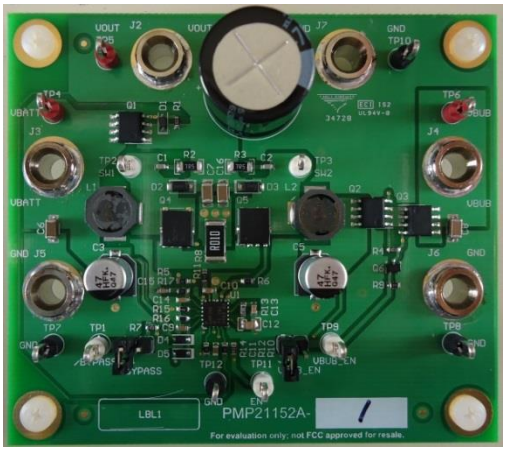
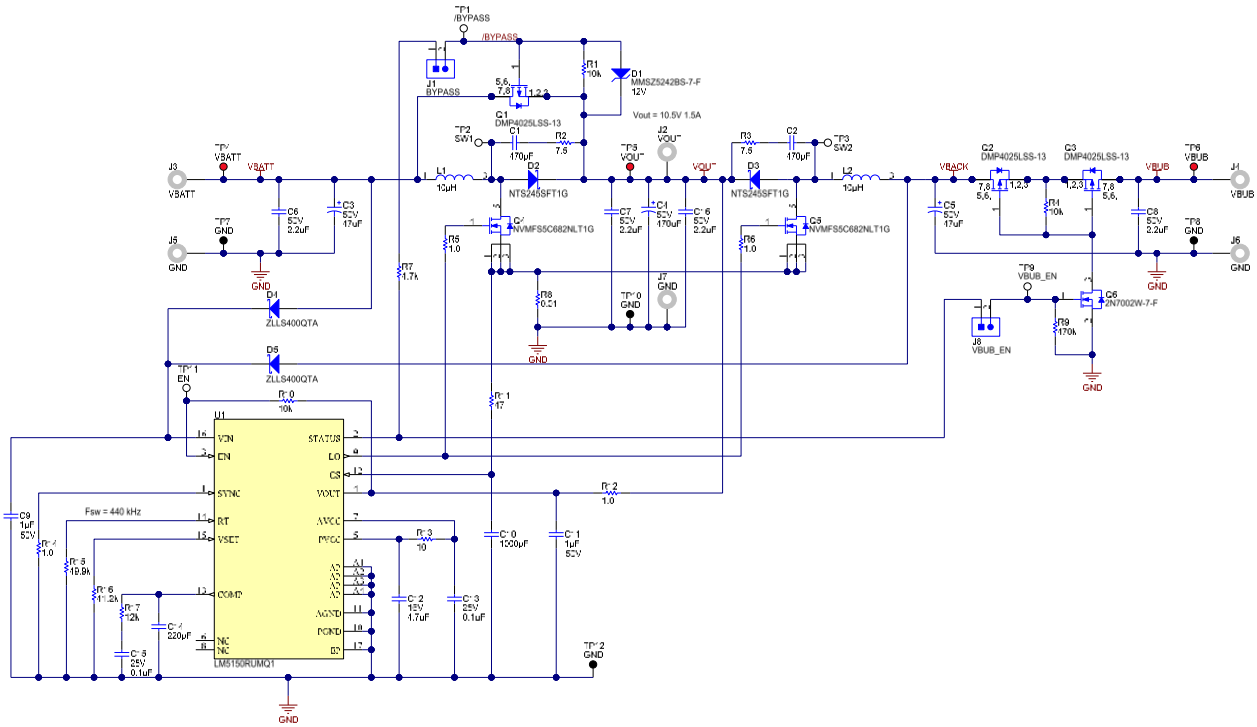
Test Report: PMP21152

Smart OR-ing boost converter reference design for automotive eCall

Description

This reference design is a smart OR-ing boost converter for automotive emergency call (eCall) applications utilizing a low quiescent current boost controller. The design uses two boost power stages driven by the same controller. The main battery input includes a bypass switch function. The backup battery input has a separate enable with disconnect switches. This combination allows for seamless crossover from the main battery to the backup battery. The switching frequency is set to 440 kHz.





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1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1. Voltage and Current Requirements

PARAMETER	SPECIFICATIONS
Input Voltage	3 V – 30 V
Output Voltage	10.5 V
Output Current	1.5 A

1.2 Required Equipment

- DC power supply
- Electronic load
- Oscilloscope

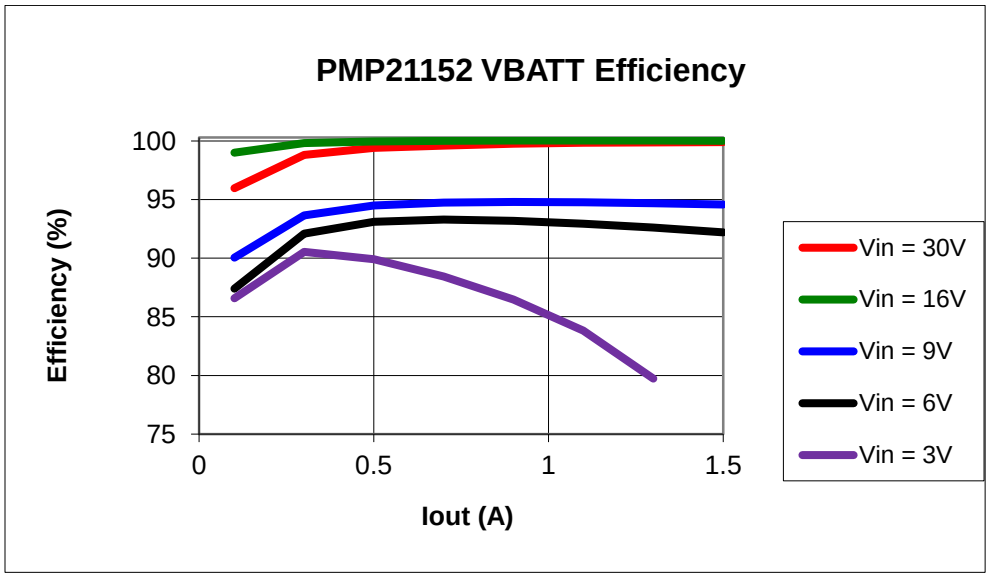
1.3 Considerations

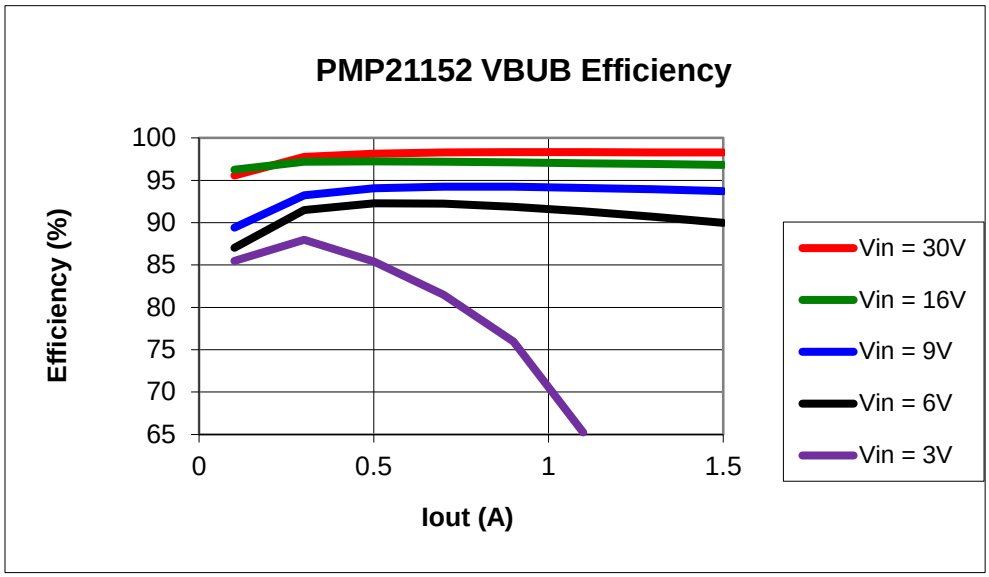
All tests were performed at room temperature on an open bench.

2 Testing and Results

2.1 Efficiency Graphs

Figures show the converter efficiency with 3-V, 6-V, 9-V, 16-V, and 30-V inputs. VBATT efficiency was taken with bypass enabled.





2.2 Efficiency Data

Table 2, Table 3, Table 4, Table 5, Table 6, Table 7, Table 8, Table 9, Table 10, and Table 11 show the efficiency data with 30-V, 16-V, 9-V, 6-V, and 3-V inputs.

Table 2. Efficiency Data 30-V Input, VBATT

V_{IN}	I_{IN}	V_{OUT}	I_{OUT}	P_{IN}	P_{OUT}	Losses	Efficiency
30.0978	0.0047	30.0976	0.0000	0.141	0.000	0.141	0.00
30.0977	0.1049	30.0951	0.1007	3.157	3.031	0.127	95.99
30.0977	0.3039	30.0911	0.3004	9.147	9.039	0.107	98.83
30.0976	0.5031	30.0866	0.5003	15.142	15.052	0.090	99.41
30.0976	0.7023	30.0822	0.7000	21.138	21.058	0.080	99.62
30.0974	0.9013	30.0778	0.8998	27.127	27.064	0.063	99.77
30.0973	1.1002	30.0734	1.0996	33.113	33.069	0.044	99.87
30.0977	1.2997	30.0693	1.2994	39.118	39.072	0.046	99.88
30.0971	1.4988	30.0649	1.4992	45.109	45.073	0.036	99.92

Table 3. Efficiency Data 16-V Input, VBATT

V_{IN}	I_{IN}	V_{OUT}	I_{OUT}	P_{IN}	P_{OUT}	Losses	Efficiency
16.0513	0.0012	16.0512	0.0000	0.019	0.000	0.019	0.00
16.0512	0.1018	16.0490	0.1008	1.634	1.618	0.016	99.00
16.0513	0.3008	16.0444	0.3004	4.828	4.820	0.008	99.82
16.0510	0.5001	16.0401	0.5003	8.027	8.025	0.002	99.97
16.0509	0.6993	16.0359	0.7001	11.224	11.227	-0.002	100.02
16.0510	0.8983	16.0312	0.8998	14.419	14.425	-0.006	100.04
16.0513	1.0974	16.0272	1.0995	17.615	17.622	-0.007	100.04
16.0509	1.2966	16.0227	1.2993	20.812	20.818	-0.007	100.03
16.0508	1.4957	16.0183	1.4991	24.007	24.013	-0.006	100.02

Table 4. Efficiency Data 9-V Input, VBATT

V_{IN}	I_{IN}	V_{OUT}	I_{OUT}	P_{IN}	P_{OUT}	Losses	Efficiency
9.0314	0.0001	11.1214	0.0000	0.001	0.000	0.001	0.00
9.0314	0.1309	10.5609	0.1008	1.182	1.065	0.118	90.05
9.0312	0.3750	10.5596	0.3004	3.387	3.172	0.215	93.66
9.0312	0.6190	10.5590	0.5003	5.590	5.283	0.308	94.50
9.0313	0.8639	10.5585	0.7001	7.802	7.392	0.410	94.74
9.0313	1.1096	10.5585	0.8998	10.021	9.501	0.521	94.80
9.0311	1.3564	10.5577	1.0996	12.250	11.609	0.641	94.77
9.0310	1.6041	10.5581	1.2994	14.487	13.719	0.767	94.70
9.0311	1.8527	10.5576	1.4992	16.732	15.828	0.904	94.60

Table 5. Efficiency Data 6-V Input, VBATT

V_{IN}	I_{IN}	V_{OUT}	I_{OUT}	P_{IN}	P_{OUT}	Losses	Efficiency
6.0174	0.0001	10.9748	0.0000	0.001	0.000	0.001	0.00
6.0174	0.2022	10.5601	0.1007	1.217	1.063	0.153	87.40
6.0173	0.5723	10.5592	0.3004	3.444	3.172	0.272	92.11
6.0171	0.9428	10.5589	0.5002	5.673	5.282	0.391	93.10
6.0172	1.3168	10.5581	0.7001	7.923	7.392	0.532	93.29
6.0172	1.6941	10.5579	0.8998	10.194	9.500	0.694	93.19
6.0171	2.0758	10.5576	1.0996	12.490	11.609	0.881	92.95
6.0171	2.4618	10.5574	1.2994	14.813	13.718	1.095	92.61
6.0169	2.8526	10.5574	1.4992	17.164	15.828	1.336	92.22
6.0174	0.0001	10.9748	0.0000	0.001	0.000	0.001	0.00

Table 6. Efficiency Data 3-V Input, VBATT

V_{IN}	I_{IN}	V_{OUT}	I_{OUT}	P_{IN}	P_{OUT}	Losses	Efficiency
3.0107	0.0000	10.9733	0.0000	0.000	0.000	0.000	NaN
3.0103	0.4079	10.5592	0.1007	1.228	1.063	0.165	86.60
3.0104	1.1637	10.5581	0.3004	3.503	3.172	0.332	90.54
3.0101	1.9510	10.5579	0.5002	5.873	5.281	0.592	89.92
3.0099	2.7763	10.5575	0.7001	8.356	7.391	0.965	88.45
3.0097	3.6504	10.5572	0.8998	10.987	9.499	1.487	86.46
3.0093	4.6015	10.5569	1.0995	13.847	11.607	2.240	83.82
3.0083	5.7183	10.5551	1.2994	17.203	13.715	3.487	79.73
3.0092	3.7460	6.3337	1.4992	11.273	9.496	1.777	84.24

Table 7. Efficiency Data 30-V Input, VBUB

V_{IN}	I_{IN}	V_{OUT}	I_{OUT}	P_{IN}	P_{OUT}	Losses	Efficiency
30.0974	0.0038	29.9113	0.0001	0.114	0.003	0.111	2.62
30.0972	0.1041	29.7347	0.1007	3.133	2.994	0.139	95.57
30.0972	0.3031	29.6902	0.3004	9.122	8.919	0.204	97.77
30.0968	0.5024	29.6616	0.5003	15.121	14.840	0.281	98.14
30.0972	0.7015	29.6375	0.7001	21.113	20.749	0.364	98.28
30.0968	0.9006	29.6157	0.8998	27.105	26.648	0.457	98.31
30.0972	1.0997	29.5950	1.0996	33.098	32.543	0.555	98.32
30.0969	1.2988	29.5743	1.2993	39.090	38.426	0.664	98.30
30.0969	1.4979	29.5546	1.4991	45.082	44.305	0.777	98.28

Table 8. Efficiency Data 16-V Input, VBUB

V_{IN}	I_{IN}	V_{OUT}	I_{OUT}	P_{IN}	P_{OUT}	Losses	Efficiency
16.0509	0.0019	29.7581	0.0000	0.030	0.000	0.030	0.00
16.0508	0.1023	15.6916	0.1007	1.642	1.580	0.062	96.23
16.0508	0.3013	15.6459	0.3004	4.836	4.700	0.136	97.19
16.0510	0.5006	15.6163	0.5003	8.035	7.813	0.222	97.23
16.0510	0.6997	15.5917	0.7001	11.231	10.916	0.315	97.19
16.0509	0.8988	15.5691	0.8998	14.427	14.009	0.418	97.11
16.0506	1.0979	15.5478	1.0996	17.622	17.096	0.526	97.02
16.0504	1.2971	15.5270	1.2994	20.819	20.176	0.643	96.91
16.0506	1.4962	15.5065	1.4991	24.015	23.246	0.769	96.80

Table 9. Efficiency Data 9-V Input, VBUB

V_{IN}	I_{IN}	V_{OUT}	I_{OUT}	P_{IN}	P_{OUT}	Losses	Efficiency
9.0313	0.0010	15.7751	0.0000	0.009	0.000	0.009	0.00
9.0310	0.1317	10.5608	0.1007	1.189	1.063	0.126	89.41
9.0308	0.3768	10.5594	0.3004	3.403	3.172	0.231	93.22
9.0309	0.6219	10.5589	0.5002	5.616	5.282	0.335	94.04
9.0309	0.8685	10.5585	0.7001	7.843	7.392	0.451	94.25
9.0308	1.1163	10.5584	0.8998	10.081	9.500	0.581	94.24
9.0311	1.3660	10.5582	1.0996	12.336	11.610	0.727	94.11
9.0308	1.6172	10.5582	1.2994	14.605	13.719	0.885	93.94
9.0308	1.8701	10.5576	1.4992	16.889	15.828	1.061	93.72

Table 10. Efficiency Data 6-V Input, VBUB

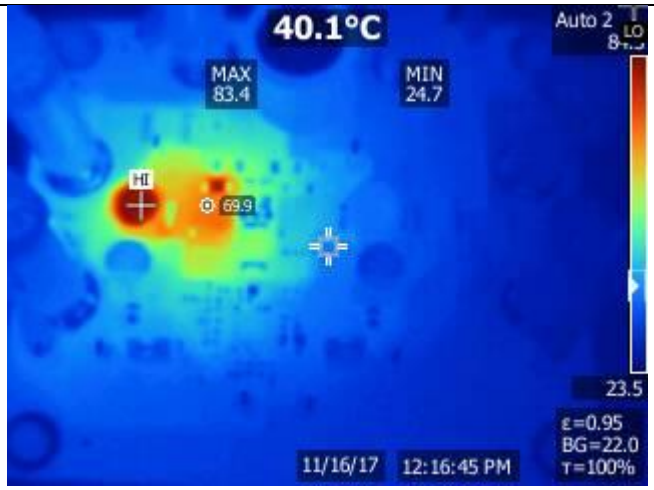
V_{IN}	I_{IN}	V_{OUT}	I_{OUT}	P_{IN}	P_{OUT}	Losses	Efficiency
6.0169	0.0007	10.9734	0.0000	0.004	0.000	0.004	0.00
6.0172	0.2040	10.6070	0.1007	1.228	1.068	0.159	87.02
6.0170	0.5762	10.5594	0.3004	3.467	3.172	0.295	91.49
6.0169	0.9511	10.5587	0.5002	5.723	5.281	0.441	92.29
6.0168	1.3318	10.5587	0.7001	8.013	7.392	0.621	92.25
6.0166	1.7188	10.5582	0.8998	10.341	9.500	0.841	91.87
6.0167	2.1126	10.5580	1.0996	12.711	11.610	1.101	91.34
6.0164	2.5140	10.5580	1.2994	15.125	13.719	1.406	90.70
6.0168	2.9240	10.5576	1.4992	17.593	15.828	1.765	89.97
6.0169	0.0007	10.9734	0.0000	0.004	0.000	0.004	0.00

Table 11. Efficiency Data 3-V Input, VBUB

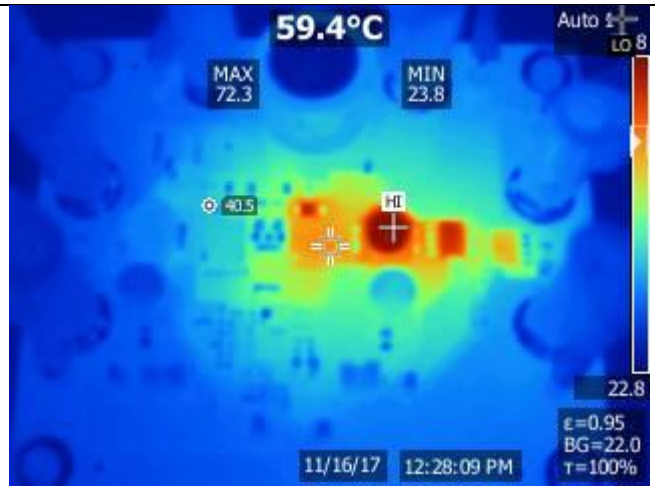
V_{IN}	I_{IN}	V_{OUT}	I_{OUT}	P_{IN}	P_{OUT}	Losses	Efficiency
3.0102	0.0003	10.9718	0.0000	0.001	0.000	0.001	0.00
3.0100	0.4133	10.5591	0.1007	1.244	1.063	0.181	85.47
3.0100	1.1977	10.5581	0.3004	3.605	3.172	0.433	87.98
3.0098	2.0545	10.5577	0.5003	6.184	5.282	0.902	85.42
3.0098	3.0141	10.5579	0.7001	9.072	7.392	1.680	81.48
3.0092	4.1566	10.5574	0.8998	12.508	9.500	3.009	75.95
3.0082	5.9151	10.5555	1.0995	17.794	11.606	6.188	65.22
3.0087	4.4060	7.1489	1.2993	13.256	9.289	3.968	70.07
3.0080	4.7120	6.4313	1.4991	14.174	9.641	4.532	68.02

2.3 Thermal Images

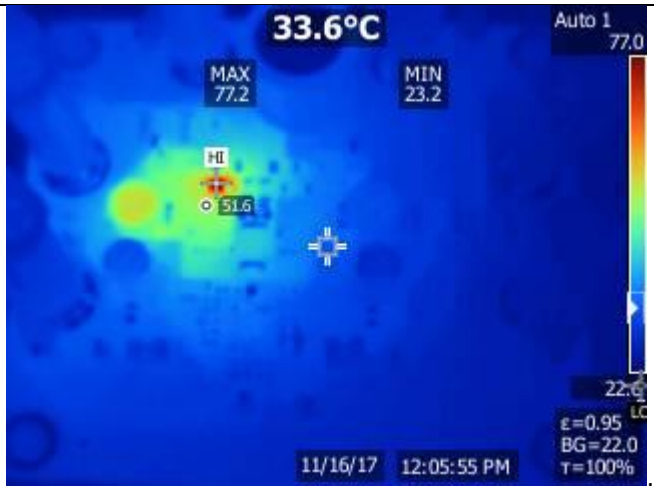
Figures show thermal performance with no airflow. The images were taken with the board at thermal equilibrium.



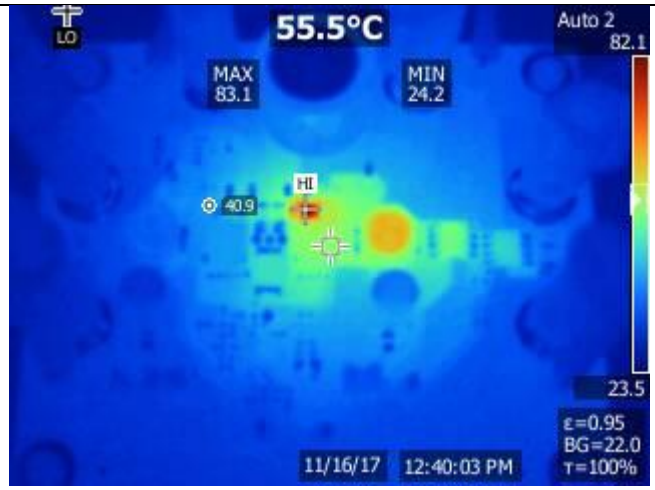
Thermal Image, 3-V Battery Input, 1-A Load



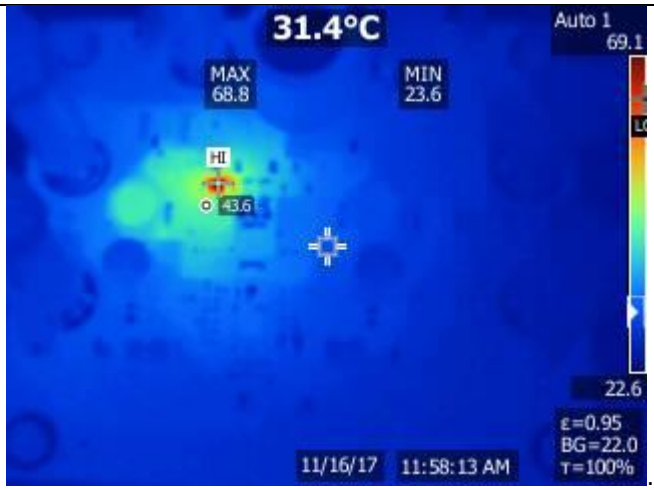
Thermal Image, 3-V Backup Input, 0.75-A Load



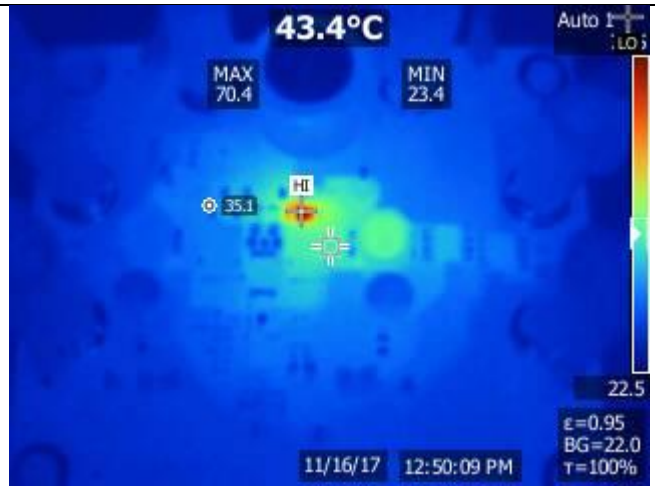
Thermal Image, 6-V Battery Input, 1.5-A Load



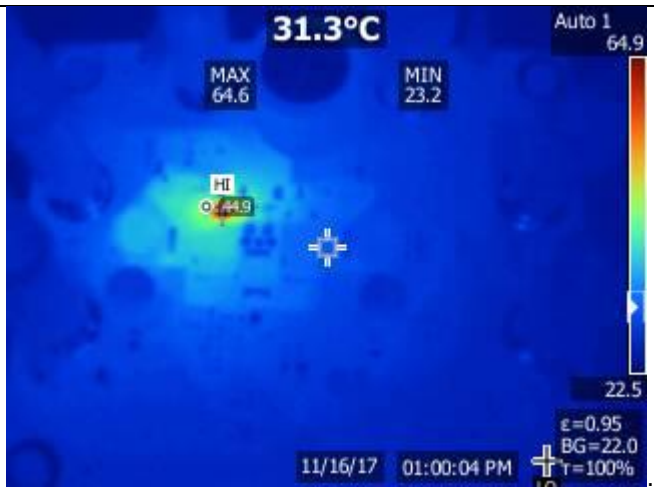
Thermal Image, 6-V Backup Input, 1.5-A Load



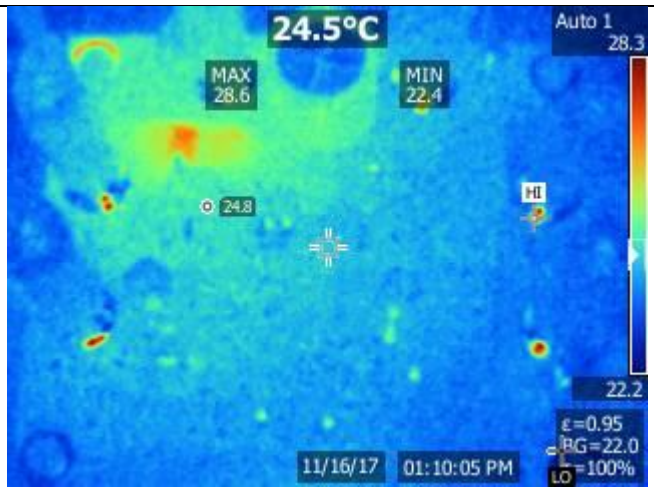
Thermal Image, 9-V Battery Input, 1.5-A Load



Thermal Image, 9-V Backup Input, 1.5-A Load



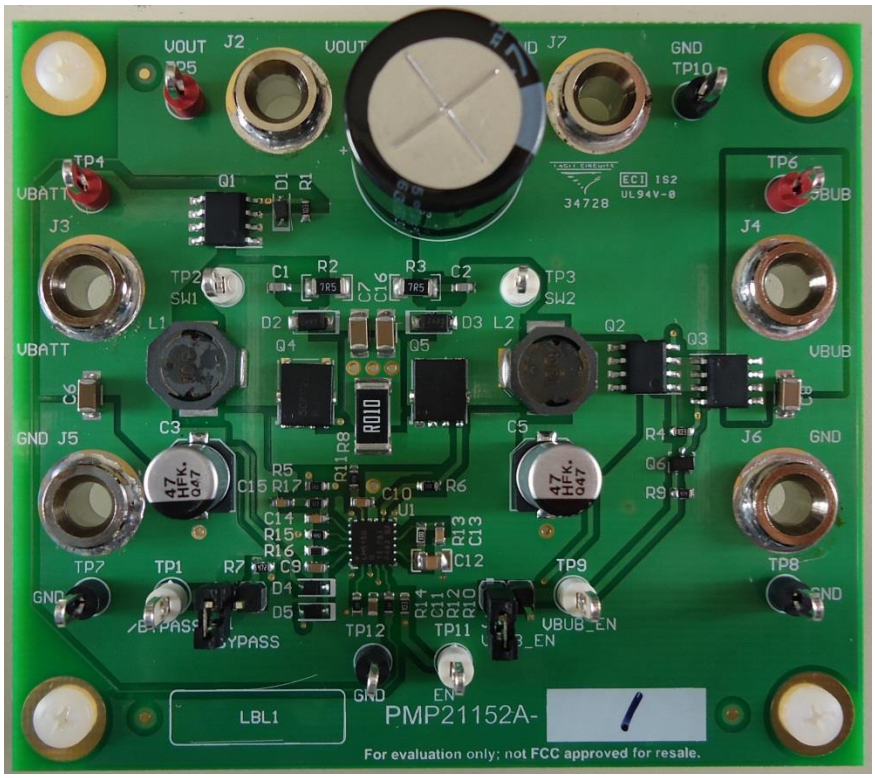
Thermal Image, 16-V Battery Input, 1.5-A Load



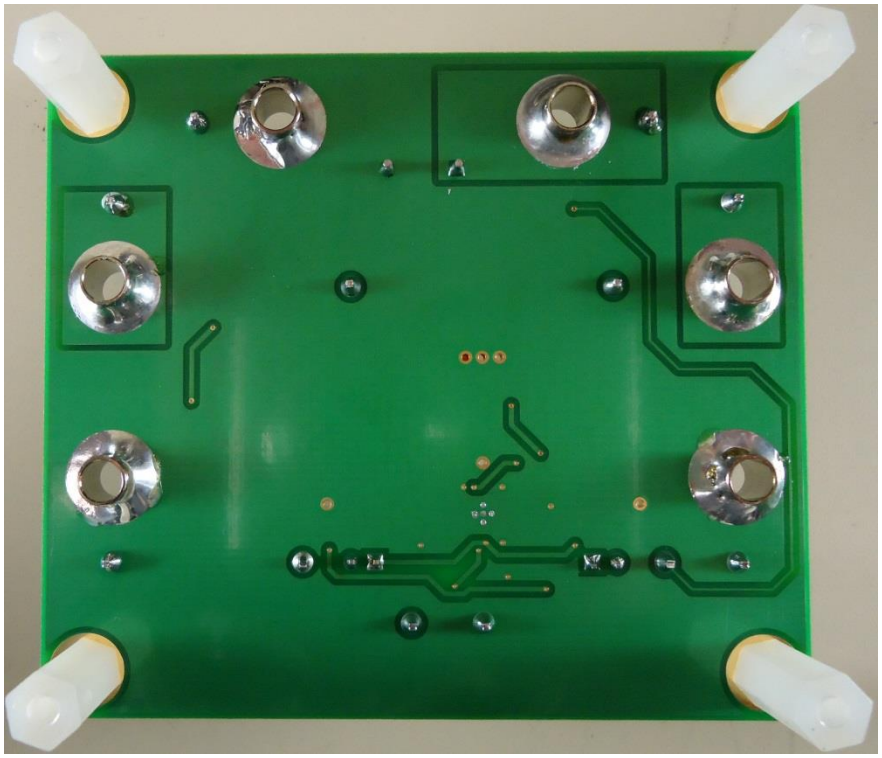
Thermal Image, 16-V Battery Input with Bypass, 1.5-A Load

2.4 Dimensions

The photographs below show the PMP21152 Rev A printed circuit board assembly. This is a 2-layer PCB with 1 oz. copper. Board dimensions are 3.2 in. x 2.8 in.



Top of PMP21152 Board

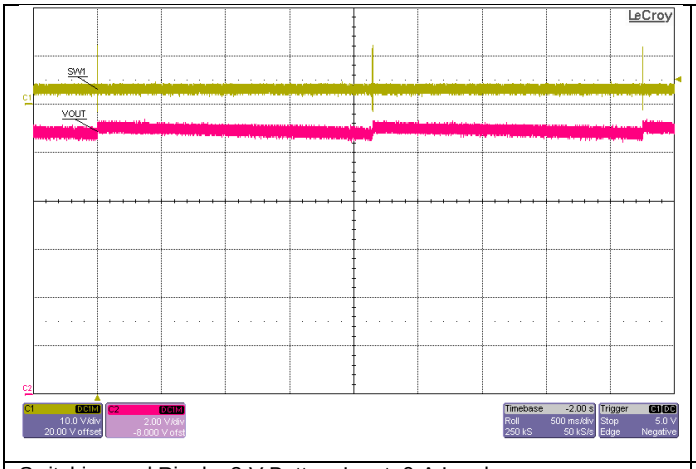


Bottom of PMP21152 Board

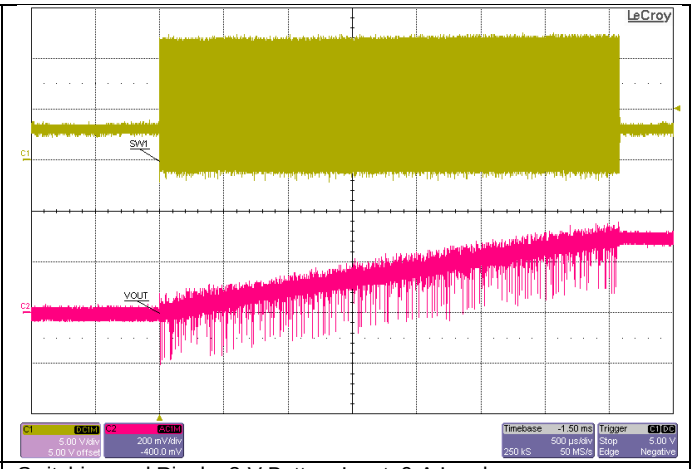
3 Waveforms

3.1 VBATT Switching and Output Voltage Ripple

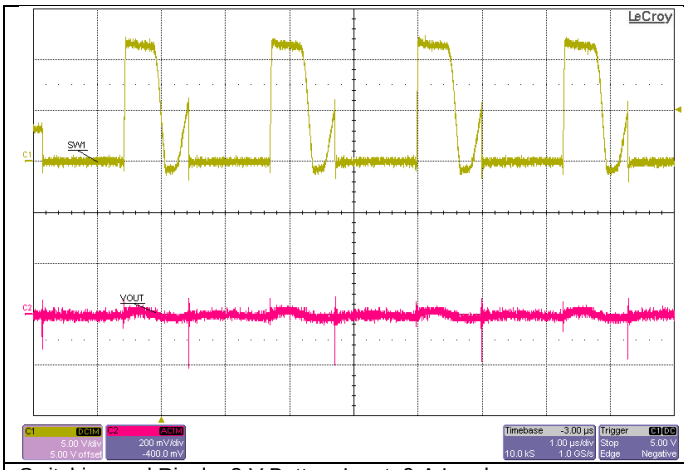
Figures show the switch node voltage and output voltage ripple of the converter while powered from the battery input. Switching was measured at full bandwidth using 500 MHz probes and 350 MHz oscilloscope.



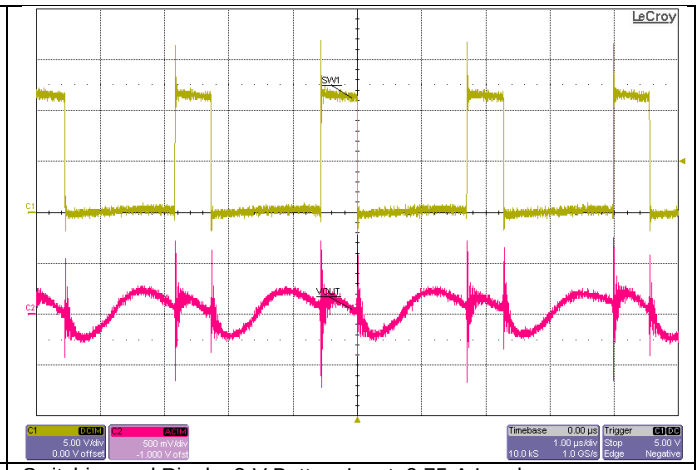
Switching and Ripple, 3-V Battery Input, 0-A Load



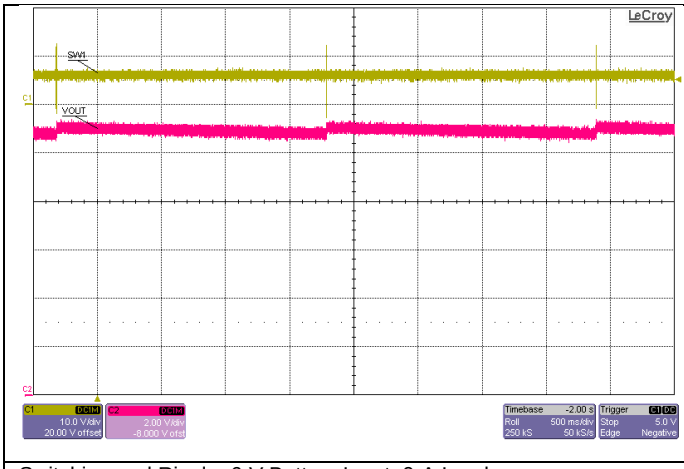
Switching and Ripple, 3-V Battery Input, 0-A Load



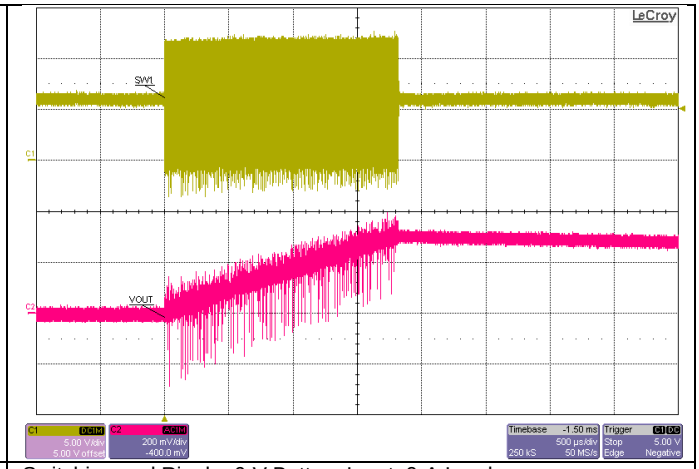
Switching and Ripple, 3-V Battery Input, 0-A Load



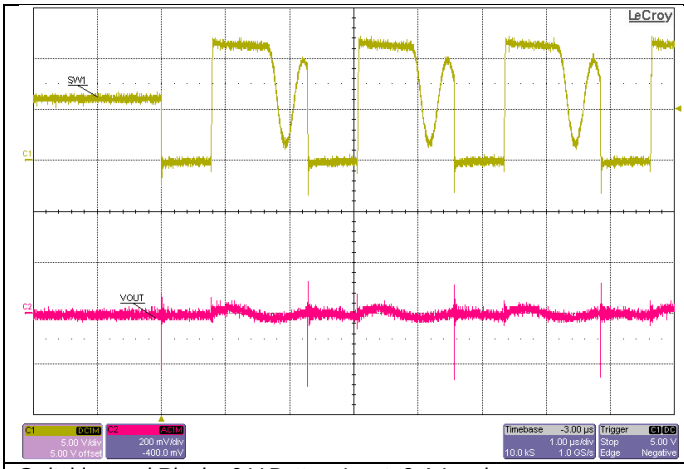
Switching and Ripple, 3-V Battery Input, 0.75-A Load



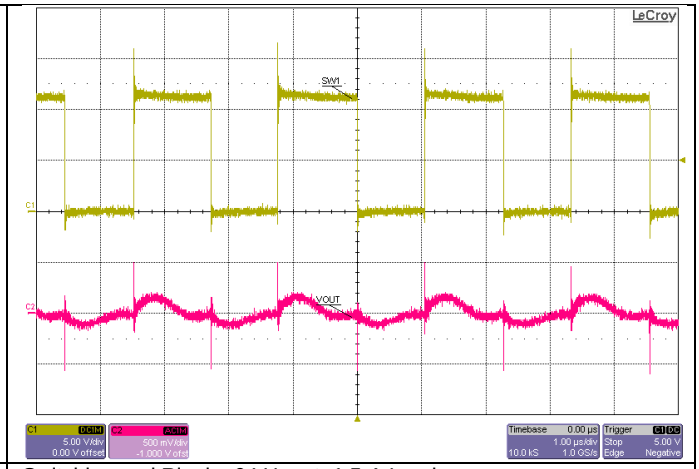
Switching and Ripple, 6-V Battery Input, 0-A Load



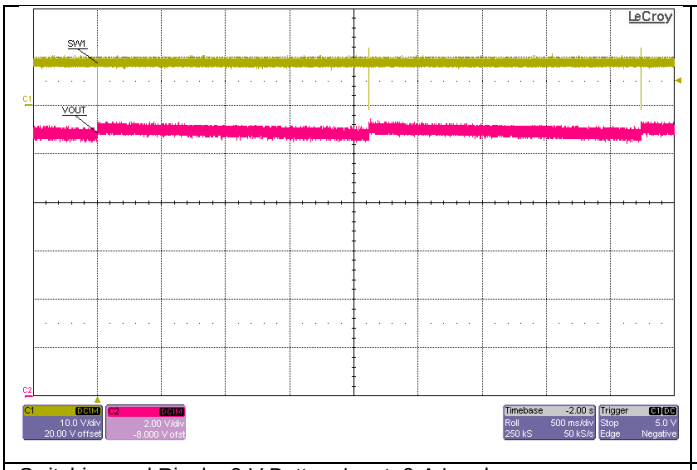
Switching and Ripple, 6-V Battery Input, 0-A Load



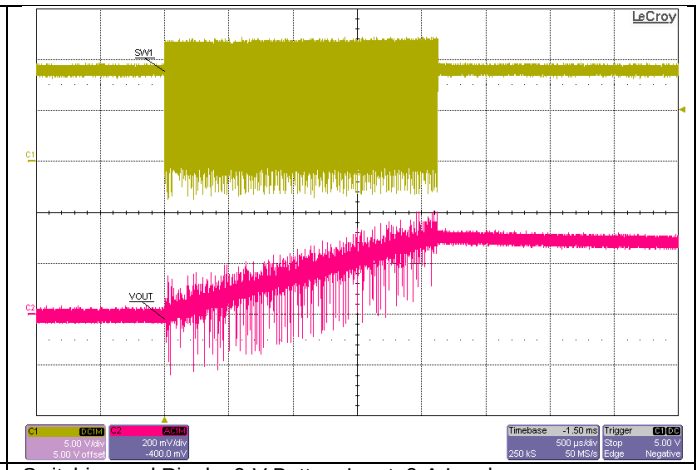
Switching and Ripple, 6-V Battery Input, 0-A Load



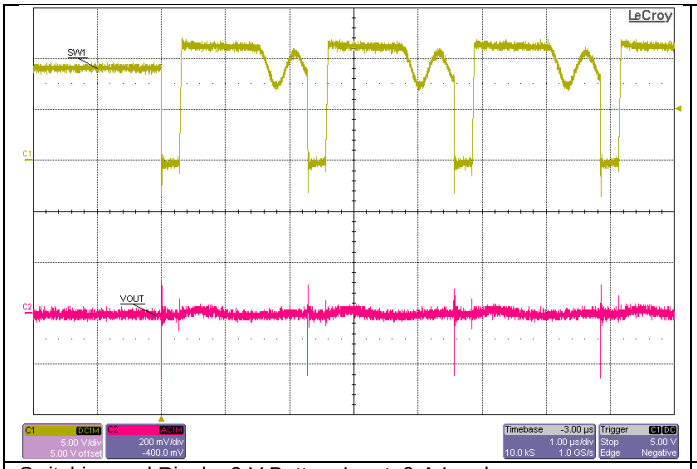
Switching and Ripple, 6-V Input, 1.5-A Load



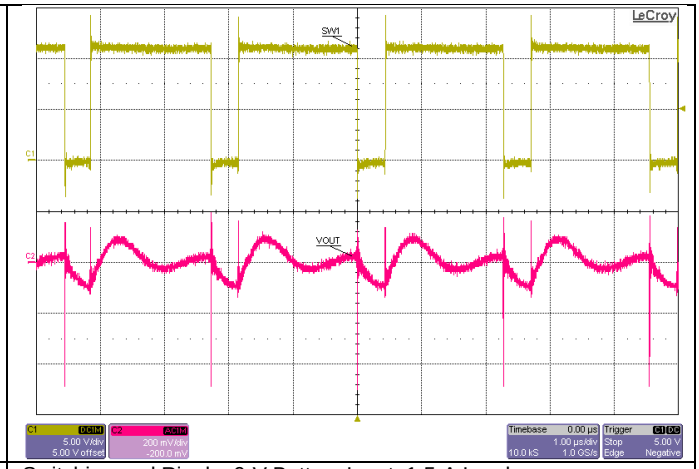
Switching and Ripple, 9-V Battery Input, 0-A Load



Switching and Ripple, 9-V Battery Input, 0-A Load



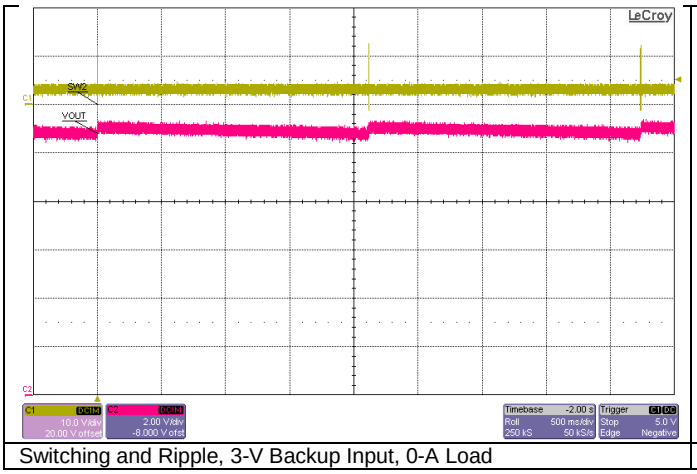
Switching and Ripple, 9-V Battery Input, 0-A Load



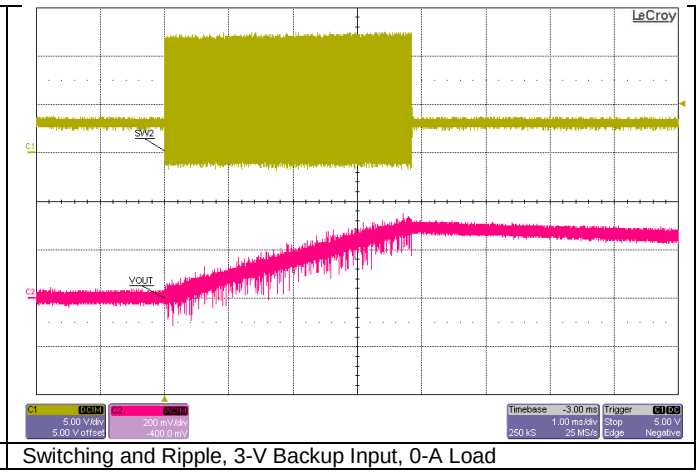
Switching and Ripple, 9-V Battery Input, 1.5-A Load

3.2 VBUB Switching and Output Voltage Ripple

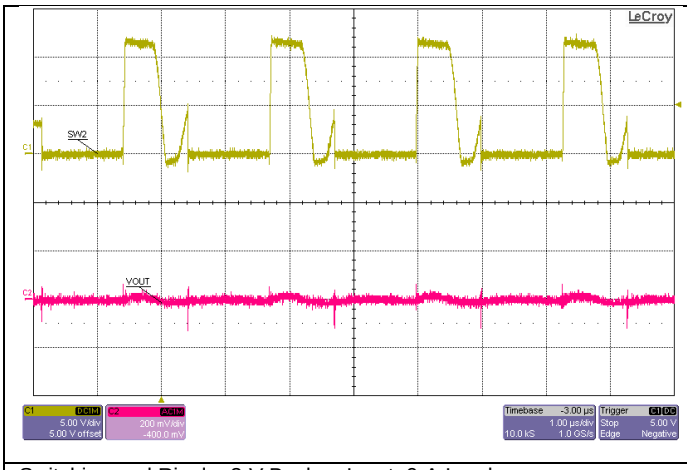
Figures show the switch node voltage and output voltage ripple of the converter while powered from the backup input. Switching was measured at full bandwidth using 500 MHz probes and 350 MHz oscilloscope.



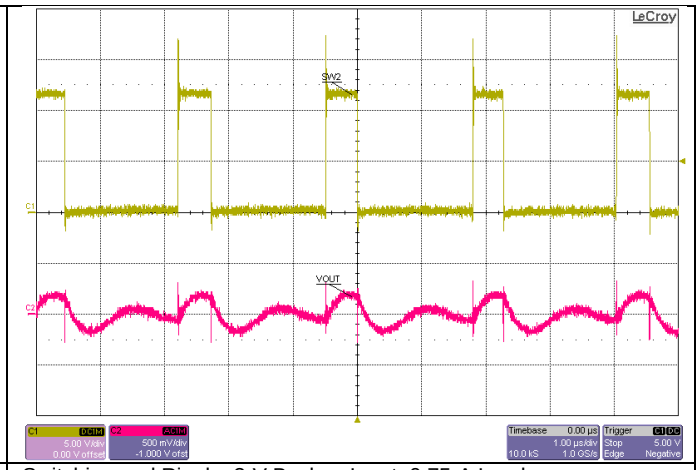
Switching and Ripple, 3-V Backup Input, 0-A Load



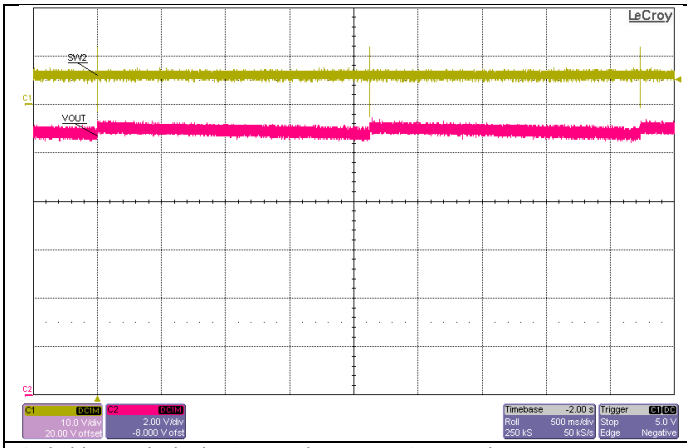
Switching and Ripple, 3-V Backup Input, 0-A Load



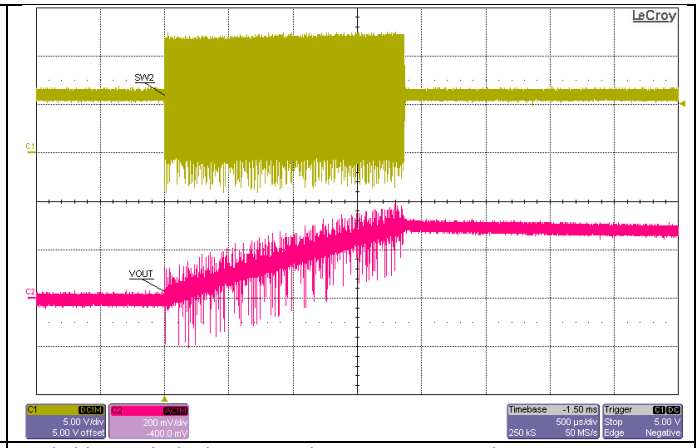
Switching and Ripple, 3-V Backup Input, 0-A Load



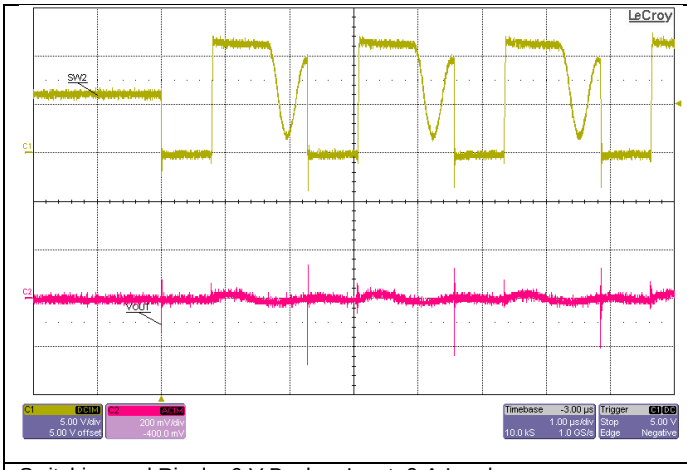
Switching and Ripple, 3-V Backup Input, 0.75-A Load



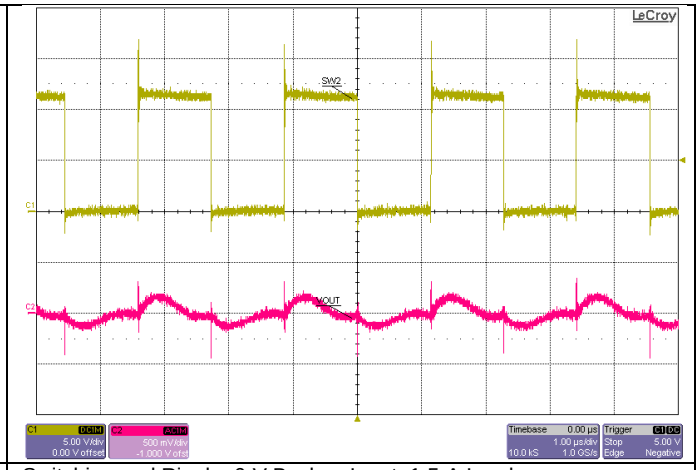
Switching and Ripple, 6-V Backup Input, 0-A Load



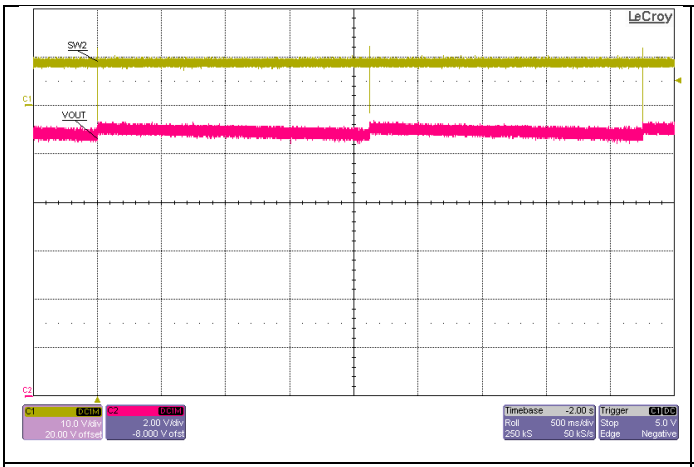
Switching and Ripple, 6-V Backup Input, 0-A Load



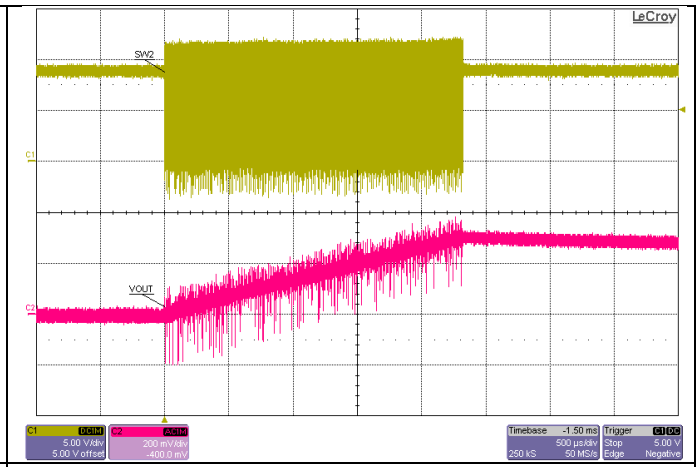
Switching and Ripple, 6-V Backup Input, 0-A Load



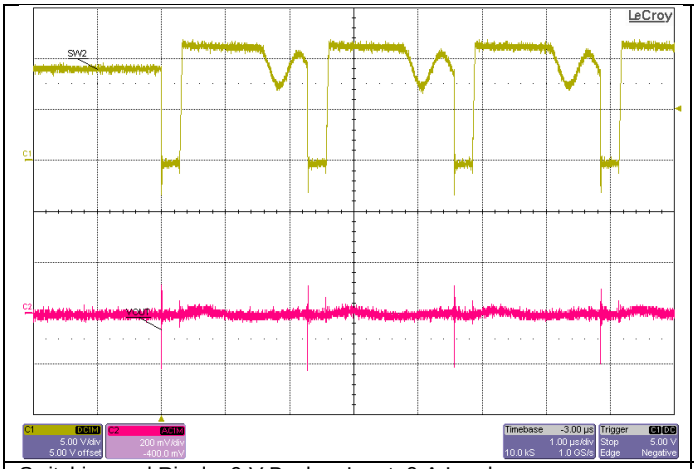
Switching and Ripple, 6-V Backup Input, 1.5-A Load



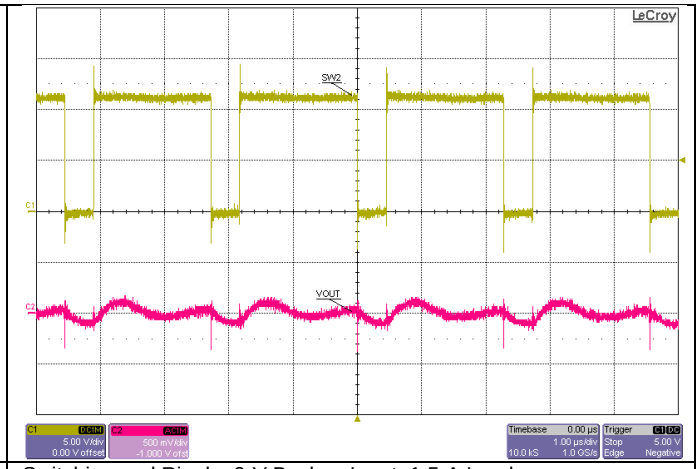
Switching and Ripple, 9-V Backup Input, 0-A Load



Switching and Ripple, 9-V Backup Input, 0-A Load



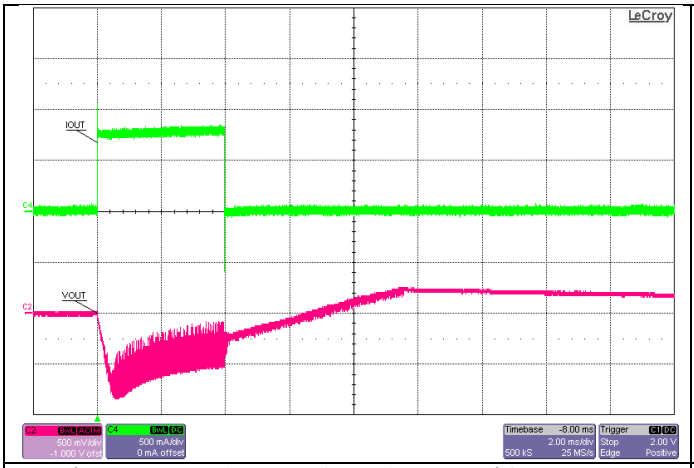
Switching and Ripple, 9-V Backup Input, 0-A Load



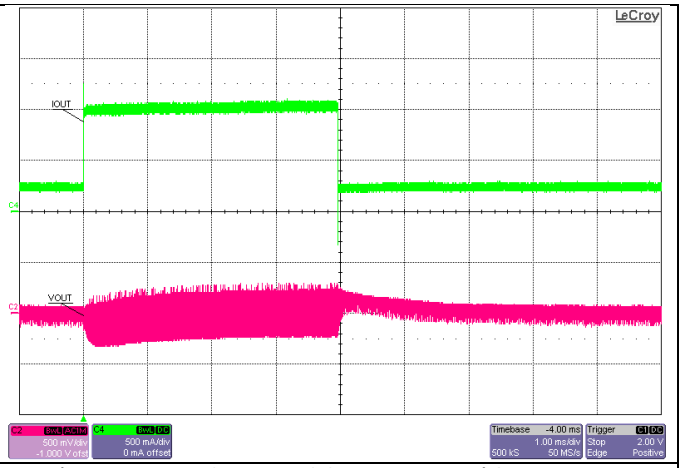
Switching and Ripple, 9-V Backup Input, 1.5-A Load

3.3 Load Transients

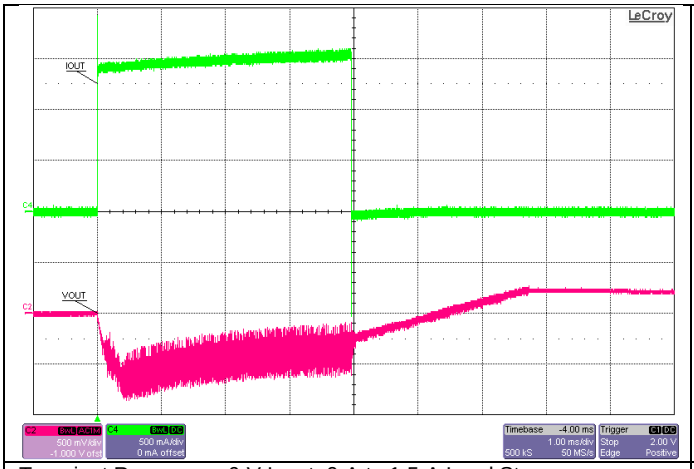
Figures show the load transient response of the converter.



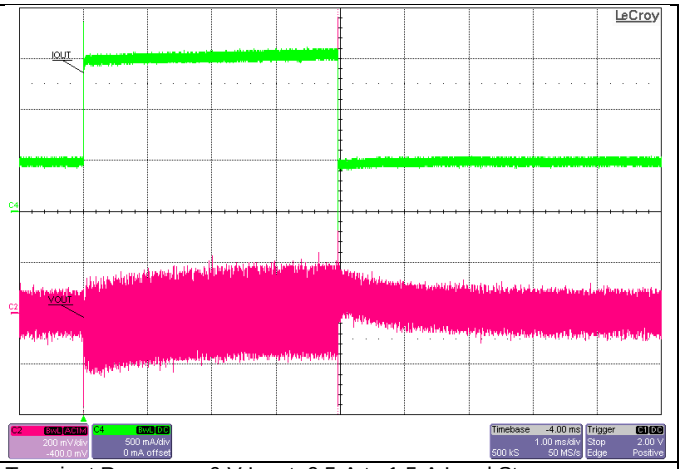
Transient Response, 3-V Input, 0-A to 0.75-A Load Step



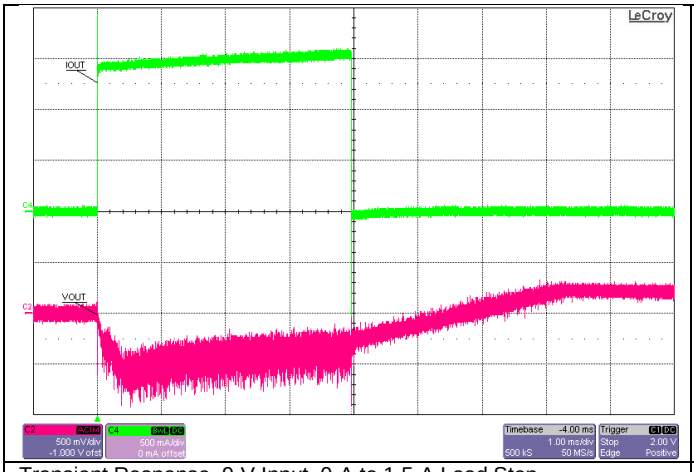
Transient Response, 3-V Input, 0.25-A to 1-A Load Step



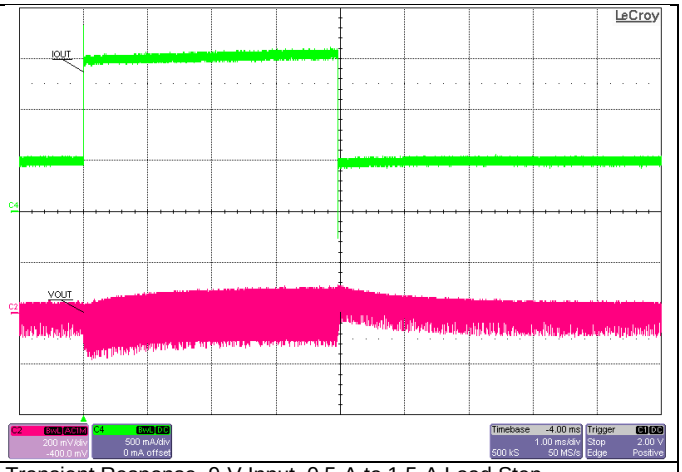
Transient Response, 6-V Input, 0-A to 1.5-A Load Step



Transient Response, 6-V Input, 0.5-A to 1.5-A Load Step



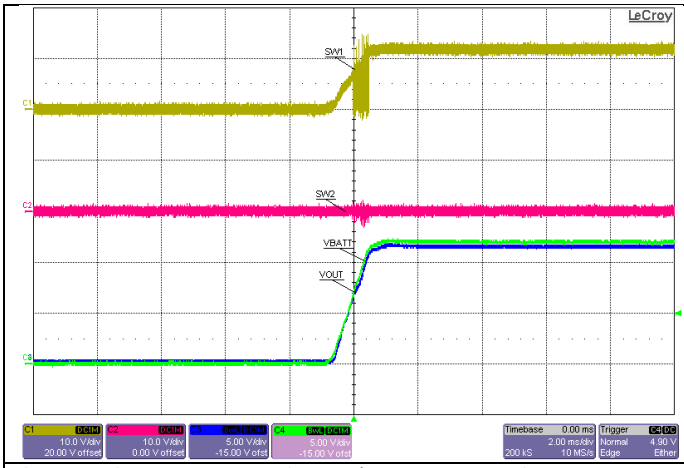
Transient Response, 9-V Input, 0-A to 1.5-A Load Step



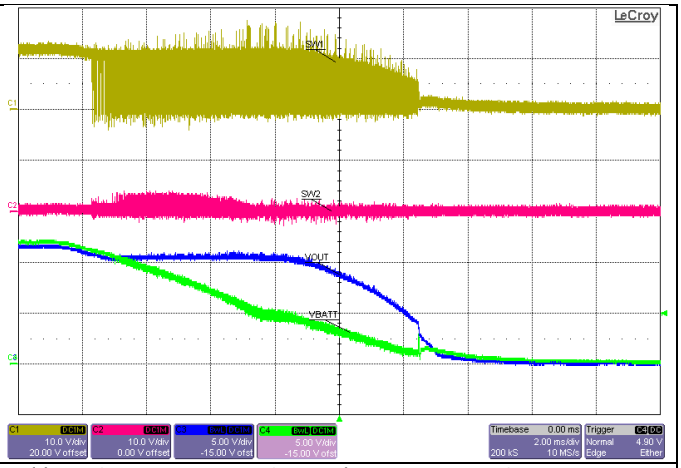
Transient Response, 9-V Input, 0.5-A to 1.5-A Load Step

3.4 Startup and Holdup from VBATT

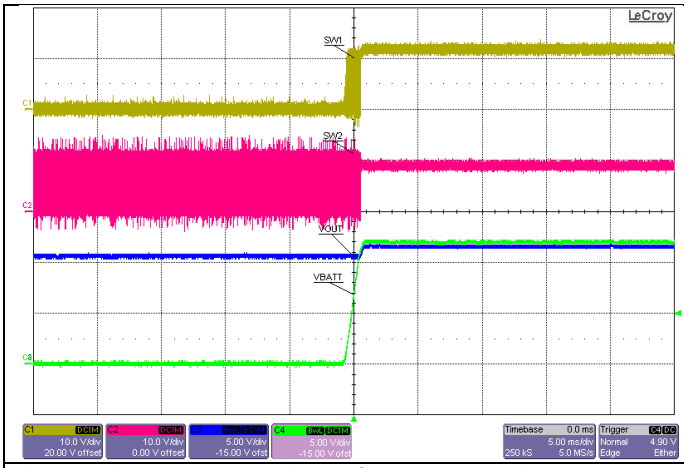
Figures show the startup and holdup performance from the battery input using a constant current electronic load.



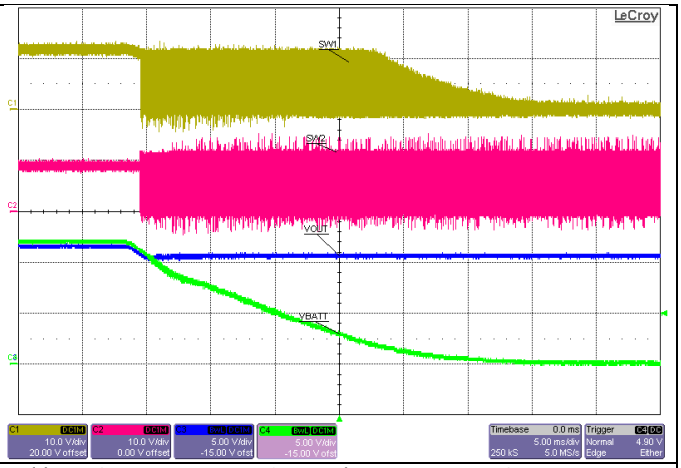
Startup, 12-V Battery Input, 0-V Backup Input, 1.5-A Constant Current Load



Holdup, 12-V Battery Input, 0-V Backup Input, 1.5-A Constant Current Load



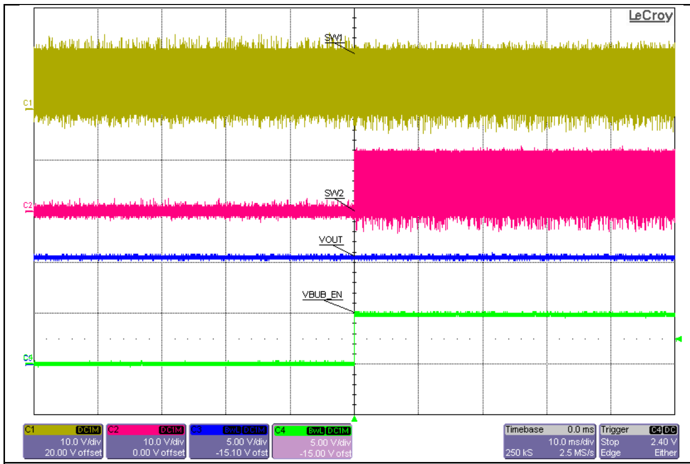
Startup, 12-V Battery Input, 9-V Backup Input, 1.5-A Constant Current Load



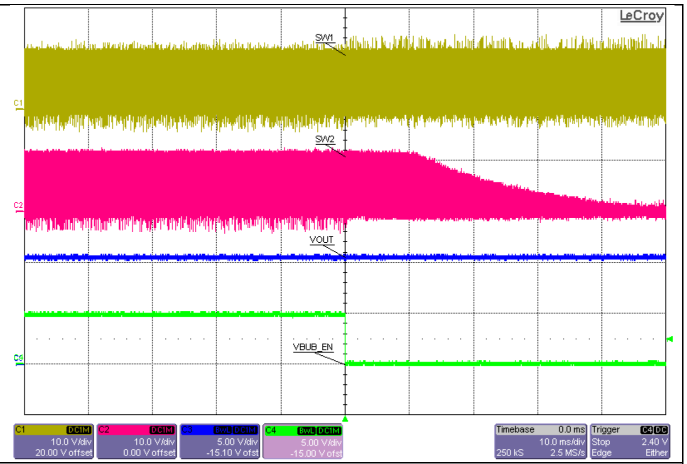
Holdup, 12-V Battery Input, 9-V Backup Input, 1.5-A Constant Current Load

3.5 Holdup using VBUB_EN

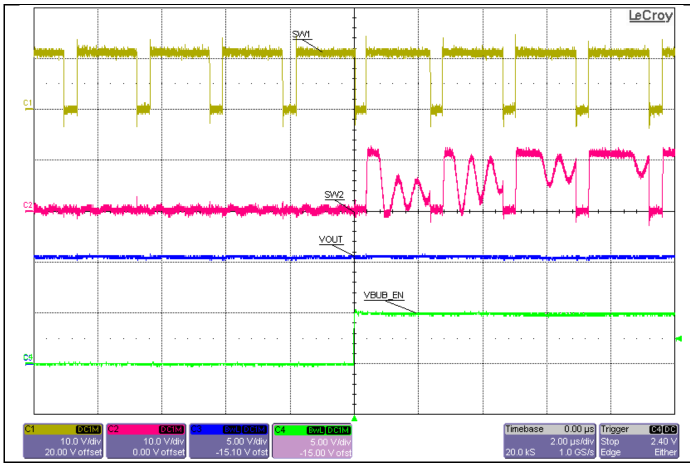
Figures show the holdup performance controlled by the backup enable using a constant current electronic load.



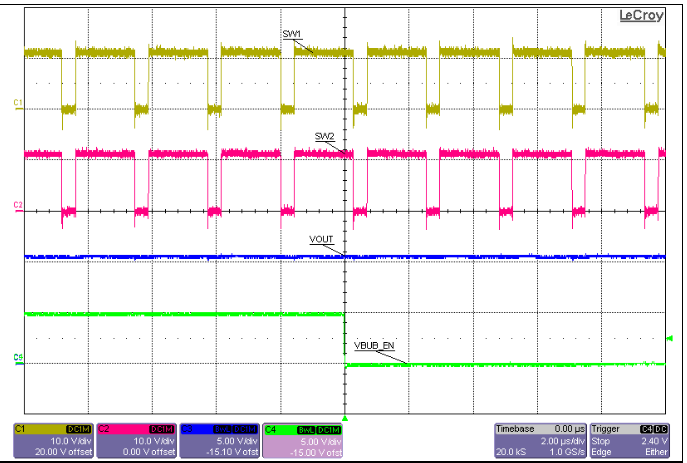
Holdup, 9-V Battery Input, 9-V Backup Input, 1.5-A Constant Current Load



Holdup, 9-V Battery Input, 9-V Backup Input, 1.5-A Constant Current Load



Holdup, 9-V Battery Input, 9-V Backup Input, 1.5-A Constant Current Load



Holdup, 9-V Battery Input, 9-V Backup Input, 1.5-A Constant Current Load

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