Test Report: PMP23365

Class 8 PoE PD Reference Design (24V, 3A) with External Hotswap and Telemetry

Description

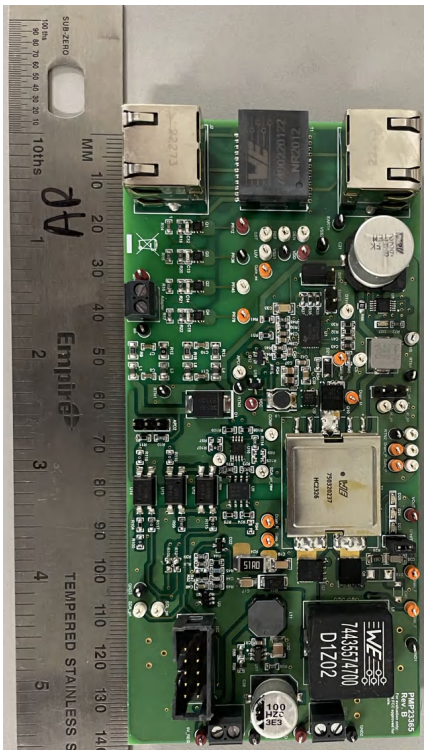
This reference design implements a Power-over-Ethernet (PoE) power device (PD) active-clamp forward converter with 24V and 3A output. A TPS23730 PD with integrated pulse-width modulator (PWM) controller provides all the necessary functions to implement the PoE PD control and the PWM control for the active-clamp forward converter. This design uses secondary-side regulation (SSR) with an optocoupler feedback. An external hot swap is added to enable Class-7,8 PD applications. INA237 is used on the primary side to monitor the DC/DC input voltage and current, and the power information is sent to the secondary side by either I2C isolator or optocoupler-based circuits.

Features

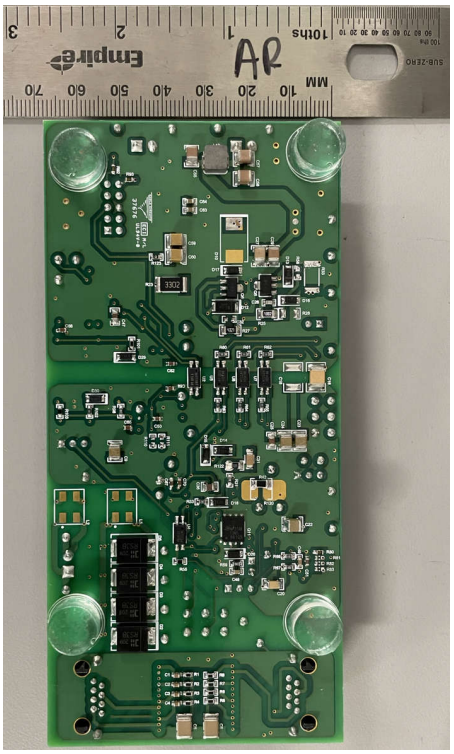
- IEEE802.3bt Type 3 compliant PoE PD
- Integrated PWM controller for flyback or active clamp forward configuration
- Frequency dithering for EMI reduction
- Soft-start control with advanced start-up and hiccup mode overload protection
- Soft-stop shutdown
- Optional adapter input

Applications

- IP network camera
- WLAN, Wi-Fi® access point
- Barcode reader



Top of Board



Bottom of Board

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

Parameter	Specifications
Input voltage	37V–57V (48V nominal)
Output voltage	24V
Output current	3A
Nominal switching frequency	250kHz

1.2 Required Equipment

- Type 4 PoE Power Source Equipment (PSE)
- Isolated DC power source, 0V to 57V, 2.5A minimum
- 24V, 3A electronic load

1.3 Considerations

All measurements were taken under the following conditions:

- Approximately 25°C ambient
- 48V input and 3A load unless noted
- Using CAT5E 1ft Ethernet cable

2 Testing and Results

2.1 Efficiency Graphs

Efficiency is shown in the following figure.

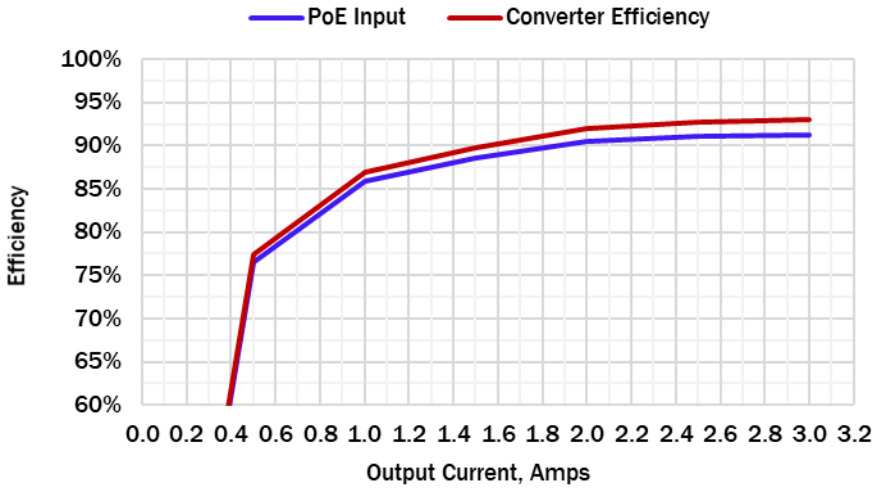


Figure 2-1. Efficiency Graph

2.2 Load Voltage Regulation

Load voltage regulation is shown in the following graph.

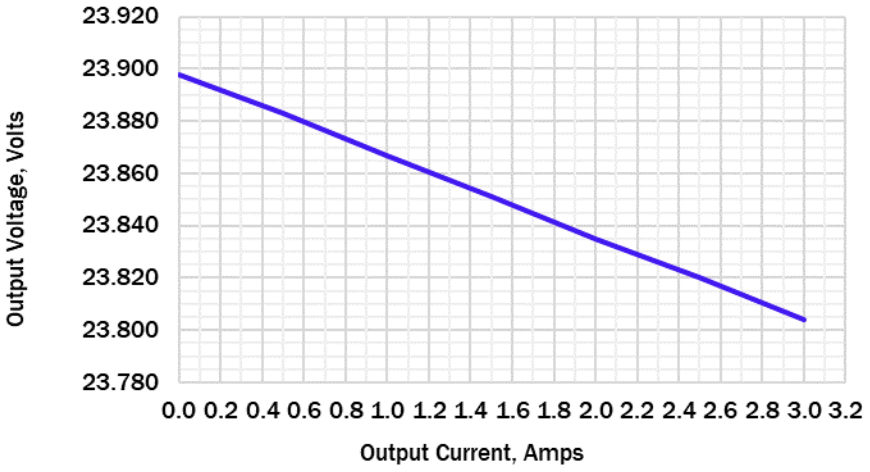


Figure 2-2. Load Voltage Regulation Curve

2.3 Efficiency Data

Efficiency and power telemetry data is shown in the following tables.

Table 2-1. Efficiency Data

POE Input Voltage (V)	PoE Input Current (A)	DC/DC Input Voltage (V)	Output Voltage (V)	Output Current (A)	PoE Efficiency	DC/DC Efficiency
48	0.078	47.630	23.898	0.000	0.0%	0.0%
48	0.325	47.500	23.883	0.500	76.5%	77.4%
48	0.579	47.444	23.867	1.000	85.9%	86.9%
48	0.842	47.318	23.851	1.500	88.5%	89.8%
48	1.098	47.228	23.835	2.000	90.4%	91.9%
48	1.362	47.180	23.820	2.500	91.1%	92.7%
48	1.630	47.113	23.804	3.000	91.3%	93.0%

Table 2-2. Telemetry Table

Output Current (A)	DC/DC Input Voltage by Telemetry (Hex)	DC/DC Input Voltage by Telemetry (V)	Shunt Voltage by Telemetry (Hex)	Current by Telemetry (A)	Telemetry Compares to Measured Input Current	Telemetry Compares to Measured DC/DC Input Voltage
0.000	3B92	47.66	0096	0.075	-3.85%	+0.06%
0.500	3B96	47.67	0290	0.328	+0.92%	+0.36%
1.000	3B56	47.47	0495	0.587	+1.30%	+0.05%
1.500	3B2E	47.34	06A4	0.850	+0.95%	+0.05%
2.000	3B10	47.25	08B8	1.116	+1.64%	+0.05%
2.500	3B00	47.20	0AD9	1.389	+1.95%	+0.04%
3.000	3AE9	47.13	0CF6	1.659	+1.78%	+0.03%

2.4 Thermal Images

Thermal images are shown in the following figures.

Measurements		
Bx1	Max	71.1 °C
Sp1		67.5 °C
Sp2		70.3 °C
Sp3		63.6 °C
Sp4		62.3 °C
Sp5		56.8 °C
Sp6		63.5 °C

Parameters	
Emissivity	0.95
Refl. temp.	20 °C

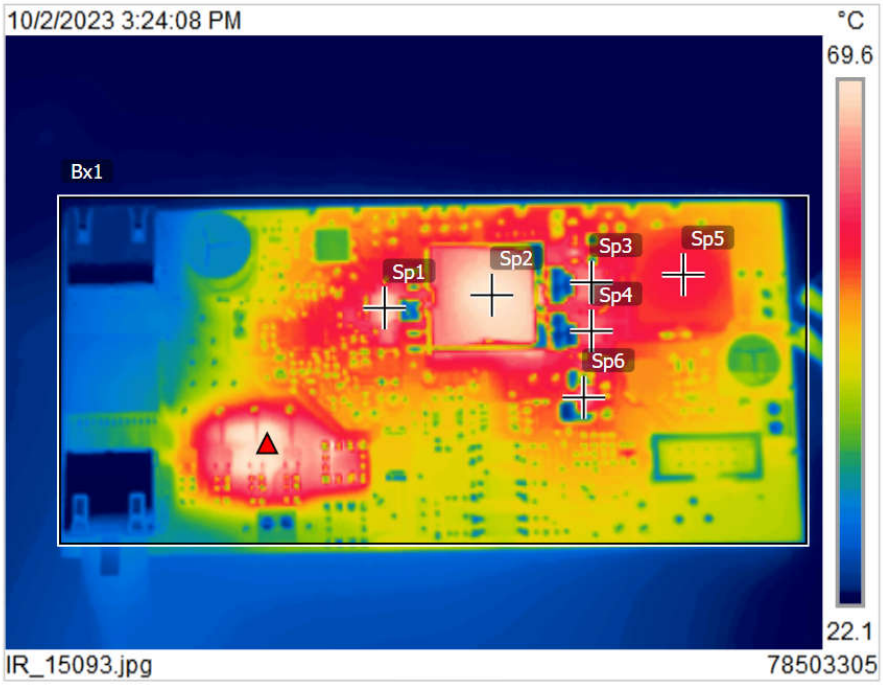


Figure 2-3. Top Thermal Image, 48V Input, 3A Load

Measurements		
Bx1	Max	77.6 °C
Sp1		73.6 °C
Sp2		70.9 °C
Sp3		73.8 °C
Sp4		57.0 °C
Sp5		58.6 °C

Parameters	
Emissivity	0.95
Refl. temp.	20 °C

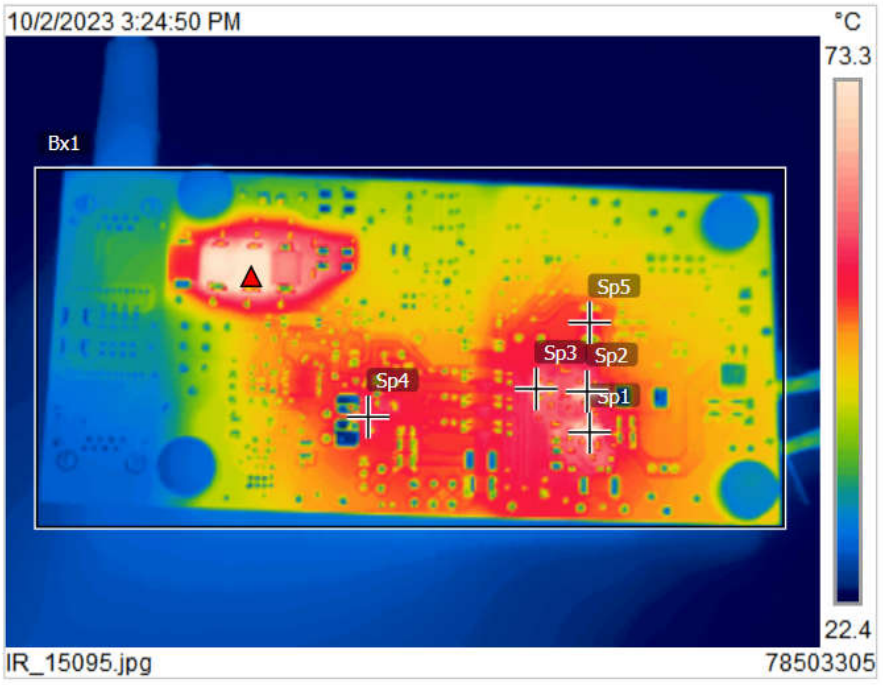


Figure 2-4. Bottom Thermal Image, 48V Input, 3A Load

2.5 Bode Plots

Bode plots are shown in the following figures.

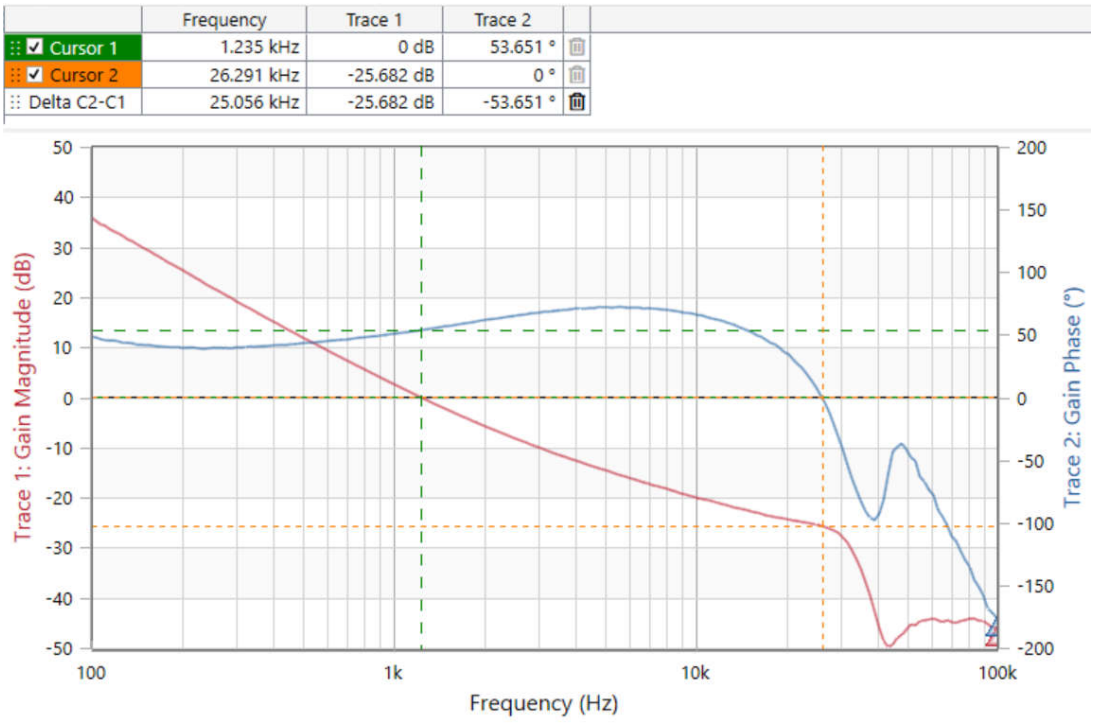


Figure 2-5. 0A Load Bandwidth = 1.235kHz, Phase Margin = 53.651Degrees, Gain Margin = 25.682dB

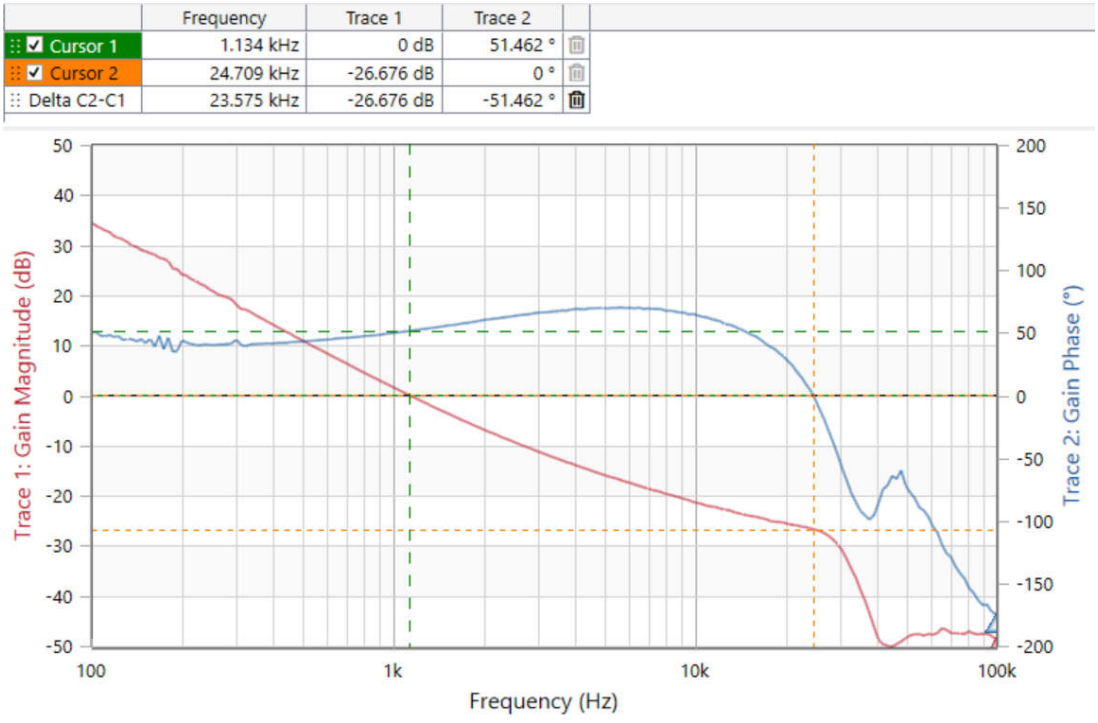


Figure 2-6. 3A Load Bandwidth = 1.134kHz, Phase Margin = 51.462Degrees, Gain Margin = 26.676dB

3 Waveforms

3.1 Switching

Switching behavior is shown in the following figures.

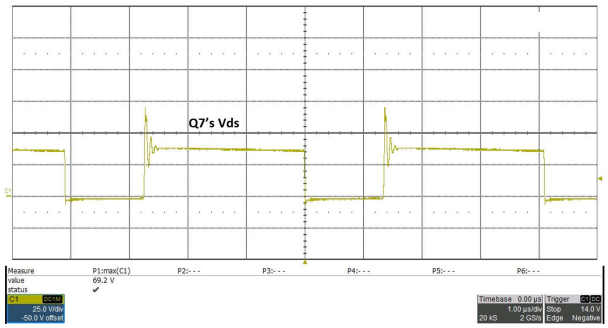


Figure 3-1. Voltage Drain-to-Source, Q7, 37V Input, 3A Load, Measured 69.2V V_{peak}

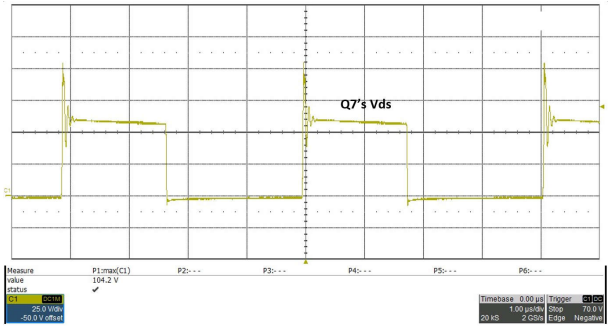


Figure 3-2. Voltage Drain-to-Source, Q7, 57V Input, 3A Load, Measured 104.2V V_{peak}

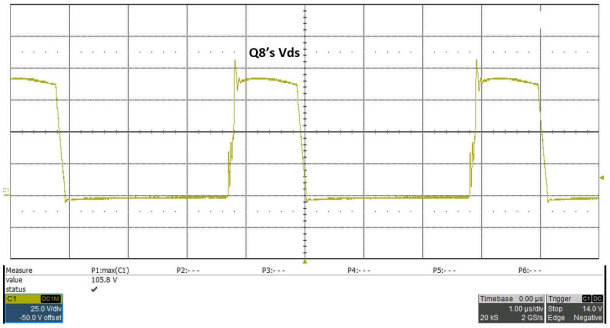


Figure 3-3. Voltage Drain-to-Source, Q8, 37V Input, 3A Load, Measured 105.8V V_{peak}

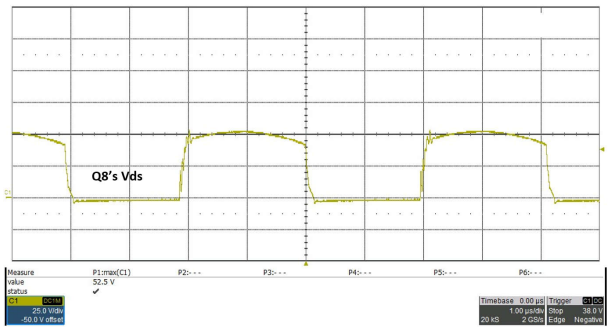


Figure 3-4. Voltage Drain-to-Source, Q8, 57V Input, 3A Load, Measured 52.5V V_{peak}

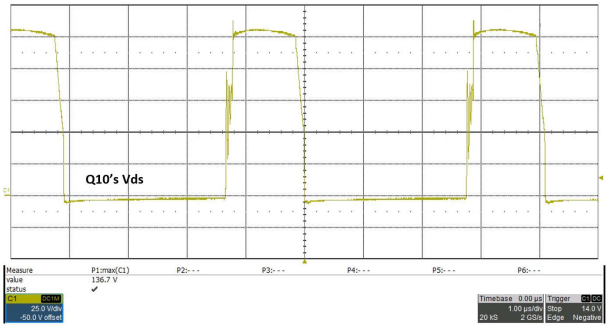


Figure 3-5. Voltage Drain-to-Source, Q10, 37V Input, 3A Load, Measured 136.7V V_{peak}

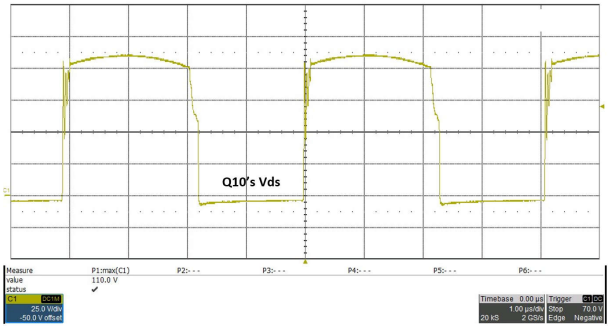


Figure 3-6. Voltage Drain-to-Source, Q10, 57V Input, 3A Load, Measured 110.0V V_{peak}

3.2 Voltage Ripple

Voltage ripple is shown in the following figures.

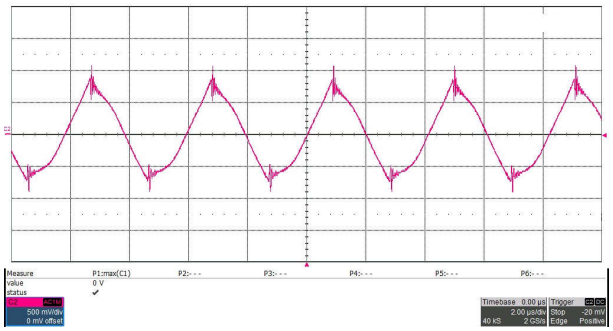


Figure 3-7. DC/DC Converter Input Voltage Ripple

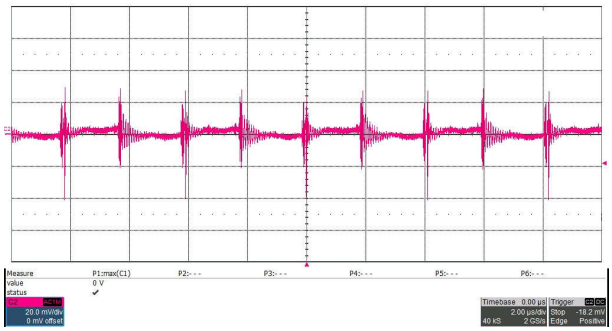


Figure 3-8. Output Voltage Ripple

3.3 Load Transients

Load transient response is shown in the following figures.

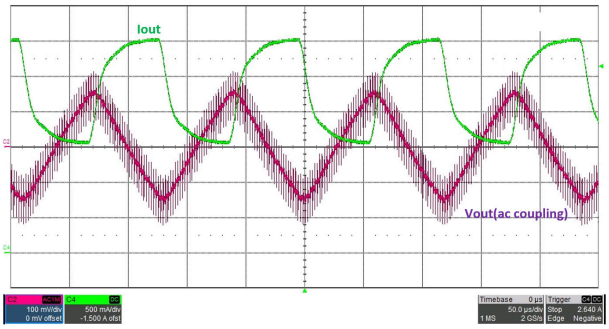


Figure 3-9. Output Load Step Response, 1.5A to 3.0A Load Step

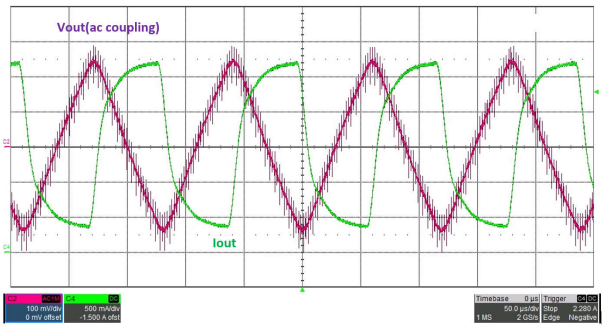


Figure 3-10. Output Load Step Response, 0.3A to 2.7A Load Step

3.4 Start-Up Sequence

Start-up behavior is shown in the following figures.

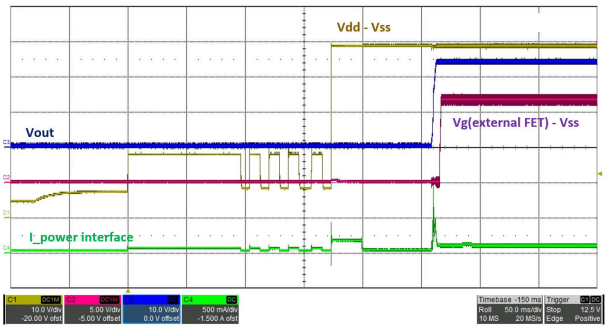


Figure 3-11. 0A Load

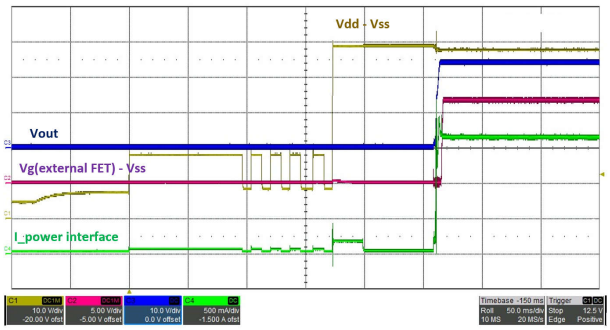


Figure 3-12. 3A Load

3.5 Power-Down Sequence

Power-down behavior is shown in the following figures.

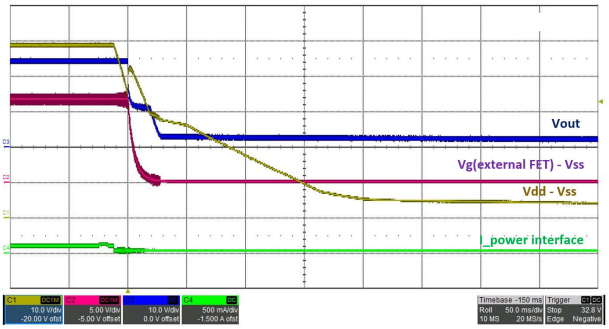


Figure 3-13. 0A Load

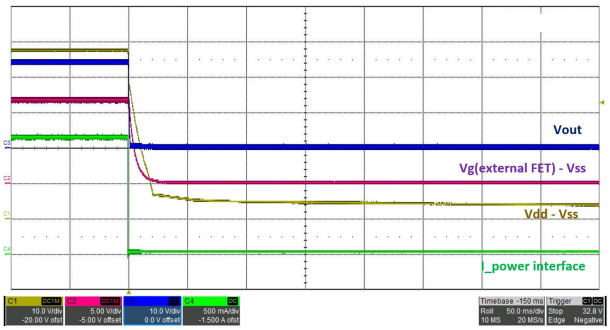


Figure 3-14. 3A Load

3.6 PoE-to-Adapter Transient

PoE-to-adapter transient behavior is shown in the following figures.

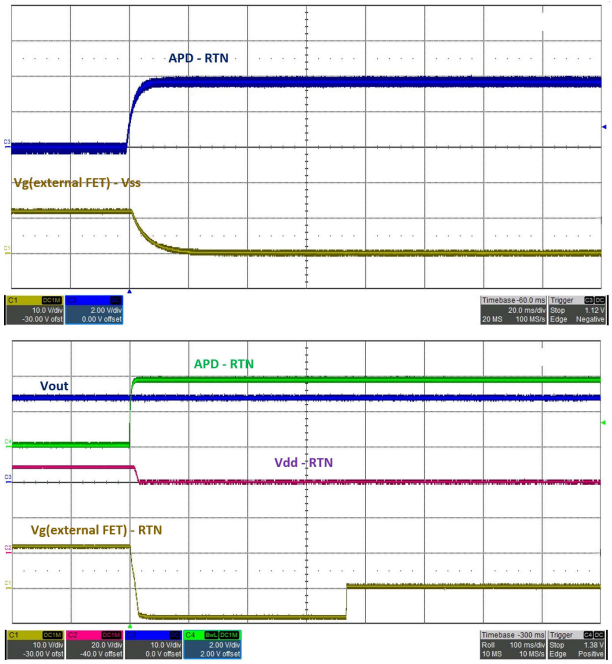


Figure 3-15. PSE Voltage = 48V, Adapter Voltage = 40V, Load = 3A

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