



Description

This reference design is a 25W isolated USB-C supply with 2× Means of Patient Protection (MOPP) isolation for portable medical devices and handheld test equipment applications. The USB-C PD sink-only controller TPS25730 provides complete power delivery (PD) negotiation with no firmware development required. Primary side regulation (PSR) flyback controller LM25185 reduces size, cost, and increases efficiency by eliminating the need for auxiliary winding. High full-load efficiency of 90.3% is achieved with the use of a synchronous rectifier controller UCC24612 paired with a synchronous rectifier MOSFET CSD18543Q3A. The design incorporates a planar transformer to achieve a low profile and high power-density.

Resources

PMP23653	Design Folder
LM25185	Product Folder
TPS25730	Product Folder
UCC24612	Product Folder

Features

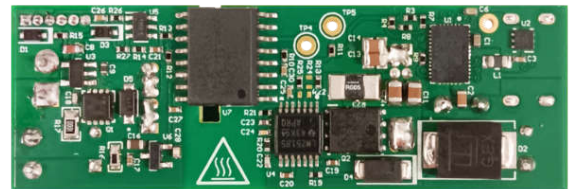
- USB-C PD sink only support (5V, 9V)
- Small form-factor (60 × 20 × 20 mm)
- 2×MOPP isolation
- Primary side control with tight load regulation
- Synchronous rectifier for high efficiency (90.3%)
- Short-circuit, over-power, and short-to-VBUS protection

Applications

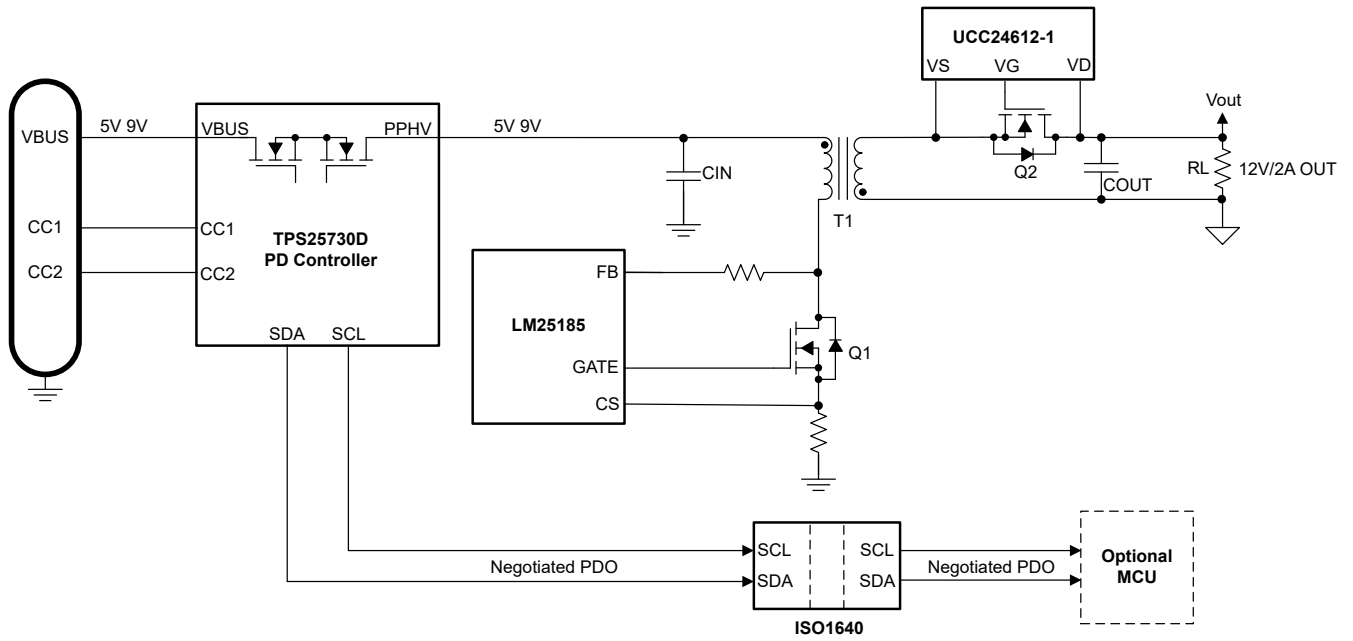
- [Infusion pump](#)
- [Oscilloscopes and digitizers](#)
- [Portable field instrumentation](#)
- [Digital multimeter \(DMM\)](#)



Top of Board



Bottom of Board



Block Diagram

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

Parameter	Specifications
Input voltage range	5VDC to 9VDC
Output voltage	12V
Maximum input current	3A
Maximum output power	25W
Switching frequency	200kHz
Topology	PSR flyback
Efficiency	90.3% at full load

1.2 Required Equipment

- DC source
- USB-C PD source capable of 5V/3A, 9V/3A
- DC Electronic load
- Oscilloscope
- Infrared thermal camera
- Digital multimeter

External Power Supply or Power Accessory Requirements:


- Nom Output Voltage: 5VDC or 9VDC
- Max Output Current: >3000mA
- Efficiency Level V

Note

TI recommends using an external power supply or power accessory which complies with applicable regional safety standards such as (by example) UL, CSA, VDE, CCC, PSE, and so on.

1.3 Considerations

All measurements were taken at approximately 23°C ambient temperature.

 WARNING	Caution Hot surface. Contact may cause burns. Do not touch.
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1.4 Dimensions

60mm × 20mm × 20mm (Open frame)

1.5 Test Setup

When using a USB-C supply, connect the USB-C cable to J1 (USB-C receptable). When using a benchtop DC supply, connect the positive terminal to TP2 (PPHV) and negative terminal to TP3 (GND). The efficiency was tested using a benchtop DC supply. When testing efficiency, add external bulk capacitance close to VIN to avoid ringing effect due to long wires. For this test, 2 × 470µF 35V aluminum electrolytic capacitors were placed in parallel.

Using a USB-C supply:

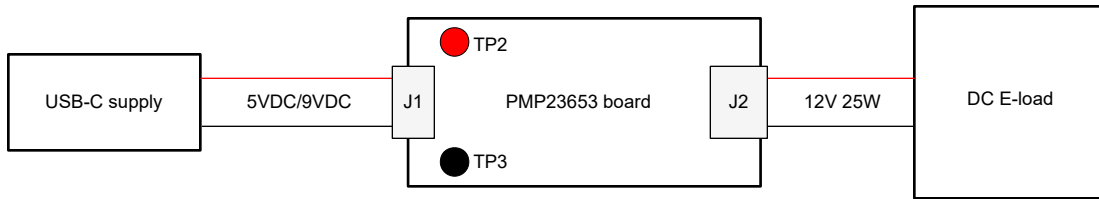


Figure 1-1. Test Setup USB-C Supply

Using a DC supply:

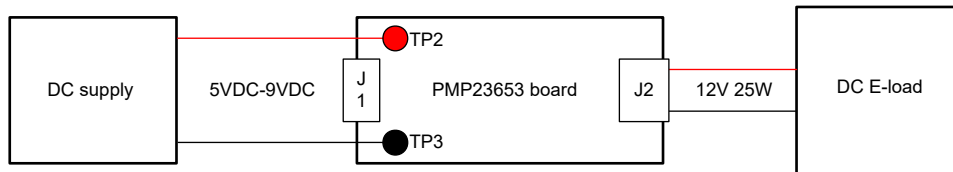


Figure 1-2. Test Setup DC Supply

2 Testing and Results

2.1 Efficiency Graphs

Efficiency is shown in [Figure 2-1](#).

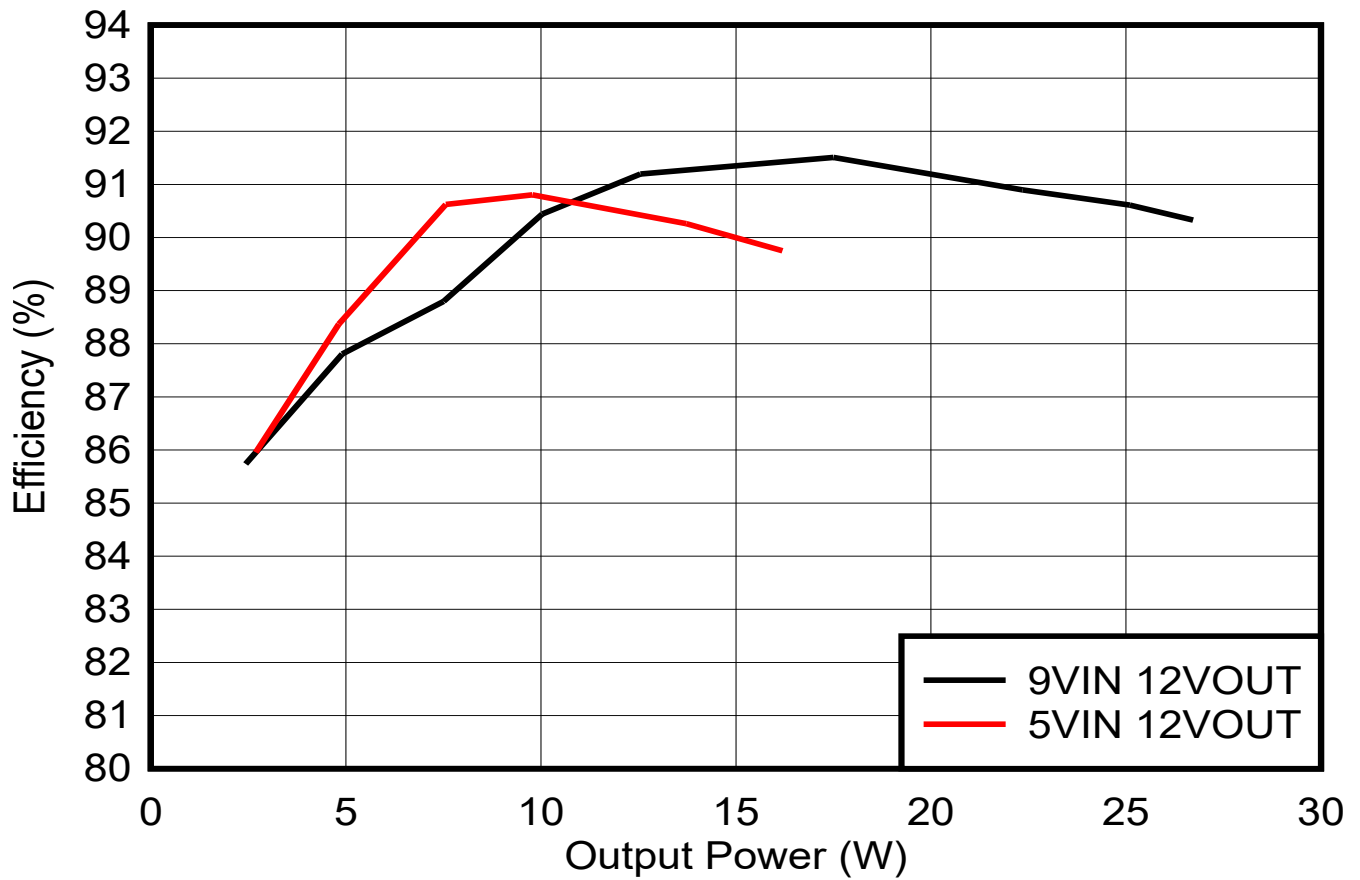


Figure 2-1. Efficiency

2.2 Efficiency Data

Efficiency data is shown in [Table 2-1](#).

Table 2-1. 1 Efficiency Data for 9VIN

V _{IN} (V)	I _{IN} (A)	V _{OUT} (V)	I _{OUT} (A)	P _{IN} (W)	P _{OUT} (W)	P _{Loss} (W)	Efficiency (%)
9.003	0.315	12.224	0.199	2.836	2.431	0.404	85.74
9.001	0.621	12.325	0.398	5.587	4.905	0.681	87.81
9.080	0.931	12.326	0.609	8.453	7.507	0.947	88.80
9.075	1.223	12.404	0.809	11.094	10.034	1.061	90.44
9.007	1.528	12.463	1.007	13.762	12.550	1.211	91.20
9.001	2.125	12.470	1.404	19.127	17.503	1.624	91.51
9.006	2.730	12.471	1.792	24.586	22.348	2.238	90.90
9.010	3.074	12.464	2.014	27.697	25.096	2.600	90.61
9.004	3.285	12.475	2.142	29.578	26.718	2.860	90.33

Table 2-2. 2 Efficiency Data for 5VIN

V _{IN} (V)	I _{IN} (A)	V _{OUT} (V)	I _{OUT} (A)	P _{IN} (W)	P _{OUT} (W)	P _{Loss} (W)	Efficiency (%)
5.012	0.625	12.391	0.217	3.133	2.693	0.440	85.96
5.002	1.091	12.372	0.390	5.459	4.824	0.635	88.37
5.008	1.667	12.467	0.607	8.346	7.563	0.783	90.62
5.009	2.151	12.460	0.785	10.776	9.785	0.991	90.80
5.010	3.036	12.449	1.103	15.209	13.728	1.481	90.26
5.001	3.608	12.453	1.300	18.044	16.194	1.850	89.75

2.3 Thermal Images

Thermal image is captured in approximately 23°C ambient temperature after running for 20 minutes.

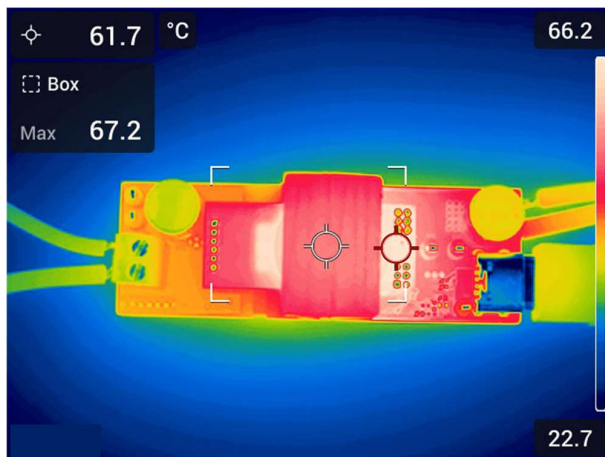


Figure 2-2. Top Thermal Image, 9VIN, 12VOUT, 26W Output Power

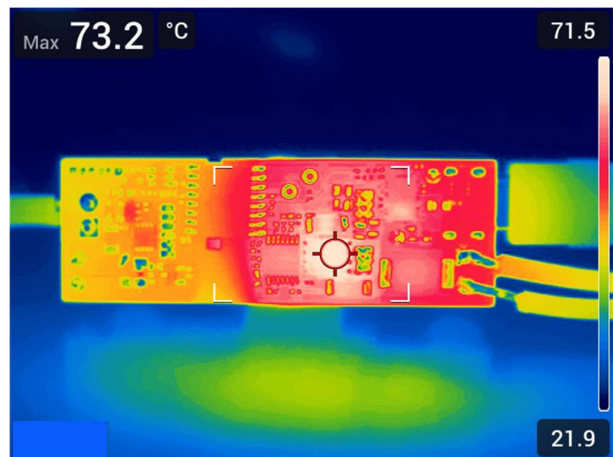


Figure 2-3. Bottom Thermal Image, 9VIN, 12VOUT, 26W Output Power

3 Waveforms

3.1 Switching

Primary and secondary side FETs switching behavior is shown in [Figure 3-1](#) and [Figure 3-2](#).

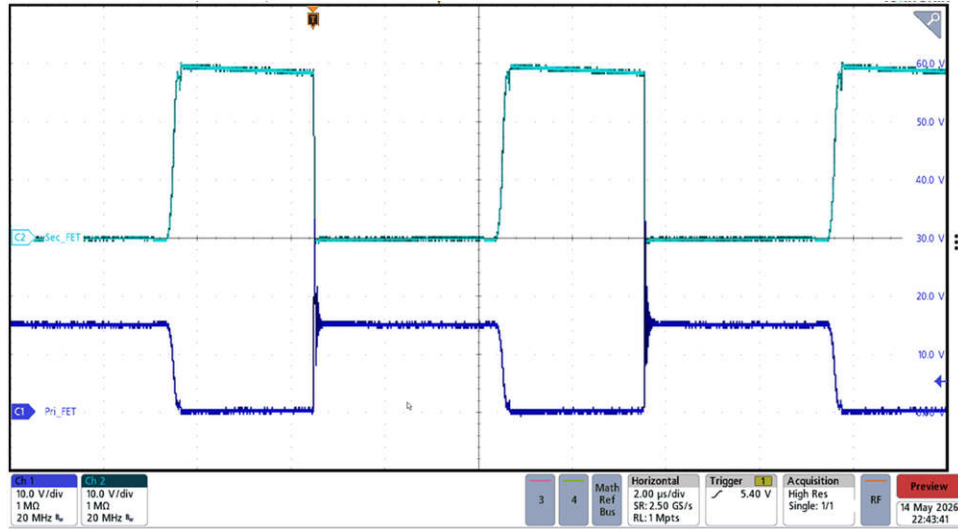


Figure 3-1. Primary and Secondary Side FET switching; 9VIN, 12VOUT, 2A Load

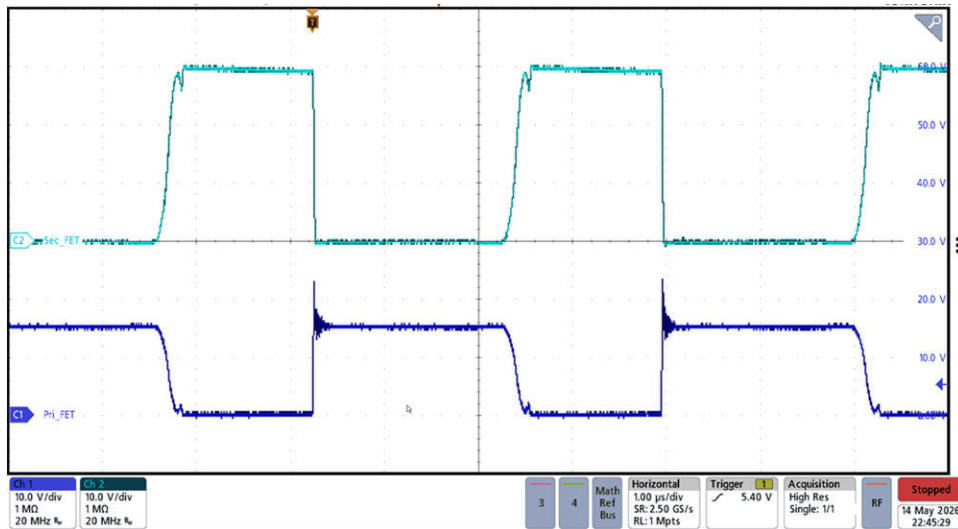


Figure 3-2. Primary and Secondary Side FET switching; 9VIN, 12VOUT, 1A Load

3.2 Output Voltage Ripple

Output voltage ripple is shown in Figure 3-3 through Figure 3-5.

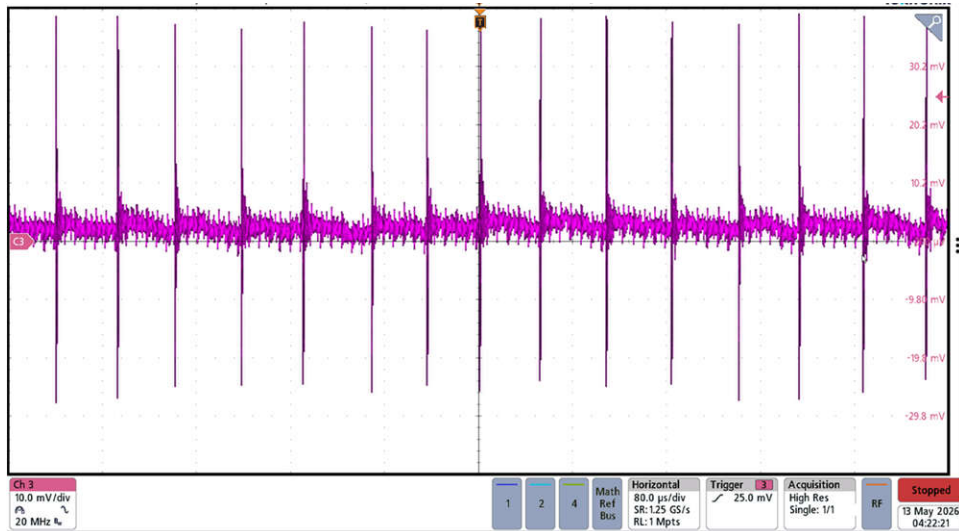


Figure 3-3. Output Voltage Ripple; 9VIN, 12VOUT, No Load

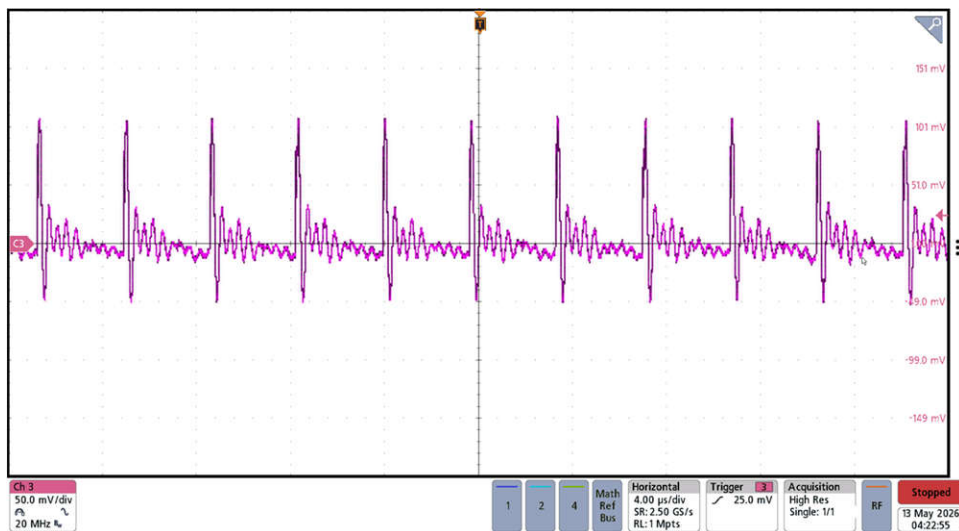


Figure 3-4. Output Voltage Ripple; 9VIN, 12VOUT, 1A Load

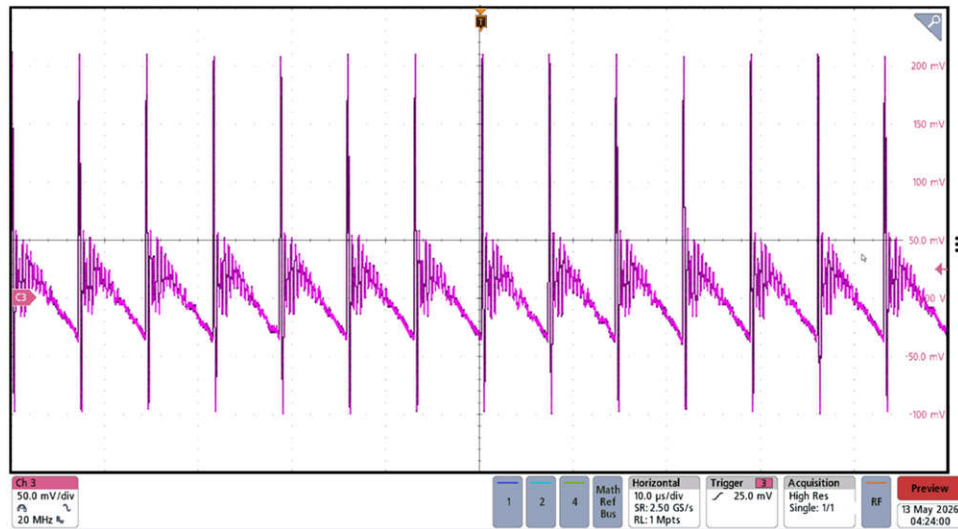


Figure 3-5. Output Voltage Ripple; 9VIN, 12VOUT, 2A Load

3.3 Short-Circuit and Over-Power Protection

Short-circuit protection is shown in [Figure 3-6](#). Converter is running at full load and output is shorted. Output drops to zero and converter attempts to restart indefinitely.

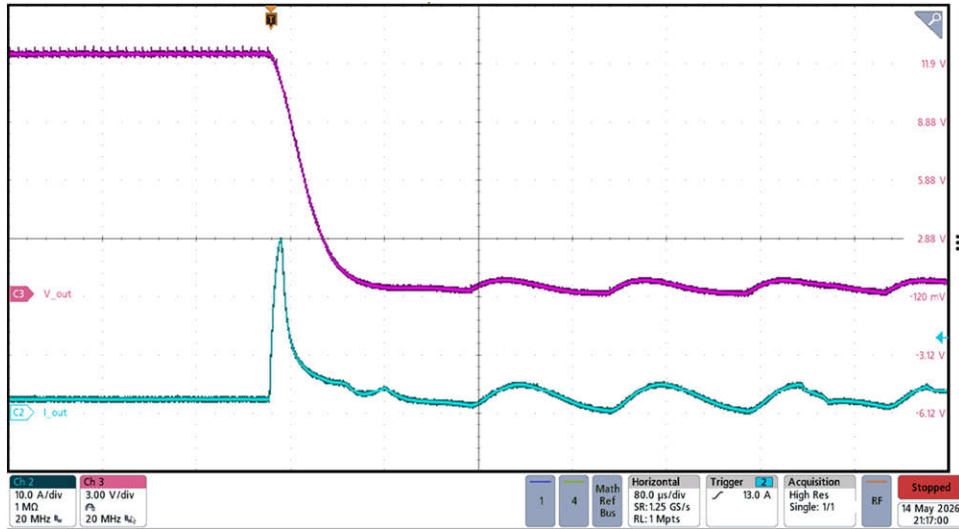


Figure 3-6. Short-Circuit Protection

Over-power protection is shown in [Figure 3-7](#). The output load is stepped from 1.5A to 3A and the converter reduces the output voltage to prevent excess power draw.

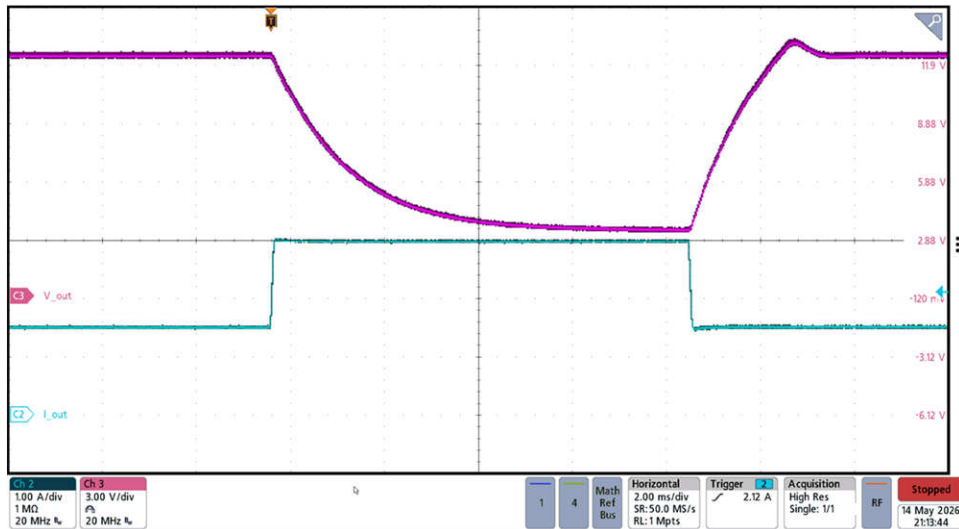


Figure 3-7. Over-Power Protection

3.4 Load Transients

Load transient response is shown in [Figure 3-8](#).

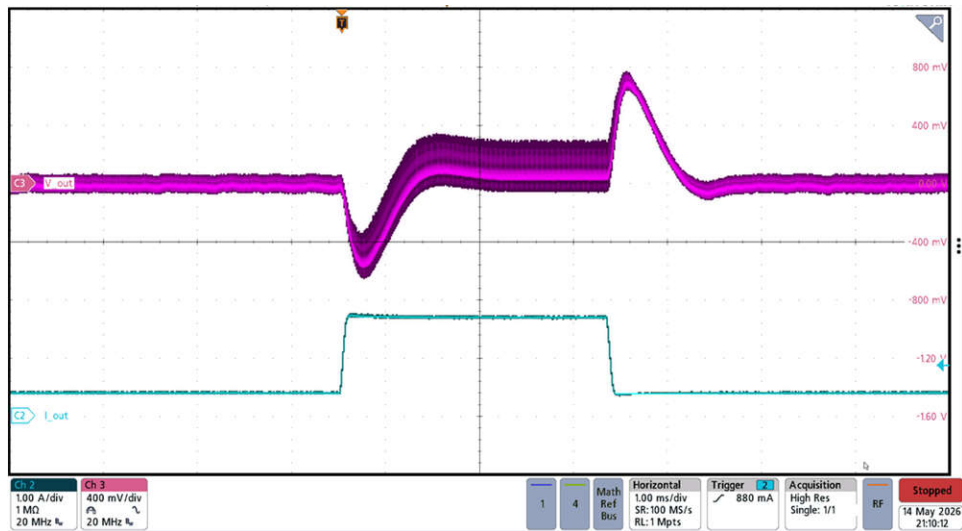


Figure 3-8. 9VIN, 12VOUT, Output Current Stepped From 0.4A to 1.7A

3.5 Start-up Sequence

Start-up behavior is shown in [Figure 3-9](#) and [Figure 3-10](#).

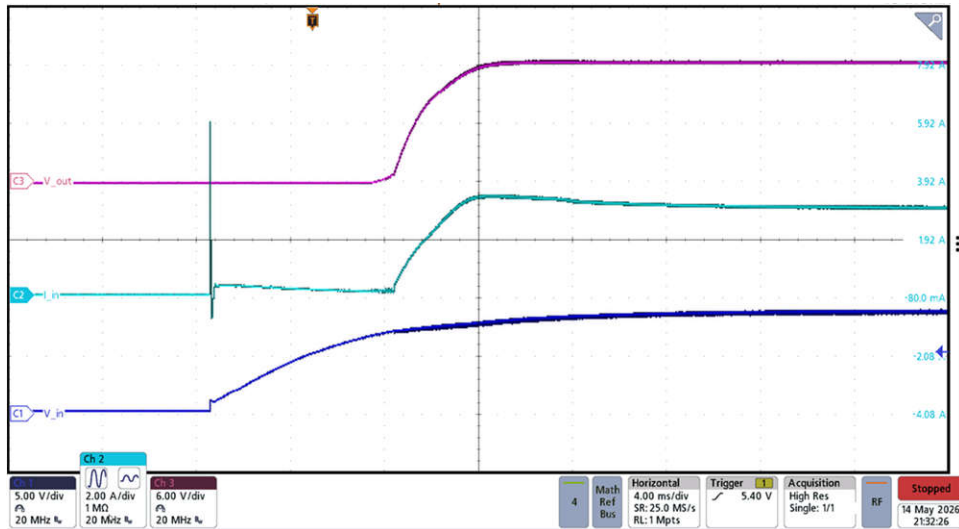


Figure 3-9. Startup Waveforms; 9VIN, 12V_{out}, 6.2Ω Load

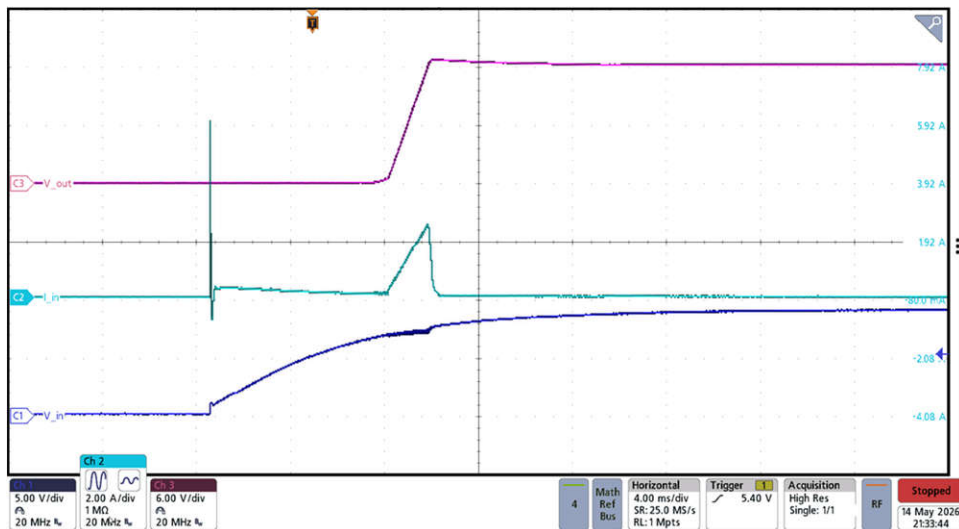


Figure 3-10. Startup Waveforms; 9VIN, 12V_{out}, 6.2Ω Load

3.6 Load Regulation

Load regulation is shown in [Figure 3-11](#).

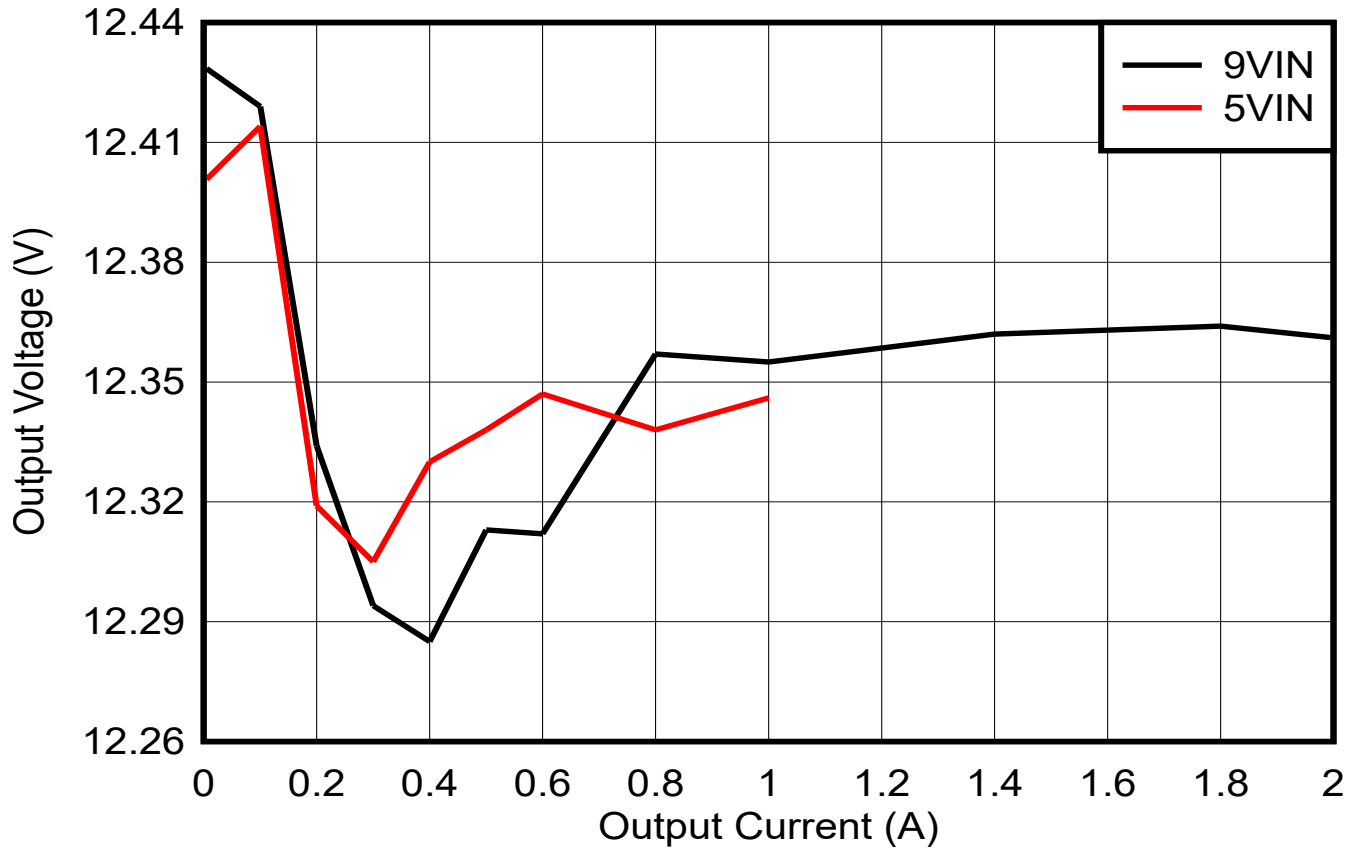


Figure 3-11. Load Regulation; 9VIN, 12VOUT

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