Test Report: PMP21611

Automotive Front-End Power for Cluster Applications Reference Design

Description

This reference design is an automotive front end power solution for use in high performance cluster applications. This design supports three output voltage rails of 5 V, 3.3 V and 1.2 V. The design also operates with a wide input voltage range and withstands reverse battery conditions. A transient voltage suppressor at the input adds protection for load dump. The above-AM band switching frequencies and dithering reduce the burden of emissions compliance. This reference design also provides results for conducted emissions tests for CISPR 25 Class 5.

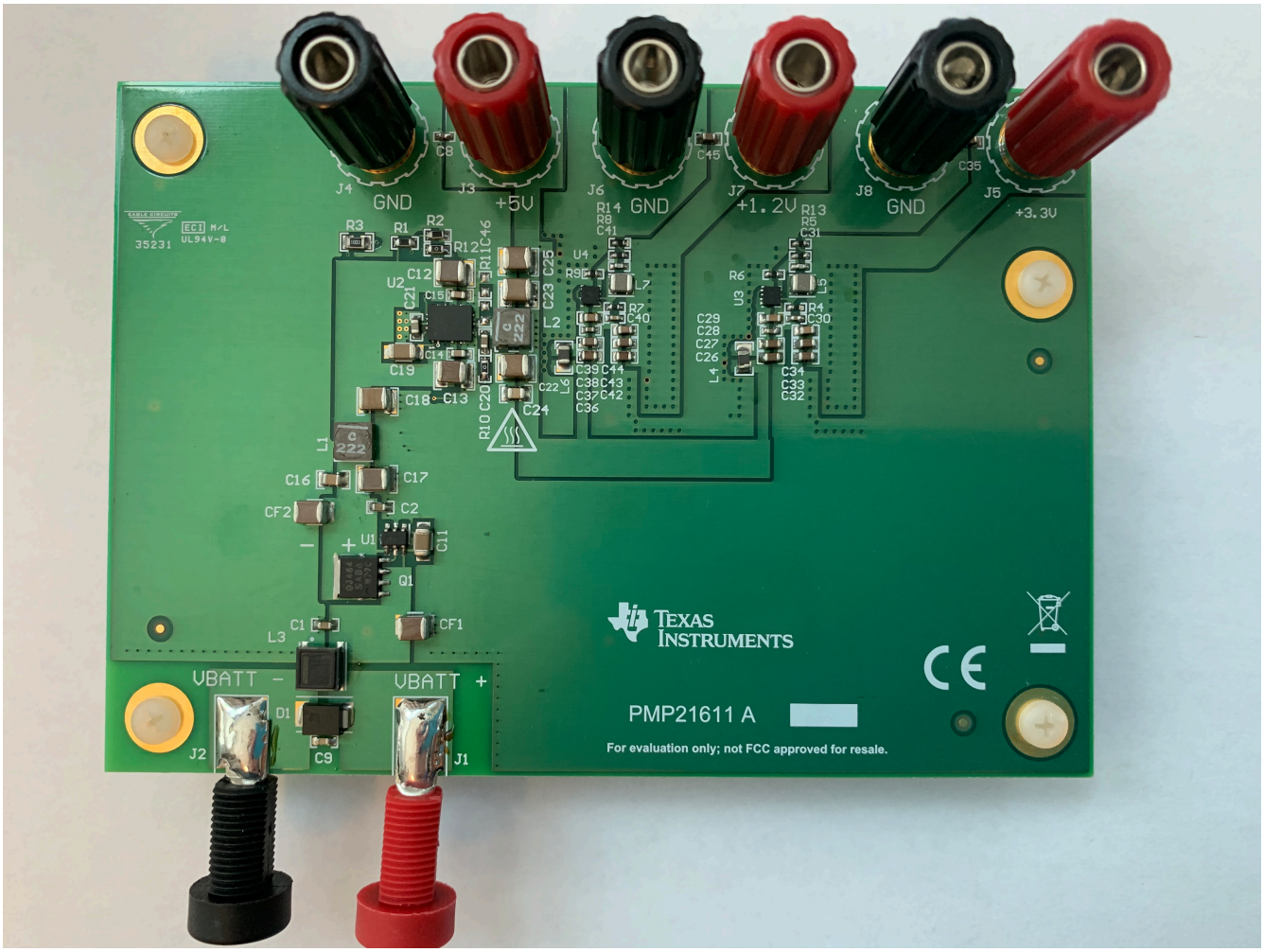

Figure 1-1. Top Board Photo

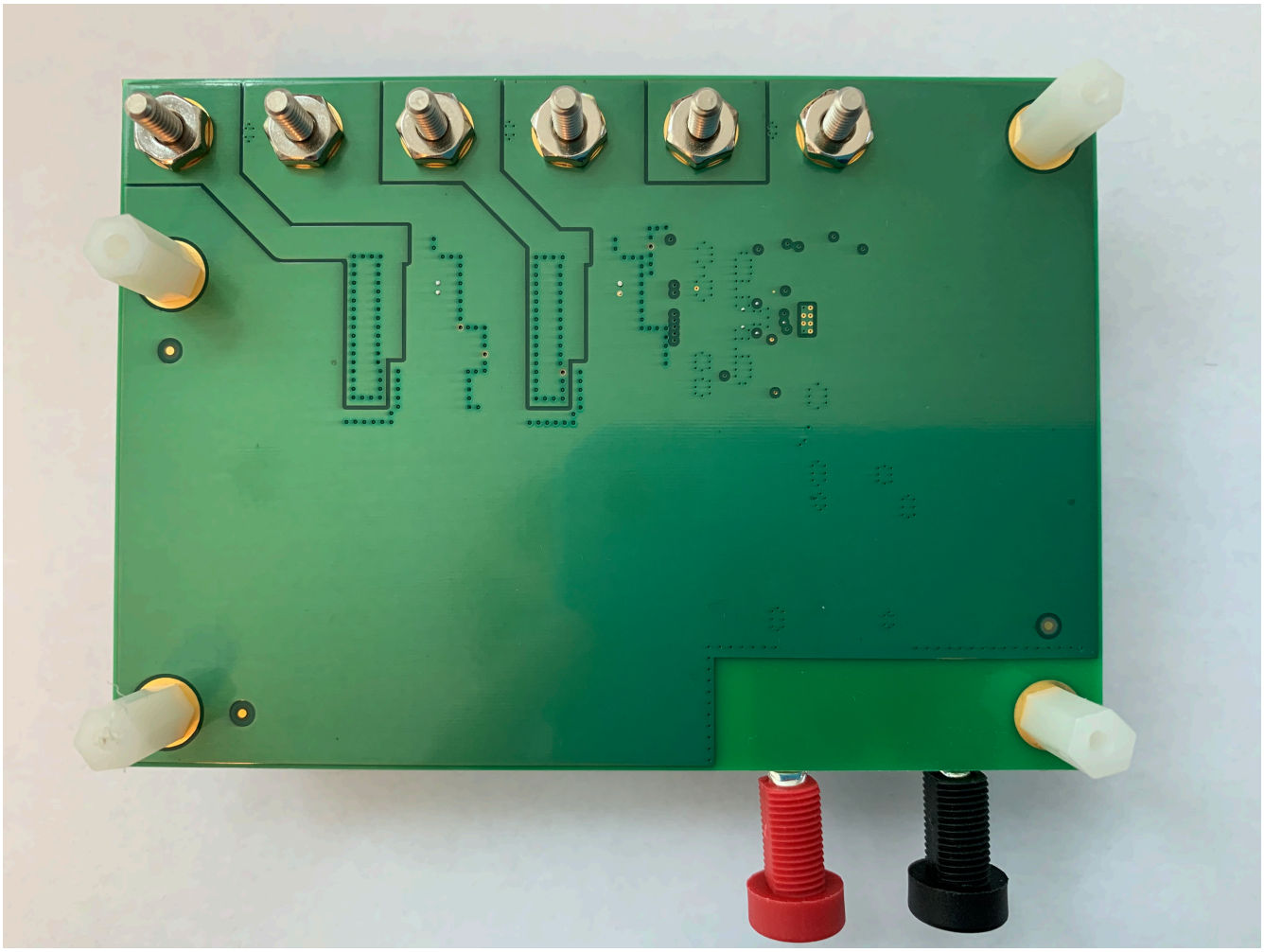

Figure 1-2. Bottom Board Photo

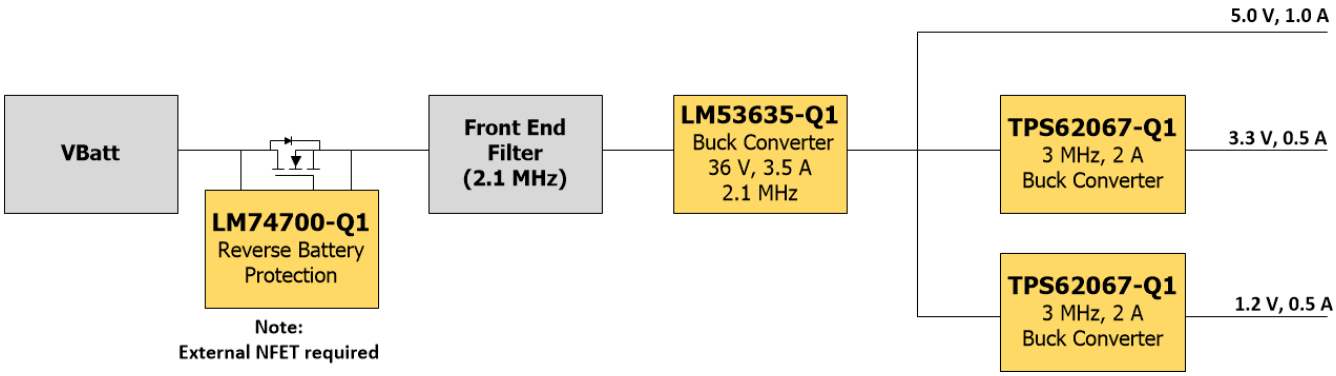

Figure 1-3. Block Diagram

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

Parameter	Specifications
Input Voltage	6 V to 28 V DC
Output Voltage 1	5 V / 1 A
Output Voltage 2	1.2 V / 0.5 A
Output Voltage 3	3.3 V / 0.5 A

1.2 Required Equipment

- Power supply
- Electronic loads
- Oscilloscope

1.3 Considerations

All tests were performed at room temperature on an open bench.

1.4 Dimensions

PMP21611 Rev A assembly was built on a 4-layer printed circuit board with 1 oz. copper. Board dimensions are 3.145 in. x 4.470 in.

2 Testing and Results

2.1 Efficiency Graphs

Efficiency is shown in the following figures.

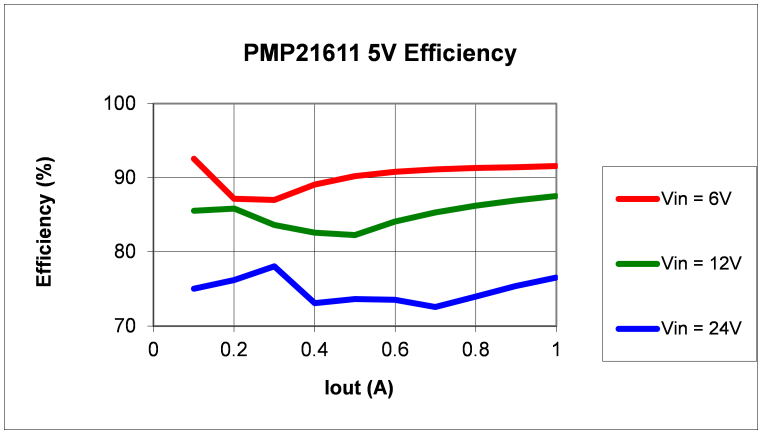

Figure 2-1. 5-V output

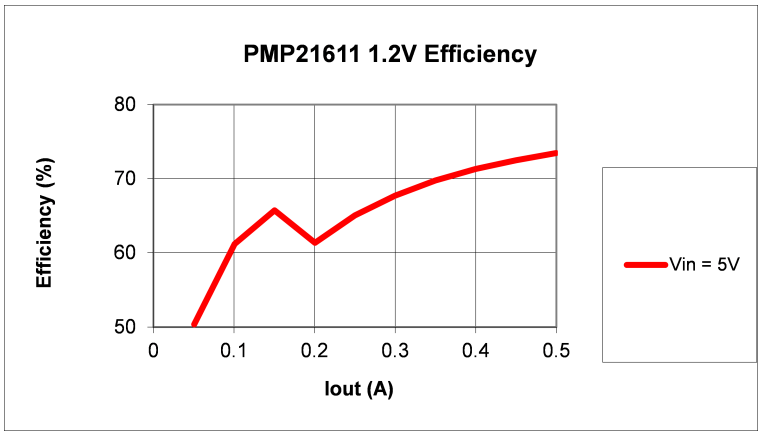

Figure 2-2. 1.2-V output

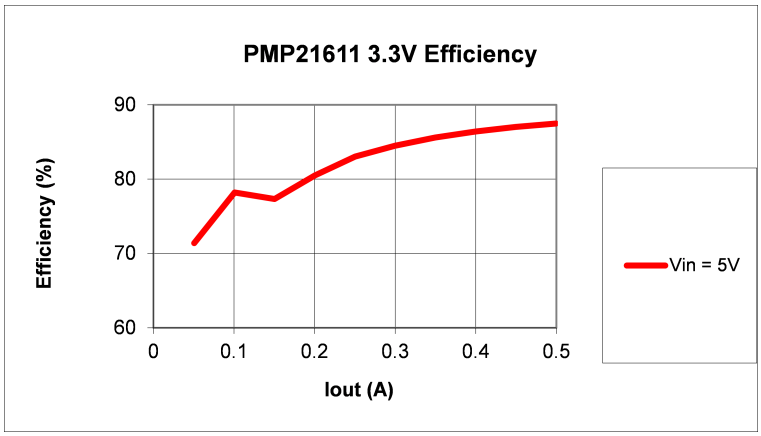

Figure 2-3. 3.3-V output

2.2 Efficiency Data

Efficiency data is shown in the following tables.

Table 2-1. 6-V input, 5-V output

V_{IN} (V)	I_{IN} (A)	V_{OUT} (V)	I_{OUT} (A)	P_{IN} (W)	P_{OUT} (W)	P_{LOSS} (W)	Efficiency (%)
6.1295	0.0013	5.0623	0.0000	0.008	0.000	0.008	0.00
6.1173	0.0899	5.0490	0.1008	0.550	0.509	0.041	92.54
6.1032	0.1889	5.0169	0.2003	1.153	1.005	0.148	87.16
6.0900	0.2832	4.9973	0.3002	1.725	1.500	0.224	86.98
6.0780	0.3691	4.9962	0.4000	2.243	1.998	0.245	89.08
6.0658	0.4562	4.9951	0.4997	2.767	2.496	0.271	90.20
6.0534	0.5445	4.9940	0.5993	3.296	2.993	0.303	90.80
6.0407	0.6343	4.9930	0.6991	3.832	3.491	0.341	91.10
6.0281	0.7246	4.9916	0.7989	4.368	3.988	0.380	91.30
6.0152	0.8155	4.9903	0.8985	4.905	4.484	0.422	91.41
6.0025	0.9064	4.9895	0.9983	5.441	4.981	0.460	91.55

Table 2-2. 12-V input, 5-V output

V_{IN} (V)	I_{IN} (A)	V_{OUT} (V)	I_{OUT} (A)	P_{IN} (W)	P_{OUT} (W)	P_{LOSS} (W)	Efficiency (%)
12.2721	0.0012	5.0582	0.0000	0.015	0.000	0.015	0.00
12.2655	0.0485	5.0481	0.1008	0.595	0.509	0.086	85.54
12.2586	0.0961	5.0396	0.2006	1.178	1.011	0.167	85.82
12.2515	0.1473	5.0264	0.3002	1.805	1.509	0.296	83.61
12.2444	0.1980	5.0052	0.4000	2.424	2.002	0.422	82.58
12.2377	0.2478	4.9927	0.4997	3.033	2.495	0.538	82.27
12.2312	0.2909	4.9913	0.5993	3.558	2.991	0.567	84.07
12.2252	0.3345	4.9902	0.6992	4.089	3.489	0.600	85.32
12.2192	0.3783	4.9889	0.7988	4.623	3.985	0.637	86.21
12.2130	0.4221	4.9874	0.8985	5.155	4.481	0.674	86.93
12.1975	0.4662	4.9856	0.9983	5.686	4.977	0.709	87.53

Table 2-3. 24-V input, 5-V output

V_{IN} (V)	I_{IN} (A)	V_{OUT} (V)	I_{OUT} (A)	P_{IN} (W)	P_{OUT} (W)	P_{LOSS} (W)	Efficiency (%)
24.5653	0.0011	5.0565	0.0000	0.027	0.000	0.027	0.00
24.5613	0.0276	5.0467	0.1008	0.678	0.509	0.169	75.04
24.5573	0.0540	5.0387	0.2005	1.326	1.010	0.316	76.18
24.5535	0.0788	5.0300	0.3002	1.935	1.510	0.425	78.04
24.5488	0.1119	5.0187	0.4000	2.747	2.007	0.740	73.08
24.5449	0.1384	5.0058	0.4997	3.397	2.501	0.896	73.64
24.5406	0.1659	4.9956	0.5993	4.071	2.994	1.077	73.54
24.5360	0.1957	4.9836	0.6991	4.802	3.484	1.318	72.56
24.5332	0.2193	4.9815	0.7988	5.380	3.979	1.401	73.96
24.5293	0.2420	4.9797	0.8985	5.936	4.474	1.462	75.37
24.5260	0.2648	4.9781	0.9983	6.494	4.970	1.525	76.52

Table 2-4. 5-V input, 1.2-V output

V_{IN} (V)	I_{IN} (A)	V_{OUT} (V)	I_{OUT} (A)	P_{IN} (W)	P_{OUT} (W)	P_{LOSS} (W)	Efficiency (%)
5.0176	0.0086	1.2113	0.0000	0.043	0.000	0.043	0.00
5.0176	0.0242	1.2085	0.0506	0.121	0.061	0.060	50.36
5.0175	0.0396	1.2082	0.1006	0.199	0.122	0.077	61.17
5.0175	0.0551	1.2083	0.1504	0.276	0.182	0.095	65.73
5.0174	0.0778	1.1954	0.2003	0.390	0.239	0.151	61.34
5.0176	0.0916	1.1952	0.2501	0.460	0.299	0.161	65.04
5.0176	0.1055	1.1950	0.2999	0.529	0.358	0.171	67.70
5.0176	0.1194	1.1948	0.3498	0.599	0.418	0.181	69.76
5.0177	0.1335	1.1948	0.3998	0.670	0.478	0.192	71.31
5.0177	0.1477	1.1946	0.4496	0.741	0.537	0.204	72.47
5.0174	0.1619	1.1944	0.4995	0.812	0.597	0.216	73.44

Table 2-5. 5-V input, 3.3-V output

V_{IN} (V)	I_{IN} (A)	V_{OUT} (V)	I_{OUT} (A)	P_{IN} (W)	P_{OUT} (W)	P_{LOSS} (W)	Efficiency (%)
5.0176	0.0085	3.3221	0.0000	0.043	0.000	0.043	0.00
5.0175	0.0469	3.3198	0.0506	0.235	0.168	0.067	71.38
5.0176	0.0851	3.3187	0.1006	0.427	0.334	0.093	78.19
5.0178	0.1259	3.2478	0.1504	0.632	0.488	0.143	77.32
5.0176	0.1612	3.2510	0.2003	0.809	0.651	0.158	80.51
5.0177	0.1973	3.2851	0.2502	0.990	0.822	0.168	83.03
5.0175	0.2324	3.2852	0.2999	1.166	0.985	0.181	84.49
5.0173	0.2676	3.2852	0.3498	1.343	1.149	0.193	85.59
5.0176	0.3030	3.2852	0.3998	1.520	1.313	0.207	86.39
5.0177	0.3383	3.2853	0.4496	1.697	1.477	0.220	87.02
5.0175	0.3739	3.2854	0.4994	1.876	1.641	0.235	87.45

2.3 Thermal Images

The thermal image in the following figure was taken at thermal equilibrium.

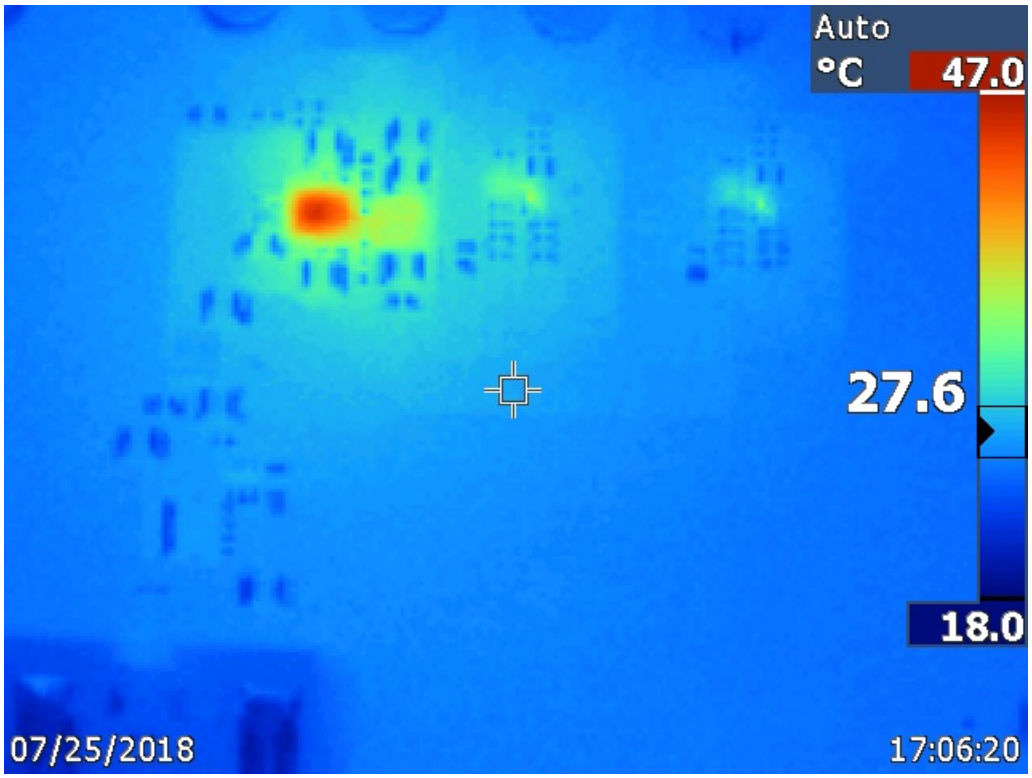

Figure 2-4. Thermal at 12-V input, full load

2.4 Conducted Emissions

CISPR 25 Class 5

Conducted emissions is shown in the following figures.

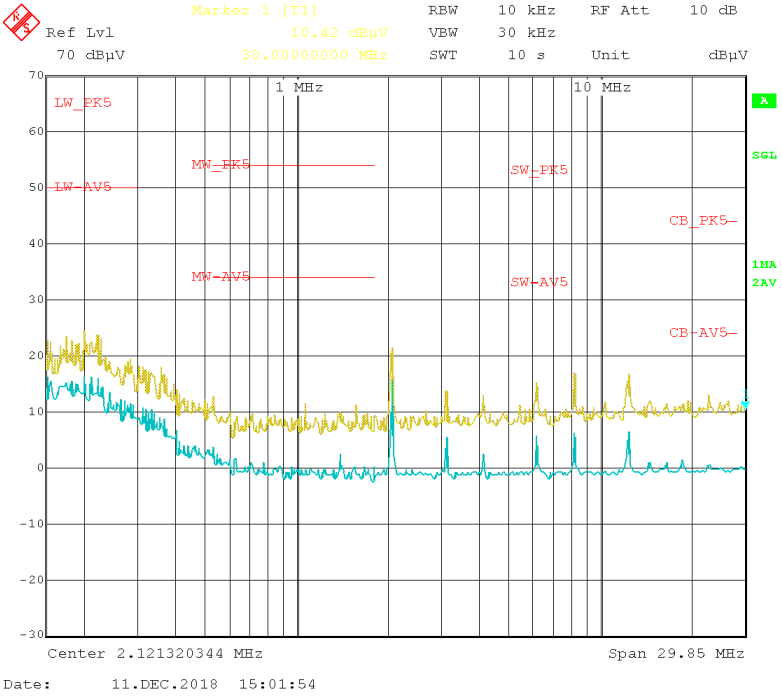

Figure 2-5. Conducted emissions low frequency

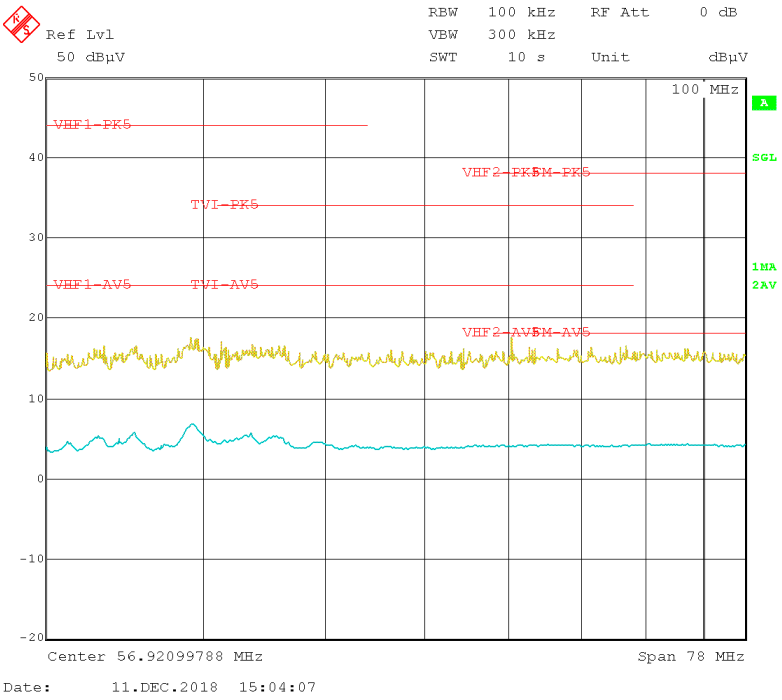

Figure 2-6. Conducted emissions high frequency

3 Waveforms

3.1 Switching

Switching behavior is shown in the following figures.

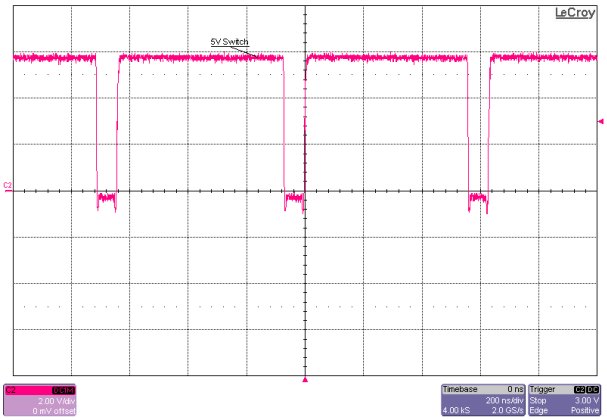

Figure 3-1. 5-V switch, 6-V input, 1-A load

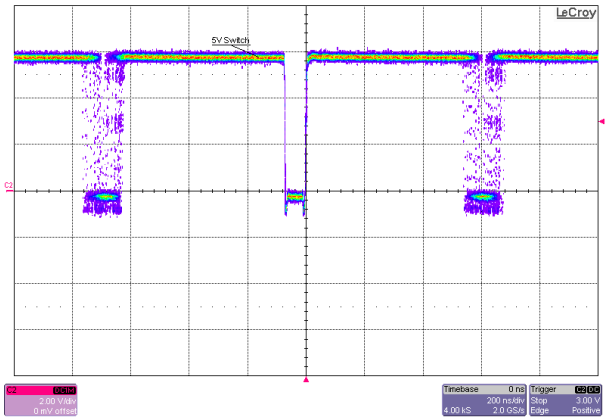

Figure 3-2. 5-V switch, 6-V input, 1-A load, dither

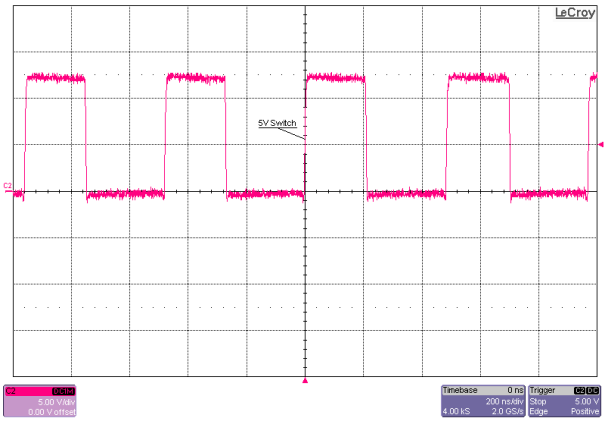

Figure 3-3. 5-V switch, 12-V input, 1-A load

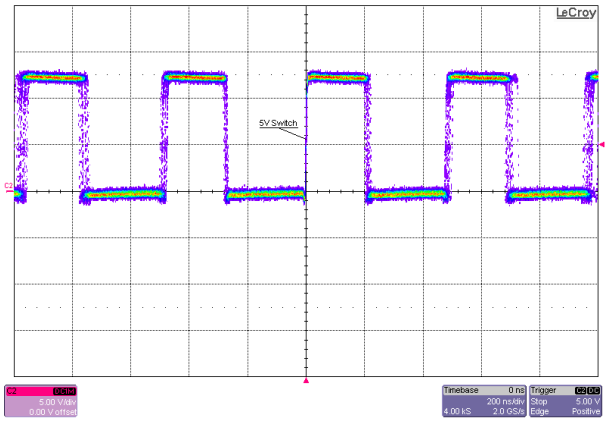

Figure 3-4. 5-V switch, 12-V input, 1-A load, dither

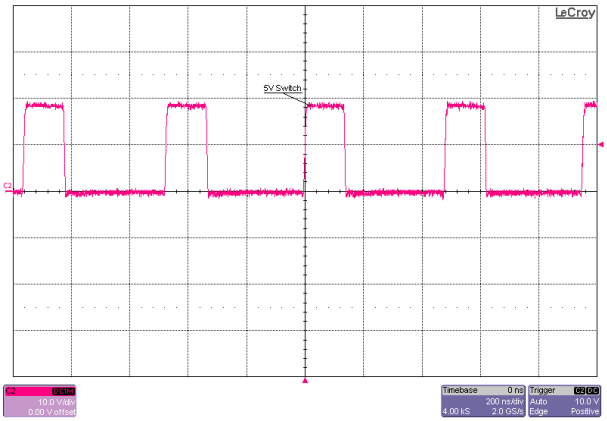

Figure 3-5. 5-V switch, 18-V input, 1-A load

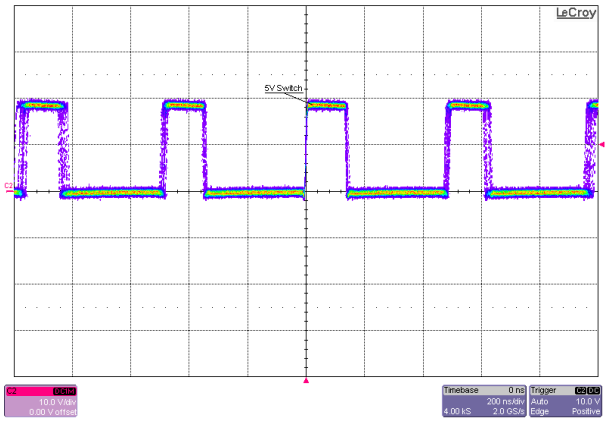

Figure 3-6. 5-V switch, 18-V input, 1-A load, dither

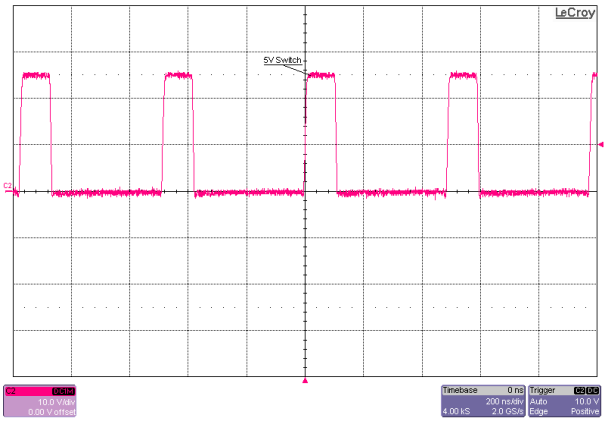

Figure 3-7. 5-V switch, 24-V input, 1-A load

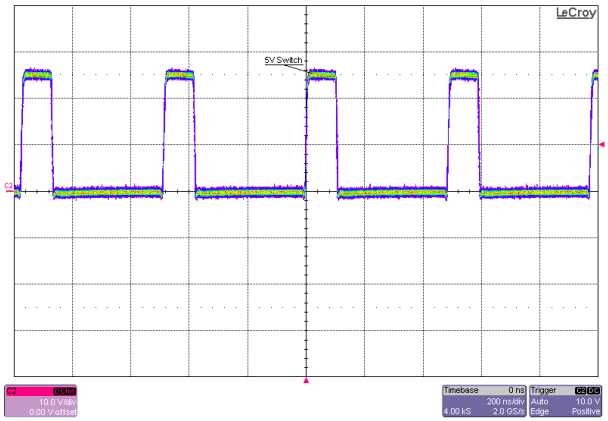

Figure 3-8. 5-V switch, 24-V input, 1-A load, dither

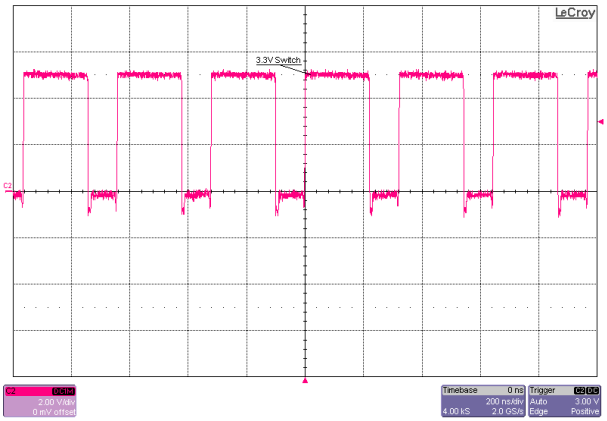

Figure 3-9. 3.3-V switch, 0.5-A load

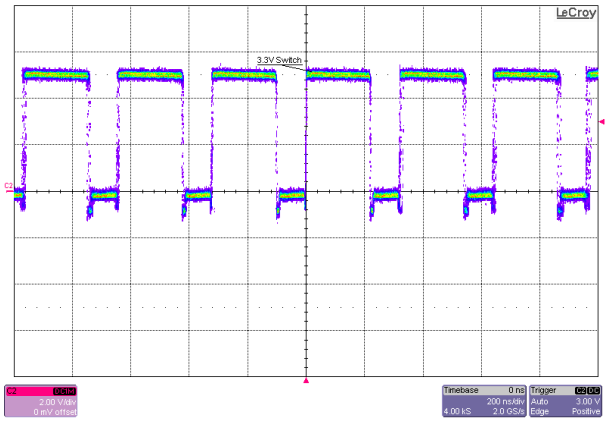

Figure 3-10. 3.3-V switch, 0.5-A load, dither

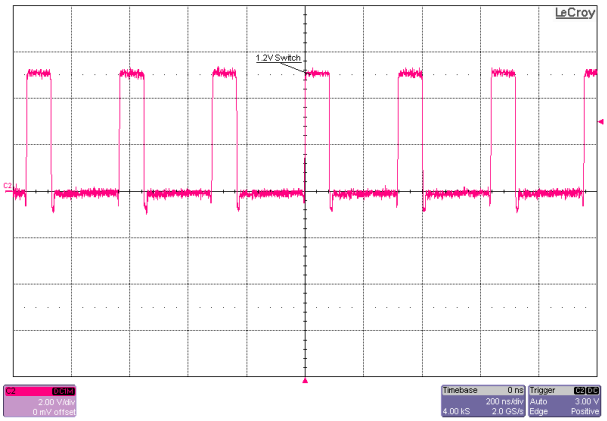

Figure 3-11. 1.2-V switch, 0.5-A load

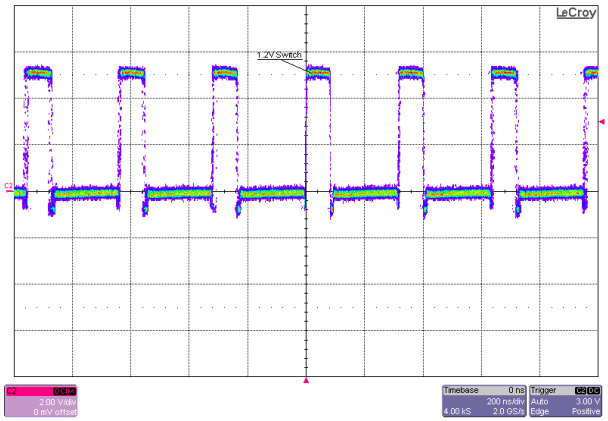

Figure 3-12. 1.2-V switch, 0.5-A load, dither

3.2 Output Voltage Ripple

Output voltage ripple is shown in the following figures.

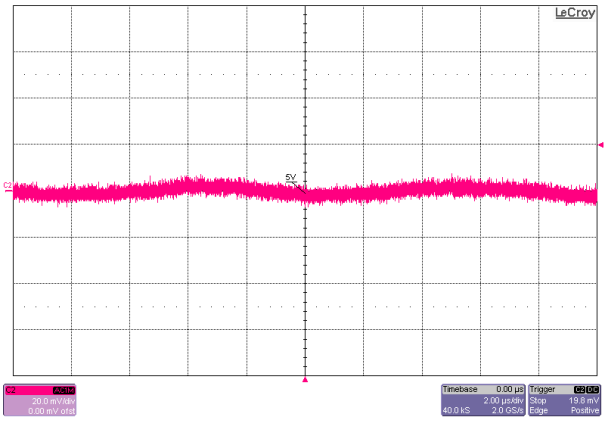

Figure 3-13. 5-V output ripple, 6-V input, 1-A load

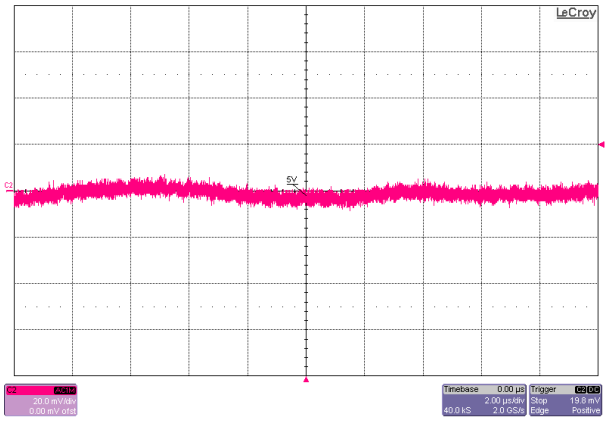

Figure 3-14. 5-V output ripple, 12-V input, 1-A load

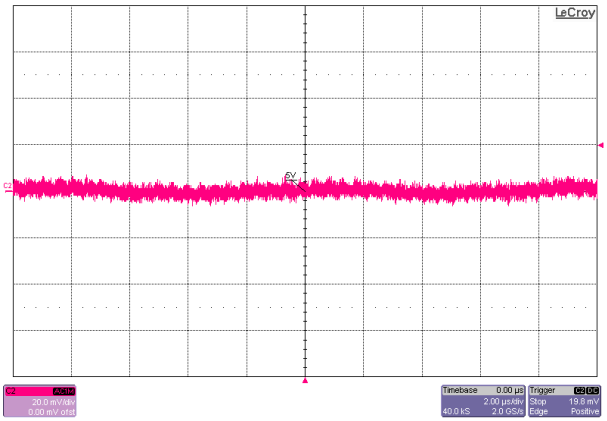

Figure 3-15. 5-V output ripple, 18-V input, 1-A load

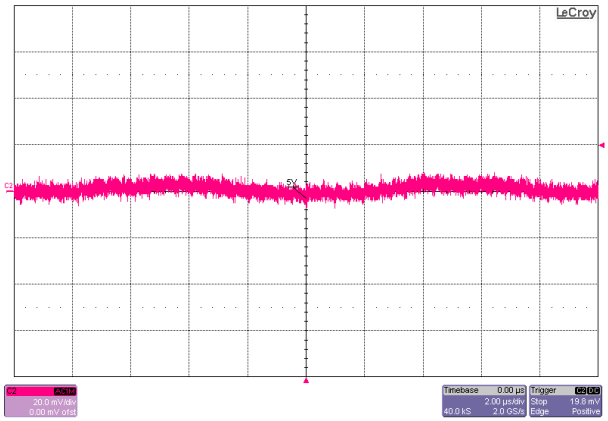

Figure 3-16. 5-V output ripple, 24-V input, 1-A load

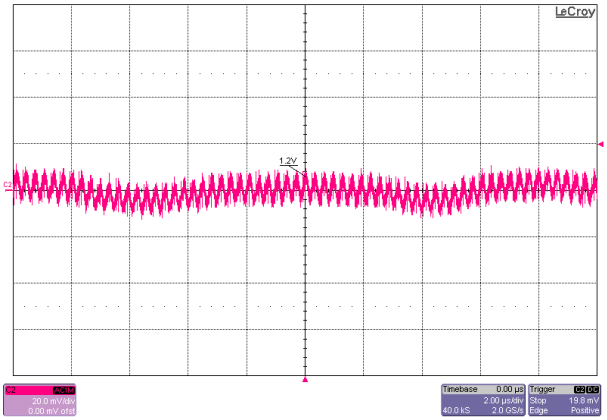

Figure 3-17. 1.2-V output ripple, 0.5-A load

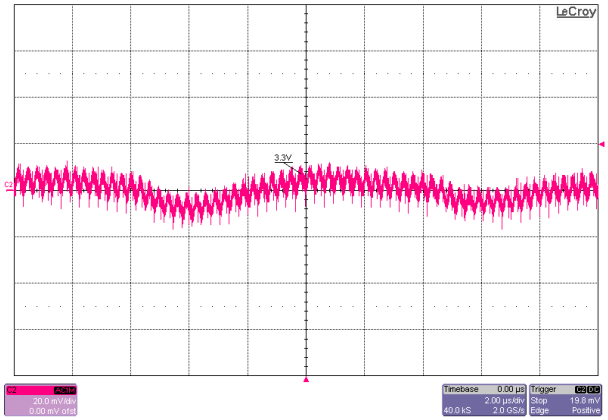

Figure 3-18. 3.3-V output ripple, 0.5-A load

3.3 Short-Circuit Protection

Short-circuit protection is shown in the following figures.

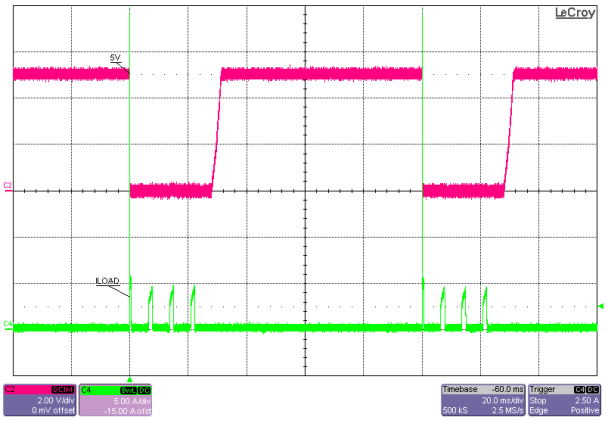

Figure 3-19. 5-V short circuit, 6-V input

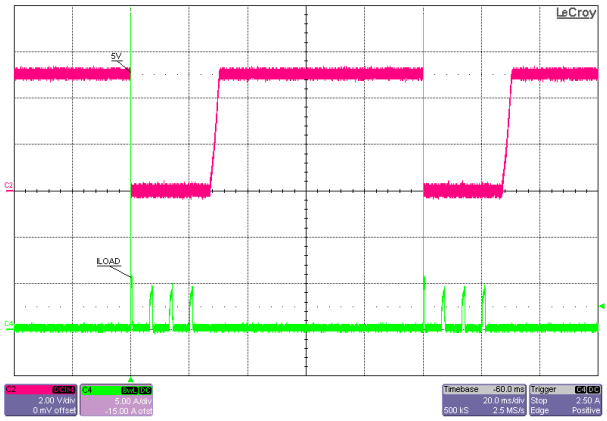

Figure 3-20. 5-V short circuit, 12-V input

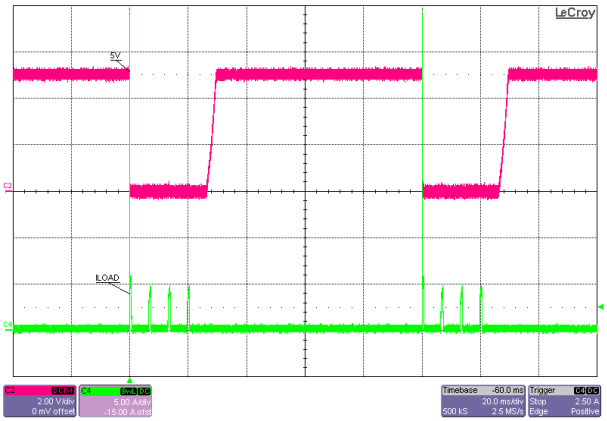

Figure 3-21. 5-V short circuit, 18-V input

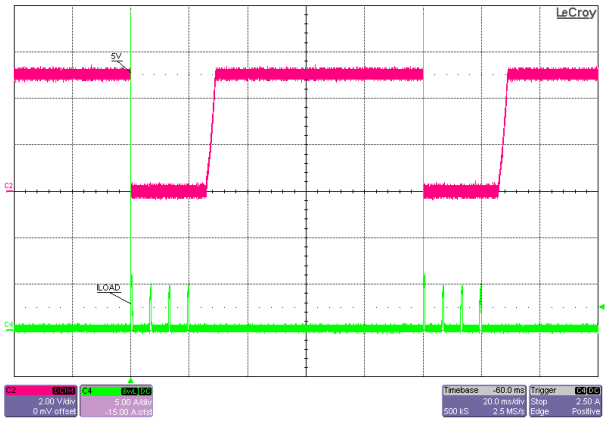

Figure 3-22. 5-V short circuit, 24-V input

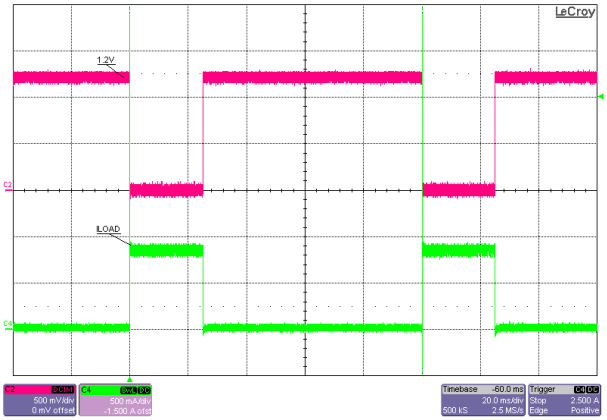

Figure 3-23. 1.2-V short circuit

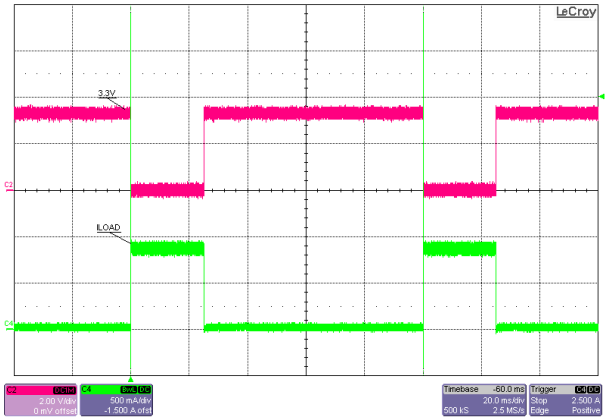

Figure 3-24. 3.3-V short circuit

3.4 Load Transients

Load transient response is shown in the following figures.

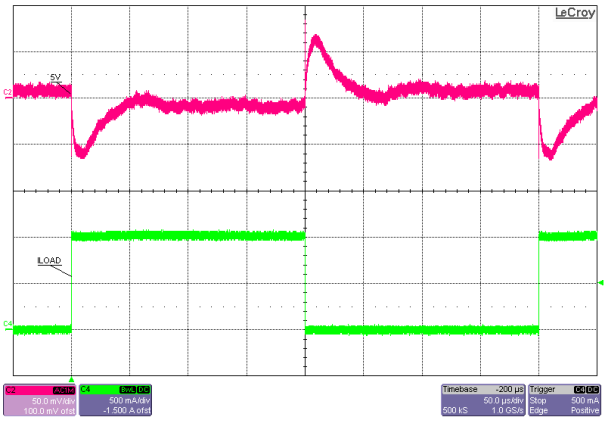

Figure 3-25. 5-V transient response, 6-V input

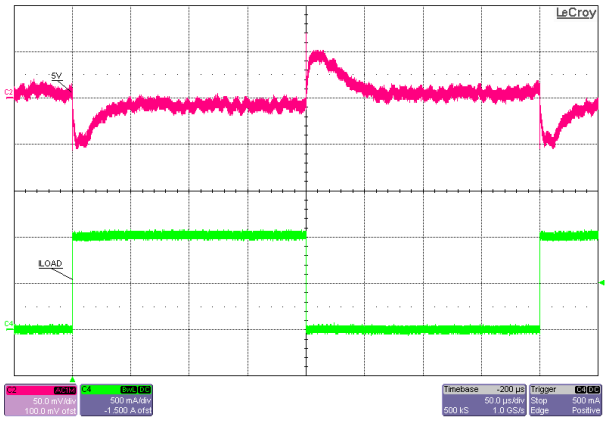

Figure 3-26. 5-V transient response, 12-V input

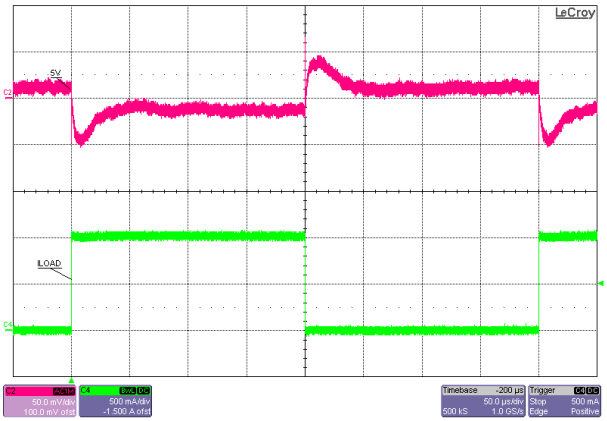

Figure 3-27. 5-V transient response, 18-V input

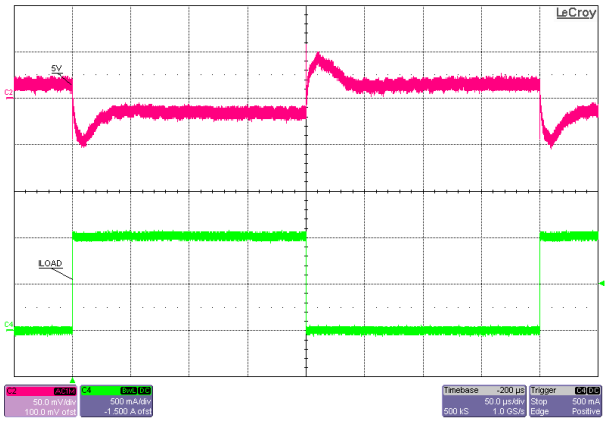

Figure 3-28. 5-V transient response, 24-V input

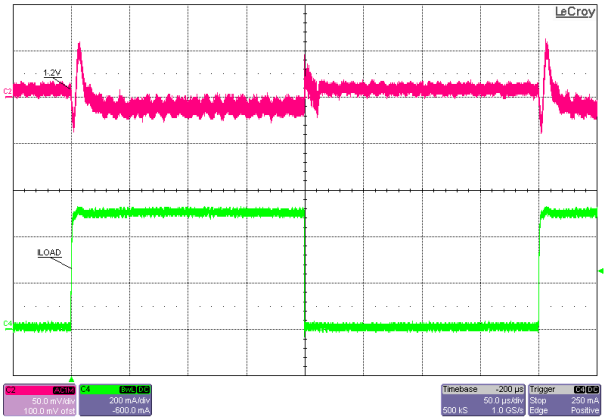

Figure 3-29. 1.2-V transient response

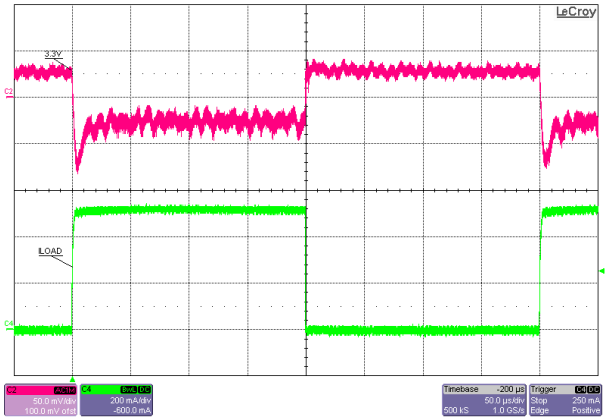

Figure 3-30. 3.3-V transient response

3.5 Start-up Sequence

Start-up and shut-down behaviour is shown in the following figures.

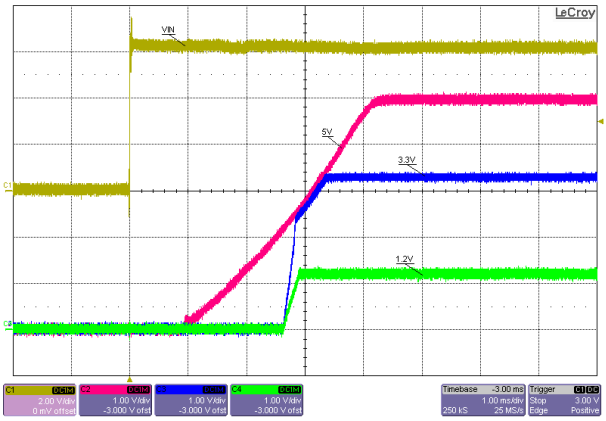

Figure 3-31. 6-V input start-up at full load

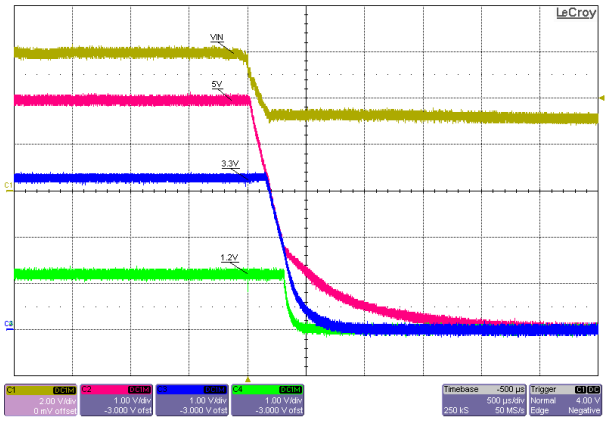

Figure 3-32. 6-V input shut-down at full load

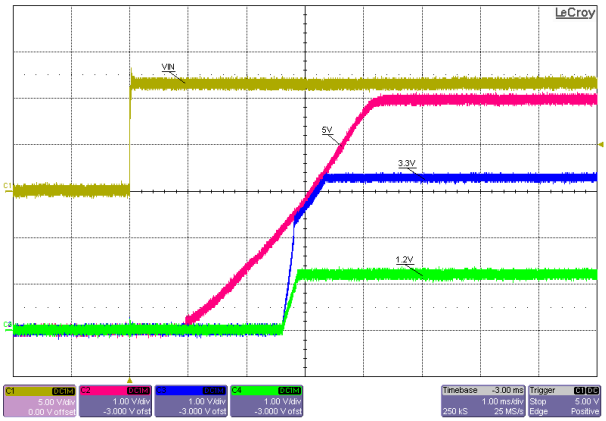

Figure 3-33. 12-V input start-up at full load

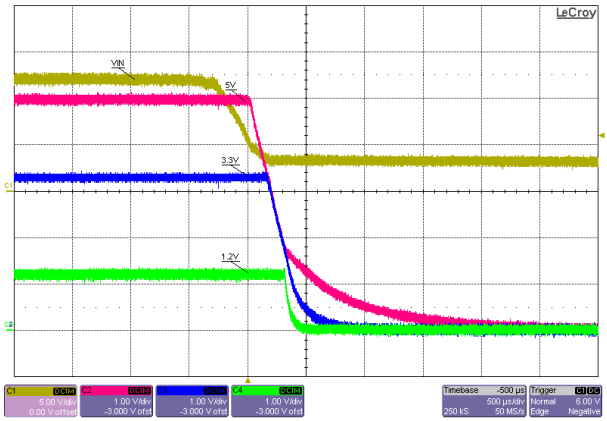

Figure 3-34. 12-V input shut-down at full load

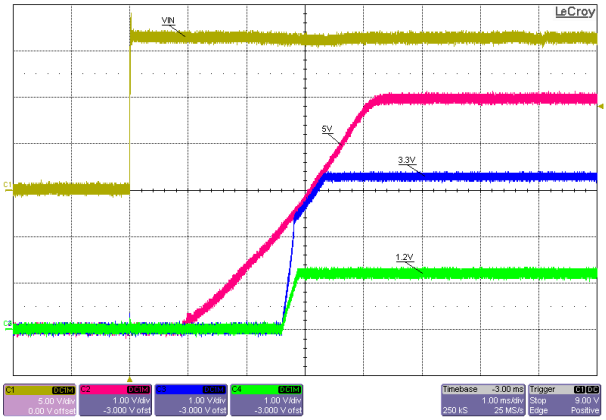

Figure 3-35. 18-V input start-up at full load

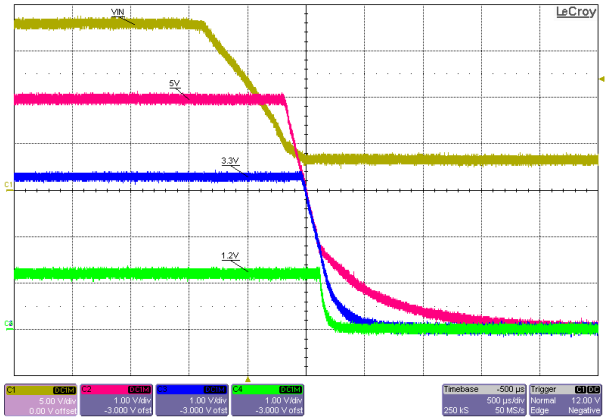

Figure 3-36. 18-V input shut-down at full load

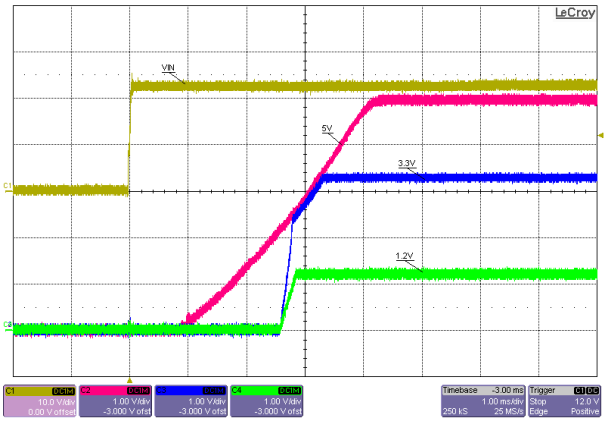

Figure 3-37. 24-V input start-up at full load

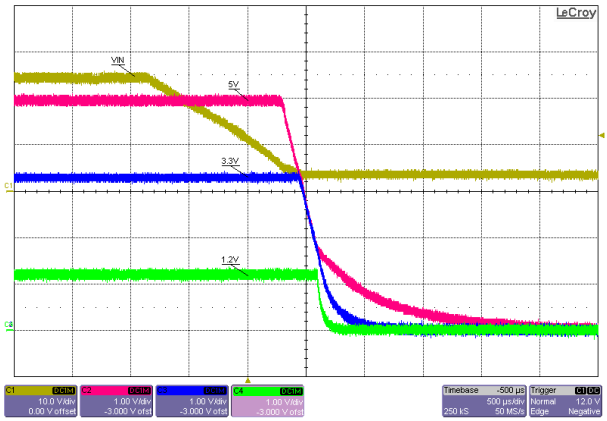

Figure 3-38. 24-V input shut-down at full load

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