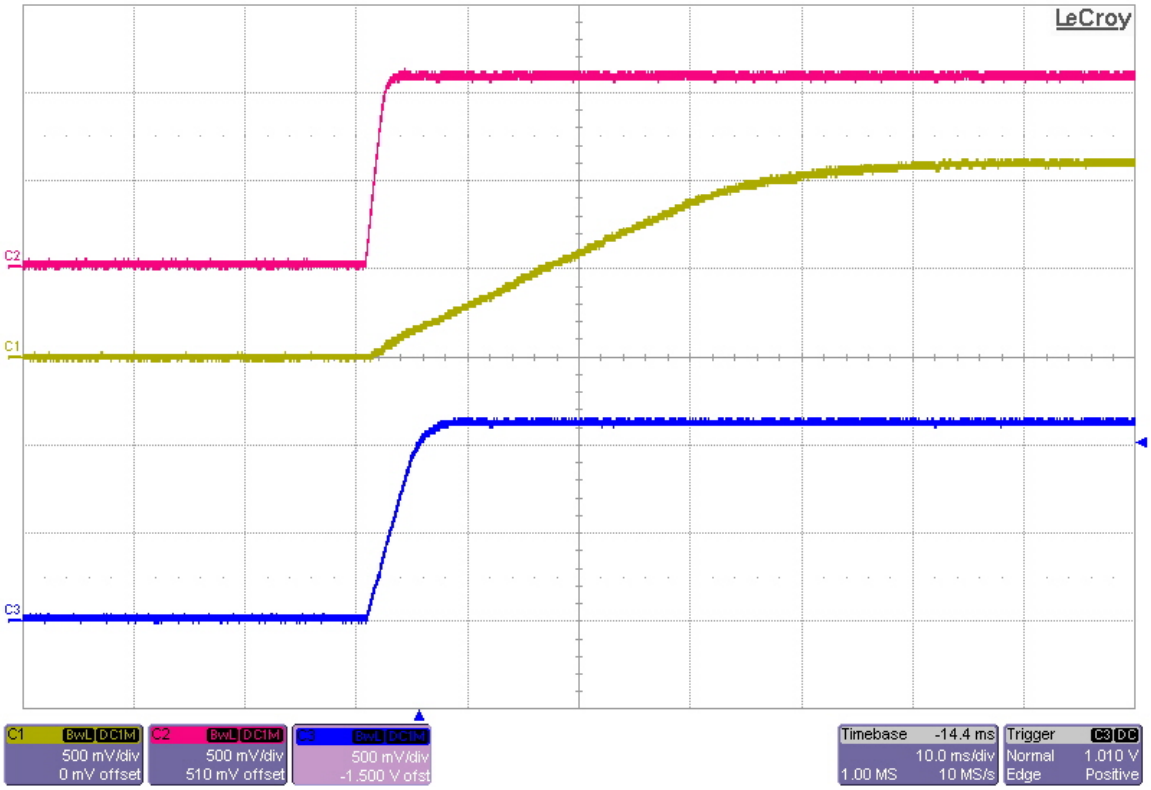
Abstract:

All the equations used to calculate component values in the PMP8275 design are located in the “Design Procedures” section of the various IC’s datasheets. The datasheet of the LM10011 details how to design the feedback network of the system.

1 Startup

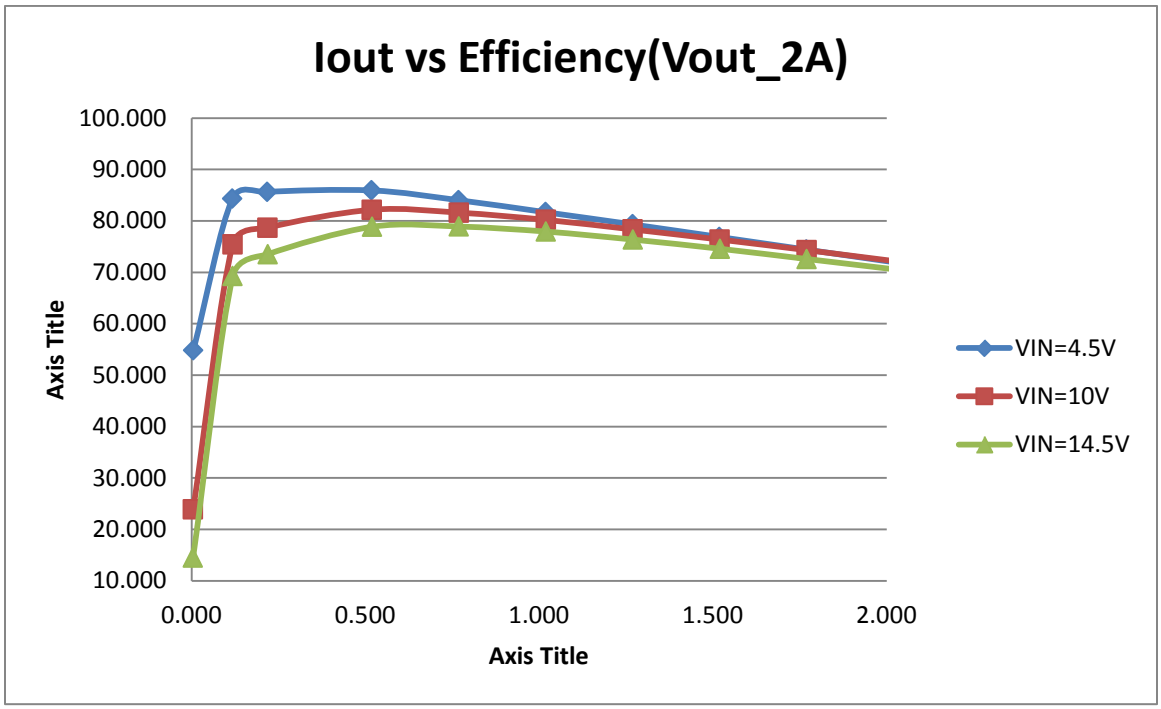
Input voltage = 12V
Output voltage = 1.1V
Load current = 0A



C1: VOUT_5A; C2:VOUT_3A; C3:VOUT_3A_MODULE

2 Efficiency

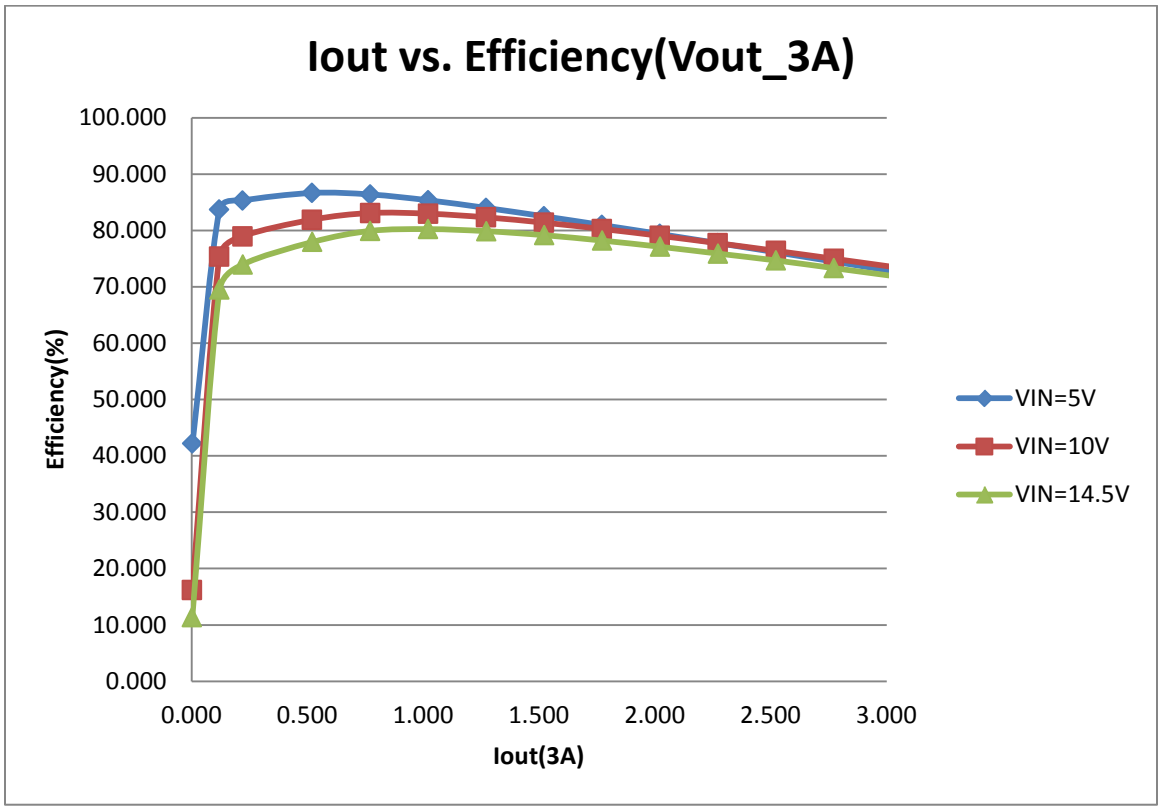
The efficiency is shown in the figure below.



VIN	IVIN	ILOAD	VOUT	EFFI%
4.500	0.002	0.005	0.977	54.852
4.500	0.030	0.118	0.975	84.307
4.500	0.055	0.218	0.970	85.637
4.500	0.130	0.518	0.970	85.926
4.500	0.197	0.769	0.970	84.028
4.500	0.269	1.019	0.970	81.688
4.500	0.345	1.269	0.970	79.315
4.500	0.426	1.519	0.970	76.869
4.500	0.513	1.769	0.970	74.416
4.500	0.605	2.020	0.970	71.972

VIN	IVIN	ILOAD	VOUT	EFFI%
10.005	0.002	0.005	0.980	23.876
10.005	0.015	0.118	0.978	75.404
10.005	0.027	0.219	0.972	78.678
10.005	0.061	0.519	0.972	82.175
10.005	0.092	0.769	0.972	81.603
10.005	0.124	1.020	0.972	80.196
10.005	0.157	1.270	0.971	78.329
10.005	0.193	1.520	0.971	76.368
10.005	0.231	1.771	0.971	74.313
10.005	0.272	2.021	0.971	72.192

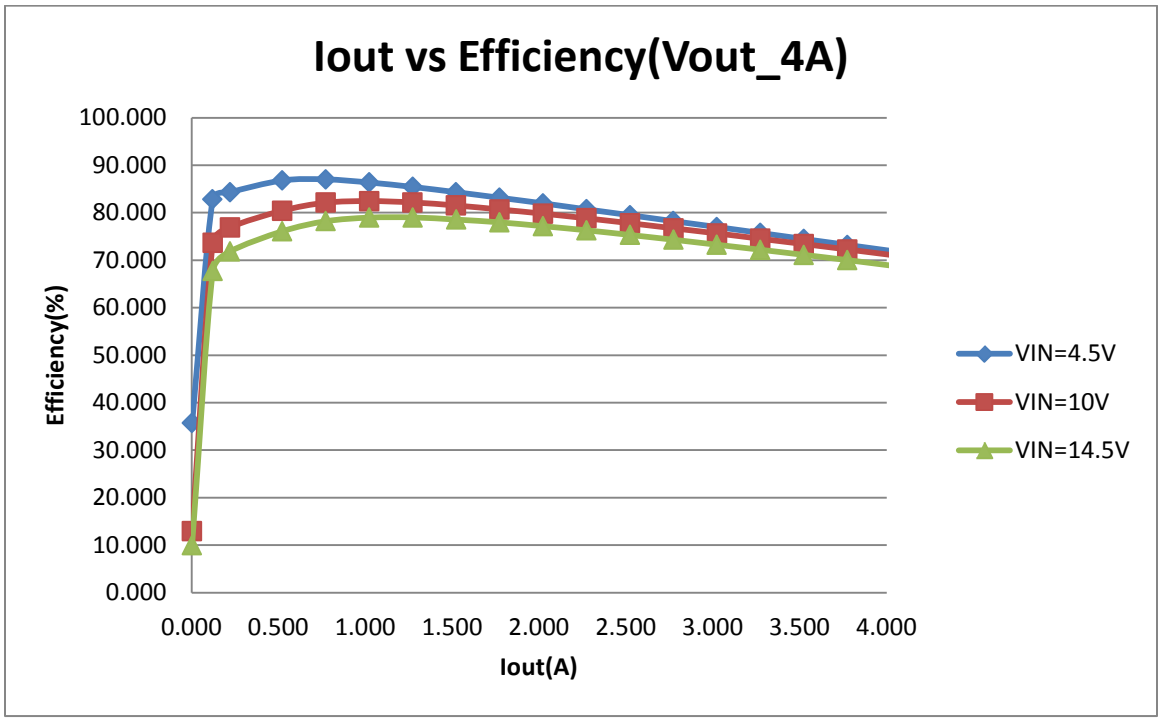
VIN	IVIN	ILOAD	VOUT	EFFI%
14.505	0.002	0.004	0.980	14.480
14.505	0.012	0.119	0.979	69.276
14.505	0.020	0.220	0.975	73.521
14.505	0.044	0.520	0.973	78.867
14.505	0.065	0.770	0.973	78.904
14.505	0.088	1.020	0.973	77.923
14.505	0.112	1.271	0.973	76.360
14.505	0.137	1.521	0.972	74.577
14.505	0.163	1.770	0.972	72.587
14.505	0.192	2.021	0.972	70.590



VIN	IVIN	ILOAD	VOUT	EFFI%
4.500	0.002	0.004	0.973	42.209
4.500	0.031	0.120	0.972	83.726
4.500	0.056	0.221	0.972	85.305
4.500	0.130	0.521	0.970	86.659
4.500	0.192	0.771	0.970	86.388
4.500	0.258	1.022	0.969	85.357
4.500	0.326	1.272	0.969	83.997
4.500	0.397	1.522	0.969	82.512
4.500	0.471	1.772	0.969	80.958
4.500	0.548	2.022	0.968	79.371
4.500	0.629	2.272	0.968	77.751
4.500	0.713	2.522	0.968	76.130
4.500	0.801	2.773	0.968	74.465
4.500	0.893	3.023	0.967	72.805

VIN	IVIN	ILOAD	VOUT	EFFI%
10.005	0.002	0.003	0.975	16.201
10.005	0.016	0.121	0.974	75.386
10.005	0.027	0.221	0.974	78.965
10.005	0.062	0.521	0.972	81.916
10.005	0.090	0.771	0.972	83.097
10.005	0.120	1.022	0.972	82.975
10.005	0.150	1.272	0.971	82.328
10.005	0.182	1.522	0.971	81.380
10.005	0.214	1.773	0.971	80.262
10.005	0.248	2.022	0.970	79.045
10.005	0.283	2.273	0.970	77.736
10.005	0.320	2.523	0.970	76.375
10.005	0.358	2.773	0.969	74.976
10.005	0.398	3.024	0.969	73.549

VIN	IVIN	ILOAD	VOUT	EFFI%
14.505	0.002	0.003	0.975	11.347
14.505	0.012	0.121	0.975	69.497
14.505	0.020	0.221	0.975	73.966
14.505	0.045	0.522	0.974	77.949
14.504	0.065	0.772	0.973	79.925
14.504	0.085	1.022	0.973	80.236
14.505	0.107	1.273	0.973	79.874
14.505	0.129	1.523	0.972	79.155
14.505	0.152	1.773	0.972	78.201
14.504	0.176	2.023	0.972	77.104
14.504	0.201	2.273	0.971	75.892
14.505	0.226	2.523	0.971	74.674
14.505	0.253	2.774	0.971	73.308
14.505	0.281	3.024	0.970	71.937



VIN	IVIN	ILOAD	VOUT	EFFI%
4.500	0.002	0.003	0.979	35.718
4.500	0.032	0.122	0.978	82.829
4.500	0.057	0.222	0.978	84.303
4.500	0.130	0.522	0.974	86.797
4.500	0.192	0.773	0.974	87.020
4.500	0.257	1.023	0.974	86.364
4.500	0.323	1.273	0.974	85.425
4.500	0.391	1.523	0.974	84.320
4.500	0.462	1.773	0.974	83.154
4.500	0.534	2.024	0.974	81.966
4.500	0.610	2.273	0.974	80.712
4.500	0.687	2.524	0.974	79.476
4.500	0.767	2.774	0.973	78.220
4.500	0.850	3.025	0.973	76.987
4.500	0.935	3.275	0.973	75.732
4.500	1.023	3.524	0.973	74.467
4.500	1.114	3.774	0.973	73.220
4.500	1.209	4.025	0.973	71.968

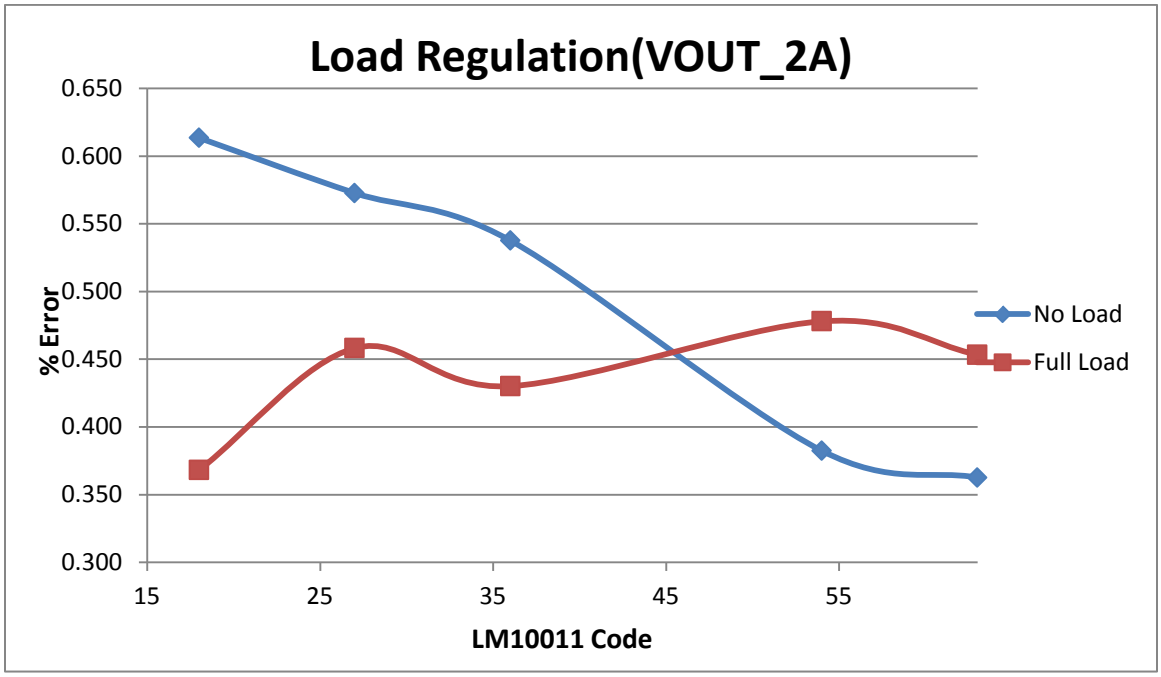
VIN	IVIN	ILOAD	VOUT	EFFI%
10.005	0.002	0.003	0.980	12.963
10.005	0.016	0.122	0.979	73.661
10.005	0.028	0.222	0.979	76.928
10.005	0.063	0.522	0.975	80.429
10.005	0.092	0.773	0.975	82.118
10.005	0.121	1.023	0.975	82.449
10.005	0.151	1.273	0.975	82.164
10.005	0.182	1.523	0.975	81.521
10.005	0.214	1.773	0.974	80.687
10.005	0.247	2.024	0.974	79.802
10.005	0.281	2.274	0.974	78.820
10.005	0.316	2.524	0.974	77.790
10.005	0.352	2.774	0.974	76.715
10.005	0.389	3.025	0.974	75.644
10.005	0.428	3.275	0.974	74.509
10.005	0.467	3.525	0.973	73.393
10.005	0.508	3.775	0.973	72.262
10.005	0.550	4.025	0.973	71.111

VIN	IVIN	ILOAD	VOUT	EFFI%
14.505	0.002	0.003	0.980	10.007
14.505	0.012	0.122	0.979	67.745
14.504	0.021	0.223	0.979	71.845
14.505	0.046	0.523	0.976	76.102
14.504	0.067	0.774	0.976	78.212
14.504	0.087	1.024	0.976	78.972
14.505	0.108	1.274	0.976	79.014
14.505	0.131	1.524	0.976	78.550
14.504	0.153	1.774	0.976	77.974
14.505	0.176	2.024	0.975	77.161
14.504	0.200	2.274	0.975	76.295
14.505	0.225	2.525	0.975	75.315
14.505	0.251	2.775	0.975	74.304
14.504	0.277	3.025	0.975	73.255
14.505	0.305	3.275	0.974	72.198
14.504	0.333	3.525	0.974	71.122
14.505	0.362	3.775	0.974	70.020
14.505	0.392	4.025	0.974	68.869

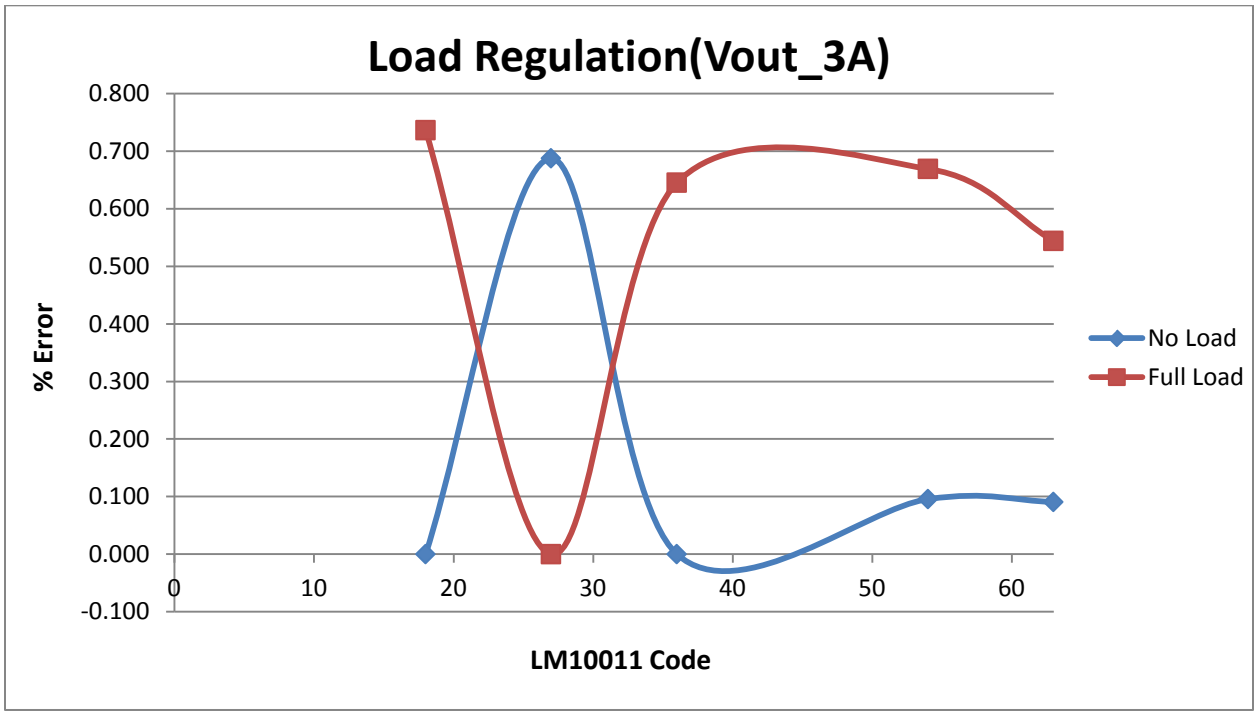
3 Load Regulation (DC Accuracy with LM10011)

The max error that can be tolerated in terms of Vout on the DSP was given to be 5%. The goal of the design was to keep the DC error to a max 2.5%, in order to allow for room to compensate for the AC error. There are 4 main contributors to the final error seen on the output. They are: the error caused by the LM10011, feedback voltage error, the error of resistors in the feedback network, and the load regulation error from the IC. If the compilation of these errors are more than the targeted 2.5%, they can be decreased by using higher precision resistors(.1% or .5%), choosing an IC to minimize the feedback voltage error, as well as the load regulation error.

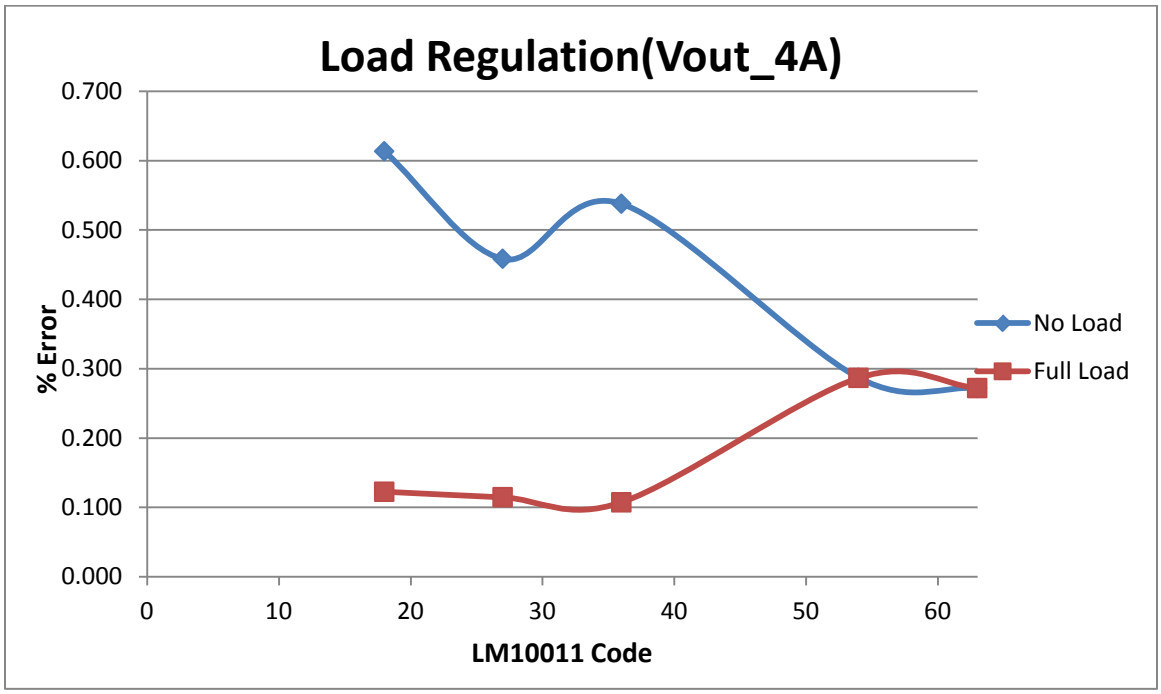
The expected output voltage, in the tables below, was based off the 6 bit-VCNTL pin specifications listed in the C6657 data manual. It also shows the total %DC error seen on the various outputs of the PMP8319 at different LM10011 codes compared to the expected voltages. The data was taken at no-load as well as full load. Please note that all three ICs on the design cannot output less than their Vref(0.765V). The C6657 Data Manual states that it will never request for a voltage below 0.85V, well within the range of all 3 output voltage ranges. The feedback resistors were precise to 1%.



	LM10011 Code	Expected output voltage	Vout_act (no load)	%ERROR (No load)	Vout_act (full load)	%ERROR (Full load)
VIDA,B,C=0	N/A	N/A	N/A	N/A	N/A	N/A
VIDA=1	N/A	N/A	N/A	N/A	N/A	N/A
VIDB=1	18	0.8150	0.82	0.613	0.8120	0.368
VIDA,B=1	27	0.8730	0.878	0.573	0.8690	0.458
VIDC=1	36	0.9300	0.935	0.538	0.9260	0.430
VIDB,C=1	54	1.0460	1.05	0.382	1.0410	0.478
VIDA,B,C=1	63	1.1030	1.107	0.363	1.0980	0.453



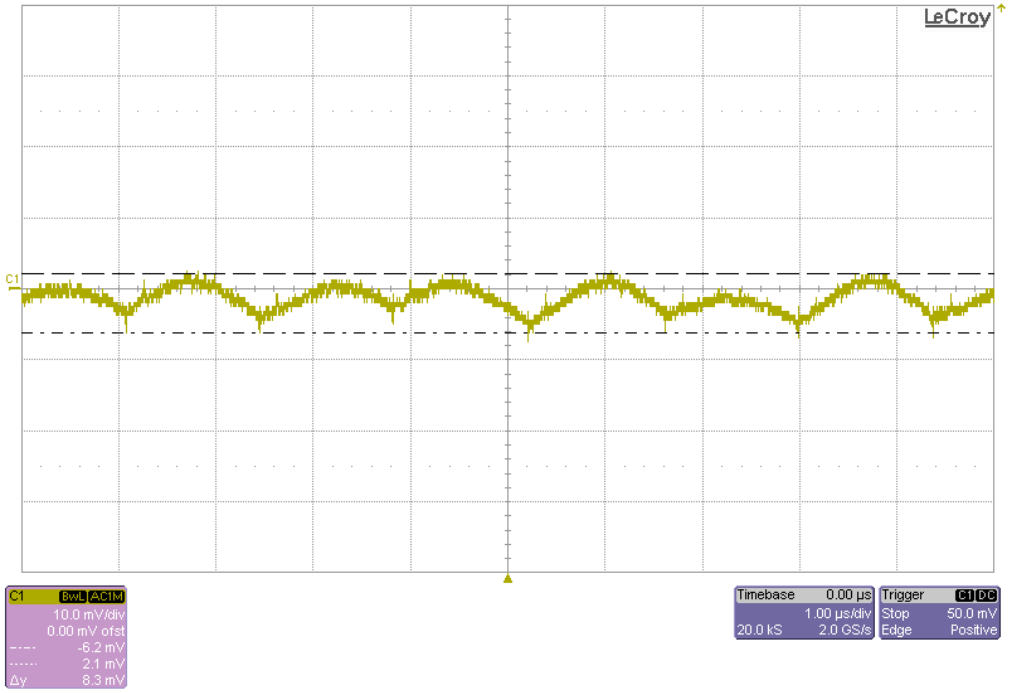
	LM10011 Code	Expected output voltage	Vout_act (no load)	%ERROR (No load)	Vout_act (full load)	%ERROR (Full load)
VIDA,B,C=0	N/A	N/A	N/A	N/A	N/A	N/A
VIDA=1	N/A	N/A	N/A	N/A	N/A	N/A
VIDB=1	18	0.8150	0.815	0.000	0.8090	0.736
VIDA,B=1	27	0.8730	0.879	0.687	0.8730	0.000
VIDC=1	36	0.9300	0.93	0.000	0.9240	0.645
VIDB,C=1	54	1.0460	1.045	0.096	1.0390	0.669
VIDA,B,C=1	63	1.1030	1.102	0.091	1.0970	0.544



	LM10011 Code	Expected output voltage	Vout_act (no load)	%ERROR (No load)	Vout_act (full load)	%ERROR (Full load)
VIDA,B,C=0	N/A	N/A	N/A	N/A	N/A	N/A
VIDA=1	N/A	N/A	N/A	N/A	N/A	N/A
VIDB=1	18	0.8150	0.82	0.613	0.8140	0.123
VIDA,B=1	27	0.8730	0.877	0.458	0.8720	0.115
VIDC=1	36	0.9300	0.935	0.538	0.9290	0.108
VIDB,C=1	54	1.0460	1.049	0.287	1.0430	0.287
VIDA,B,C=1	63	1.1030	1.106	0.272	1.1000	0.272

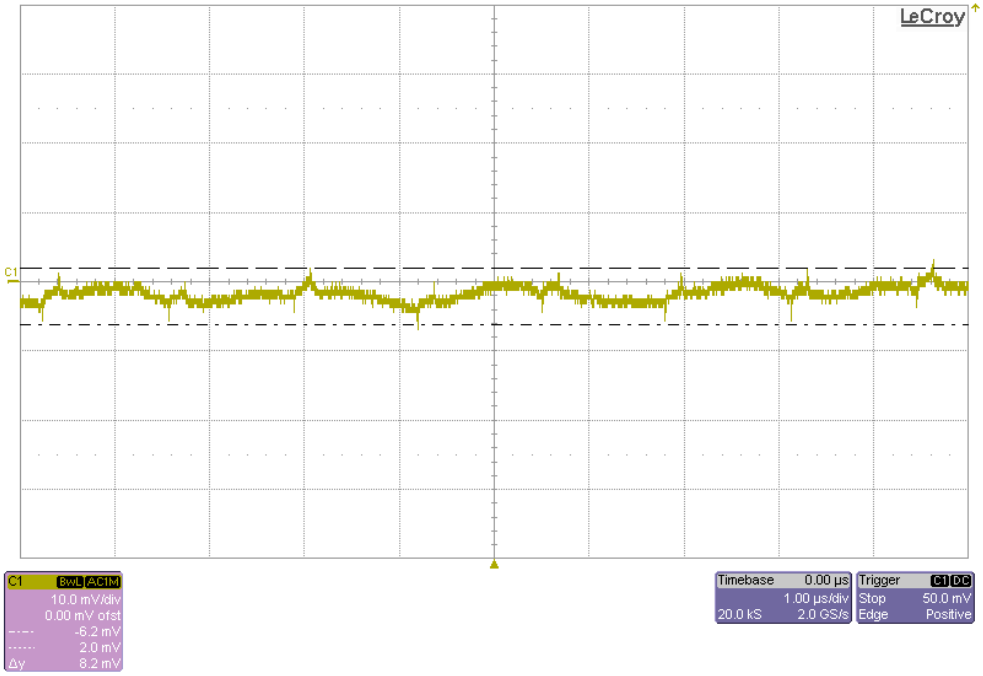
4 Output Voltage Ripple

Input voltage = 10V
Output voltage = 1V
Load current = 2A



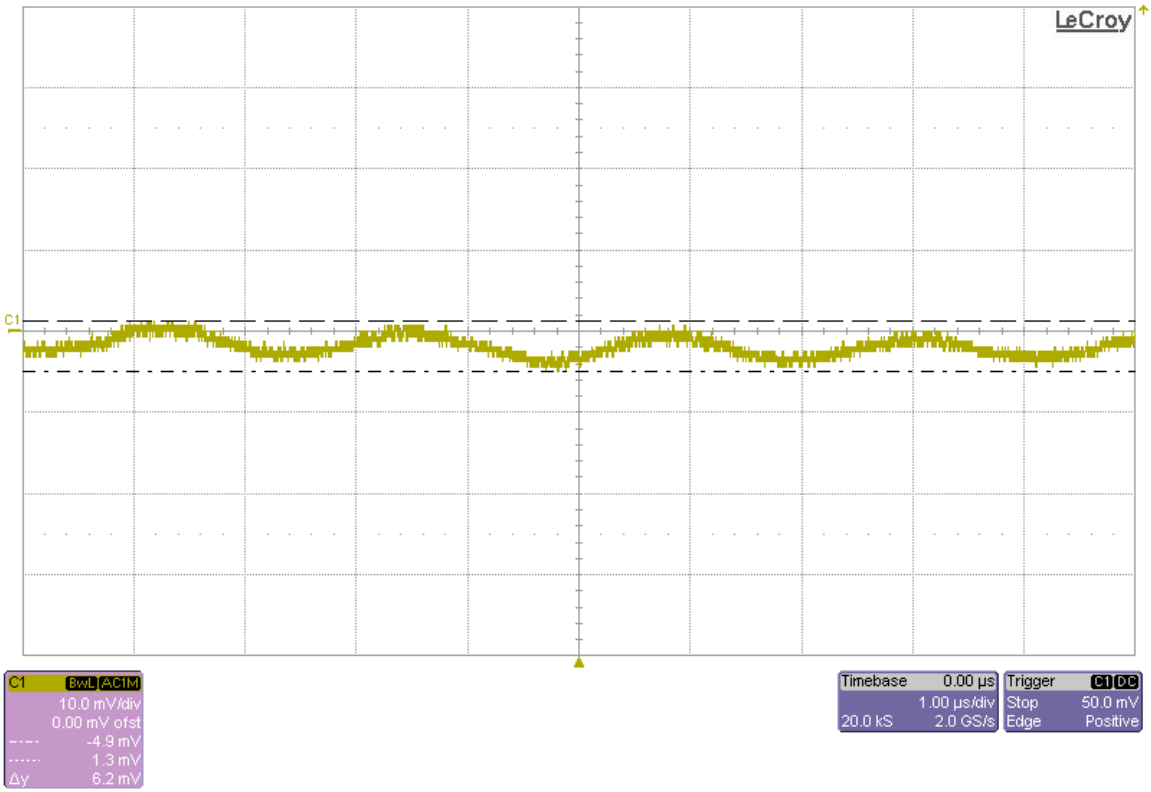
C1: VOUT_2A

Input voltage = 10V
Output voltage = 1V
Load current = 3A



C1: VOUT_3A

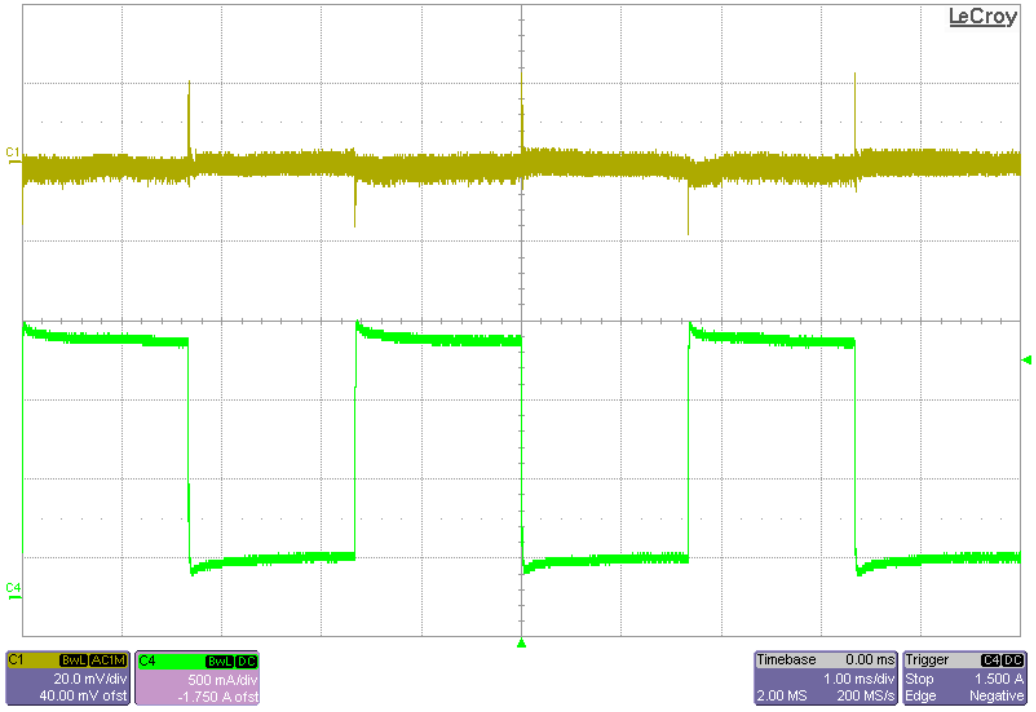
Input voltage = 10V
Output voltage = 1V
Load current = 4A



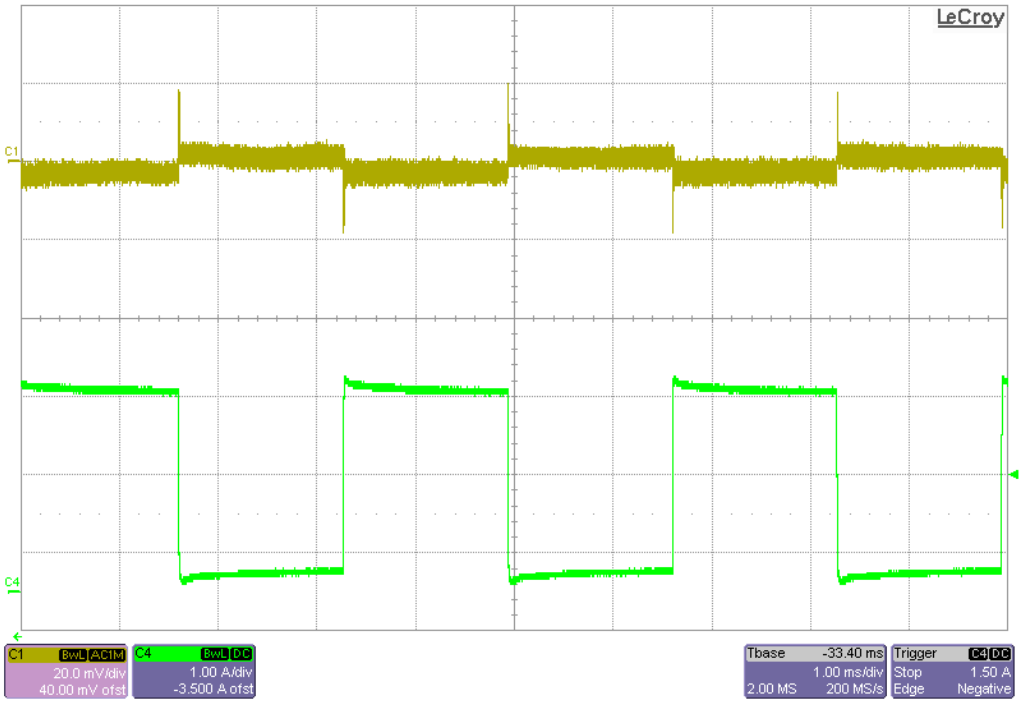
C1: VOUT_4A

5 Load Transients

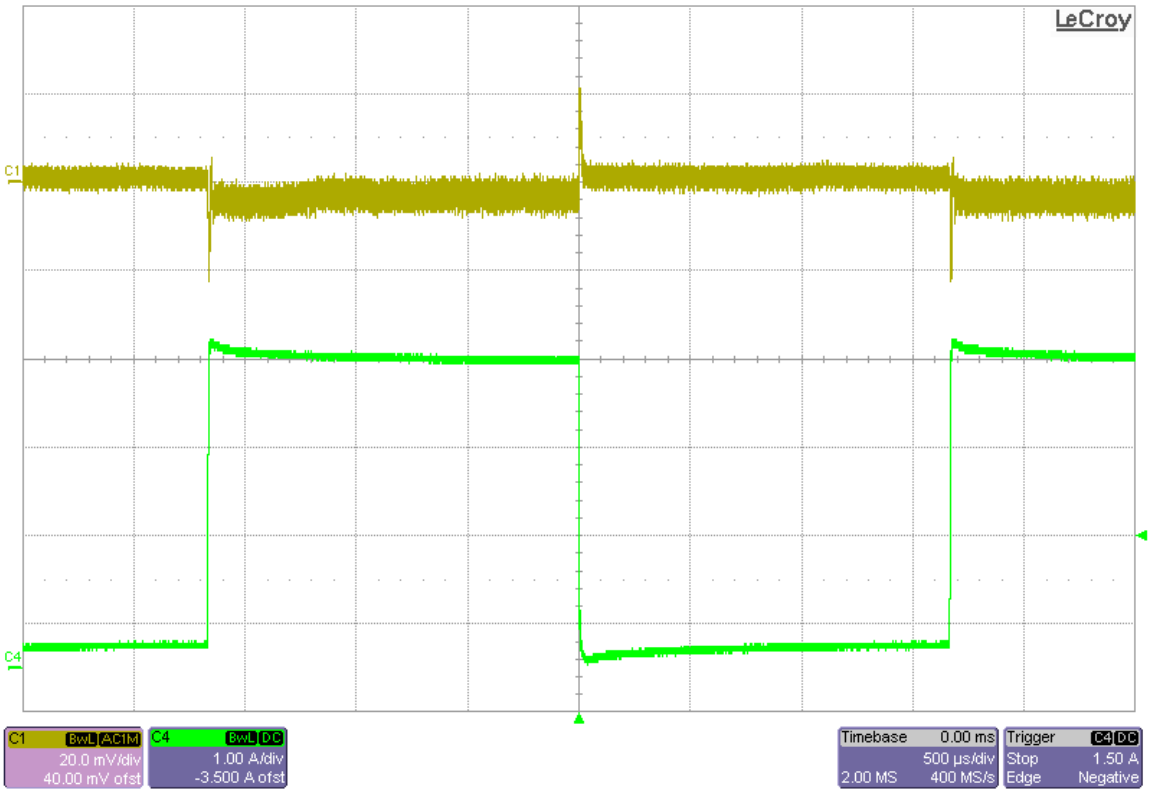
Channel 1 : Vout_2A (AC coupled)
Channel 4 : Load current



Channel 1 : Vout_3A (AC coupled)
Channel 4 : Load current



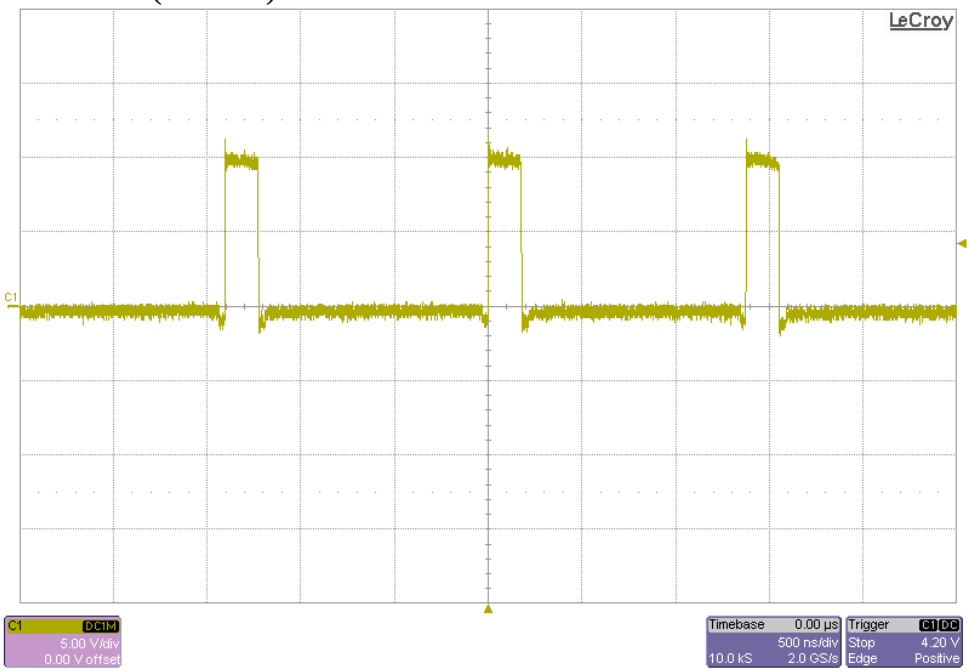
Channel 1 : Vout_3A (AC coupled)
Channel 4 : Load current



6 Switch Node Waveforms

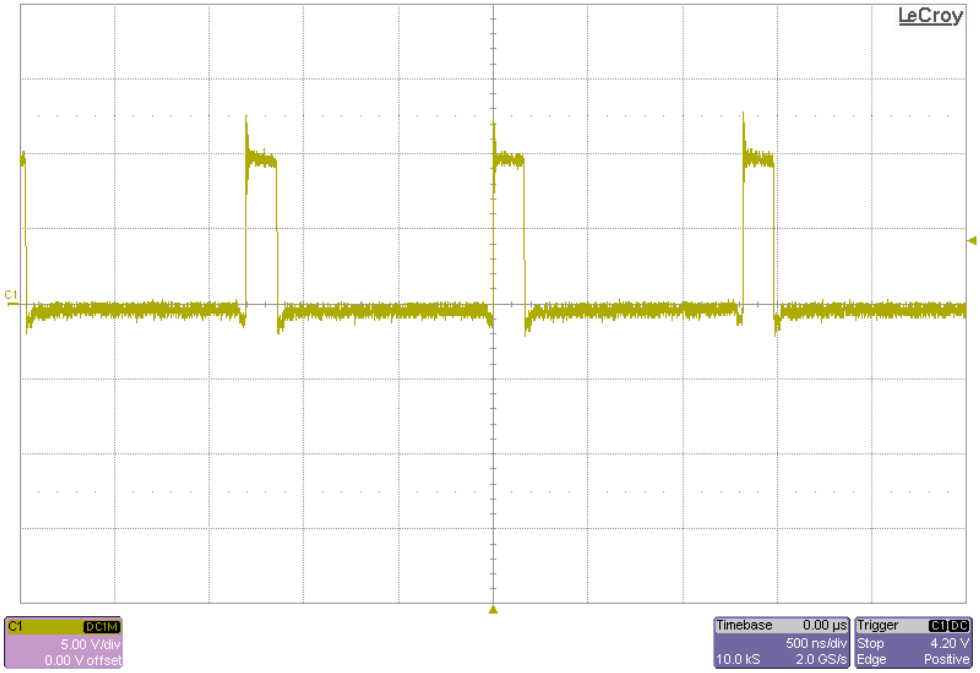
The following figures show the full bandwidth switch node waveforms at:

Input voltage = 10V
Output voltage = 1V
Load current = 2A (full BW)



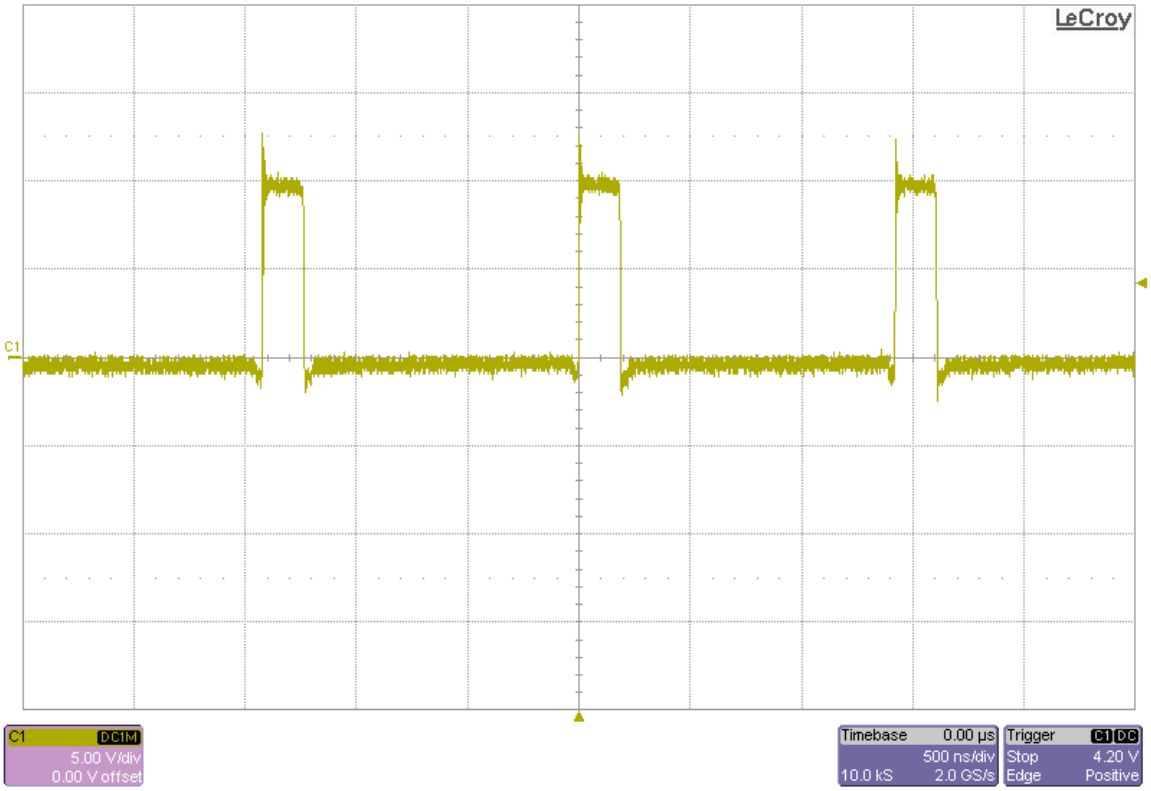
C1: VOUT_2A

Input voltage = 10V
Output voltage = 1V
Load current = 3A (full BW)



C1: VOUT_3A

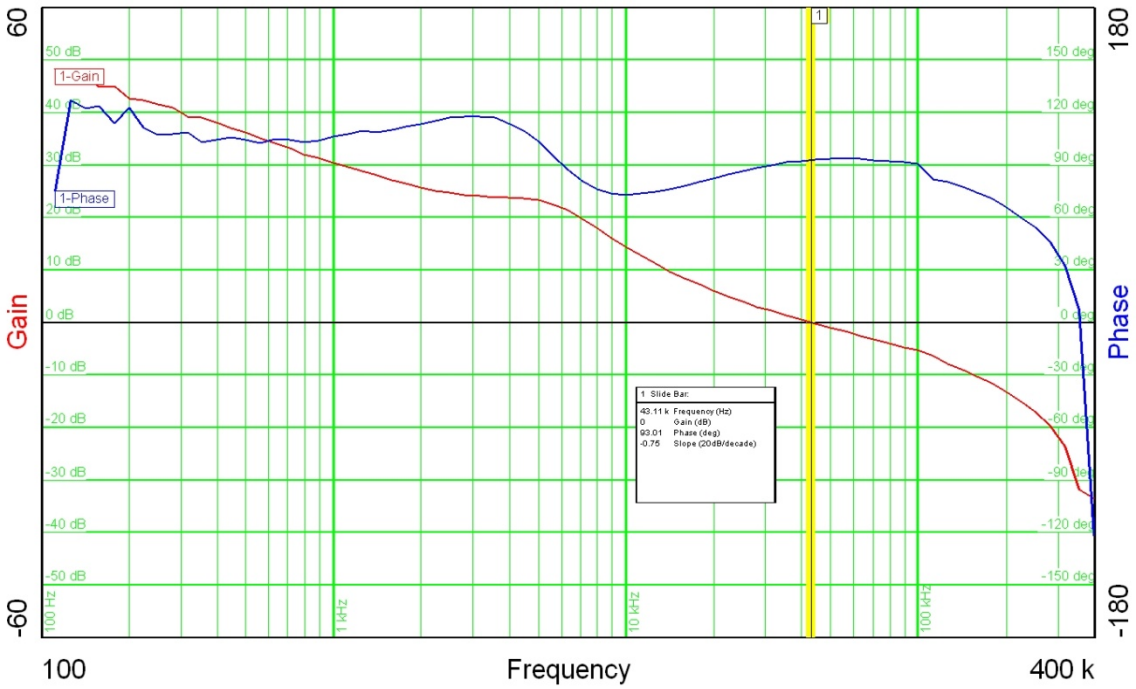
Input voltage = 10V
Output voltage = 1V
Load current = 4A (full BW)



C1: VOUT_4A

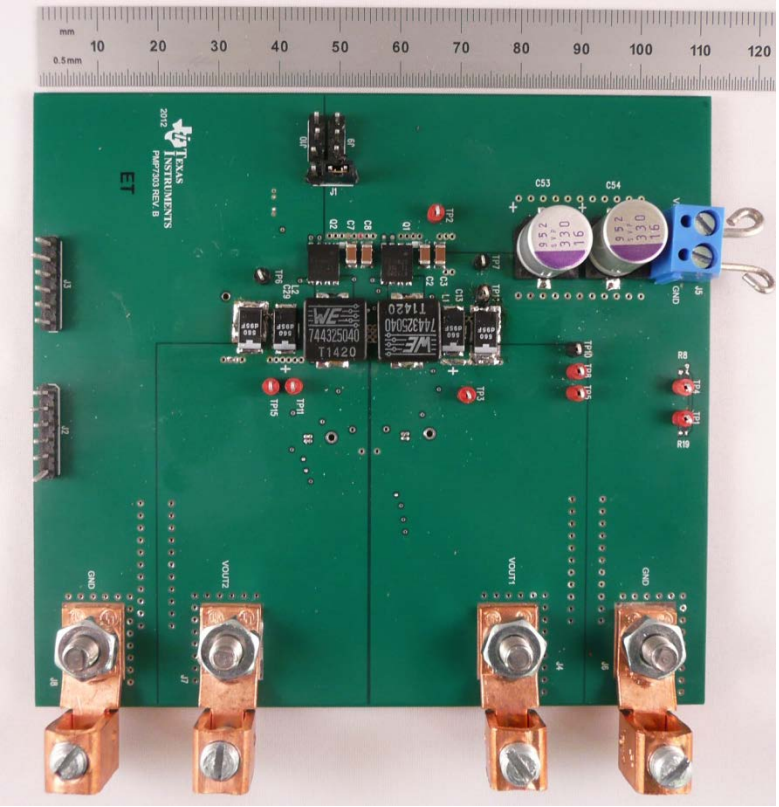
7 Control Loop Frequency Response

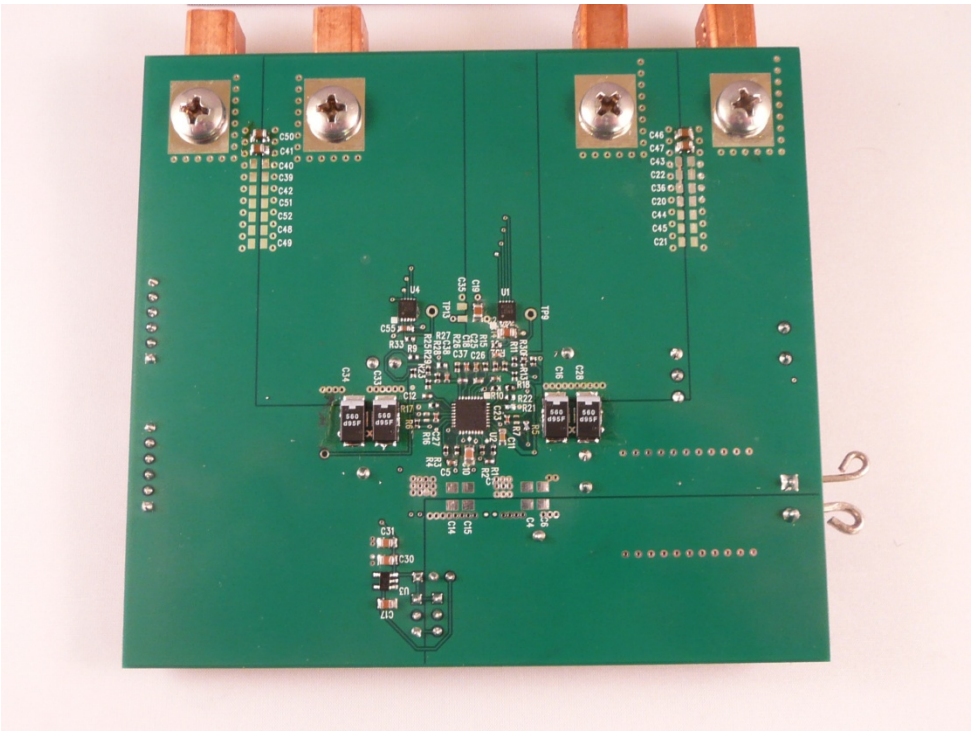
Input voltage = 10VDC
Output voltage = 1V
Load current = 25A
Phase margin = 93.01°
Bandwidth = 43.11kHz



8 Photo

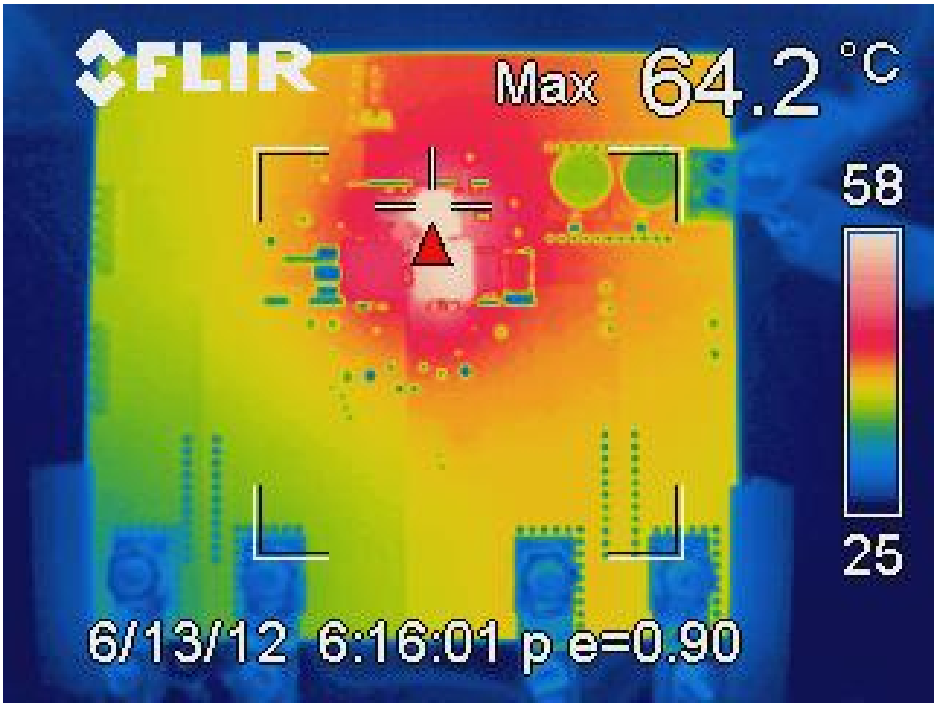
The images below show the top and bottom view, respectively, of the PMP7303 REVB prototype board.

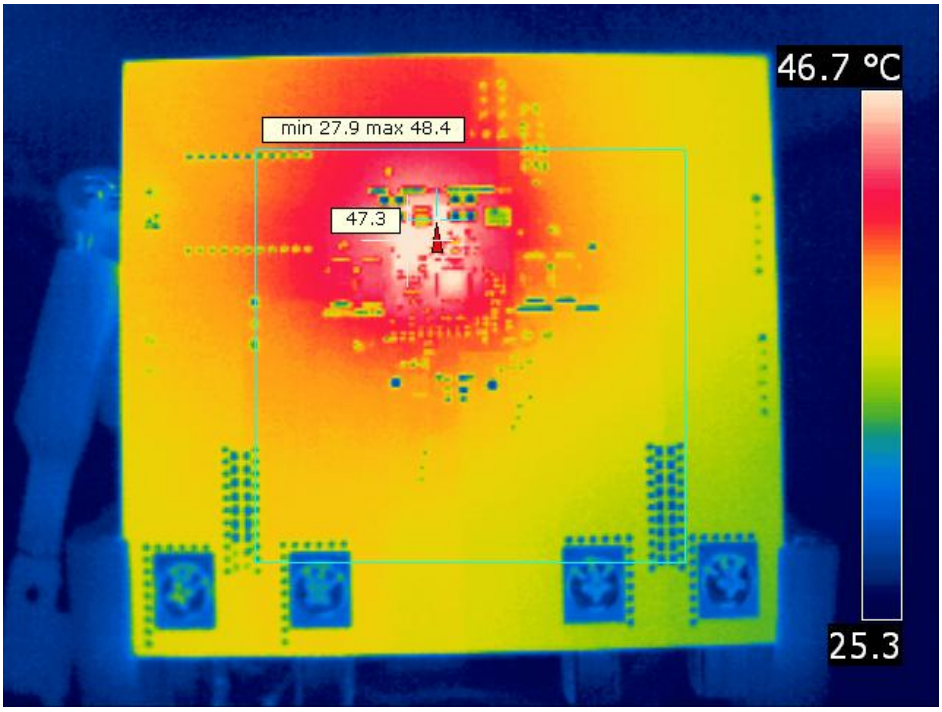




9 Thermal Analysis

The images below show the infrared images (top and bottom, respectively) taken from the FlexCam after 10min at full load (1V@25A). Input voltage = 10 VDC.





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