

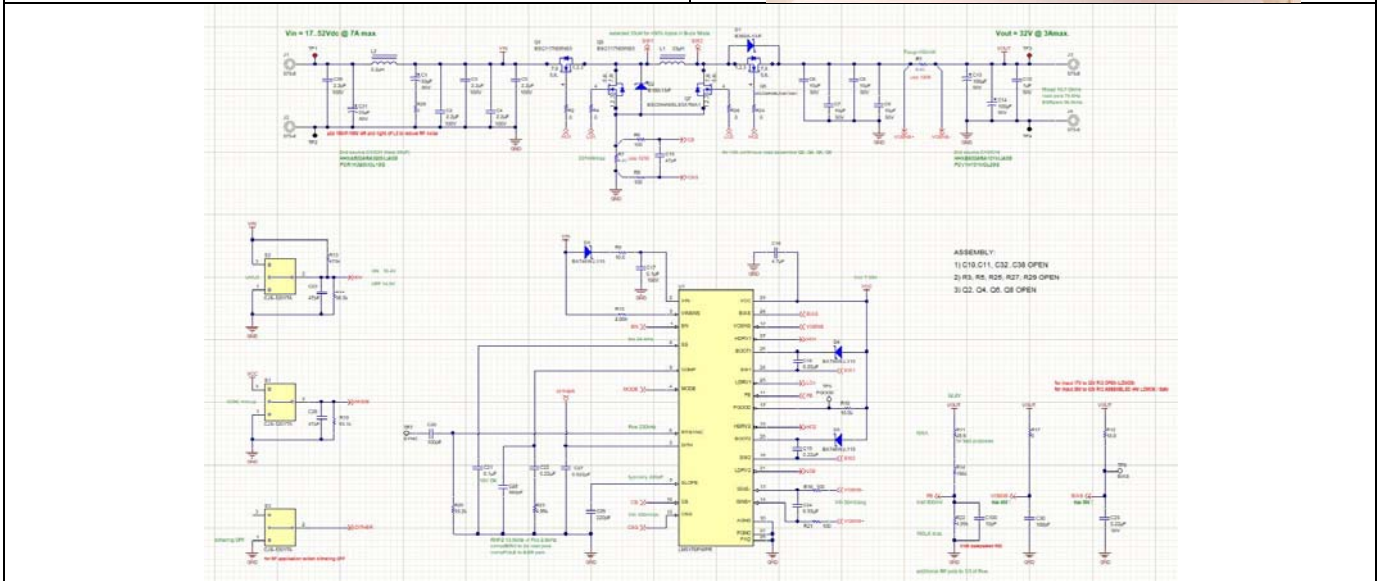
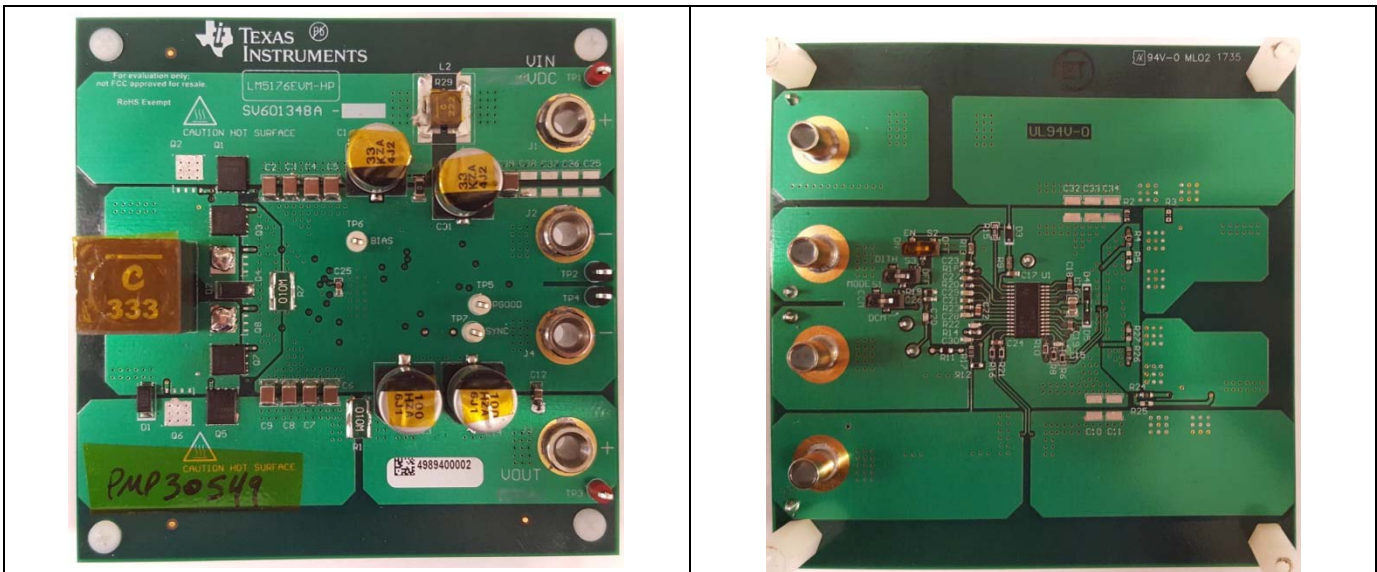
Test Report: PMP30549

High Efficient 32-V / 3-A Synchronous 4-Switch Buck-Boost Reference Design



Description

PMP30549 is a Synchronous 4-Switch Buck-Boost Converter circuit using the LM5176 controller IC. The converter accepts an input voltage of 17V_{in} to 52V_{in} and provides a regulated output of 32V_{out} that can deliver a maximum of 3A of current to the load. The design is built on the LM5176EVM-HP evaluation board which is a 6-layer FR-4 PCB, with 2oz. Copper for each of the six layers.



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1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1. Voltage and Current Requirements

PARAMETER	SPECIFICATIONS
V_{IN}	17 V – 52 V
V_{OUT}	32 V
I_{OUT}	3 A
Approximate Switching Frequency	250KHz (during Boost and Buck operation) 125KHz (during Buck-Boost operation)

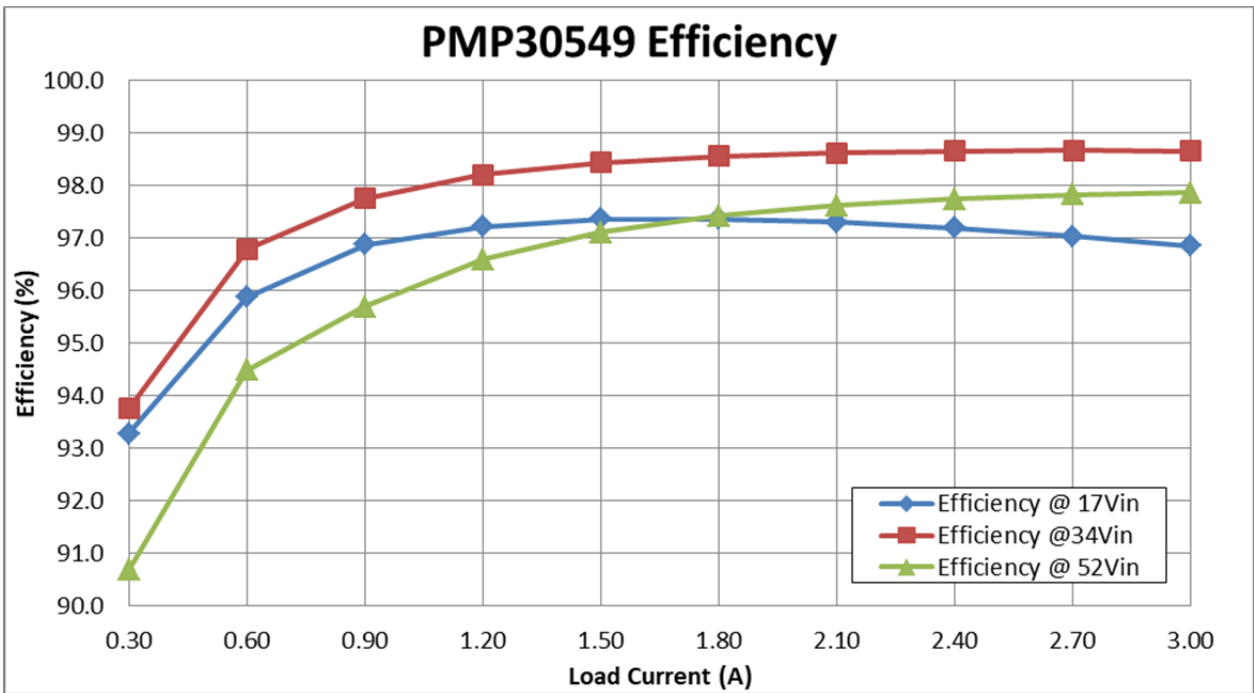
1.2 Considerations*

All tests were performed under the following conditions:

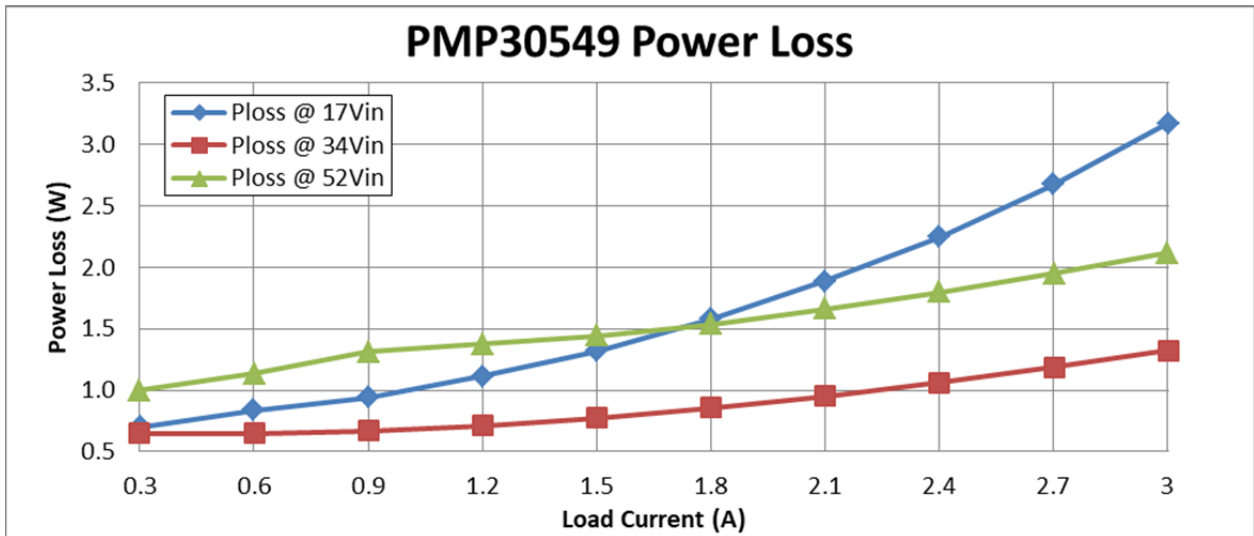
1. Switching frequency dithering (spread spectrum feature) disabled
2. Controller set to Hiccup mode and Force PWM/CCM operation

2 Testing and Results

2.1 Efficiency Graph



2.2 Power Loss Graph



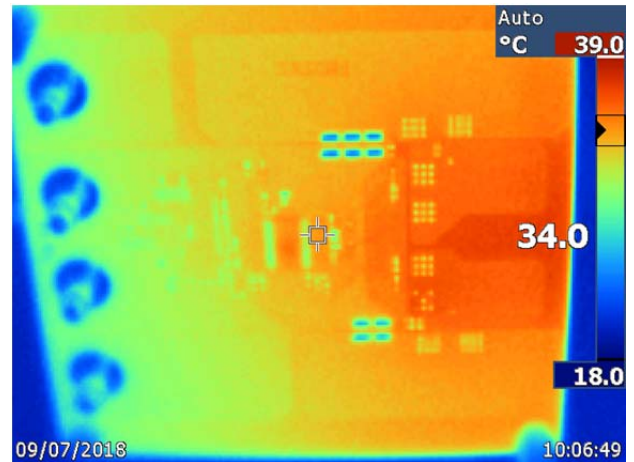
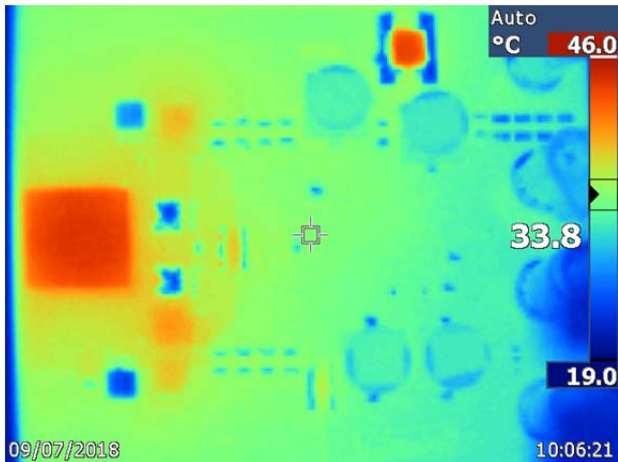
2.3 Efficiency Data

Vin (V)	Iin (A)	Vout (V)	Iout (A)	Pin (W)	Pout (W)	Ploss (W)	Efficiency (%)
17	0.6151	32.436	0.3007	10.4567	9.7535	0.7032	93.28
17	1.1943	32.442	0.6	20.3031	19.4652	0.8379	95.87
17	1.7749	32.449	0.9008	30.1733	29.2301	0.9432	96.87
17	2.3568	32.458	1.2001	40.0656	38.9528	1.1128	97.22
17	2.9438	32.466	1.5008	50.0446	48.7250	1.3196	97.36
17	3.5312	32.471	1.8001	60.0304	58.4510	1.5794	97.37
17	4.1227	32.476	2.1	70.0859	68.1996	1.8863	97.31
17	4.7189	32.48	2.4006	80.2213	77.9715	2.2498	97.20
17	5.3166	32.484	2.7	90.3822	87.7068	2.6754	97.04
17	5.9224	32.489	3.0012	100.6808	97.5060	3.1748	96.85

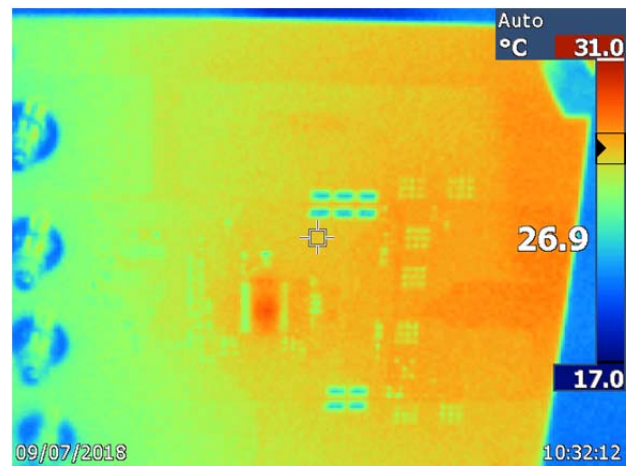
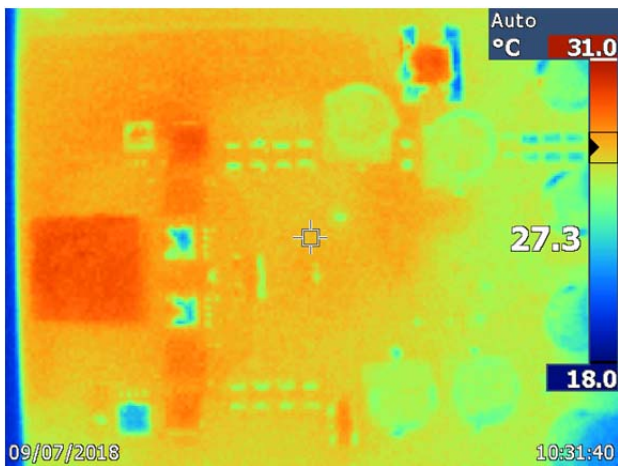
Vin (V)	Iin (A)	Vout (V)	Iout (A)	Pin (W)	Pout (W)	Ploss (W)	Efficiency (%)
34	0.3053	32.408	0.3003	10.3802	9.7321	0.6481	93.76
34	0.5918	32.409	0.6009	20.1212	19.4746	0.6466	96.79
34	0.8779	32.411	0.9003	29.8486	29.1796	0.6690	97.76
34	1.1647	32.412	1.1998	39.5998	38.8879	0.7119	98.20
34	1.4533	32.415	1.5005	49.4122	48.6387	0.7735	98.43
34	1.7423	32.417	1.801	59.2382	58.3830	0.8552	98.56
34	2.0312	32.419	2.1009	69.0608	68.1091	0.9517	98.62
34	2.32	32.422	2.4002	78.8800	77.8193	1.0607	98.66
34	2.6118	32.424	2.7022	88.8012	87.6161	1.1851	98.67
34	2.901	32.427	3.001	98.6340	97.3134	1.3206	98.66

Vin (V)	Iin (A)	Vout (V)	Iout (A)	Pin (W)	Pout (W)	Ploss (W)	Efficiency (%)
52	0.2061	32.397	0.3	10.7172	9.7191	0.9981	90.69
52	0.3961	32.397	0.6007	20.5972	19.4609	1.1363	94.48
52	0.5861	32.397	0.9002	30.4772	29.1638	1.3134	95.69
52	0.7746	32.398	1.2009	40.2792	38.9068	1.3724	96.59
52	0.9625	32.399	1.5002	50.0500	48.6050	1.4450	97.11
52	1.1517	32.402	1.8008	59.8884	58.3495	1.5389	97.43
52	1.341	32.403	2.1007	69.7320	68.0690	1.6630	97.62
52	1.5302	32.406	2.4	79.5704	77.7744	1.7960	97.74
52	1.7214	32.407	2.702	89.5128	87.5637	1.9491	97.82
52	1.9112	32.413	3.0008	99.3824	97.2649	2.1175	97.87

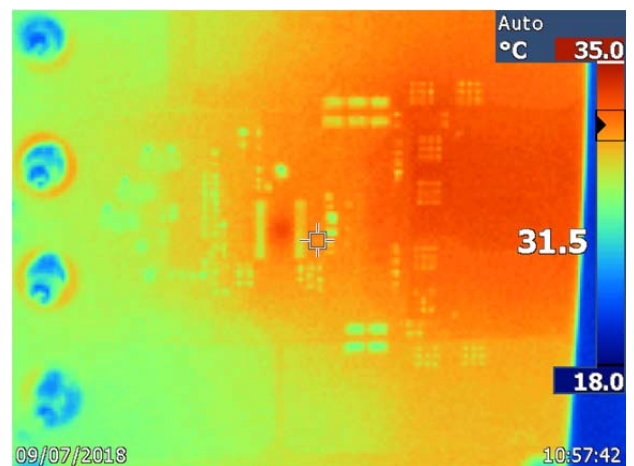
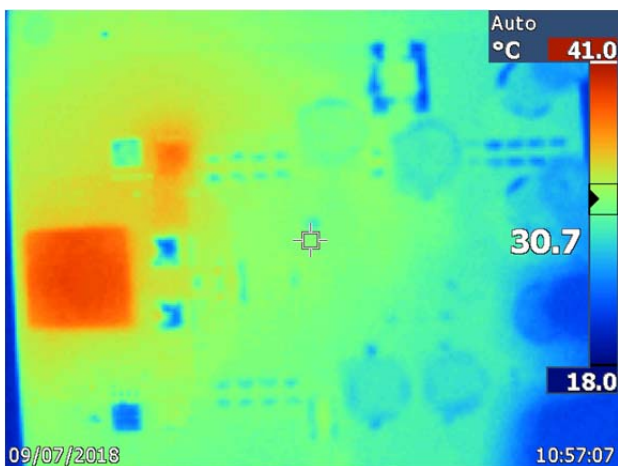
2.4 Thermal Images



IR thermal image taken at steady state at 17Vin and 3A Load (no airflow; image on left is of top side of board; image on right is of bottom side of board)



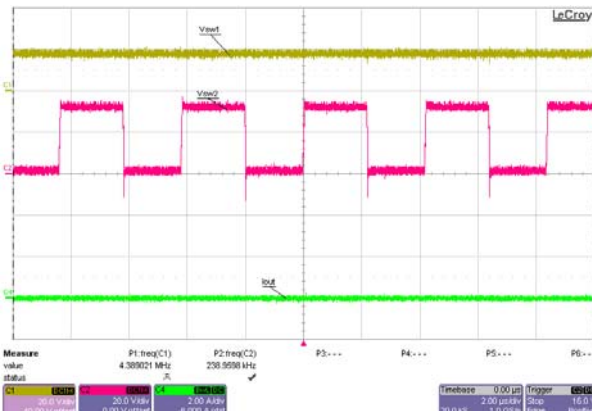
IR thermal image taken at steady state at 34Vin and 3A Load (no airflow; image on left is of top side of board; image on right is of bottom side of board)



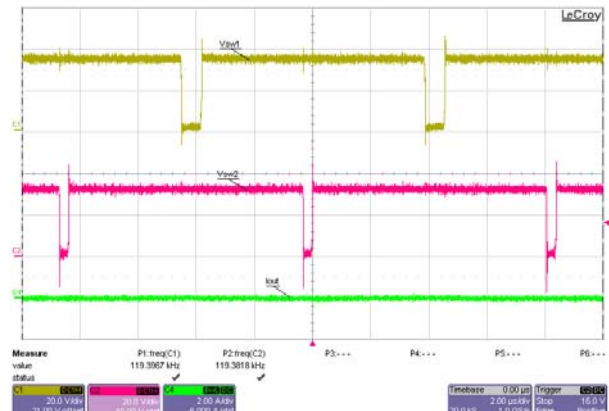
IR thermal image taken at steady state at 52Vin and 3A Load (no airflow; image on left is of top side of board; image on right is of bottom side of board)

3 Waveforms

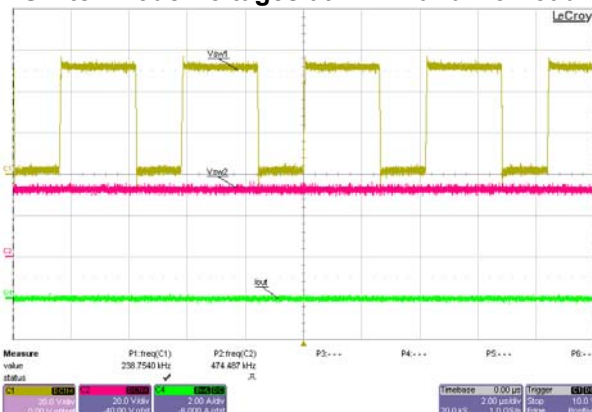
3.1 Switching



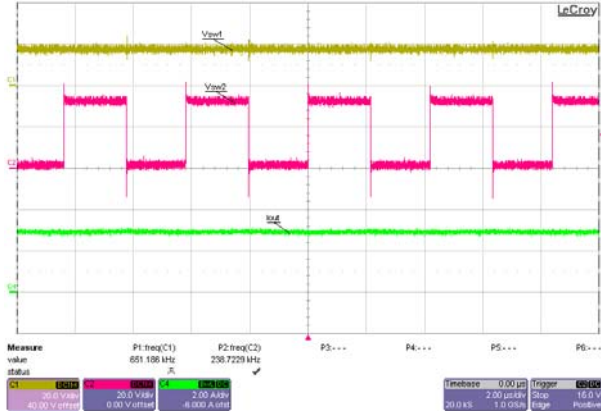
Switch Node Voltages at 17Vin and No Load



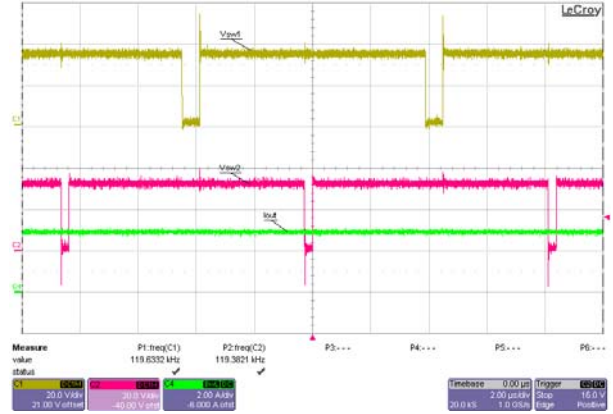
Switch Node Voltages at 34Vin and No Load



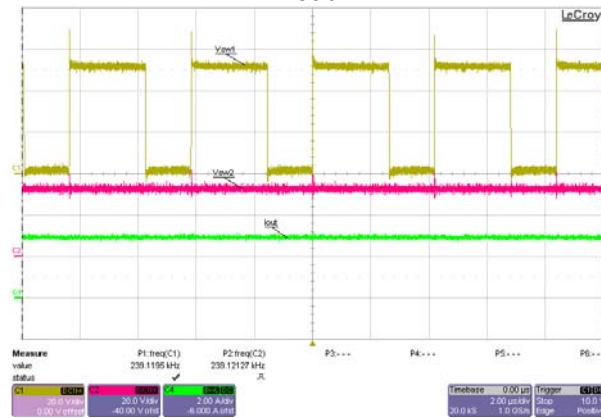
Switch Node Voltages at 52Vin and No Load



Switch Node Voltages at 17Vin and Full (3A) Load

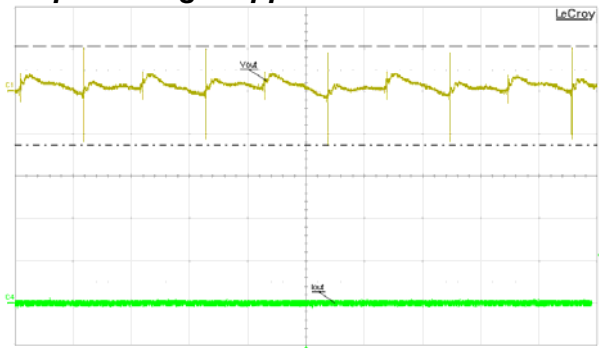


Switch Node Voltages at 34Vin and Full (3A) Load



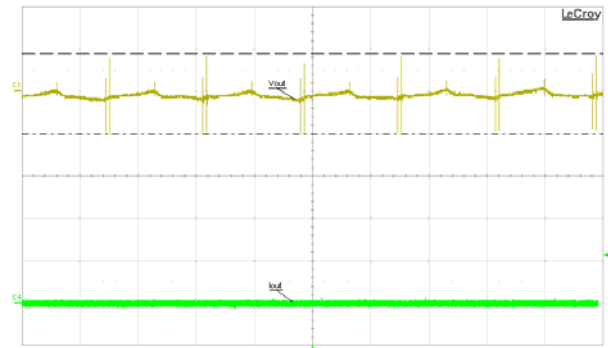
Switch Node Voltages at 52Vin and Full (3A) Load

3.2 Output Voltage Ripple



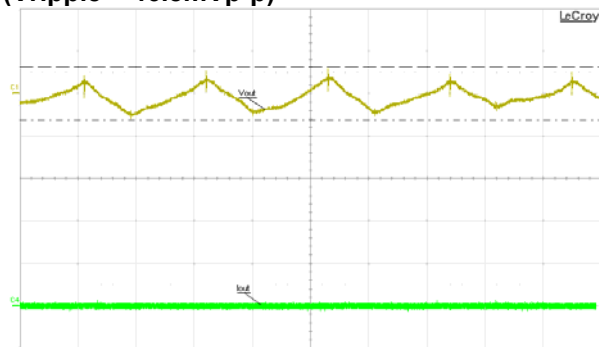
Ch1	Unit	Value	Ch2	Unit	Value
40.00 mV/div	2.00 A/div		40.00 mV/div	4.000 A/div	
25.0 mV	7.44 A		12.5 mV	12.5 A	
40.0 mV	4.88 A				

Output Voltage Ripple at 17Vin and No Load (Vripple ≈ 46.8mVp-p)



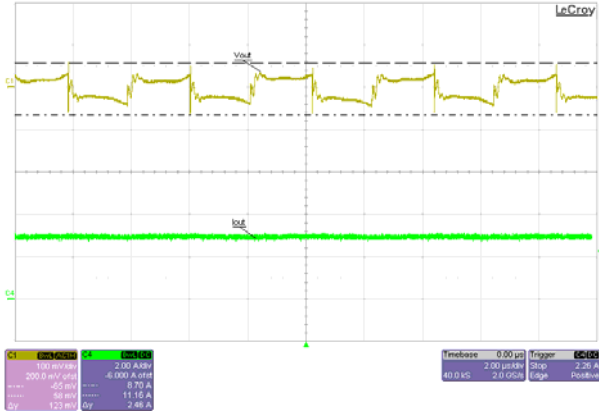
Ch1	Unit	Value	Ch2	Unit	Value
50.0 mV/div	2.00 A/div		50.0 mV/div	4.000 A/div	
48.0 mV	7.98 A		48.0 mV	11.50 A	
95.0 mV	3.92 A				

Output Voltage Ripple at 34Vin and No Load (Vripple ≈ 95.5mVp-p)

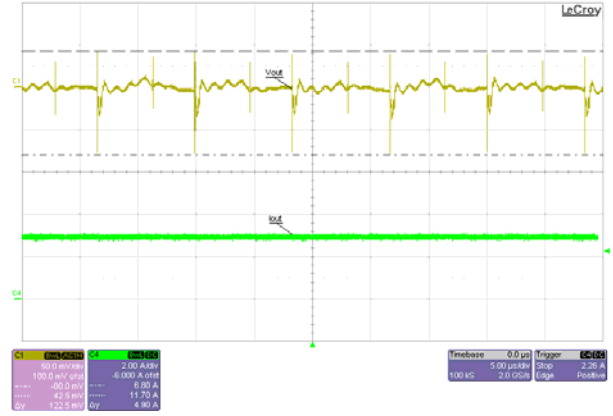


Ch1	Unit	Value	Ch2	Unit	Value
40.00 mV/div	2.00 A/div		40.00 mV/div	4.000 A/div	
12.5 mV	3.74 A		11.25 mV	11.25 A	
25.2 mV	2.92 A				

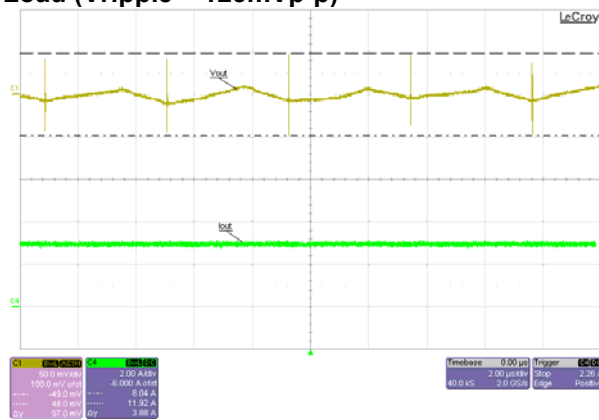
Output Voltage Ripple at 52Vin and No Load (Vripple ≈ 25.2mVp-p)



Output Voltage Ripple at 17Vin and Full (3A) Load (Vripple ≈ 123mVp-p)

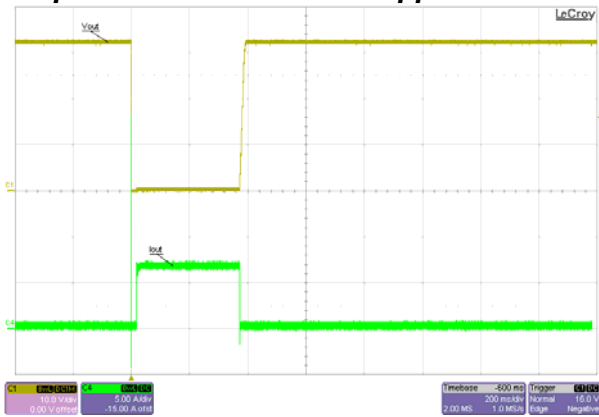


Output Voltage Ripple at 34Vin and Full (3A) Load (Vripple ≈ 122.5mVp-p)

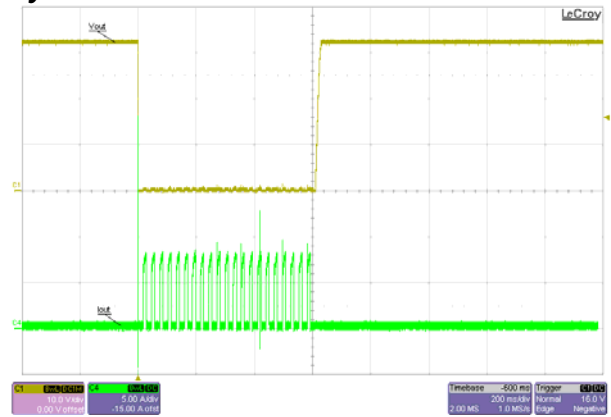


Output Voltage Ripple at 52Vin and Full (3A) Load (Vripple ≈ 97mVp-p)

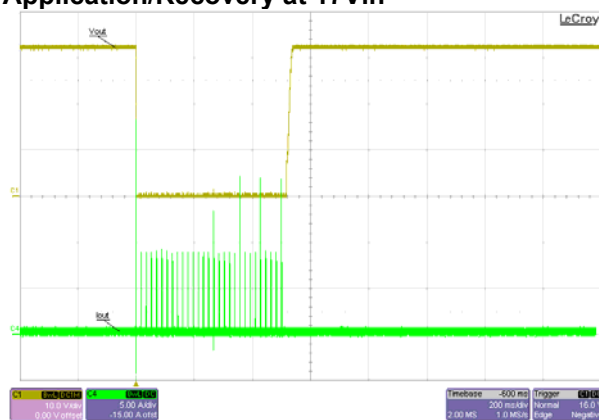
3.3 Output Load Over-Current Application/Recovery



Output Load Over-Current Application/Recovery at 17Vin

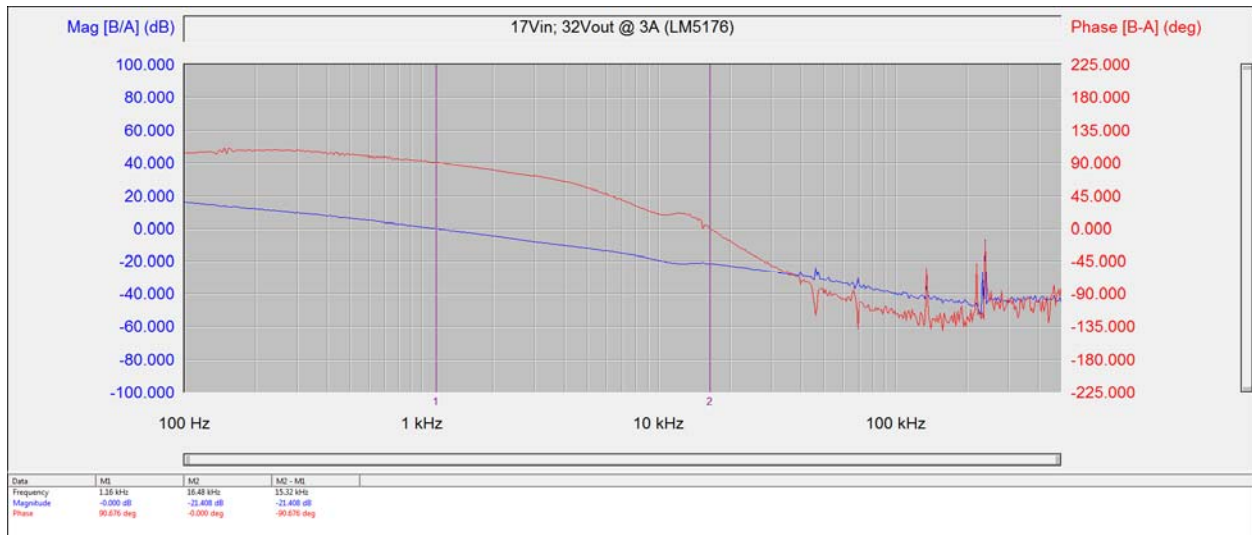


Output Load Over-Current Application/Recovery at 34Vin

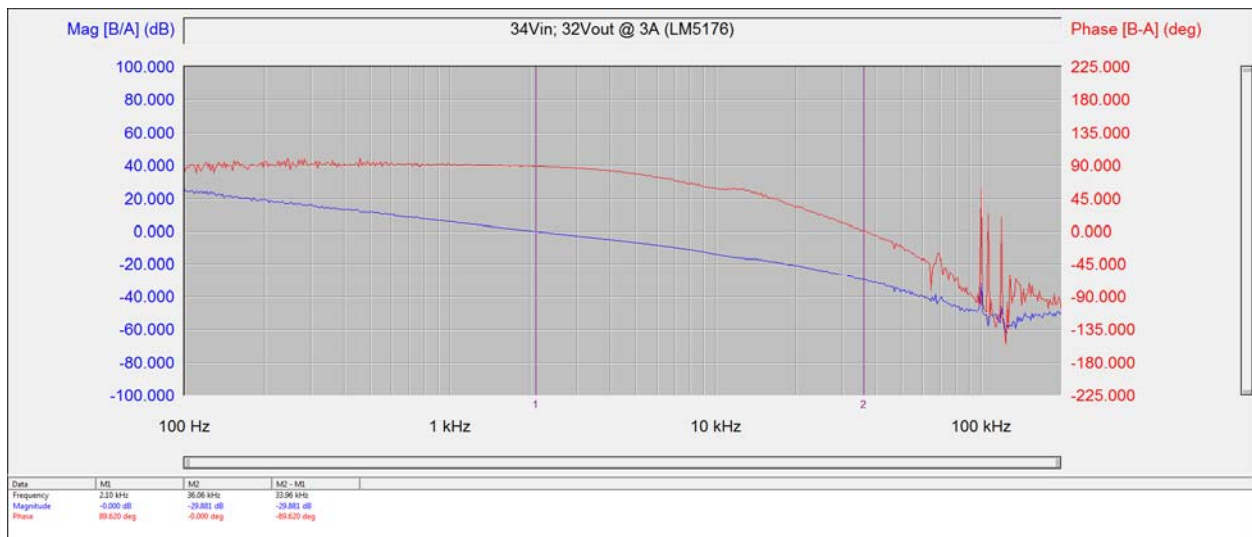


Output Load Over-Current Application/Recovery at 52Vin

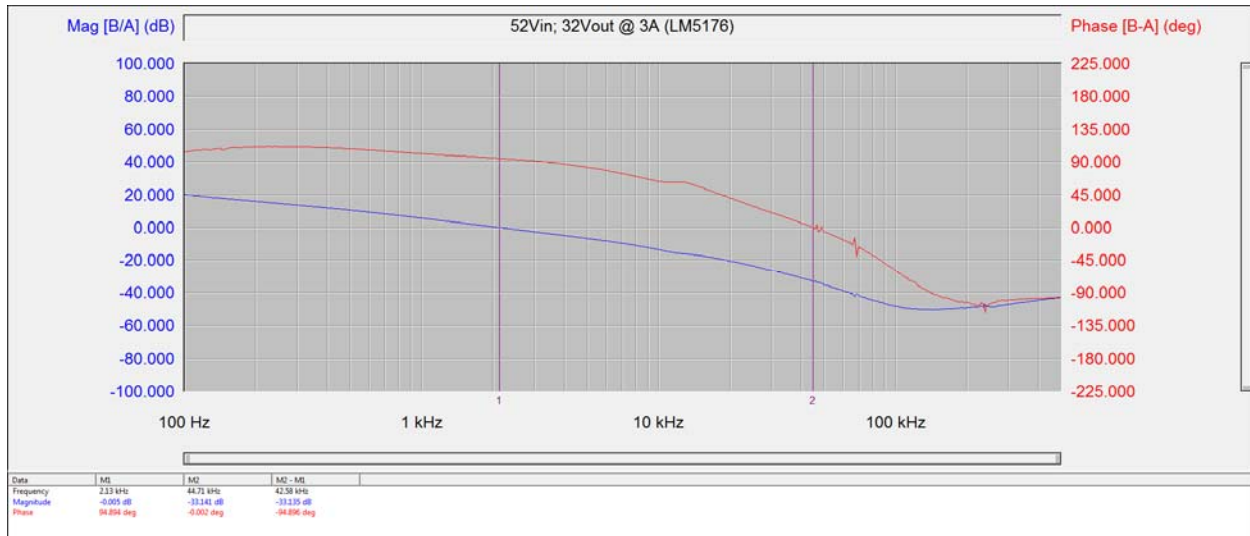
3.4 Bode Plot



Loop Frequency Response at 17Vin and Full (3A) Load (Crossover Frequency = 1.16KHz; Phase Margin = 90.7 degrees; Gain Margin = -21.4dB)

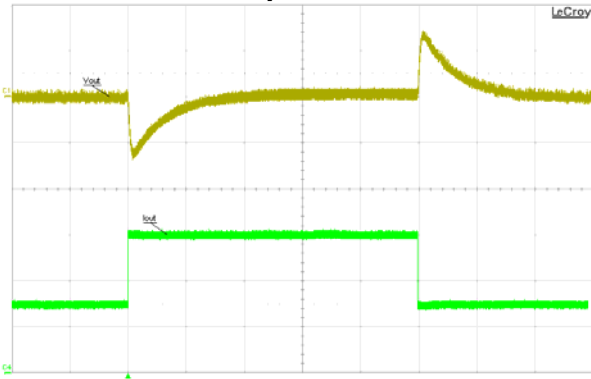


Loop Frequency Response at 34Vin and Full (3A) Load (Crossover Frequency = 2.1KHz; Phase Margin = 89.6 degrees; Gain Margin = -29.9dB)

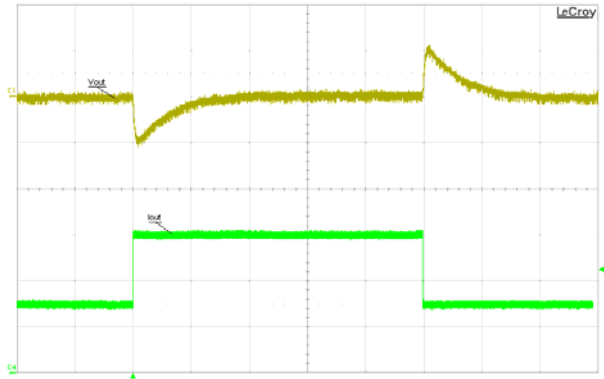


Loop Frequency Response at 52Vin and Full (3A) Load (Crossover Frequency = 2.13KHz; Phase Margin = 94.9 degrees; Gain Margin = -33.1dB)

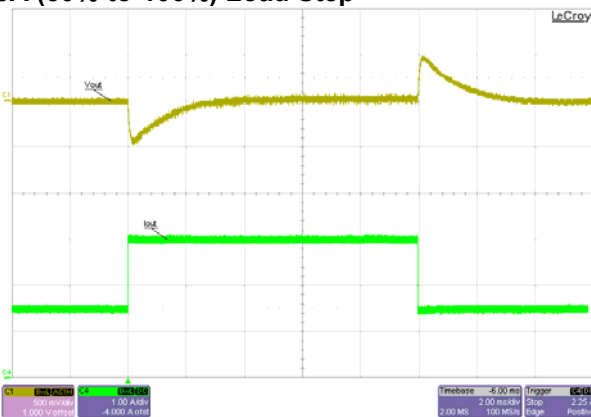
3.5 Load Transient Response



Load Transient Response at 17Vin and 1.5A-to-3A (50%-to-100%) Load Step

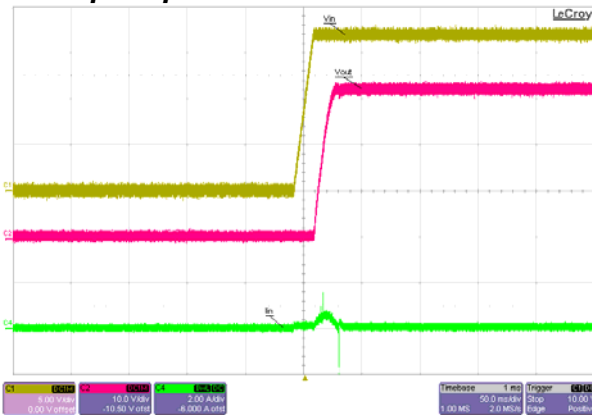


Load Transient Response at 34Vin and 1.5A-to-3A (50%-to-100%) Load Step

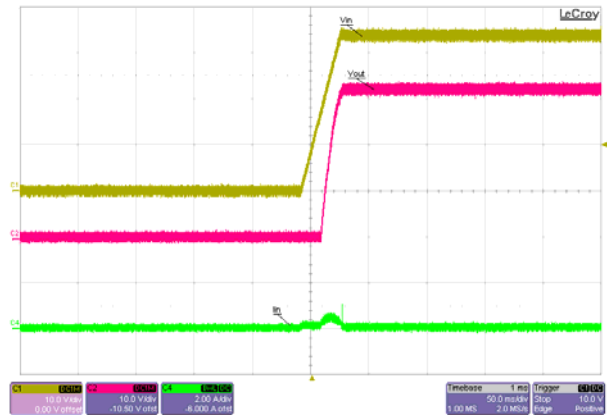


Load Transient Response at 52Vin and 1.5A-to-3A (50%-to-100%) Load Step

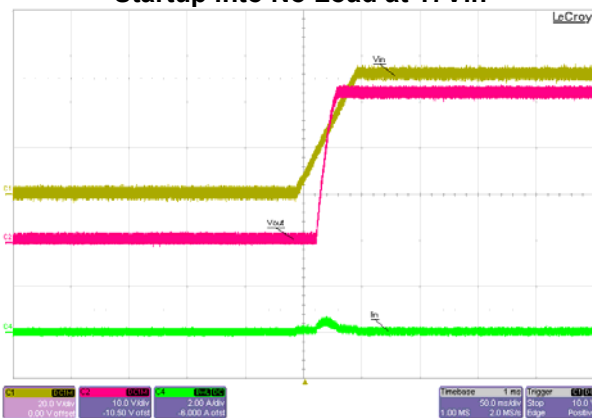
3.6 Start-up Sequence



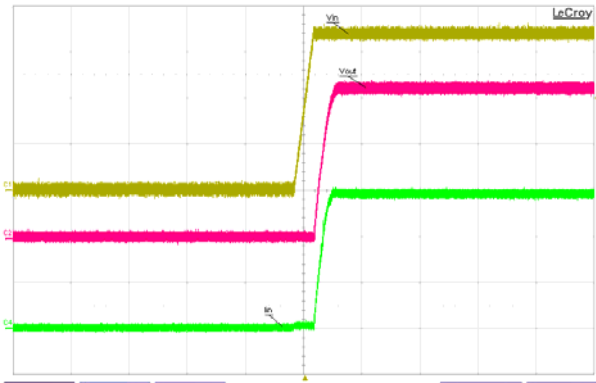
Startup into No Load at 17Vin



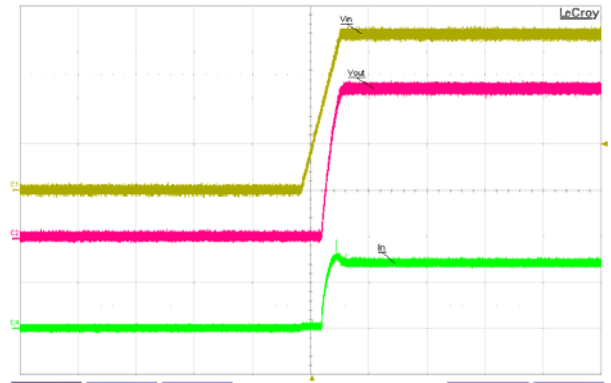
Startup into No Load at 34Vin



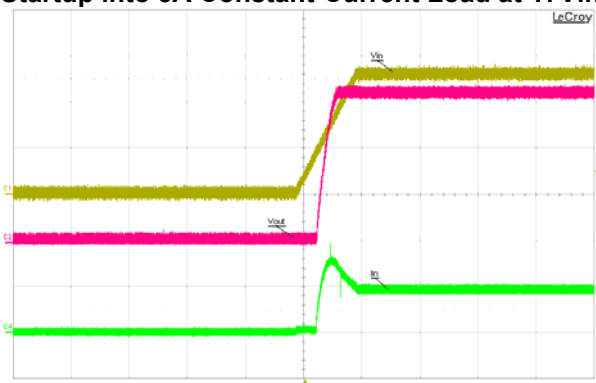
Startup into No Load at 52Vin



Startup into 3A Constant-Current Load at 17Vin



Startup into 3A Constant-Current Load at 34Vin



Startup into 3A Constant-Current Load at 52Vin

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