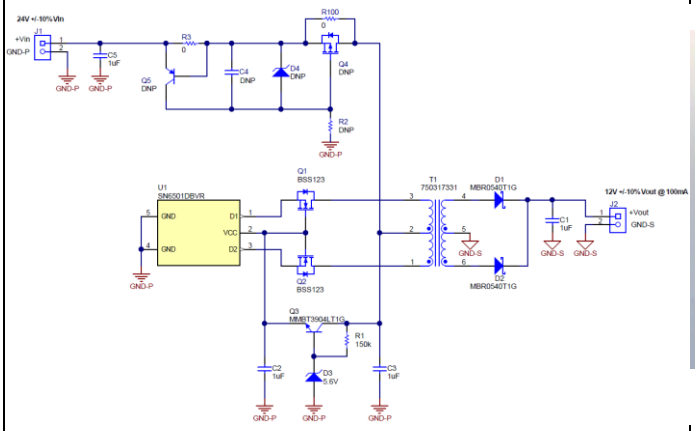
Test Report: PMP30440 Rev_B

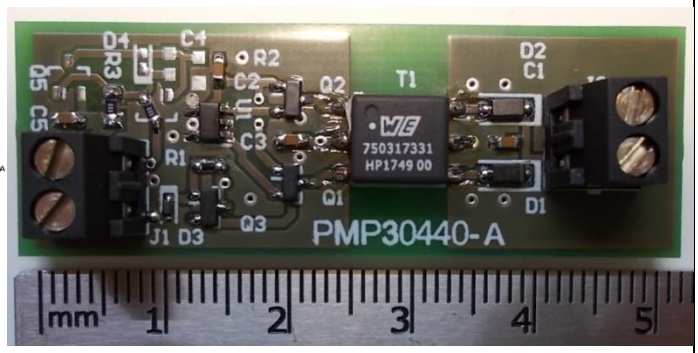
24 Vin to 12 Vout @ 100mA Isolated Push-Pull Reference Design With Cascode FETs

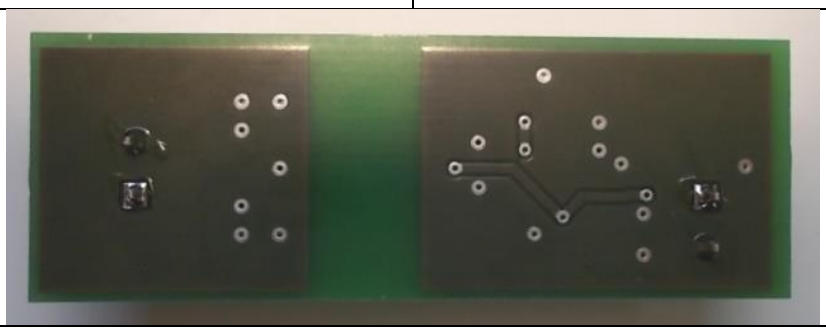
TEXAS INSTRUMENTS

Description

This reference design is an isolated Push-Pull with “cascode” SOT-23 FETs. This connection extends input voltage range to 24 Vin ±10% into 12V unregulated (open loop). With a selection of four different transformers, it is possible to get 12 Vout (@ 100mA) or 5 Vout (@ 250mA) from 12 V or 24 V source.
The PMP30440 Rev_B Reference Design has been built on PMP30440 Rev_A PCB.







1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1. Voltage and Current Requirements

PARAMETER	SPECIFICATIONS
Input Voltage	12 V or 24 V ± 10% (DC)
Output Voltage	12 V or 5 V ± 10% (DC)
Output Current	100 mA or 250 mA

Vin / Vout Variants	Transformer Manufacturer:	Transformer p/n:
24 Vin, 12 Vout @ 100 mA	Würth Elektronik	750317331
24 Vin, 5 Vout @ 250 mA	Würth Elektronik	750317828
12 Vin, 12 Vout @ 100 mA	Würth Elektronik	750317829
12 Vin, 5 Vout @ 250 mA	Würth Elektronik	750317830

1.2 Required Equipment

- 0…30 V, (min. 300 mA), constant voltage source (VS1)
- 0…15 V, (0…300 mA), constant current electronic load
- Oscilloscope (min. 100 MHz bandwidth)
- Current probe (min. 100 KHz bandwidth)

1.3 Considerations

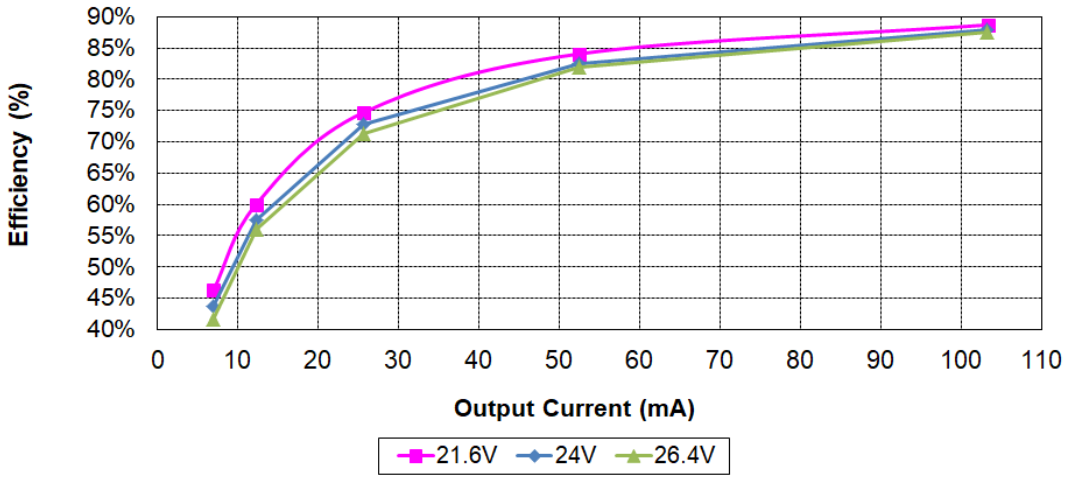
a) Connect the source VS1 to J1, pin 1 & 2
b) Connect the load to J2, pin 1 & 2, set to CC mode.
c) Connect oscilloscope probes to Q2-Drain and Q2-Gate versus primary ground and C1 differential voltage (or versus secondary ground).

2 Testing and Results

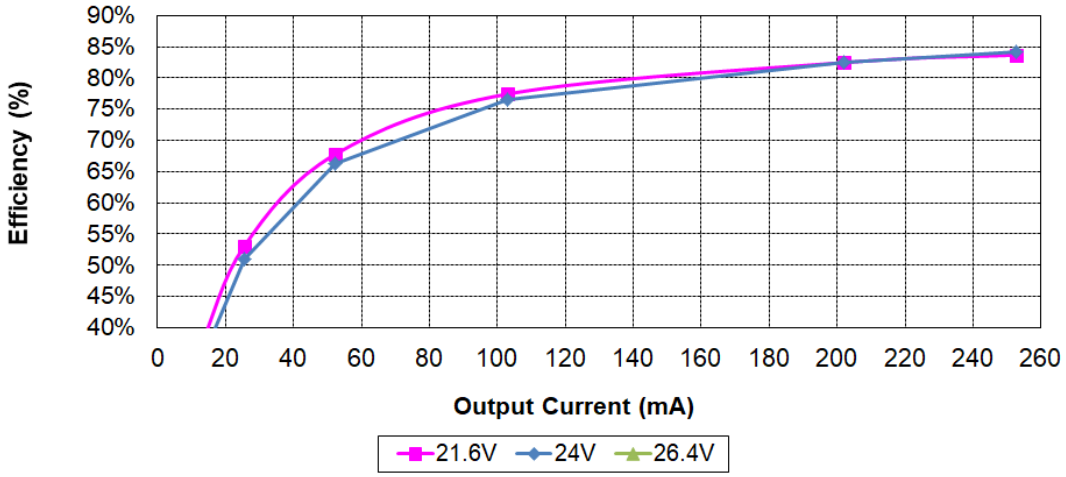
2.1 *Efficiency Graphs:*

The efficiency graphs, versus output current, are shown below. Four different version have been built: 24 V →12 V, 24 V →5 V, 12 V →12 V, 12 V →5 V.

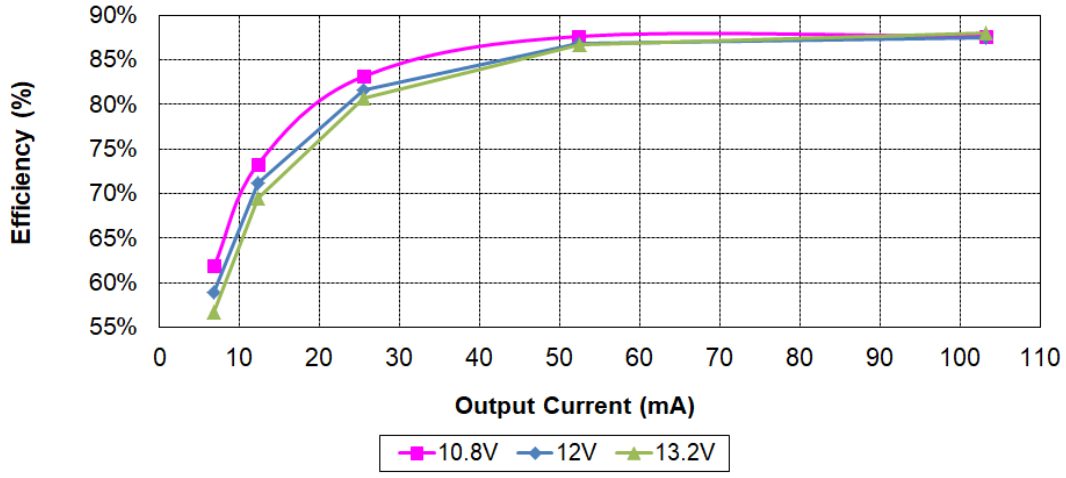
24V to 12V:



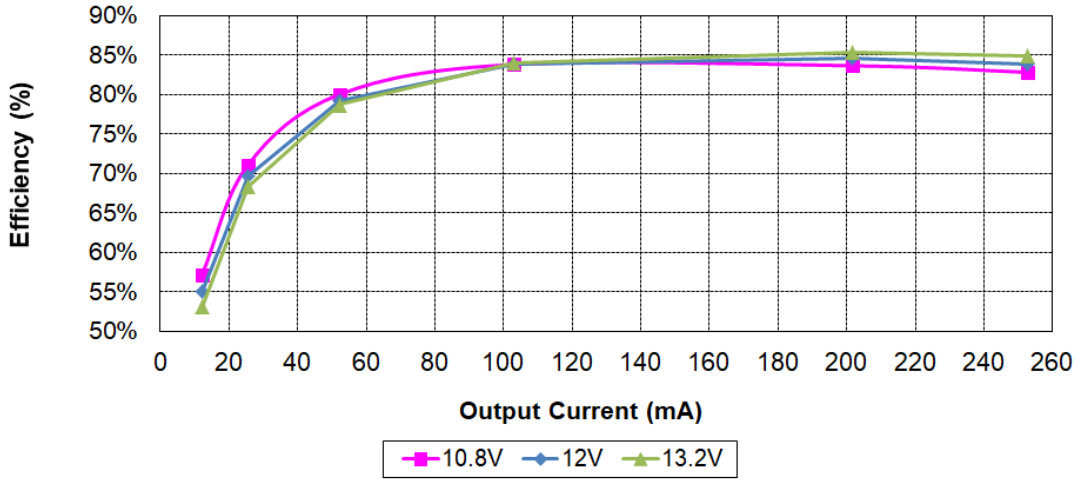
24V to 5V:



12V to 12V:



12V to 5V:



2.2 Efficiency Data:

The efficiency graph reports the data from the table shown below:

24Vin to 12Vout						
Vin(V)	Iin(mA)	Pin (W)	Vout (V)	Iout(mA)	Pout (W)	Efficiency (%)
21.66	4.0	0.087	11.889	0	0.000	0.0%
21.66	7.5	0.162	10.885	6.9	0.075	46.23%
21.66	10.2	0.221	10.858	12.2	0.132	59.96%
21.66	17.1	0.370	10.809	25.6	0.277	74.71%
21.65	30.9	0.669	10.733	52.4	0.562	84.07%
21.63	57.1	1.235	10.605	103.3	1.095	88.70%

24Vin to 12Vout						
Vin(V)	Iin(mA)	Pin (W)	Vout (V)	Iout(mA)	Pout (W)	Efficiency (%)
24.04	4.3	0.103	13.10	0	0.000	0.0%
24.04	7.9	0.190	12.03	6.9	0.083	43.71%
24.04	10.6	0.255	12.00	12.2	0.146	57.45%
24.03	17.5	0.421	11.95	25.6	0.306	72.75%
24.02	31.4	0.754	11.88	52.4	0.623	82.54%
24.01	57.5	1.381	11.75	103.2	1.213	87.83%

24Vin to 12Vout						
Vin(V)	Iin(mA)	Pin (W)	Vout (V)	Iout(mA)	Pout (W)	Efficiency (%)
26.46	4.7	0.124	14.41	0	0.000	0.0%
26.46	8.3	0.220	13.28	6.9	0.092	41.72%
26.45	11.0	0.291	13.25	12.3	0.163	56.01%
26.45	17.9	0.473	13.20	25.6	0.338	71.37%
26.44	31.7	0.838	13.12	52.4	0.687	82.02%
26.43	57.9	1.530	12.99	103.2	1.341	87.60%

24Vin to 5Vout						
Vin(V)	Iin(mA)	Pin (W)	Vout (V)	Iout(mA)	Pout (W)	Efficiency (%)
21.64	4.4	0.095	4.967	0	0.000	0.0%
21.64	7.1	0.154	4.577	12.2	0.056	36.34%
21.64	10.1	0.219	4.549	25.5	0.116	53.07%
21.64	16.1	0.348	4.515	52.3	0.236	67.78%
21.63	27.5	0.595	4.468	103.1	0.461	77.44%
21.61	49.8	1.076	4.396	201.9	0.888	82.47%
21.60	61.2	1.322	4.378	252.7	1.106	83.69%

24Vin to 5Vout						
Vin(V)	Iin(mA)	Pin (W)	Vout (V)	Iout(mA)	Pout (W)	Efficiency (%)
24.08	4.8	0.116	5.541	0	0.000	0.0%
24.08	7.6	0.183	5.128	12.1	0.062	33.90%
24.08	10.6	0.255	5.100	25.5	0.130	50.95%
24.08	16.6	0.400	5.066	52.3	0.265	66.28%
24.07	28.1	0.676	5.019	103.1	0.517	76.51%
24.05	50.3	1.210	4.946	201.9	0.999	82.55%
24.04	61.6	1.481	4.929	252.7	1.246	84.11%

24Vin to 5Vout						
Vin(V)	Iin(mA)	Pin (W)	Vout (V)	Iout(mA)	Pout (W)	Efficiency (%)
26.43	5.4	0.143	6.094	0	0.000	0.0%
26.43	8.1	0.214	5.659	12.2	0.069	32.25%
26.43	11.1	0.293	5.631	25.5	0.144	48.94%
26.42	17.2	0.454	5.597	52.3	0.293	64.42%
26.41	28.6	0.755	5.550	103.1	0.572	75.76%
26.40	50.8	1.341	5.478	201.9	1.106	82.47%
26.40	61.6	1.626	5.447	252.7	1.376	84.64%

12Vin to 12Vout						
Vin(V)	Iin(mA)	Pin (W)	Vout (V)	Iout(mA)	Pout (W)	Efficiency (%)
10.834	4.1	0.044	11.930	0	0.000	0.0%
10.823	11.2	0.121	11.029	6.8	0.075	61.87%
10.816	16.9	0.183	10.971	12.2	0.134	73.22%
10.802	30.8	0.333	10.851	25.5	0.277	83.17%
10.819	58.9	0.637	10.677	52.3	0.558	87.63%
10.806	112.2	1.212	10.300	103.2	1.063	87.67%

12Vin to 12Vout						
Vin(V)	Iin(mA)	Pin (W)	Vout (V)	Iout(mA)	Pout (W)	Efficiency (%)
12.01	4.5	0.054	13.22	0	0.000	0.0%
12.01	11.7	0.141	12.18	6.8	0.083	58.94%
12.00	17.3	0.208	12.12	12.2	0.148	71.23%
12.01	31.3	0.376	12.03	25.5	0.307	81.61%
12.01	59.4	0.713	11.84	52.3	0.619	86.80%
12.03	112.6	1.355	11.50	103.1	1.186	87.53%

12Vin to 12Vout						
Vin(V)	Iin(mA)	Pin (W)	Vout (V)	Iout(mA)	Pout (W)	Efficiency (%)
13.22	5.0	0.066	14.55	0	0.000	0.0%
13.21	12.2	0.161	13.44	6.8	0.091	56.71%
13.20	17.8	0.235	13.38	12.2	0.163	69.47%
13.21	31.8	0.420	13.29	25.5	0.339	80.67%
13.22	59.9	0.792	13.11	52.4	0.687	86.75%
13.23	113.1	1.496	12.76	103.2	1.317	88.01%

12Vin to 5Vout						
Vin(V)	Iin(mA)	Pin (W)	Vout (V)	Iout(mA)	Pout (W)	Efficiency (%)
10.814	3.5	0.038	4.831	0	0.000	0.0%
10.806	8.9	0.096	4.541	12.1	0.055	57.13%
10.801	14.9	0.161	4.500	25.4	0.114	71.02%
10.798	26.9	0.290	4.445	52.3	0.232	80.03%
10.825	49.7	0.538	4.374	103.1	0.451	83.82%
10.815	94.1	1.018	4.219	201.8	0.851	83.66%
10.806	116.8	1.262	4.137	252.7	1.045	82.83%

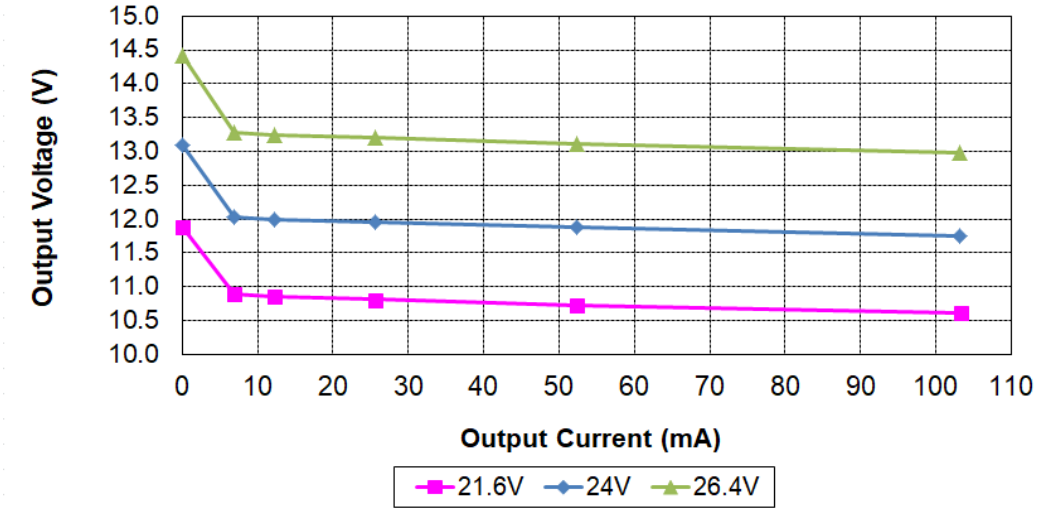
12Vin to 5Vout						
Vin(V)	Iin(mA)	Pin (W)	Vout (V)	Iout(mA)	Pout (W)	Efficiency (%)
12.04	3.9	0.047	5.391	0	0.000	0.0%
12.04	9.3	0.112	5.090	12.1	0.062	55.00%
12.03	15.3	0.184	5.050	25.4	0.128	69.69%
12.02	27.4	0.329	4.990	52.3	0.261	79.24%
12.01	50.2	0.603	4.904	103.1	0.506	83.86%
12.00	94.5	1.134	4.754	201.8	0.959	84.60%
12.00	117.3	1.408	4.673	252.7	1.181	83.89%

12Vin to 5Vout						
Vin(V)	Iin(mA)	Pin (W)	Vout (V)	Iout(mA)	Pout (W)	Efficiency (%)
13.27	4.3	0.057	5.956	0	0.000	0.0%
13.26	9.7	0.129	5.644	12.1	0.068	53.10%
13.26	15.7	0.208	5.603	25.4	0.142	68.36%
13.25	27.8	0.368	5.543	52.3	0.290	78.70%
13.22	50.6	0.669	5.449	103.1	0.562	83.98%
13.21	94.9	1.254	5.298	201.8	1.069	85.28%
13.21	117.7	1.555	5.221	252.7	1.319	84.86%

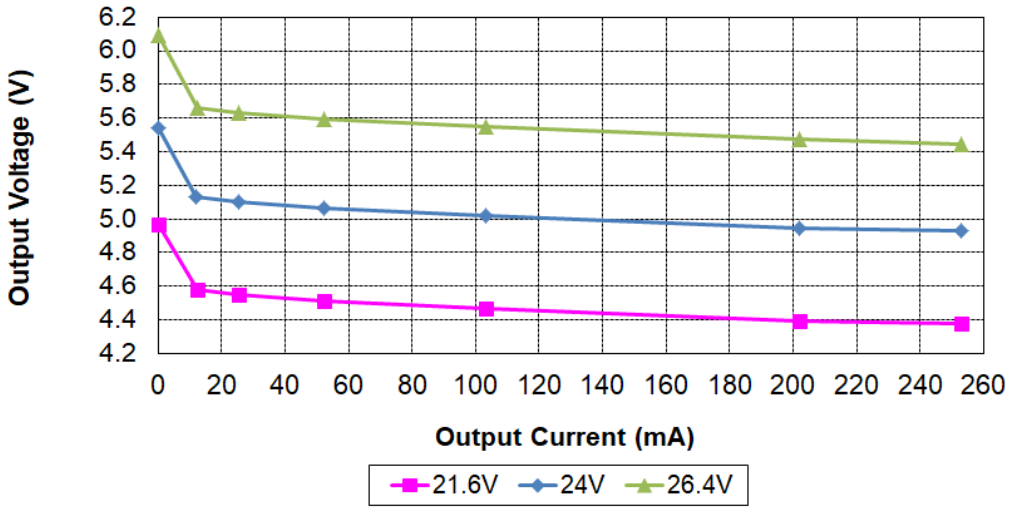
2.3 Output Voltage Regulation

The output voltage regulation graphs, for each version, are shown below.

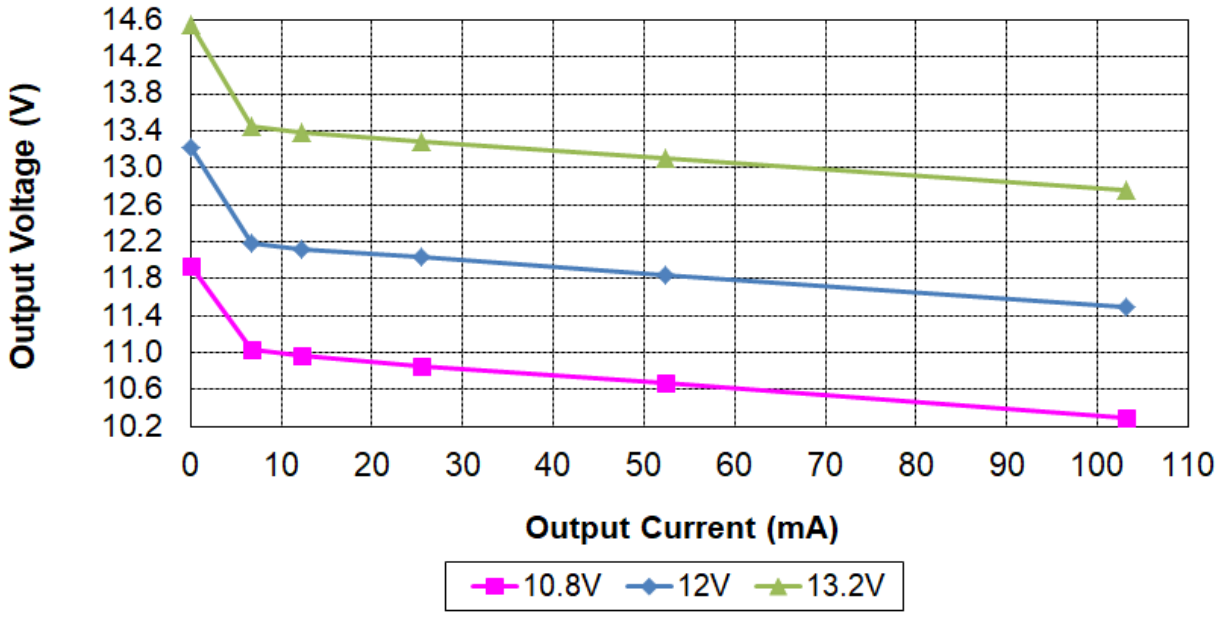
24V to 12V:



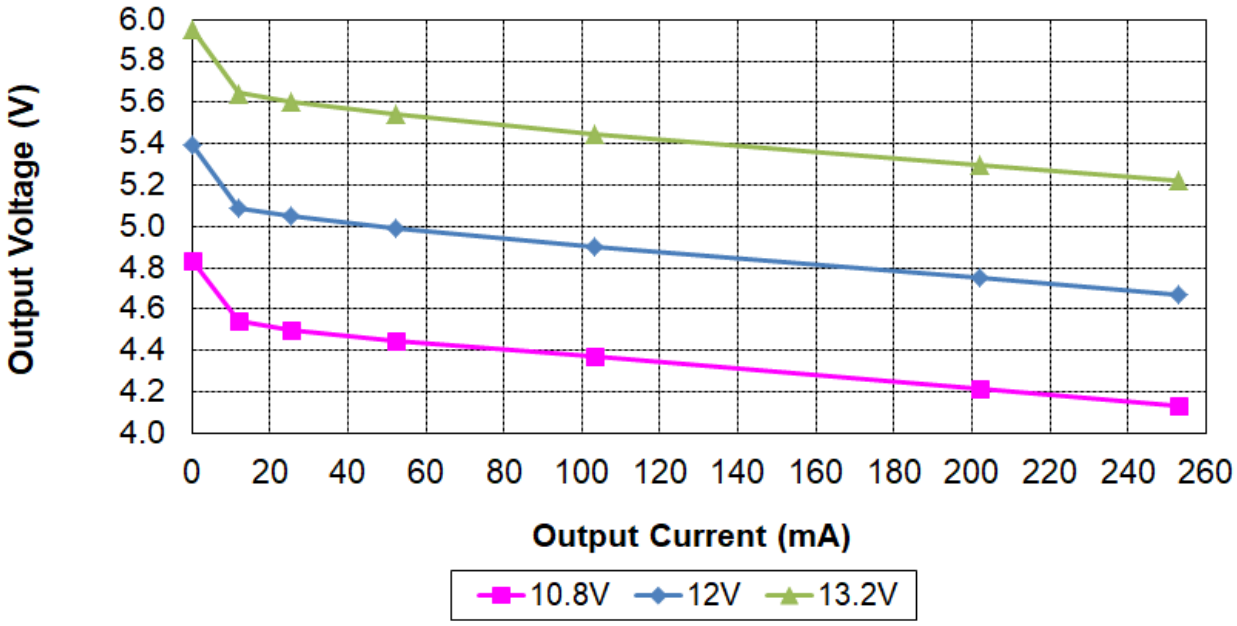
24V to 5V:



12V to 12V:



12V to 5V:



2.4 Dimensions

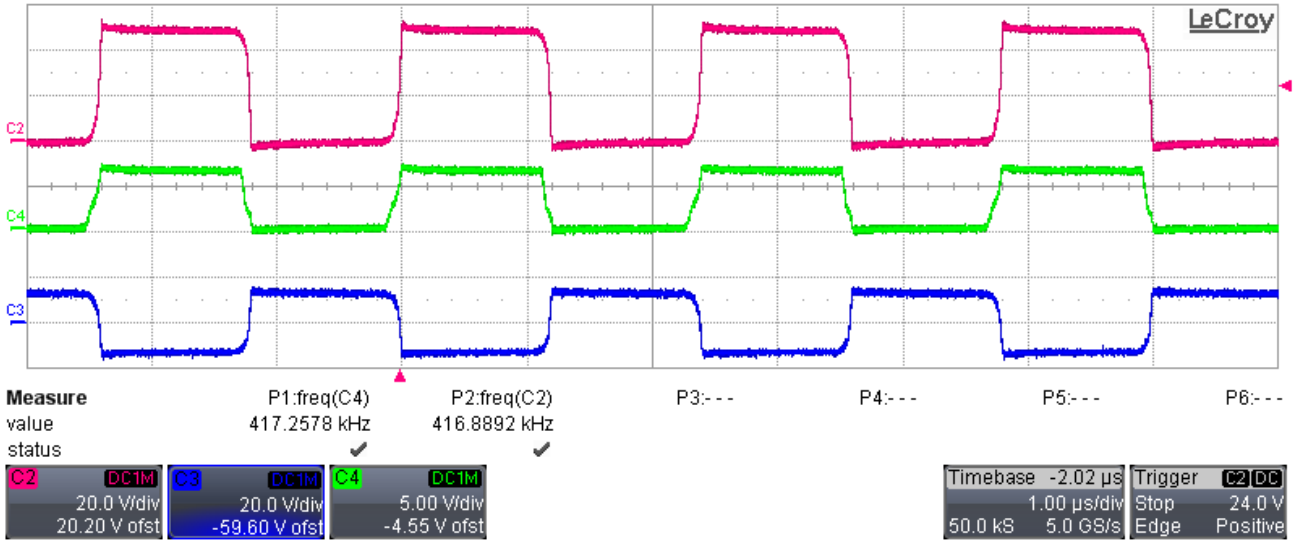
The board dimensions are 51.56 mm x 18.03 mm, height 8.5 mm.

3 Waveforms

3.1 Switching

The switching waveforms have been measured by supplying the converter at 24V in full load condition (Vout, Iout = 12 V, 100mA).

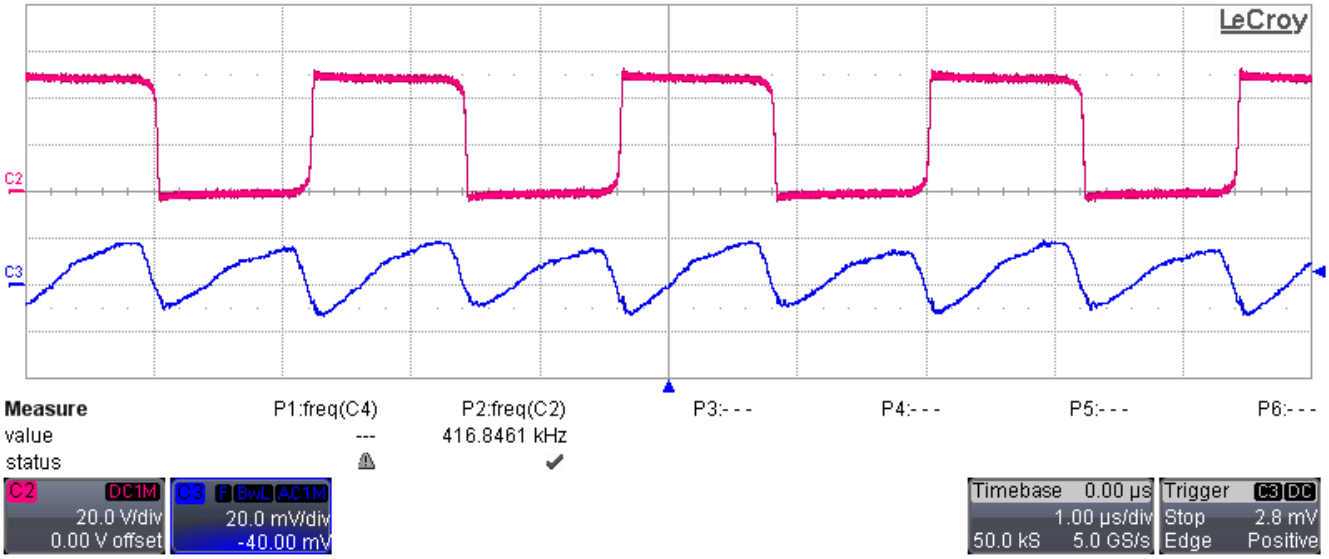
C2: V_{DS} voltage of Q2 (20 V/div, 1 usec/div, no BWL)
C3: Voltage on D2- anode (20 V/div,no BWL)
C4: V_{GS} voltage of Q2 (5 V/div, no BWL)



3.2 Output Voltage Ripple

The output voltage ripple, and the next measurements regarding startup, shut down and load transients, have been measured by supplying the converter at 24 V and by considering the 24 V to 12 V version. The converter was fully loaded.

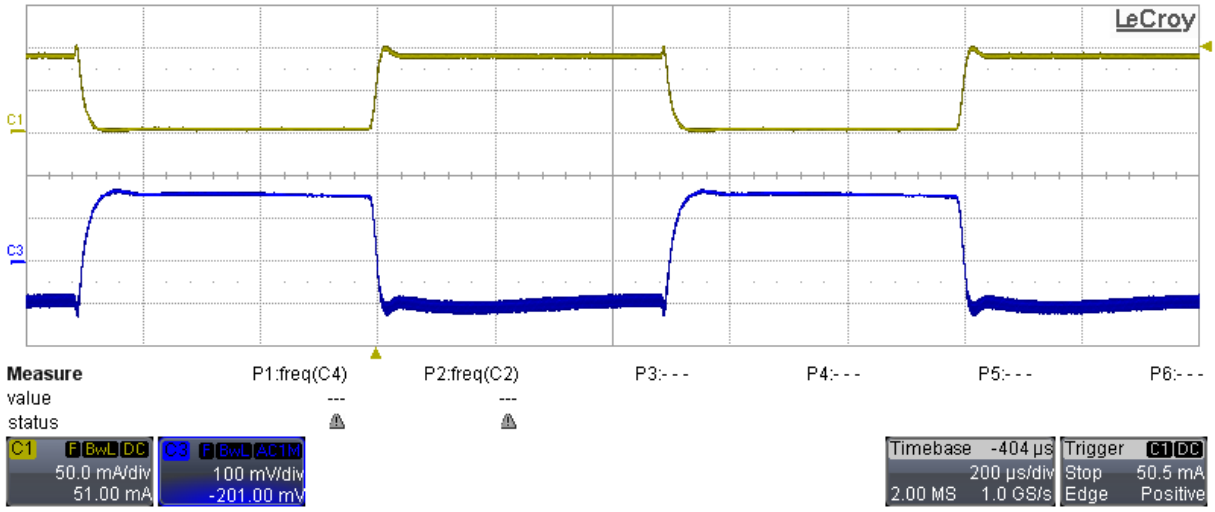
C2: V_{DS} voltage of Q2 (20 V/div, 1 usec/div, no BWL)
C3: Output voltage (20 mV/div,20 MHz BWL, AC coupling)



3.3 Load Transients

Conditions: Vin = 24 V, Vout = 12V, 100mA.

C1: Output current (50 mA/div, 200 usec/div, 20 MHz BWL, DC coupling)
C3: Output voltage (100 mV/div,20 MHz BWL, AC coupling)



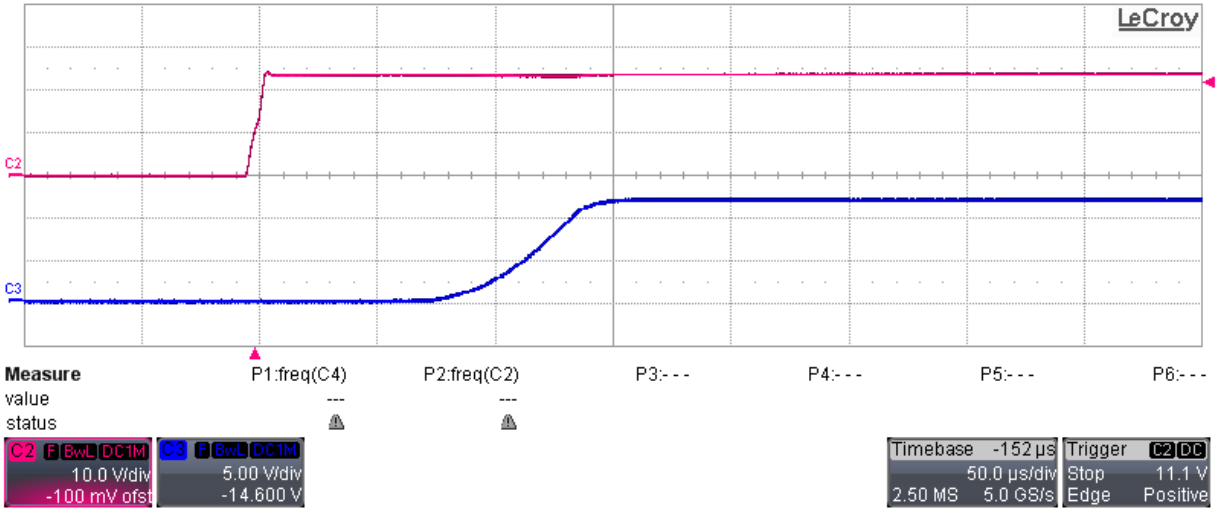
3.4 Startup

The output voltage versus input voltage behavior has been measured and shown below.

In this graph, Vin has been applied by connecting the source to the power supply.

Conditions: Vin = 24 V, Vout = 12V, 100mA.

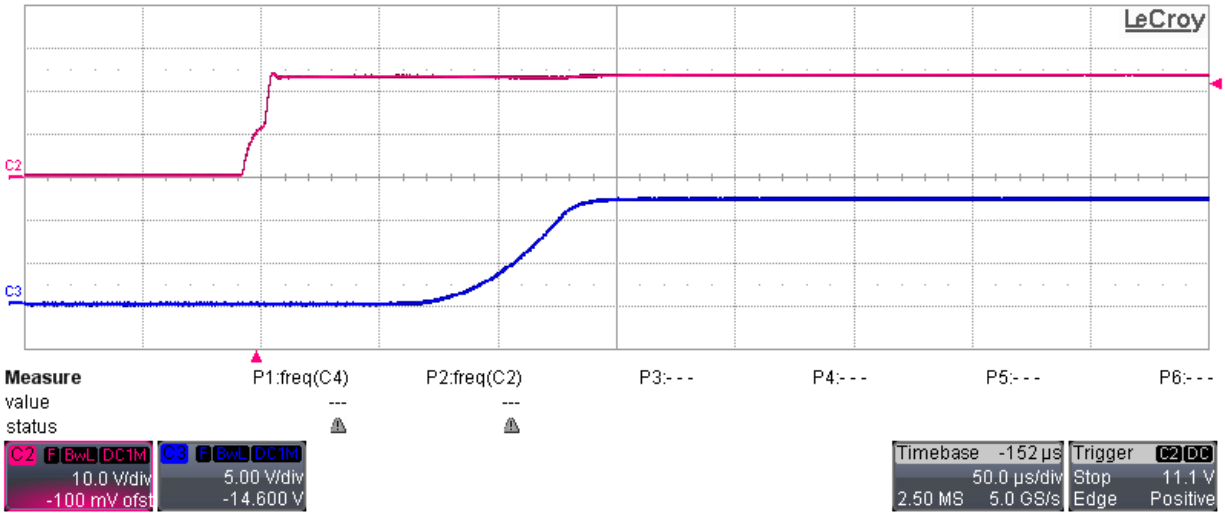
C2: Input voltage (10 V/div, 50 usec/div, 20 MHz BWL)
C3: Output voltage (5 V/div,20 MHz BW)



Conditions: Vin = 24 V, Vout = 12V, load not connected.

C2: Input voltage (10 V/div, 50 usec/div, 20 MHz BWL)

C3: Output voltage (5 V/div,20 MHz BW)

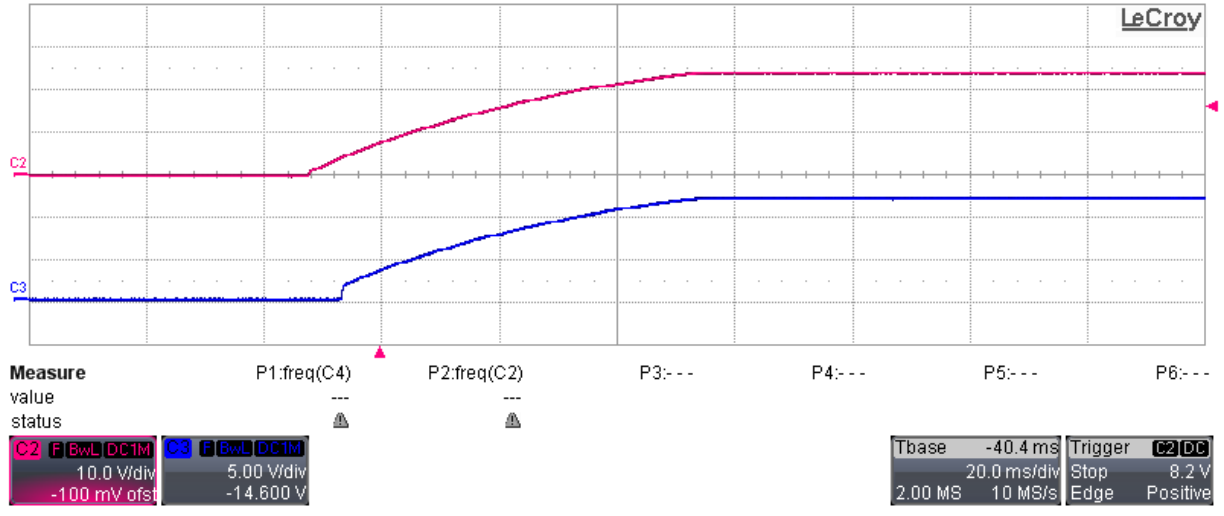


In the next two graphs, Vin has been applied by switching on the DC voltage source, therefore the $\Delta V/\Delta T$ is much slower.

Conditions: Vin = 24 V, Vout = 12V, 100mA.

C2: Input voltage (10 V/div, 20 msec/div, 20 MHz BWL)

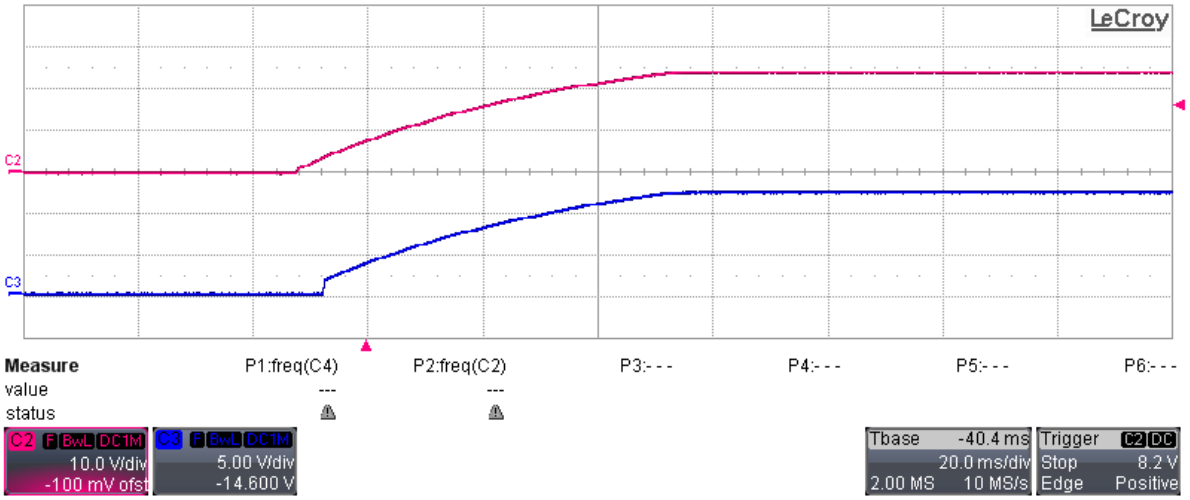
C3: Output voltage (5 V/div,20 MHz BW)



Conditions: Vin = 24 V, Vout = 12V, load not connected.

C2: Input voltage (10 V/div, 20 msec/div, 20 MHz BWL)

C3: Output voltage (5 V/div,20 MHz BW)



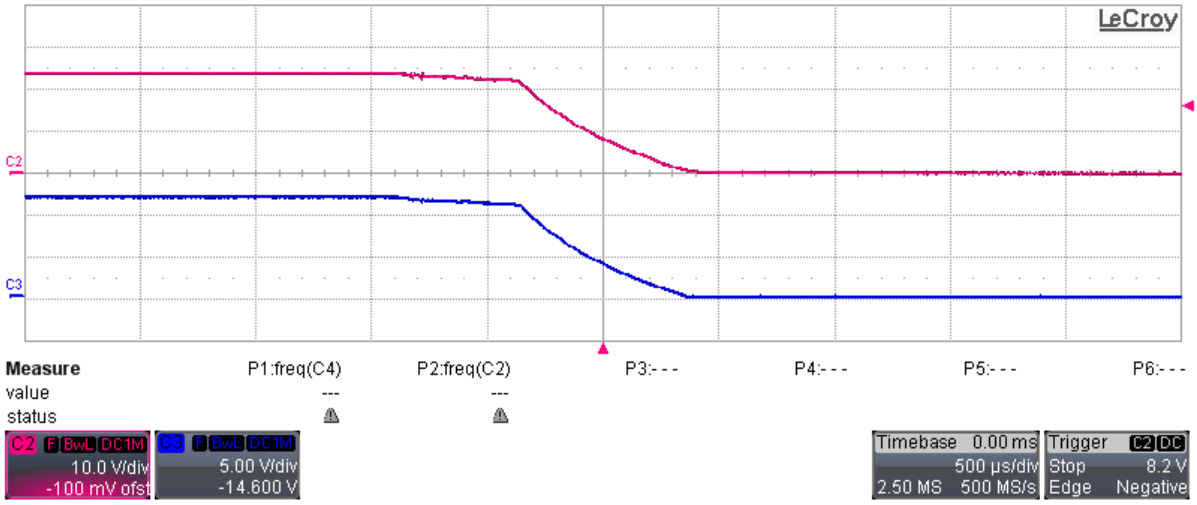
3.5 Shut down

The output voltage versus input voltage behavior, during shut down, has been measured and shown below.

Conditions: Vin = 24 V, Vout = 12V, 100 mA.

C2: Input voltage (10 V/div, 500usec/div, 20 MHz BWL)

C3: Output voltage (5 V/div,20 MHz BW)



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