Test Data

For TIDA-00748

10/14/2015

Contents

1. Design Specifications

Table 1: TIDA-00748 design specifications and recommended operating conditions

Vin Minimum	8VDC
Vin Maximum	15VDC
Vout	16V - 24V (Boost only), 9V – 12V (Boost-to-Battery)
LED Drive Current (maximum)	3A
Approximate Switching Frequency	140 KHz Approx
LED Dimming	0A - 3A with no flickering

2. Circuit Description and PCB details

2.1 Boost Configuration

TIDA-00748 is a 60W Synchronous Boost Design for automotive LED application utilizing the Synchronous Boost Converter LM5122-Q1. This design applies to automotive lighting for exterior lighting such as headlights and taillights and also interior LED lighting systems. The design accepts an input voltage of 8Vin to 15Vin and can drive multiple strings of 6 to 7 LEDS (16V to 24V) in series at 3A constant current. It is a low cost solution and provides undervoltage as well as overvoltage protection. This solutions offers 97% efficiency compared to inefficient nonsynchronous Boost solutions.

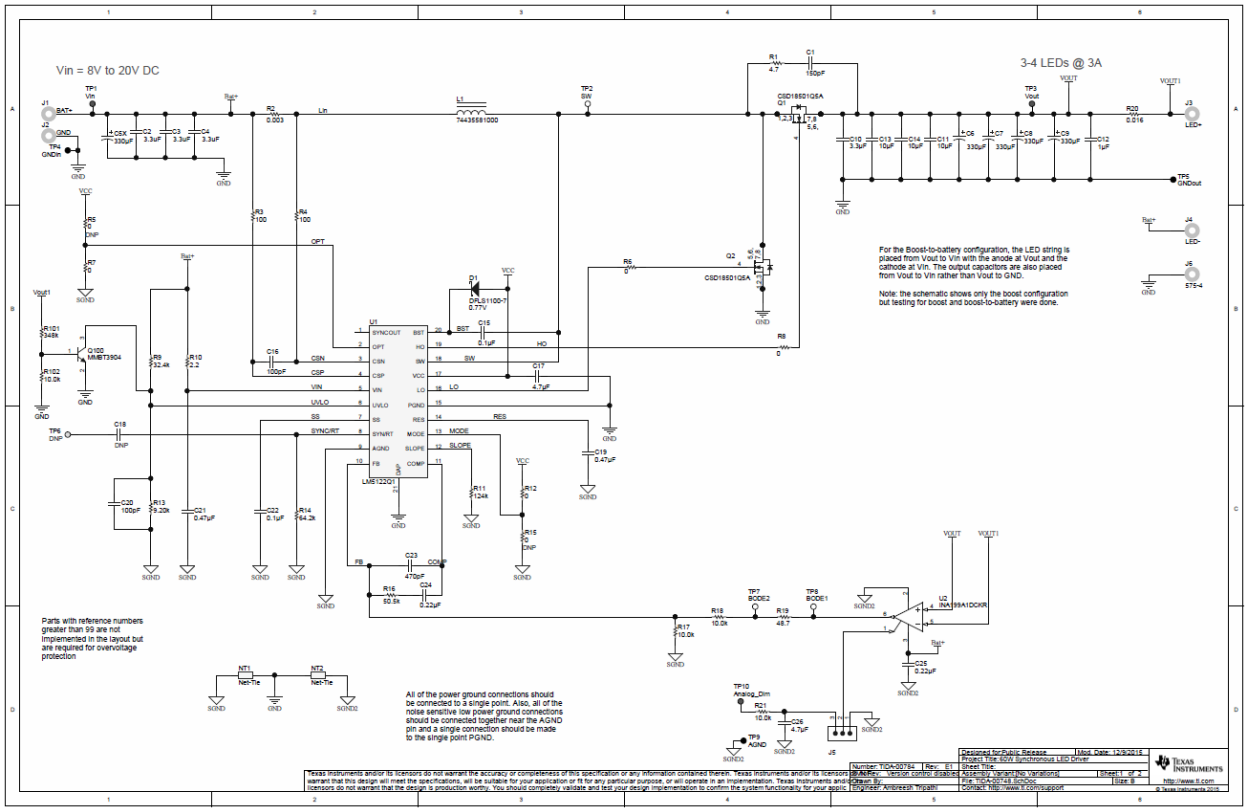

Figure 1: Boost configuration and LM5122 schematic

2.2 Boost-to-Battery Configuration

The TIDA-00748 can also be modified to a Boost-to-Battery configuration by connecting the cathode of the LED string (9V to 12V) to the input rather than ground and connecting the output capacitors from input to output. In this configuration, the 8V to 15V input can power strings of LEDs that require voltages lower than, higher than, or equal to the input voltage which would not work with the standard Boost configuration which requires the output voltage to be higher than the input voltage. See Figure 1 for the Boost-to-Battery configuration along with the internal block diagram of the LM5122.

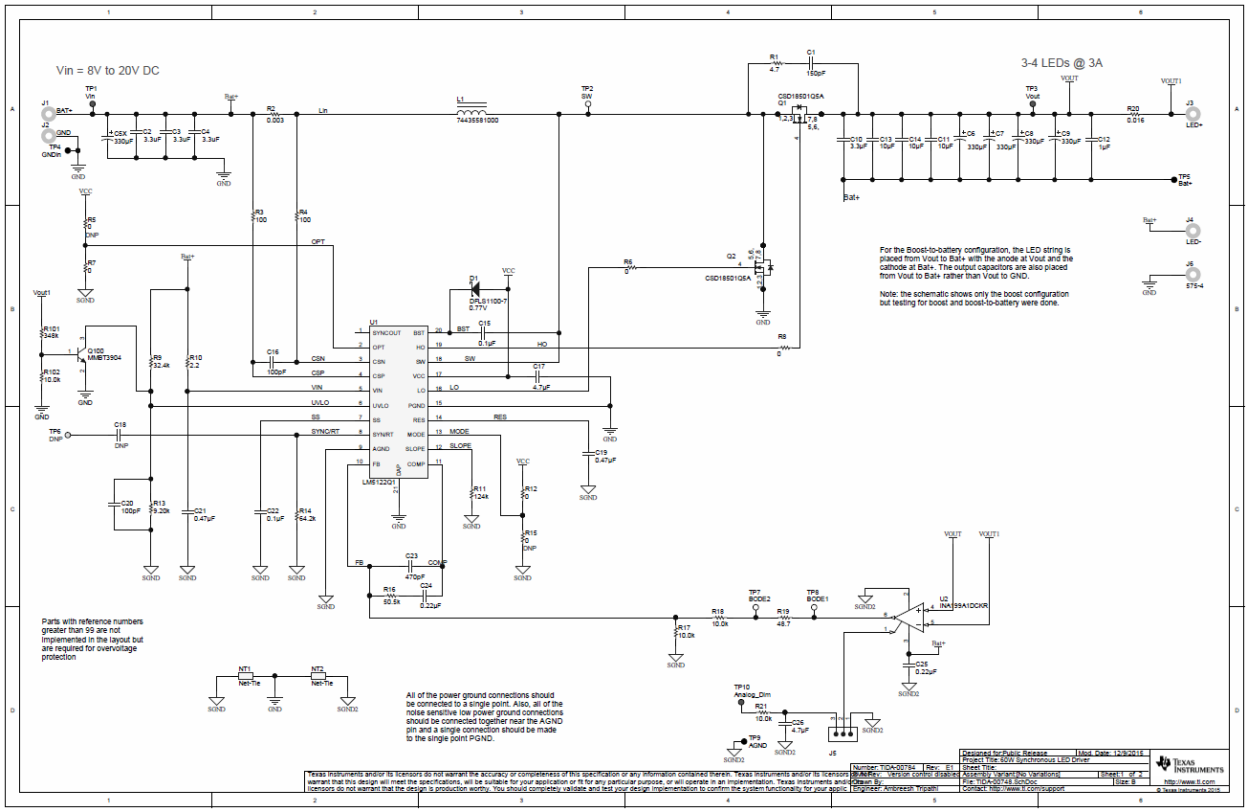

Figure 2: Boost-to-Battery configuration and LM5122 schematic

The Board dimension of TIDA-00748 PCB is 2100mil * 5200mil. Four layer PCB was used for the design.

3. TIDA-00748 Board Photos

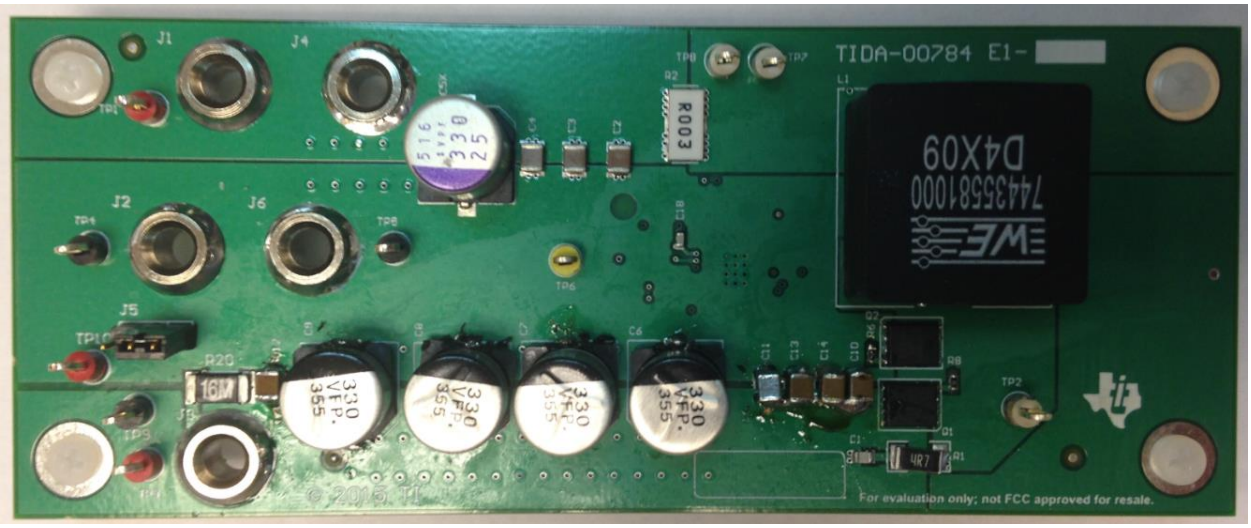

Figure 3: TIDA-00748 board top

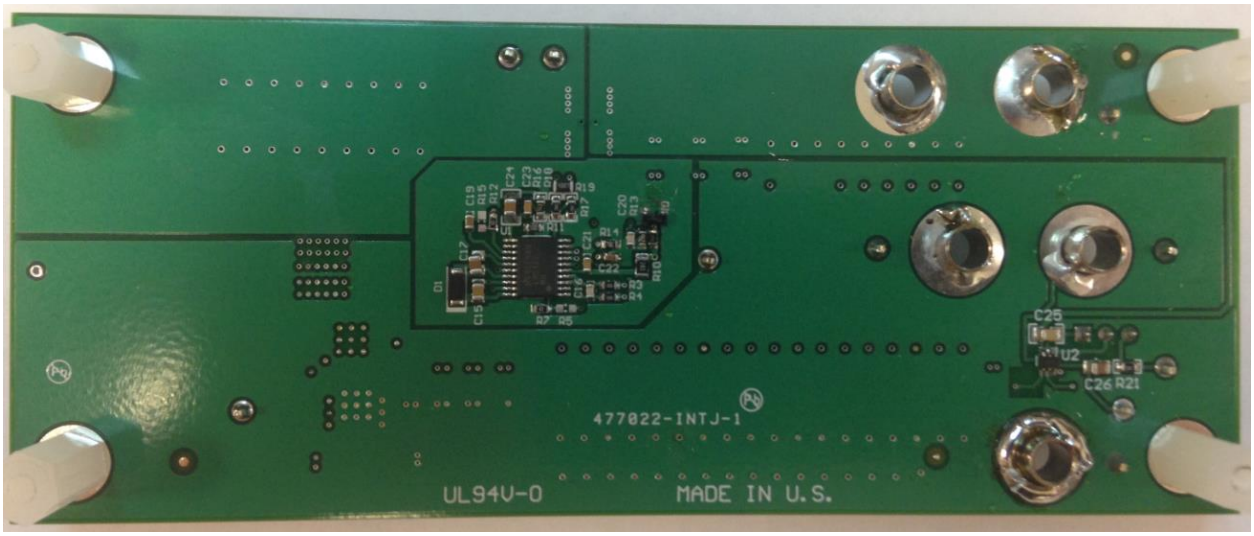

Figure 4: TIDA-00748 board bottom

4. Thermal Data – Boost Configuration

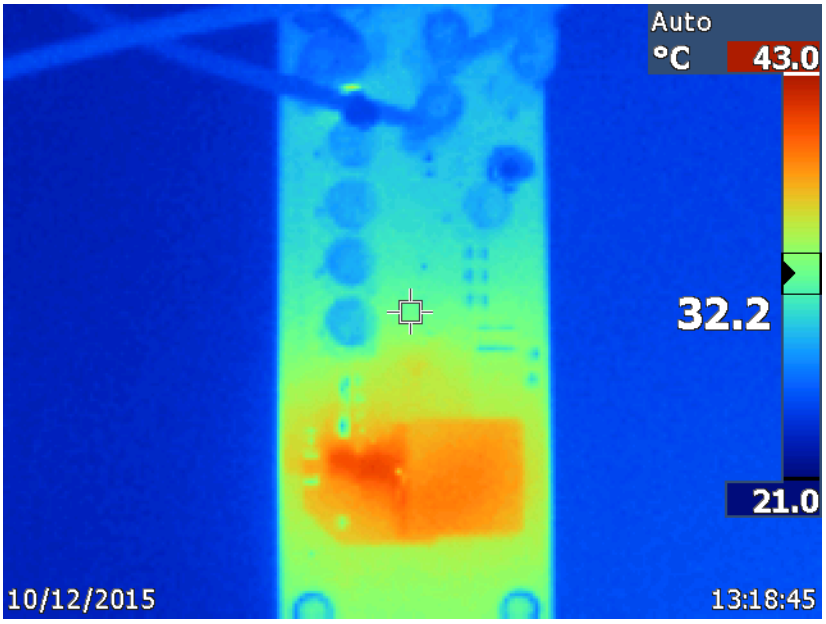

Figure 5: Board top at 12Vin and full load of 3A load current (current sense comparator reference set to 0V) for Boost configuration

5. Efficiency – Boost Configuration

5.1 Efficiency Chart

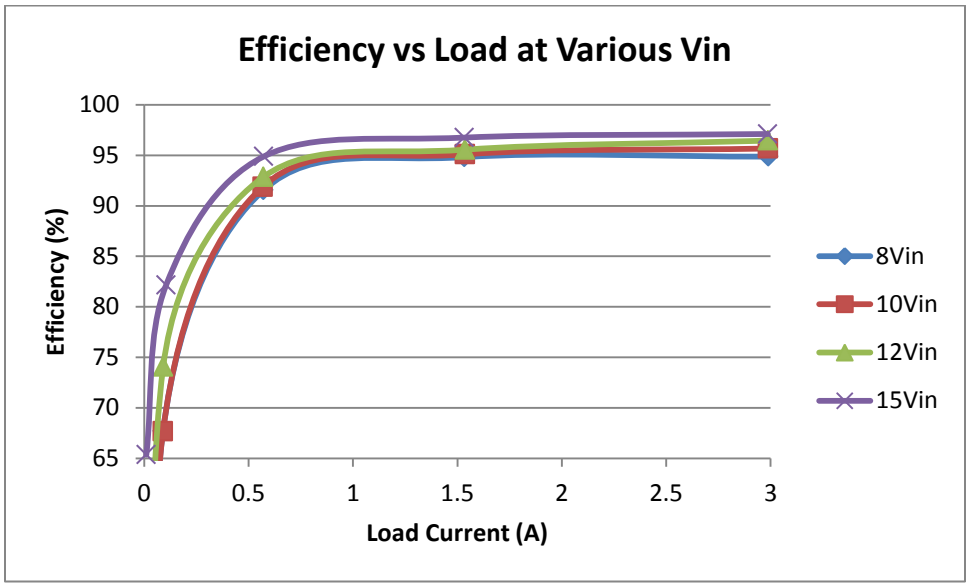

Figure 6: Efficiency vs load current at various input voltages

5.2 Efficiency Data

Table 2: Efficiency table at 8Vin

Ref V (V)	Vin (V)	Iin (A)	Vout (V)	Iout (A)	Eff (%)
0	8.001	8.407	21.342	2.99	94.86827
1	8.0001	3.8976	19.274	1.534	94.821
1.8	8.0007	1.3633	17.469	0.5717	91.56233
2.2	8.0002	0.2644	15.874	0.0902	67.69095
2.4	8.0019	0.0044	8	0	0

Table 3: Efficiency table at 10Vin

Ref V (V)	Vin (V)	Iin (A)	Vout (V)	Iout (A)	Eff (%)
0	10.0014	6.6054	21.152	2.9881	95.6724
1	10.0012	3.1056	19.222	1.5366	95.0959
1.8	10.0001	1.0746	17.402	0.5674	91.88345
2.2	10.004	0.2077	15.589	0.0902	67.67287
2.4	10.0023	0.0046	9.5796	0	0

Table 4: Efficiency table at 12Vin

Ref V (V)	Vin (V)	Iin (A)	Vout (V)	Iout (A)	Eff (%)
0	12.008	5.436	21.077	2.9871	96.45138
1	12.006	2.5747	19.23	1.5361	95.55949
1.8	12.002	0.8936	17.428	0.5715	92.86819
2.2	12.004	0.1615	15.849	0.0906	74.06816
2.4	12.006	0.0048	11.5896	0	0

Table 5: Efficiency table at 15Vin

Ref V (V)	Vin (V)	Iin (A)	Vout (V)	Iout (A)	Eff (%)
0	15.008	4.2645	20.812	2.9863	97.10829
1	15.008	2.0048	18.985	1.5334	96.75473
1.8	15.006	0.6944	17.259	0.5729	94.88986
2.2	15.008	0.1344	15.84	0.1046	82.14191
2.4	15.007	0.0153	15.006	0.01	65.35512

6. Waveforms – Boost Configuration

6.1 Switching and Output Current

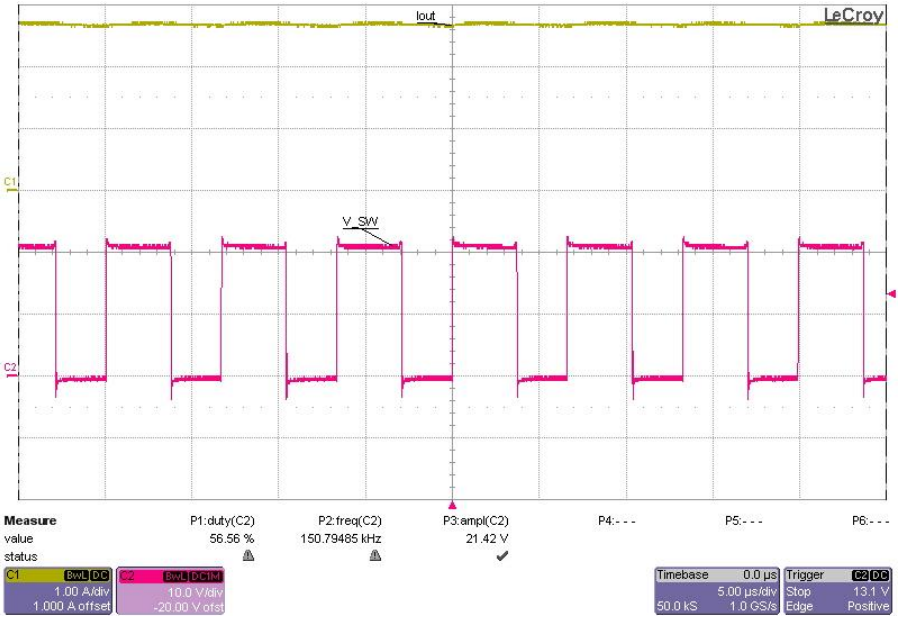

Figure 7: 12Vin and 0V reference on the current sense comparator provides maximum output current. Ch1 (yellow trace): output current, Ch2 (pink trace): Switch node voltage

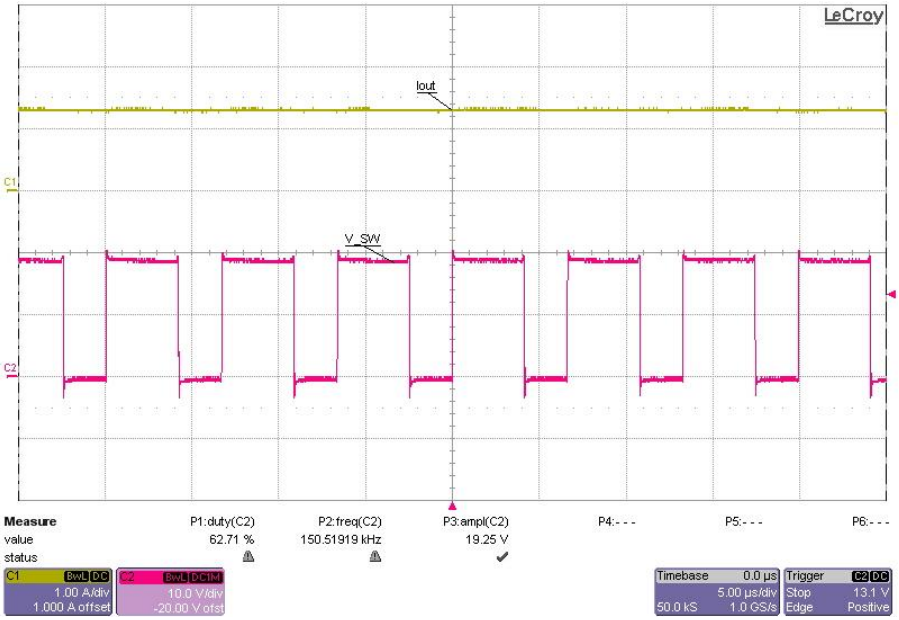

Figure 8: 12Vin and 1.2V reference on the current sense comparator provides half of maximum output current. Ch1 (yellow trace): output current, Ch2 (pink trace): Switch node voltage

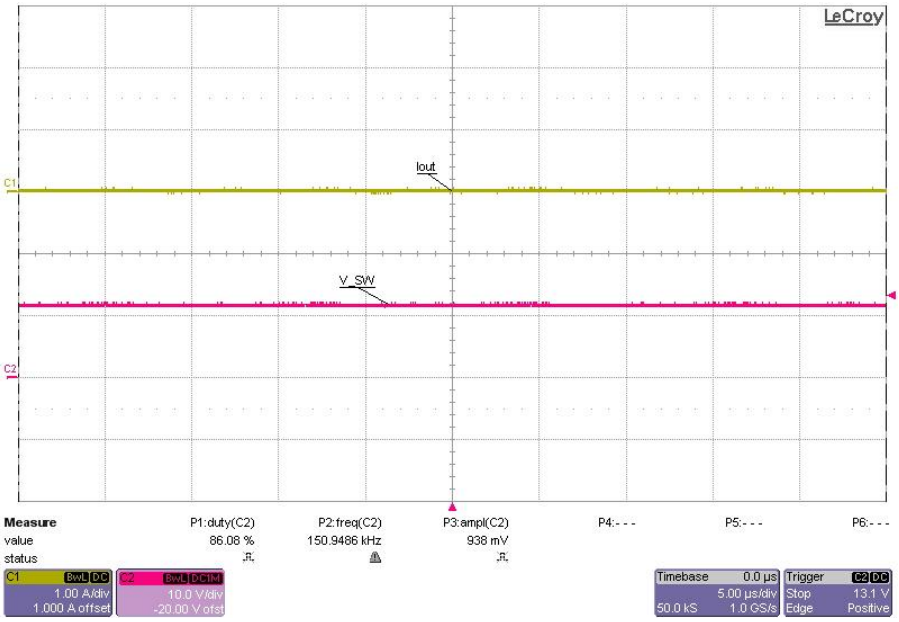

Figure 9: 12Vin and 2.4V reference on the current sense comparator provides zero output current. Ch1 (yellow trace): output current, Ch2 (pink trace): Switch node voltage

6.2 Startup

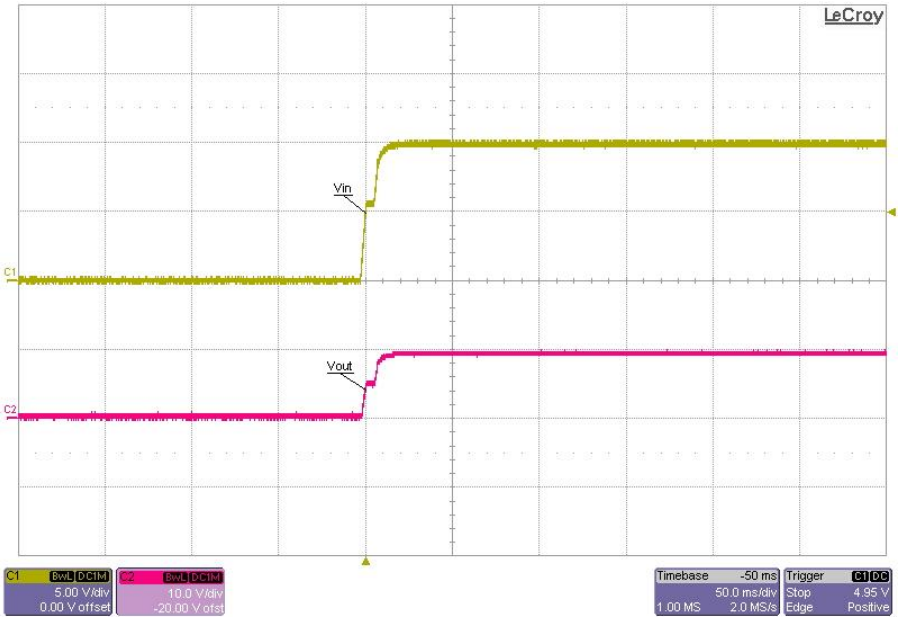

Figure 10: Startup into no load (current sense comparator reference voltage set to 2.4V) at 10Vin. Ch1 (yellow trace): Vin, Ch2 (pink trace): Vout

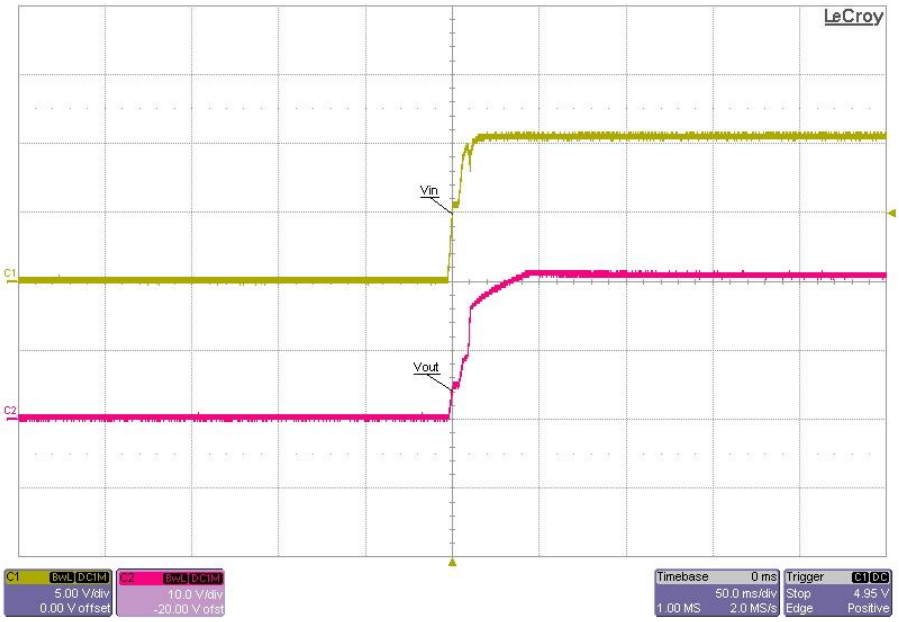

Figure 11: Startup into full load (current sense comparator reference voltage set to 0V) at 10Vin. Ch1 (yellow trace): Vin, Ch2 (pink trace): Vout

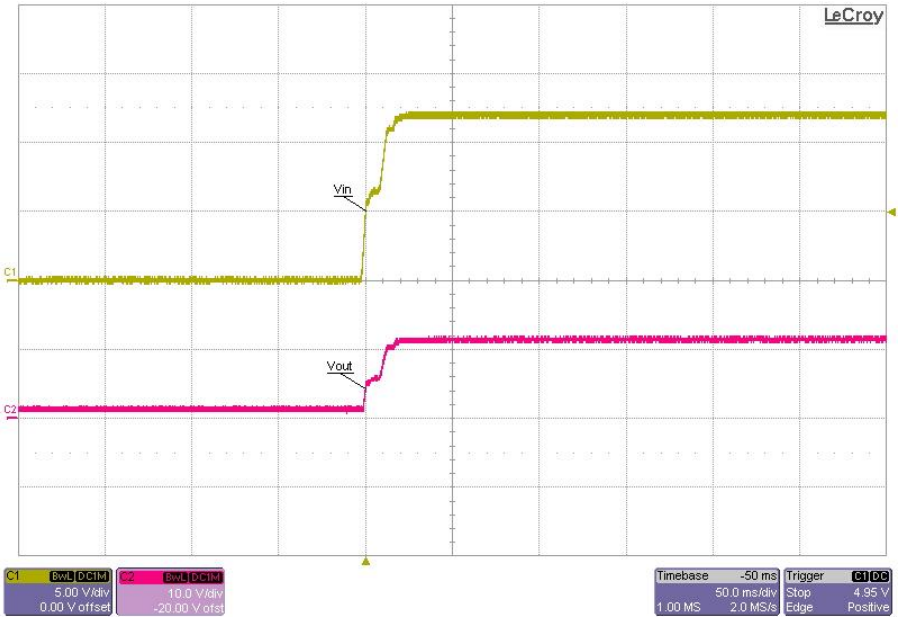

Figure 12: Startup into no load (current sense comparator reference voltage set to 2.4V) at 12Vin. Ch1 (yellow trace): Vin, Ch2 (pink trace): Vout

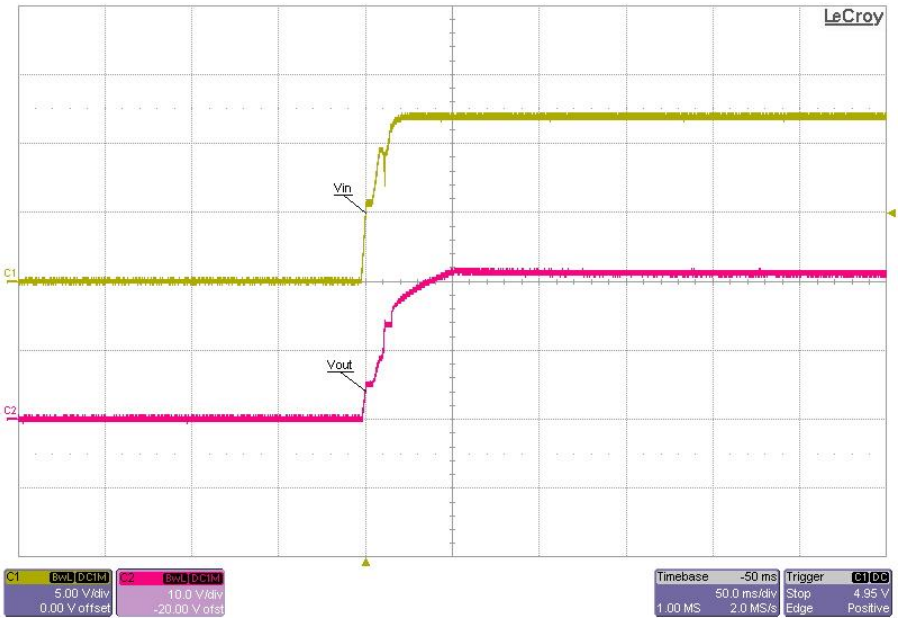

Figure 13: Startup into full load (current sense comparator reference voltage set to 0V) at 12Vin. Ch1 (yellow trace): Vin, Ch2 (pink trace): Vout

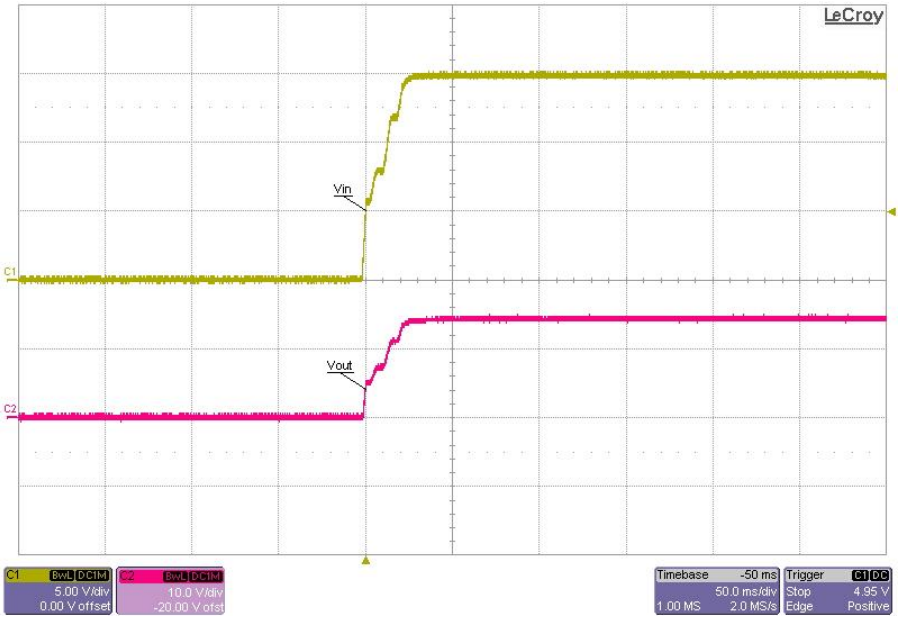

Figure 14: Startup into no load (current sense comparator reference voltage set to 2.4V) at 15Vin. Ch1 (yellow trace): Vin, Ch2 (pink trace): Vout

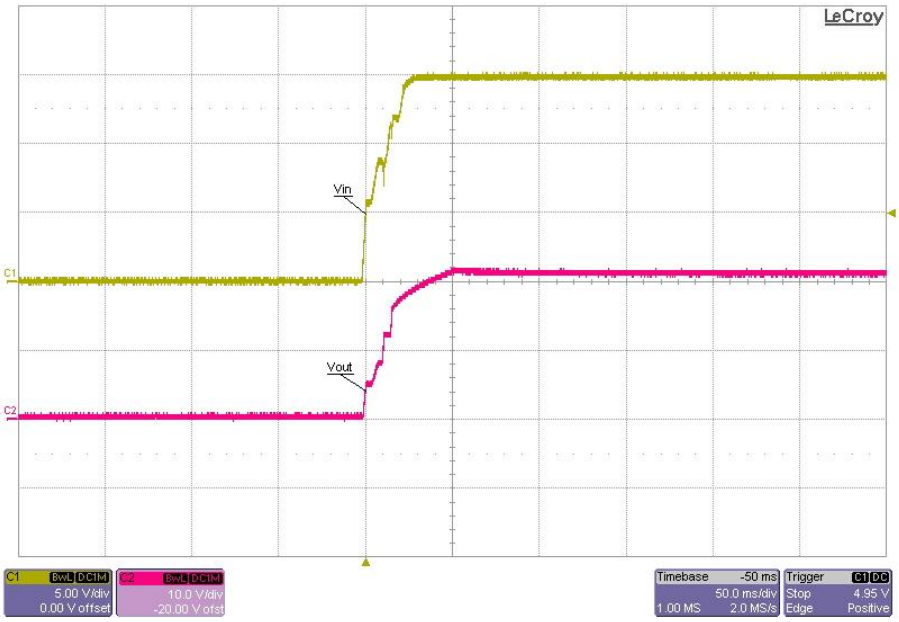

Figure 15: Startup into full load (current sense comparator reference voltage set to 0V) at 15Vin. Ch1 (yellow trace): Vin, Ch2 (pink trace): Vout

6.3 Loop Response

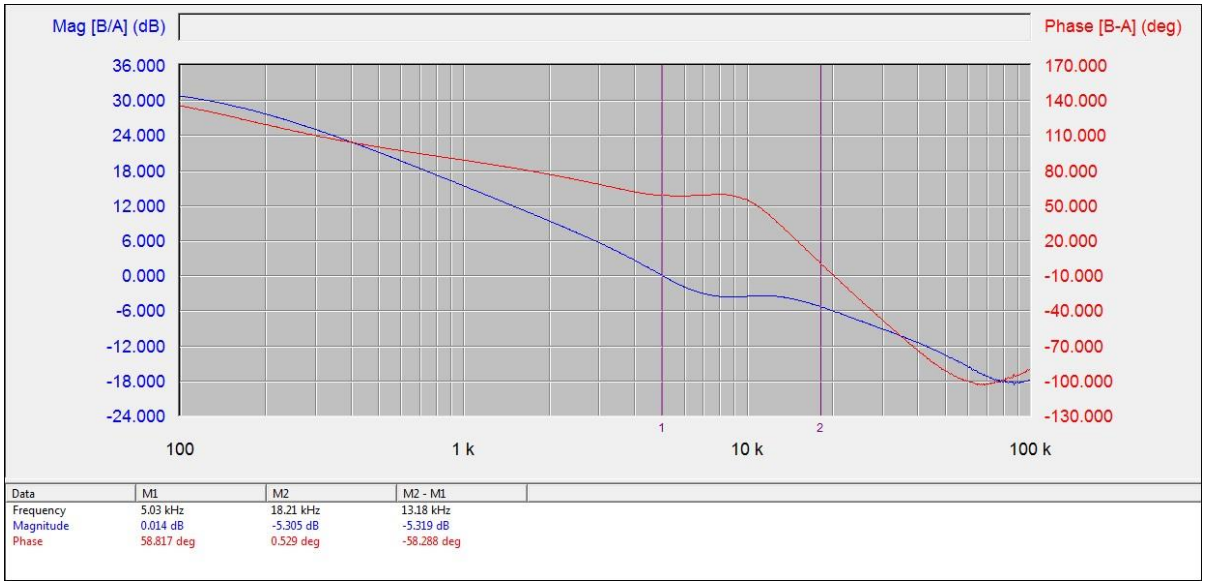

Figure 16: Loop response showing a stable system with gain margin: 5.3 dB and phase margin: 58.8°

7. Thermal Data – Boost-to-Battery Configuration

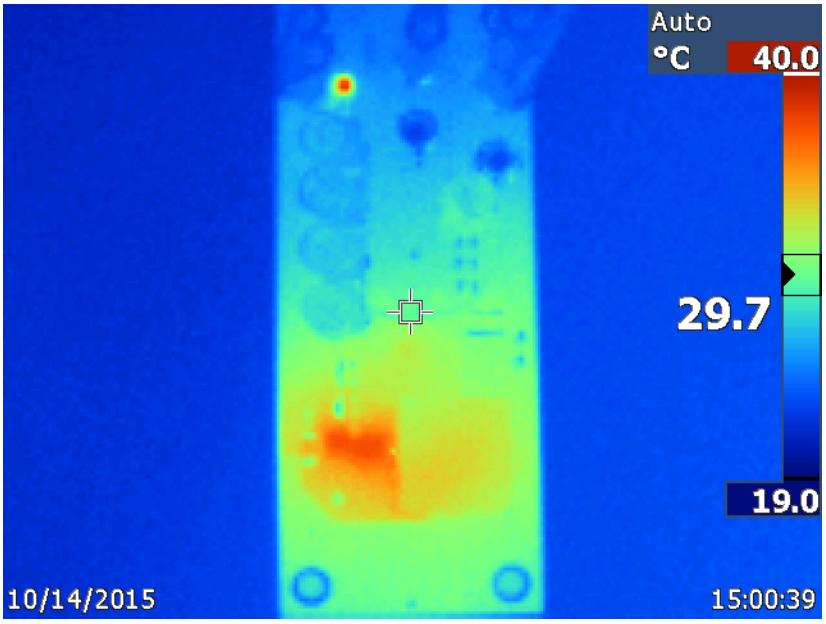

Figure 17: Board top at 12Vin and full load of 3A load current (current sense comparator reference set to 0V) for Boost-to-Battery configuration

8. Efficiency – Boost-to-Battery Configuration

8.1 Efficiency Chart

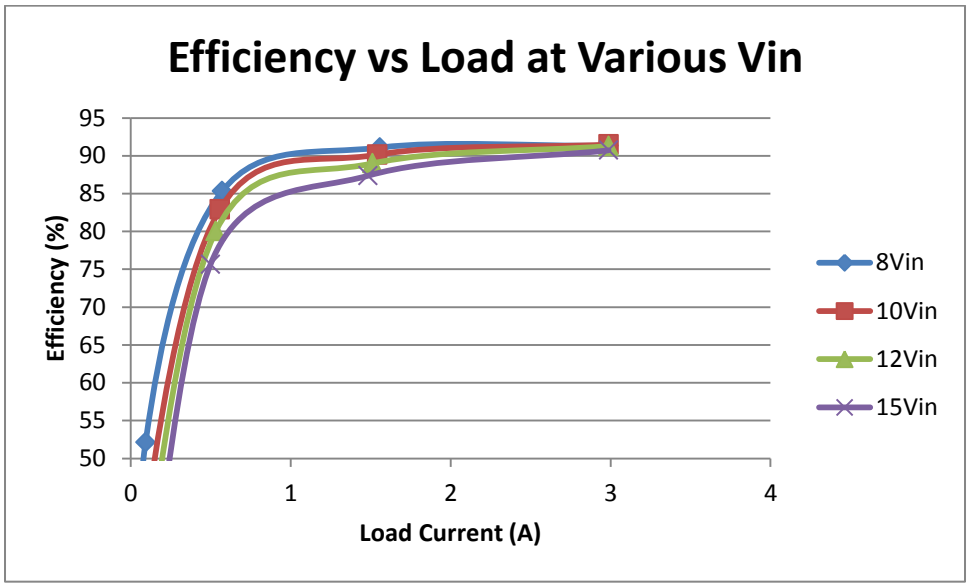

Figure 18: Efficiency vs load current at various input voltages

8.2 Efficiency Data

Table 6: Efficiency table at 8Vin

Ref V (V)	Vin (V)	Iin (A)	Vout (V)	Iout (A)	Eff (%)
0	8.0008	4.0634	9.936	2.9883	91.32986
1	8.0004	1.9575	9.1599	1.5574	91.09141
1.8	8.0007	0.7047	8.417	0.5714	85.3032
2.2	8.001	0.1748	7.8109	0.0933	52.10711
2.4	8.0011	0.0045	0.000014	0	0

Table 7: Efficiency table at 10Vin

Ref V (V)	Vin (V)	Iin (A)	Vout (V)	Iout (A)	Eff (%)
0	10.0009	3.2378	9.915	2.9877	91.48304
1	10.001	1.5701	9.179	1.5422	90.14992
1.8	10.0003	0.5666	8.4264	0.5575	82.90817
2.2	10.0007	0.1344	7.7507	0.0658	37.94348
2.4	10.001	0.0046	-0.039	0	0

Table 8: Efficiency table at 12Vin

Ref V (V)	Vin (V)	Iin (A)	Vout (V)	Iout (A)	Eff (%)
0	12.002	2.7007	9.9038	2.9875	91.28088
1	12.007	1.2914	9.1335	1.5108	88.99158
1.8	12.009	0.4647	8.3904	0.5324	80.04629
2.2	12.004	0.1123	7.69	0.0472	26.92543
2.4	12.002	0.0048	0.0000016	0	0

Table 9: Efficiency table at 15Vin

Ref V (V)	Vin (V)	Iin (A)	Vout (V)	Iout (A)	Eff (%)
0	15.002	2.1721	9.896	2.9874	90.7244
1	15.004	1.0327	9.1224	1.484	87.36989
1.8	15.007	0.368	8.3672	0.4993	75.64845
2.2	15.007	0.0871	7.5387	0.0173	9.977702
2.4	15.003	0.005	-0.39	0	0

9. Waveforms – Boost-to-Battery Configuration

9.1 Switching and Output Current

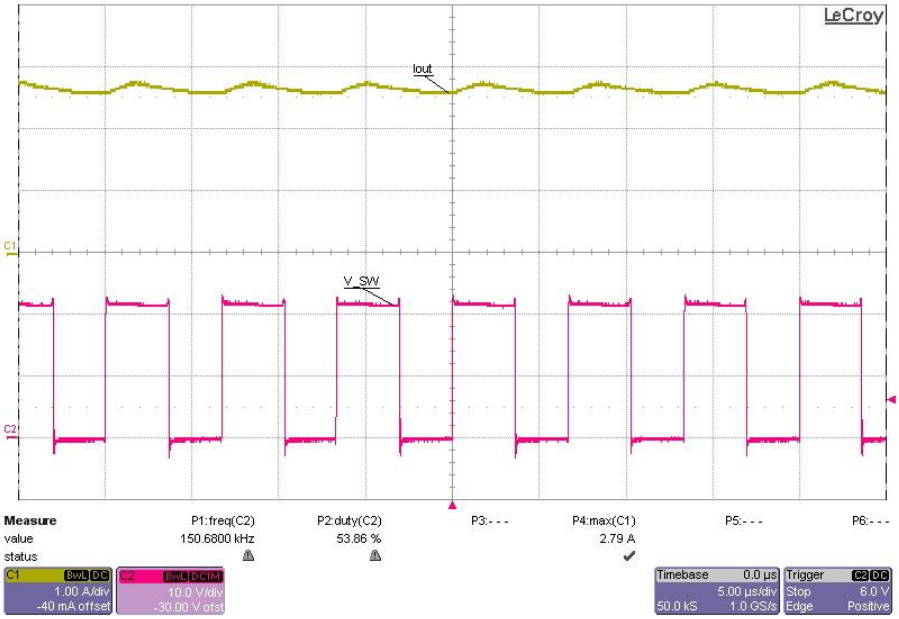

Figure 19: 12Vin and 0V reference on the current sense comparator provides maximum output current. Ch1 (yellow trace): output current, Ch2 (pink trace): Switch node voltage

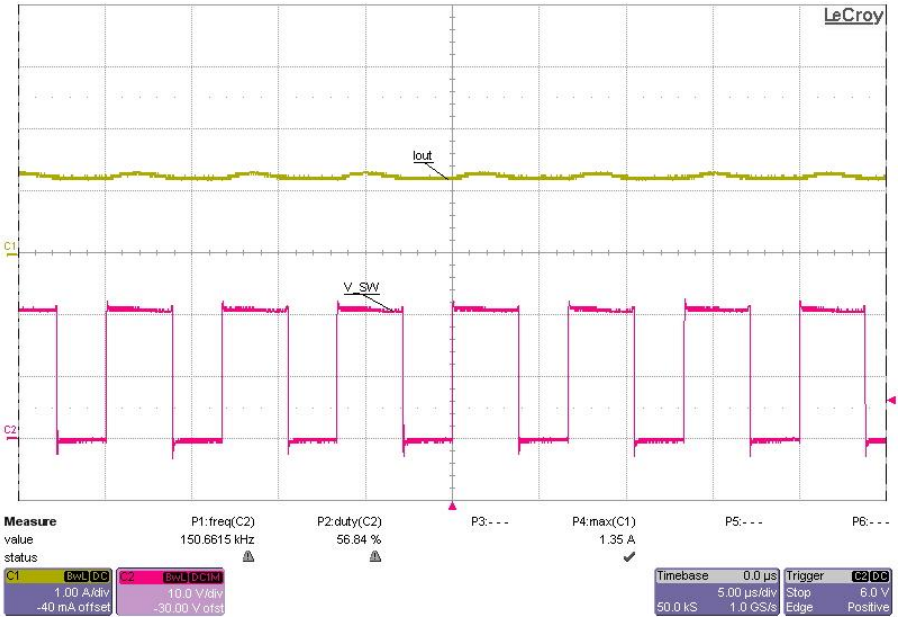

Figure 20: 12Vin and 1.2V reference on the current sense comparator provides half of the maximum output current. Ch1 (yellow trace): output current, Ch2 (pink trace): Switch node voltage

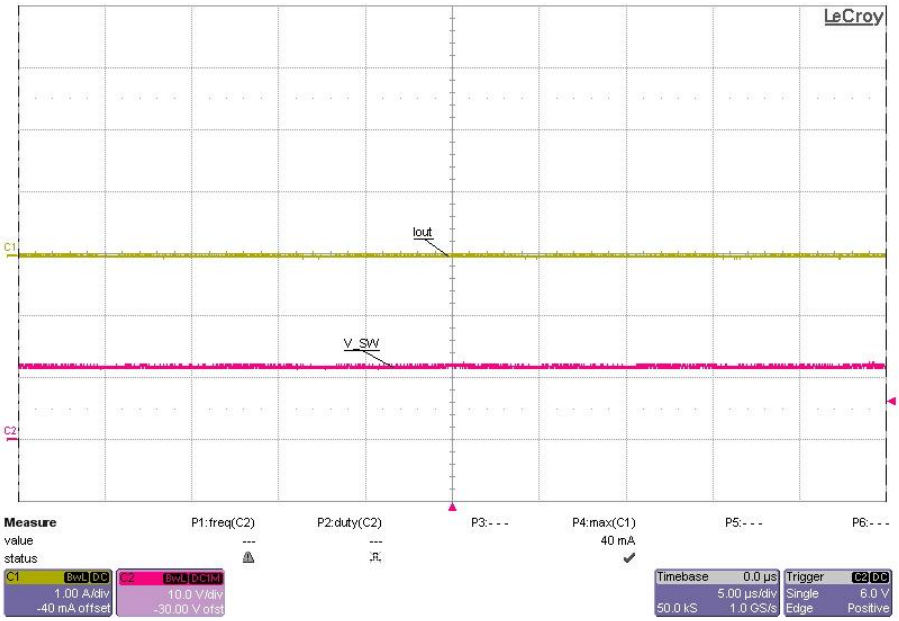

Figure 21: 12Vin and 2.4V reference on the current sense comparator provides zero output current. Ch1 (yellow trace): output current, Ch2 (pink trace): Switch node voltage

9.2 Startup

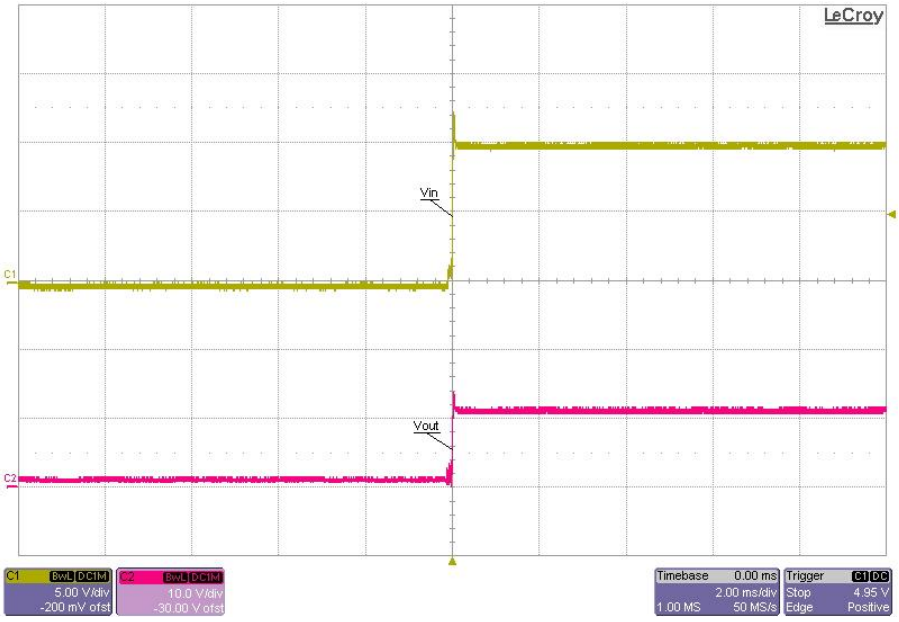

Figure 22: Startup into no load (current sense comparator reference voltage set to 2.4V) at 10Vin. Ch1 (yellow trace): Vin, Ch2 (pink trace): Vout

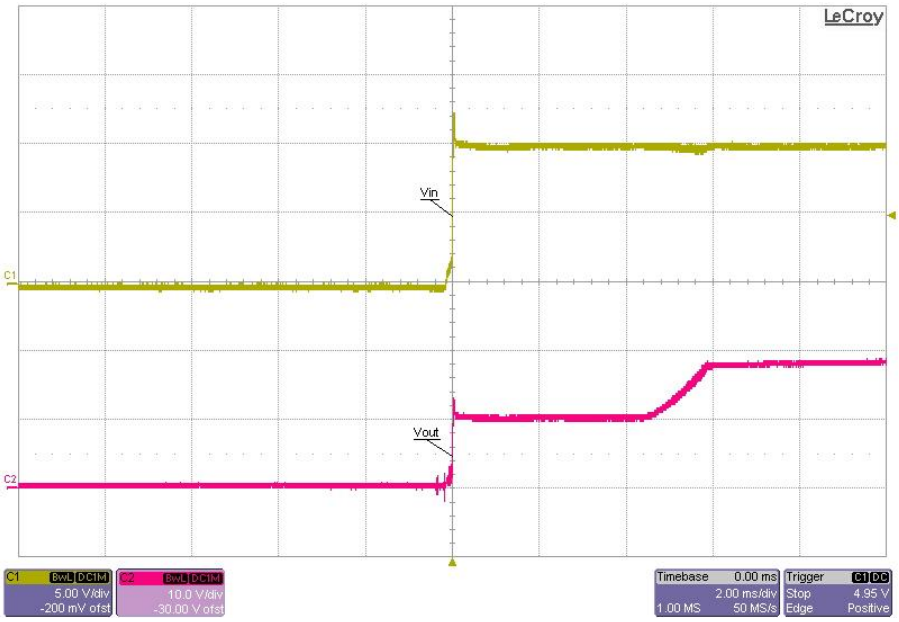

Figure 23: Startup into full load (current sense comparator reference voltage set to 0V) at 10Vin. Ch1 (yellow trace): Vin, Ch2 (pink trace): Vout

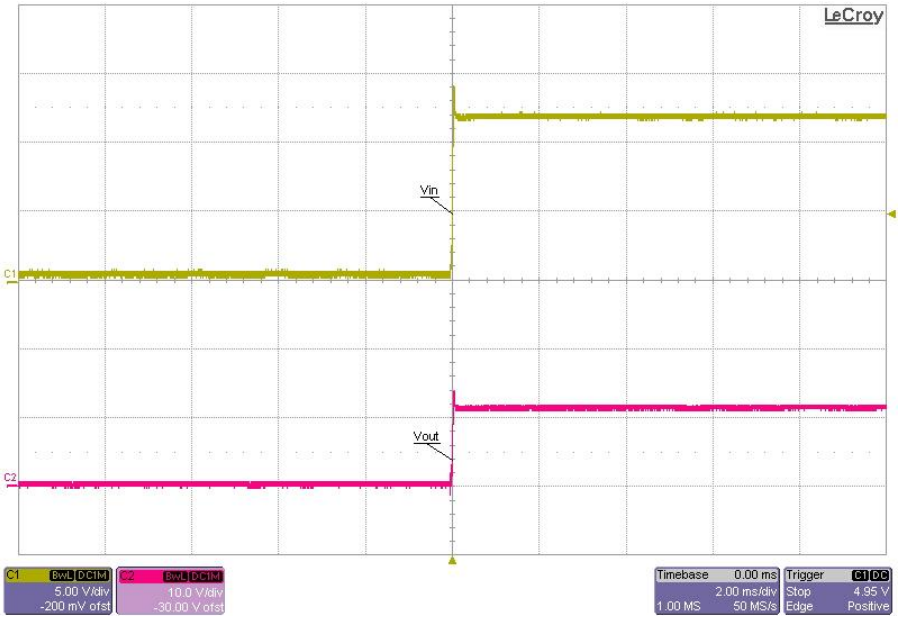

Figure 24: Startup into no load (current sense comparator reference voltage set to 2.4V) at 12Vin. Ch1 (yellow trace): Vin, Ch2 (pink trace): Vout

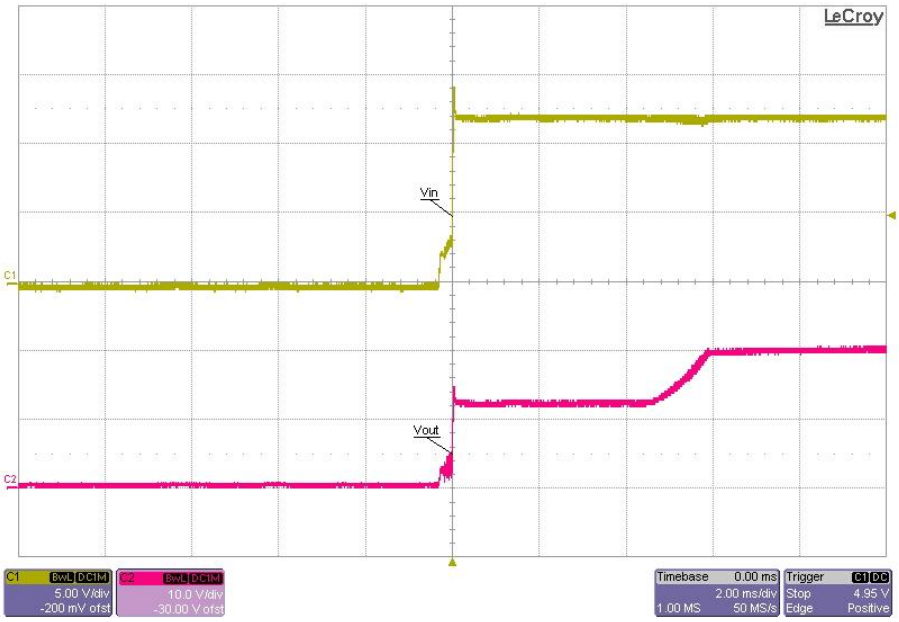

Figure 25: Startup into full load (current sense comparator reference voltage set to 0V) at 12Vin. Ch1 (yellow trace): Vin, Ch2 (pink trace): Vout

Figure 26: Startup into no load (current sense comparator reference voltage set to 2.4V) at 15Vin. Ch1 (yellow trace): Vin, Ch2 (pink trace): Vout

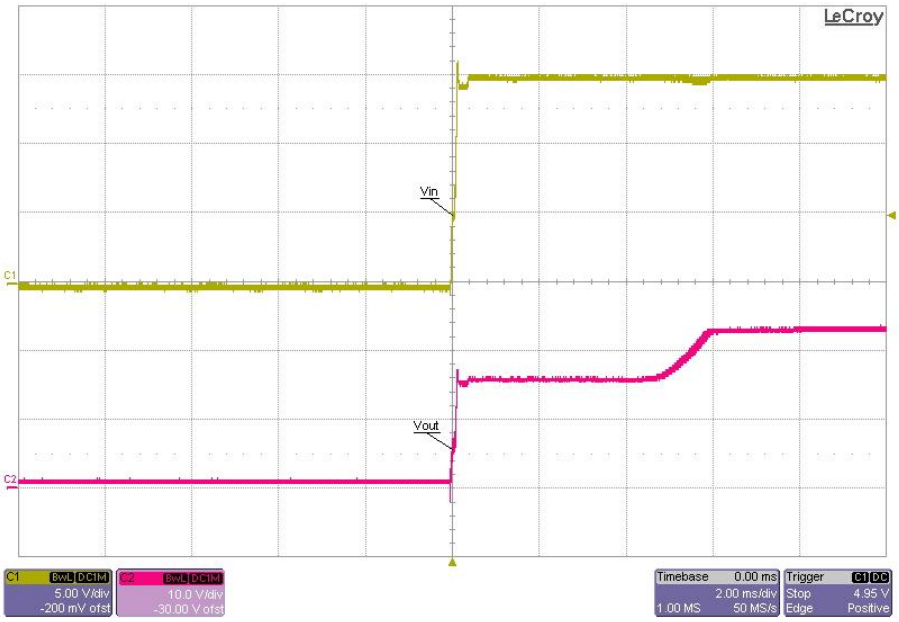

Figure 27: Startup into full load (current sense comparator reference voltage set to 0V) at 15Vin. Ch1 (yellow trace): Vin, Ch2 (pink trace): Vout

9.3 Loop Response

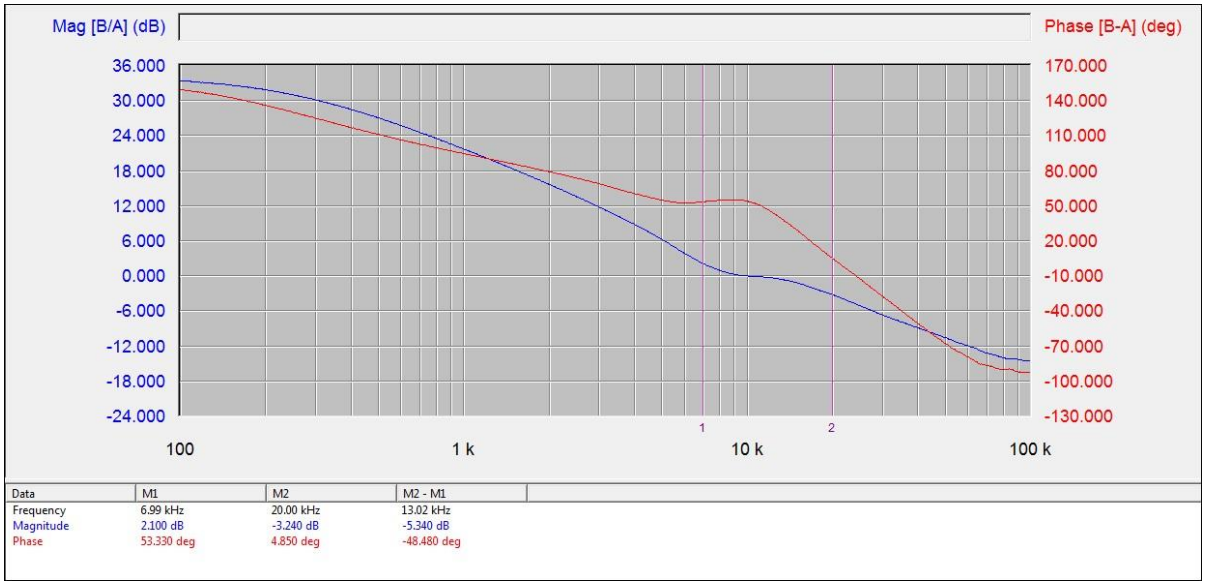

Figure 28: Loop response showing a stable system with gain margin: 5.8 dB and phase margin: 54°

10. Current Regulation

Using an external voltage (or PWM signal) injected into the current sense reference at TP10 allows for analog dimming of the LEDs at the output by changing the output current. This current sense comparator also keeps the output current constant if the input voltage varies to provide continuous, flicker-free operation for the LEDs. The current sense comparator circuitry is shown below in Figure 5.

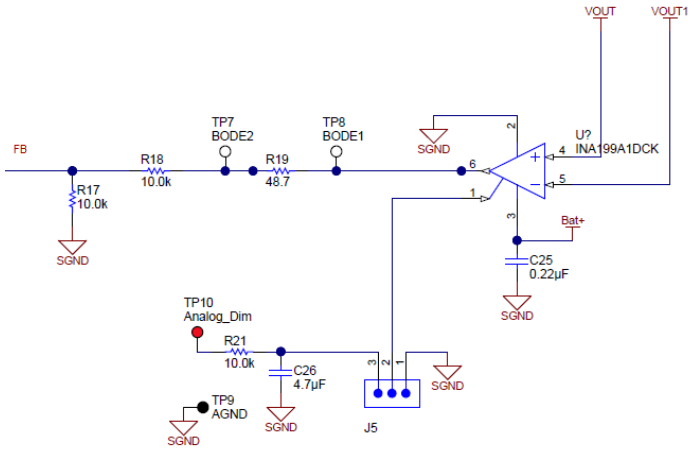

Figure 29: Current sense comparator with reference voltage for analog dimming measures output current via current sense resistor and modifies the feedback voltage according to the set reference voltage

The reference voltage of the current sense comparator linearly sets the output current as shown below in Figure 28 for the Boost configuration and Figure 29 for the Boost-to-Battery configuration

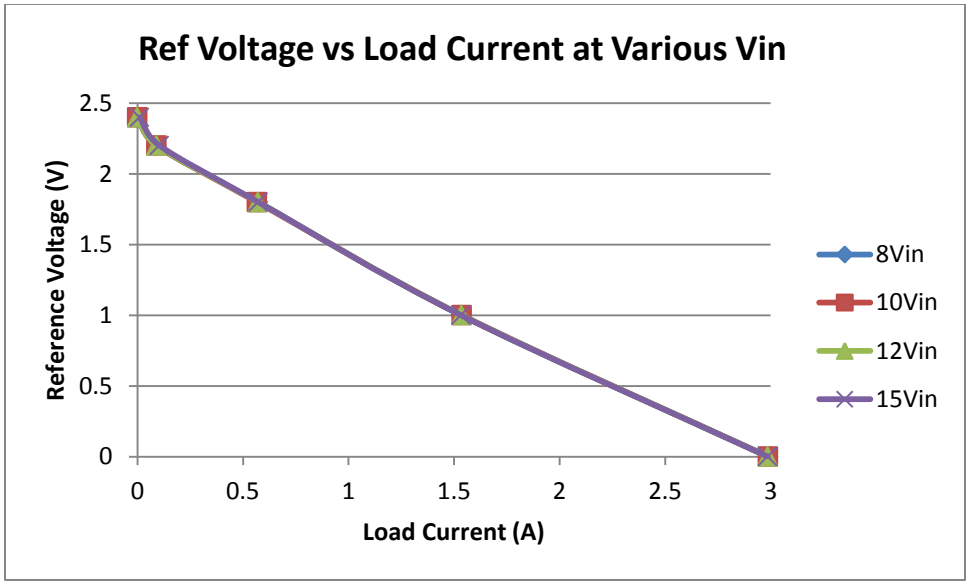

Figure 30: Reference voltage for the current sense comparator vs the load current shows the current regulation for the Boost configuration

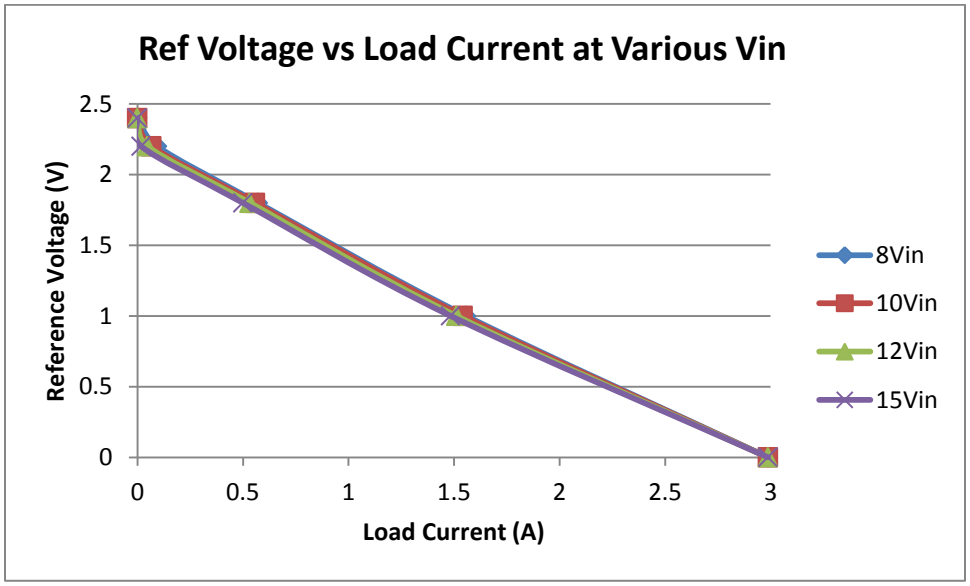

Figure 31: Reference voltage for the current sense comparator vs the load current shows the current regulation for the Boost-to-Battery configuration

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