

FEB212-001 User Guide FSFR2100 Evaluation Board Test Report Application for LCD TV Power Supply

Featured Fairchild Products: FSFR2100

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1. Featured Fairchild Products

1.1. FSFR2100

FSFR2100 is an integrated Pulse-Frequency-Modulation (PFM) controller and MOSFETs especially designed for Zero-Voltage-Switching (ZVS) resonant half-bridge converter topologies.

- Variable frequency control with 50% duty cycle for half-bridge resonant converter topology
- High efficiency through zero voltage switching (ZVS)
- Internal SuperFETs with fast recovery type body diode ($t_{tr}=120ns$)
- Fixed dead time (350ns)
- Up to 300kHz operating frequency
- Pulse skipping for frequency limit (programmable) at light-load condition
- Simple remote ON/OFF control
- Various protection functions: Over-Voltage Protection (OVP), Overload Protection (OLP), Over-Current Protection (OCP), Abnormal Over-Current Protection (AOCP), Internal Thermal Shutdown (TSD)

1.2. Power Supply Specifications

20ms hold-up time for $V_{IN}=390V_{DC}$

Application	FPS Device	Input Voltage Range	Rated Output Power	Output Voltage (Rated Current)
LCD TV	FSFR2100	V_{IN} nominal: $390V_{DC}$ • ($340\sim 400V_{DC}$) V_{CC} supply: $18V_{DC}$	192W	24V-8A

Description	Min.	Typ.	Max.	Units
Input Voltage (V_{IN})	340V	390V	400V	V_{DC}
Output Voltage (V_{OUT})		24V		V_{DC}
Output Current (I_{OUT})	0		8	A_{DC}
Rated Output Power (P_O)			192	W

1.3. Board Schematic

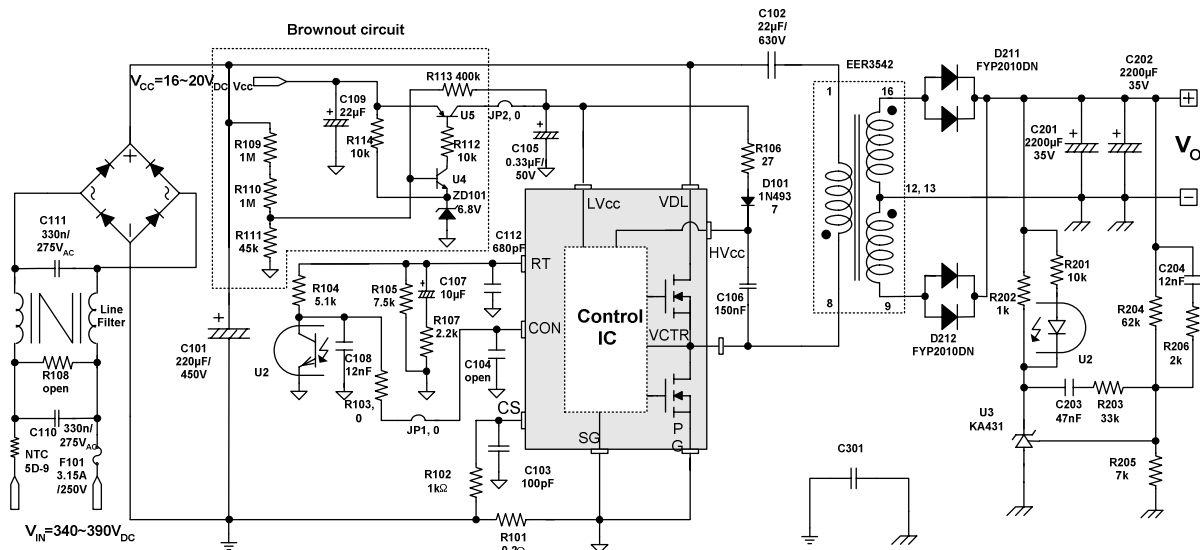


Figure 1. FSFR2100 Evaluation Board (LCC Resonant Converter)

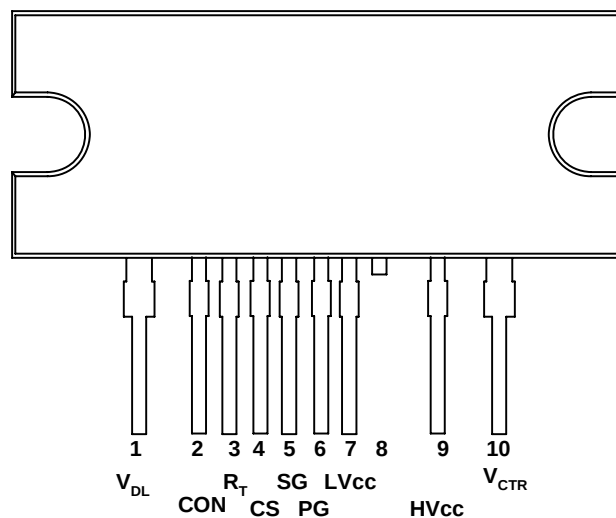


Figure 2. FSFR2100 Package Diagram (9-SIP)

1.4. Bill of Materials

Part	Value	Note	Part		Note
Resistor			Zener Diode		
R101	0.2Ω	1W	Z101	1N4736	6.8V
R102	1kΩ	1/4W			
R103	Short				
R104	5.1kΩ	1/4W	Diode		
R105	7.5kΩ	1/4W	D101	1N4937	600V/1A
R106	27Ω	1/4W	D211	FYP2010DN	100V/20A
R107	2.2kΩ	1/4W	D212	FYP2010DN	100V/20A
R108	No use				
R109	1MΩ	1/4W			
R110	1MΩ	1/4W	IC		
R111	45kΩ	1/4W	U1	FSFR2100	FPS™
R112	10kΩ	1/4W	U2	H11A817B	Opto-Coupler
R113	400kΩ	1/4W	U3	KA431	Voltage Reference
R114	10kΩ	1/4W	U4	2N2222	NPN Transistor
R201	10kΩ	1/4W	U5	2N2907	PNP Transistor
R202	1kΩ	1/4W			
R203	33kΩ	1/4W			
R204	62kΩ	1/4W			
R205	7KΩ	1/4W	NTC		
R206	2kΩ	1/4W	RT101	5D-9	
Capacitor			Bridge Diode		
C101	220μF/450V _{DC}	Electrolytic	BD101	RBV-606	Bridge Diode
C102	22nF/630V	Film			
C103	100pF	Ceramic			
C104					
C105	0.33μF/50V	Electrolytic	Line Filter		
C106	150nF	Film	LF101	23mH	
C107	10μF/50V	Electrolytic			
C108	12nF	Film			
C109	22μF/50V	Electrolytic	Fuse		
C110	330nF/275V _{AC}	Box	F101	3.15A/250V	
C111	330nF/275V _{AC}	Box			
C112	680pF	Ceramic			
C201	2200μF/35V	Electrolytic			
C202	2200μF/35V	Electrolytic			
C203	47nF	Film			
C204	12nF	Film			
C301	3.3nF	AC Ceramic			

1.5. Transformer Specification

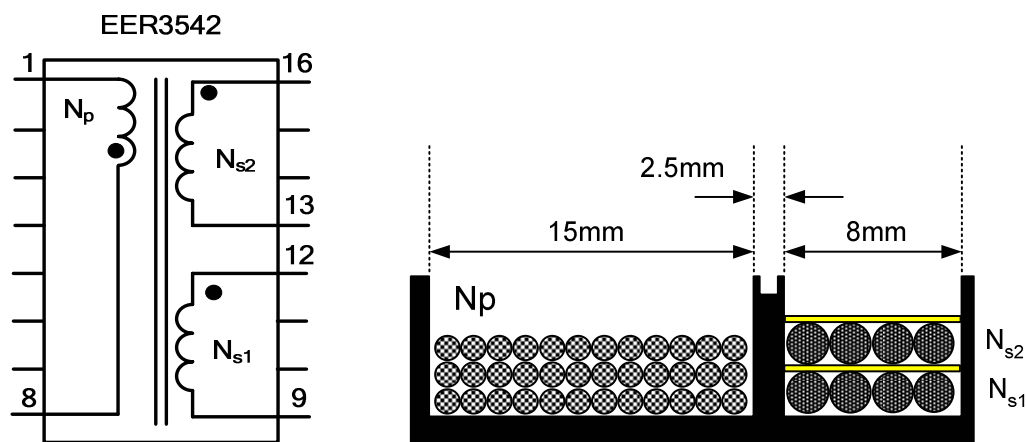


Figure 3. Transformer Specifications

1.5.1 Winding Specification

	Pin (S → F)	Wire	Turns	Winding Method
N _p	8 → 1	0.12φ×30 (Litz wire)	36	Section winding
N _{s1}	12 → 9	0.1φ×100 (Litz wire)	4	Section winding
N _{s2}	16 → 13	0.1φ×100 (Litz wire)	4	Section winding

1.5.2 Core & Bobbin

Core: EER3542 (A_e=107mm²)
Bobbin: EER3542 (Horizontal)

1.5.3 Electrical Specifications

	Pin	Specification	Remark
Primary-Side Inductance (L _P)	1-8	630μH ± 5%	100kHz, 1V
Primary-Side Effective Leakage (L _R)	1-8	135μH Maximum	Short one of the secondary windings

1.6. FSR2100 (LLC) Printed Circuit Board

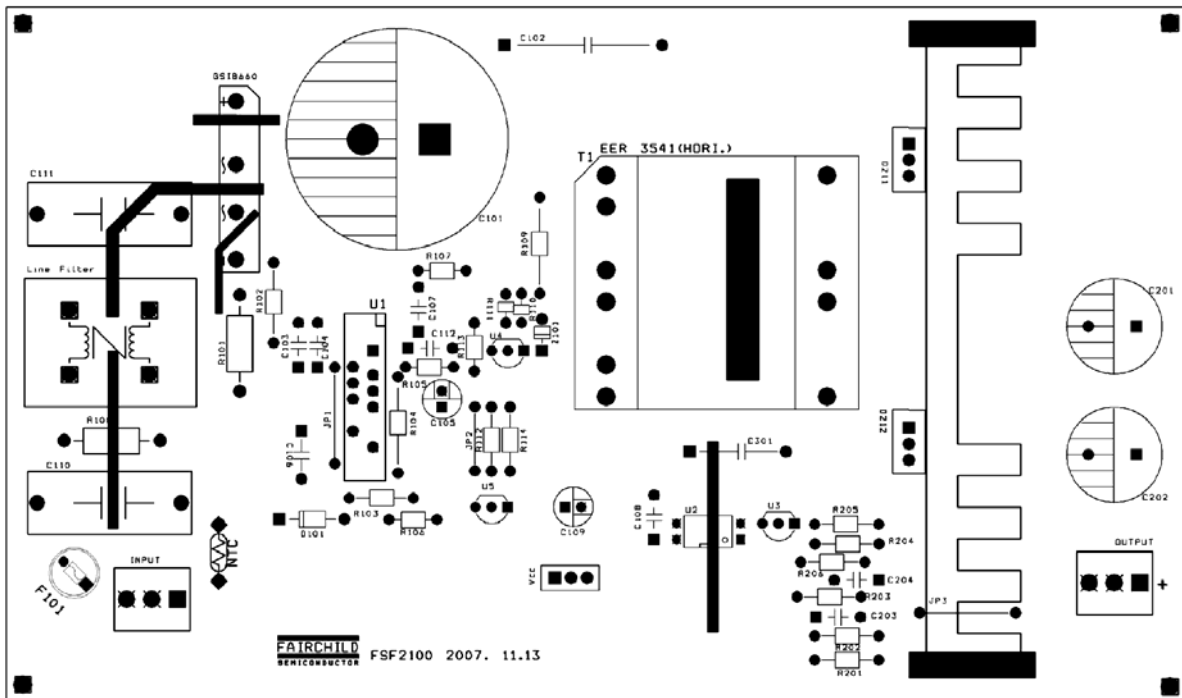


Figure 4. Top PCB Image of the Evaluation Board

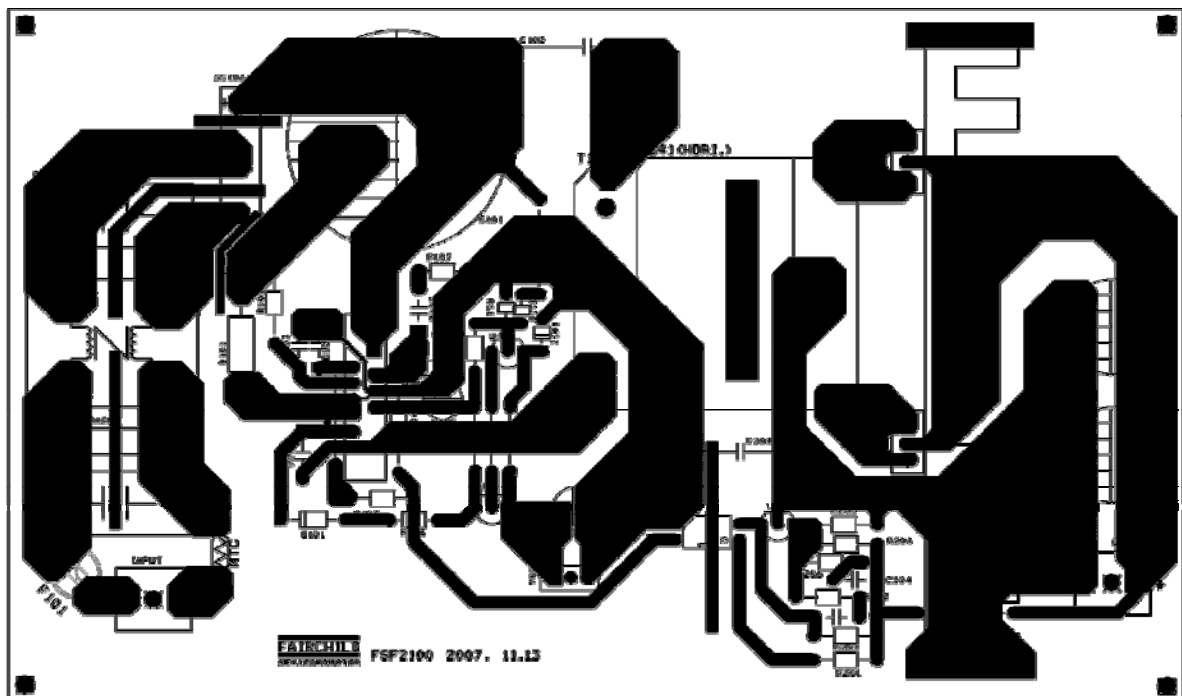


Figure 5. Bottom PCB Image of the Evaluation Board

2. Test Results

2.1. Primary-Side MOSFET Voltage and Current Waveforms

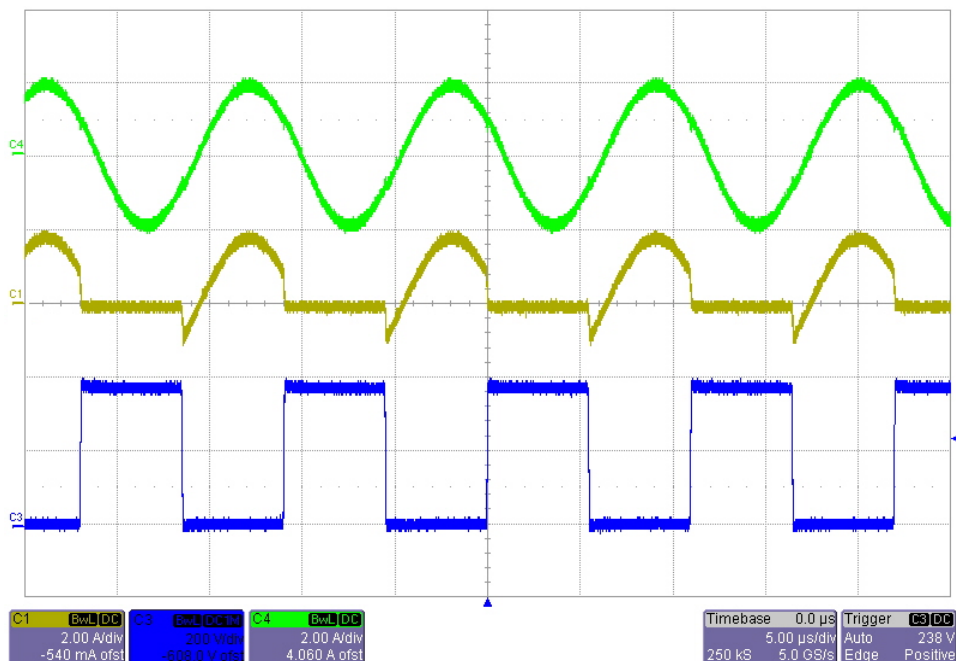


Figure 6. Operation Waveforms at Nominal Input Voltage [$V_{IN}=390V_{DC}$, $P_O=192W$ (24V/8A)]
C4: Transformer Primary-Side Current (2A/div), C1: Low-Side MOSFET Current (2A/div)
C3: Low-Side MOSFET V_{DS} (200V/div), Time: 5μs/div

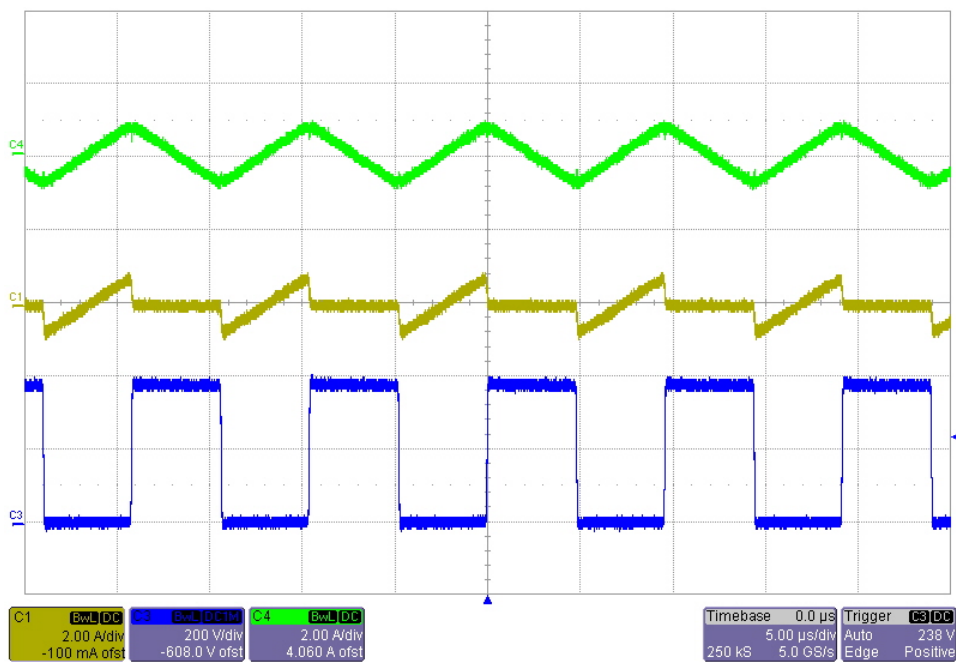


Figure 7. Operation Waveforms at Nominal Input Voltage [$V_{IN}=390V_{DC}$, $P_O=0W$ (24V/0A)]
C4: Transformer Primary-Side Current (2A/div), C1: Low-Side MOSFET Current (2A/div)
C3: Low-Side MOSFET V_{DS} (200V/div), Time: 5μs/div

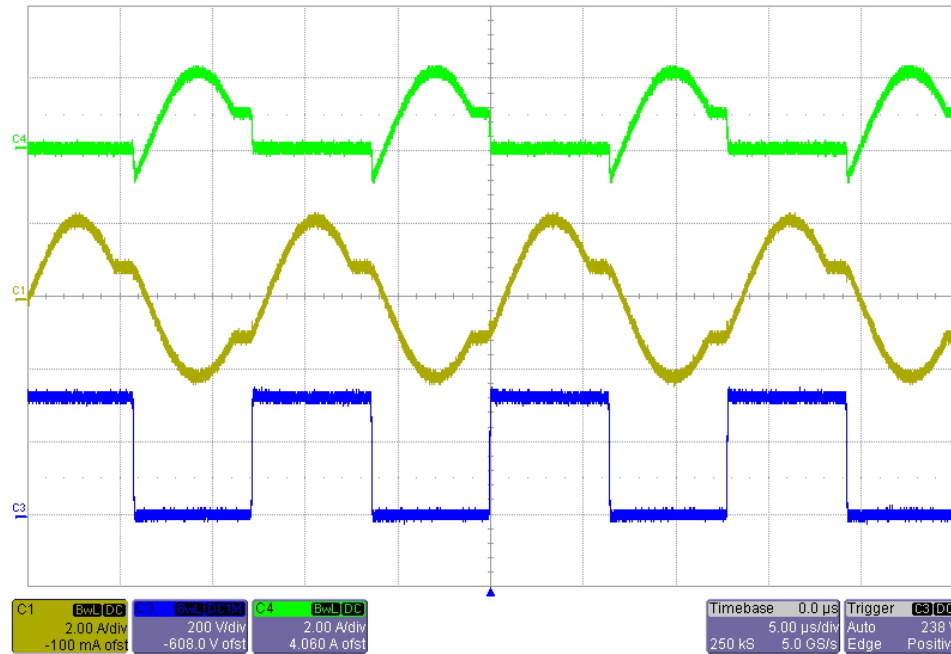


Figure 8. Operation Waveforms at Minimum Input Voltage [$V_{IN}=340V_{DC}$, $P_O=192W$ (24V/8A)]
C4: Transformer Primary-Side Current (2A/div), C1: Low-Side MOSFET Current (2A/div)
C3: Low-Side MOSFET V_{DS} (200V/div), Time: 5 μ s/div

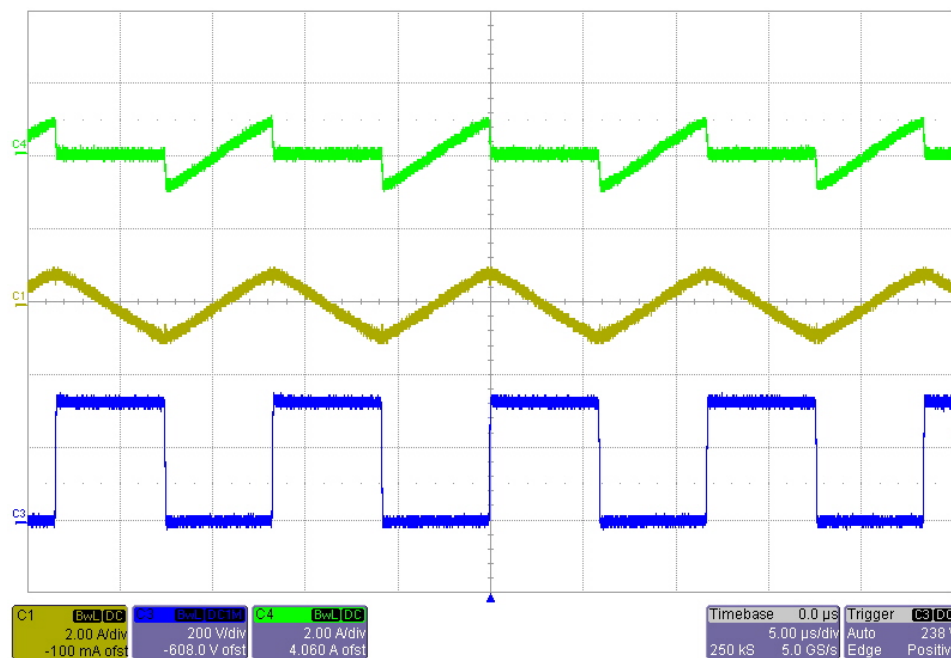


Figure 9. Operation Waveforms at Minimum Input Voltage [$V_{IN}=340V_{DC}$, $P_O=0W$ (24V/0A)]
C4: Transformer Primary-Side Current (2A/div), C1: Low-Side MOSFET Current (2A/div)
C3: Low-Side MOSFET V_{DS} (200V/div), Time: 5 μ s/div

2.2. Secondary-Side Rectifier Diodes Voltage and Current Waveforms

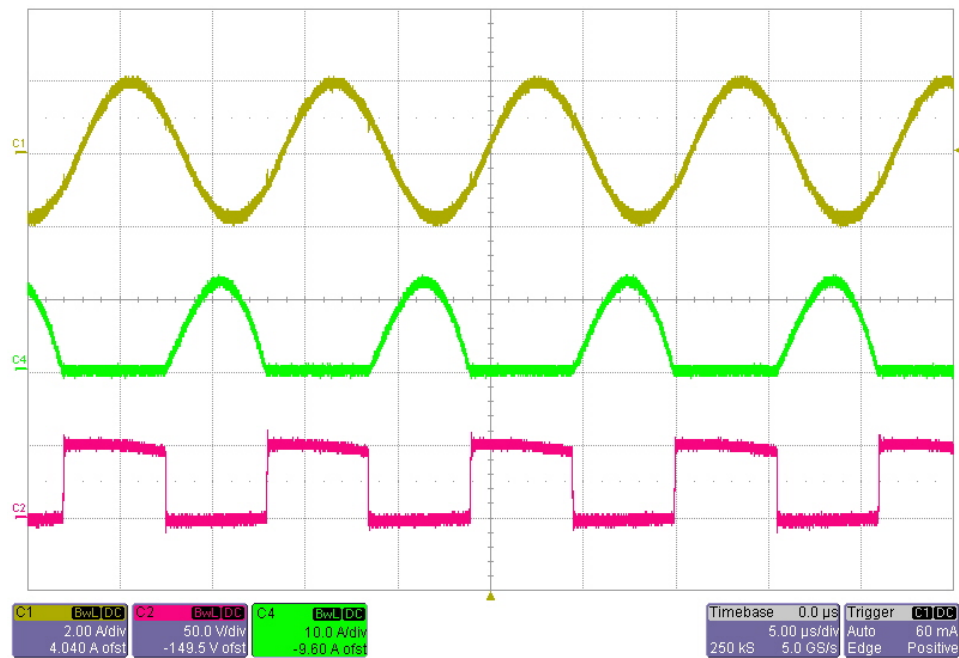


Figure 10. Operation Waveforms at Nominal Input Voltage [$V_{IN}=390V_{DC}$, $P_O=192W$ (24V/8A)]
C1: Transformer Primary-Side Current (2A/div), C4: Rectifier Diode (D211) Current (10A/div)
C2: Rectifier Diode (D211) Voltage (50V/div), Time: 5μs/div

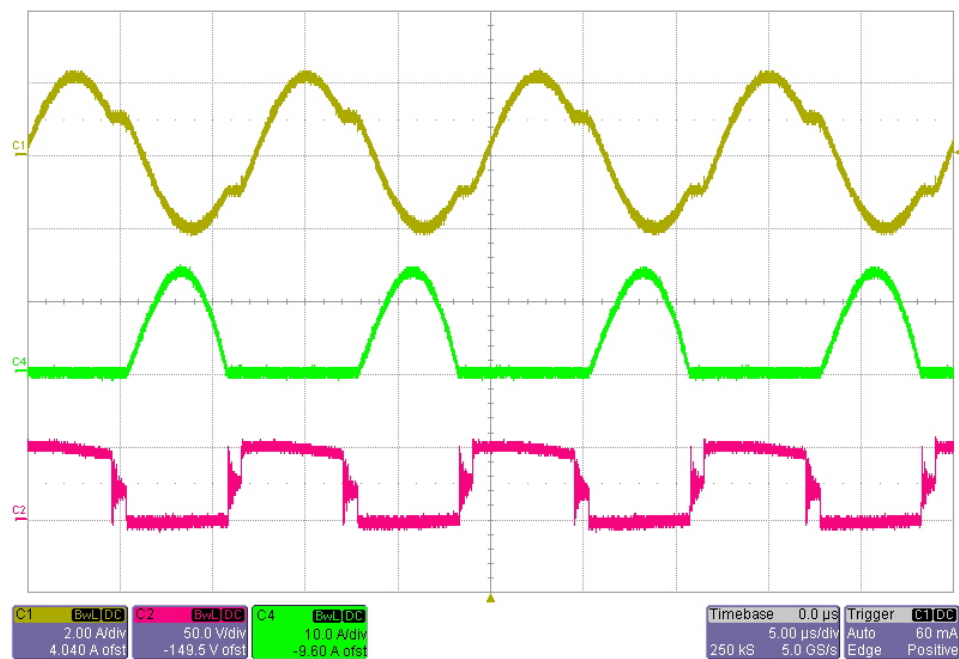


Figure 11. Operation Waveforms at Minimum Input Voltage [$V_{IN}=340V_{DC}$, $P_O=192W$ (24V/8A)]
C1: Transformer Primary-Side Current (2A/div), C4: Rectifier (D211) Diode Current (10A/div)
C2: Rectifier Diode (D211) Voltage (50V/div), Time: 5μs/div

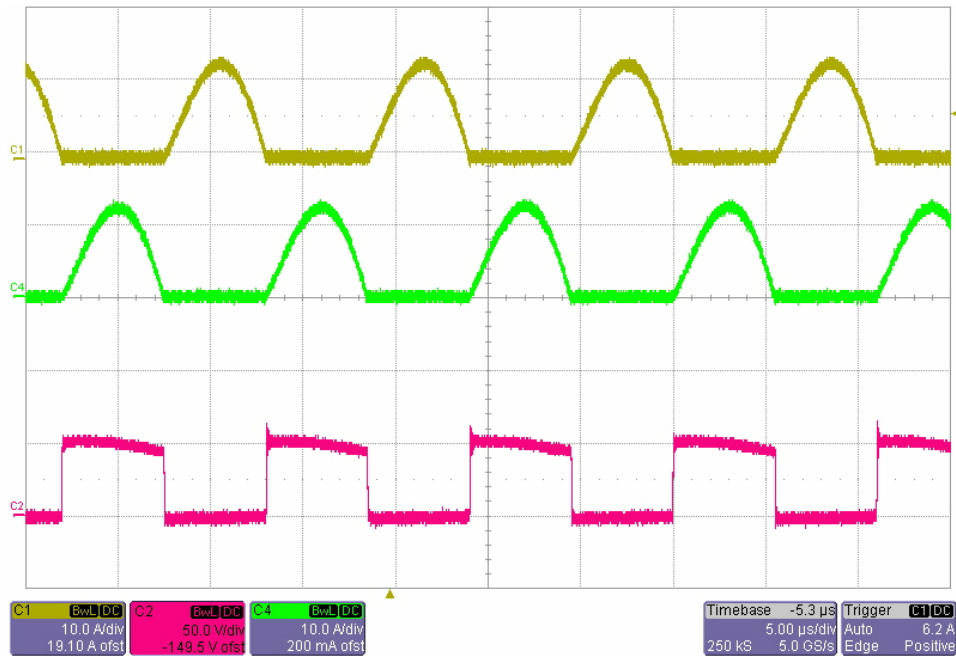


Figure 12. Operation Waveforms at Nominal Input Voltage [$V_{IN}=390V_{DC}$, $P_O=192W$ (24V/8A)]
C1: Rectifier Diode (D211) Current (10A/div), C4: Rectifier Diode (D212) Current (10A/div)
C3: Rectifier Diode Voltage (50V/div), Time: 5 μ s/div

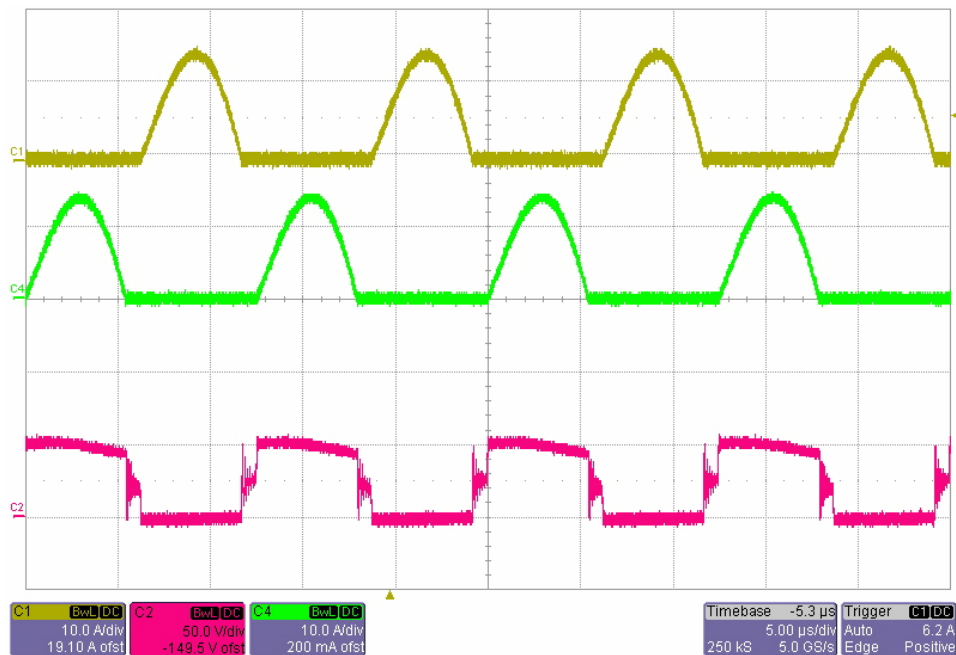


Figure 13. Operation Waveforms at Minimum Input Voltage [$V_{IN}=340V_{DC}$, $P_O=192W$ (24V/8A)]
C1: Rectifier Diode (D211) Current (10A/div), C4: Rectifier Diode (D212) Current (10A/div)
C3: Rectifier Diode Voltage (50V/div), Time: 5 μ s/div

2.3. On/Off Waveforms

Figures 14 and 15 show the soft-start waveforms at full-load and no-load conditions, respectively, for nominal input voltage condition. For these waveforms, the input DC bus is applied first, then V_{CC} for FSFR2100 is supplied.

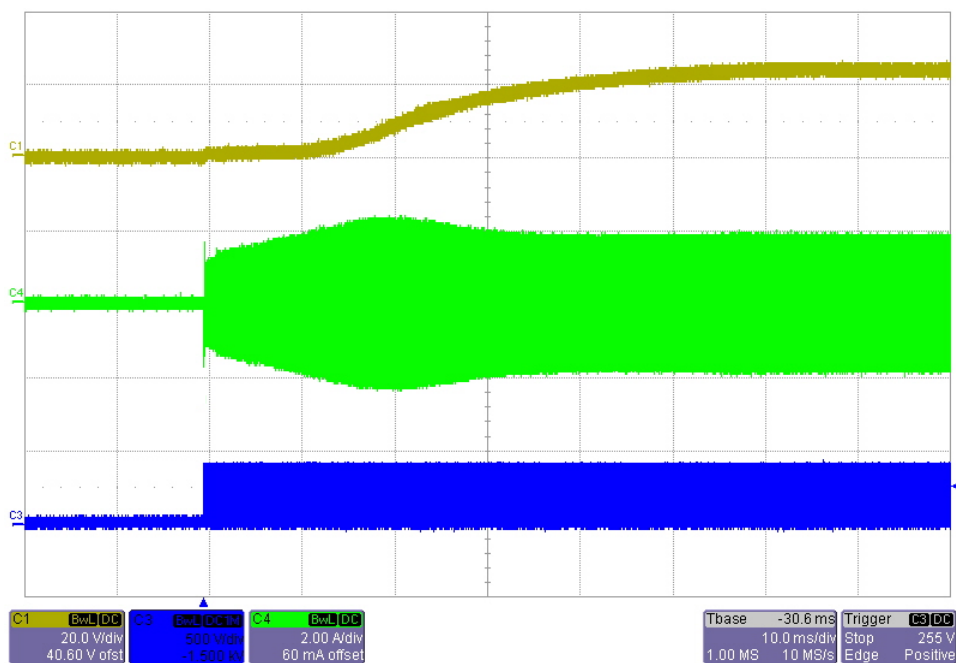


Figure 14. Start-up Waveforms at Nominal Input Voltage [$V_{IN}=390V_{DC}$, $P_O=192W$ (24V/8A)]
C1: Output Voltage (20V/div), C4: Transformer Primary-Side Current (2A/div)
C3: Low-Side MOSFET V_{DS} (500V/div), Time: 10ms/div

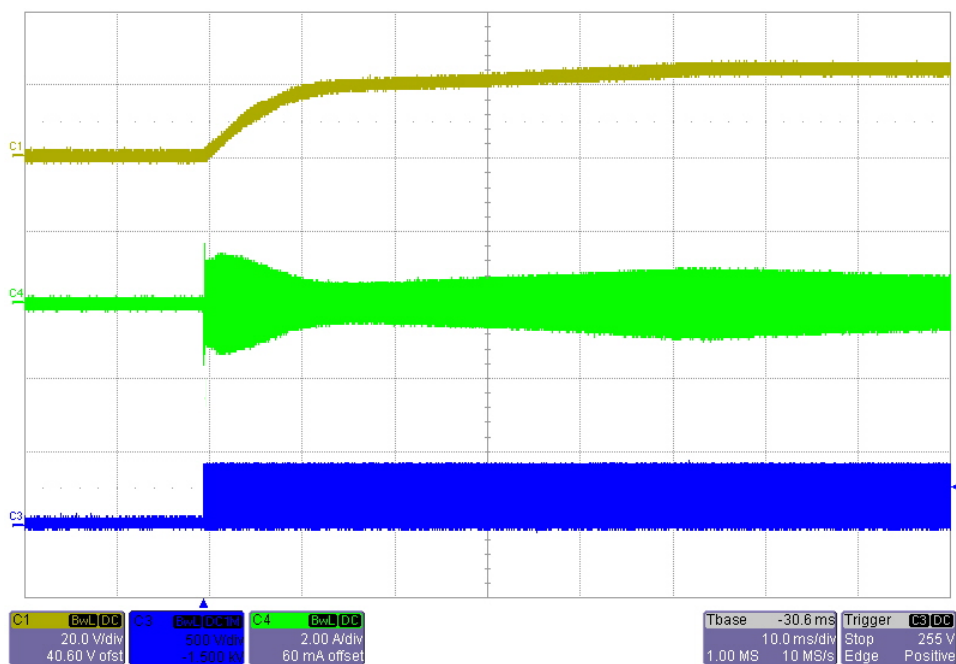


Figure 15. Start-up Waveforms at Nominal Input Voltage [$V_{IN}=390V_{DC}$, $P_O=0W$ (24V/0A)]
C1: Output Voltage (20V/div), C4: Transformer Primary-Side Current (2A/div)
C3: Low-Side MOSFET V_{DS} (500V/div), Time: 10ms/div

Figure 16 shows start-up waveforms when V_{CC} of 18V is supplied first, then the input voltage source is applied. When the DC bus voltage reaches $\sim 330V$, the external brownout circuit connects V_{CC} supply voltage to FSFR2100 so it starts up. Figure 17 shows shutdown waveforms when the input voltage source is turned off. When the DC bus voltage reaches $\sim 260V$, the external brownout circuit disconnects V_{CC} from FSFR2100 so it stops operation.

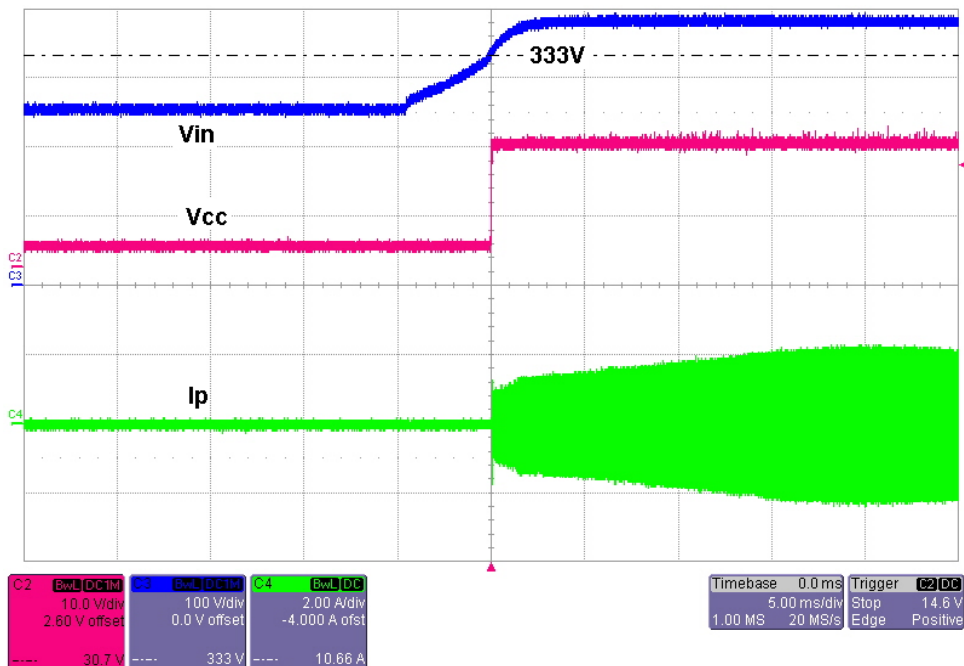


Figure 16. Power-on Waveforms at Nominal Input Voltage [$V_{IN}=390V_{DC}$, $P_O=192W$ (24V/8A)]
C1: Output Voltage (20V/div), C4: Transformer Primary-Side Current (2A/div)
C3: Low-Side MOSFET V_{DS} (500V/div), Time: 5ms/div

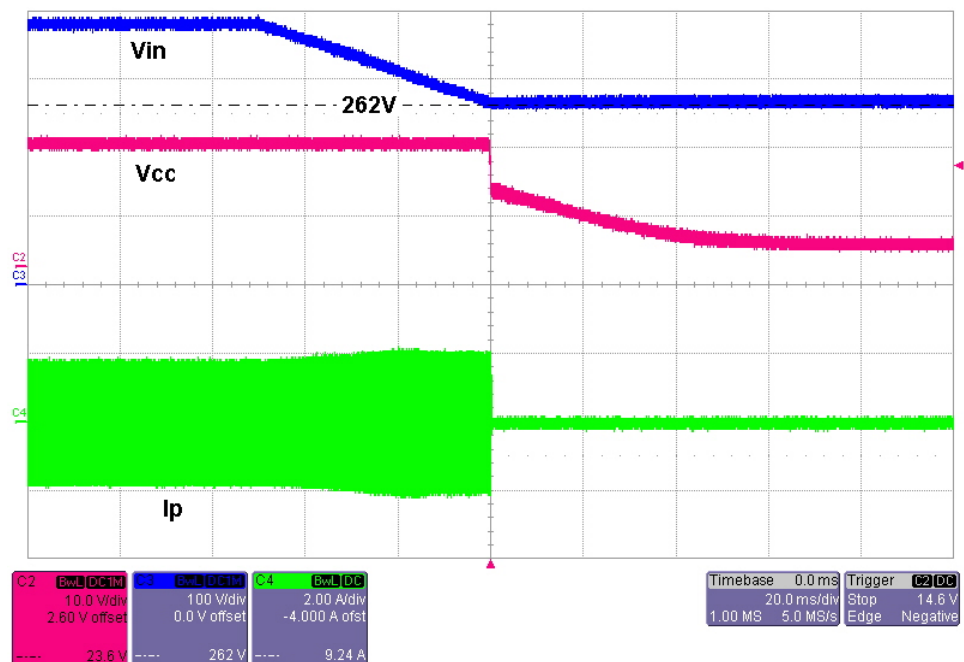


Figure 17. Power-Off Waveforms at Nominal Input Voltage [$V_{IN}=390V_{DC}$, $P_O=192W$ (24V/8A)]
C3: Input Voltage (100V/div), C2: V_{CC} Supply Voltage (10V/div)
C4: Transformer Primary-Side Current (2A/div), Time: 20ms/div

2.4. Output Voltage Ripple

Figure 18 shows the output voltage ripple at nominal input voltage and full-load condition. The peak-to-peak ripple voltage is 0.5V, about 2% of the output voltage. Figure 19 shows the output voltage ripple with pulse load at nominal input voltage. The peak-to-peak ripple voltage is 0.8V, about 3% of the output voltage.

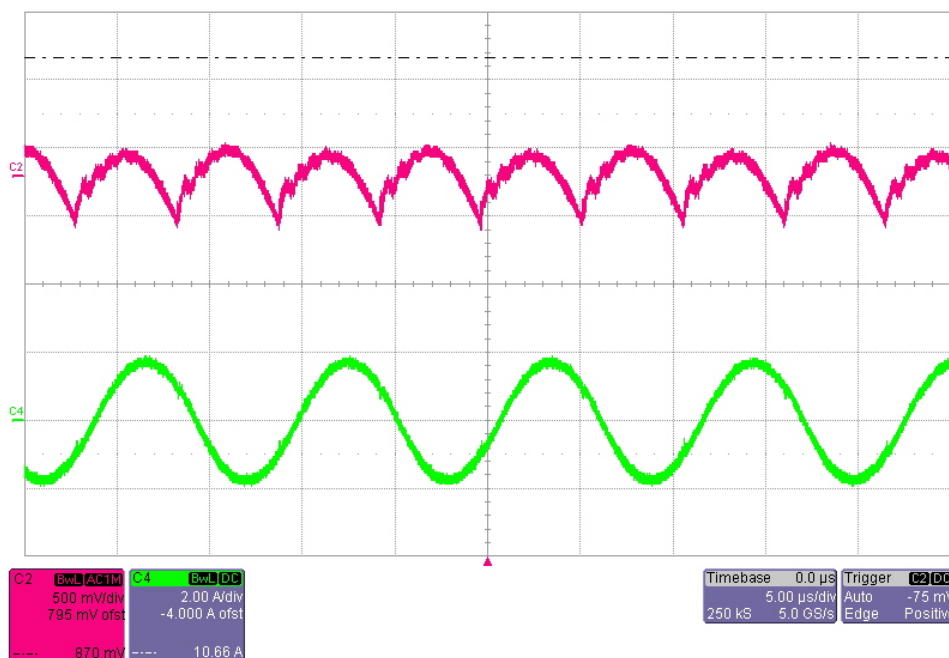


Figure 18. Output Voltage Ripple at Nominal Input Voltage [$V_{IN}=390V_{DC}$, $P_O=192W$ (24V/8A)]
C2: Output Voltage (500mV/div), C4: Transformer Primary-Side Current (2A/div), Time: 20ms/div

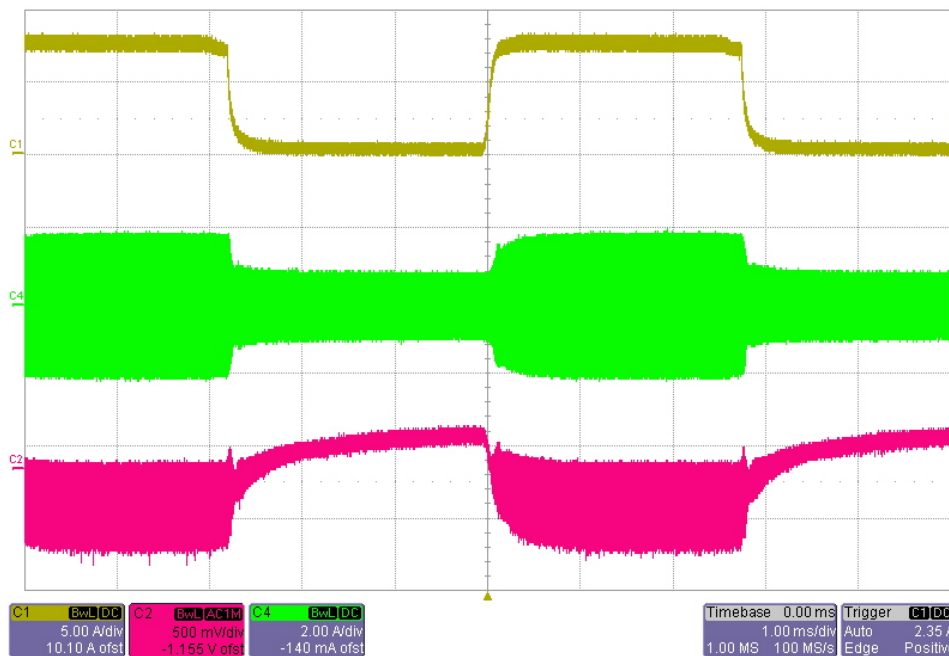


Figure 19. Output Voltage Ripple with Pulse Load Current at Nominal Input Voltage
[$V_{IN}=390V_{DC}$, ($I_O=0A \leftrightarrow 8A$, Slew Rate=50mA/μs, Duty Cycle=50%, Frequency=180Hz)]
C1: Output Current (5A/div), C4: Transformer Primary-Side Current (2A/div)
C2: Output Voltage Ripple, Time: 20ms/div

2.5. Hold-Up Time Test

To see the hold-up time, the input DC bus is disconnected while the converter operates in full-load condition. Observe that the output voltage is maintained for 34ms when the input DC bus is disconnected.

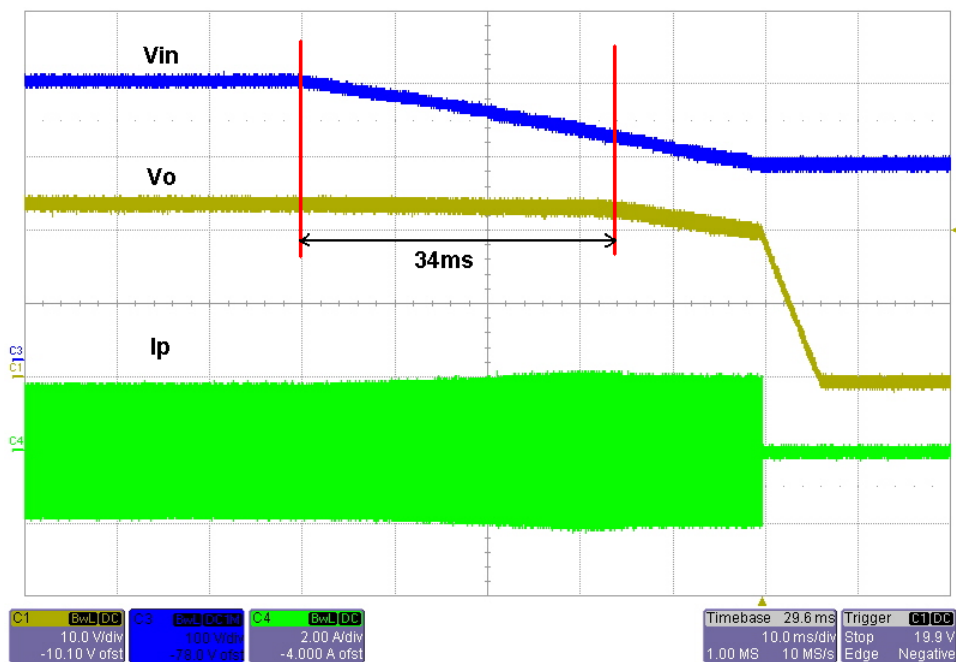


Figure 20. Output Voltage Waveform after Turning Off Input Voltage [$V_{IN}=390V_{DC}$, $P_O=192W$ (24V/8A)]
C3: Input Voltage (100V/div), C1: Output Voltage (10V/div)
C4: Transformer Primary-Side Current (2A/div), Time: 10ms/div

2.6. Protection Operation Waveforms

Figure 21 shows the overload protection (OLP) waveforms. The output current increases from 8A to 16A. When the transformer primary-side current reaches its trip point of 3A, the over-current protection is triggered. Figure 22 shows the output short protection waveforms. When the transformer primary-side current reaches its trip point of 3A, the over-current protection is triggered.

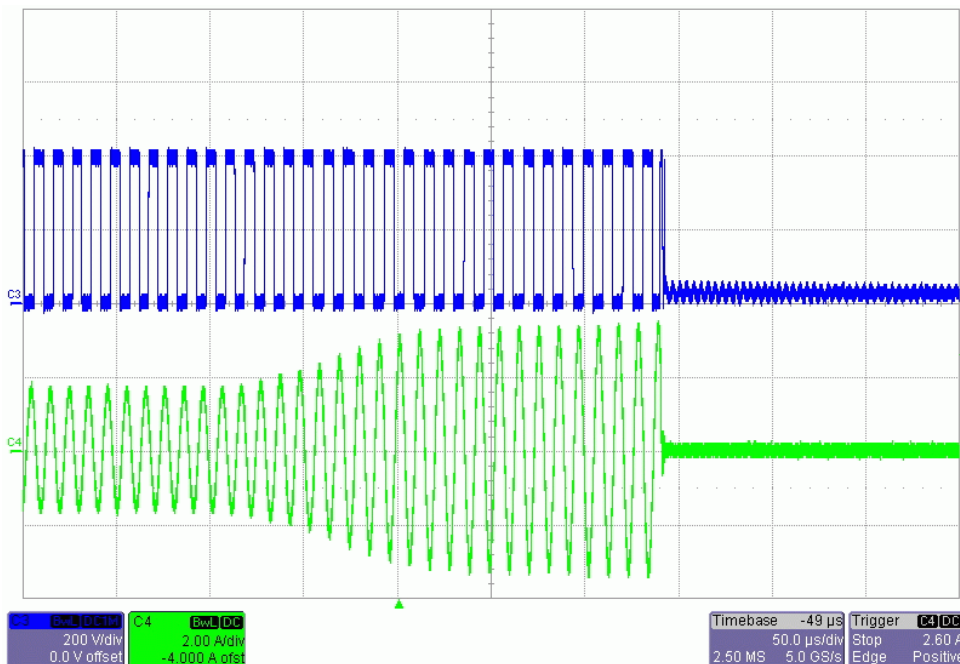


Figure 21. Protection Waveform at Overload Condition [$V_{IN}=390V_{DC}$, ($I_O=8A \rightarrow 16A$)]
C3: Low-Side Drain Voltage (200V/div), C4: Transformer Primary-Side Current (2A/div), Time: 50μs/div

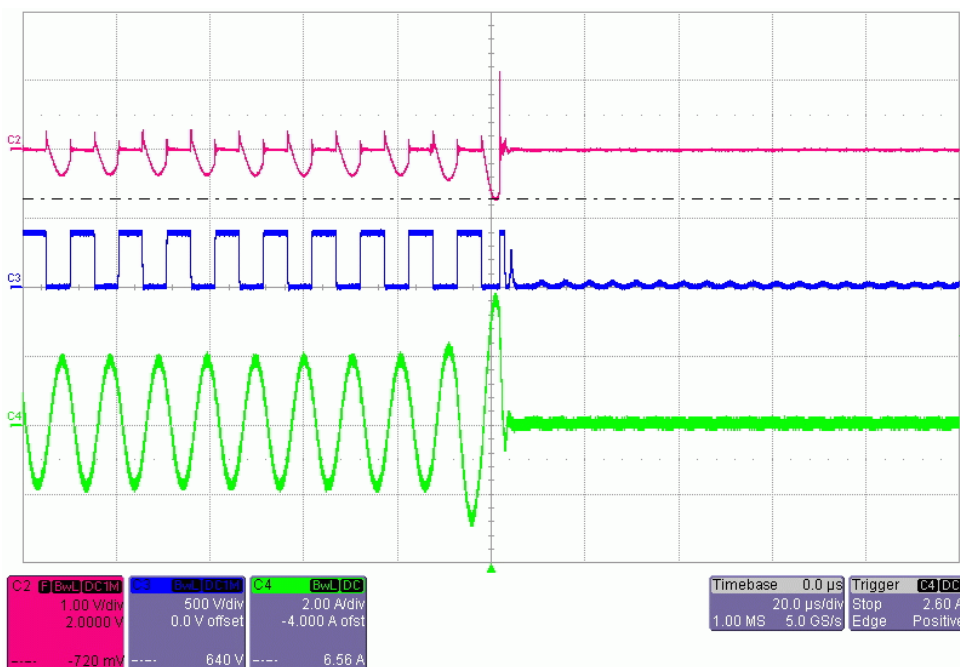


Figure 22. Protection Waveform at Output Short Condition [$V_{IN}=390V_{DC}$, ($I_O=8A \rightarrow \text{Short}$)]
C2: Current Sensing Pin (CS) Voltage (1V/div), C3: Low-Side MOSFET V_{DS} (500V/div)
C4: Transformer Primary-Side Current (2A/div), Time: 20μs/div

2.7. Efficiency

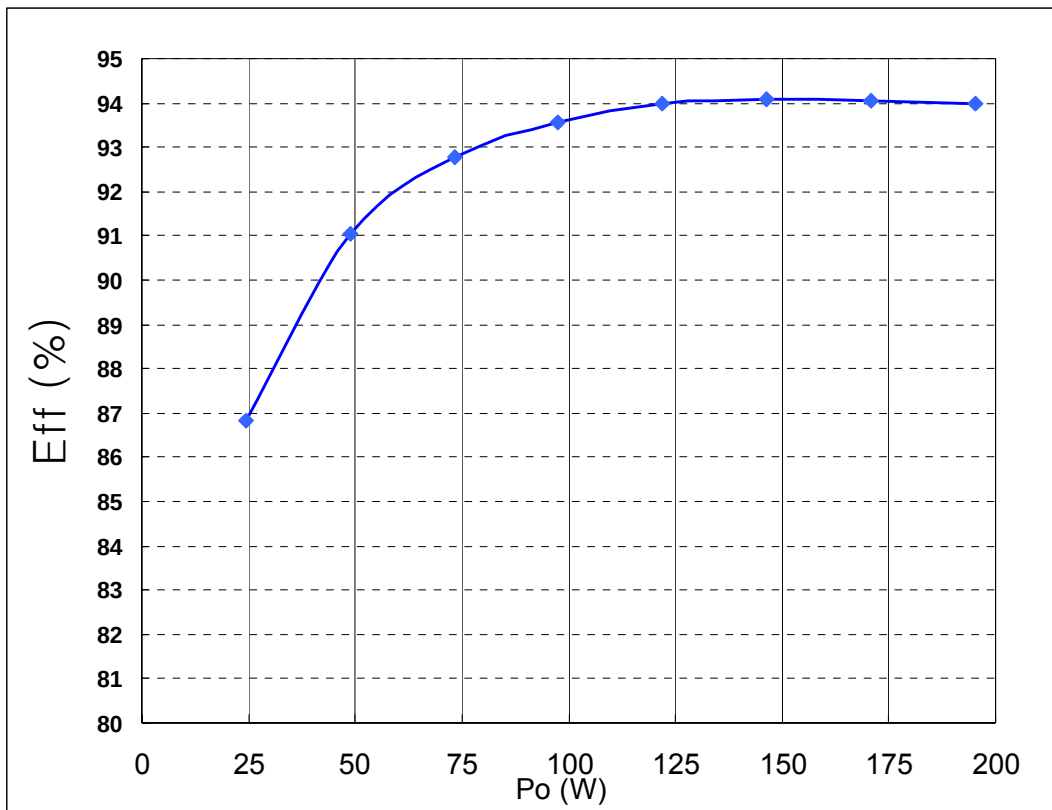


Figure 23. Measured Efficiency



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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.