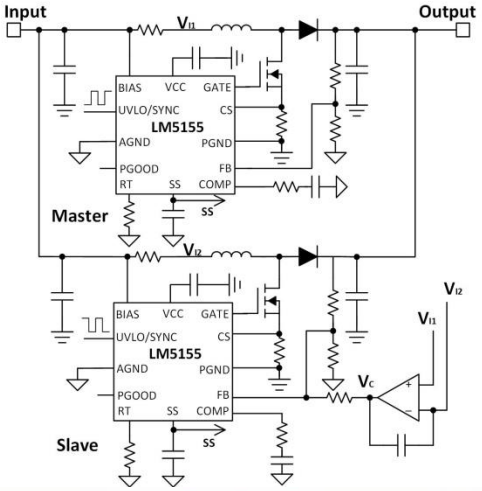
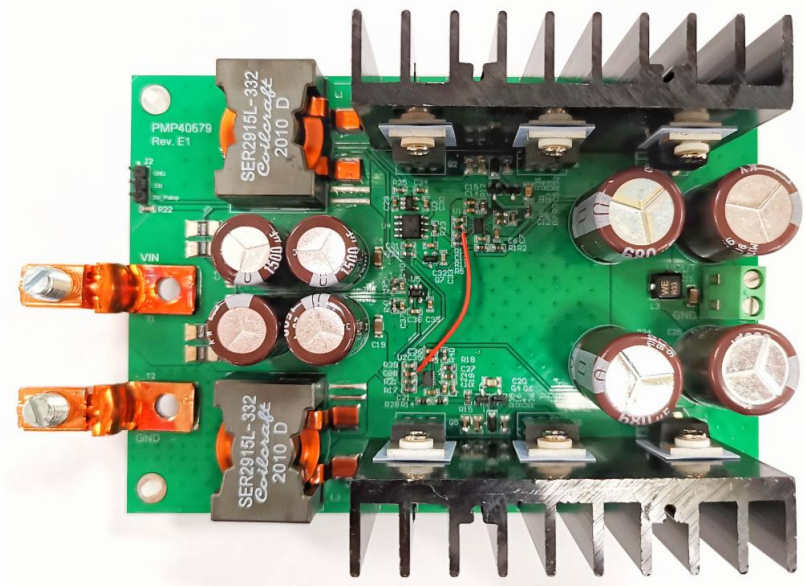
Test Report: PMP40679

9.8~13.5-V Input, 46-V 300-W Output Interleave Boost Reference Design

Description

This reference design is a 300-W power output interleaving combination of two Boost converters using LM5155 controller. Each converter outputs continuous 150-W and 200-W peak. A LMC555 circuit generates 150k-Hz square wave signal and its anti-phase signal for synchronous clock for the two LM5155, making two converters working with 180° phase shift, which helps reduce the output voltage ripple. An amplifier samples input current of the two converters, outputs error signal V_C to control slave phase to share current with master phase. There is only 4.6°C temperature difference between two phases in the thermal result, good current sharing is achieved. Efficiency of the design is higher than 91% at 400-W peak output. Peak to peak ripple is within 250-mV during 200-W to 400-W transient. The design shows a valid way to expand the output power by paralleling two Boost converters.





An IMPORTANT NOTICE at the end of this TI reference design addresses authorized use, intellectual property matters and other important disclaimers and information.

Copyright © 2020, Texas Instruments Incorporated

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1. Voltage and Current Requirements

PARAMETER	SPECIFICATIONS
Input Voltage	9.8~13.5 Vdc
Output Voltage	46 Vdc
Continuous Output Current	6.5A
Peak Output Current	8.75 A@(V_{IN}=10.5~13.5V)

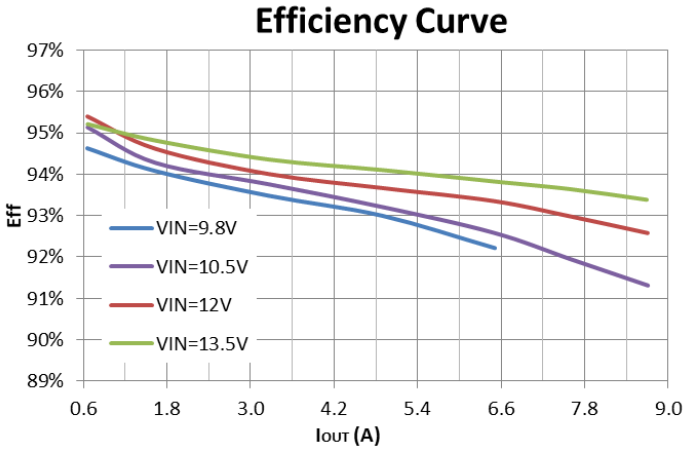
1.2 Required Equipment

- Multi-meter (current): Fluke 287C
- Multi-meter (voltage): Fluke 287C
- DC Source: Chroma 62006P-100-50
- E-Load: Chroma 63105A module
- Oscilloscope: Tektronix DPO3054,
- Electrical Thermography: Fluke TiS65

Copyright © 2020, Texas Instruments Incorporated

2 Testing and Results

2.1 Efficiency Graphs



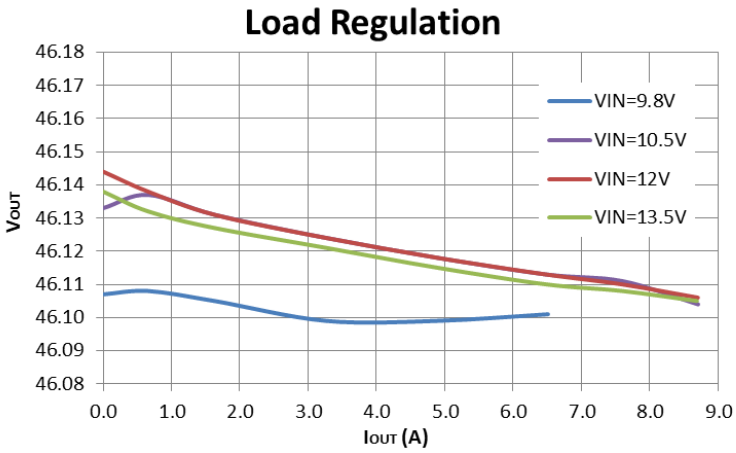
2.2 Efficiency Data

V_{IN} (V)	I_{IN} (A)	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	P_{OUT} (W)	P_{LOSS} (W)	Eff
9.800	0.0300	0.2940	46.107	0.0000	0.0000	0.2940	
9.804	3.2613	31.9738	46.108	0.6562	30.2561	1.7177	**94.63%**
9.802	8.1458	79.8451	46.105	1.6293	75.1189	4.7263	**94.08%**
9.805	16.3990	160.7922	46.099	3.2606	150.3104	10.4818	**93.48%**
9.803	24.7360	242.4870	46.099	4.8918	225.5071	16.9799	**93.00%**
9.806	33.1890	325.4513	46.101	6.5100	300.1175	25.3338	**92.22%**
10.508	0.0294	0.3089	46.133	0.0000	0.0000	0.3089	
10.508	3.0460	32.0074	46.137	0.6600	30.4504	1.5569	**95.14%**
10.502	7.6180	80.0042	46.131	1.6350	75.4242	4.5801	**94.28%**
10.496	15.3180	160.7777	46.124	3.2681	150.7378	10.0399	**93.76%**
10.496	23.1050	242.5101	46.118	4.9012	226.0335	16.4765	**93.21%**
10.498	30.7780	323.1074	46.113	6.4875	299.1581	23.9494	**92.59%**
10.502	36.2890	381.1071	46.111	7.5993	350.4113	30.6958	**91.95%**
10.498	41.8800	439.6562	46.104	8.7075	401.4506	38.2057	**91.31%**
12.006	0.0300	0.3602	46.144	0.0000	0.0000	0.3602	
12.003	2.6517	31.8284	46.138	0.6581	30.3634	1.4649	**95.40%**
12.004	6.6330	79.6225	46.131	1.6331	75.3365	4.2860	**94.62%**
12.000	13.3550	160.2600	46.124	3.2662	150.6502	9.6098	**94.00%**
12.003	20.0970	241.2243	46.118	4.8993	225.9459	15.2784	**93.67%**
12.000	26.6970	320.3640	46.113	6.4856	299.0705	21.2935	**93.35%**
11.997	31.4050	376.7658	46.110	7.5974	350.3161	26.4497	**92.98%**
12.002	36.1160	433.4642	46.106	8.7037	401.2928	32.1714	**92.58%**

Copyright © 2020, Texas Instruments Incorporated

13.507	0.0302	0.4079	46.138	0.0000	0.0000	0.4079	
13.498	2.3756	32.0658	46.132	0.6618	30.5302	1.5357	**95.21%**
13.495	5.8941	79.5409	46.127	1.6350	75.4176	4.1232	**94.82%**
13.501	11.8390	159.8383	46.121	3.2700	150.8157	9.0227	**94.36%**
13.496	17.7970	240.1883	46.115	4.9012	226.0188	14.1695	**94.10%**
13.493	23.6350	318.9071	46.110	6.4893	299.2216	19.6854	**93.83%**
13.500	27.7250	374.2875	46.108	7.6012	350.4761	23.8114	**93.64%**
13.497	31.7900	429.0696	46.105	8.6906	400.6801	28.3895	**93.38%**

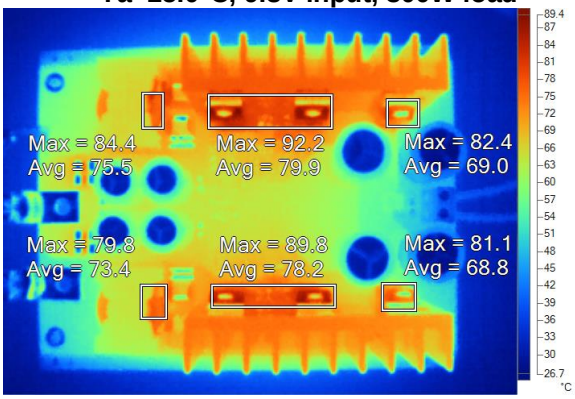
2.3 Load Regulation



2.4 Thermal Images

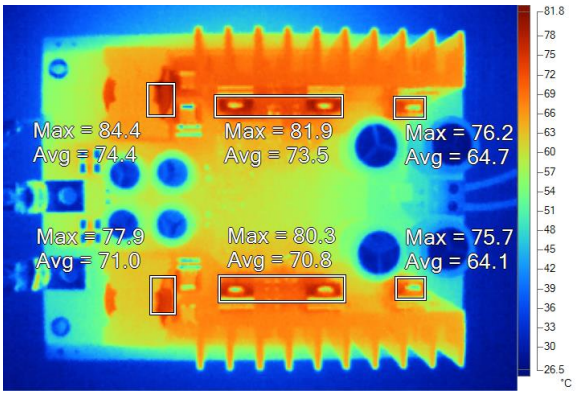
Note: 2-oz copper, tested after 20min operation, open frame and without fan cooling.

Ta=25.0°C, 9.8V input, 300W load

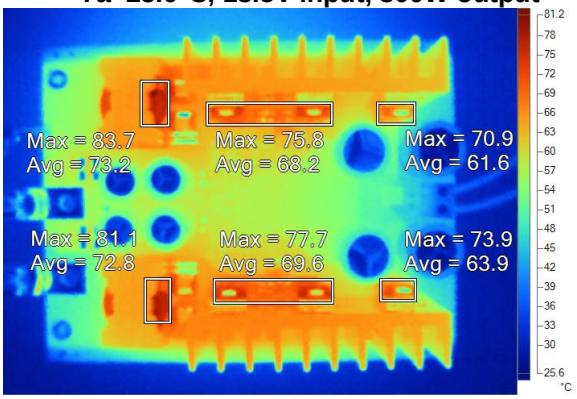


Ta=25.0°C, 12V input, 300W output

Copyright © 2020, Texas Instruments Incorporated

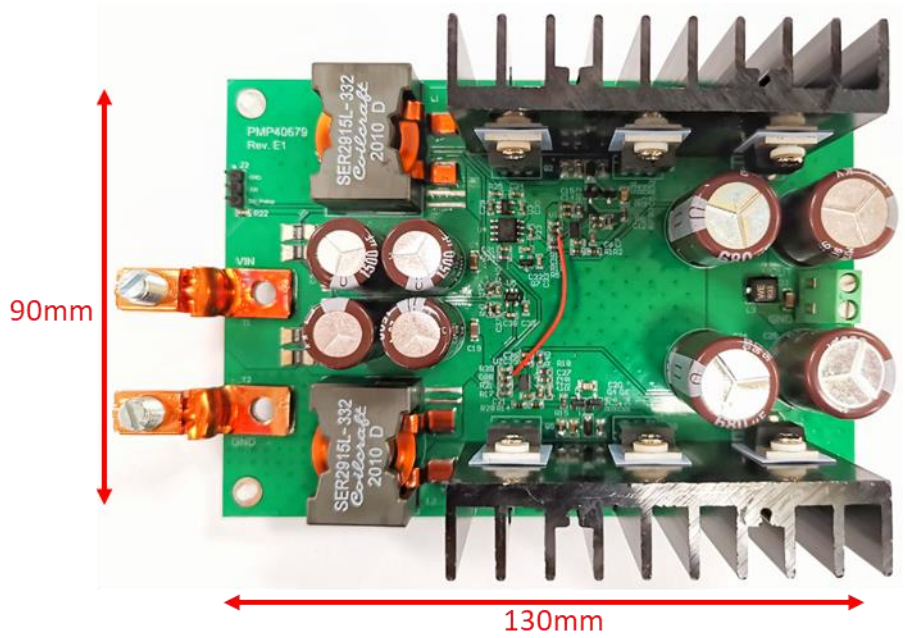


Ta=25.0°C, 13.5V input, 300W output



2.5 Dimensions

The dimension of this board is 130mm 90mm (width)*40mm (height).
Note: Test done on E1 PCB, E2 only modify the connection of SS pins on E1.



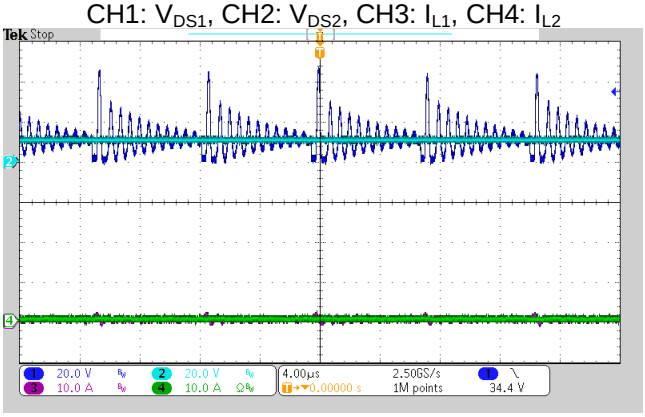
Copyright © 2020, Texas Instruments Incorporated

3 Waveforms

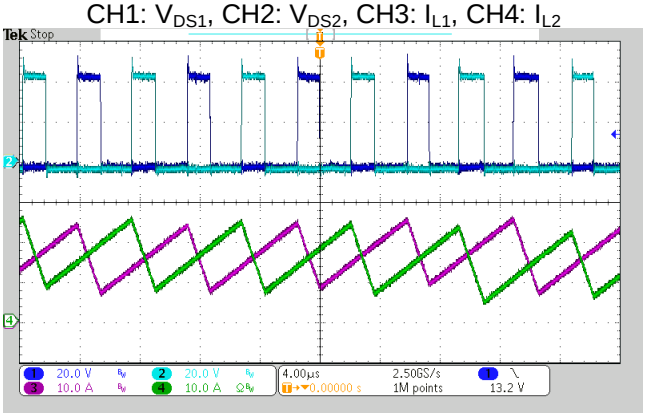
3.1 Switching

The waveforms of switching nodes at no load and full load condition are shown in following pictures.

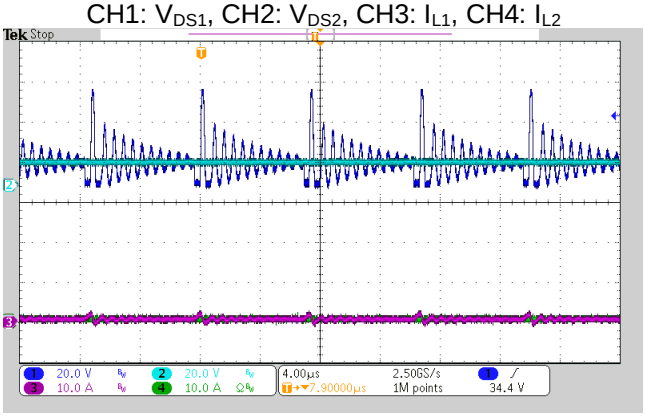
9.8V input, 46V no-load
CH1: V_{DS1}, CH2: V_{DS2}, CH3: I_{L1}, CH4: I_{L2}



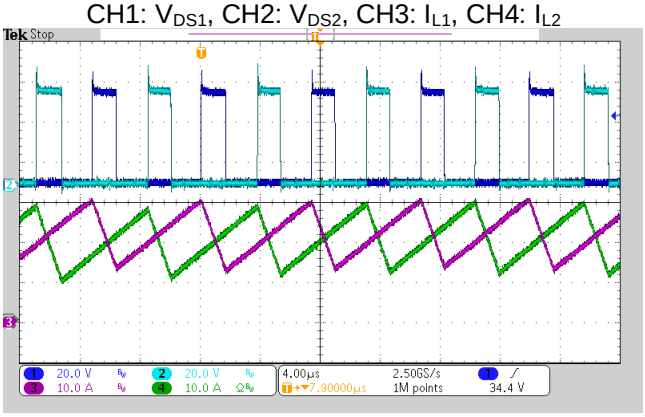
9.8V input, 46V 300W load
CH1: V_{DS1}, CH2: V_{DS2}, CH3: I_{L1}, CH4: I_{L2}



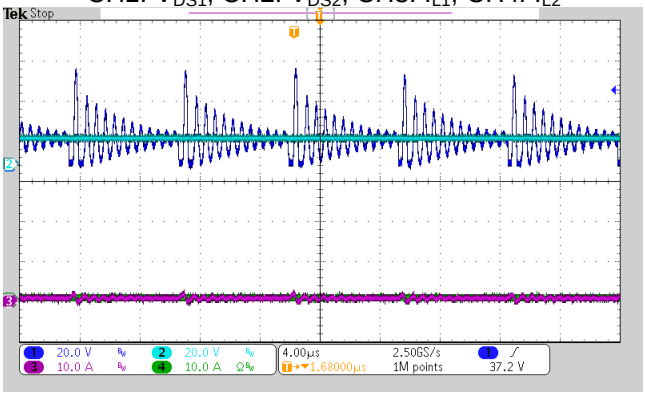
10.5V input, 46V no-load
CH1: V_{DS1}, CH2: V_{DS2}, CH3: I_{L1}, CH4: I_{L2}



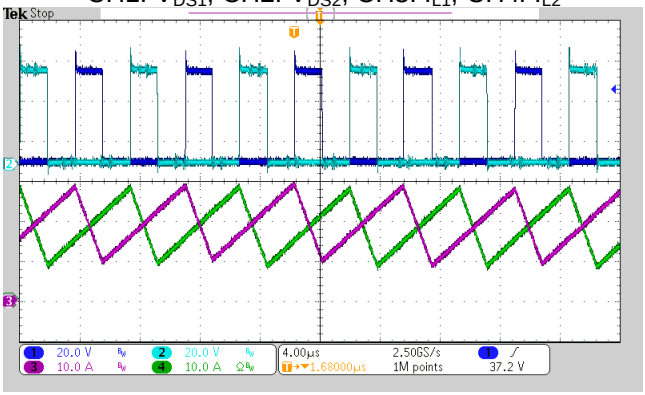
10.5V input, 46V 400W load
CH1: V_{DS1}, CH2: V_{DS2}, CH3: I_{L1}, CH4: I_{L2}



12V input, 46V no-load
CH1: V_{DS1}, CH2: V_{DS2}, CH3: I_{L1}, CH4: I_{L2}

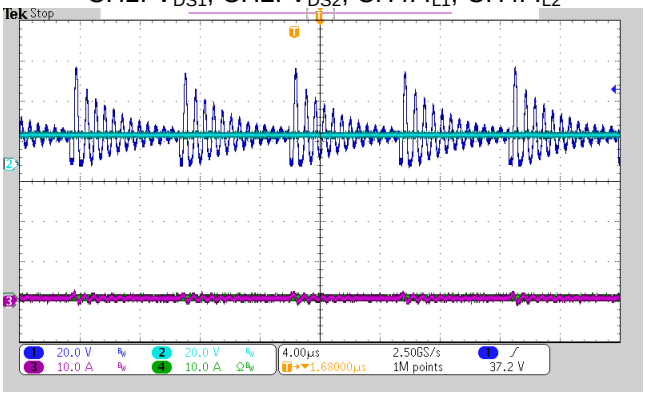


12V input, 46V 400W load
CH1: V_{DS1}, CH2: V_{DS2}, CH3: I_{L1}, CH4: I_{L2}

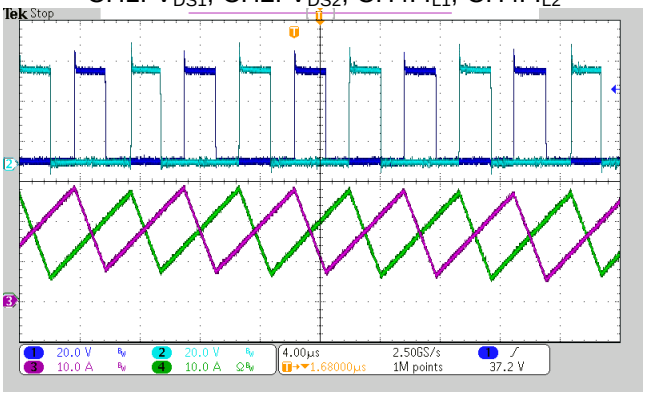


Copyright © 2020, Texas Instruments Incorporated

13.5V input, 46V no-load
CH1: V_{DS1}, CH2: V_{DS2}, CH4: I_{L1}, CH4: I_{L2}



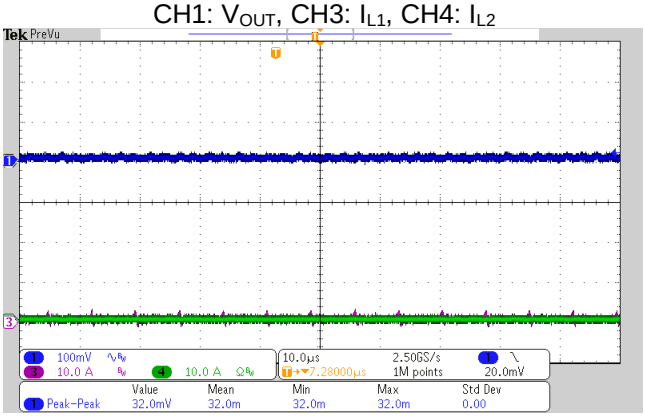
13.5V input, 46V 400W load
CH1: V_{DS1}, CH2: V_{DS2}, CH4: I_{L1}, CH4: I_{L2}



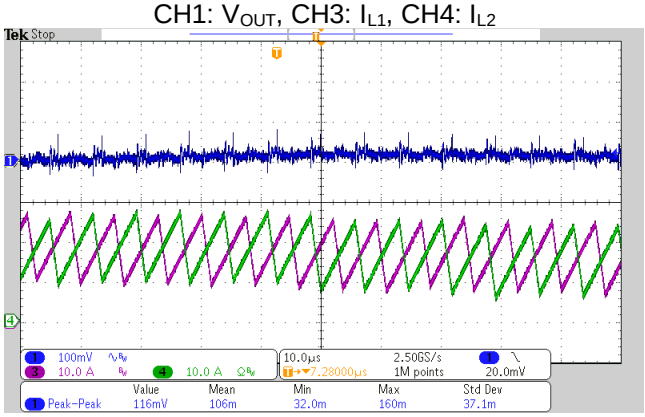
3.2 Output Voltage Ripple

The waveforms of output AC ripples at no load and full load condition are shown in following pictures.

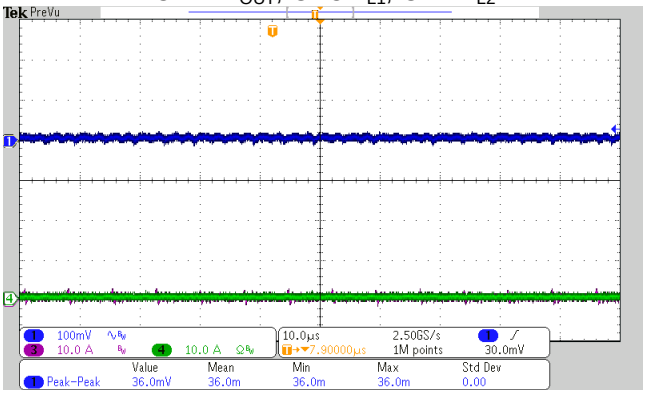
9.8V input, 46V no-load
CH1: V_{OUT}, CH3: I_{L1}, CH4: I_{L2}



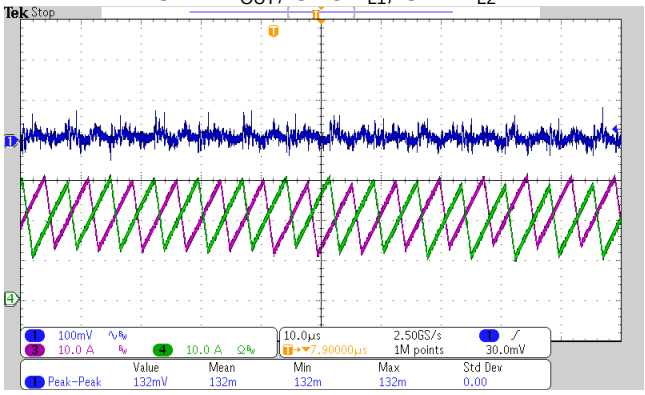
9.8V input, 46V 300W load
CH1: V_{OUT}, CH3: I_{L1}, CH4: I_{L2}



10.5V input, 46V no-load
CH1: V_{OUT}, CH3: I_{L1}, CH4: I_{L2}

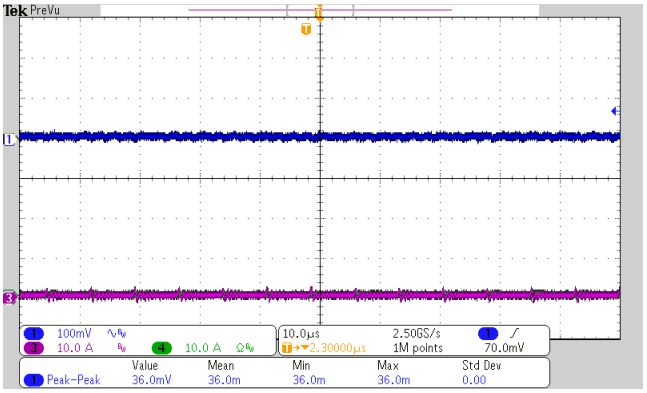


10.5V input, 46V 400W load
CH1: V_{OUT}, CH3: I_{L1}, CH4: I_{L2}

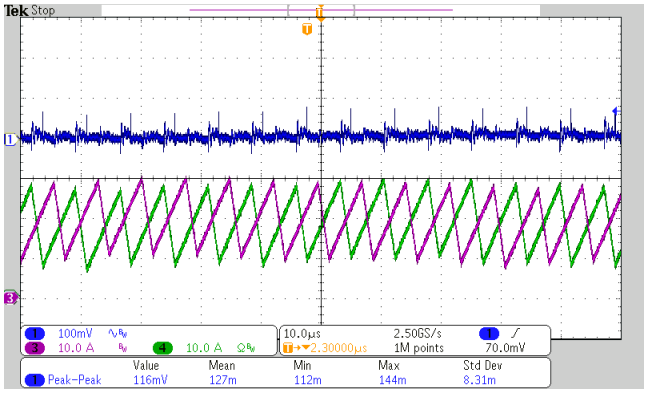


Copyright © 2020, Texas Instruments Incorporated

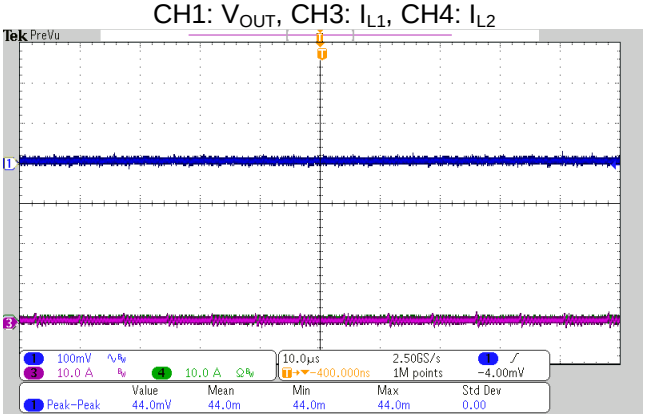
12V input, 46V no-load
CH1: V_{OUT}, CH3: I_{L1}, CH4: I_{L2}



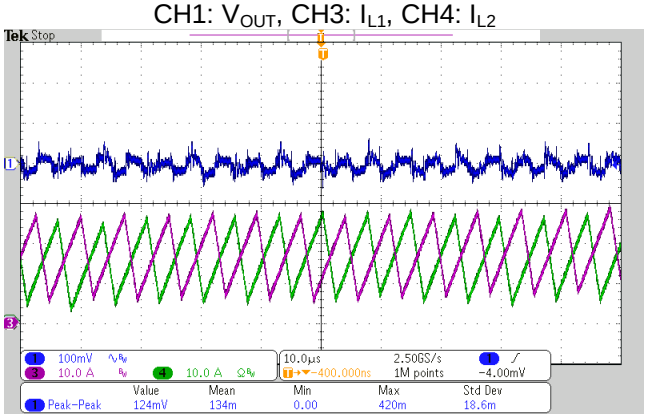
12V input, 46V 400W load
CH1: V_{OUT}, CH3: I_{L1}, CH4: I_{L2}



13.5V input, 46V no-load
CH1: V_{OUT}, CH3: I_{L1}, CH4: I_{L2}



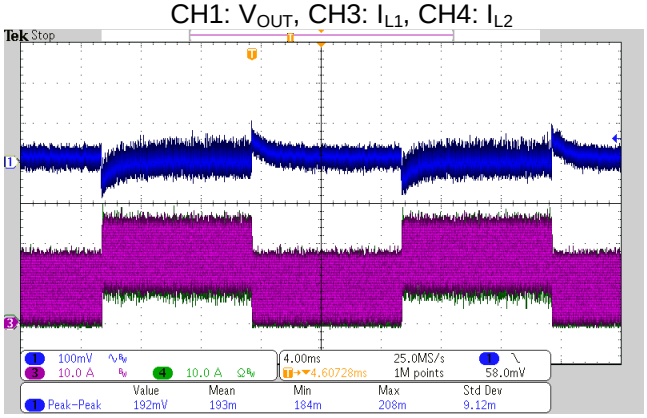
13.5V input, 46V 400W load
CH1: V_{OUT}, CH3: I_{L1}, CH4: I_{L2}



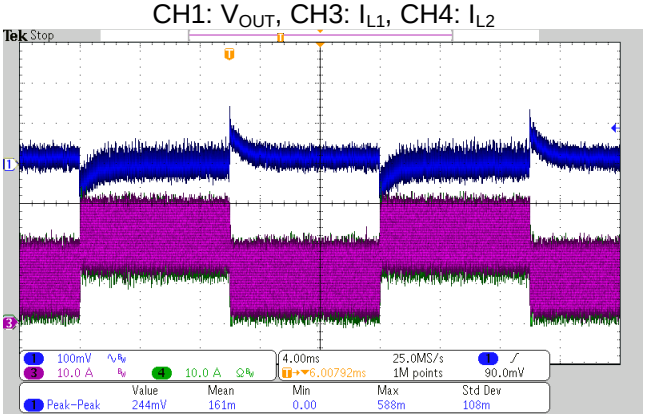
3.3 Load Transient

The waveforms of output AC ripples at load transient are shown in following pictures. The high current level is full load for 10ms; the low current level is half load for 10ms, with a slew rate of 0.4A/us.

9.8V input, 3.26A->6.52A
CH1: V_{OUT}, CH3: I_{L1}, CH4: I_{L2}

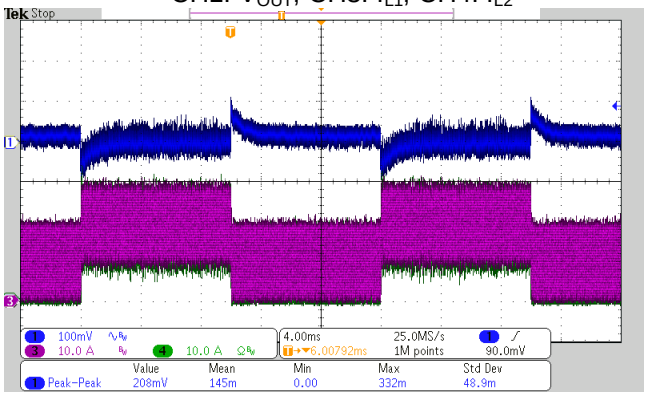


10.5V input, 4.35A->8.7A
CH1: V_{OUT}, CH3: I_{L1}, CH4: I_{L2}

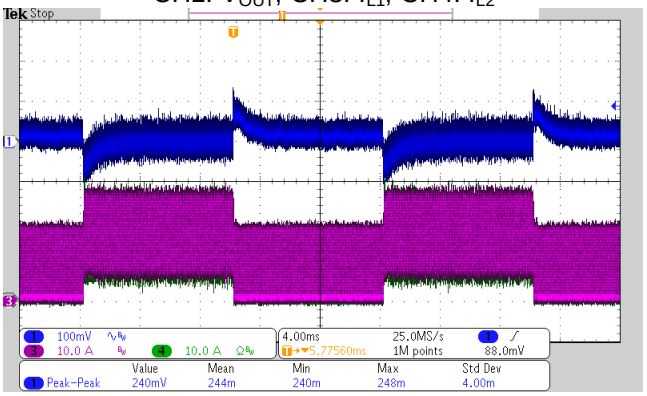


Copyright © 2020, Texas Instruments Incorporated

12V input, 4.35A->8.7A
CH1: V_{OUT}, CH3: I_{L1}, CH4: I_{L2}



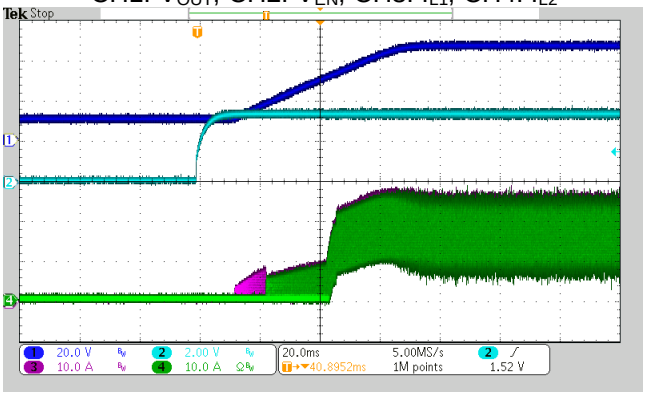
13.5V input, 4.35A->8.7A
CH1: V_{OUT}, CH3: I_{L1}, CH4: I_{L2}



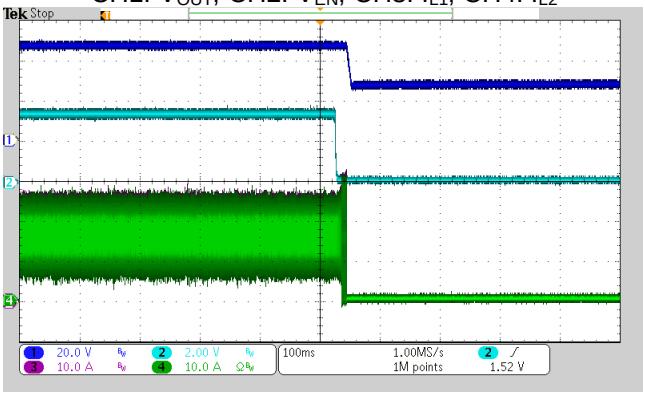
3.4 Power on/off

The waveforms of system power on and off with full load outputs are shown in following pictures. V_{ON} of e-load is set at 30V.

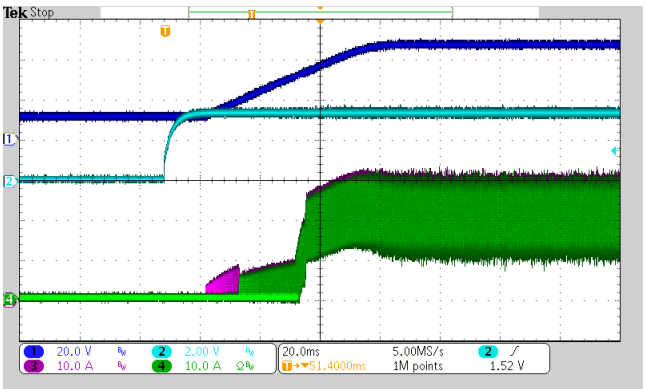
9.8V input, 300W load Power On
CH1: V_{OUT}, CH2: V_{EN}, CH3: I_{L1}, CH4: I_{L2}



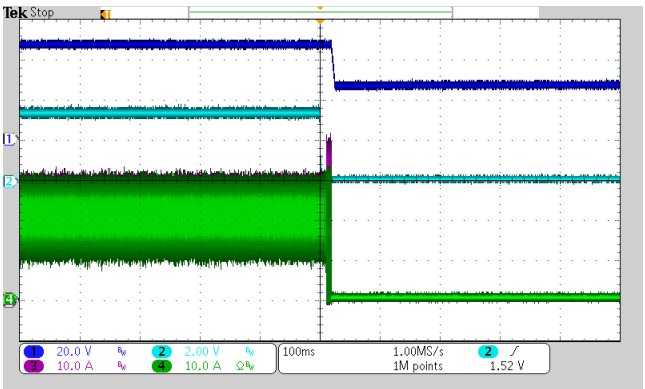
9.8V input, 300W load Power Off
CH1: V_{OUT}, CH2: V_{EN}, CH3: I_{L1}, CH4: I_{L2}



10.5V input, 400W load Power On
CH1: V_{OUT}, CH2: V_{EN}, CH3: I_{L1}, CH4: I_{L2}

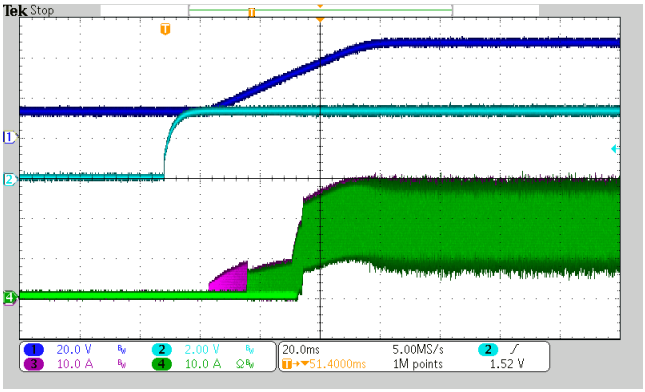


10.5V input, 400W load Power Off
CH1: V_{OUT}, CH2: V_{EN}, CH3: I_{L1}, CH4: I_{L2}

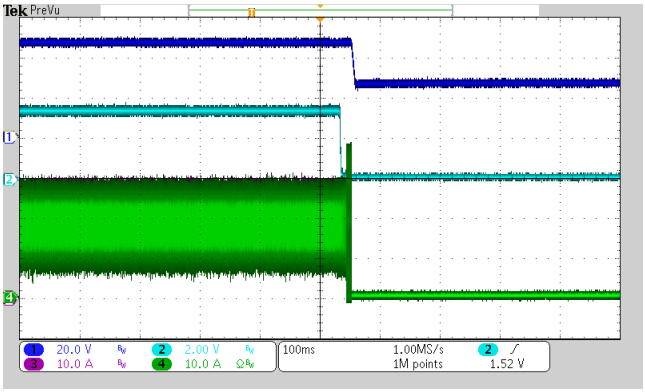


Copyright © 2020, Texas Instruments Incorporated

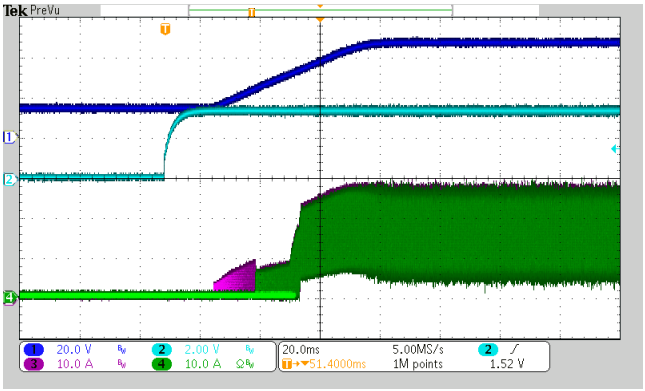
12V input, 400W load Power On
CH1: V_{OUT}, CH2: V_{EN}, CH3: I_{L1}, CH4: I_{L2}



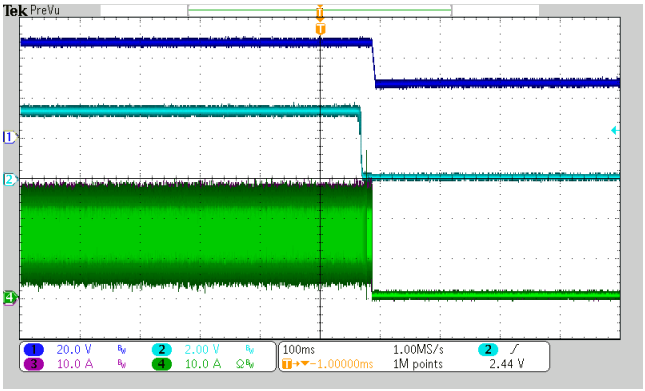
12V input, 400W load Power Off
CH1: V_{OUT}, CH2: V_{EN}, CH3: I_{L1}, CH4: I_{L2}



13.5V input, 400W load Power On
CH1: V_{OUT}, CH2: V_{EN}, CH3: I_{L1}, CH4: I_{L2}



13.5V input, 400W load Power Off
CH1: V_{OUT}, CH2: V_{EN}, CH3: I_{L1}, CH4: I_{L2}



Copyright © 2020, Texas Instruments Incorporated

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI’s products are provided subject to TI’s Terms of Sale (https:www.ti.com/legal/termsofsale.html) or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI’s provision of these resources does not expand or otherwise alter TI’s applicable warranties or warranty disclaimers for TI products.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2021, Texas Instruments Incorporated