Test Data
For PMP10545
11/4/2014

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1. Design Specifications

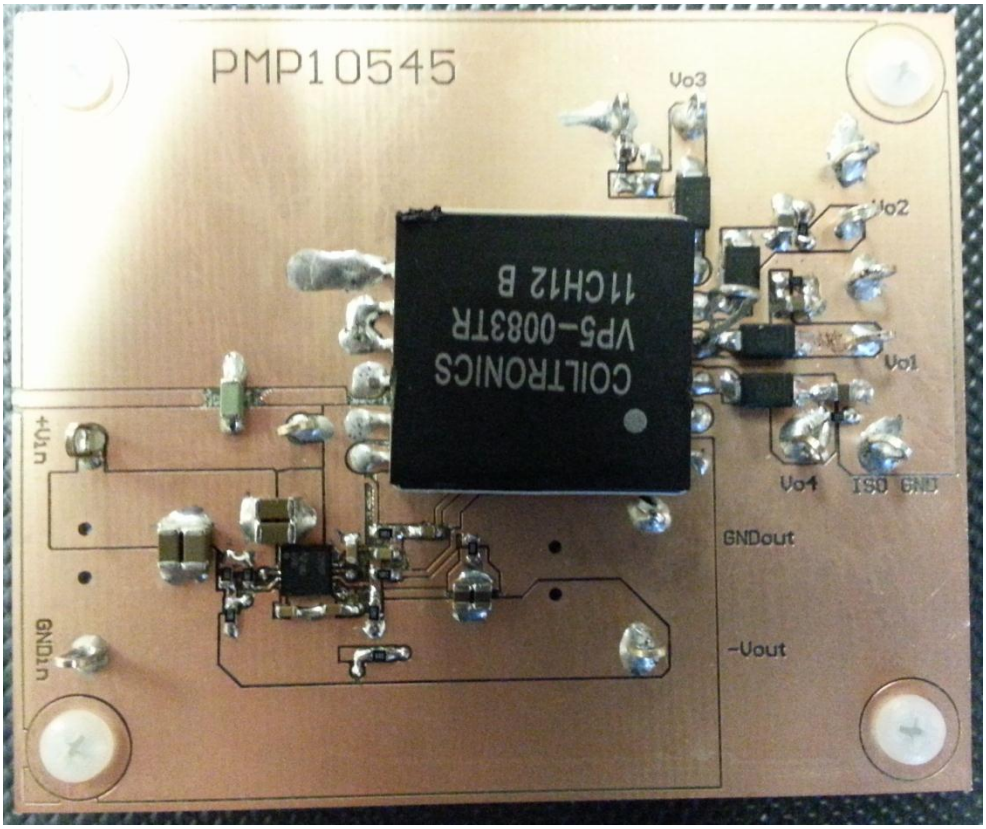
Vin Minimum	**9VDC**
Vin Maximum	**30VDC**
Vout1	**+5.7VDC @ 350mA**
Vout2	**+5.7VDC @ 350mA**
Vout3	**+5.7VDC @ 350mA**
Vout4	**+5.7VDC @ 350mA**
Nominal Switching Frequency	**≈ 280KHz**

2. Circuit Description

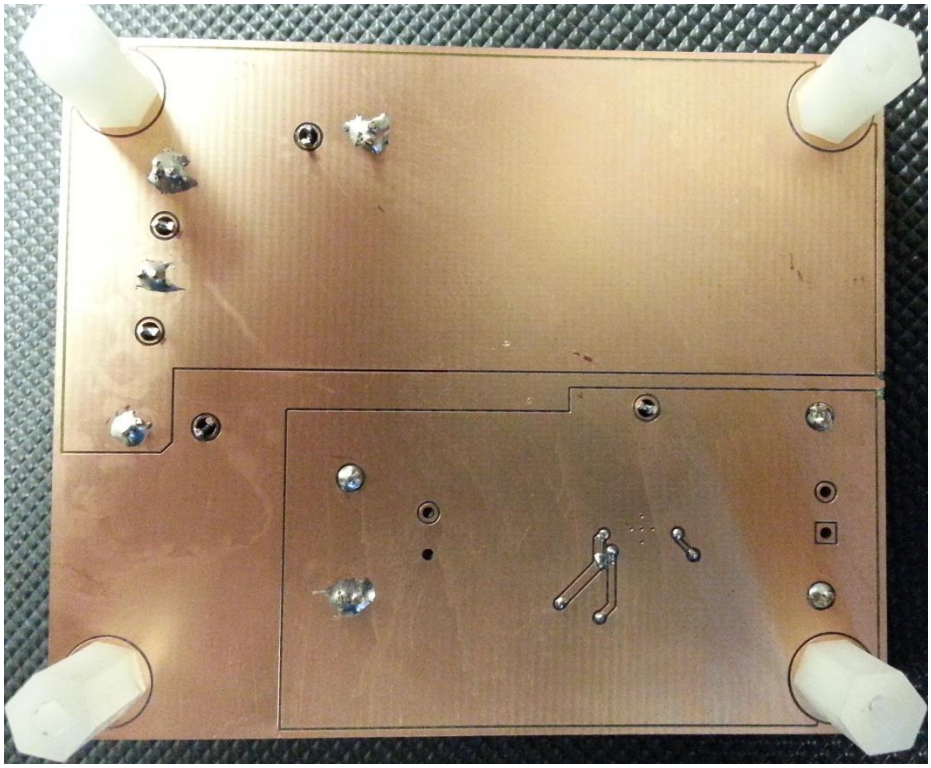
PMP10545 is an Isolated Flyback Converter with the primary configured as a buck-boost inverter, using the LM5160 regulator IC. The design accepts an input voltage of 9Vin to 30Vin and provides four isolated outputs of +5.7Vout, each capable of supplying 350mA. The nominal switching frequency of the design is 280KHz. The board is a 2-layer PCB with 1 oz. copper on the top and bottom layers. A PCB milling machine was used to build the board. All tests for oscilloscope waveform captures were performed on Vo1 at 9Vin and 30Vin. Efficiency testing and thermal image captures were performed at 9Vin, 12Vin, 19.5Vin, and 30Vin. The design uses an easily available off-the-shelf transformer, making it a more cost effective design solution.

3. PMP10545 Board Photos

Board Dimensions: 3” x 2.5”

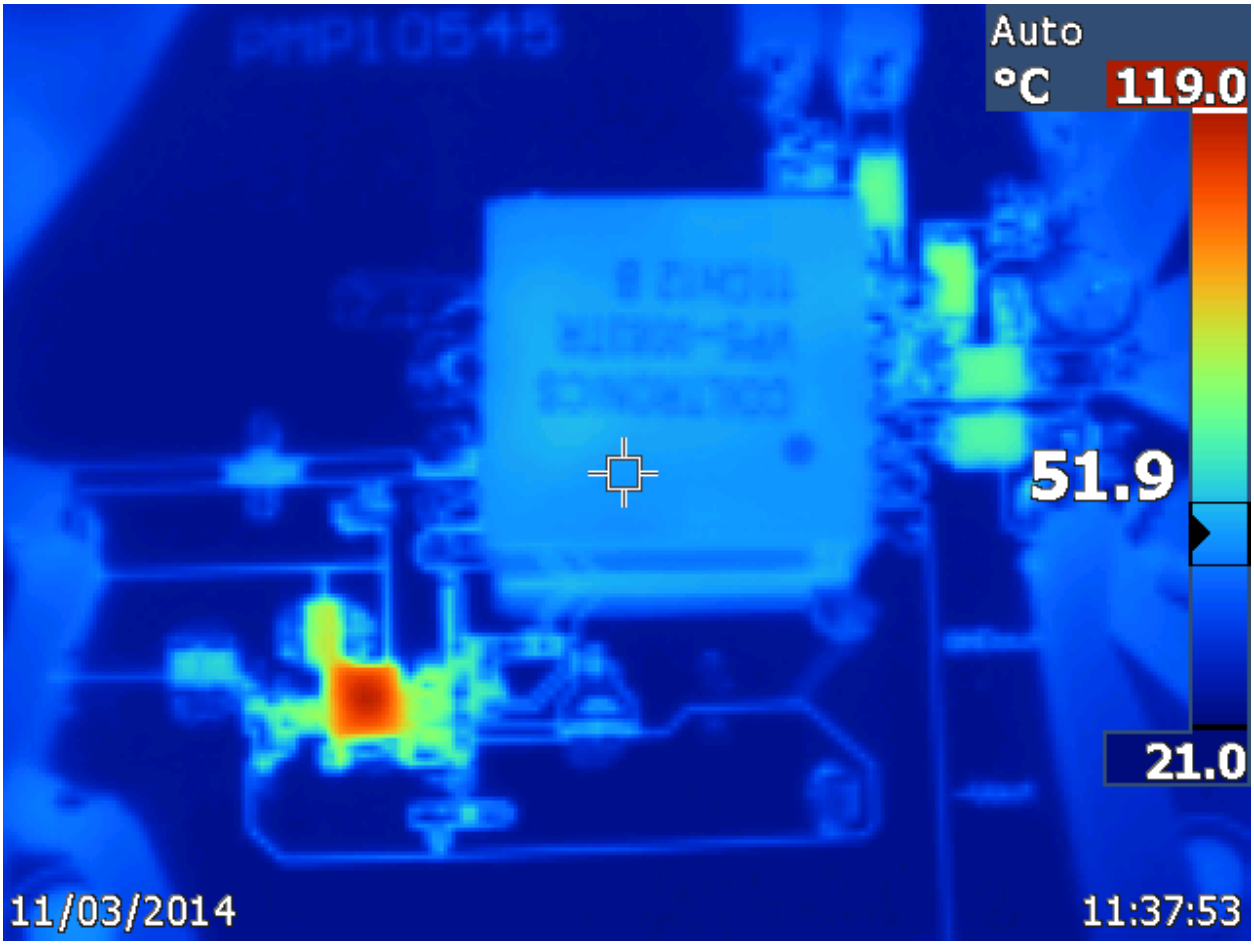


Board Photo (Top)

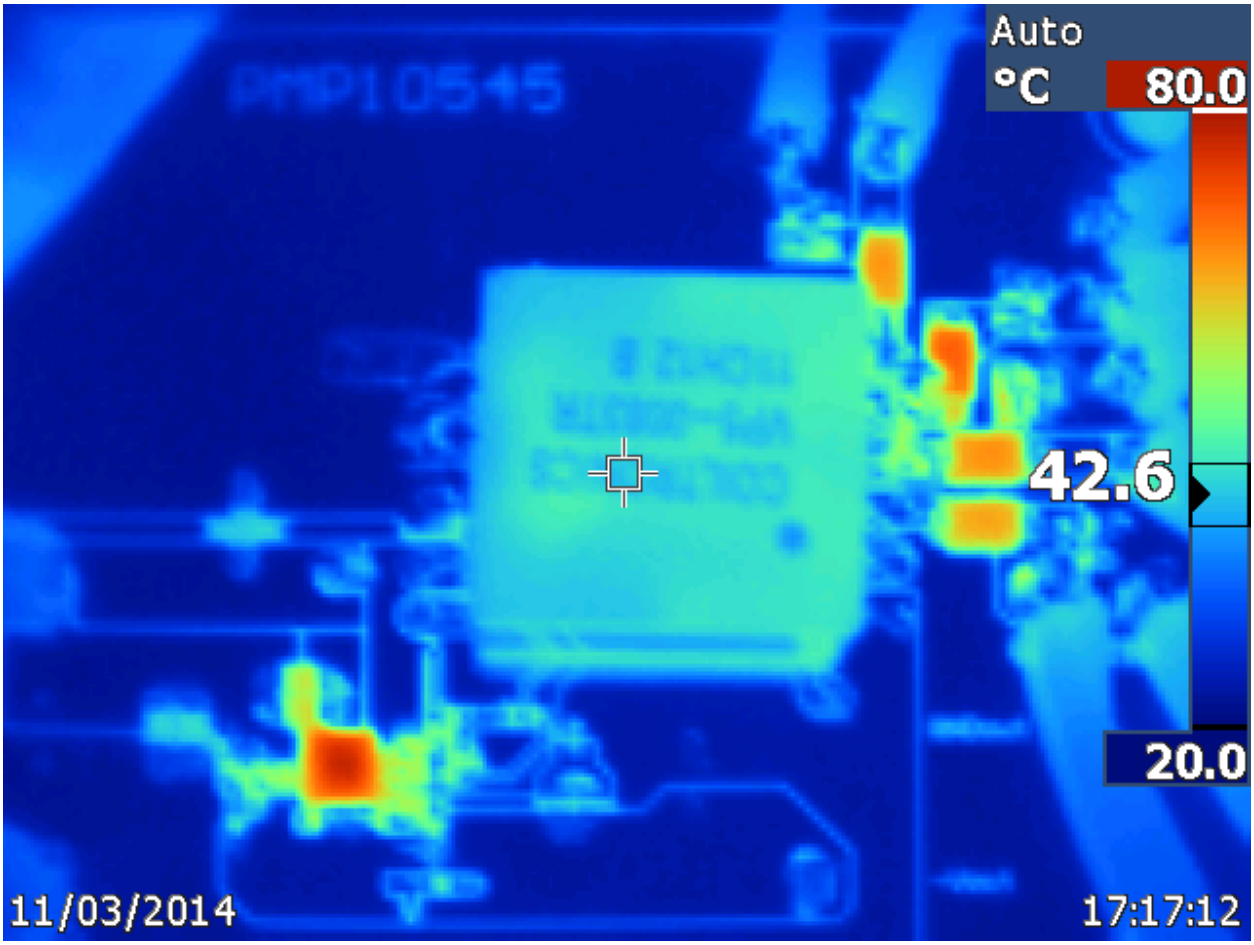


Board Photo (Bottom)

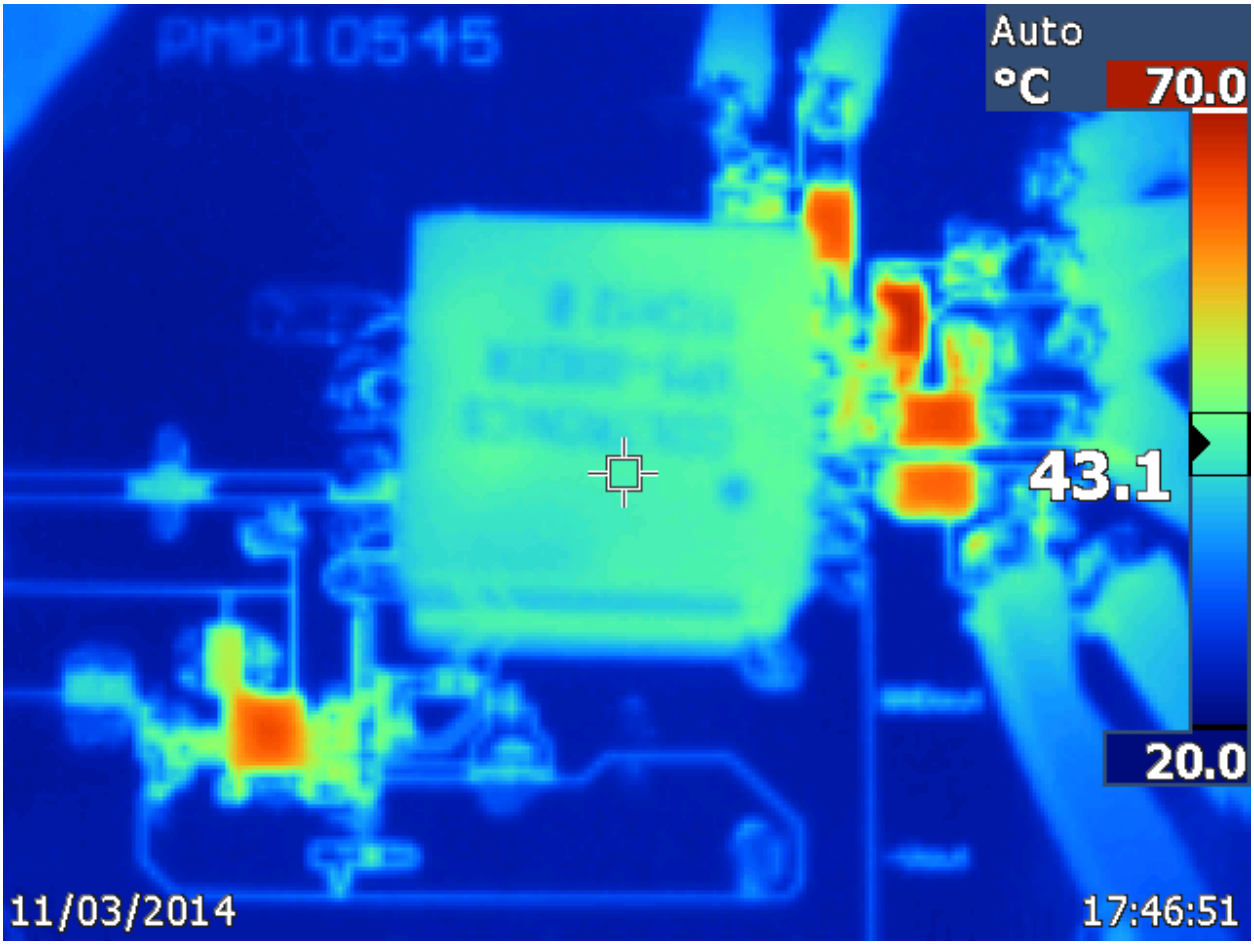
4. Thermal Data



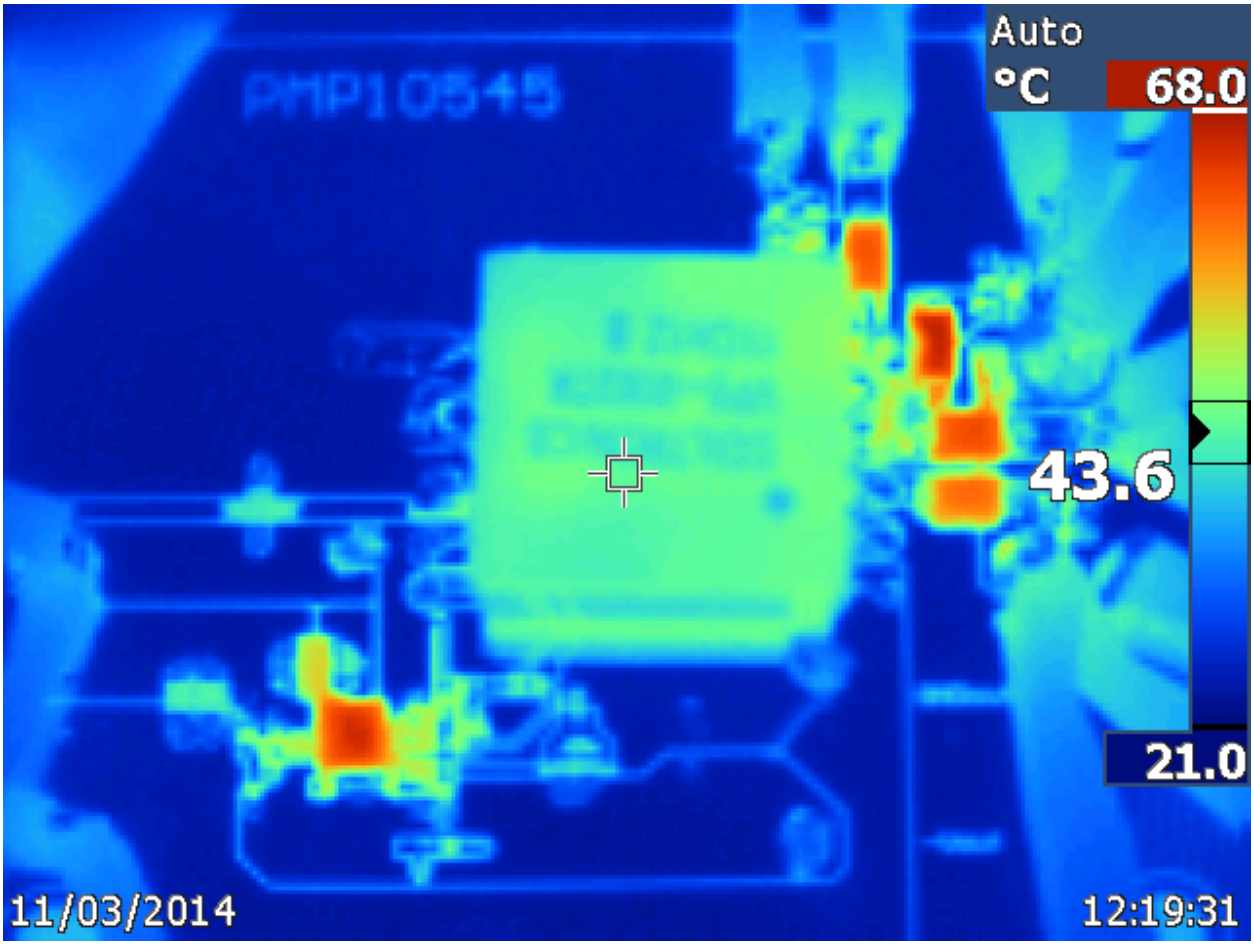
IR Thermal Image Taken at Steady State at 9Vin and All Output Rails at Full Load (Vout Primary Unloaded); (A PCB milling machined was used to build the board. Due to this, the vias under the DAP, or Exposed Pad, of the LM5160 could not be connected to the bottom layer copper, hence increasing the thermal resistance and leading to higher IC temperatures. Manufacturing the PCB at a fabrication house will allow for these vias to exist and will noticeably improve the thermal performance of the design. Another available option for improving thermal performance is to use a larger copper area for the DAP)



IR Thermal Image Taken at Steady State at 12Vin and All Output Rails at Full Load (Vout Primary Unloaded)



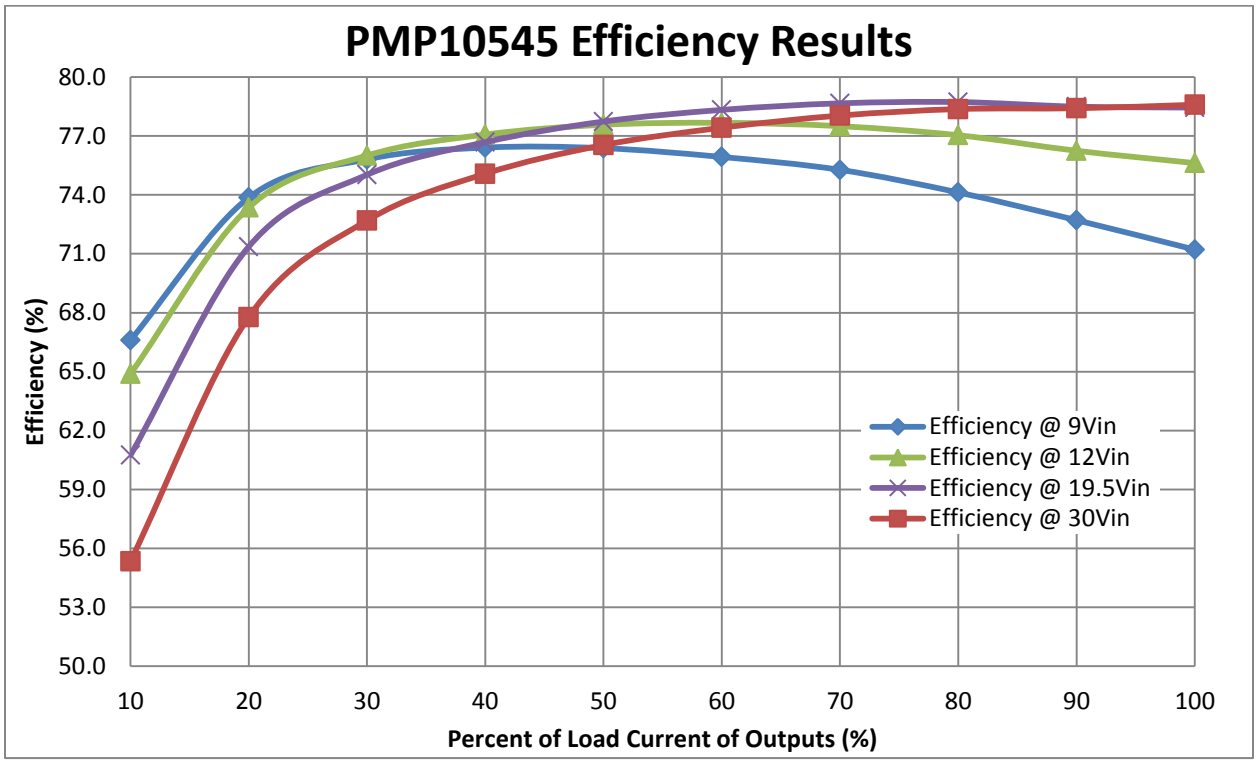
IR Thermal Image Taken at Steady State at 19.5Vin and All Output Rails at Full Load (Vout Primary Unloaded)



IR Thermal Image Taken at Steady State at 30Vin and All Output Rails at Full Load (Vout Primary Unloaded)

5. Efficiency

5.1 Efficiency Chart



5.2 Efficiency Data

Vin (V)	Iin (A)	Vo1 (V)	Io1 (A)	Vo2 (V)	Io2 (A)	Vo3 (V)	Io3 (A)	Vo4 (V)	Io4 (A)	Pin (W)	Po1 (W)	Po2 (W)	Po3 (W)	Po4 (W)	Po Total (W)	Ploss (W)	Efficiency (%)	% Load Per Output Rail
9	0.136	5.7995	0.035	5.7988	0.035	5.8147	0.035	5.81	0.035	1.2204	0.2030	0.2030	0.2035	0.2034	0.8128	0.4076	66.6	10
9	0.242	5.7403	0.07	5.7389	0.07	5.7567	0.07	5.755	0.07	2.1789	0.4018	0.4017	0.4030	0.4029	1.6094	0.5695	73.9	20
9	0.351	5.7007	0.105	5.6964	0.105	5.714	0.105	5.717	0.105	3.1617	0.5986	0.5981	0.6000	0.6003	2.3970	0.7647	75.8	30
9	0.461	5.6585	0.14	5.6509	0.14	5.6686	0.14	5.676	0.14	4.1508	0.7922	0.7911	0.7936	0.7946	3.1716	0.9792	76.4	40
9	0.573	5.6194	0.175	5.6079	0.175	5.6265	0.175	5.638	0.175	5.1534	0.9834	0.9814	0.9846	0.9867	3.9361	1.2173	76.4	50
9	0.686	5.5821	0.21	5.5652	0.21	5.5839	0.21	5.602	0.21	6.1767	1.1722	1.1687	1.1726	1.1764	4.6900	1.4867	75.9	60
9	0.802	5.5436	0.245	5.5217	0.245	5.5411	0.245	5.565	0.245	7.2162	1.3582	1.3528	1.3576	1.3634	5.4320	1.7842	75.3	70
9	0.923	5.5025	0.28	5.4759	0.28	5.495	0.28	5.527	0.28	8.3106	1.5407	1.5333	1.5386	1.5476	6.1601	2.1505	74.1	80
9	1.05	5.4602	0.315	5.4271	0.315	5.4456	0.315	5.485	0.315	9.4518	1.7200	1.7095	1.7154	1.7278	6.8726	2.5792	72.7	90
9	1.181	5.4131	0.35	5.374	0.35	5.3934	0.35	5.44	0.35	10.6263	1.8946	1.8809	1.8877	1.9040	7.5672	3.0591	71.2	100

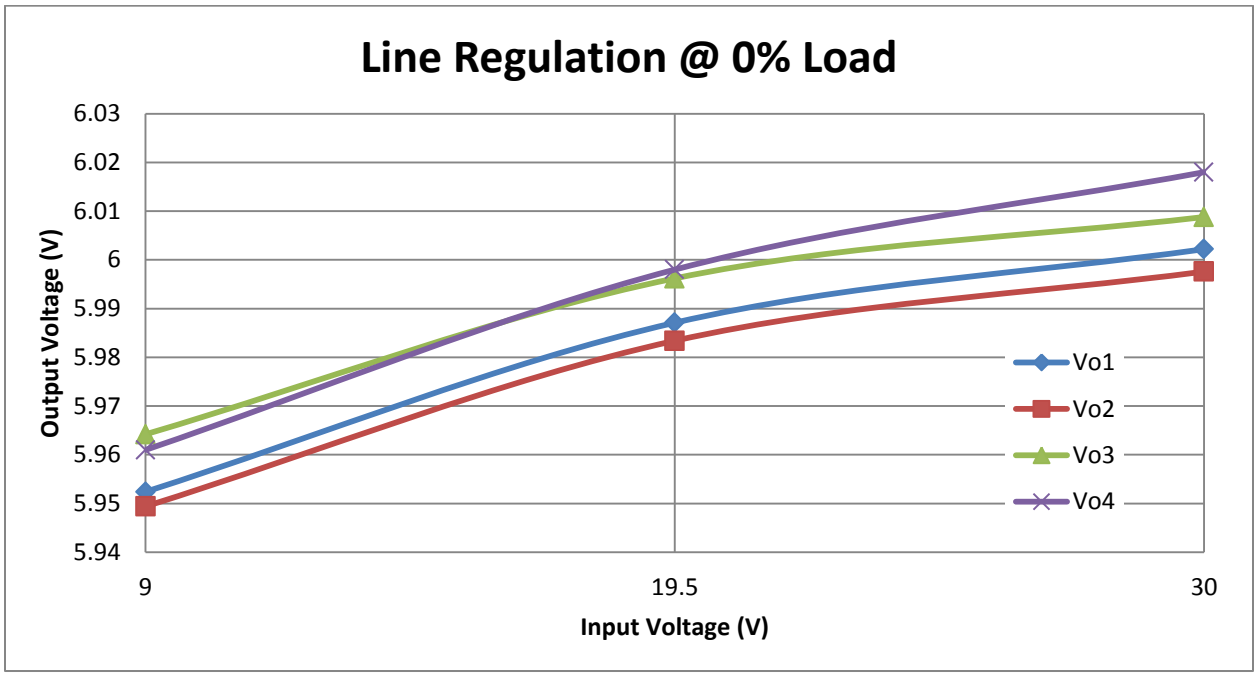
Vin (V)	Iin (A)	Vo1 (V)	Io1 (A)	Vo2 (V)	Io2 (A)	Vo3 (V)	Io3 (A)	Vo4 (V)	Io4 (A)	Pin (W)	Po1 (W)	Po2 (W)	Po3 (W)	Po4 (W)	Po Total (W)	Ploss (W)	Efficiency (%)	% Load Per Output Rail
12	0.105	5.8047	0.035	5.8055	0.035	5.8215	0.035	5.816	0.035	1.2540	0.2032	0.2032	0.2038	0.2036	0.8137	0.4403	64.9	10
12	0.183	5.7543	0.07	5.7552	0.07	5.7722	0.07	5.768	0.07	2.1996	0.4028	0.4029	0.4041	0.4038	1.6135	0.5861	73.4	20
12	0.264	5.7178	0.105	5.7182	0.105	5.7353	0.105	5.733	0.105	3.1644	0.6004	0.6004	0.6022	0.6020	2.4050	0.7594	76.0	30
12	0.345	5.6884	0.14	5.6874	0.14	5.7047	0.14	5.704	0.14	4.1388	0.7964	0.7962	0.7987	0.7986	3.1898	0.9490	77.1	40
12	0.426	5.6613	0.175	5.6585	0.175	5.6763	0.175	5.679	0.175	5.1156	0.9907	0.9902	0.9934	0.9938	3.9681	1.1475	77.6	50
12	0.509	5.6363	0.21	5.6307	0.21	5.6484	0.21	5.653	0.21	6.1020	1.1836	1.1824	1.1862	1.1871	4.7394	1.3626	77.7	60
12	0.592	5.612	0.245	5.6037	0.245	5.6219	0.245	5.63	0.245	7.1028	1.3749	1.3729	1.3774	1.3794	5.5046	1.5982	77.5	70
12	0.677	5.5866	0.28	5.5757	0.28	5.5936	0.28	5.606	0.28	8.1276	1.5642	1.5612	1.5662	1.5697	6.2613	1.8663	77.0	80
12	0.766	5.5597	0.315	5.5462	0.315	5.5636	0.315	5.58	0.315	9.1920	1.7513	1.7471	1.7525	1.7577	7.0086	2.1834	76.2	90
12	0.854	5.5331	0.35	5.5163	0.35	5.5344	0.35	5.555	0.35	10.2468	1.9366	1.9307	1.9370	1.9443	7.7486	2.4982	75.6	100

Vin (V)	Iin (A)	Vo1 (V)	Io1 (A)	Vo2 (V)	Io2 (A)	Vo3 (V)	Io3 (A)	Vo4 (V)	Io4 (A)	Pin (W)	Po1 (W)	Po2 (W)	Po3 (W)	Po4 (W)	Po Total (W)	Ploss (W)	Efficiency (%)	% Load Per Output Rail
19.5	0.069	5.85	0.035	5.8486	0.035	5.8626	0.035	5.859	0.035	1.3494	0.2048	0.2047	0.2052	0.2051	0.8197	0.5297	60.7	10
19.5	0.117	5.7977	0.07	5.7985	0.07	5.8147	0.07	5.809	0.07	2.2776	0.4058	0.4059	0.4070	0.4066	1.6254	0.6522	71.4	20
19.5	0.166	5.7637	0.105	5.7655	0.105	5.7816	0.105	5.776	0.105	3.2312	0.6052	0.6054	0.6071	0.6065	2.4241	0.8070	75.0	30
19.5	0.215	5.7382	0.14	5.7401	0.14	5.7563	0.14	5.751	0.14	4.1964	0.8033	0.8036	0.8059	0.8051	3.2180	0.9784	76.7	40
19.5	0.264	5.7164	0.175	5.7188	0.175	5.7356	0.175	5.731	0.175	5.1558	1.0004	1.0008	1.0037	1.0029	4.0078	1.1480	77.7	50
19.5	0.314	5.6991	0.21	5.7007	0.21	5.7171	0.21	5.714	0.21	6.1211	1.1968	1.1971	1.2006	1.1999	4.7945	1.3266	78.3	60
19.5	0.364	5.6823	0.245	5.6837	0.245	5.7005	0.245	5.698	0.245	7.0902	1.3922	1.3925	1.3966	1.3960	5.5773	1.5129	78.7	70
19.5	0.414	5.6657	0.28	5.6668	0.28	5.6837	0.28	5.682	0.28	8.0730	1.5864	1.5867	1.5914	1.5910	6.3555	1.7175	78.7	80
19.5	0.466	5.6485	0.315	5.649	0.315	5.6652	0.315	5.666	0.315	9.0812	1.7793	1.7794	1.7845	1.7848	7.1280	1.9531	78.5	90
19.5	0.516	5.6327	0.35	5.6324	0.35	5.6488	0.35	5.651	0.35	10.0679	1.9714	1.9713	1.9771	1.9779	7.8977	2.1701	78.4	100

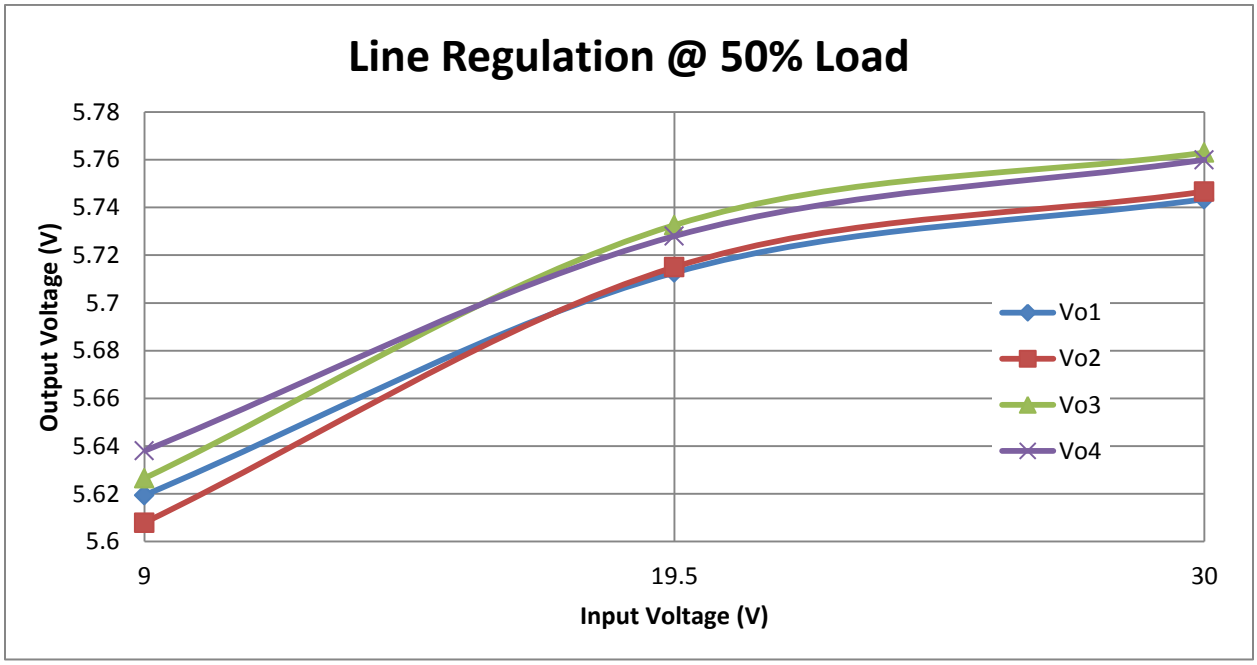
Vin (V)	Iin (A)	Vo1 (V)	Io1 (A)	Vo2 (V)	Io2 (A)	Vo3 (V)	Io3 (A)	Vo4 (V)	Io4 (A)	Pin (W)	Po1 (W)	Po2 (W)	Po3 (W)	Po4 (W)	Po Total (W)	Ploss (W)	Efficiency (%)	% Load Per Output Rail
30	0.05	5.8649	0.035	5.8633	0.035	5.8776	0.035	5.877	0.035	1.4850	0.2053	0.2052	0.2057	0.2057	0.8219	0.6631	55.3	10
30	0.08	5.8165	0.07	5.8172	0.07	5.8336	0.07	5.83	0.07	2.4060	0.4072	0.4072	0.4084	0.4081	1.6308	0.7752	67.8	20
30	0.112	5.7861	0.105	5.788	0.105	5.8042	0.105	5.8	0.105	3.3480	0.6075	0.6077	0.6094	0.6090	2.4337	0.9143	72.7	30
30	0.144	5.7626	0.14	5.765	0.14	5.7812	0.14	5.778	0.14	4.3050	0.8068	0.8071	0.8094	0.8089	3.2322	1.0728	75.1	40
30	0.175	5.7435	0.175	5.7467	0.175	5.763	0.175	5.76	0.175	5.2620	1.0051	1.0057	1.0085	1.0080	4.0273	1.2347	76.5	50
30	0.208	5.7276	0.21	5.7308	0.21	5.7469	0.21	5.744	0.21	6.2250	1.2028	1.2035	1.2068	1.2062	4.8194	1.4056	77.4	60
30	0.24	5.7138	0.245	5.7174	0.245	5.7335	0.245	5.731	0.245	7.1880	1.3999	1.4008	1.4047	1.4041	5.6094	1.5786	78.0	70
30	0.272	5.7017	0.28	5.7055	0.28	5.721	0.28	5.719	0.28	8.1630	1.5965	1.5975	1.6019	1.6013	6.3972	1.7658	78.4	80
30	0.305	5.6873	0.315	5.6915	0.315	5.7066	0.315	5.706	0.315	9.1560	1.7915	1.7928	1.7976	1.7974	7.1793	1.9767	78.4	90
30	0.336	5.6448	0.35	5.649	0.35	5.6635	0.35	5.663	0.35	10.0740	1.9757	1.9772	1.9822	1.9821	7.9171	2.1569	78.6	100

6 Output Voltage Regulation

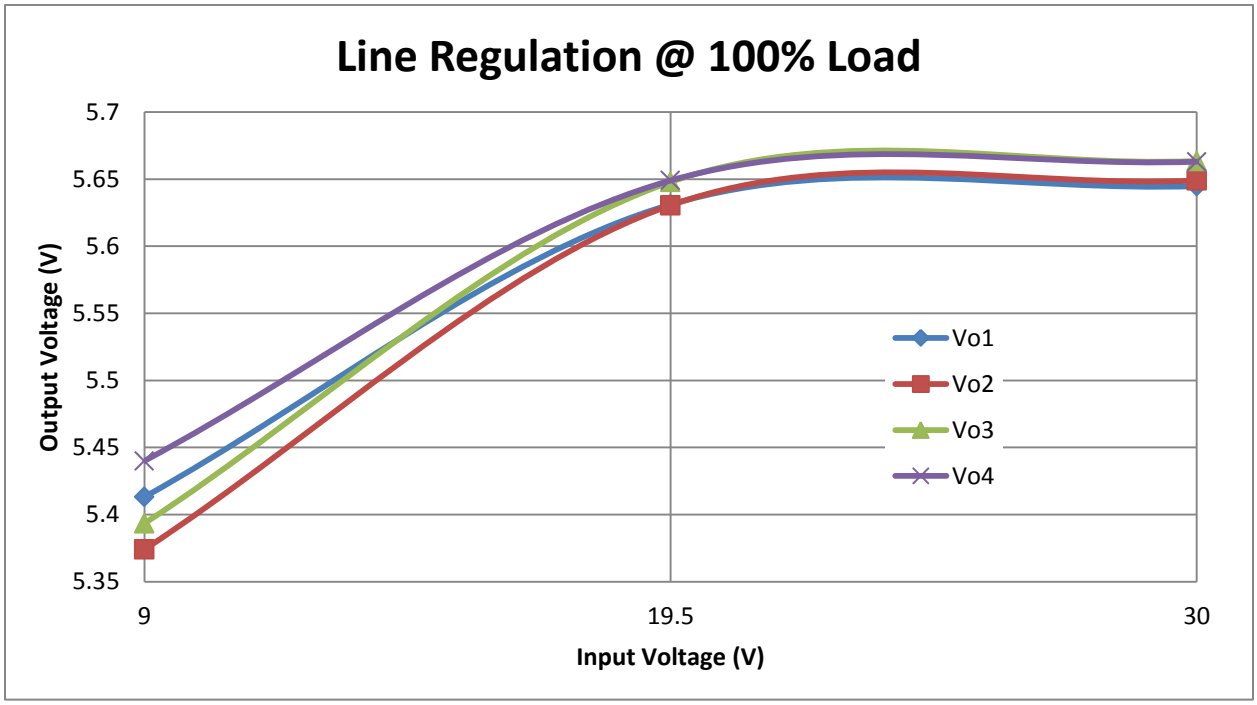
6.1 Line Regulation



Line Regulation @ 0% Load				
Vin (V)	**Vo1 (V)**	**Vo2 (V)**	**Vo3 (V)**	**Vo4 (V)**
9	5.9524	5.9494	5.9642	5.961
19.5	5.9871	5.9834	5.9962	5.998
30	6.0022	5.9976	6.0088	6.018

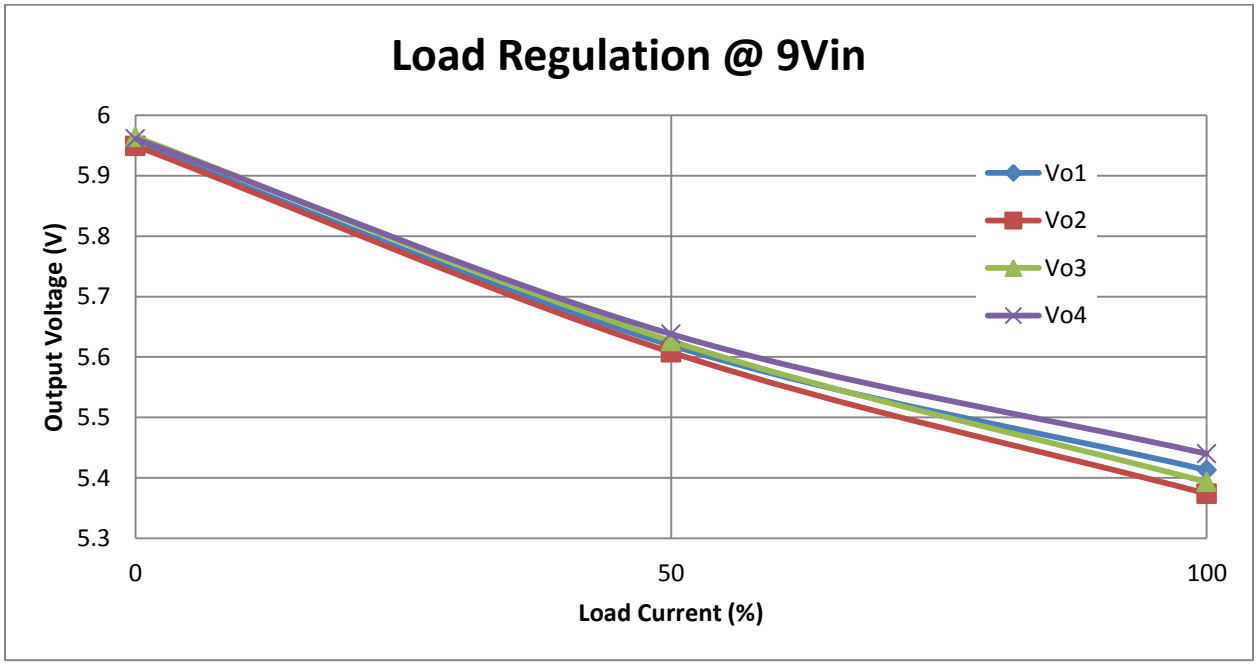


Line Regulation @ 50% Load				
Vin (V)	**Vo1 (V)**	**Vo2 (V)**	**Vo3 (V)**	**Vo4 (V)**
9	5.6194	5.6079	5.6265	5.638
19.5	5.7127	5.715	5.7326	5.728
30	5.7435	5.7467	5.763	5.76

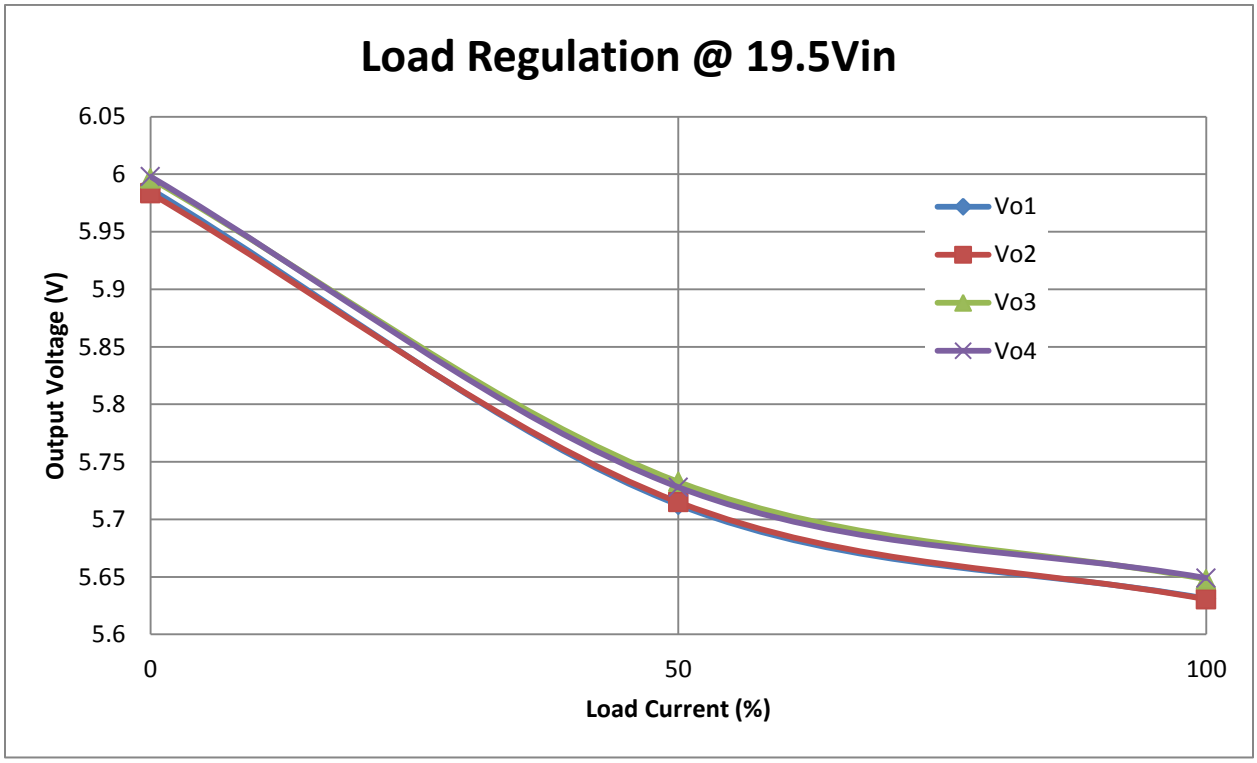


Line Regulation @ 100% Load				
Vin (V)	**Vo1 (V)**	**Vo2 (V)**	**Vo3 (V)**	**Vo4 (V)**
9	5.4131	5.374	5.3934	5.44
19.5	5.6311	5.6305	5.6479	5.649
30	5.6448	5.649	5.6635	5.663

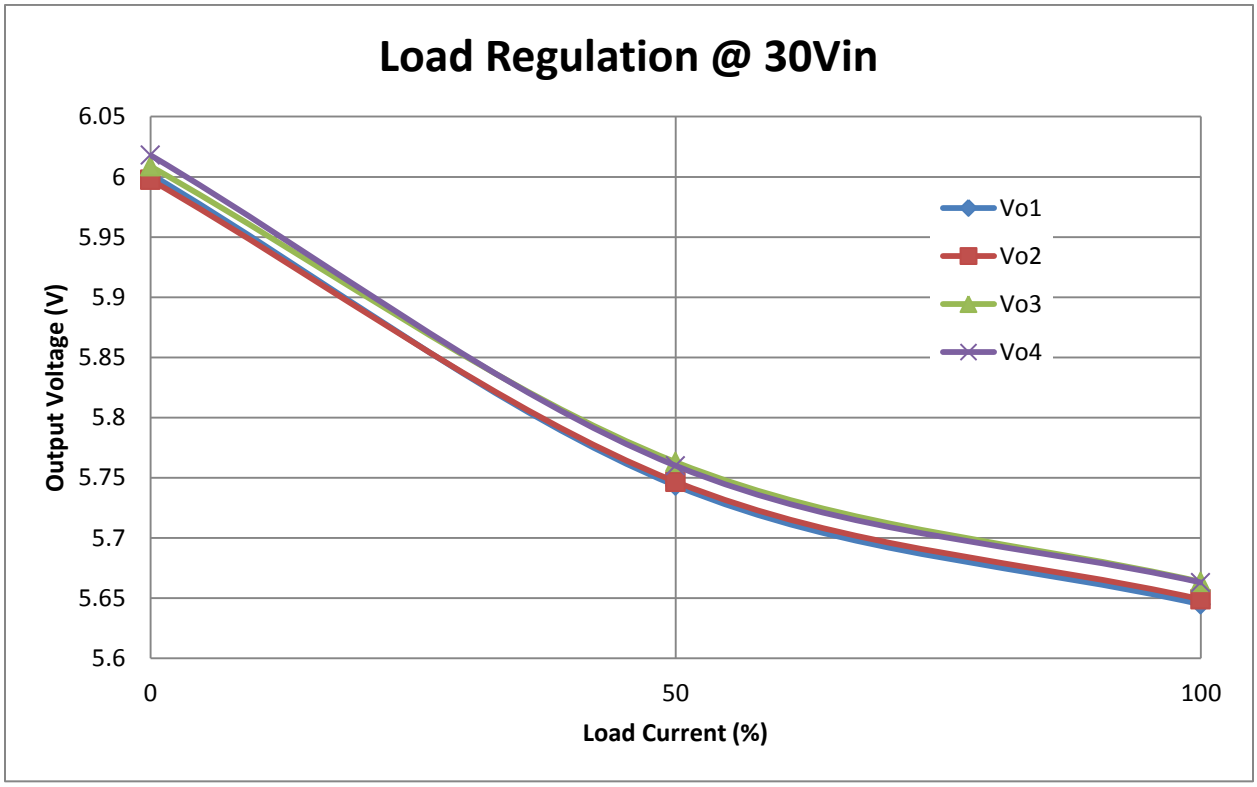
6.2 Load Regulation



Load Regulation @ 9Vin				
Load (%)	**Vo1 (V)**	**Vo2 (V)**	**Vo3 (V)**	**Vo4 (V)**
0	5.9524	5.9494	5.9642	5.961
50	5.6194	5.6079	5.6265	5.638
100	5.4131	5.374	5.3934	5.44



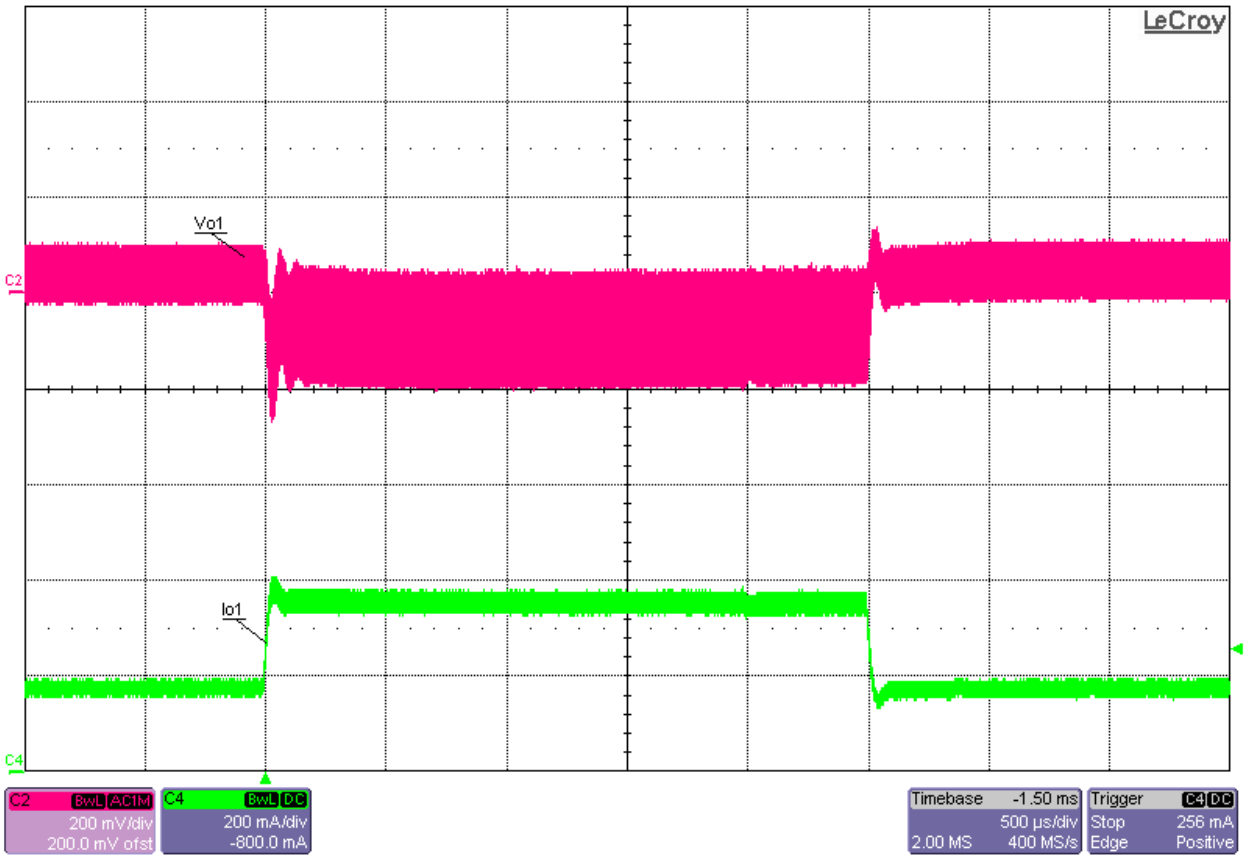
Load Regulation @ 19.5Vin				
Load (%)	**Vo1 (V)**	**Vo2 (V)**	**Vo3 (V)**	**Vo4 (V)**
0	5.9871	5.9834	5.9962	5.998
50	5.7127	5.715	5.7326	5.728
100	5.6311	5.6305	5.6479	5.649



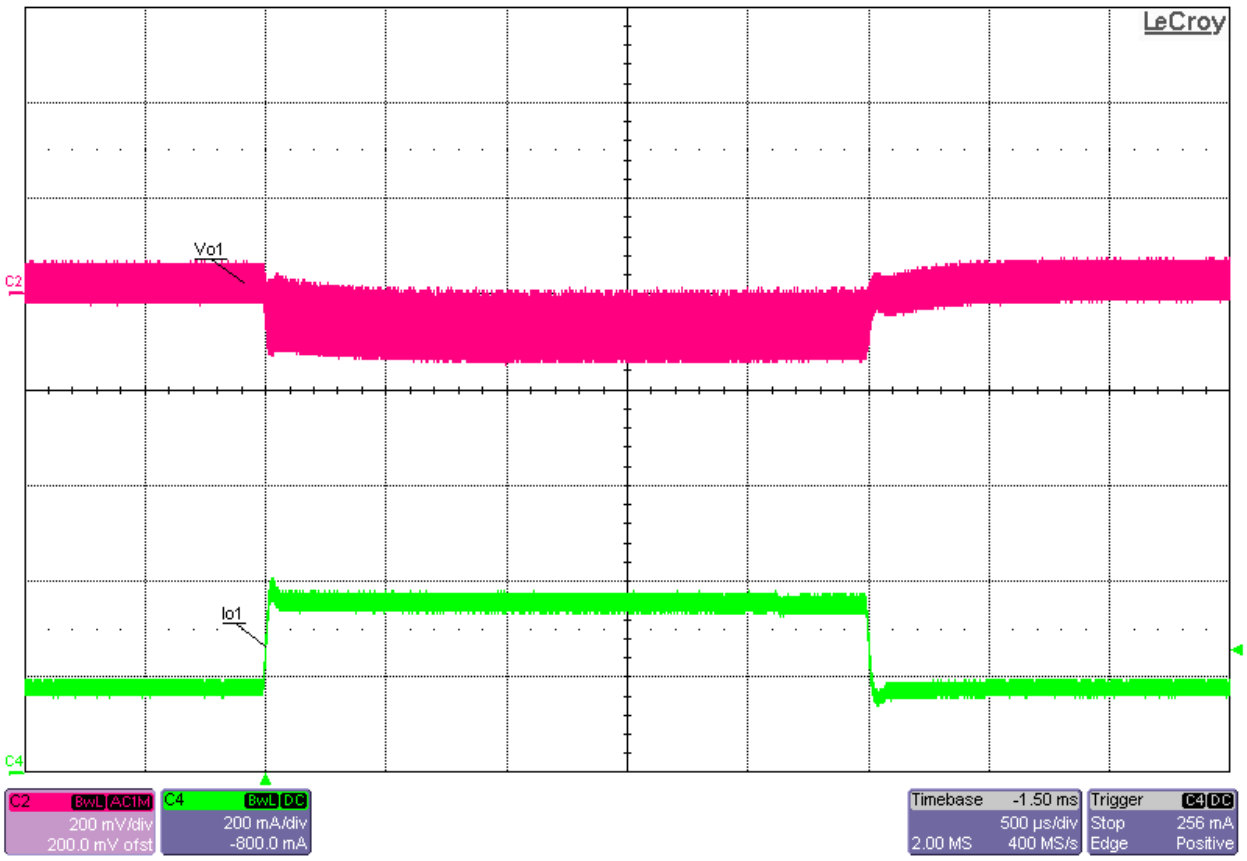
Load Regulation @ 30Vin				
Load (%)	**Vo1 (V)**	**Vo2 (V)**	**Vo3 (V)**	**Vo4 (V)**
0	6.0022	5.9976	6.0088	6.018
50	5.7435	5.7467	5.763	5.76
100	5.6448	5.649	5.6635	5.663

7 Waveforms

7.1 Load Transient Response

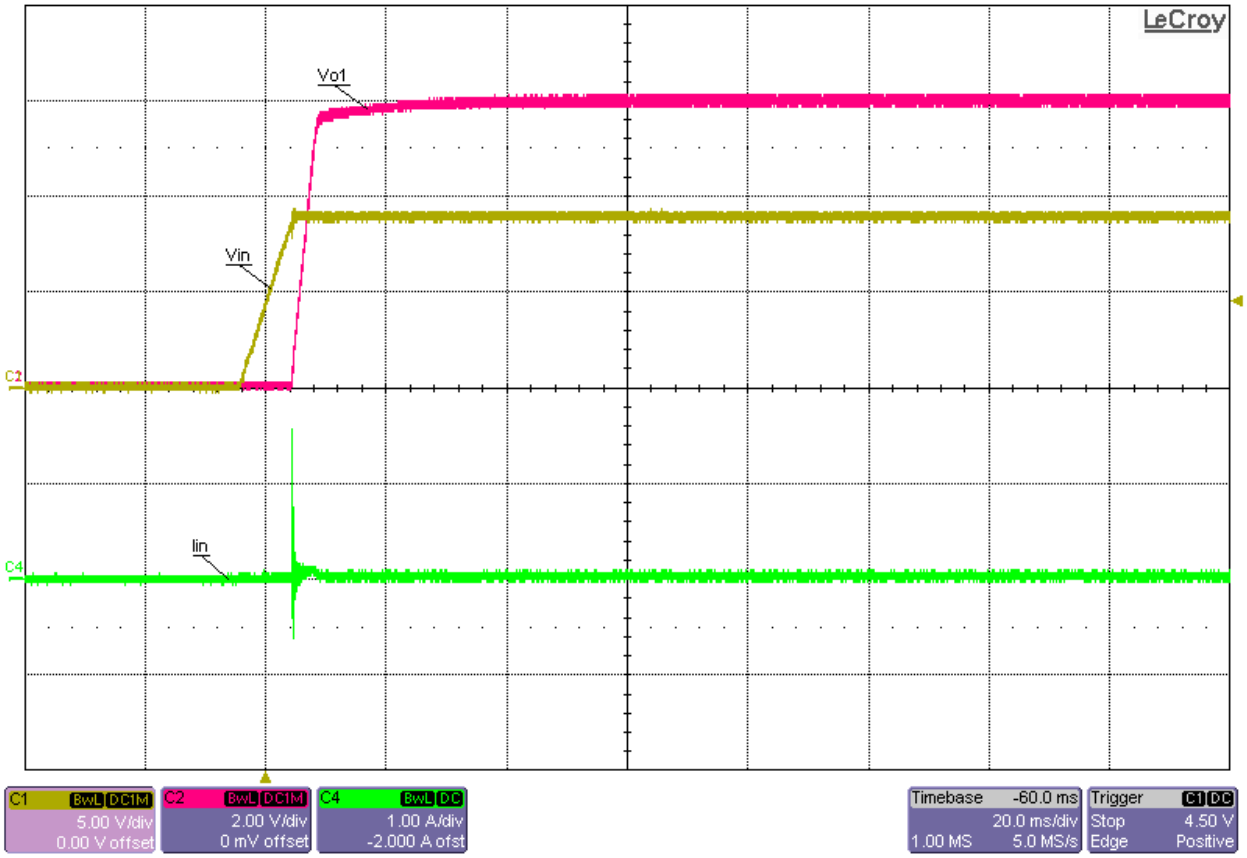


Load Transient Response of Vo1 Rail Undergoing 50% to 100% (0.175A-to-0.35A) Load Step and All Other Rails at Full Load and Input Voltage at 9Vin

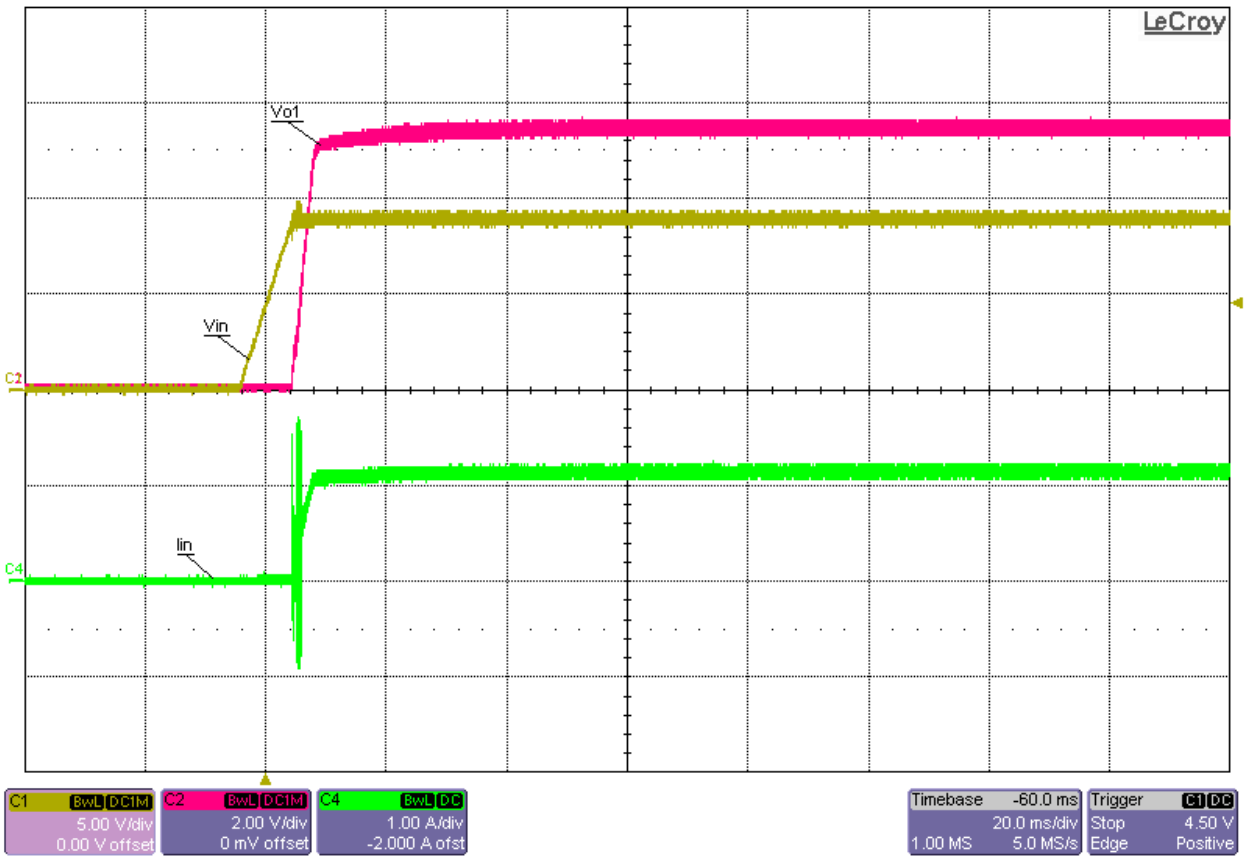


Load Transient Response of Vo1 Rail Undergoing 50% to 100% (0.175A-to-0.35A) Load Step and All Other Rails at Full Load and Input Voltage at 30Vin

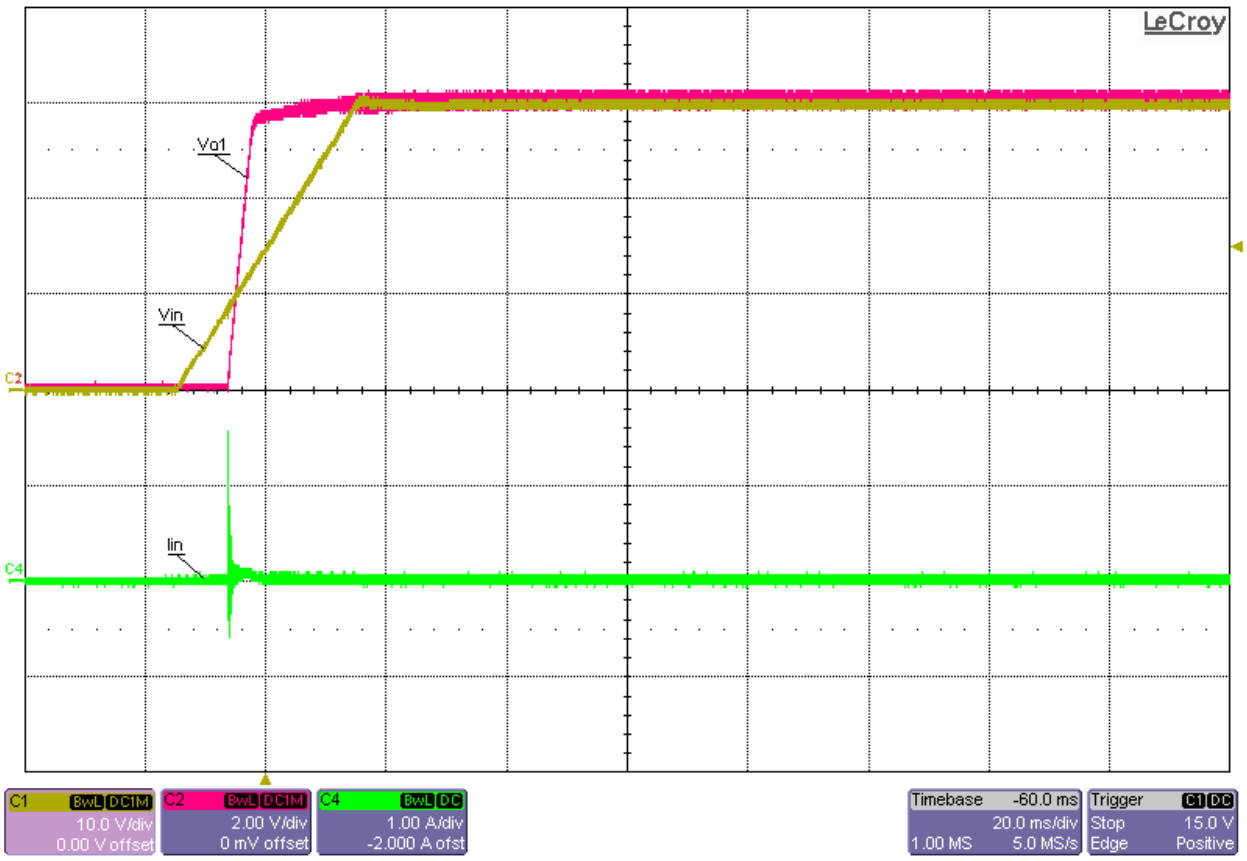
7.2 Startup



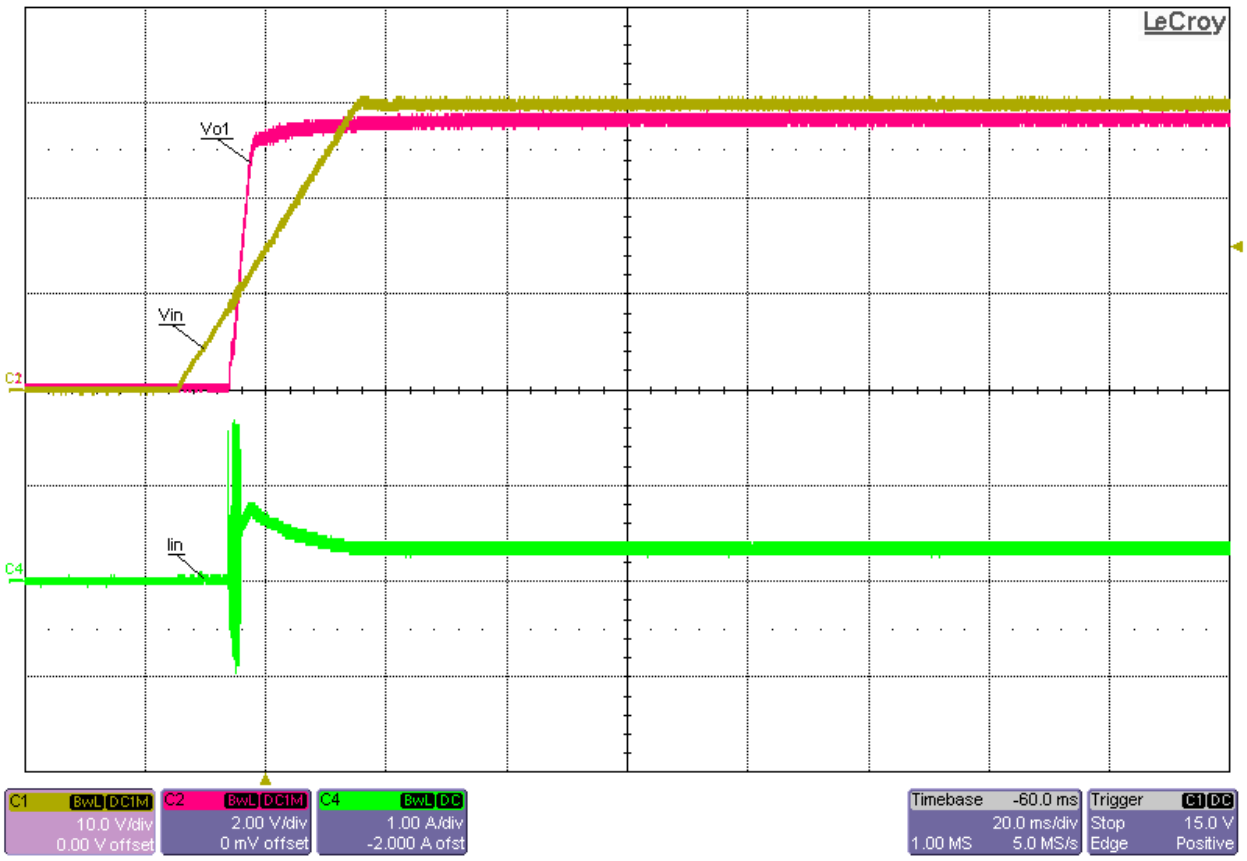
Startup into No Load (on All Output Rails) at 9Vin



Startup into Full Load (on All Output Rails) at 9Vin

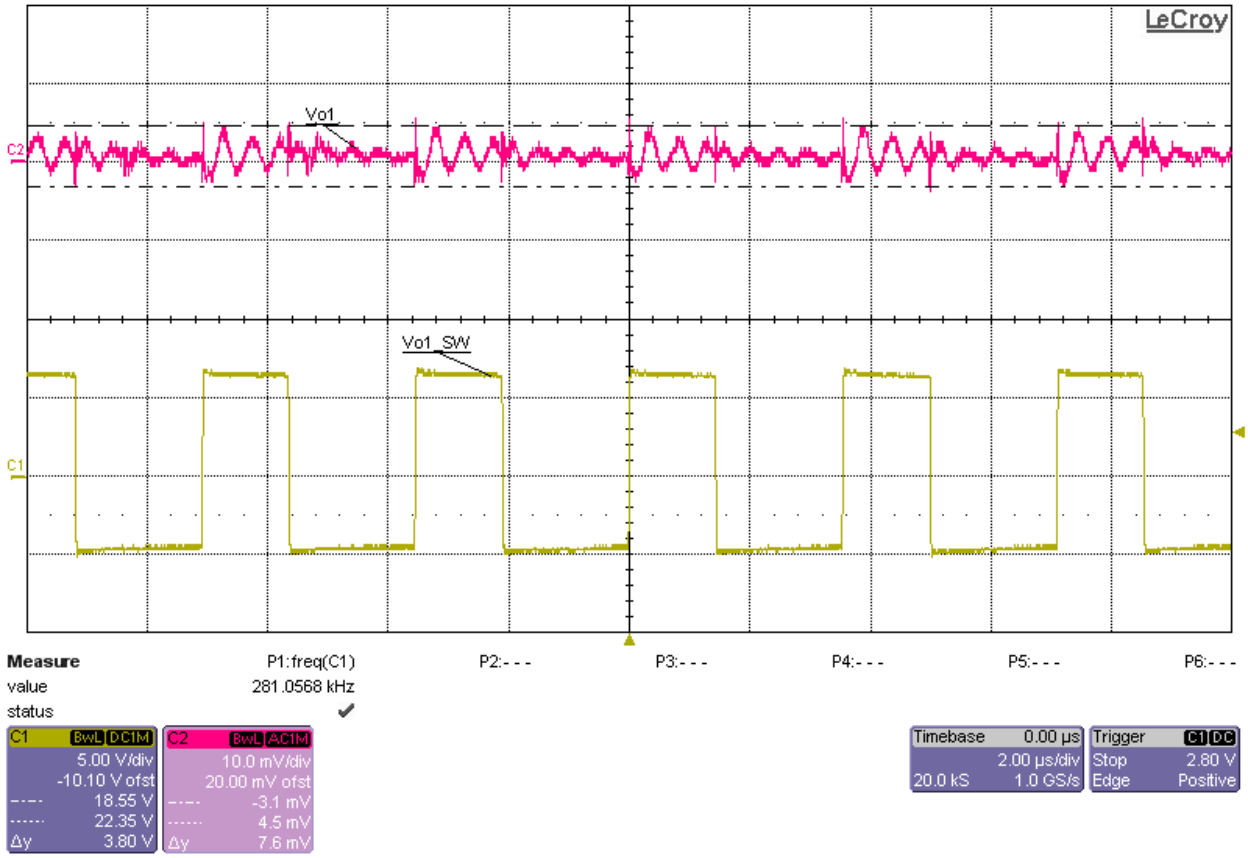


Startup into No Load (on All Output Rails) at 30Vin

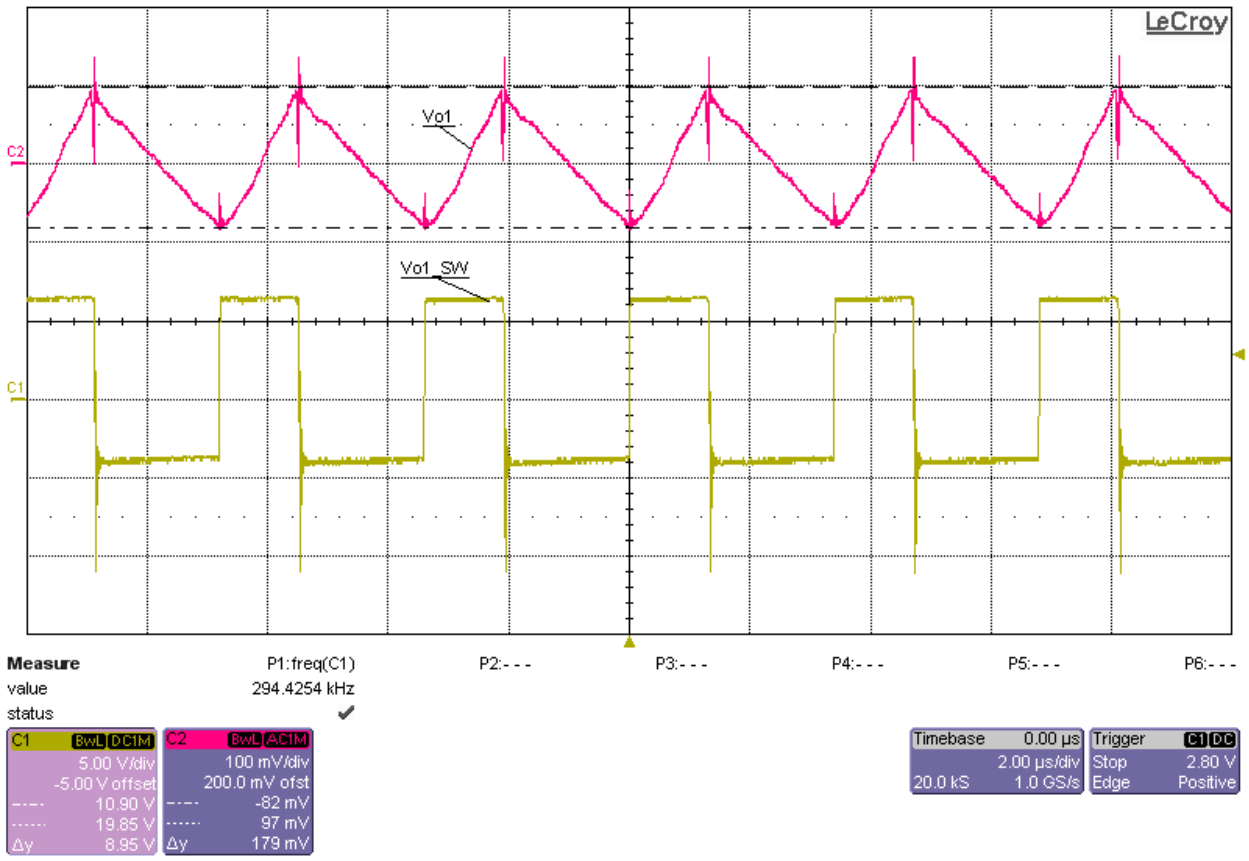


Startup into Full Load (on All Output Rails) at 30Vin

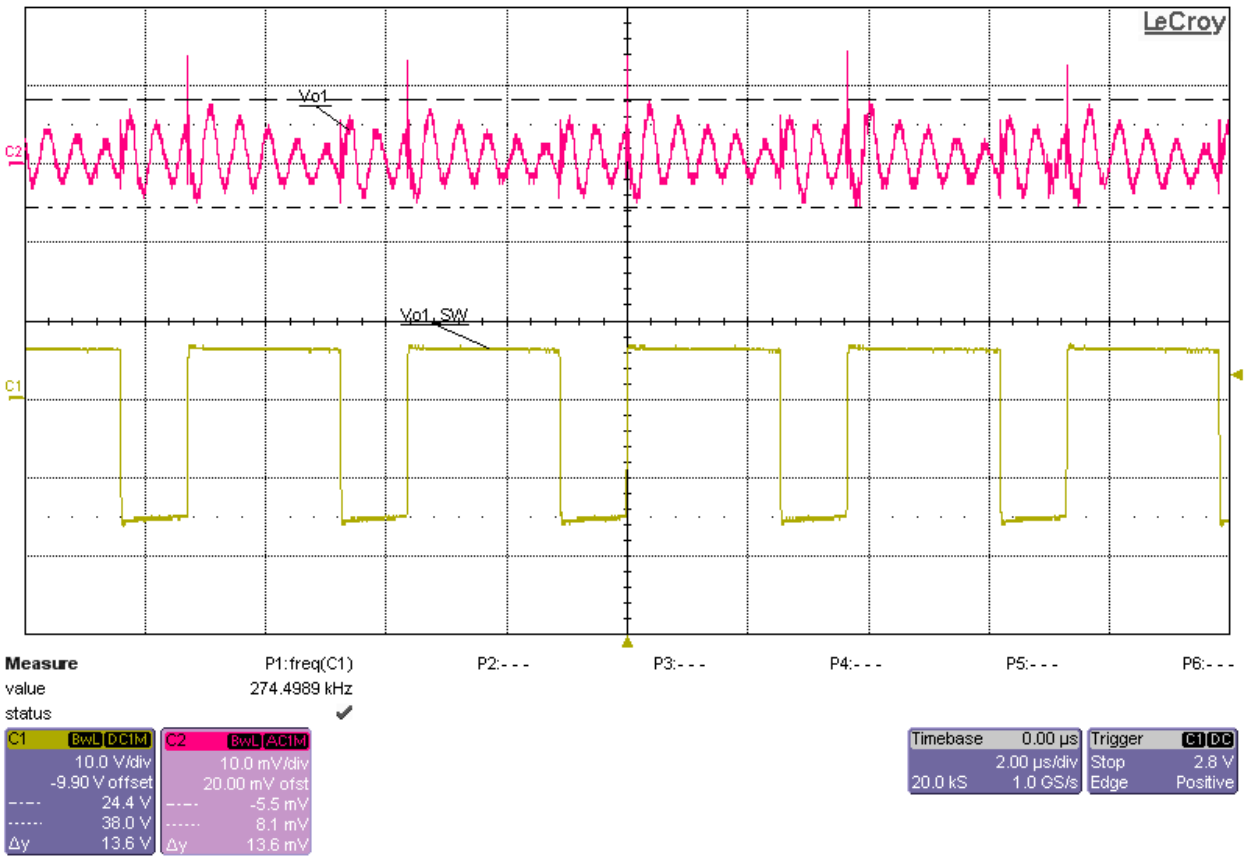
7.3 Output Voltage Ripple and Switch Node Voltage



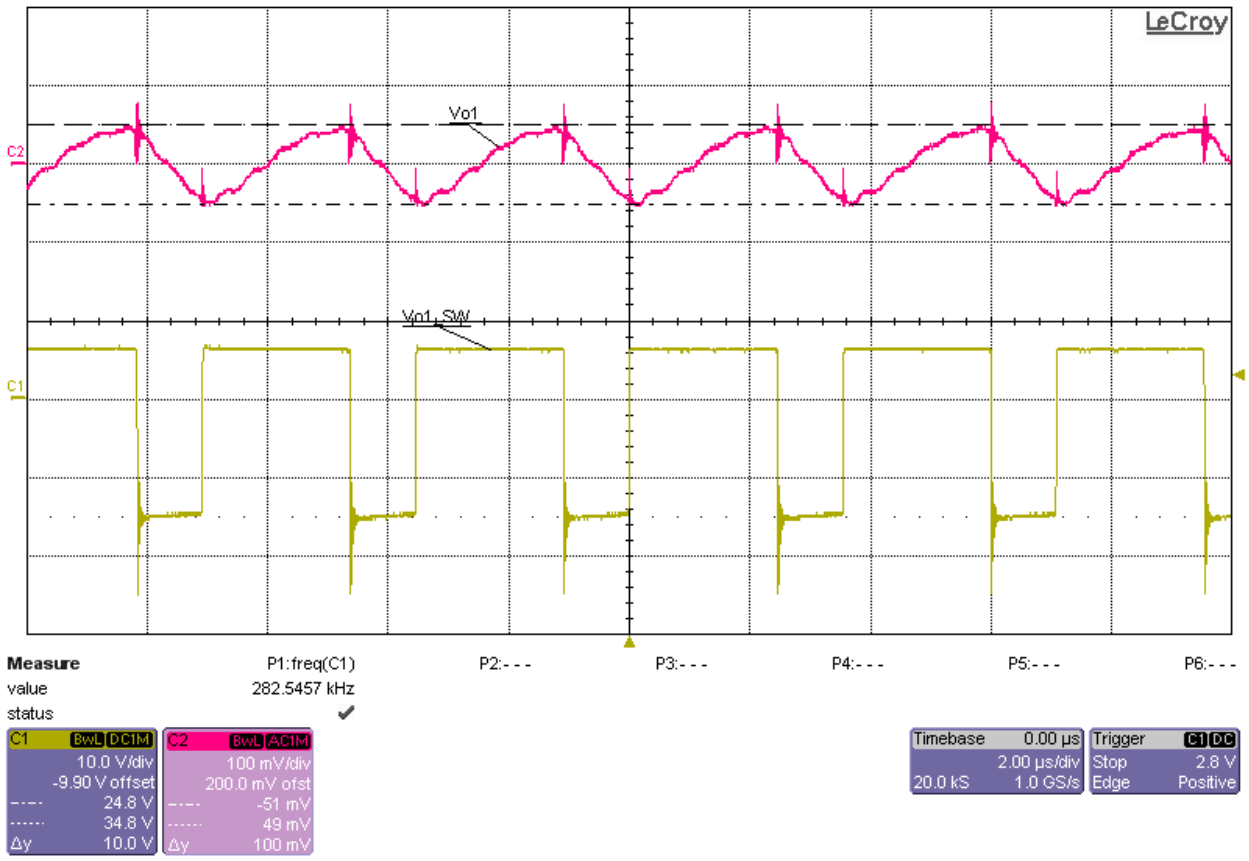
Vo1 Rail Switch Node Voltage and Output Voltage Ripple at 9Vin and All Output Rails at No Load (Vripple ≈ 7.6mVp-p)



Vo1 Rail Switch Node Voltage and Output Voltage Ripple at 9Vin and All Output Rails at Full Load (Vripple ≈ 179mVp-p)

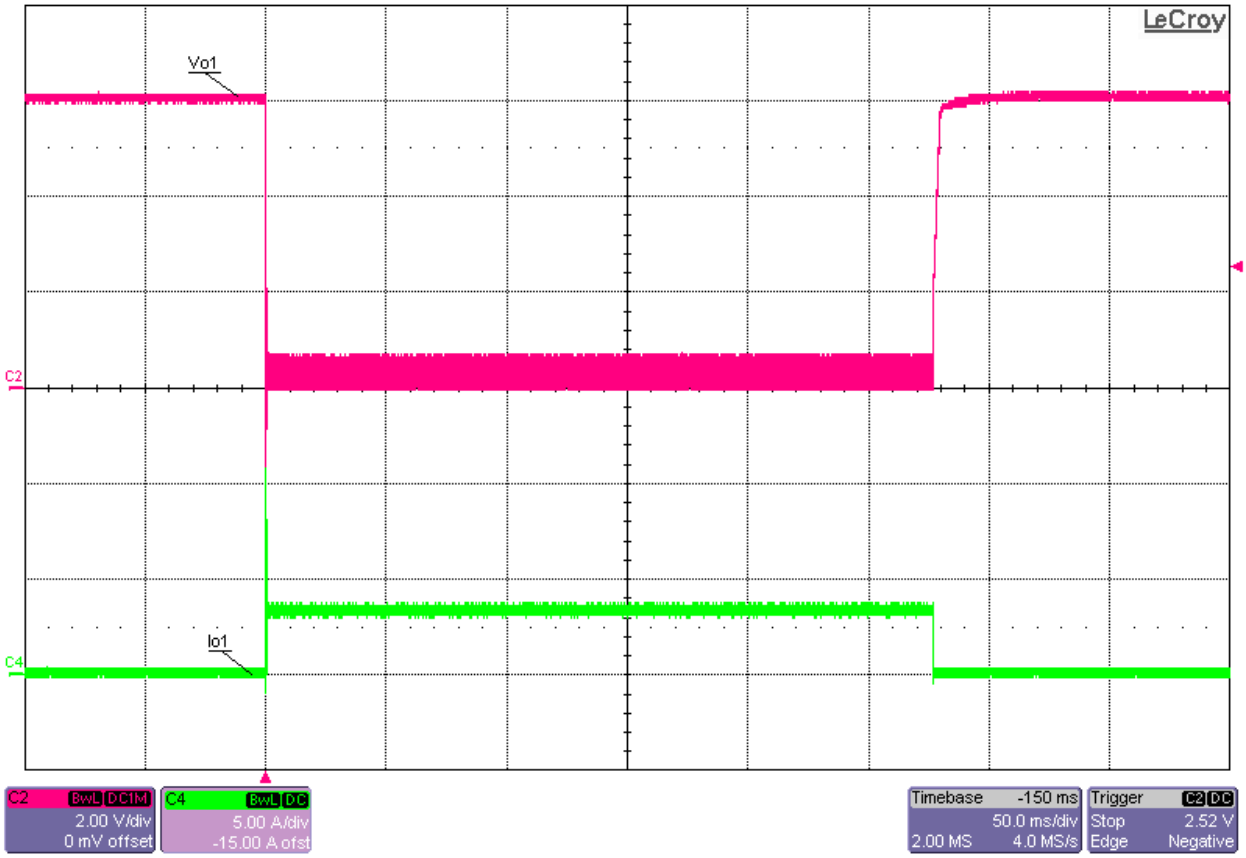


Vo1 Rail Switch Node Voltage and Output Voltage Ripple at 30Vin and All Output Rails at No Load (Vripple ≈ 13.6mVp-p)

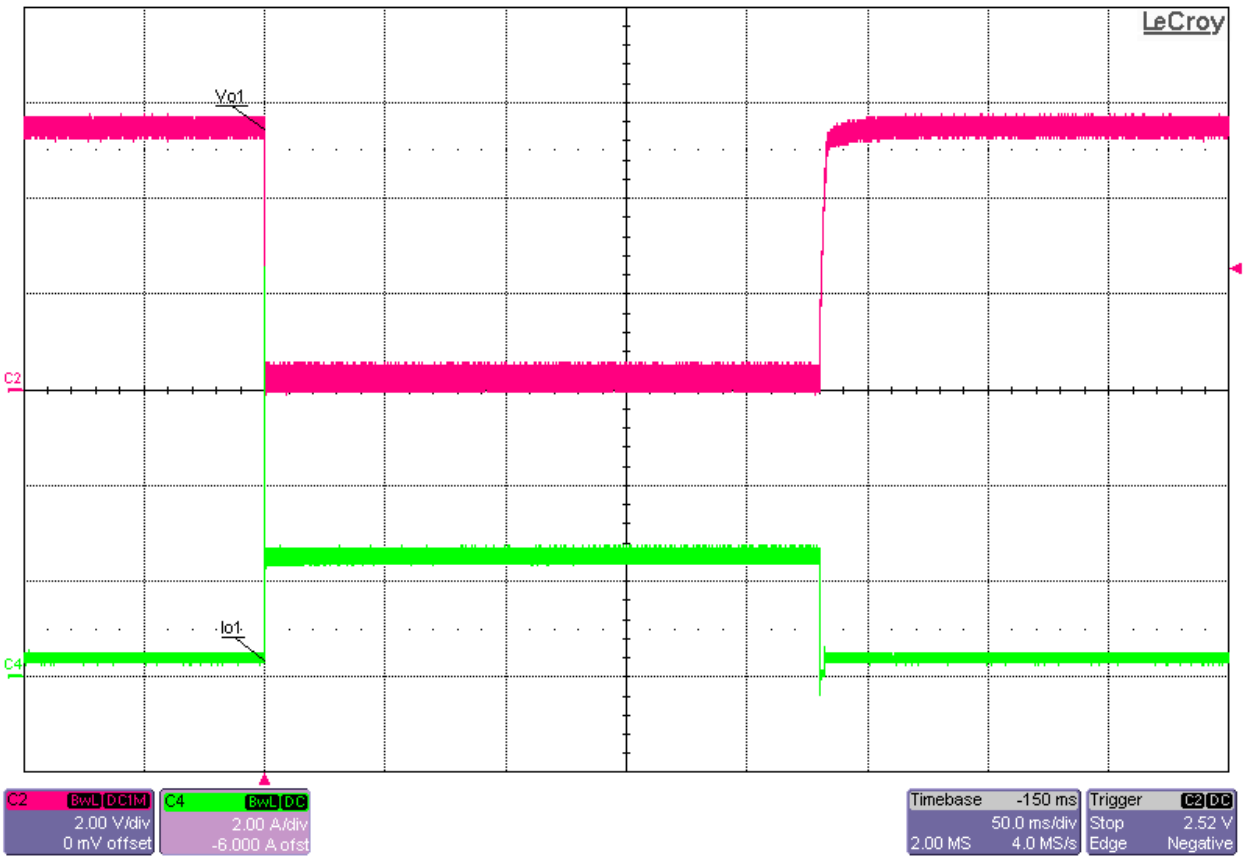


Vo1 Rail Switch Node Voltage and Output Voltage Ripple at 30Vin and All Output Rails at Full Load (Vripple ≈ 100mVp-p)

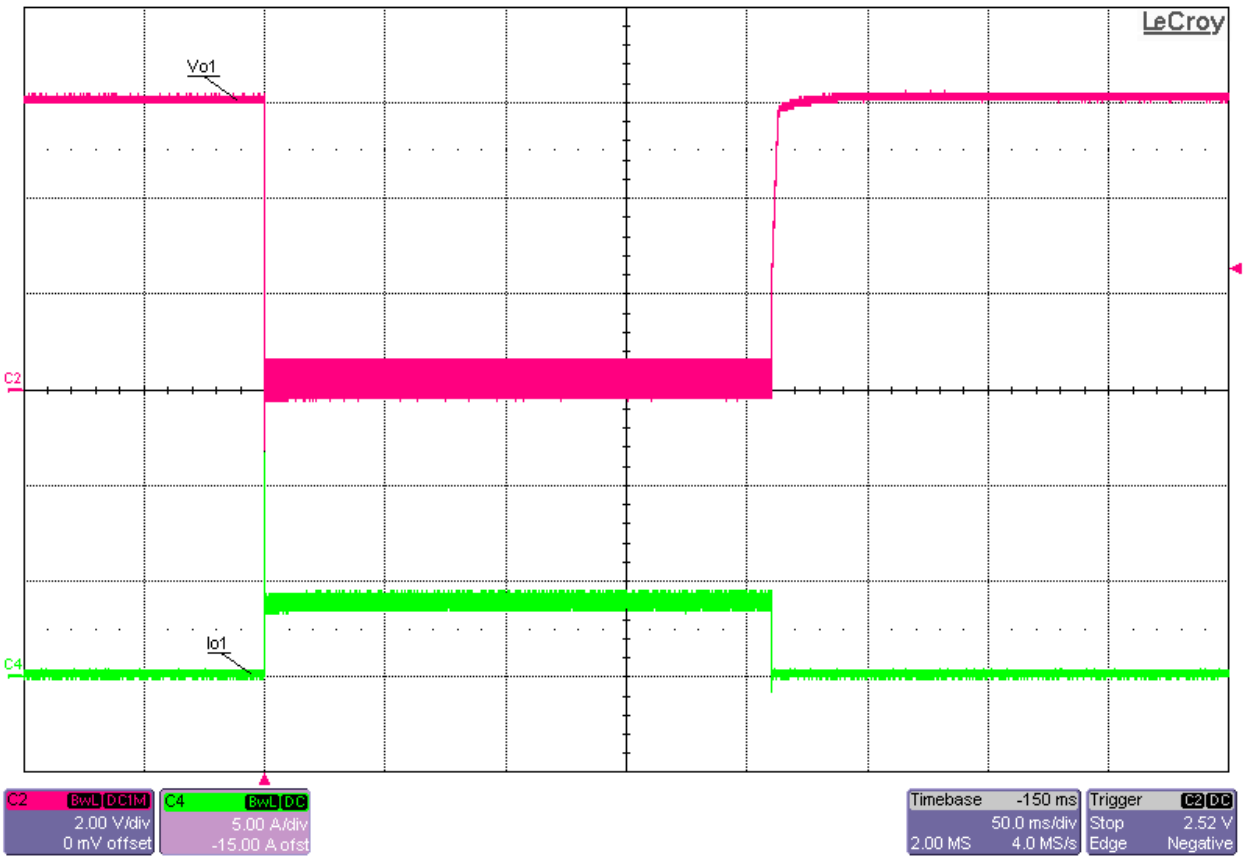
7.4 Short Circuit Testing



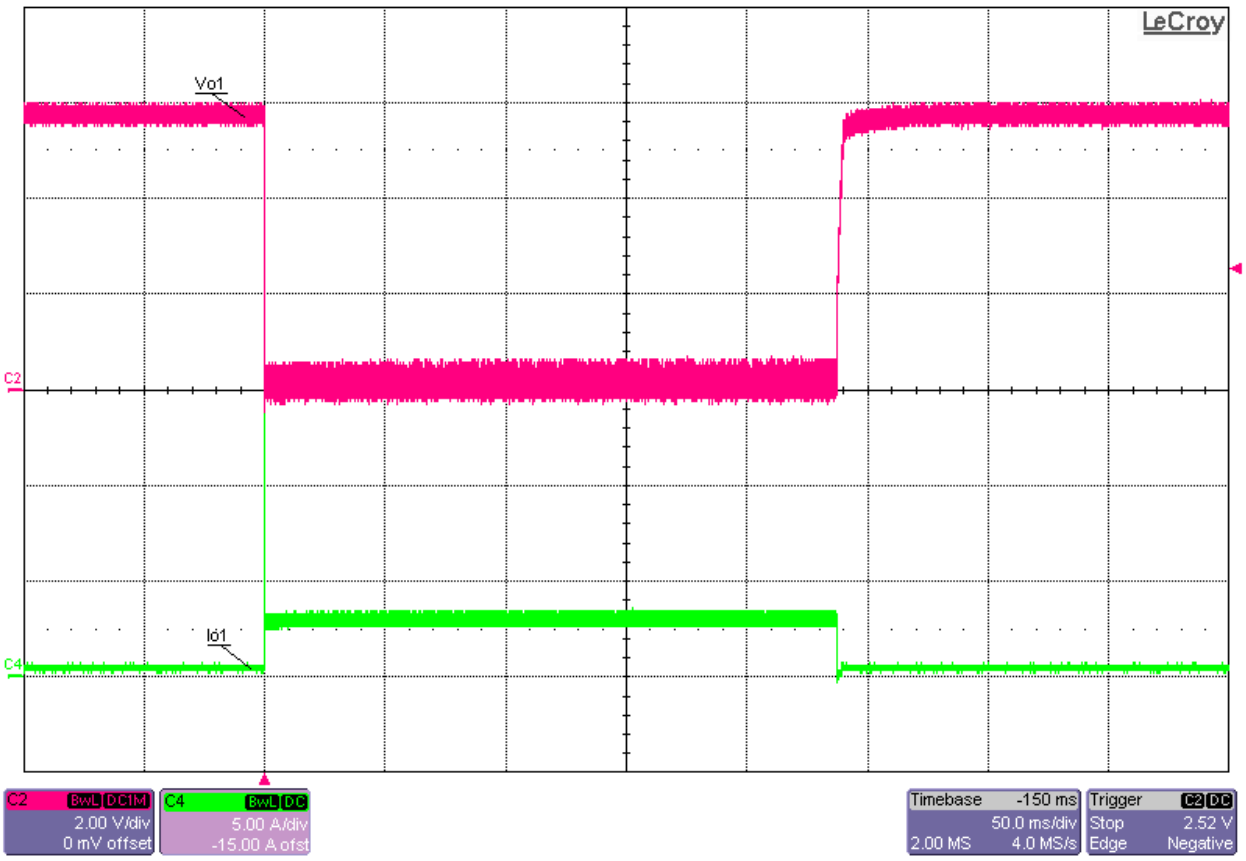
Short Circuit Testing on Vo1 Output Rail with All Output Rails at No Load and Input Voltage at 9V



Short Circuit Testing on Vo1 Output Rail with All Output Rails at Full Load and Input Voltage at 9V



Short Circuit Testing on Vo1 Output Rail with All Output Rails at No Load and Input Voltage at 30V



Short Circuit Testing on Vo1 Output Rail with All Output Rails at Full Load and Input Voltage at 30V

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