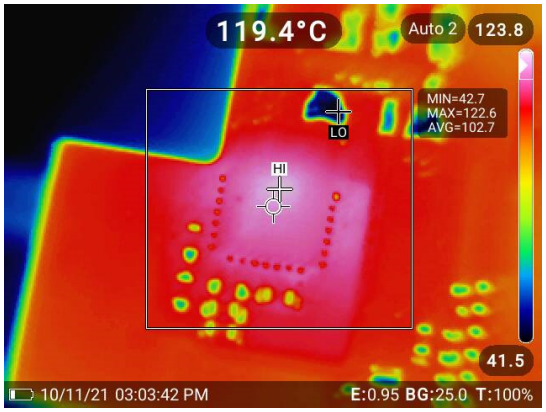


Thermal Measurements

V_{IN} = 90V_{AC}/60Hz, V_{OUT} = 20V, I_{OUT} = 3.25A,
L1: 75°C

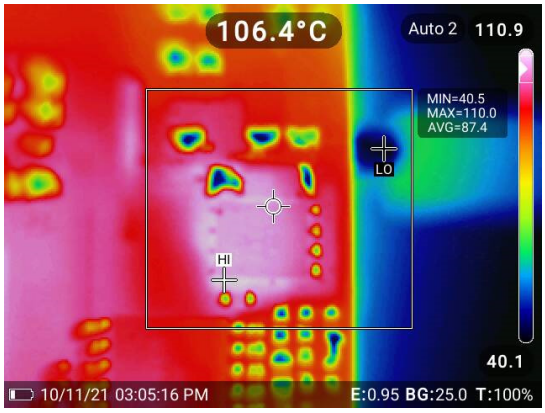
Thermal Measurements

V_{IN} = 90V_{AC}/60Hz, V_{OUT} = 20V, I_{OUT} = 3.25A,
Q1: 122.6°C



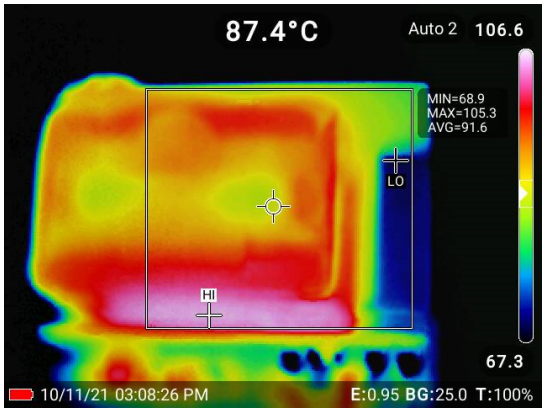
Thermal Measurements

V_{IN} = 90V_{AC}/60Hz, V_{OUT} = 20V, I_{OUT} = 3.25A,
Q3: 110°C



Thermal Measurements

V_{IN} = 90V_{AC}/60Hz, V_{OUT} = 20V, I_{OUT} = 3.25A,
T1: 105.3°C

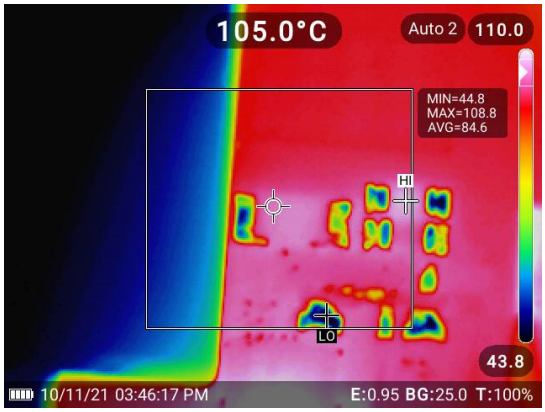


EVB TEST RESULTS *(continued)*

Performance waveforms are tested on the evaluation board.

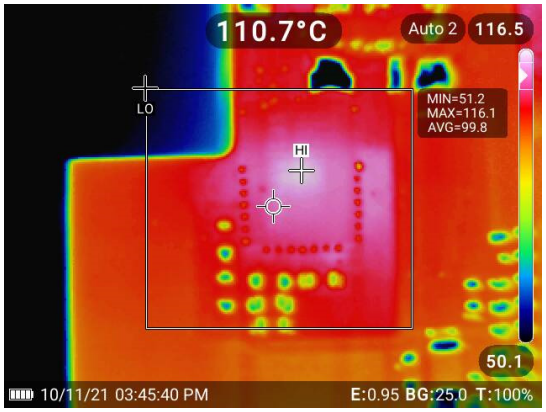
Thermal Measurements

V_{IN} = 264V_{AC}/50Hz, V_{OUT} = 20V, I_{OUT} = 3.25A,
D1: 105°C



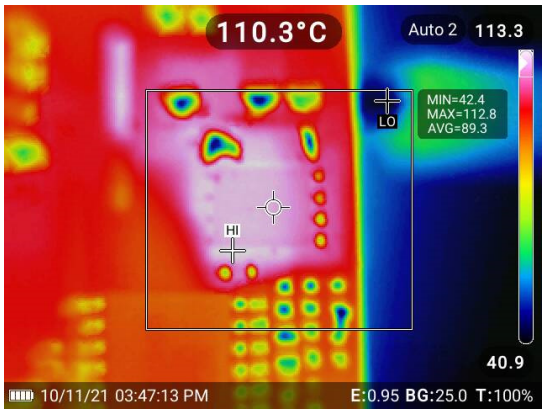
Thermal Measurements

V_{IN} = 264V_{AC}/50Hz, V_{OUT} = 20V, I_{OUT} = 3.25A,
Q1: 116.1°C



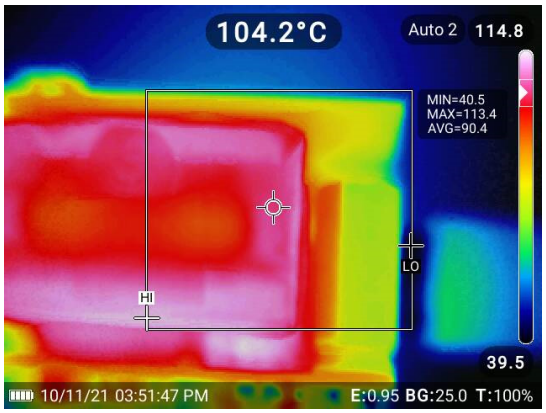
Thermal Measurements

V_{IN} = 264V_{AC}/50Hz, V_{OUT} = 20V, I_{OUT} = 3.25A,
Q3: 112.8°C



Thermal Measurements

V_{IN} = 264V_{AC}/50Hz, V_{OUT} = 20V, I_{OUT} = 3.25A,
T1: 113.4°C



PCB LAYOUT

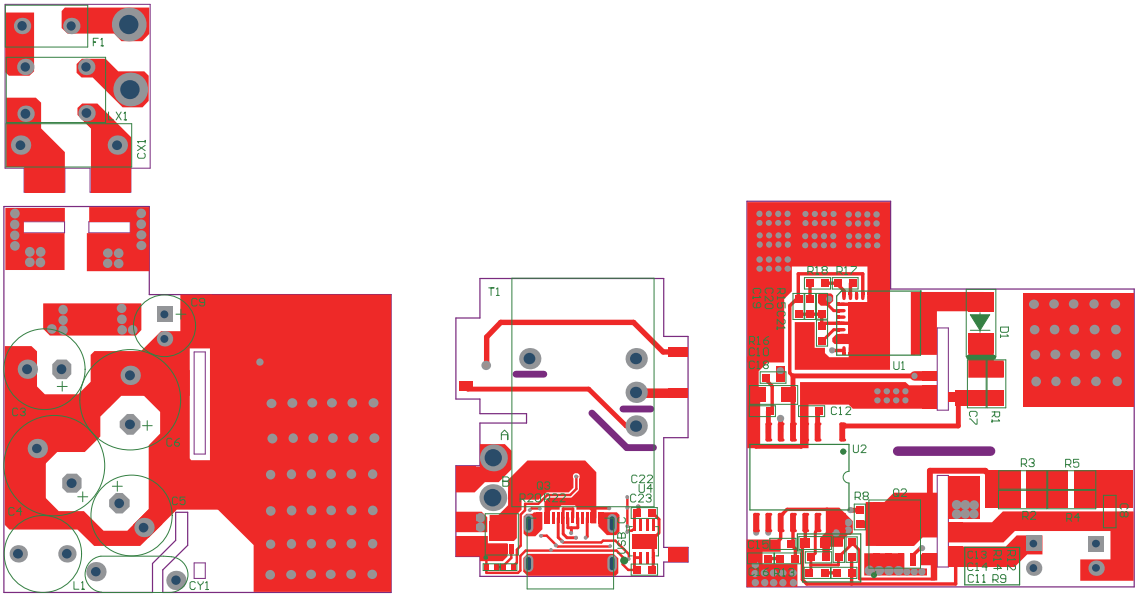


Figure 3: Top Layer

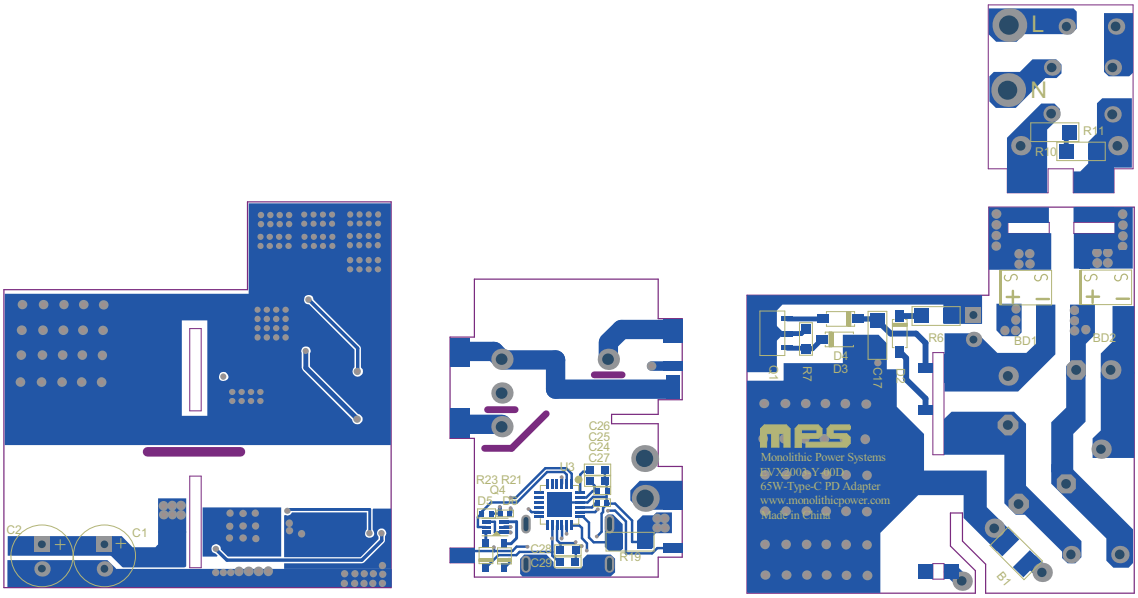


Figure 4: Bottom Layer

APPENDIX: FLYBACK TRANSFORMER T1 SPECIFICATION

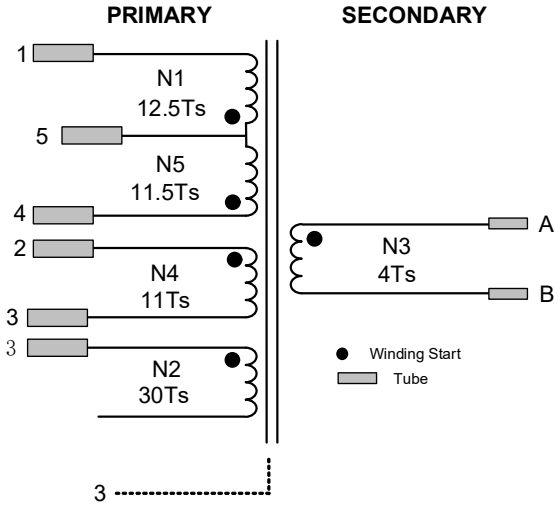


Figure 5: Electrical Diagram

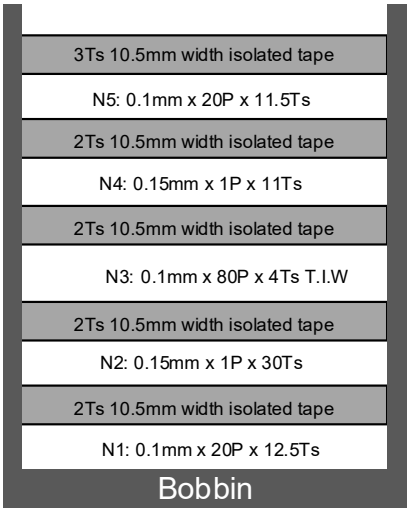


Figure 7: Winding Diagram

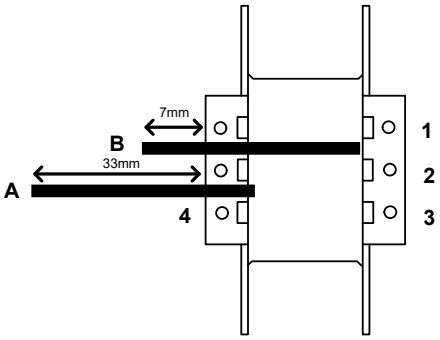


Figure 6: Pin Definition of Bobbin (View from Top)

Table 8: Electrical Characteristic

Parameter	Condition	Value
Primary inductance	L_P (1-4)	260μH ±5%
Leakage inductance	L_{LK} (1-4)	5μH max
Core	-	ATQ23.7
Bobbin	-	ATQ23.7
Core material	-	PN95
Turn ratio	N1:N3:N4:N5	12.5:4:11:11.5

Table 9: Winding Specification

Tape Turns	Winding No.	Start to End	Wire Diameter (φ)	Turns	Winding	Tube
	N1	4 to X	0.1mm x 20P	12.5Ts	2 layers	Yes
2Ts	N2	3 to NC	0.15mm x 1P	30Ts	1 full layer	Yes
2Ts	N3	A to B	0.1mm x 80P (T.I.W)	4Ts	1 full layer	Yes
2Ts	N4	2 to 3	0.15mm x 1P	11Ts	1 layer spread	Yes
2Ts	N5	X to 1	0.1mm x 20P	11.5Ts	2 layer	Yes
3Ts						
	Connect the core to GND (pin 3) via 1.1Ts copper.					

REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	8/19/2022	Initial Release	-