

24-V, 1.2-A DC-DC Flyback Reference Design



Description

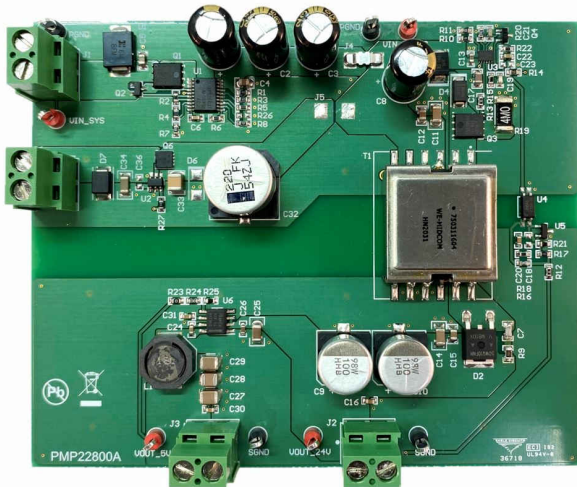
This reference design uses the LM51551 as a secondary side regulated (SSR) flyback controller. It converts an input of 8–28.8 V to 24 V at a max power of 28.8 W. The supply starts up at a minimum input of 15.5 V and can operate down to 8-V input. The design also includes the synchronous buck converter, LMR33620, to step down 24 V to 5 V. This design features the option to evaluate either the TPS26631 eFuse or LM74700 ideal diode controller as input protection devices.

Features

- DC-DC flyback maintains precise output regulation with SSR
- Hiccup mode overcurrent protection
- Catalog transformer
- All components on top layer
- Option to compare two different input protection circuits

Applications

- [DIN rail power supply](#)



Board Top View



Board Side View

1 Test Prerequisites

Select one of the input protection circuits to evaluate during testing:

TPS26631: Connect input to terminal J1, DNP jumper J5

LM74700: Connect input to terminal J6, DNP jumper J4

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

Parameter	Specifications
Input Voltage	8–28.8 VDC
Output Voltage 1	24 VDC
Output Current 1	1.2 A
Output Voltage 2	5 VDC
Output Current 2	1.6 A

1.2 Required Equipment

- DC Source (30 V, 4 A)
- Electronic load
- Oscilloscope
- Multimeters
- Frequency response analyzer

2 Testing and Results

2.1 Efficiency Graphs

The PMP22800 efficiency graphs are shown in the following images.

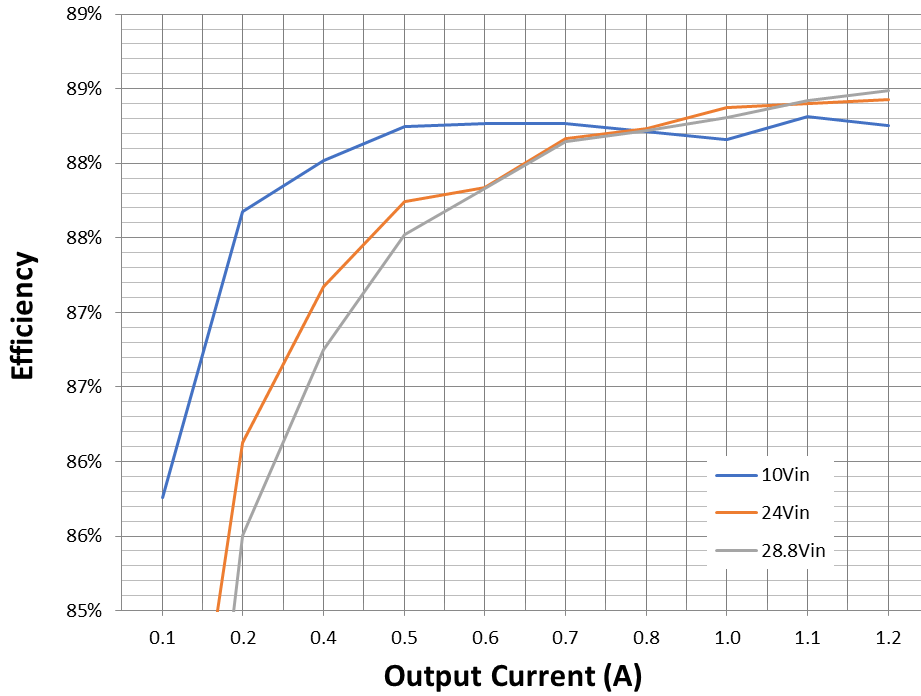


Figure 2-1. Flyback Efficiency Graph: 24-V Output

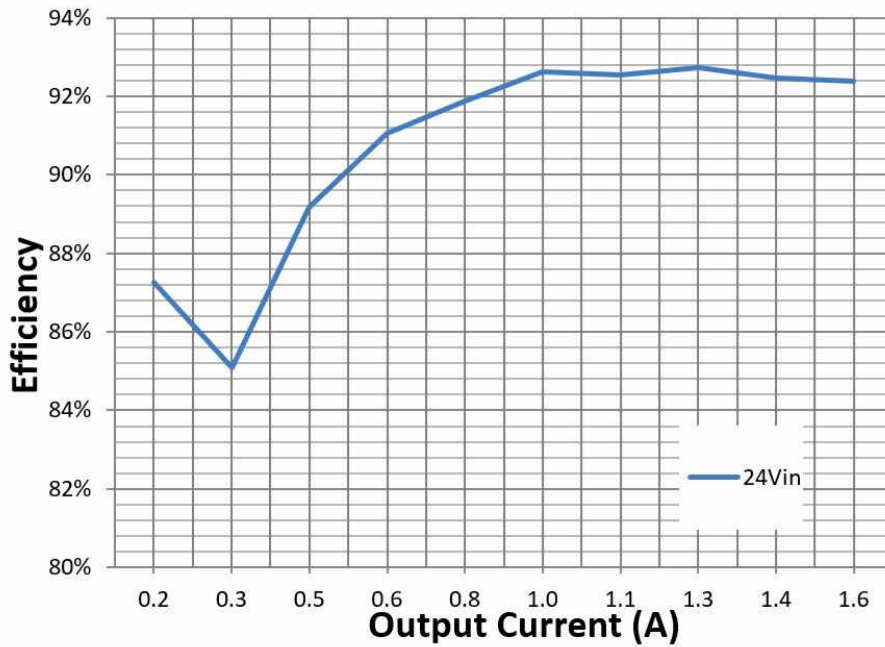


Figure 2-2. Buck Efficiency Graph: 5-V Output

2.2 Efficiency Data

Efficiency data is shown in the following tables.

Table 2-1. Flyback 10-V Input Efficiency

V _{in_sys} (V)	V _{in_dc/dc} (V)	I _{IN} (A)	P _{IN} (W)	V _{OUT} (V)	I _{OUT} (A)	P _{OUT} (W)	Eff (%)	Loss (W)
10.06	10.04	0.34	3.37	24.11	0.12	2.89	85.76%	0.48
9.99	9.96	0.67	6.65	24.11	0.24	5.83	87.68%	0.82
10.09	10.05	0.98	9.89	24.11	0.36	8.70	88.02%	1.18
10.03	9.97	1.32	13.14	24.11	0.48	11.59	88.24%	1.54
9.97	9.89	1.66	16.41	24.10	0.60	14.49	88.27%	1.93
10.07	9.97	1.97	19.69	24.10	0.72	17.38	88.26%	2.31
10.07	9.96	2.31	23.00	24.10	0.84	20.29	88.21%	2.71
10.00	9.87	2.66	26.29	24.09	0.96	23.18	88.16%	3.11
10.07	9.93	2.97	29.52	24.10	1.08	26.07	88.32%	3.45
9.99	9.81	3.34	32.76	24.05	1.20	28.91	88.25%	3.85

Table 2-2. Flyback 24-V Input Efficiency

V _{in_sys} (V)	V _{in_dc/dc} (V)	I _{IN} (A)	P _{IN} (W)	V _{OUT} (V)	I _{OUT} (A)	P _{OUT} (W)	Eff (%)	Loss (W)
24.08	24.07	0.15	3.56	24.10	0.12	2.94	82.52%	0.62
24.05	24.04	0.28	6.83	24.10	0.24	5.88	86.13%	0.95
24.02	24.00	0.42	10.03	24.10	0.36	8.75	87.17%	1.29
24.00	23.97	0.55	13.21	24.10	0.48	11.59	87.74%	1.62
24.07	24.04	0.69	16.51	24.09	0.60	14.50	87.84%	2.01
24.04	24.01	0.82	19.76	24.09	0.72	17.42	88.17%	2.34
24.02	23.97	0.96	23.04	24.08	0.84	20.33	88.23%	2.71
23.99	23.94	1.10	26.26	24.07	0.96	23.21	88.37%	3.05
24.03	23.97	1.23	29.51	24.07	1.08	26.09	88.40%	3.42
24.00	23.94	1.37	32.73	24.06	1.20	28.94	88.43%	3.79

Table 2-3. Flyback 28.8-V Input Efficiency

V _{in_sys} (V)	V _{in_dc/dc} (V)	I _{IN} (A)	P _{IN} (W)	V _{OUT} (V)	I _{OUT} (A)	P _{OUT} (W)	Eff (%)	Loss (W)
28.81	28.80	0.12	3.57	24.10	0.12	2.89	80.96%	0.68
28.78	28.77	0.24	6.82	24.09	0.24	5.83	85.50%	0.99
28.83	28.81	0.35	10.03	24.09	0.36	8.70	86.75%	1.33
28.81	28.78	0.46	13.24	24.09	0.48	11.59	87.52%	1.65
28.82	28.79	0.56	16.21	24.09	0.59	14.24	87.83%	1.97
28.80	28.76	0.69	19.70	24.09	0.72	17.37	88.15%	2.34
28.84	28.80	0.80	22.98	24.08	0.84	20.28	88.22%	2.71
28.82	28.78	0.91	26.21	24.06	0.96	23.15	88.31%	3.06
28.80	28.75	1.02	29.44	24.06	1.08	26.03	88.42%	3.41
28.81	28.75	1.14	32.66	24.05	1.20	28.90	88.49%	3.76

Table 2-4. Buck Efficiency

V _{in_24V} (V)	I _{in} (A)	P _{IN} (W)	V _{OUT} (V)	I _{OUT} (A)	P _{OUT} (W)	Eff (%)	Loss (W)
24.03	0.04	0.94	5.05	0.16	0.82	87.25%	0.12
24.02	0.08	1.90	5.03	0.32	1.61	85.08%	0.28
24.01	0.11	2.71	5.03	0.48	2.42	89.17%	0.29
24.00	0.15	3.55	5.03	0.64	3.23	91.05%	0.32
23.99	0.18	4.39	5.03	0.80	4.03	91.88%	0.36
23.98	0.22	5.23	5.03	0.96	4.84	92.63%	0.39
24.00	0.25	6.10	5.03	1.12	5.64	92.54%	0.45
23.99	0.29	6.96	5.03	1.28	6.45	92.72%	0.51
24.01	0.33	7.85	5.03	1.44	7.26	92.47%	0.59
24.00	0.37	8.88	5.03	1.63	8.20	92.39%	0.68

2.3 Thermal Images

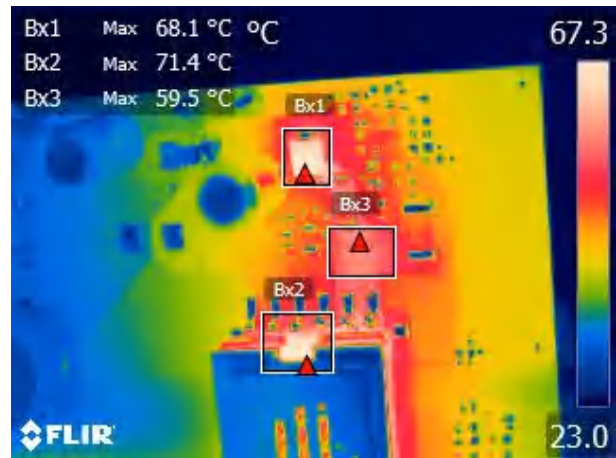
Thermal image are shown in the following figures.

All images were taken after running the supply at maximum load for 30 minutes. The board was mounted horizontally in open air at an ambient temp of 21°C with no additional air flow.



Bx1 – IC (U6)

Figure 2-3. Buck: 24-V Input



Bx1 – TVS Clamp (D3)

Bx2 – Transformer (T1)

Bx3 – Primary FET (Q3)

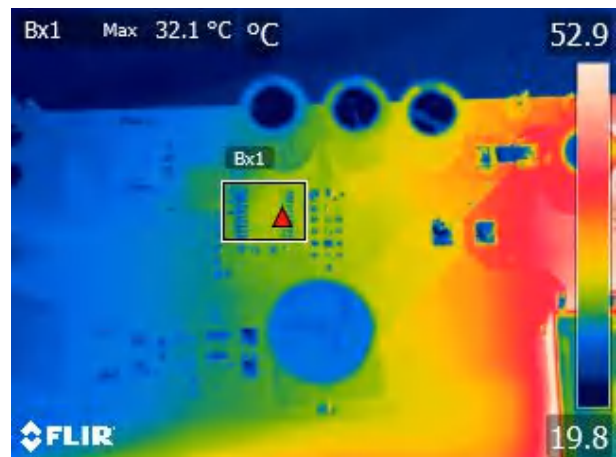
Figure 2-4. Flyback Primary: 24-V Input



Bx1 – Diode (D2)

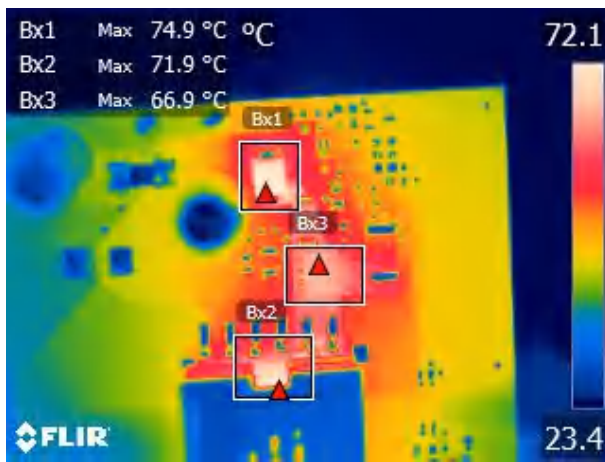
Bx2 – Transformer (T1)

Figure 2-5. Flyback Secondary: 24-V Input



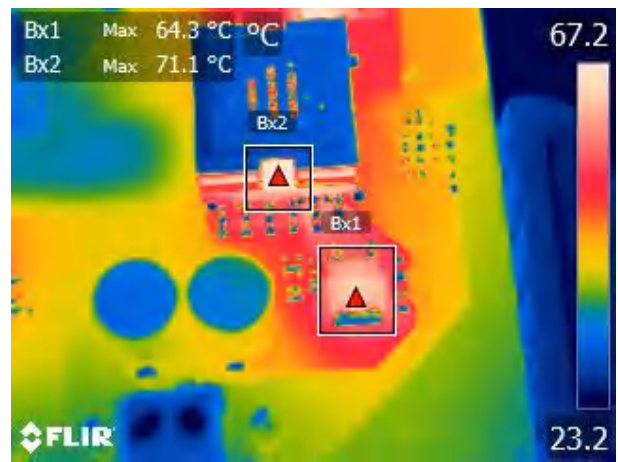
Bx1 – eFuse (U1)

Figure 2-6. Input Protection: 24-V Input



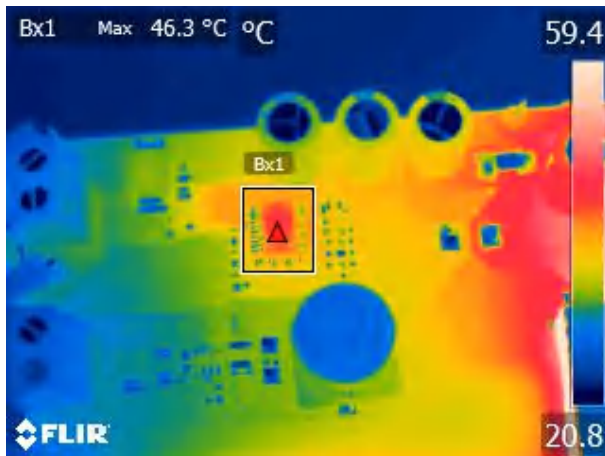
Bx1 – TVS Clamp (D3)
 Bx2 – Transformer (T1)
 Bx3 – Primary FET (Q3)

Figure 2-7. Flyback Primary: 10-V Input



Bx1 – Diode (D2)
 Bx2 – Transformer (T1)

Figure 2-8. Flyback Secondary: 10-V Input



Bx1 – eFuse (U1)

Figure 2-9. Input Protection: 10-V Input

2.4 Bode Plots

The PMP22800 bode plots are illustrated in the following images.

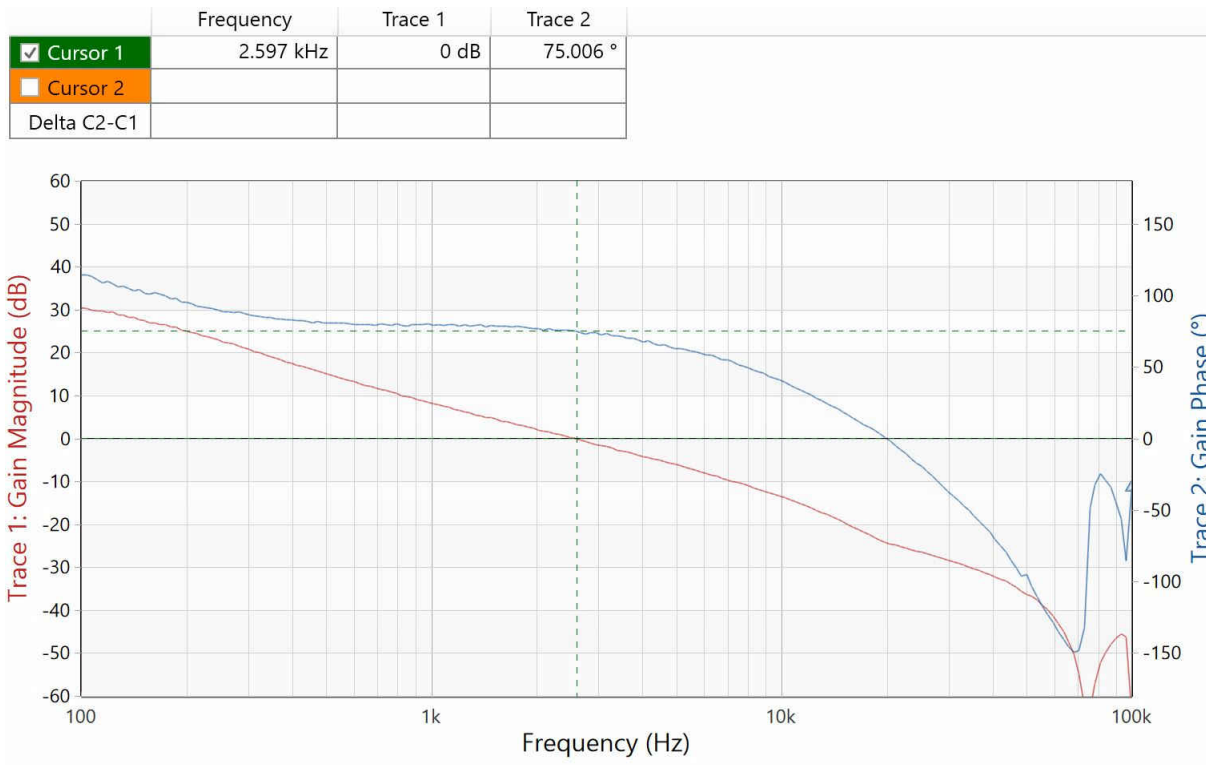


Figure 2-10. Flyback: 10-V Input, 1.2-A Output

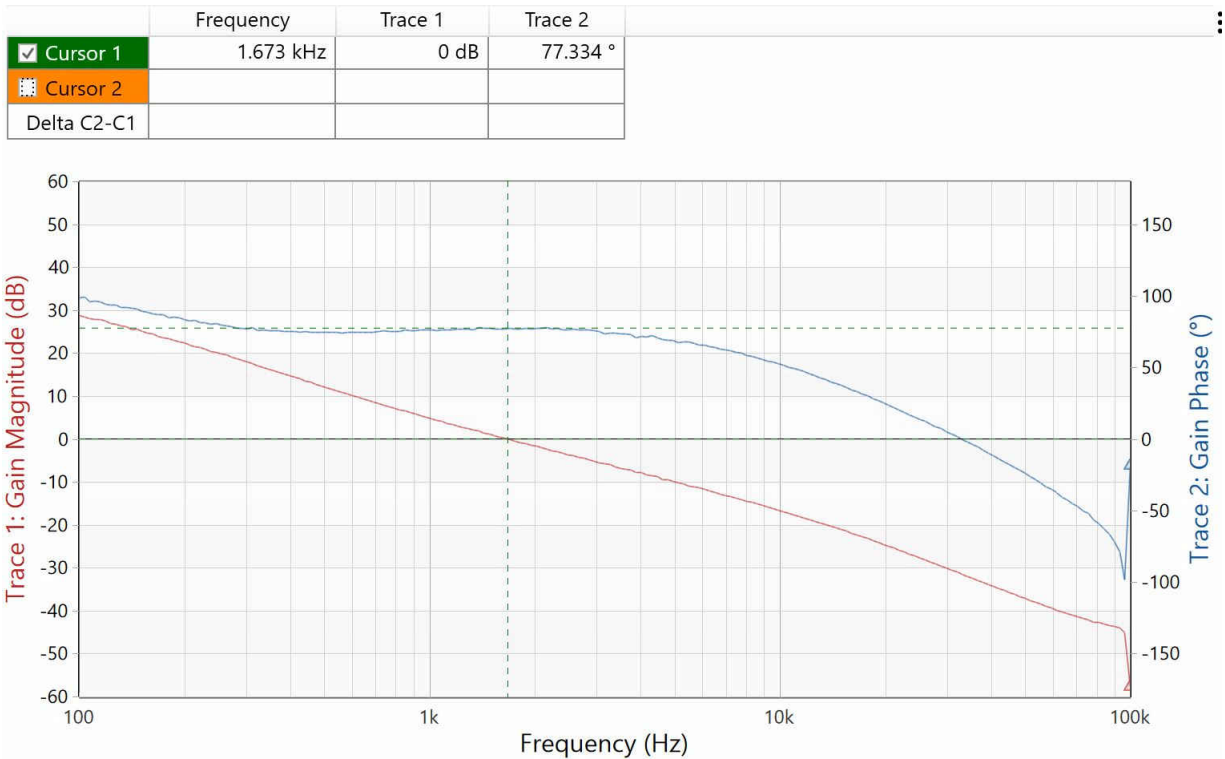


Figure 2-11. Flyback: 24-V Input, 1.2-A Output

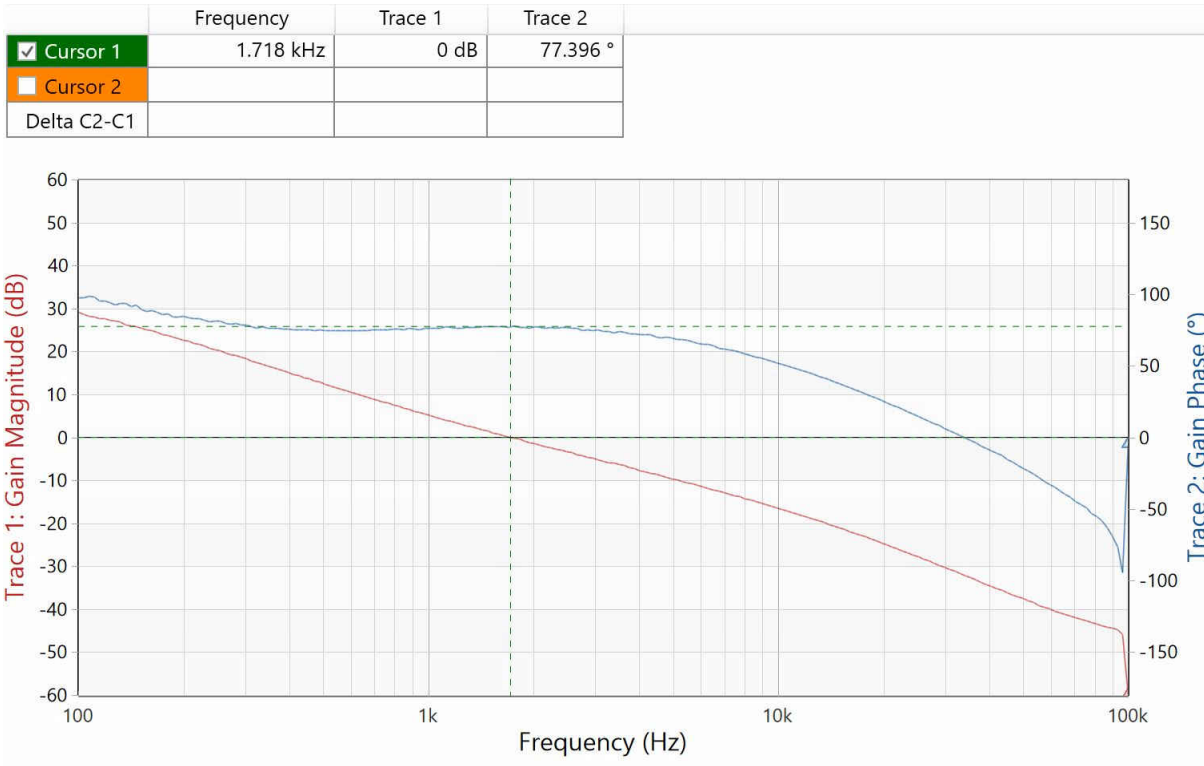


Figure 2-12. Flyback: 28.8-V Input, 1.2-A Output

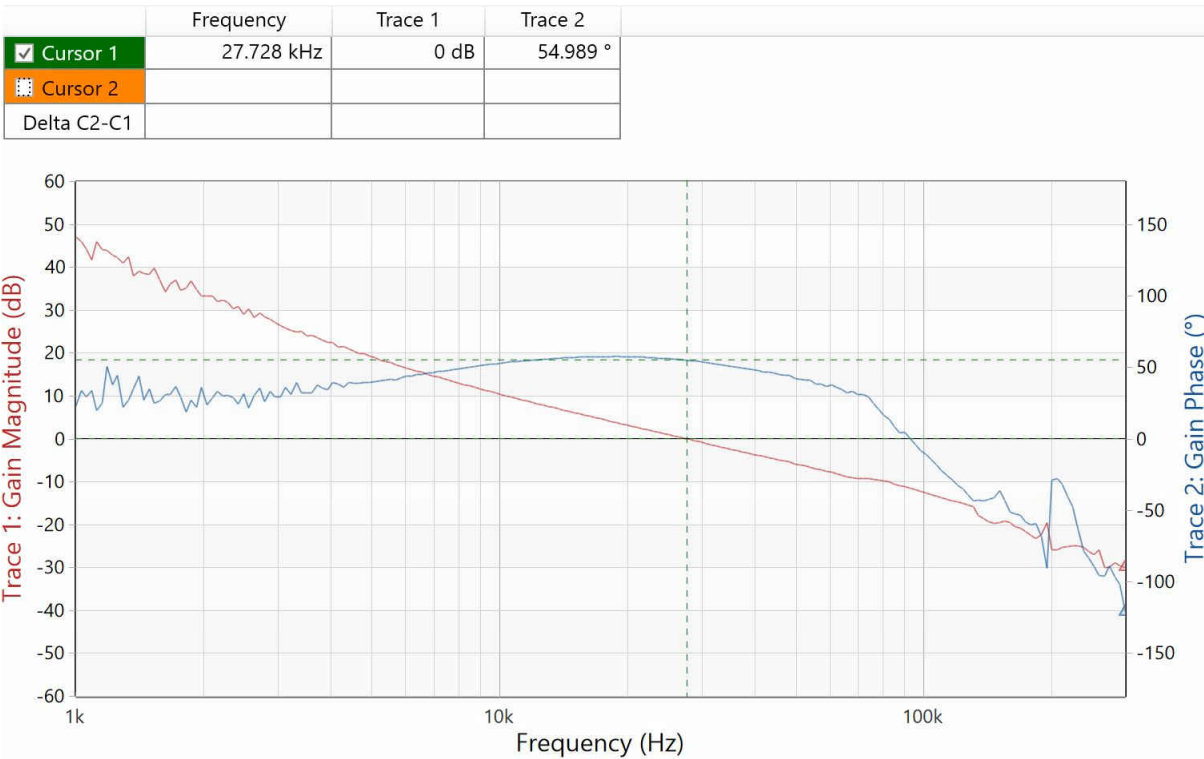


Figure 2-13. Buck: 24-V Input, 1.63-A Output

3 Waveforms

3.1 Switching

Switching behavior is shown in the following figures.

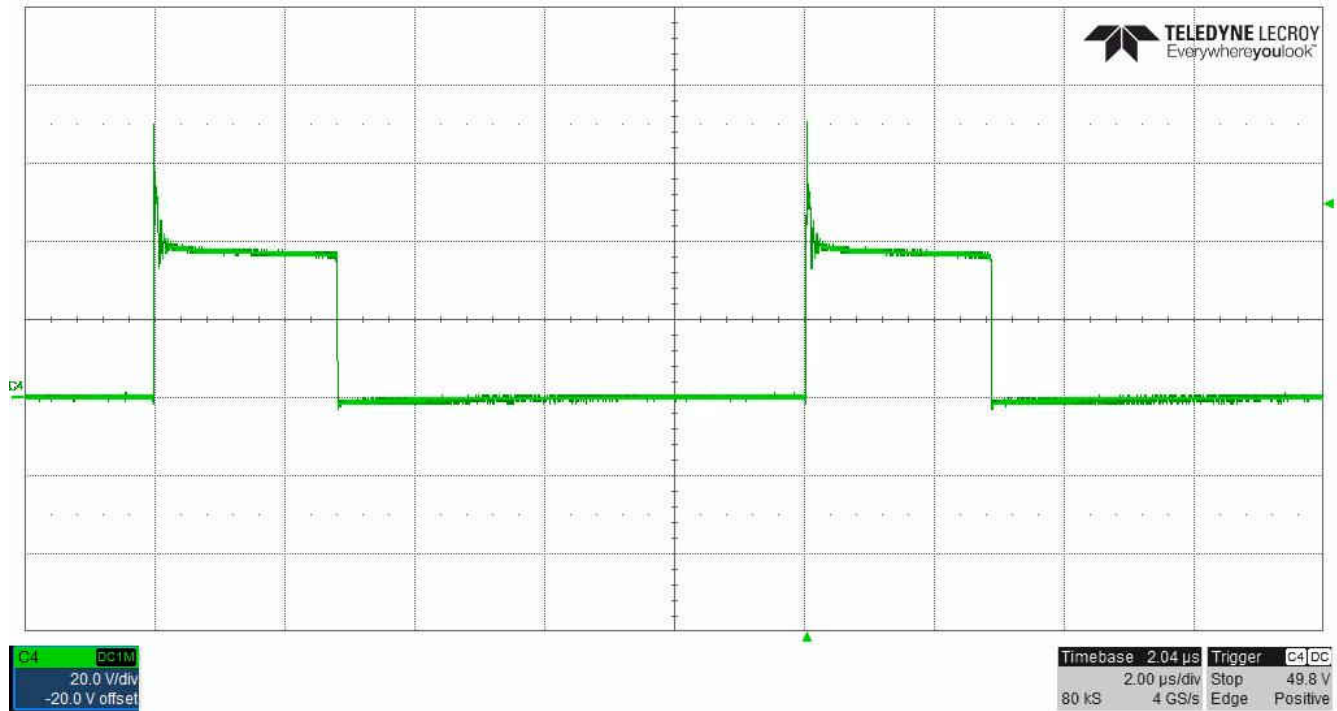


Figure 3-1. SW Node - Primary FET (Q3): 10-V Input, 1.2-A Output

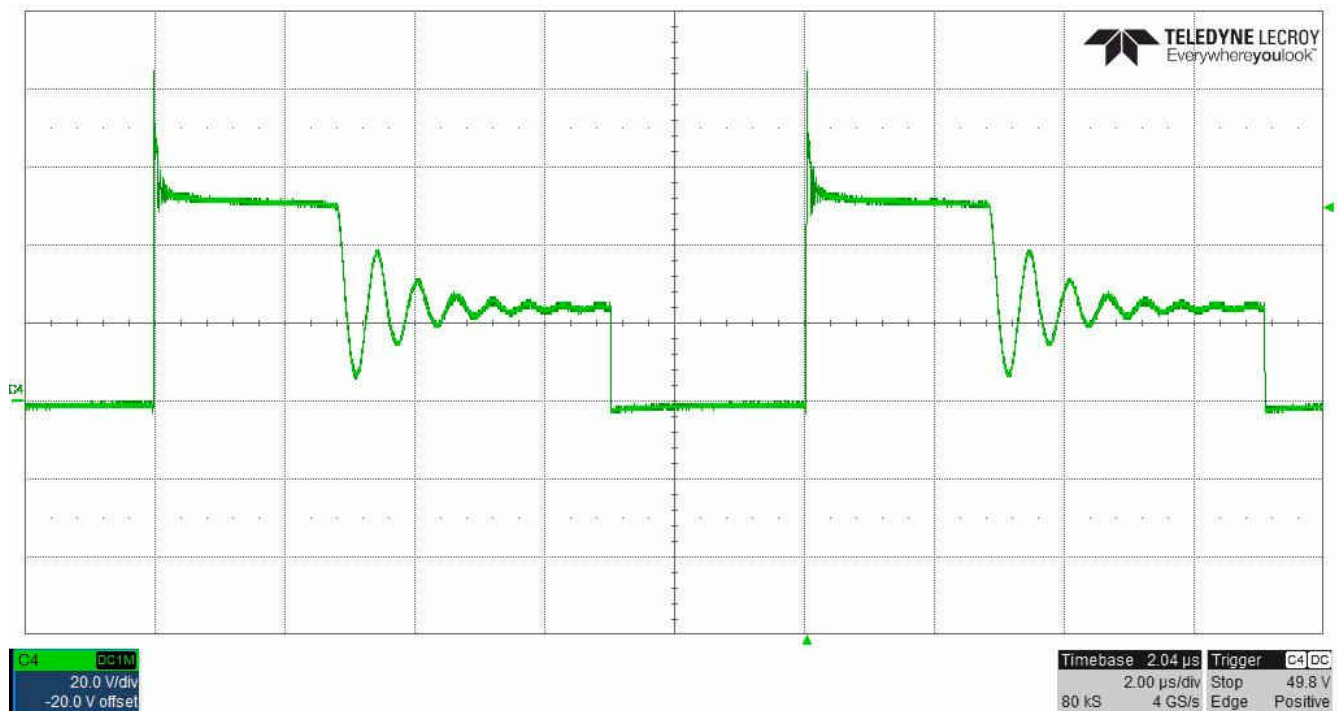


Figure 3-2. Primary FET (Q3): 24-V Input, 1.2-A Output

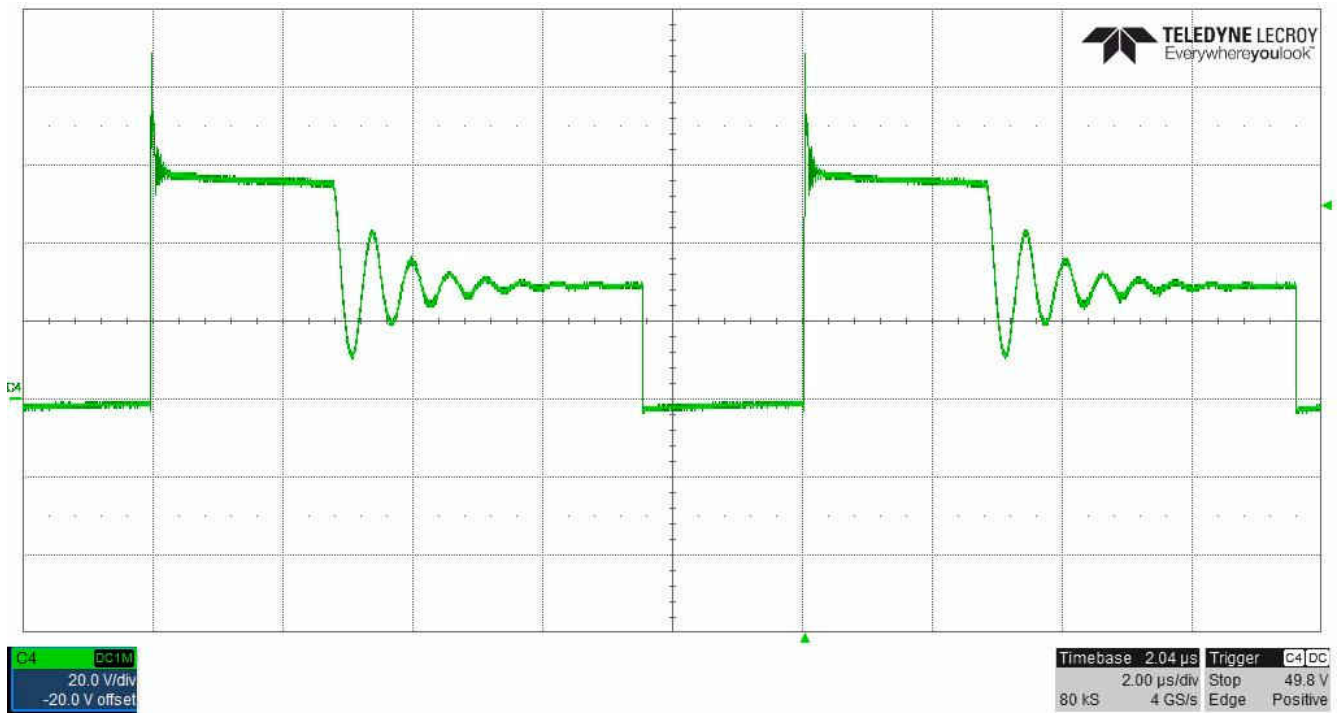


Figure 3-3. SW Node - Primary FET (Q3): 28.8-V Input, 1.2-A Output

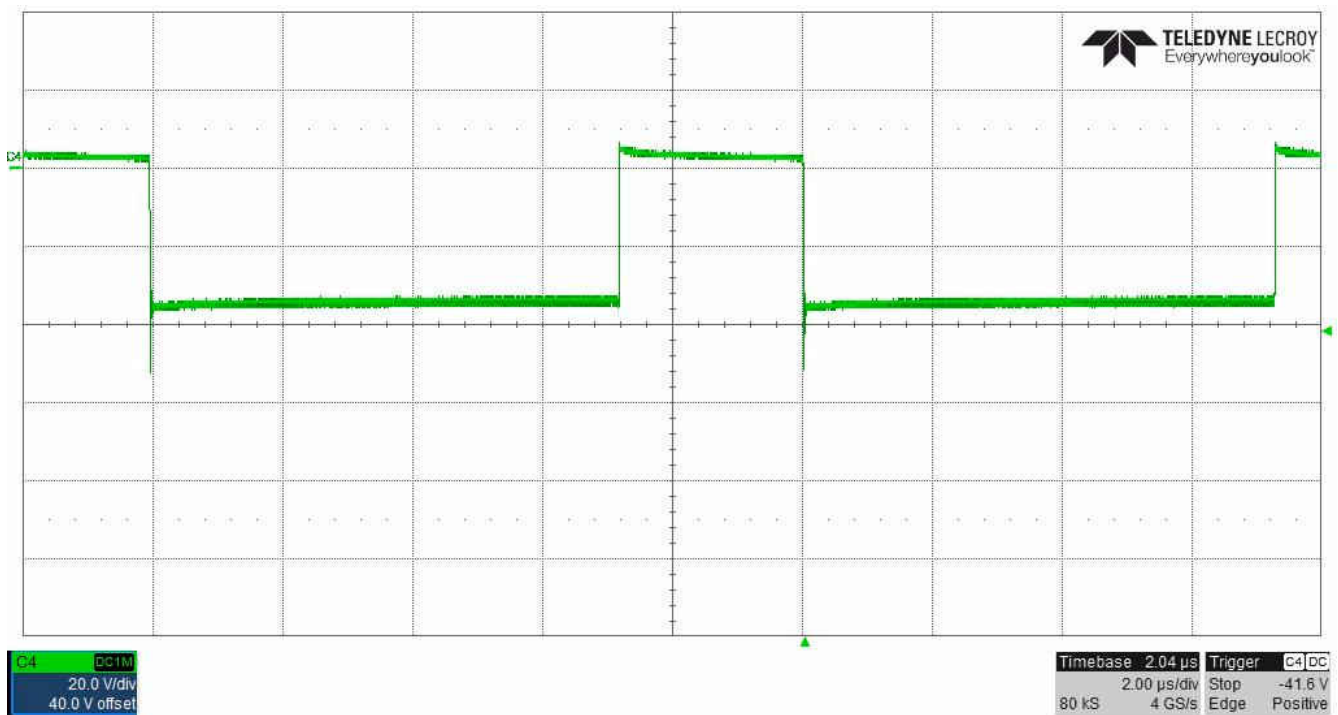


Figure 3-4. Diode (D2): 10-V Input, 1.2-A Output

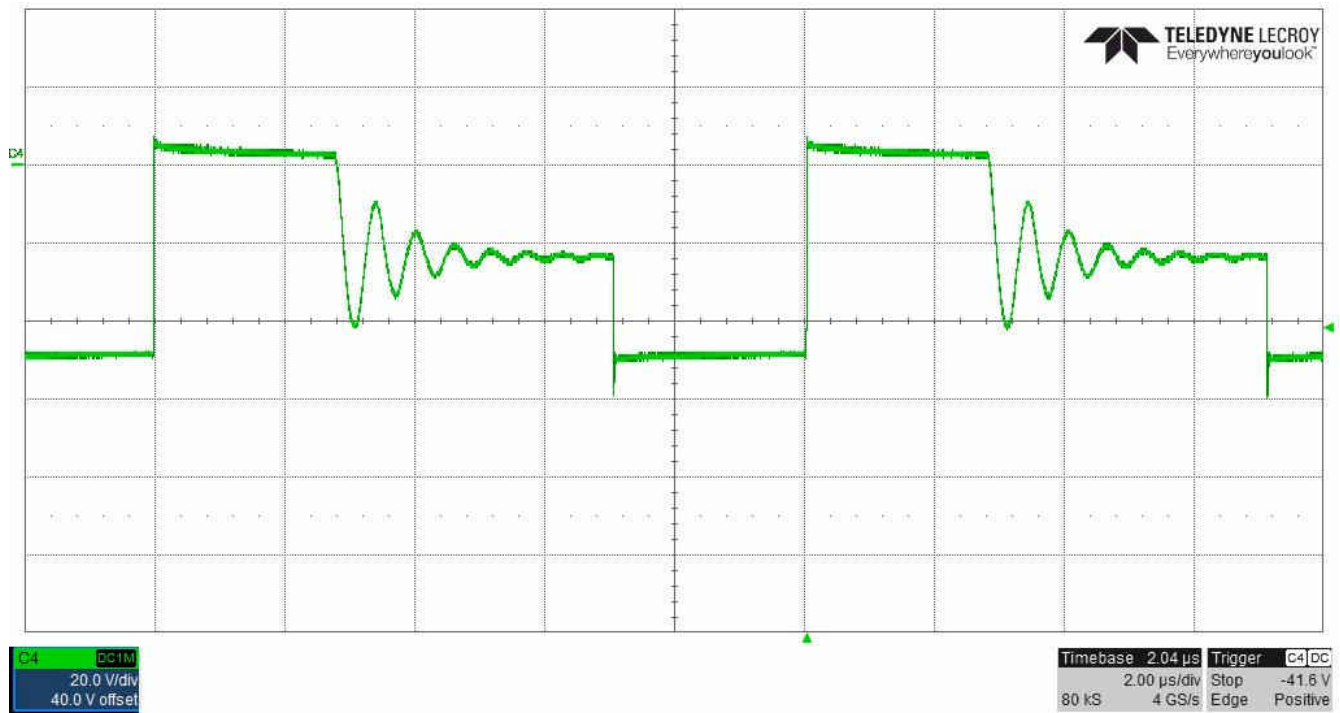


Figure 3-5. Diode (D2): 24-V Input, 1.2-A Output

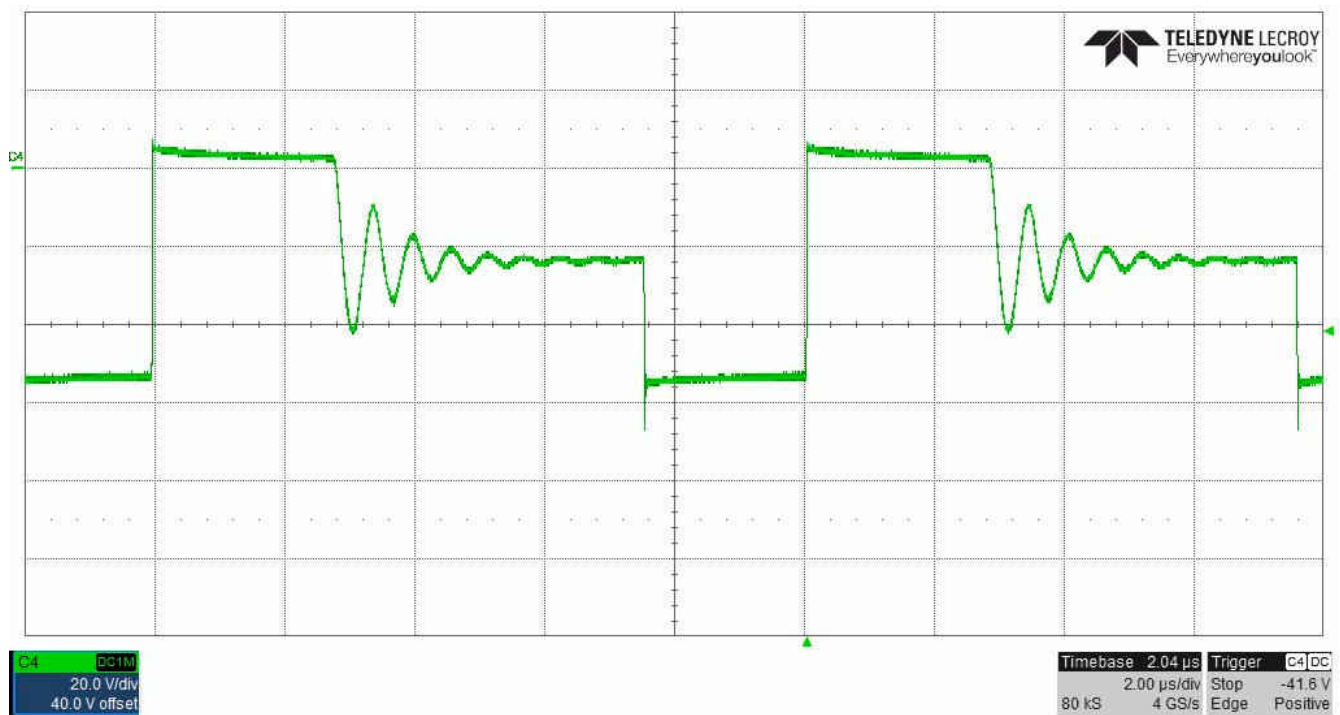


Figure 3-6. Diode (D2): 28.8-V Input, 1.2-A Output

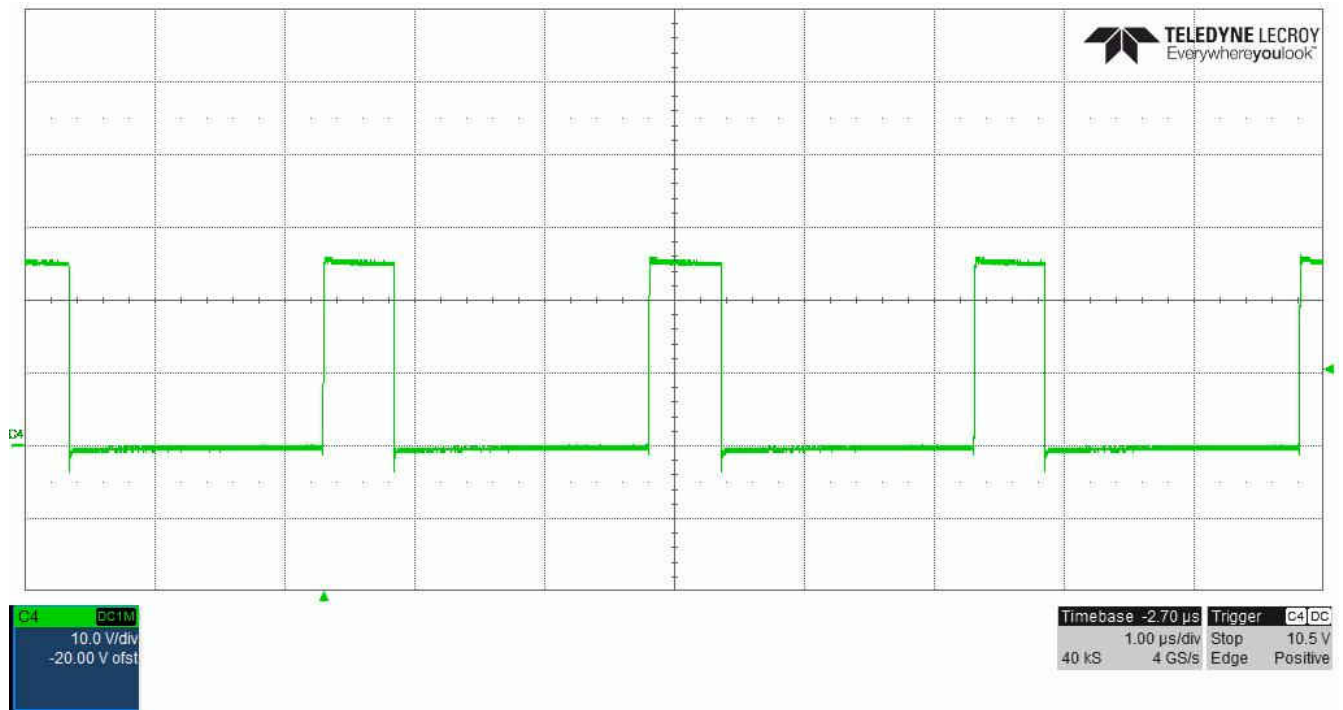


Figure 3-7. SW Pin - Buck (U6): 24-V Input, 1.63-A Output

3.2 Output Voltage Ripple

The waveforms in the following images were measured at C16 (flyback) and C30 (buck).

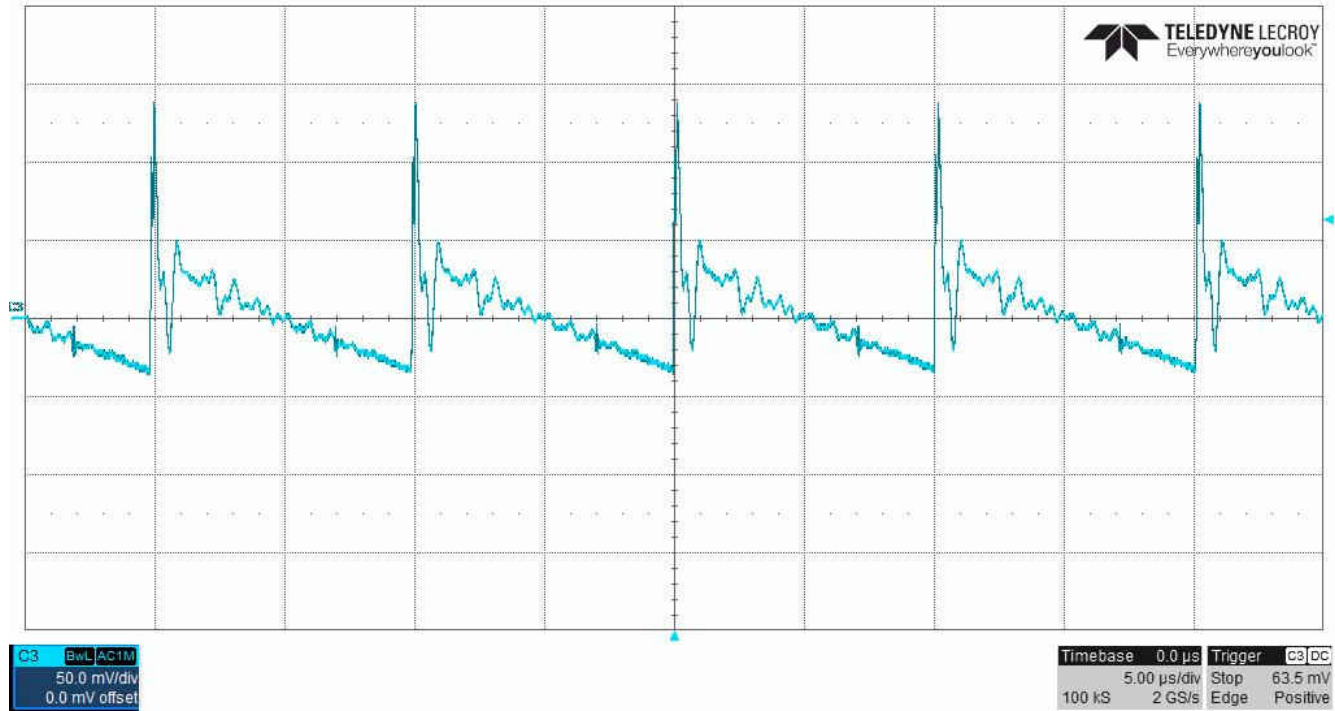


Figure 3-8. Flyback: 24-V Input, 1.2-A Output

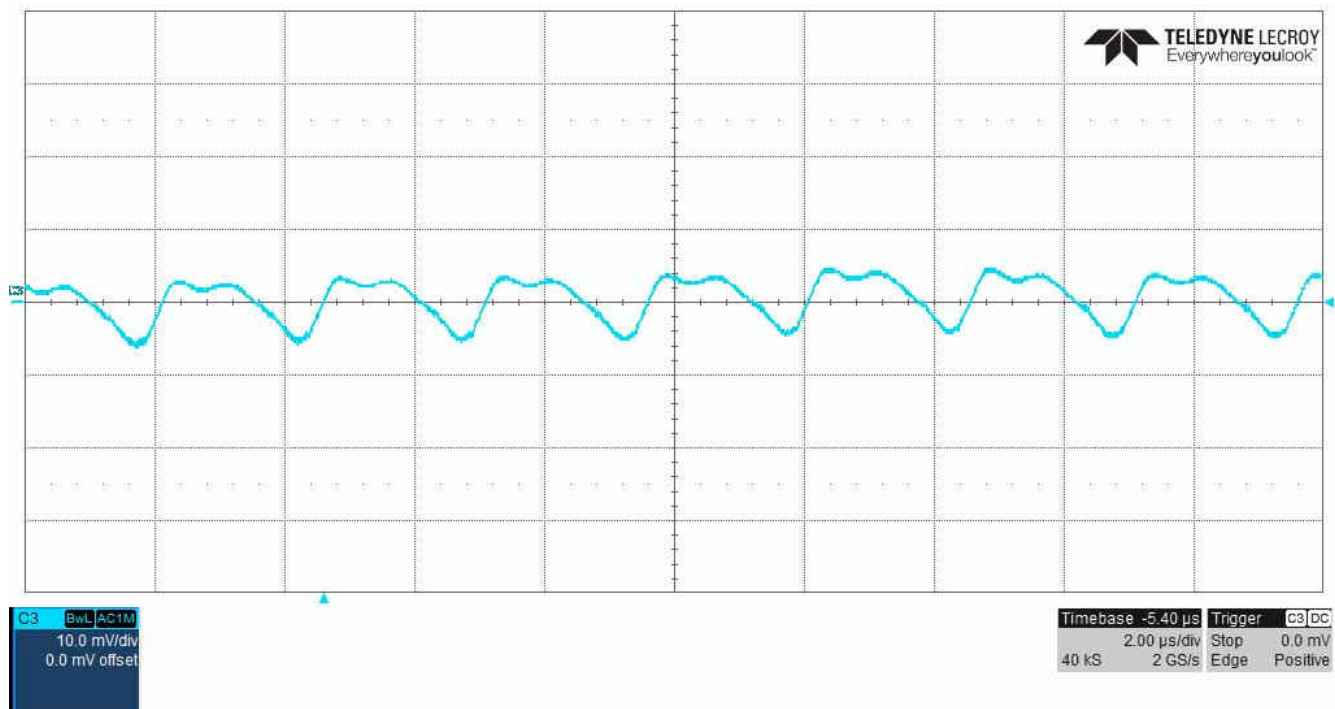
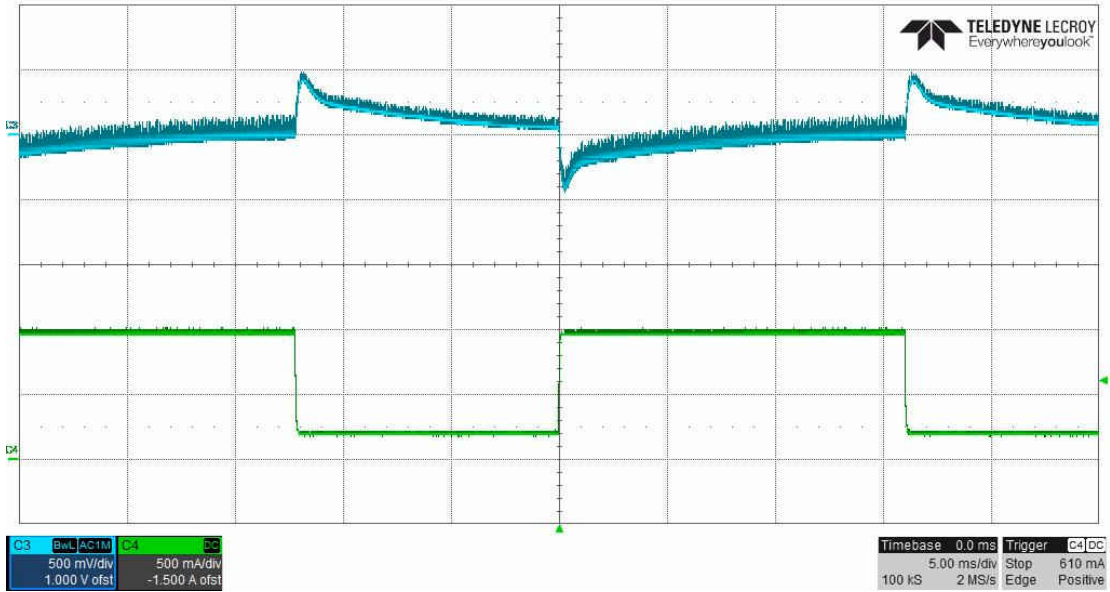


Figure 3-9. Buck: 24-V Input, 1.63-A Output

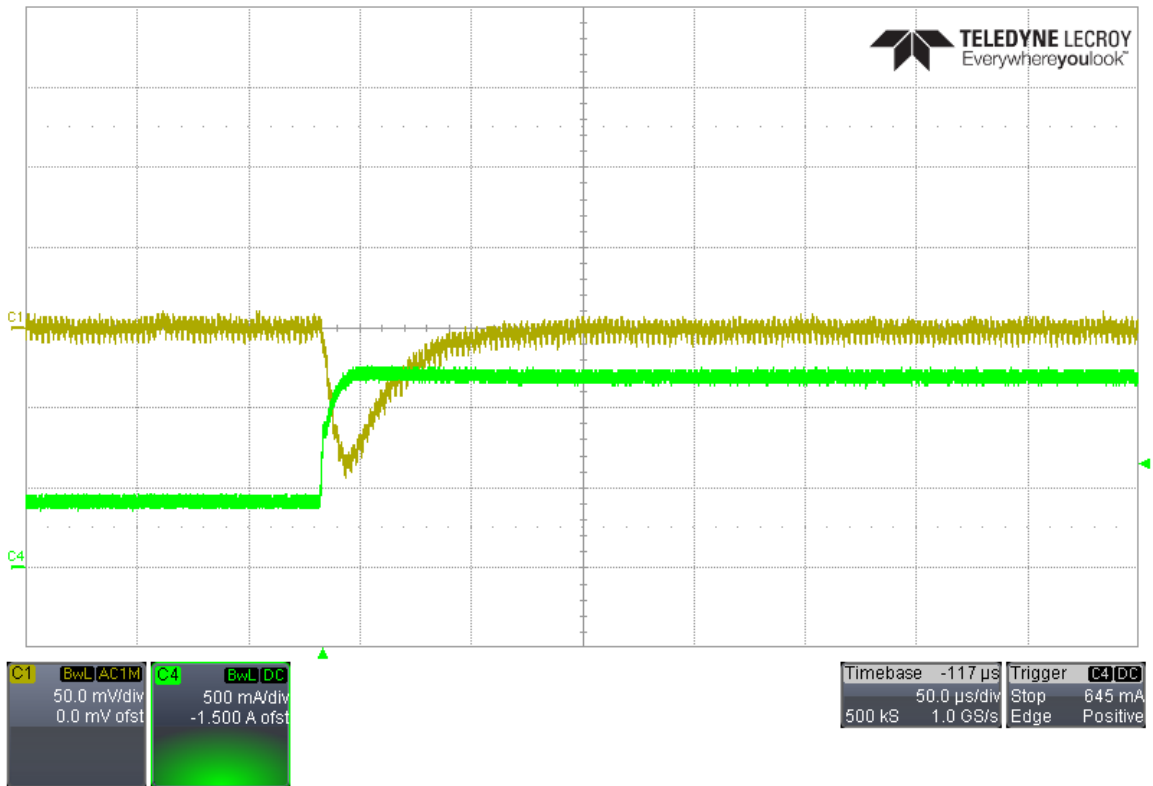
3.3 Load Transients

Voltage measured at C16 (flyback) and C30 (buck).



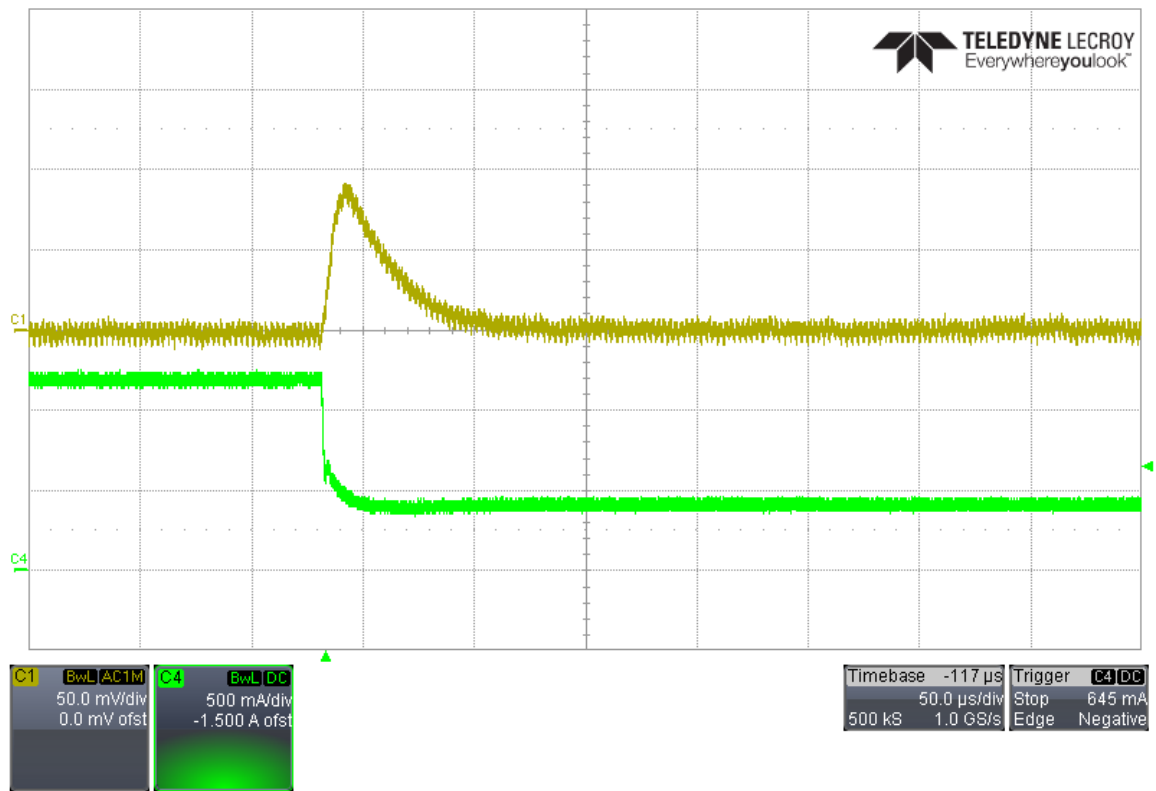
C3: V_{OUT}; C4: I_{OUT}

Figure 3-10. Flyback: 24-V Input, 0.2-A to 1-A Load Transient



C1: V_{OUT}; C4: I_{OUT}

Figure 3-11. Buck: 24-V Input, 0.4-A to 1.2-A Load Transient

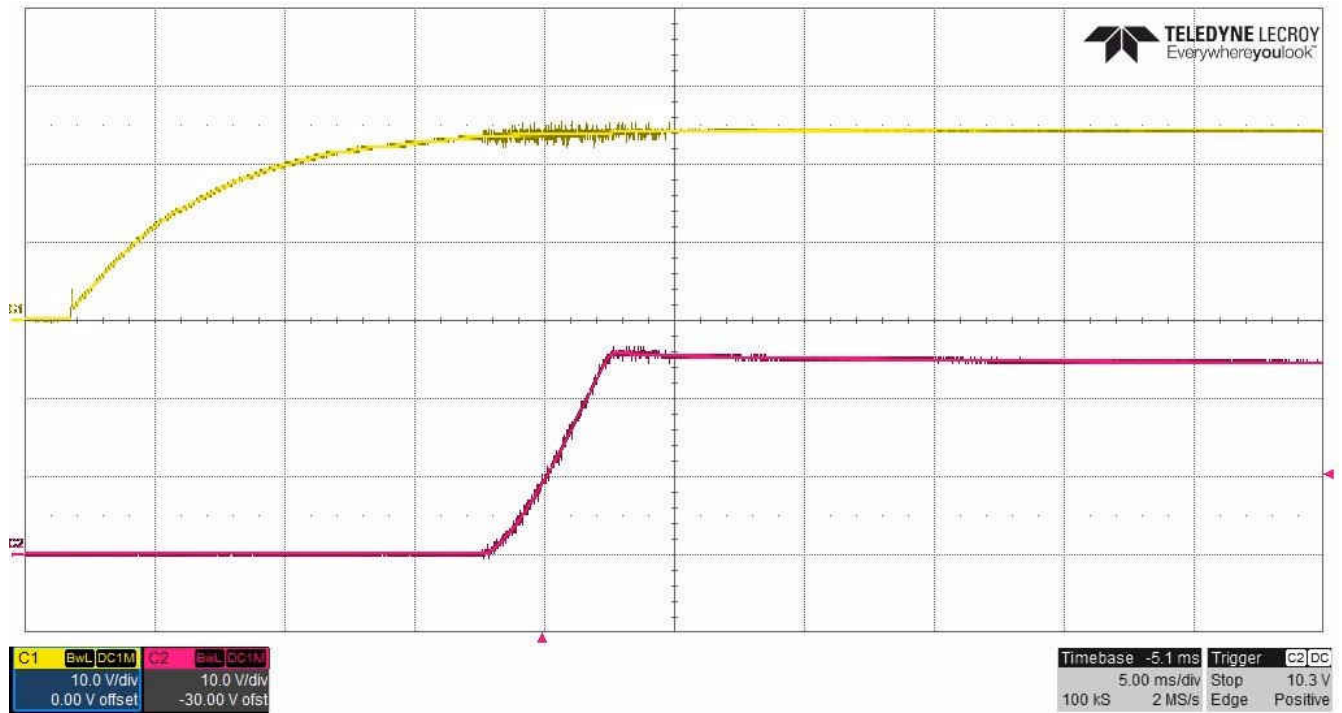


C1: Vout; C4: Iout

Figure 3-12. Buck: 24-V Input, 1.2-A to 0.4-A Load Transient

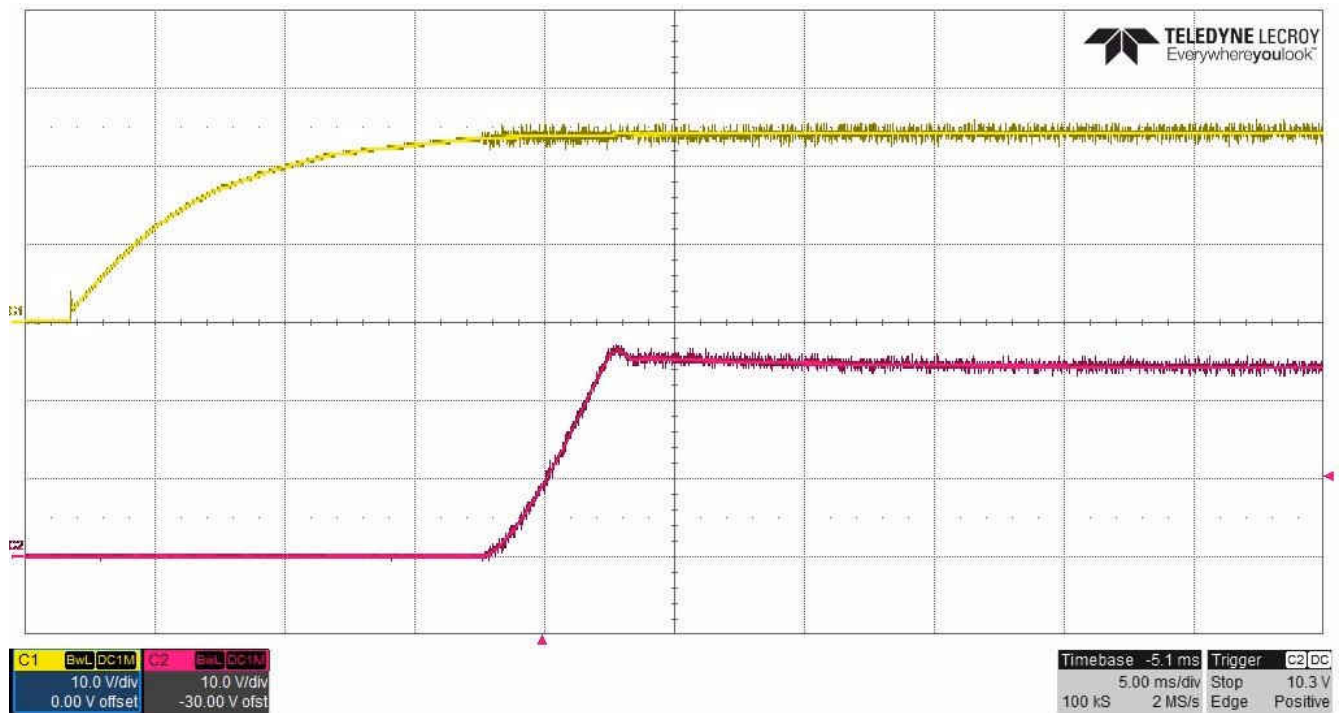
3.4 Start-Up Sequence

The following images show the start-up sequence waveforms.



C1 = V_{IN} ; C2 = 24 V (output)

Figure 3-13. Flyback: 24-V Input, No Load



C1 = V_{IN} ; C2 = 24 V (output)

Figure 3-14. Flyback: 24-V Input, Full Load

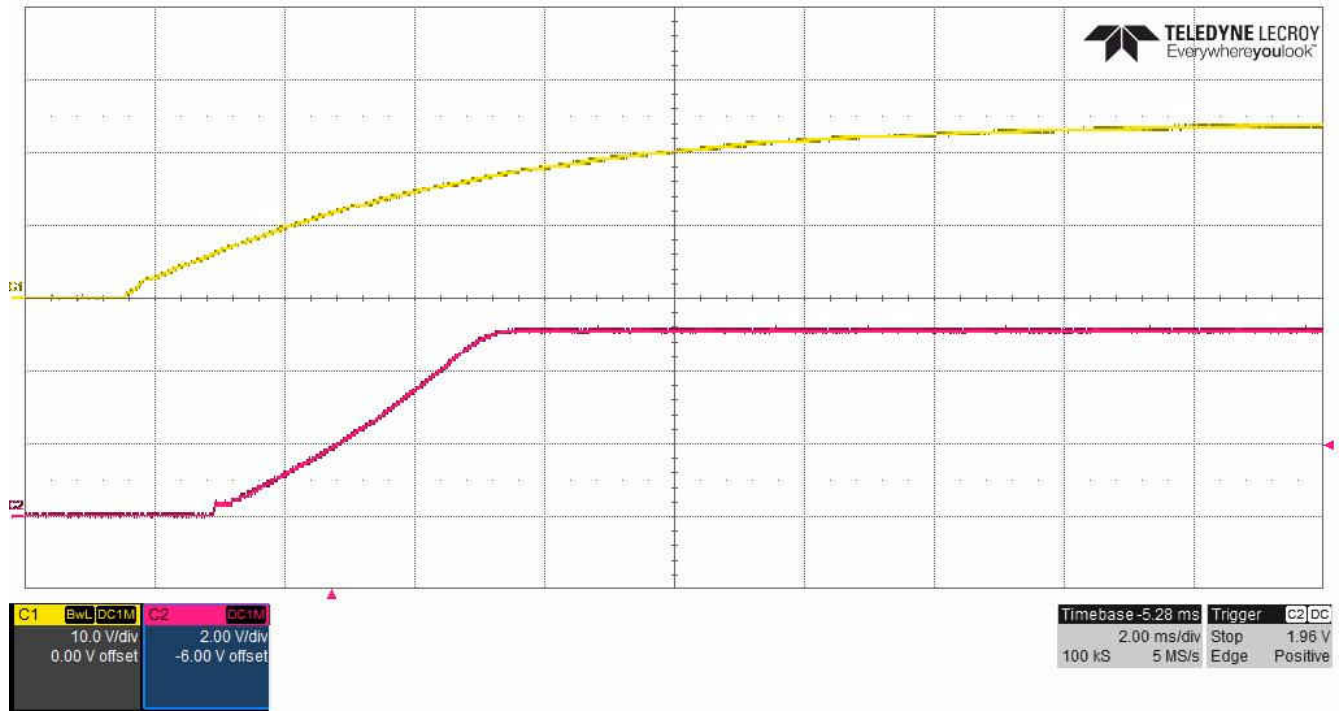


Figure 3-15. Buck: 24-V Input, No Load

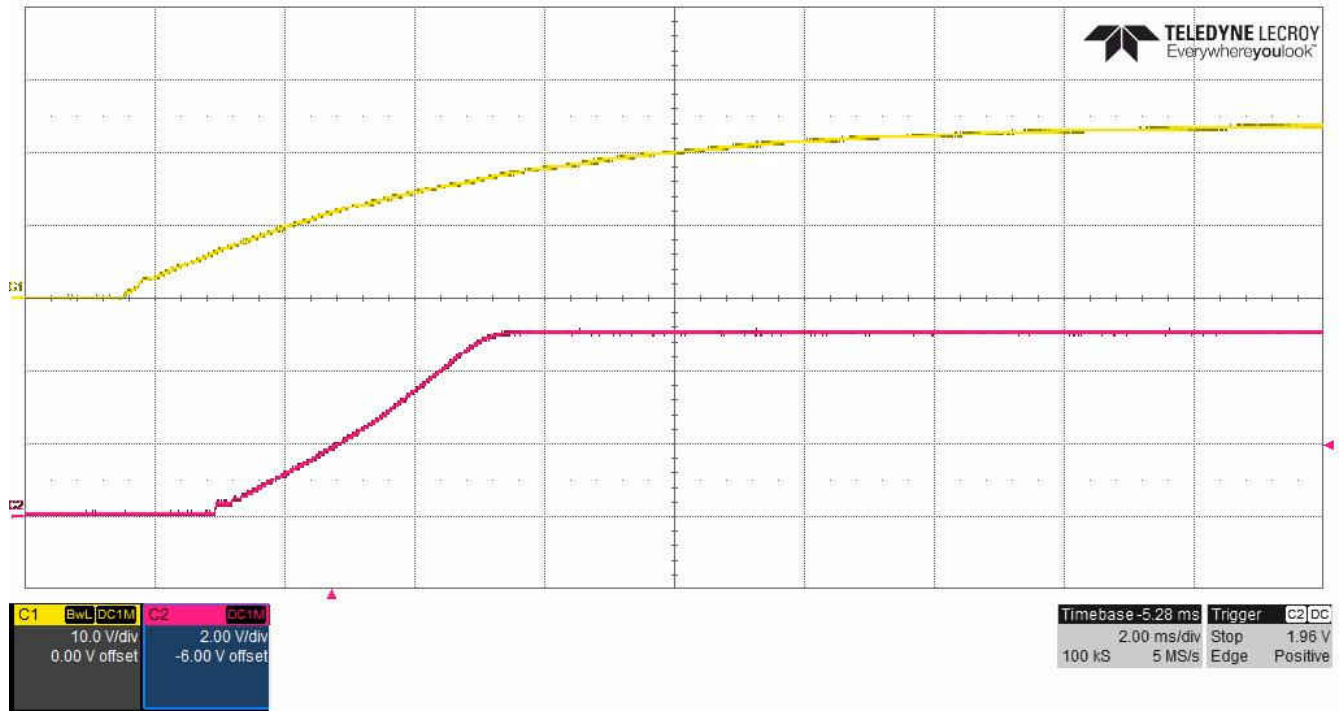


Figure 3-16. Buck: 24-V Input, Full Load

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