Test Data
For PMP9461
09/24/2014

Contents

1. Design Specifications for Grid Tie Microinverter

1.1 Specifications for Flyback DC-DC Stage

Vin Minimum	**25VDC**
Vin Maximum	**40VDC**
Vout1	**250V-400V**
Iout 1	**0.600A**
Approximate Switching Frequency	**100KHz PWM Switching Frequency**
Max Input Power	**150W(per Phase)**

1.2 Specifications for Inverter Stage

Output Voltage and Frequency	**220V,50Hz and 110V, 60Hz AC Connection**
Max Output Power	**300W**
Approximate Switching Frequency	**50 KHz PWM Switching Frequency**

2. Circuit Description and PCB details

PMP9461 is a Reference design of Complete Power Requirements as well as Gate Driver Requirements in Grid Tie Solar Micro Inverter. Significant Integration can be achieved using the reference design .The solution Features SM72295 – Full Bridge Gate Driver, SM74101 Single Driver, SM72482 Dual Low Side Driver, LM5017 as Primary and Secondary Bias Supply Provider and LM5017 for Powering up the Drivers DC/AC section of Inverters.

2.1 DC/DC Section of Micro Inverter

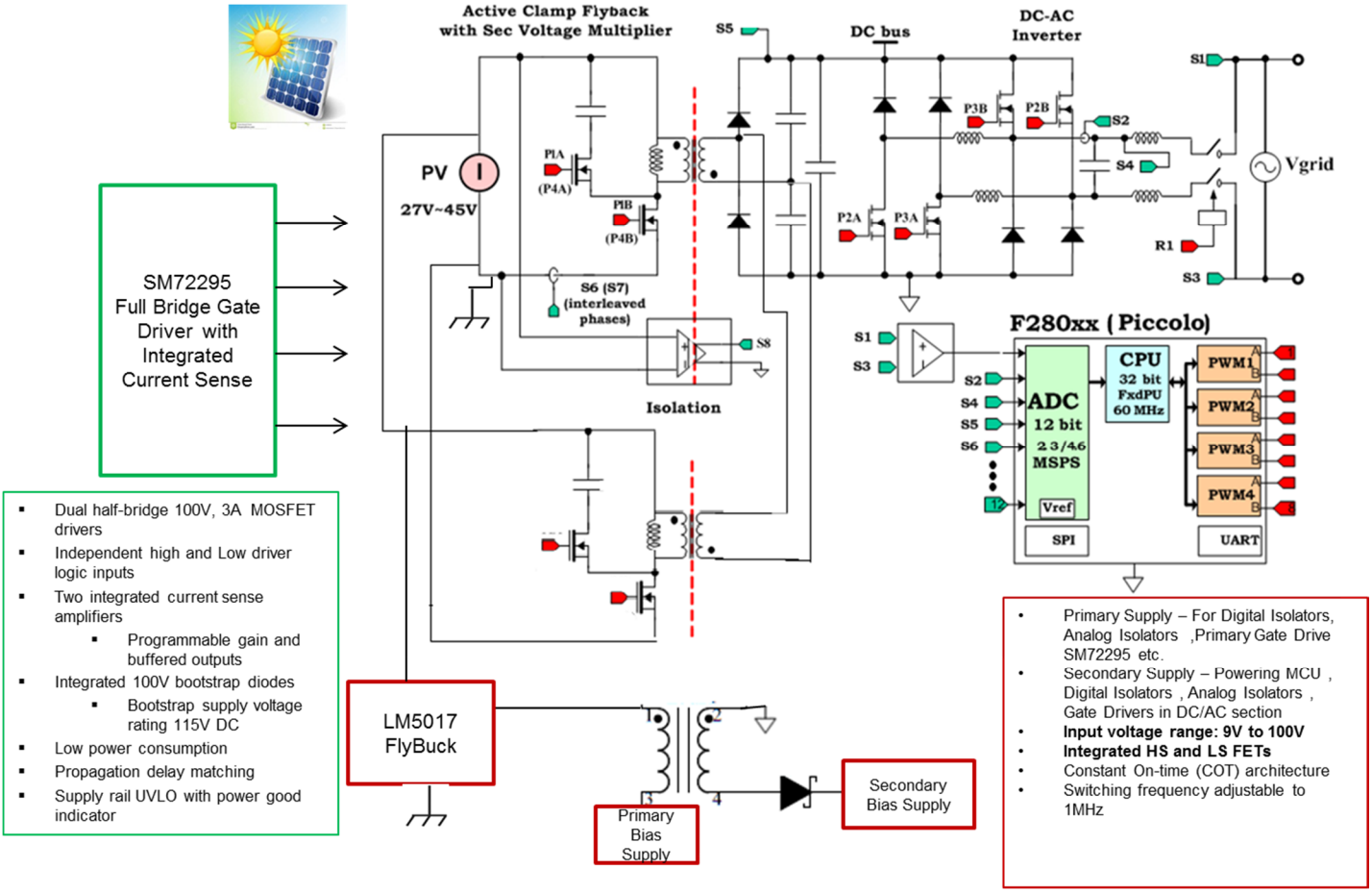
As Shown in Figure Below, Interleave Active Clamp flyback is used in DC/DC stage to Boost Low Panel Voltage to High Voltage DC Bus. SM72295 is used to drive DC/DC stage which is a Highly Integrated Dual Half Bridge Gate Driver with 3A Source/Sink Capability. Further LM5017 was used to provide Primary as well as Secondary Isolated Bias Power Supply using simple Coupled Inductors. This removes the need for External Adapters needed in Micro inverters.

Gate Drive Requirements: **Refer to Page 3 of the Schematic**

Primary Stage Topology	**Interleaved Clamped Flyback**
Boostrap Voltage	**75V max(IC Max is 118V)**
Gate Drive Source Current	**1A(IC Max is 3A)**
Gate Drive Sink Current	**1A(IC Max is 3A)**

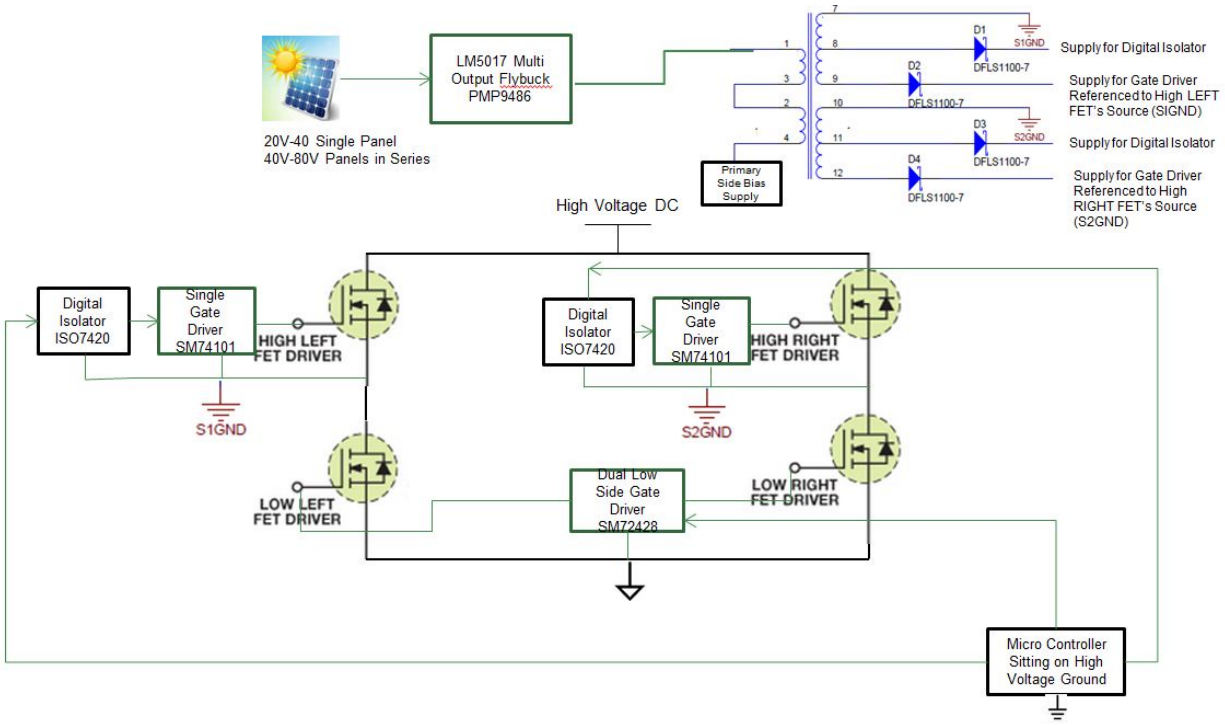
Bias Supply Requirements: **Refer to Page 5 of the Schematic**

Vin Minimum	**20VDC**
Vin Maximum	**60VDC(TO avoid Transient)**
Vout1	**12**
Iout 1	**0.250A**
Vout2	**12**
Iout 2	**0.25**
Approximate Switching Frequency	**330 KHz PWM Switching Frequency**



2.1 AC/DC Section of Micro Inverter

The DC-DC output voltage, Vbus, is applied to the inverter stage input. The inverter output is connected to grid. The inverter is controlled as a current source and essentially consists of two DC-AC buck converters each operating in one of the half cycles of the AC line voltage.
Digital Isolator and Single Driver are used to Drive High Side FETs in the H bridge and their Grounds are referenced to their respective FET source. A Single LM5017 with Multiple outputs was used to provide the Isolated Power rail to all Drivers and Isolators in DC/AC Section.

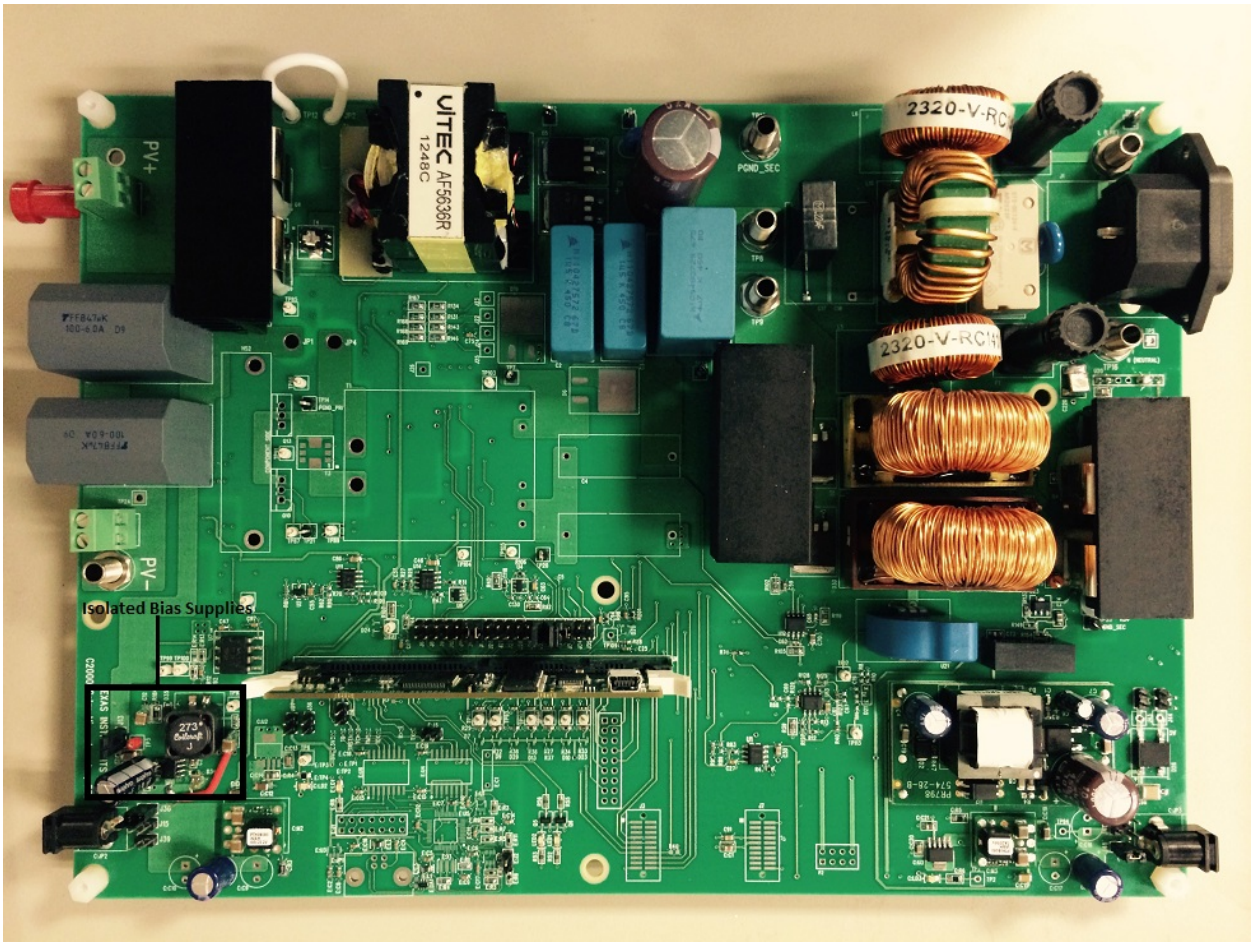


Isolated Bias Supply Requirements: **Separate design board PMP9486 is used for Evaluation (Page 9 DC/AC Drive Section is updated in Page 10 but not implemented in PCB design)**

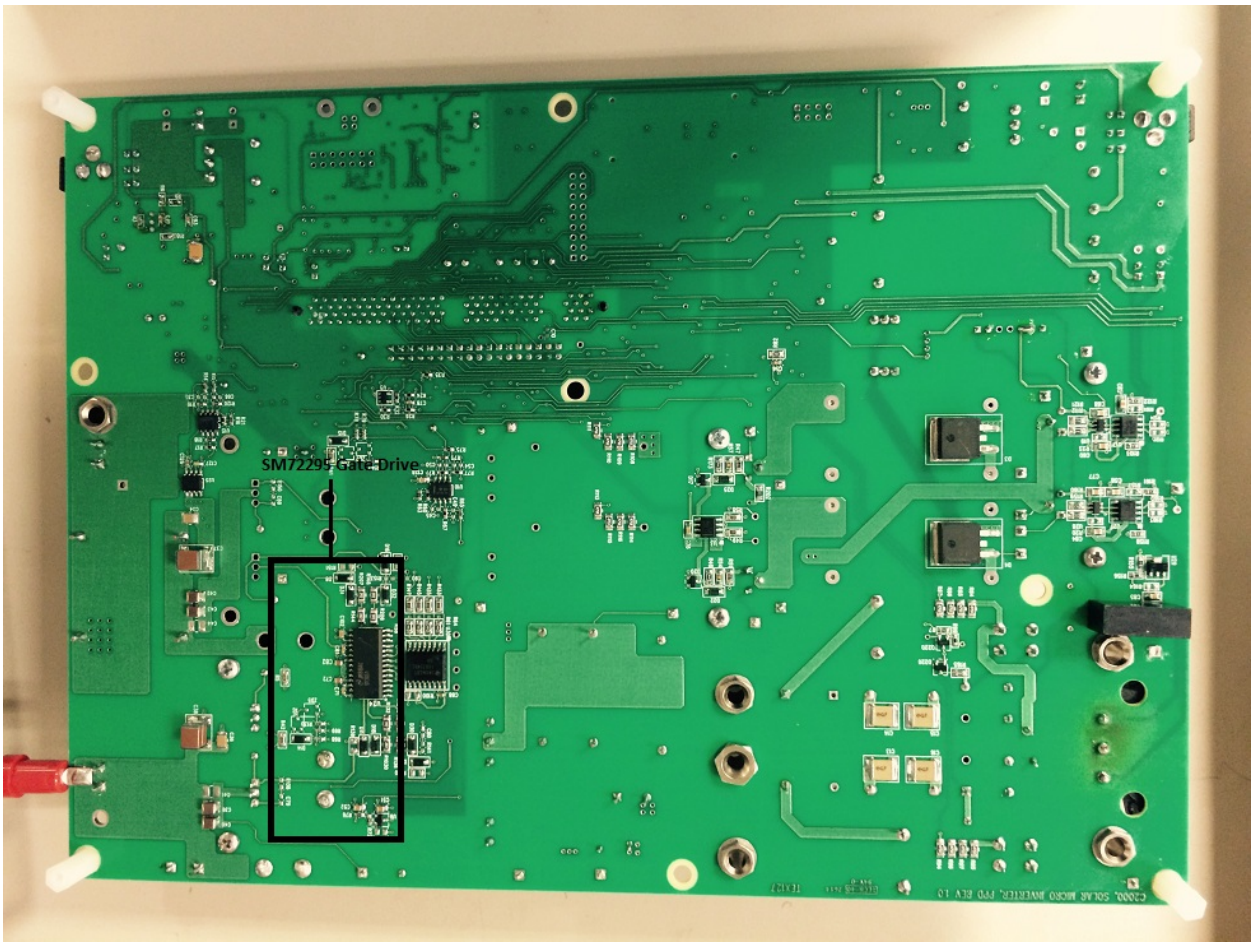
Vin Minimum	**20VDC**
Vin Maximum	**40VDC**
Vout1	**14.5VDC**
Iout 1	**0.100A**
Vout2	**9VDC**
Iout 2	**0.100A**
Vout3	**14.5DC**
Iout 3	**0.100A**
Vout4	**9VDC**
Iout4	**0.100A**
Vout5	**10.5VDC**
Iout 5	**3mA (Just a Reference Supply)**
Approximate Switching Frequency	**300KHz Approx**

Vout 1 and Vout 2 are referenced to same Ground (GND1), Vout3 and Vout4 are referenced to same ground (GND2) . Vout5 is reference to Input Supply's Ground

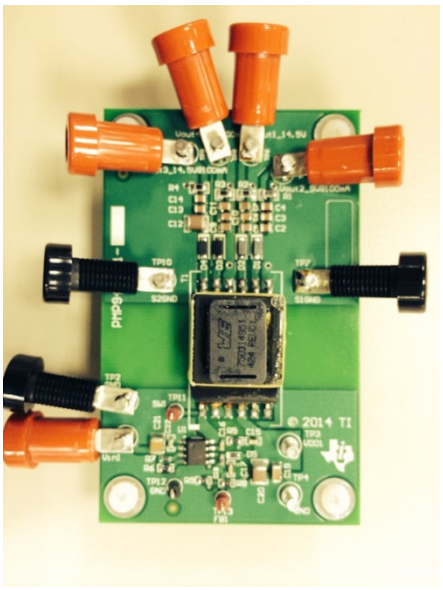
3. PMP9461 Photos



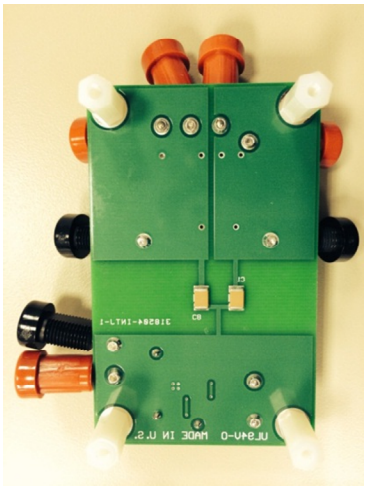
Board Photo (Top)



Board Photo (Bottom)



PMP9486 Board Photo (Top)

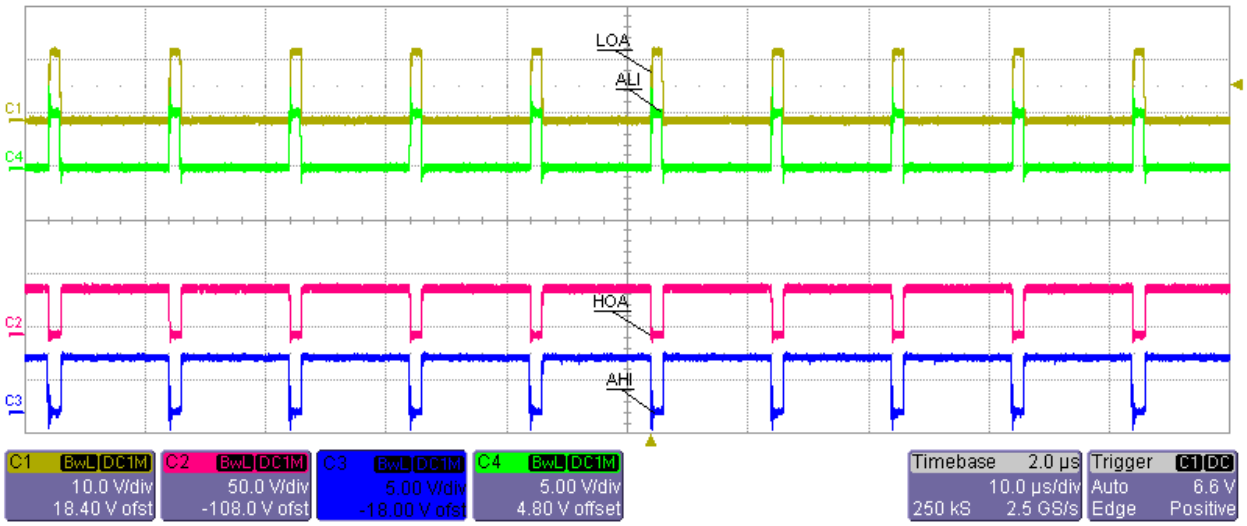


PMP9486 Board Photo (Bottom)

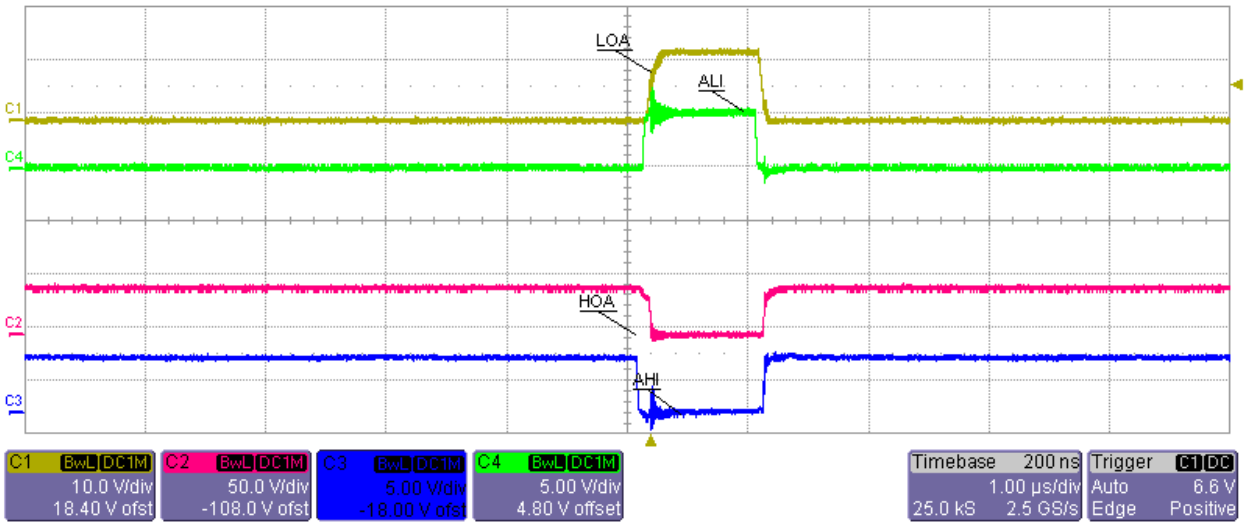
4. DC/DC Section

All the Testing was done with LM5017 Based Isolated Bias Supply for Primary and Secondary Bias .

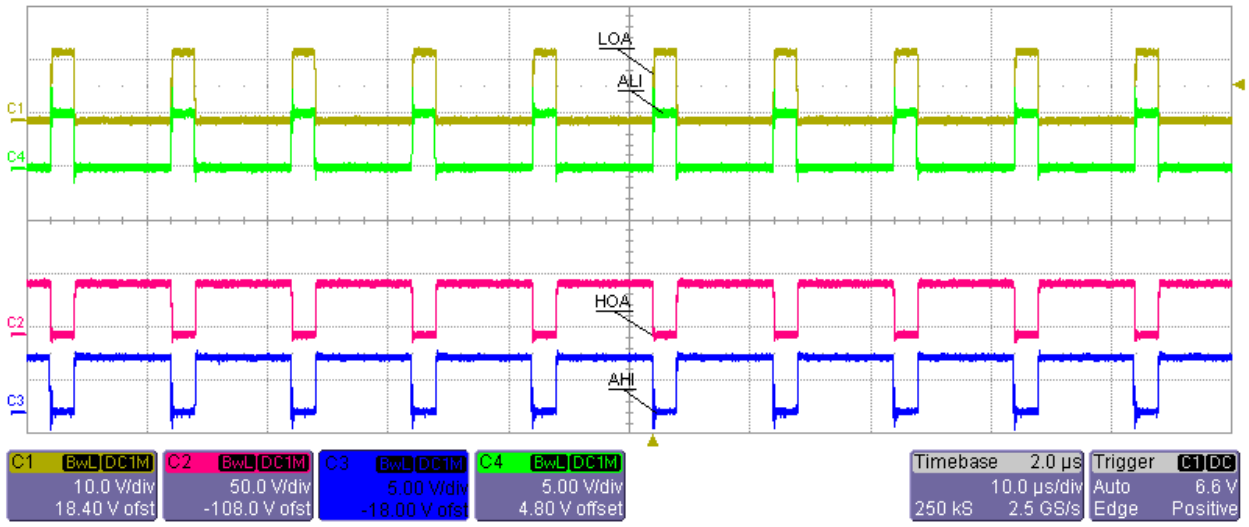
4.1 Interleaved Clamped Fly back –Gate Driver Performance



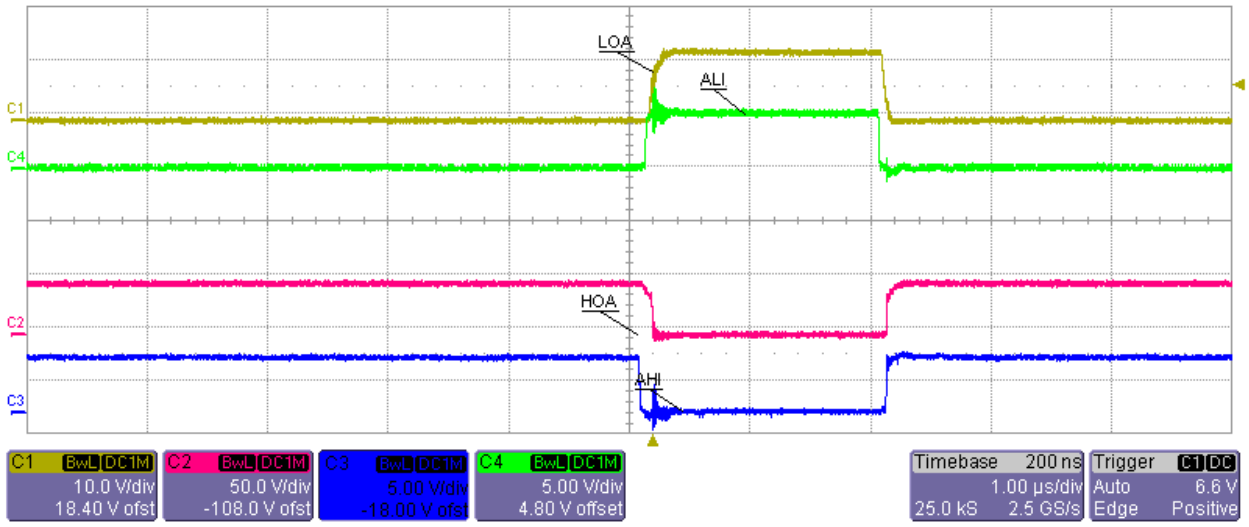
30W Single Phase Output (10 Percent Duty Cycle)



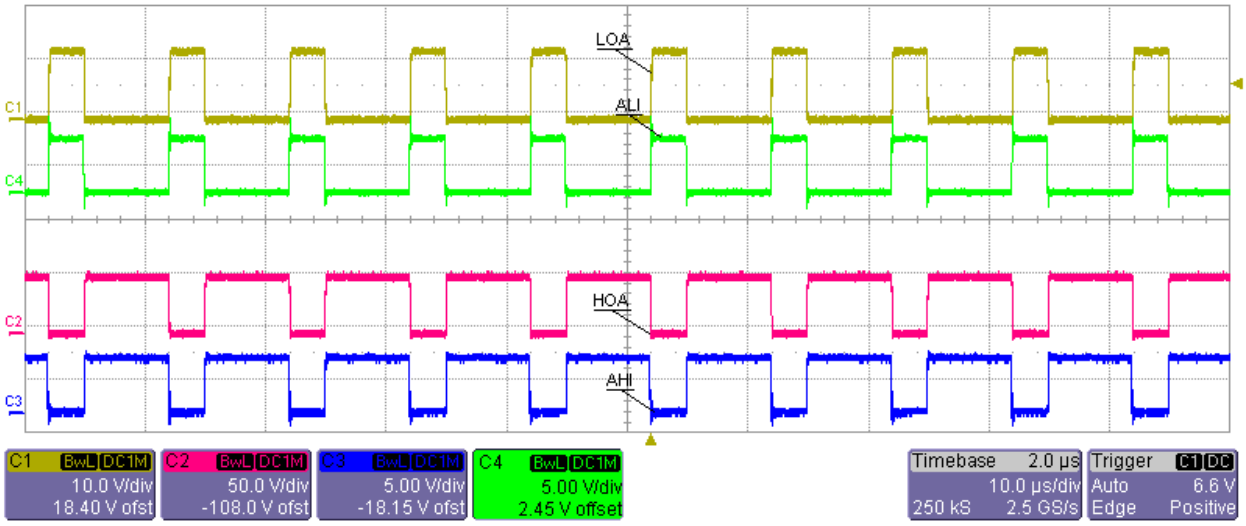
Zoomed in - 30W Single Phase Output (10 Percent Duty Cycle)



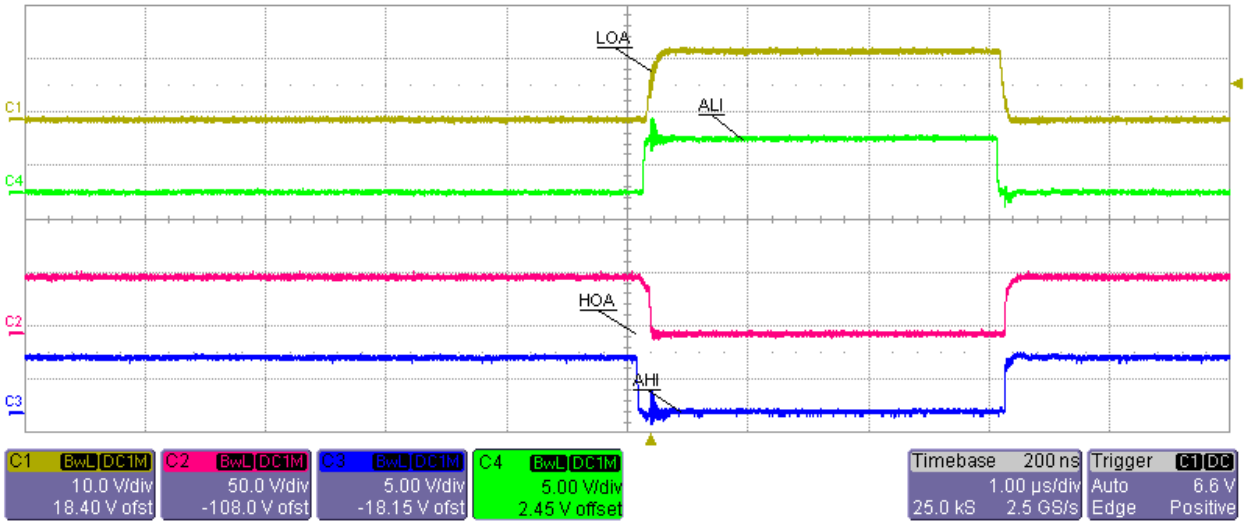
45W Single Phase Output (20 Percent Duty Cycle)



Zoomed in - 45W Single Phase Output (20 Percent Duty Cycle)

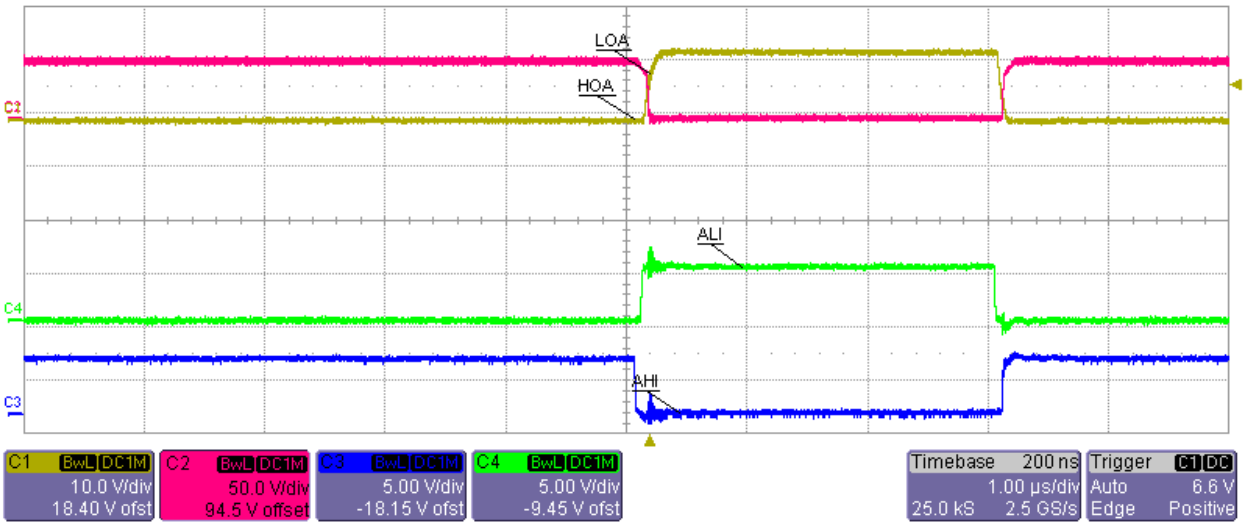


60W Single Phase Output (30 Percent Duty Cycle)



Zoomed In- 60W Single Phase Output (30 Percent Duty Cycle)

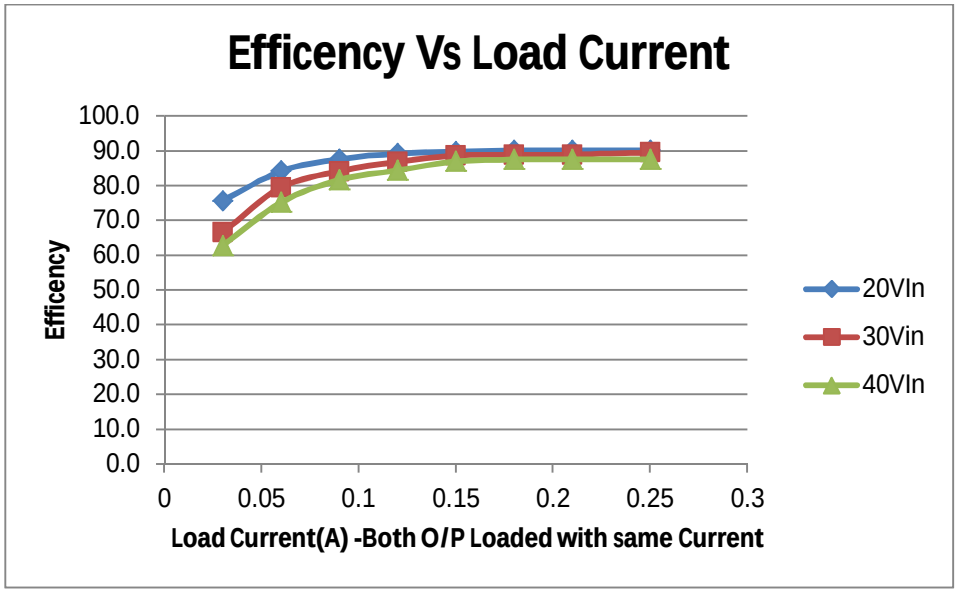
4.2 Interleaved Clamped Fly back –Cross Conduction Avoidance



Zoomed In- 60W Single Phase Output (30 Percent Duty Cycle)

4.3 Isolated Bias Supply – Efficiency

4.3.1 Isolated Bias Supply – Efficiency Chart



4.3.2 Isolated Bias Supply – Efficiency Data

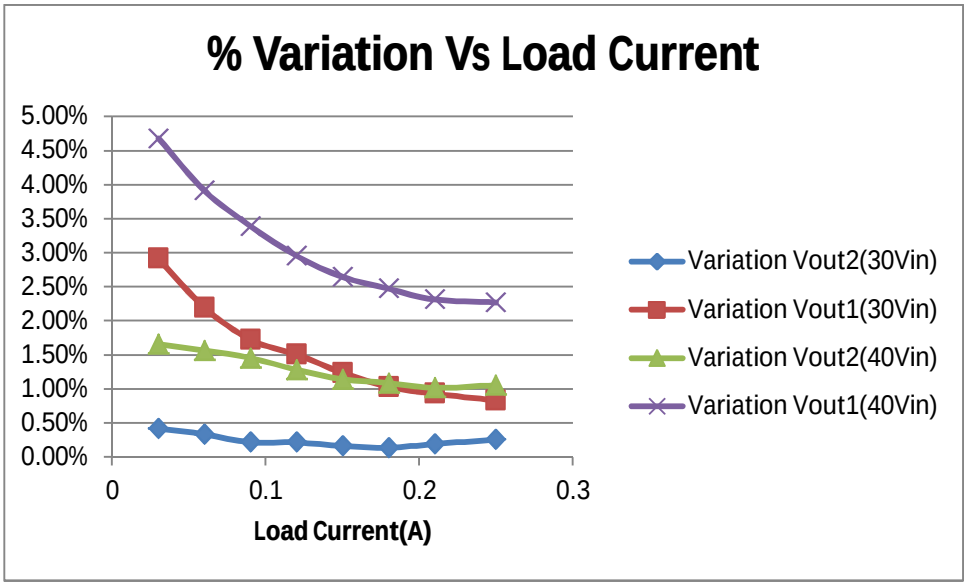
Iin (A)	Vout2(V)	Iout2 (A)	Vout1(V)	Iout1(V)	Pin (W)	Pout (W)	Efficiency (%)
0.047	12.522	0.03	11.98	0.03	0.971114	0.73506	75.7
0.085	12.522	0.06	11.896	0.06	1.7391	1.46508	84.2
0.12	12.544	0.09	11.863	0.09	2.5044	2.19663	87.7
0.157	12.55	0.12	11.809	0.12	3.273921	2.92308	89.3
0.195	12.567	0.15	11.771	0.15	4.062825	3.6507	89.9
0.233	12.582	0.18	11.736	0.18	4.850827	4.37724	90.2
0.272	12.604	0.21	11.708	0.21	5.657872	5.10552	90.2
0.324	12.634	0.25	11.668	0.25	6.732072	6.0755	90.2

Iin (A)	Vout2(V)	Iout2 (A)	Vout1(V)	Iout1(V)	Pin (W)	Pout (W)	Efficiency (%)
0.037	12.804	0.03	12.35	0.03	1.132977	0.75462	66.6
0.062	12.793	0.06	12.264	0.06	1.889946	1.50342	79.5
0.088	12.778	0.09	12.207	0.09	2.670272	2.24865	84.2
0.112	12.778	0.12	12.181	0.12	3.446576	2.99508	86.9
0.137	12.771	0.15	12.149	0.15	4.214394	3.738	88.7
0.164	12.768	0.18	12.124	0.18	5.043	4.48056	88.8
0.191	12.775	0.21	12.112	0.21	5.870767	5.22627	89.0
0.226	12.783	0.25	12.1	0.25	6.943172	6.22075	89.6

Iin (A)	Vout2(V)	Iout2 (A)	Vout1(V)	Iout1(V)	Pin (W)	Pout (W)	Efficiency (%)
0.03	12.962	0.03	12.562	0.03	1.21953	0.76572	62.8
0.05	12.95	0.06	12.47	0.06	2.02735	1.5252	75.2
0.069	12.936	0.09	12.407	0.09	2.790498	2.28087	81.7
0.089	12.914	0.12	12.355	0.12	3.589904	3.03228	84.5
0.108	12.896	0.15	12.318	0.15	4.344624	3.7821	87.1
0.127	12.889	0.18	12.297	0.18	5.176647	4.53348	87.6
0.148	12.88	0.21	12.278	0.21	6.031296	5.28318	87.6
0.176	12.885	0.25	12.273	0.25	7.17024	6.2895	87.7

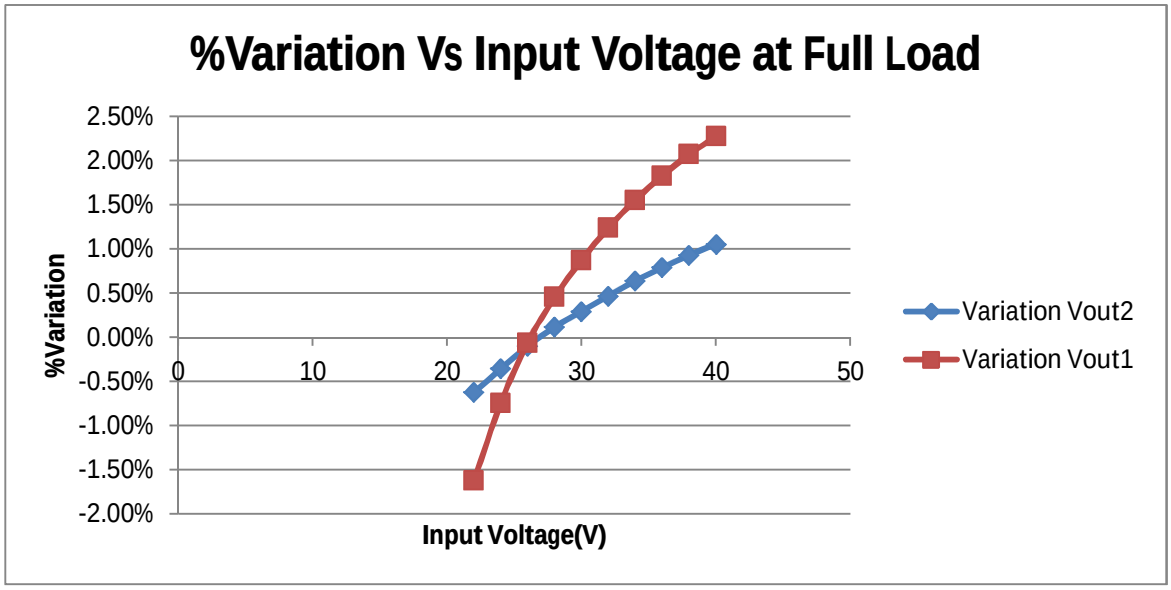
4.4 Isolated Bias Supply – Cross Regulation

The Cross regulation was tested by Sweeping Vin(keeping Load Constant) or Output Load(Keeping Vin Constant)



Iin (A)	Vout2(V)	Iout2 (A)	Vout1(V)	Iout1(V)	Pin (W)	Pout (W)	Efficiency (%)	Variation Vout2	Variation Vout1
0.037	12.804	0.03	12.35	0.03	1.132977	0.75462	66.6	0.42%	2.92%
0.062	12.793	0.06	12.264	0.06	1.889946	1.50342	79.5	0.34%	2.20%
0.088	12.778	0.09	12.207	0.09	2.670272	2.24865	84.2	0.22%	1.73%
0.112	12.778	0.12	12.181	0.12	3.446576	2.99508	86.9	0.22%	1.51%
0.137	12.771	0.15	12.149	0.15	4.214394	3.738	88.7	0.16%	1.24%
0.164	12.768	0.18	12.124	0.18	5.043	4.48056	88.8	0.14%	1.03%
0.191	12.775	0.21	12.112	0.21	5.870767	5.22627	89.0	0.20%	0.93%
0.226	12.783	0.25	12.1	0.25	6.943172	6.22075	89.6	0.26%	0.83%

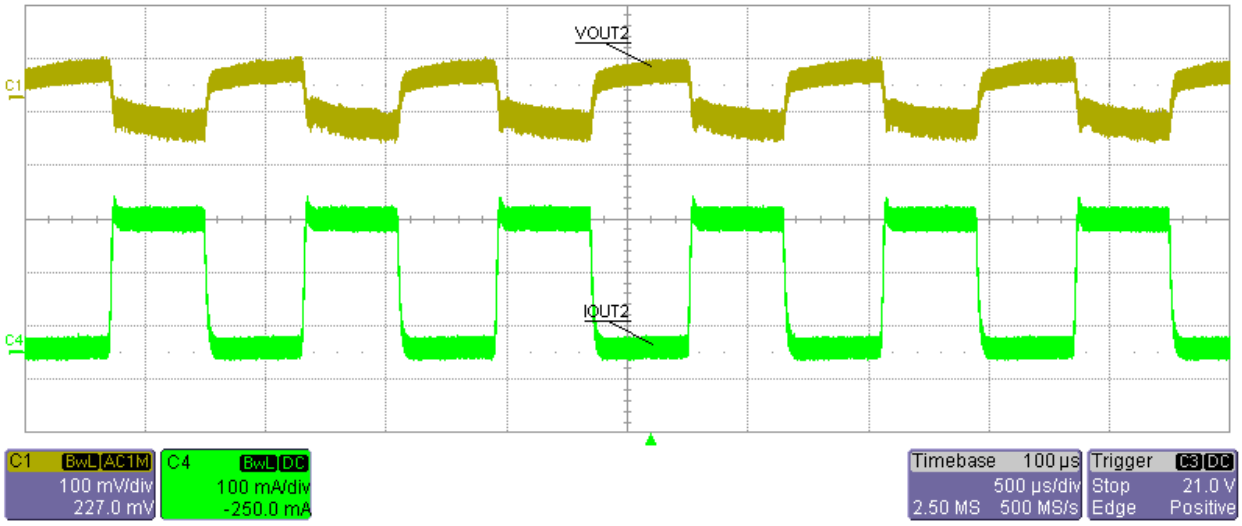
Iin (A)	Vout2(V)	Iout2 (A)	Vout1(V)	Iout1(V)	Pin (W)	Pout (W)	Efficiency (%)	Variation Vout2	Variation Vout1
0.03	12.962	0.03	12.562	0.03	1.21953	0.76572	62.8	1.66%	4.68%
0.05	12.95	0.06	12.47	0.06	2.02735	1.5252	75.2	1.57%	3.92%
0.069	12.936	0.09	12.407	0.09	2.790498	2.28087	81.7	1.46%	3.39%
0.089	12.914	0.12	12.355	0.12	3.589904	3.03228	84.5	1.29%	2.96%
0.108	12.896	0.15	12.318	0.15	4.344624	3.7821	87.1	1.15%	2.65%
0.127	12.889	0.18	12.297	0.18	5.176647	4.53348	87.6	1.09%	2.48%
0.148	12.88	0.21	12.278	0.21	6.031296	5.28318	87.6	1.02%	2.32%
0.176	12.885	0.25	12.273	0.25	7.17024	6.2895	87.7	1.06%	2.28%



Vout2(V)	Vout1(V)	Iout	Variation Vout2	Variation Vout 1
12.885	12.274	0.25	1.06%	2.28%
12.869	12.249	0.25	0.93%	2.08%
12.851	12.22	0.25	0.79%	1.83%
12.832	12.187	0.25	0.64%	1.56%
12.81	12.149	0.25	0.47%	1.24%
12.788	12.105	0.25	0.30%	0.88%
12.765	12.055	0.25	0.12%	0.46%
12.738	11.993	0.25	-0.09%	-0.06%
12.705	11.911	0.25	-0.35%	-0.74%
12.671	11.806	0.25	-0.62%	-1.62%

4.4 Isolated Bias Supply – Waveforms

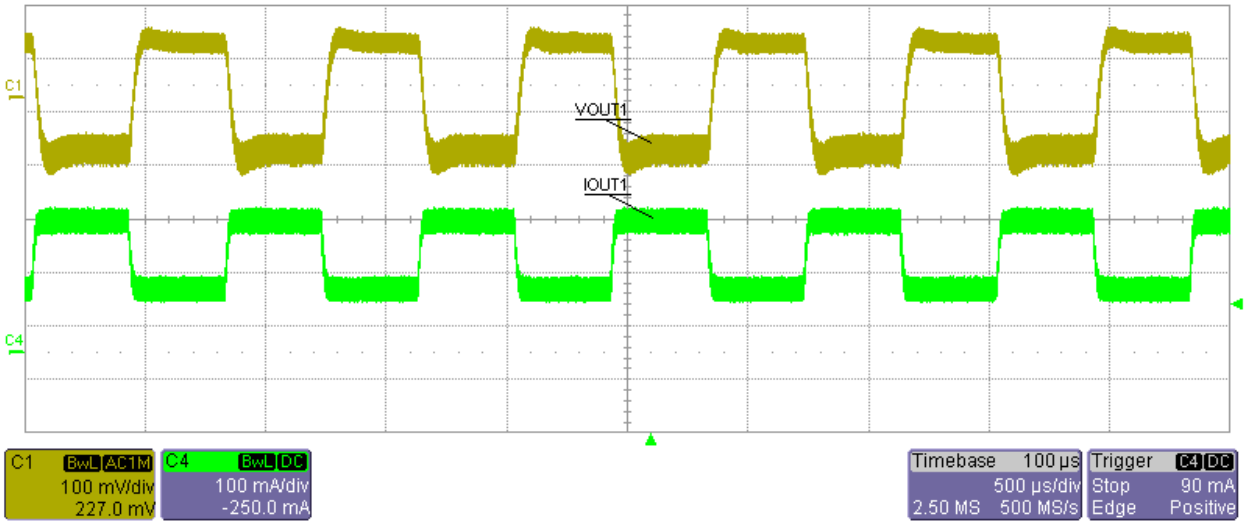
4.4.1 Load Transient Response



Load Transient Response at 20Vin and 0%-to-100% (0mA-to-250mA) Load Step on 12V Output Vout2(Load was not connected to other output)

Ch2 – Vout2 (AC coupled)

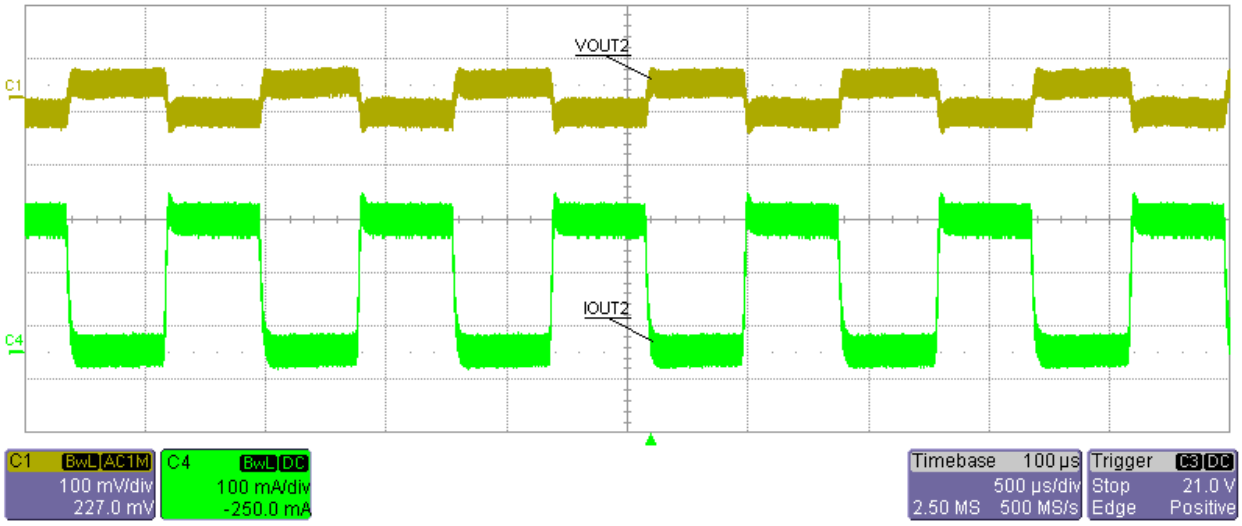
Ch4- Iout 2



Load Transient Response at 20Vin and 50%-to-100% (125mA-to-250mA) Load Step on 12V Output Vout1(Load was not connected to other output)

Ch2 – Vout1 (AC coupled)

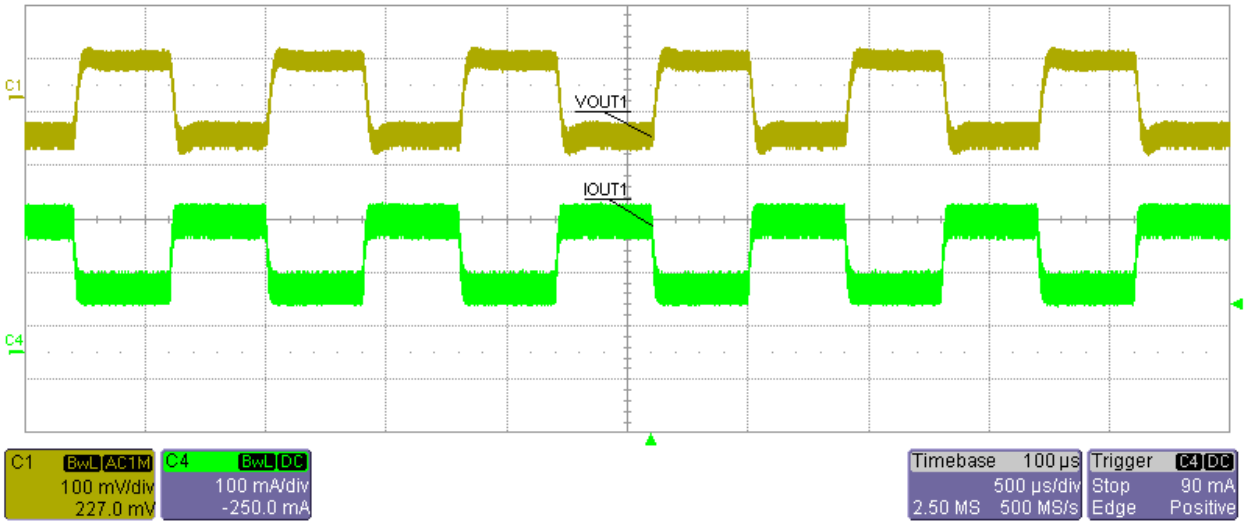
Ch4- Iout 1



Load Transient Response at 30Vin and 0%-to-100% (0mA-to-250mA) Load Step on 12V Output Vout2(Load was not connected to other output)

Ch2 – Vout2 (AC coupled)

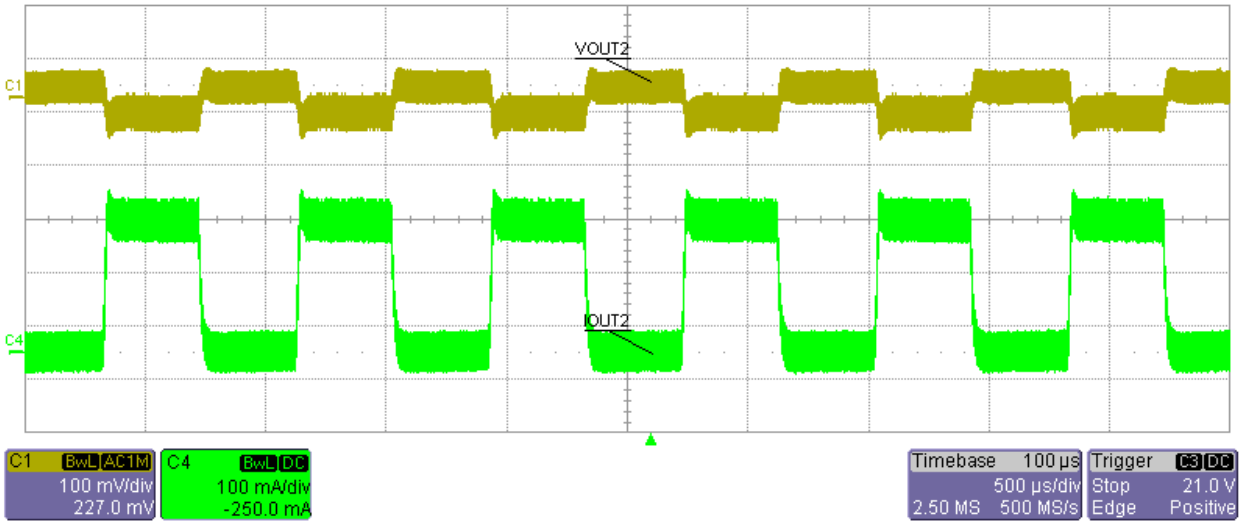
Ch4- Iout2



Load Transient Response at 30Vin and 50%-to-100% (125mA-to-250mA) Load Step on 12V Output Vout1(Load was not connected to other output)

Ch2 – Vout1 (AC coupled)

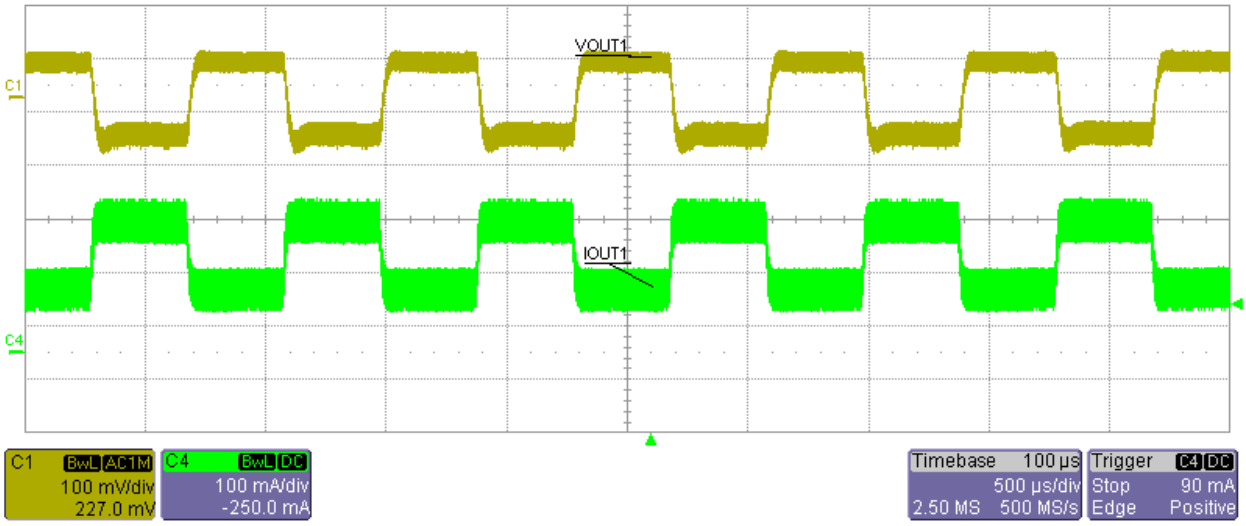
Ch4- Iout 1



Load Transient Response at 40Vin and 0%-to-100% (0mA-to-250mA) Load Step on 12V Output Vout2(Load was not connected to other output)

Ch2 – Vout2 (AC coupled)

Ch4- Iout2

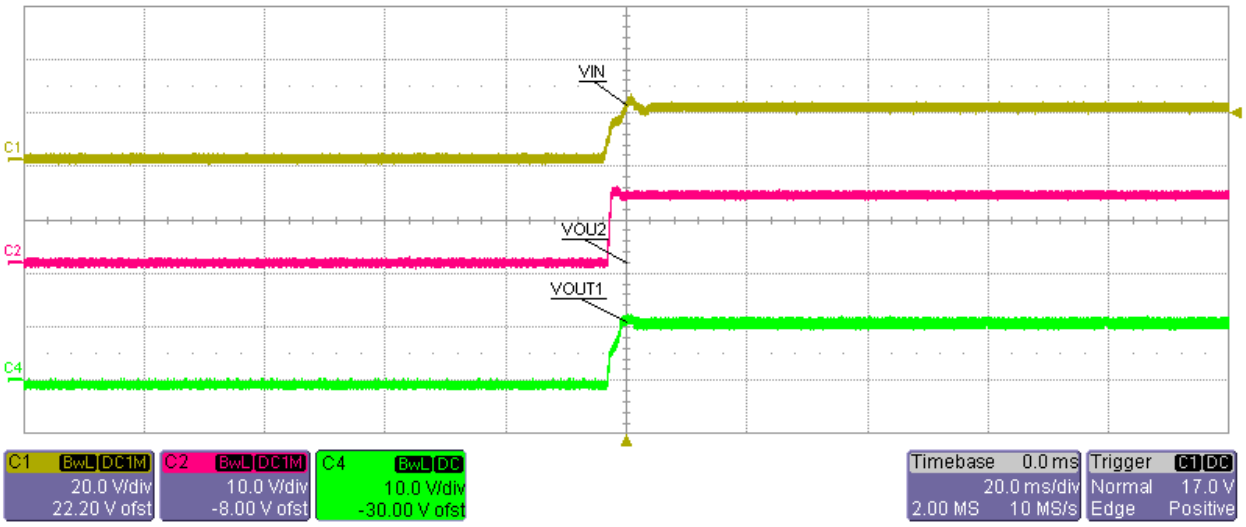


Load Transient Response at 40Vin and 50%-to-100% (125mA-to-250mA) Load Step on 12V Output Vout1(Load was not connected to other output)

Ch2 – Vout1 (AC coupled)

Ch4- Iout 1

4.4.2 Startup

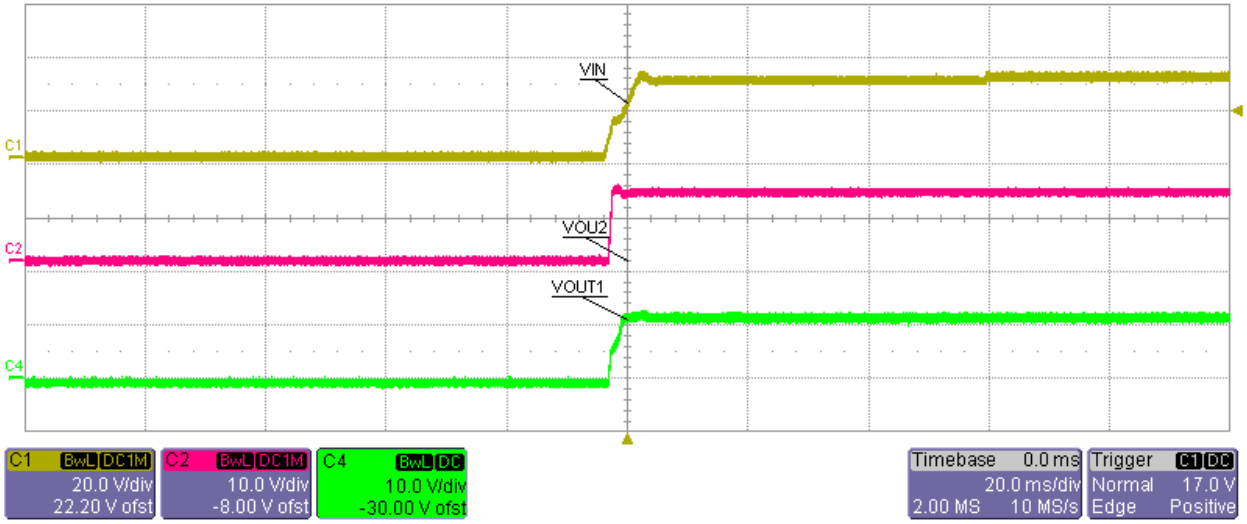


Startup into full Load (all the outputs was connected to full Load) at 20 Vin

Ch1-Vin

Ch2-Vout 2

Ch4-Vout 1

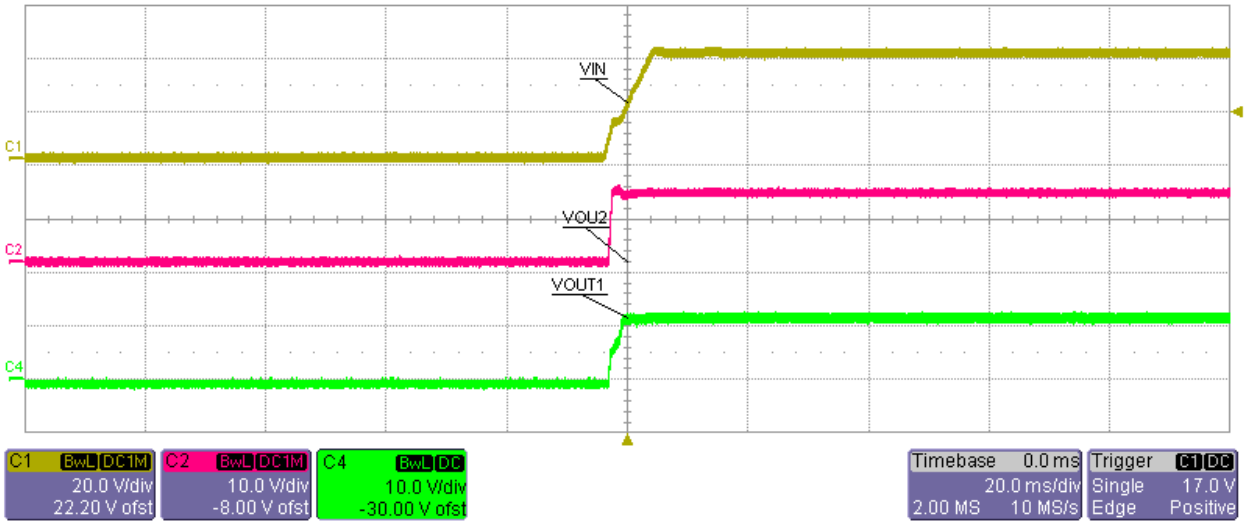


Startup into full Load (all the outputs was connected to full Load) at 30 Vin

Ch1-Vin

Ch2-Vout 2

Ch4-Vout 1

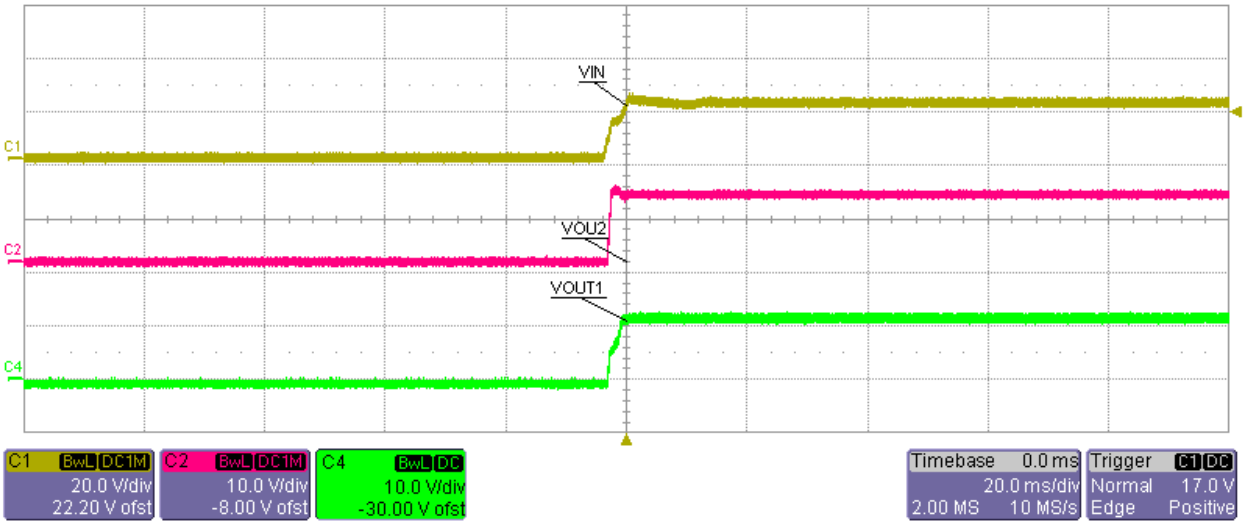


Startup into full Load (all the outputs was connected to full Load) at 40 Vin

Ch1-Vin

Ch2-Vout 2

Ch4-Vout 1

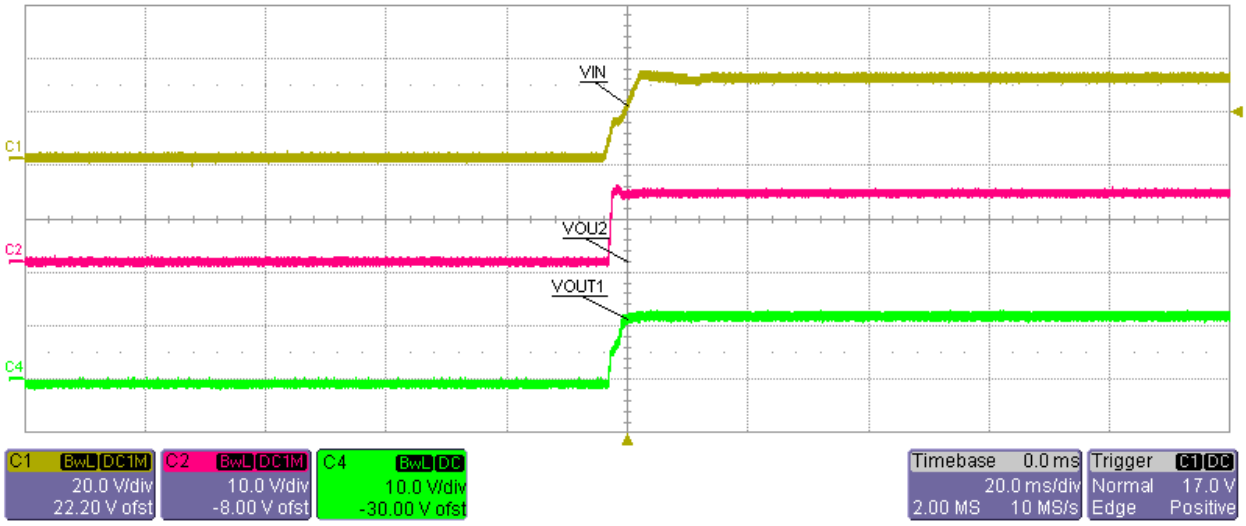


Startup into No Load (all the outputs was connected to full Load) at 20 Vin

Ch1-Vin

Ch2-Vout 2

Ch4-Vout 1

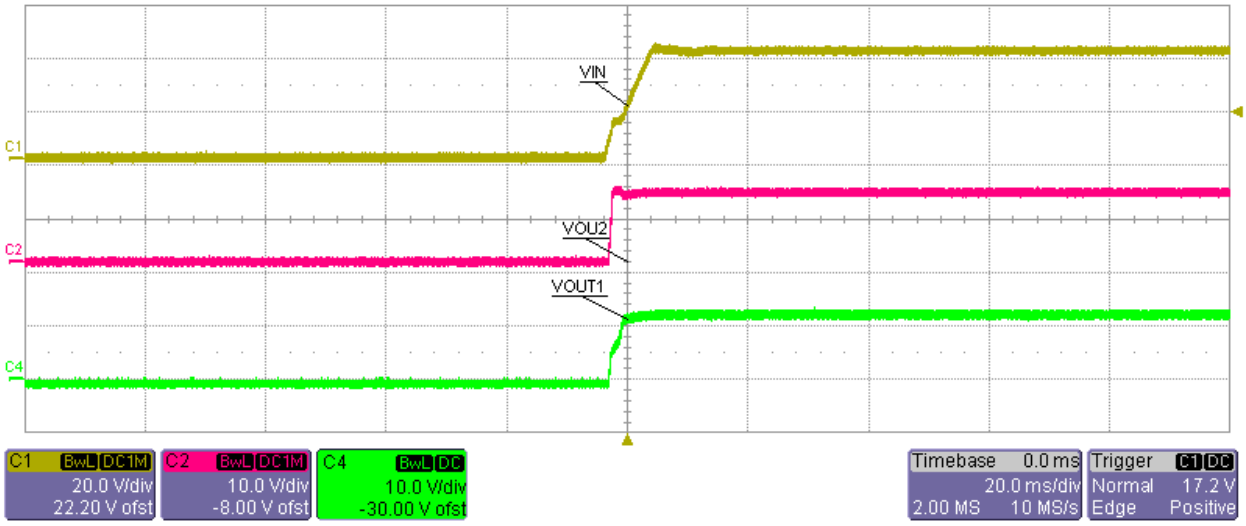


Startup into No Load (all the outputs was connected to full Load) at 30 Vin

Ch1-Vin

Ch2-Vout 2

Ch4-Vout 1



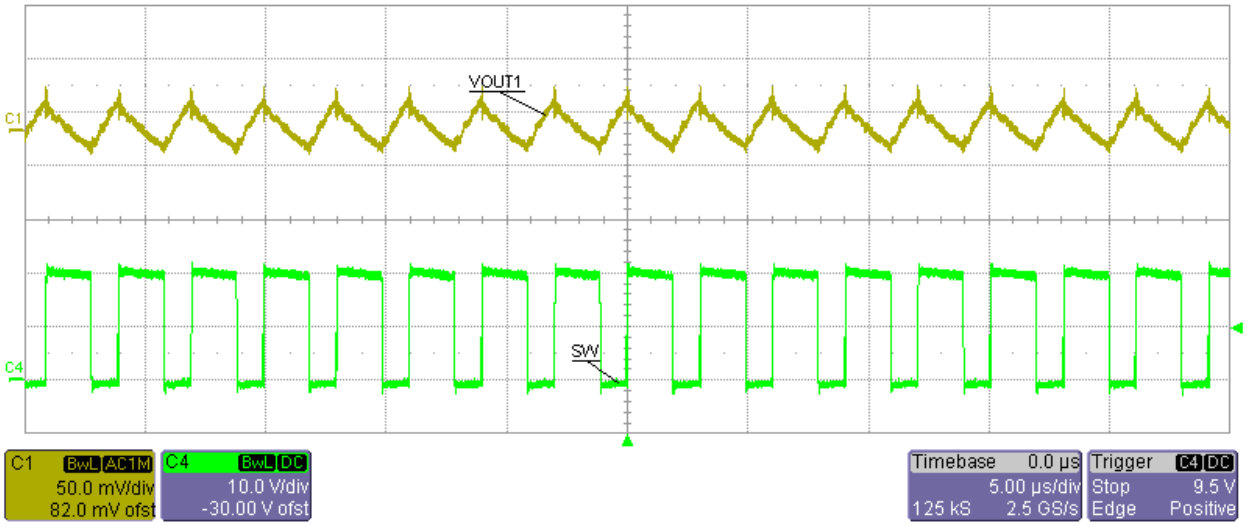
Startup into No Load (all the outputs was connected to full Load) at 40 Vin

Ch1-Vin

Ch2-Vout 2

Ch4-Vout 1

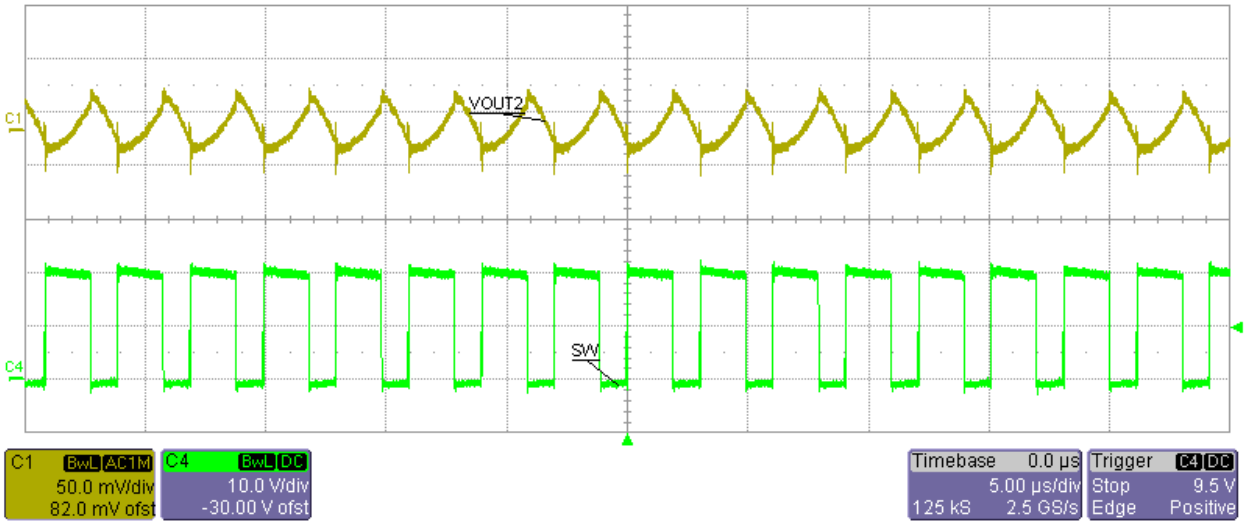
4.4.3 Output Voltage Ripple and Switch Node Voltage



Switch Node Voltage and Output Voltage Ripple at 20 Vin and Full Load on all the outputs (Vripple < 50mVp-p)

Ch2-Vout1 (AC Coupled)

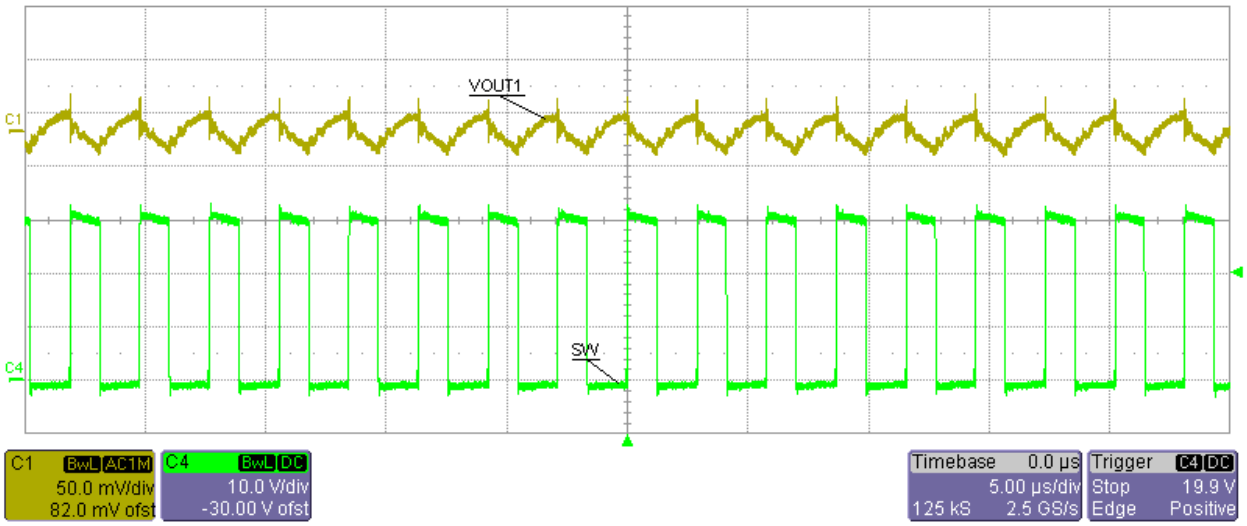
Ch4-Switching Waveform



Switch Node Voltage and Output Voltage Ripple at 20 Vin and Full Load on all the outputs (Vripple < 80mVp-p)

Ch2-Vout2 (AC Coupled)

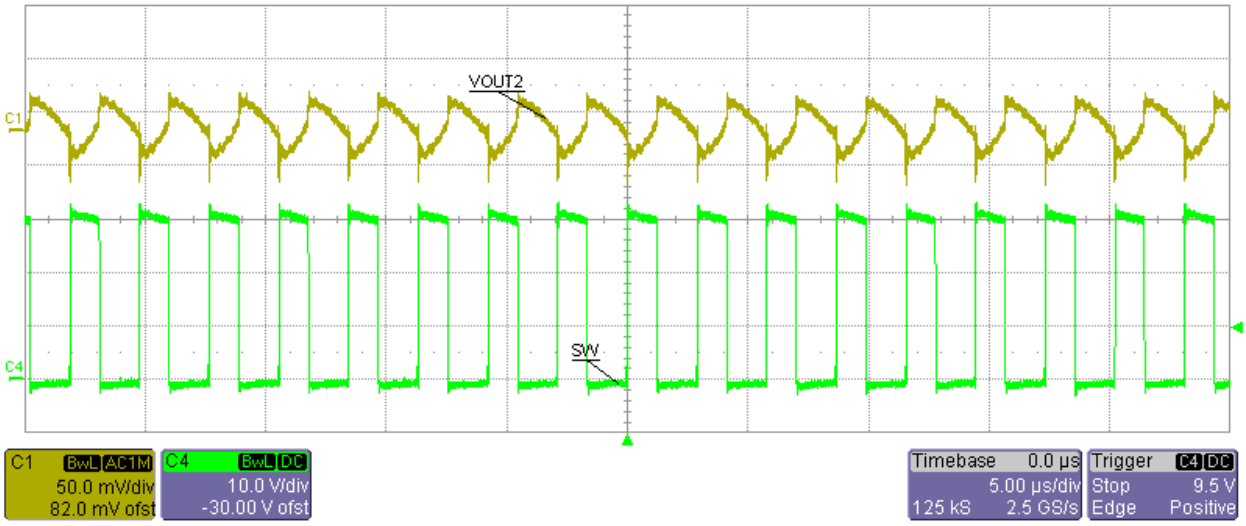
Ch4-Switching Waveform



Switch Node Voltage and Output Voltage Ripple at 30Vin and Full Load on all the outputs (Vripple < 50mVp-p)

Ch2-Vout1 (AC Coupled)

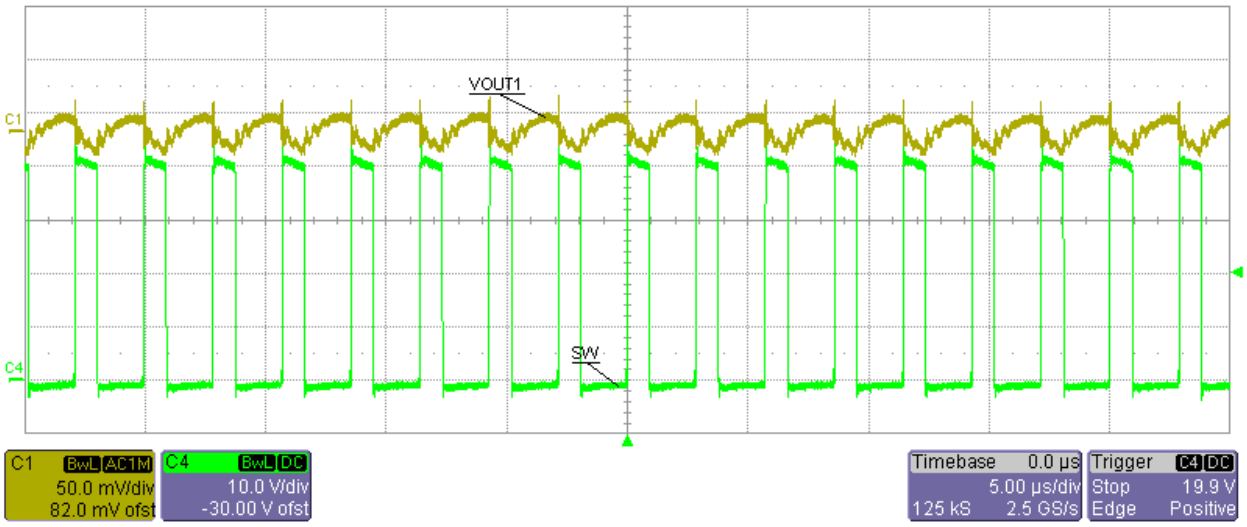
Ch4-Switching Waveform



Switch Node Voltage and Output Voltage Ripple at 30 Vin and Full Load on all the outputs (Vripple < 80mVp-p)

Ch2-Vout2 (AC Coupled)

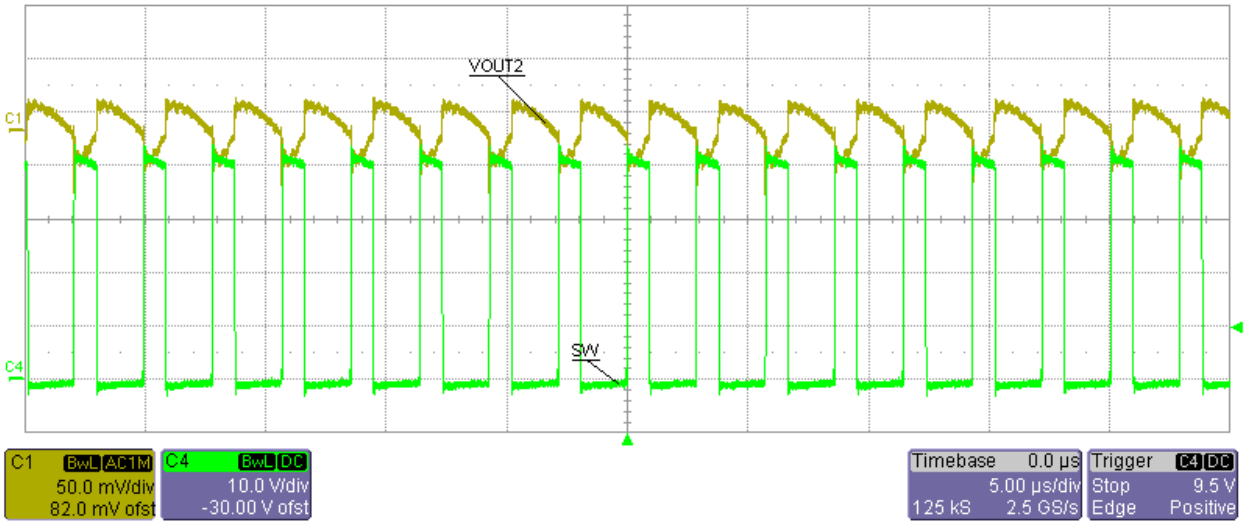
Ch4-Switching Waveform



Switch Node Voltage and Output Voltage Ripple at 40 Vin and Full Load on all the outputs (Vripple < 50mVp-p)

Ch2-Vout1 (AC Coupled)

Ch4-Switching Waveform

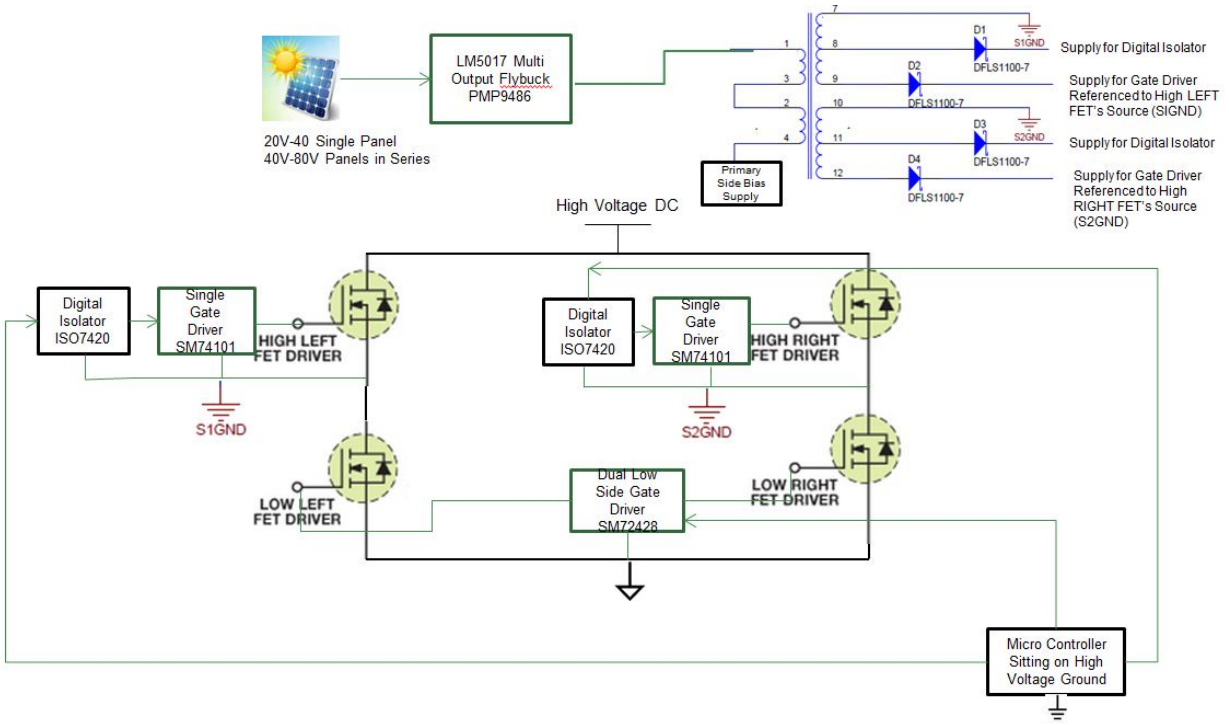


Switch Node Voltage and Output Voltage Ripple at 40 Vin and Full Load on all the outputs (Vripple < 80mVp-p)

Ch2-Vout2 (AC Coupled)

Ch4-Switching Waveform

5. DC/AC Section

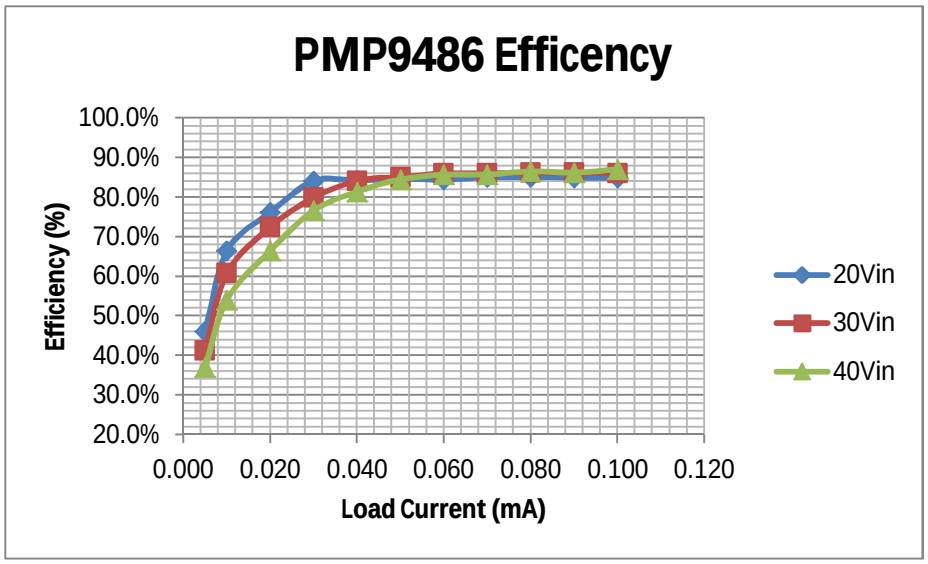


PMP9486 is a 5 output Flybuck Converter for driving Isolated Driver stages(GND wrt High Side Sources) in DC/AC section of High Frequency Commercial or residential Inverters(Ex-Solar Micro inverters) using the LM5017 regulator IC. The design accepts an input voltage of 20Vin to 40Vin DC(from Single Panel in Microinverters or 12V/24V batteries) and provides Isolated outputs of 14.5V,9V @100mA(referenced to same ground) and 14.5V,9V@100mA(referenced to same Ground). It features a small size and is an inexpensive and more efficient solution to using Flyback or Pushpull converters

Separate design board PMP9486 is used for Evaluation (Page 9 DC/AC Drive Section is updated in Page 10 but not implemented in PCB design)

5.1 Penta Output Fly Buck- Efficiency

5.1.1 Isolated Bias Supply – Efficiency Chart



5.1.2 Isolated Bias Supply – Efficiency data

Vin	Iin	Iout1	Vout1	Pout1	Iout2	Vout2	Pout2	Iout3	Vout3	Pout3	Iout4	Vout4	Pout4	TotalPout	Losses	Efficiency
20.88	0.025	0.005	14.989	0.07	0.005	9.270	0.05	0.005	15.106	0.08	0.005	9.321	0.05	0.24	0.285	46.1%
20.82	0.035	0.010	14.903	0.15	0.010	9.220	0.09	0.010	15.027	0.15	0.010	9.268	0.09	0.48	0.245	66.4%
20.89	0.060	0.020	14.711	0.29	0.020	9.080	0.18	0.020	14.817	0.30	0.020	9.129	0.18	0.95	0.298	76.2%
20.57	0.082	0.030	14.564	0.44	0.030	8.980	0.27	0.030	14.698	0.44	0.030	9.041	0.27	1.42	0.268	84.1%
20.45	0.109	0.040	14.473	0.58	0.040	8.910	0.36	0.040	14.628	0.59	0.040	8.970	0.36	1.88	0.350	84.3%
20.96	0.132	0.050	14.426	0.72	0.050	8.870	0.44	0.050	14.601	0.73	0.050	8.948	0.45	2.34	0.424	84.7%
20.95	0.158	0.060	14.355	0.86	0.060	8.810	0.53	0.060	14.546	0.87	0.060	8.899	0.53	2.80	0.513	84.5%
20.94	0.182	0.070	14.272	1.00	0.070	8.740	0.61	0.070	14.486	1.01	0.070	8.840	0.62	3.24	0.567	85.1%
20.93	0.207	0.080	14.189	1.14	0.080	8.680	0.69	0.080	14.418	1.15	0.080	8.790	0.70	3.69	0.646	85.1%
20.91	0.232	0.090	14.093	1.27	0.090	8.610	0.77	0.090	14.346	1.29	0.090	8.736	0.79	4.12	0.731	84.9%
20.90	0.256	0.100	13.976	1.40	0.100	8.530	0.85	0.100	14.250	1.43	0.100	8.660	0.87	4.54	0.810	84.9%

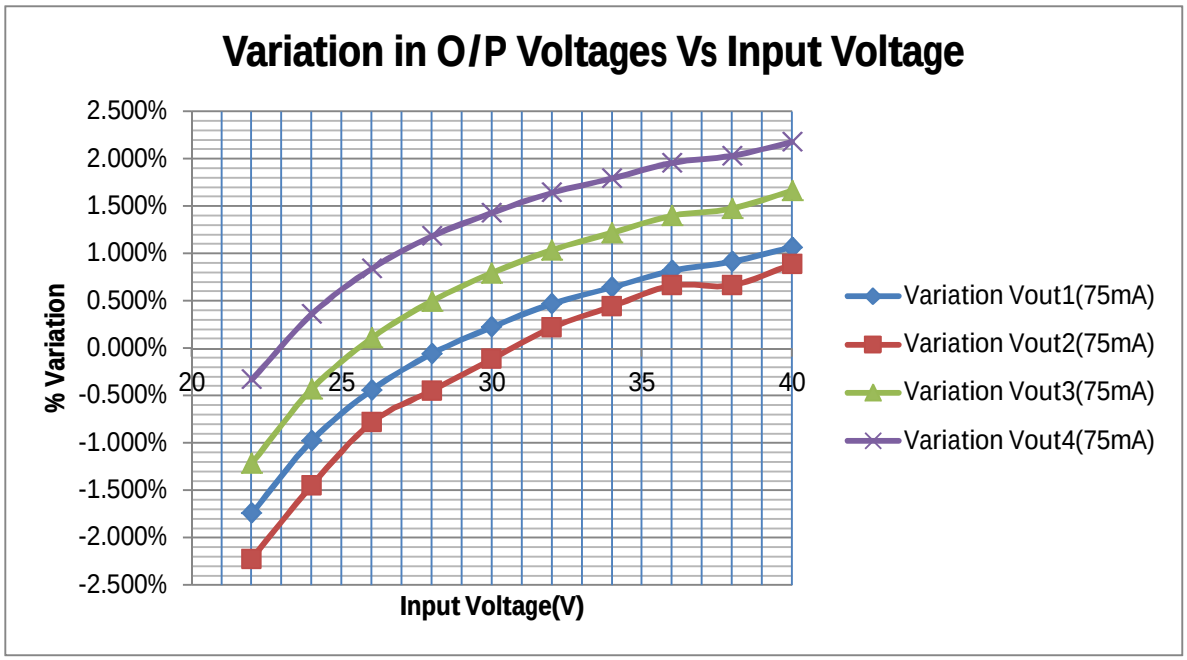
Vin	Iin	Iout1	Vout1	Pout1	Iout2	Vout2	Pout2	Iout3	Vout3	Pout3	Iout4	Vout4	Pout4	TotalPout	Losses	Efficiency
29.91	0.020	0.005	15.224	0.08	0.005	9.400	0.05	0.005	15.350	0.08	0.005	9.450	0.05	0.25	0.351	41.3%
29.87	0.027	0.010	15.095	0.15	0.010	9.340	0.09	0.010	15.224	0.15	0.010	9.380	0.09	0.49	0.316	60.8%
29.77	0.045	0.020	14.964	0.30	0.020	9.250	0.19	0.020	15.068	0.30	0.020	9.290	0.19	0.97	0.368	72.5%
29.68	0.061	0.030	14.853	0.45	0.030	9.170	0.28	0.030	14.975	0.45	0.030	9.224	0.28	1.45	0.364	79.9%
29.61	0.077	0.040	14.760	0.59	0.040	9.110	0.36	0.040	14.902	0.60	0.040	9.166	0.37	1.92	0.362	84.1%
29.52	0.095	0.050	14.714	0.74	0.050	9.070	0.45	0.050	14.863	0.74	0.050	9.129	0.46	2.39	0.416	85.2%
29.96	0.111	0.060	14.683	0.88	0.060	9.030	0.54	0.060	14.844	0.89	0.060	9.105	0.55	2.86	0.466	86.0%
29.96	0.129	0.070	14.643	1.03	0.070	9.000	0.63	0.070	14.820	1.04	0.070	9.070	0.63	3.33	0.537	86.1%
29.95	0.147	0.080	14.607	1.17	0.080	8.970	0.72	0.080	14.797	1.18	0.080	9.052	0.72	3.79	0.608	86.2%
29.94	0.165	0.090	14.564	1.31	0.090	8.930	0.80	0.090	14.772	1.33	0.090	9.025	0.81	4.26	0.684	86.2%
29.93	0.183	0.100	14.518	1.45	0.100	8.890	0.89	0.100	14.741	1.47	0.100	8.995	0.90	4.71	0.763	86.1%

Vin	Iin	Iout1	Vout1	Pout1	Iout2	Vout2	Pout2	Iout3	Vout3	Pout3	Iout4	Vout4	Pout4	TotalPout	Losses	Efficiency
39.99	0.017	0.005	15.510	0.08	0.005	9.550	0.05	0.005	15.667	0.08	0.005	9.610	0.05	0.25	0.428	37.0%
39.88	0.023	0.010	15.286	0.15	0.010	9.430	0.09	0.010	15.427	0.15	0.010	9.488	0.09	0.50	0.421	54.1%
39.81	0.037	0.020	15.106	0.30	0.020	9.330	0.19	0.020	15.211	0.30	0.020	9.379	0.19	0.98	0.492	66.6%
39.75	0.048	0.030	15.010	0.45	0.030	9.270	0.28	0.030	15.130	0.45	0.030	9.320	0.28	1.46	0.446	76.6%
39.68	0.060	0.040	14.930	0.60	0.040	9.210	0.37	0.040	15.063	0.60	0.040	9.269	0.37	1.94	0.442	81.4%
39.63	0.072	0.050	14.856	0.74	0.050	9.160	0.46	0.050	14.994	0.75	0.050	9.217	0.46	2.41	0.442	84.5%
39.56	0.085	0.060	14.803	0.89	0.060	9.120	0.55	0.060	14.952	0.90	0.060	9.179	0.55	2.88	0.480	85.7%
39.50	0.099	0.070	14.762	1.03	0.070	9.080	0.64	0.070	14.925	1.04	0.070	9.152	0.64	3.35	0.556	85.8%
39.44	0.112	0.080	14.731	1.18	0.080	9.050	0.72	0.080	14.905	1.19	0.080	9.129	0.73	3.83	0.592	86.6%
39.37	0.127	0.090	14.698	1.32	0.090	9.020	0.81	0.090	14.889	1.34	0.090	9.109	0.82	4.29	0.686	86.2%
39.95	0.137	0.100	14.675	1.47	0.100	9.000	0.90	0.100	14.877	1.49	0.100	9.092	0.91	4.76	0.709	87.1%

5.2 Penta Output Fly Buck- Cross Regulation

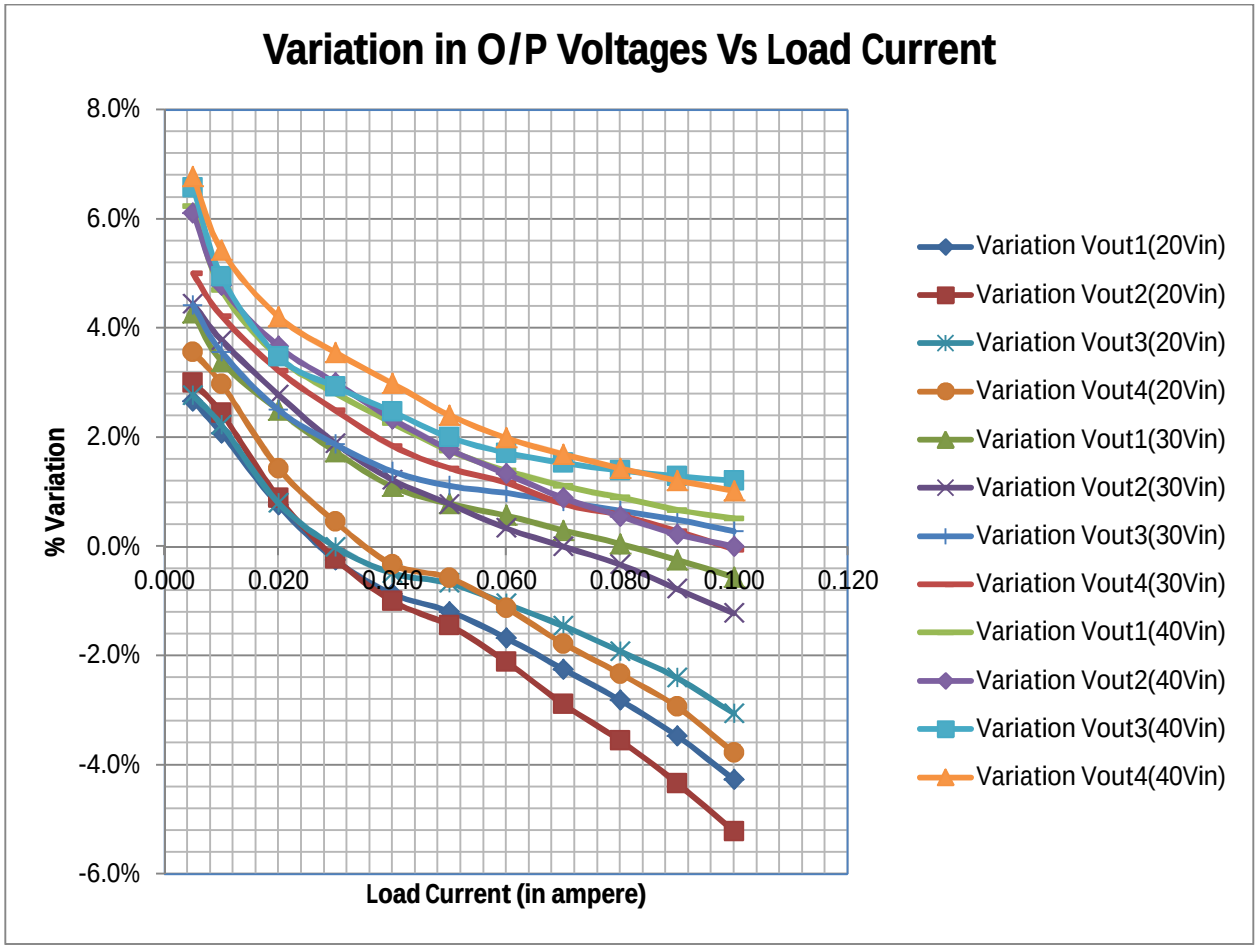
The Cross regulation was tested by Sweeping Vin(keeping Load Constant) or Output Load(Keeping Vin Constant)

5.2.1 Vin Sweep Response



Vin	Vout1	Vout2	Vout3	Vout4	Iout	Variation Vout 1		Variation Vout2		Variation Vout 3		Variation Vout 4
40	14.756	9.08	14.918	9.15	70mA	1.068%		0.889%		1.667%		2.178%
38	14.734	9.06	14.897	9.133	70mA	0.918%		0.667%		1.478%		2.034%
36	14.72	9.06	14.886	9.126	70mA	0.822%		0.667%		1.400%		1.959%
34	14.694	9.04	14.862	9.11	70mA	0.644%		0.444%		1.222%		1.795%
32	14.669	9.02	14.84	9.0934	70mA	0.473%		0.222%		1.038%		1.644%
30	14.633	8.99	14.809	9.0718	70mA	0.226%		-0.111%		0.798%		1.432%
28	14.592	8.96	14.773	9.045	70mA	-0.055%		-0.444%		0.500%		1.185%
26	14.536	8.93	14.723	9.01	70mA	-0.438%		-0.778%		0.111%		0.842%
24	14.458	8.87	14.653	8.9615	70mA	-0.973%		-1.444%		-0.428%		0.363%
22	14.346	8.8	14.552	8.891	70mA	-1.740%		-2.222%		-1.211%		-0.329%

5.2.2 Output Load Sweep Response



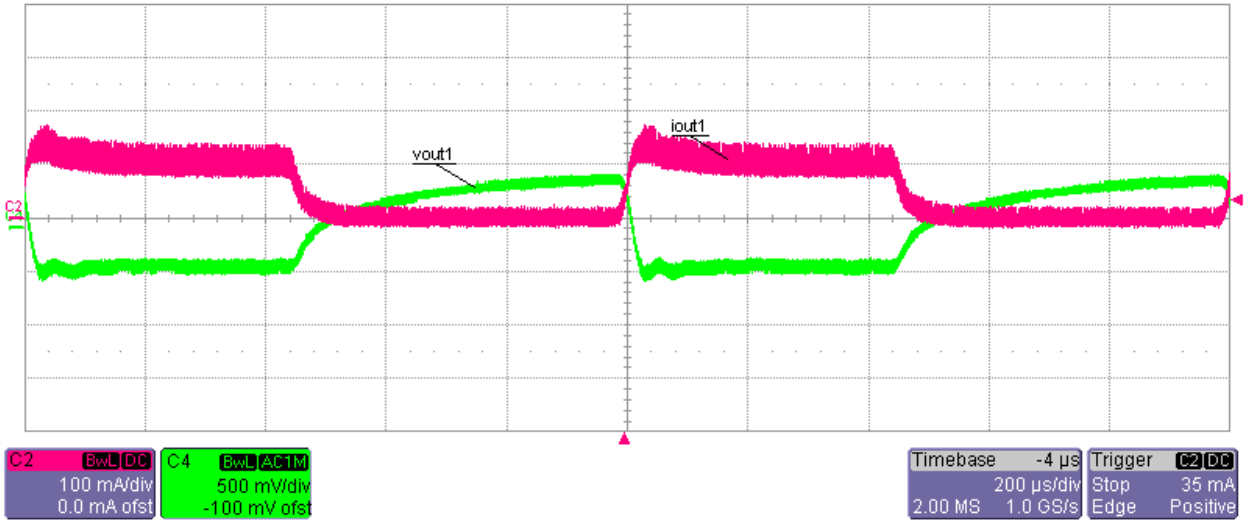
Vin	Iin	Iout1	Vout1	Pout1	Iout2	Vout2	Pout2	Iout3	Vout3	Pout3	Iout4	Vout4	Pout4	TotalPout	Losses	Efficiency	Variant Vout1	Variant Vout2	Variant Vout3	Variant Vout4
20.88	0.025	0.005	14.989	0.07	0.005	9.270	0.05	0.005	15.106	0.08	0.005	9.321	0.05	0.24	0.285	46.1%	2.7%	3.0%	2.8%	3.6%
20.82	0.035	0.010	14.903	0.15	0.010	9.220	0.09	0.010	15.027	0.15	0.010	9.268	0.09	0.48	0.245	66.4%	2.1%	2.4%	2.2%	3.0%
20.89	0.060	0.020	14.711	0.29	0.020	9.080	0.18	0.020	14.817	0.30	0.020	9.129	0.18	0.95	0.298	76.2%	0.8%	0.9%	0.8%	1.4%
20.57	0.082	0.030	14.564	0.44	0.030	8.980	0.27	0.030	14.698	0.44	0.030	9.041	0.27	1.42	0.268	84.1%	-0.2%	-0.2%	0.0%	0.5%
20.45	0.109	0.040	14.473	0.58	0.040	8.910	0.36	0.040	14.628	0.59	0.040	8.970	0.36	1.88	0.350	84.3%	-0.9%	-1.0%	-0.5%	-0.3%
20.96	0.132	0.050	14.426	0.72	0.050	8.870	0.44	0.050	14.601	0.73	0.050	8.948	0.45	2.34	0.424	84.7%	-1.2%	-1.4%	-0.7%	-0.6%
20.95	0.158	0.060	14.355	0.86	0.060	8.810	0.53	0.060	14.546	0.87	0.060	8.899	0.53	2.80	0.513	84.5%	-1.7%	-2.1%	-1.0%	-1.1%
20.94	0.182	0.070	14.272	1.00	0.070	8.740	0.61	0.070	14.486	1.01	0.070	8.840	0.62	3.24	0.567	85.1%	-2.2%	-2.9%	-1.5%	-1.8%
20.93	0.207	0.080	14.189	1.14	0.080	8.680	0.69	0.080	14.418	1.15	0.080	8.790	0.70	3.69	0.646	85.1%	-2.8%	-3.6%	-1.9%	-2.3%
20.91	0.232	0.090	14.093	1.27	0.090	8.610	0.77	0.090	14.346	1.29	0.090	8.736	0.79	4.12	0.731	84.9%	-3.5%	-4.3%	-2.4%	-2.9%
20.90	0.256	0.100	13.976	1.40	0.100	8.530	0.85	0.100	14.250	1.43	0.100	8.660	0.87	4.54	0.810	84.9%	-4.3%	-5.2%	-3.1%	-3.8%

Vin	Iin	Iout1	Vout1	Pout1	Iout2	Vout2	Pout2	Iout3	Vout3	Pout3	Iout4	Vout4	Pout4	TotalPout	Losses	Efficiency	Variant Vout1	Variant Vout2	Variant Vout3	Variant Vout4
29.91	0.020	0.005	15.224	0.08	0.005	9.400	0.05	0.005	15.350	0.08	0.005	9.450	0.05	0.25	0.351	41.3%	4.3%	4.4%	4.4%	5.0%
29.87	0.027	0.010	15.095	0.15	0.010	9.340	0.09	0.010	15.224	0.15	0.010	9.380	0.09	0.49	0.316	60.8%	3.4%	3.8%	3.6%	4.2%
29.77	0.045	0.020	14.964	0.30	0.020	9.250	0.19	0.020	15.068	0.30	0.020	9.290	0.19	0.97	0.368	72.5%	2.5%	2.8%	2.5%	3.2%
29.68	0.061	0.030	14.853	0.45	0.030	9.170	0.28	0.030	14.975	0.45	0.030	9.224	0.28	1.45	0.364	79.9%	1.7%	1.9%	1.9%	2.5%
29.61	0.077	0.040	14.760	0.59	0.040	9.110	0.36	0.040	14.902	0.60	0.040	9.166	0.37	1.92	0.362	84.1%	1.1%	1.2%	1.4%	1.8%
29.52	0.095	0.050	14.714	0.74	0.050	9.070	0.45	0.050	14.863	0.74	0.050	9.129	0.46	2.39	0.416	85.2%	0.8%	0.8%	1.1%	1.4%
29.96	0.111	0.060	14.683	0.88	0.060	9.030	0.54	0.060	14.844	0.89	0.060	9.105	0.55	2.86	0.466	86.0%	0.6%	0.3%	1.0%	1.2%
29.96	0.129	0.070	14.643	1.03	0.070	9.000	0.63	0.070	14.820	1.04	0.070	9.070	0.63	3.33	0.537	86.1%	0.3%	0.0%	0.8%	0.8%
29.95	0.147	0.080	14.607	1.17	0.080	8.970	0.72	0.080	14.797	1.18	0.080	9.052	0.72	3.79	0.608	86.2%	0.0%	-0.3%	0.7%	0.6%
29.94	0.165	0.090	14.564	1.31	0.090	8.930	0.80	0.090	14.772	1.33	0.090	9.025	0.81	4.26	0.684	86.2%	-0.2%	-0.8%	0.5%	0.3%
29.93	0.183	0.100	14.518	1.45	0.100	8.890	0.89	0.100	14.741	1.47	0.100	8.995	0.90	4.71	0.763	86.1%	-0.6%	-1.2%	0.3%	-0.1%

Vin	Iin	Iout1	Vout1	Pout1	Iout2	Vout2	Pout2	Iout3	Vout3	Pout3	Iout4	Vout4	Pout4	TotalPout	Losses	Efficiency	Variant Vout1	Variant Vout2	Variant Vout3	Variant Vout4
39.99	0.017	0.005	15.510	0.08	0.005	9.550	0.05	0.005	15.667	0.08	0.005	9.610	0.05	0.25	0.428	37.0%	6.2%	6.1%	6.6%	6.8%
39.88	0.023	0.010	15.286	0.15	0.010	9.430	0.09	0.010	15.427	0.15	0.010	9.488	0.09	0.50	0.421	54.1%	4.7%	4.8%	4.9%	5.4%
39.81	0.037	0.020	15.106	0.30	0.020	9.330	0.19	0.020	15.211	0.30	0.020	9.379	0.19	0.98	0.492	66.6%	3.5%	3.7%	3.5%	4.2%
39.75	0.048	0.030	15.010	0.45	0.030	9.270	0.28	0.030	15.130	0.45	0.030	9.320	0.28	1.46	0.446	76.6%	2.8%	3.0%	2.9%	3.6%
39.68	0.060	0.040	14.930	0.60	0.040	9.210	0.37	0.040	15.063	0.60	0.040	9.269	0.37	1.94	0.442	81.4%	2.3%	2.3%	2.5%	3.0%
39.63	0.072	0.050	14.856	0.74	0.050	9.160	0.46	0.050	14.994	0.75	0.050	9.217	0.46	2.41	0.442	84.5%	1.8%	1.8%	2.0%	2.4%
39.56	0.085	0.060	14.803	0.89	0.060	9.120	0.55	0.060	14.952	0.90	0.060	9.179	0.55	2.88	0.480	85.7%	1.4%	1.3%	1.7%	2.0%
39.50	0.099	0.070	14.762	1.03	0.070	9.080	0.64	0.070	14.925	1.04	0.070	9.152	0.64	3.35	0.556	85.8%	1.1%	0.9%	1.5%	1.7%
39.44	0.112	0.080	14.731	1.18	0.080	9.050	0.72	0.080	14.905	1.19	0.080	9.129	0.73	3.83	0.592	86.6%	0.9%	0.6%	1.4%	1.4%
39.37	0.127	0.090	14.698	1.32	0.090	9.020	0.81	0.090	14.889	1.34	0.090	9.109	0.82	4.29	0.686	86.2%	0.7%	0.2%	1.3%	1.2%
39.95	0.137	0.100	14.675	1.47	0.100	9.000	0.90	0.100	14.877	1.49	0.100	9.092	0.91	4.76	0.709	87.1%	0.5%	0.0%	1.2%	1.0%

5.3 Penta Output Fly Buck- Waveforms

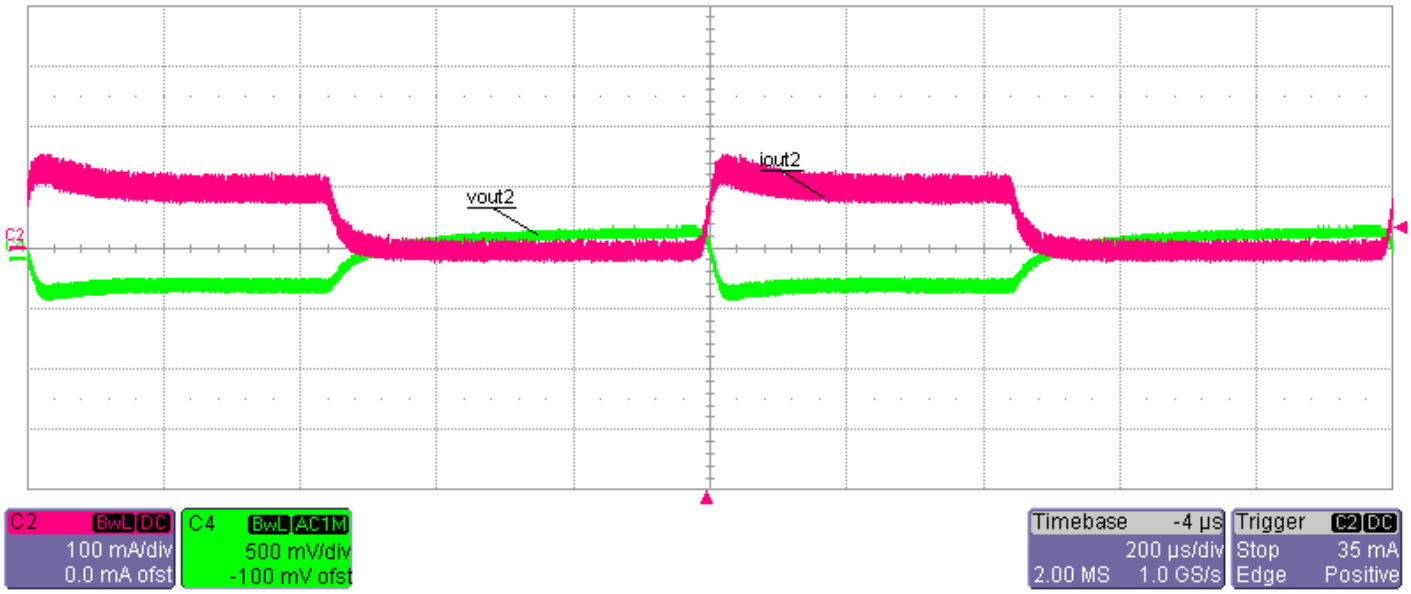
5.3.1 Load Transient Response



Load Transient Response at 20Vin and 0%-to-100% (0mA-to-100mA) Load Step on 14.5V Output Vout1(Load were no connected to any other outputs)

Ch4 – Vout1 (AC coupled)

Ch2- Iout 1

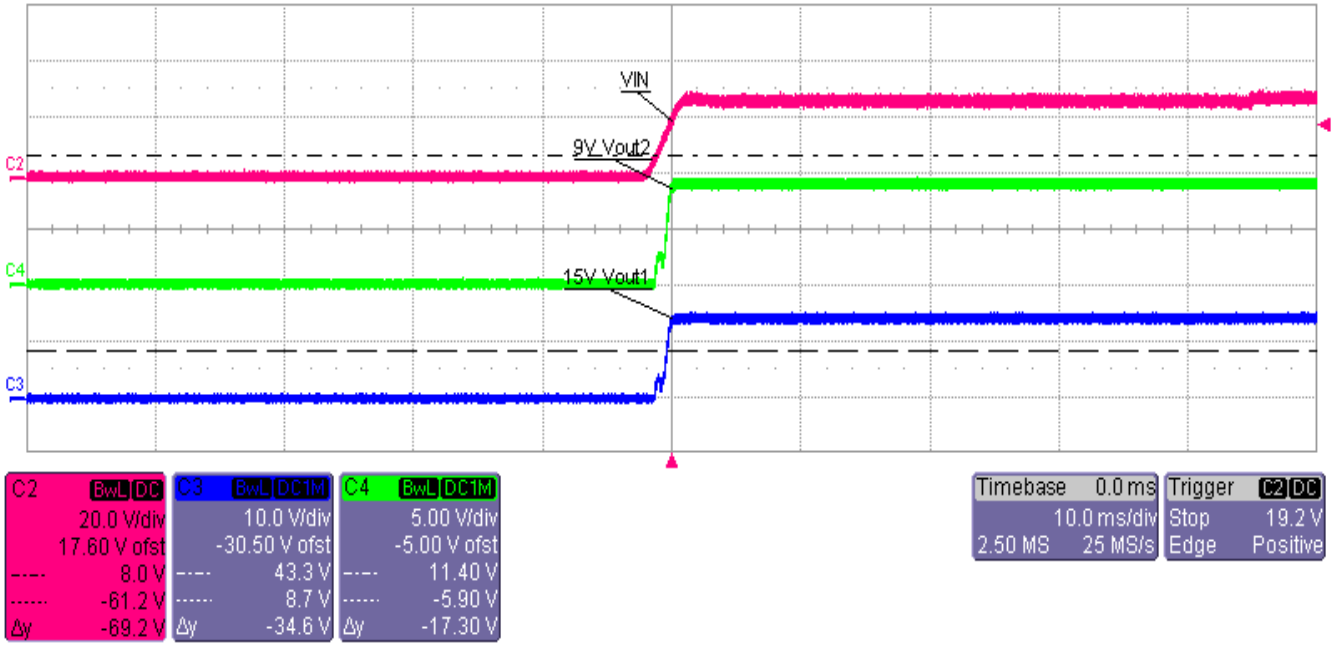


Load Transient Response at 20Vin and 0%-to-100% (0mA-to-100mA) Load Step on 9V Output Vout2(Load were no connected to any other outputs)

Ch4 – Vout2 (AC coupled)

Ch2- Iout 2

5.3.2 Startup



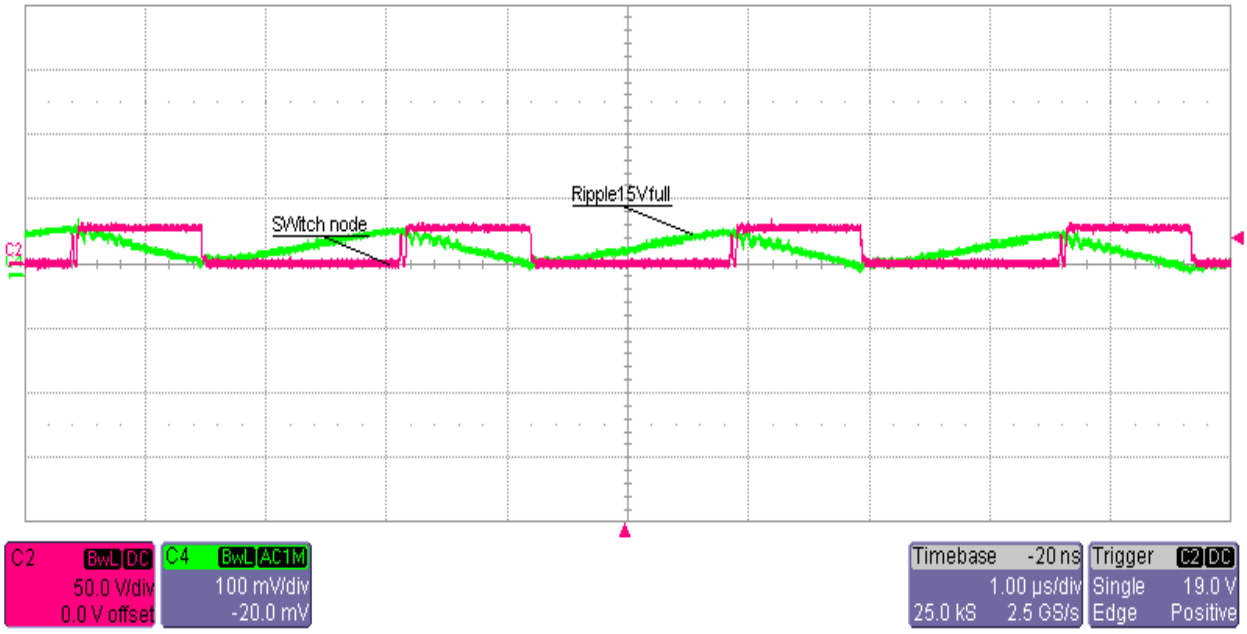
Startup into full Load (all the output was connected to 100mA) at 20 Vin

Ch2-Vin

Ch3-Vout 1

Ch4-Vout 2

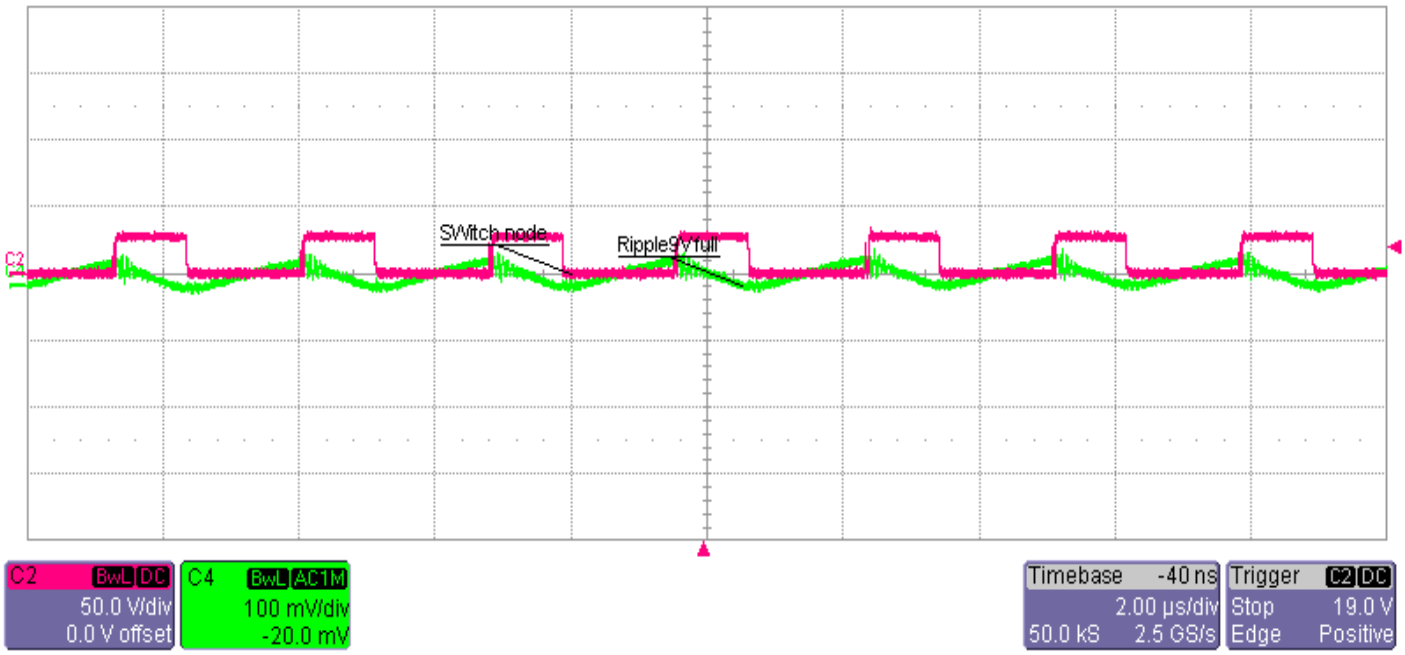
5.3.3 Output Voltage Ripple and Switch Node Voltage



Switch Node Voltage and Output Voltage Ripple at 20 Vin and Full (100mA) Load on all the outputs (Vripple < 60mVp-p)

Ch4-Vout1 (AC Coupled)

Ch2-Switching Waveform

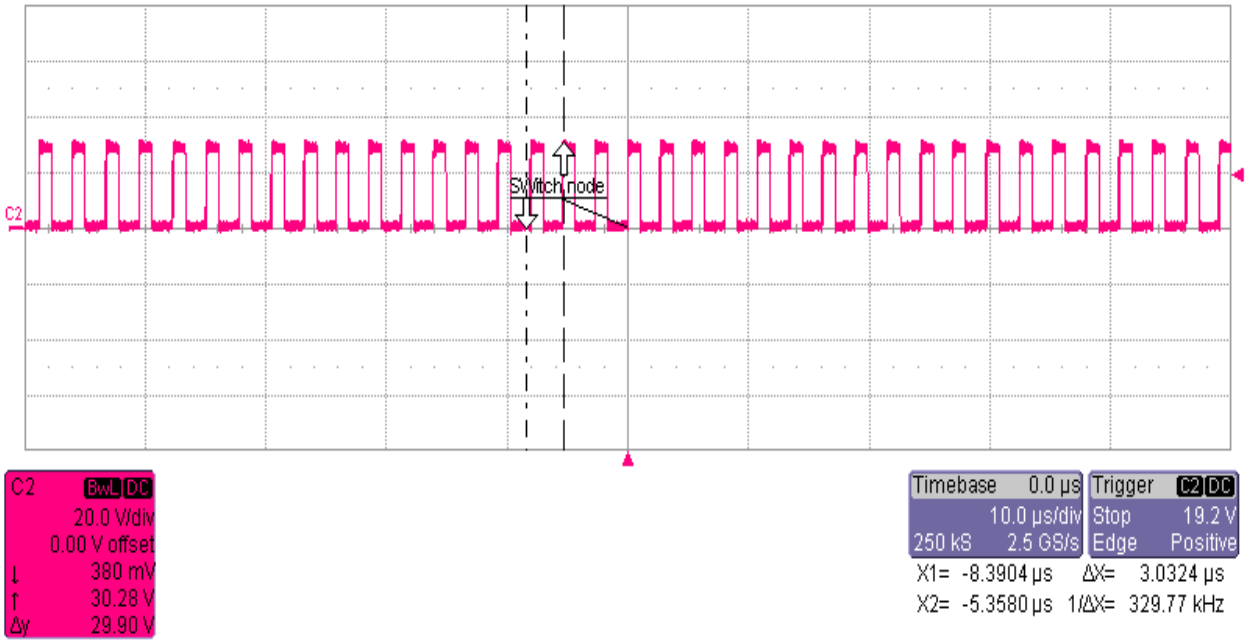


Switch Node Voltage and Output Voltage Ripple at 20 Vin and Full (100mA) Load on all the outputs (Vripple < 60mVp-p)

Ch4-Vout2 (AC Coupled)

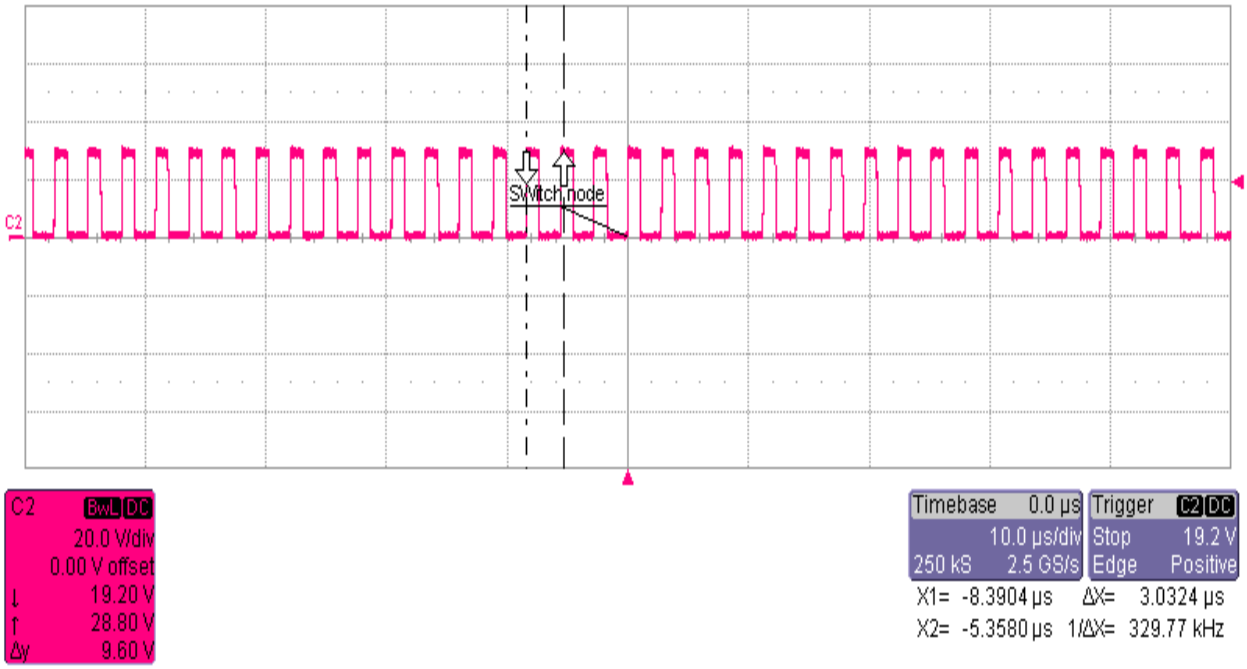
Ch2-Switching Waveform

5.3.4 Primary Side Switching Waveform



Switch Node Voltage(Primary side) at 30 Vin and Full (100mA) Load on all the outputs

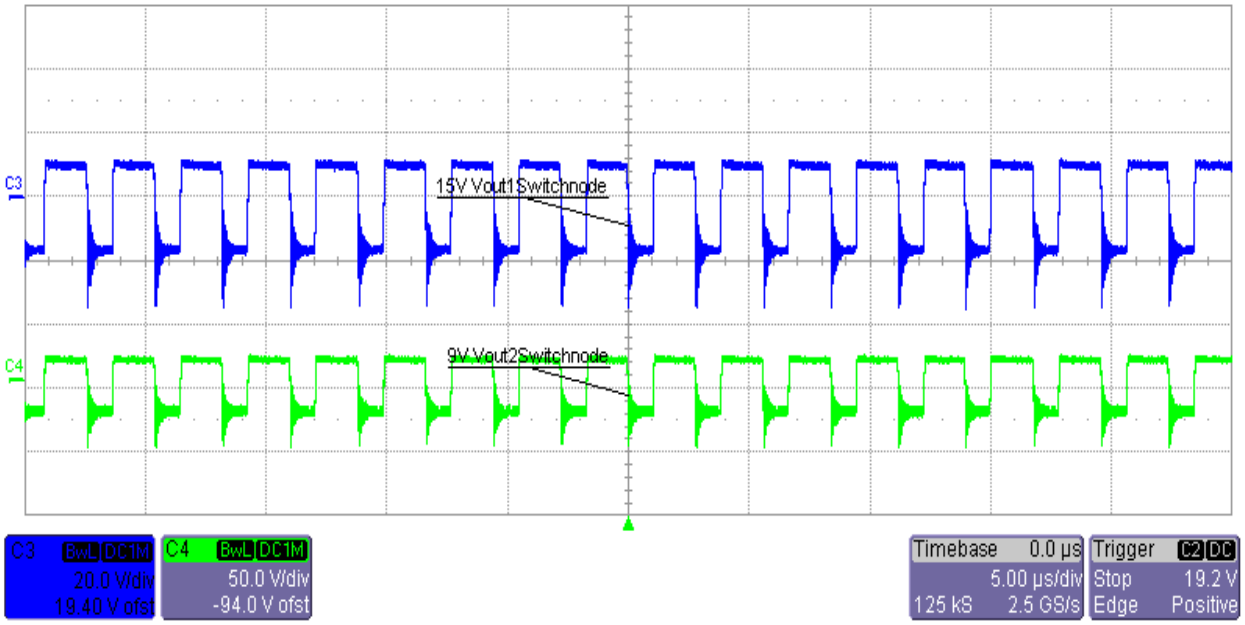
Ch2-Switching Waveform



Switch Node Voltage(Primary side) at 30 Vin and No Load on all the outputs

Ch2-Switching Waveform

5.3.5 Secondary Side Switching Waveform



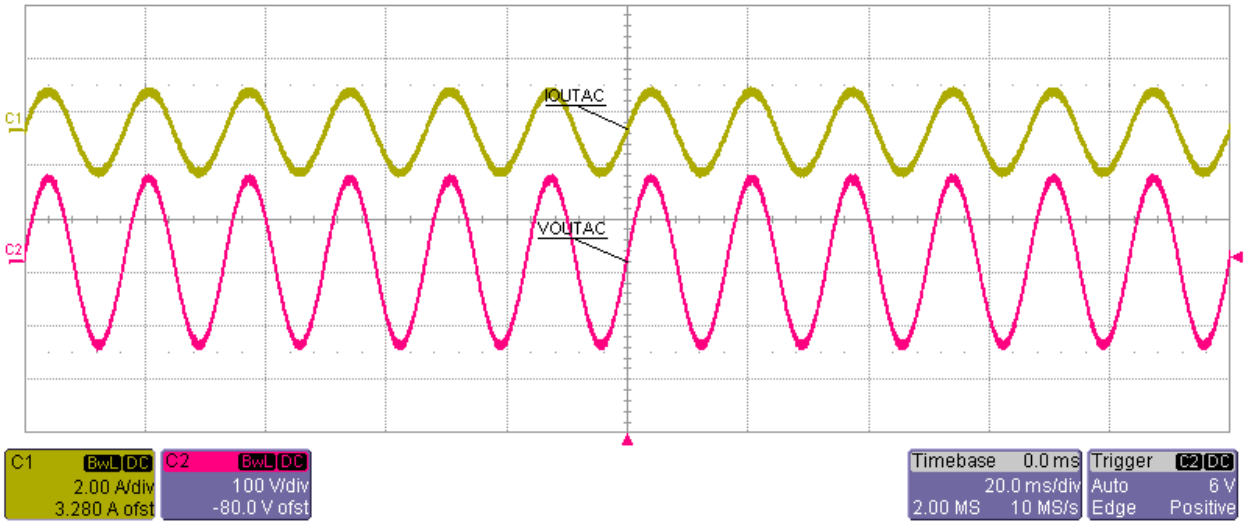
All the outputs were loaded with 100mA and waveform was taken at Secondary switch node for Vout1 14.5V as well as Vout2 9V.

Ch3-Switching Waveform from Anode of Diode to Secondary Ground – 9V

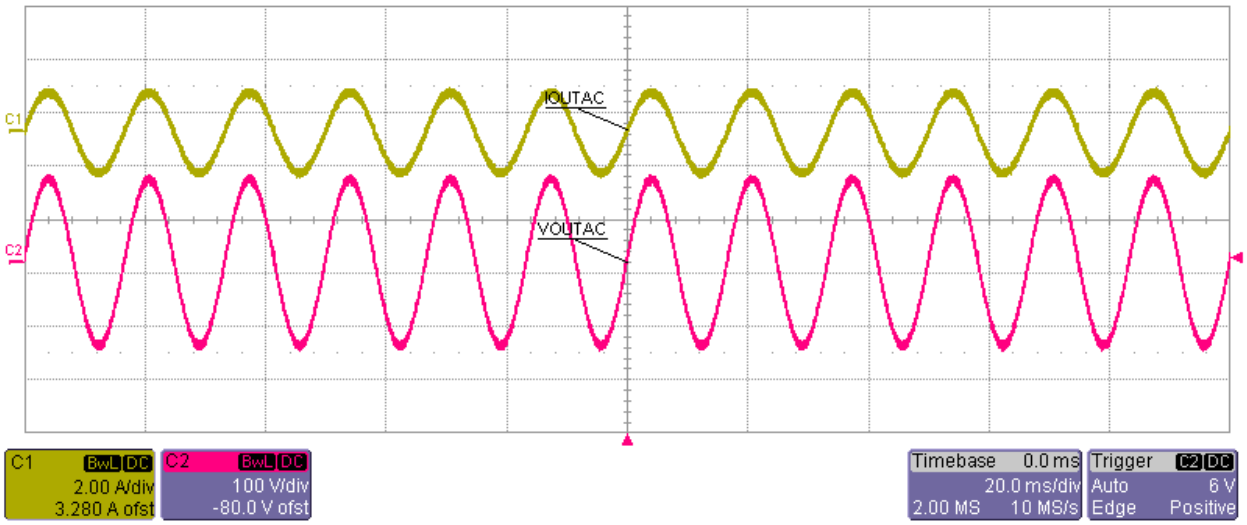
Ch4- Switching Waveform from Anode of Diode to Secondary Ground – 14.5V

6. MicroInverter's Output Waveform

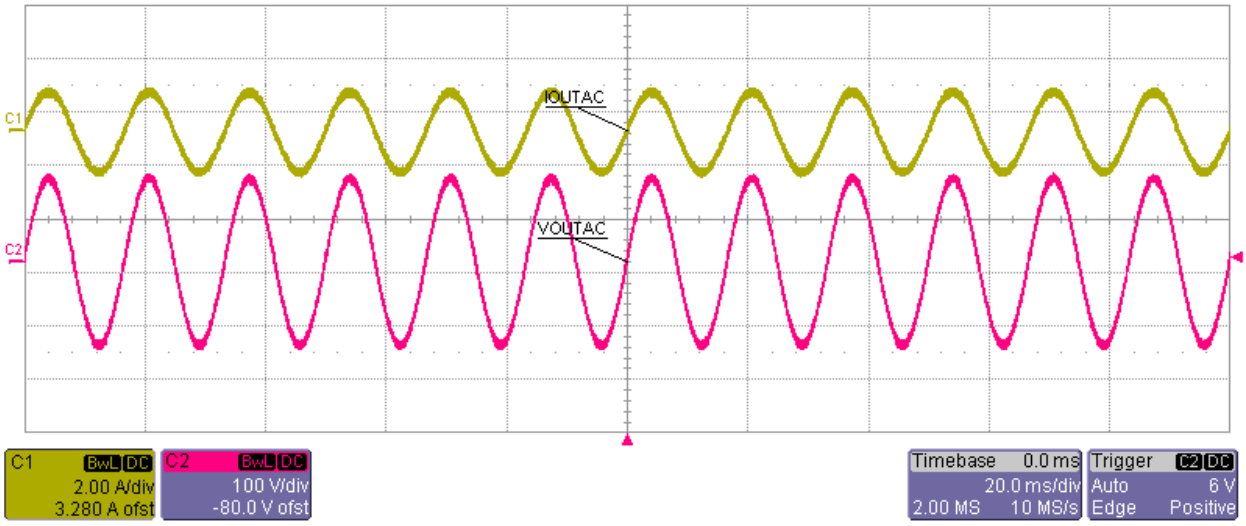
The output was taken with SM72295 Gate Driver, LM5017 Bias Supplies on DC/DC Section and SM74101 and SM72428 in DC/AC Section:



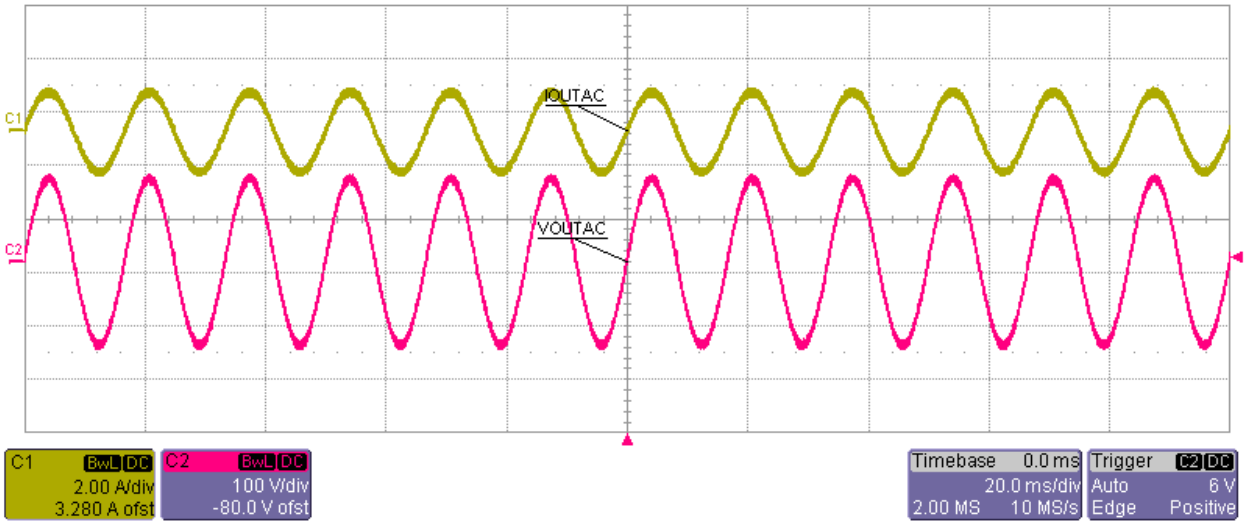
120W Output from AC Power Source Replicating the Grid



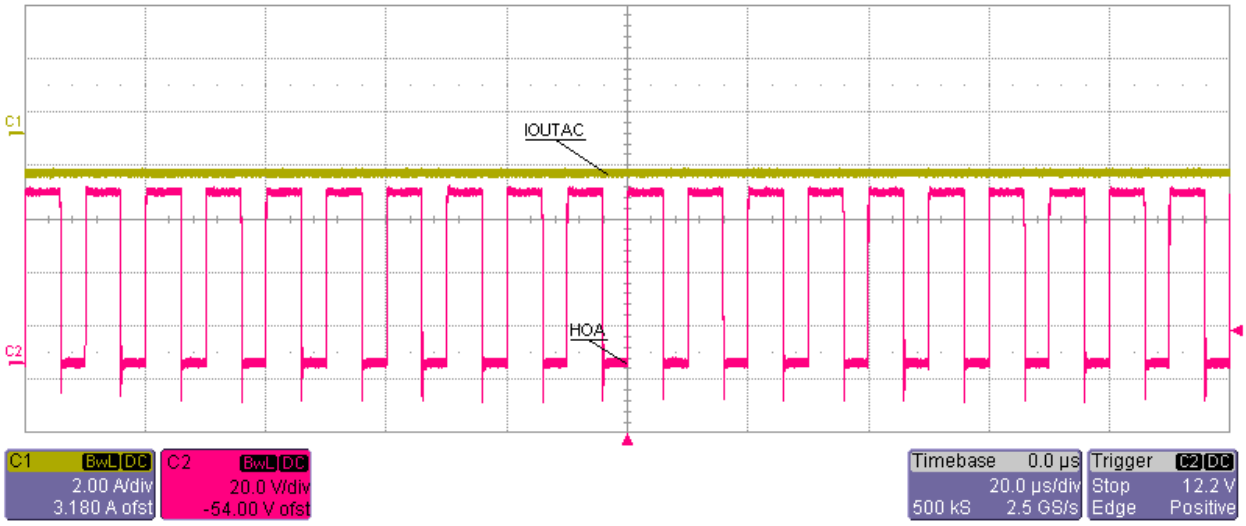
120W Total Output : 60W from Grid + 60W from Microinverter

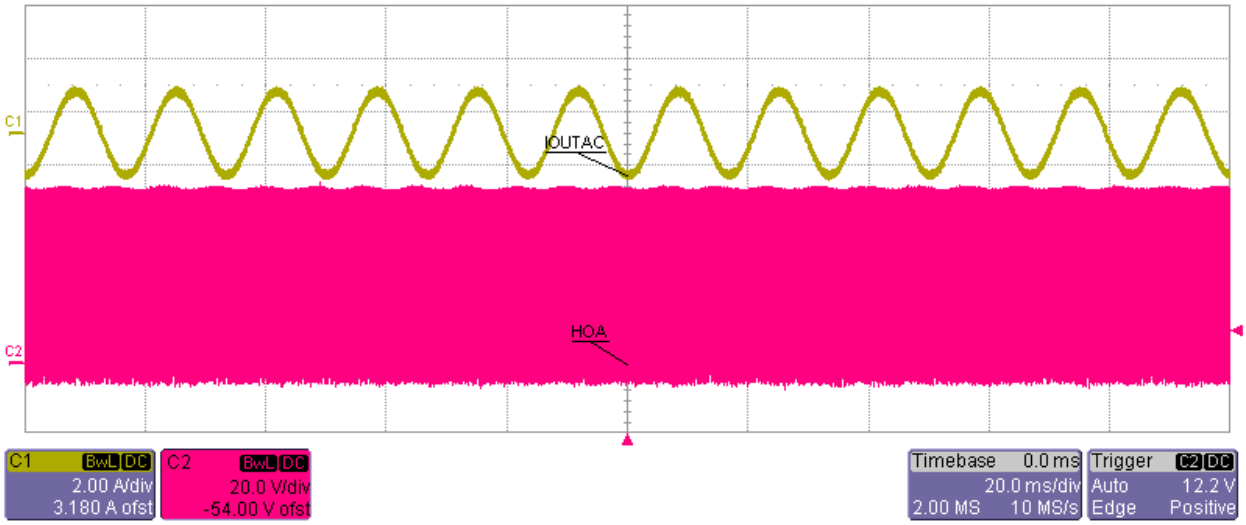


120W Total Output : 40W from Grid + 80W from Microinverter



120W Total Output : 20W from Grid + 100W from Microinverter





High Side Primary Clamped Fly back Switch Vs Output AC Current with Grid Connected total 120W Load (100W Microinverter + 20W Grid)

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265