The Test Report of FAN7621 Evaluation Board	
Document Number	FSEB-FAN7621-LCD-035
E/B Number	FAN7621 2009.02.06 ver1.1
Application	LCD TV Power Supply
Featured Products	FAN7621
Date.	APR. 02. 2009
Design Reference	FAN7621 Datasheet
	FAN4151 Application Note

Application	FPS device	Input voltage range	Rated output power	Output voltage (Rated current)
LCD TV	FAN7621	V_{IN} nominal : $390V_{DC}$* ($340\sim400V_{DC}$) LV_{CC} supply : $18V_{DC}$	200W	24V-8.3A

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

Contents

1. General Board Description

1.1 Featured Fairchild Product

FAN7621 is a Pulse-Frequency-Modulation (PFM) controller for high-efficiency half-bridge resonant converters.

- Variable frequency control with 50% duty cycle for half-bridge resonant converter topology
- High efficiency through Zero-Voltage-Switching (ZVS)
- Fixed dead time (350ns)
- Up to 300kHz operating frequency
- Pulse skipping for frequency limit (programmable) at light load condition
- Remote On/Off control using control pin
- Various Protection functions: Over Voltage Protection (OVP), Over Load Protection (OLP), Over Current Protection (OCP), Abnormal Over Current Protection (AOCP), Internal Thermal Shutdown (TSD)

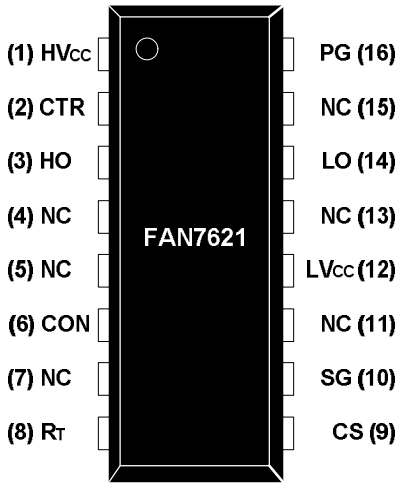

Figure 1. FAN7621 Package diagram (16-DIP)

1.2 Specification for Evaluation Board

Table 1. Power supply specifications

FPS Device	FAN7621
Minimum / Nominal / Maximum Input Voltage Range	$340V_{DC}$ / $390V_{DC}$ / $400V_{DC}$
Rated Output Power	200W
Rated Output Voltage / Output Current	24V / 8.3A
Output voltage ripple	350mV
Maximum Efficiency	94.9%
Application	LCD TV

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

1.3 200W FAN7621 Evaluation Board

Dimension : 11.5 cm(W) x 20.1 cm(L)

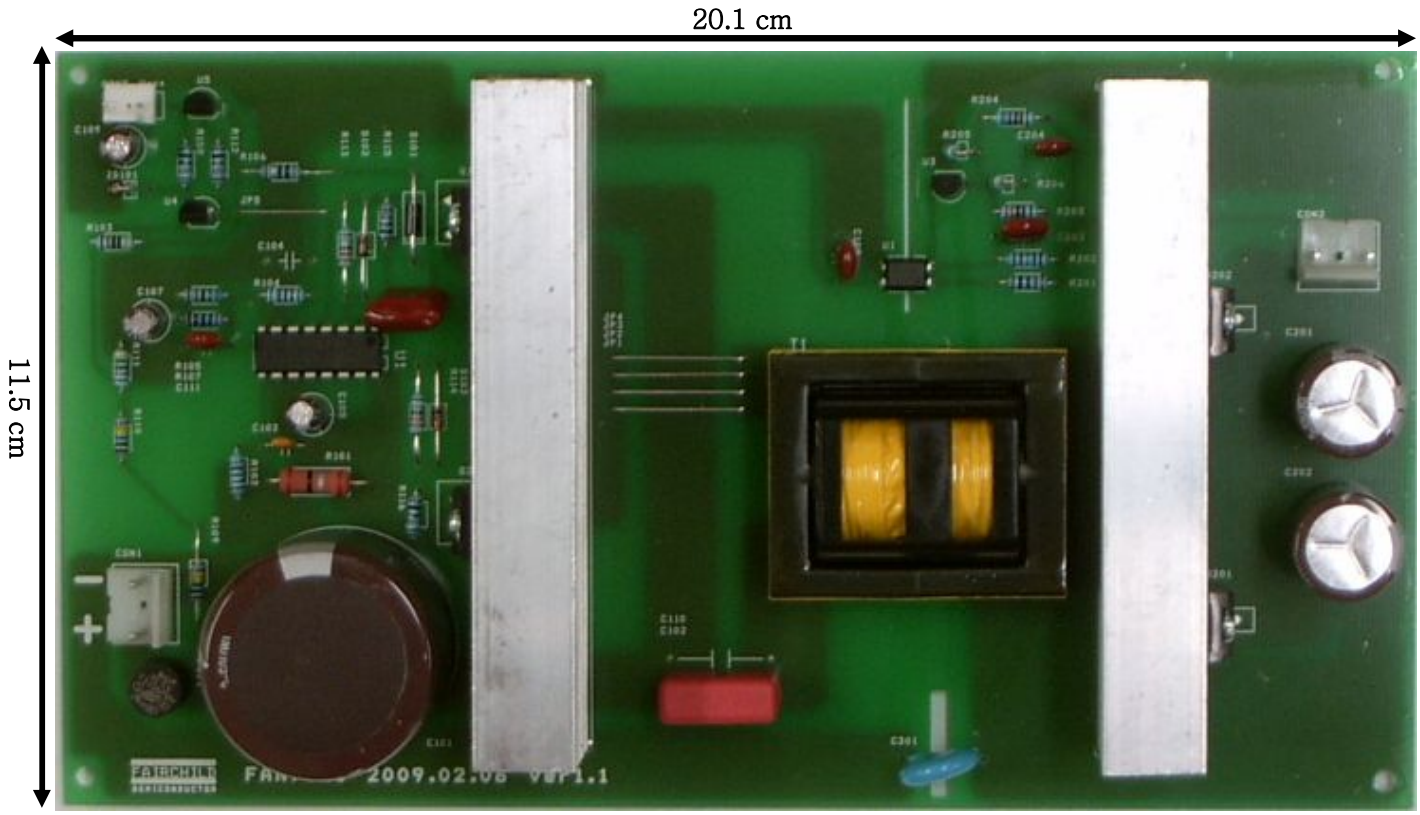

Figure 2. Photograph of evaluation board top side

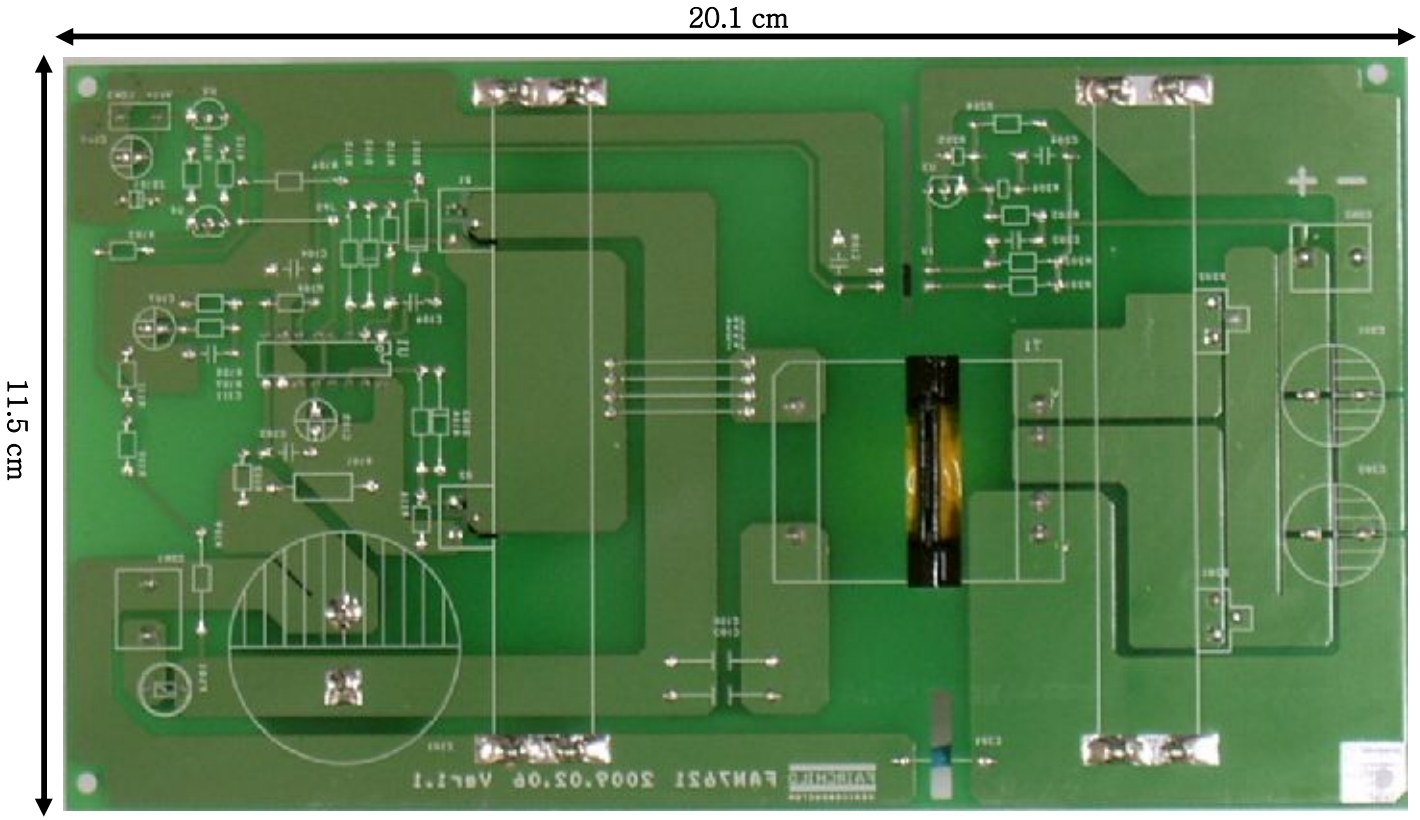

Figure 3. Photograph of evaluation board bottom side

Dimension : 11.5 cm(W) x 20.1 cm(L)

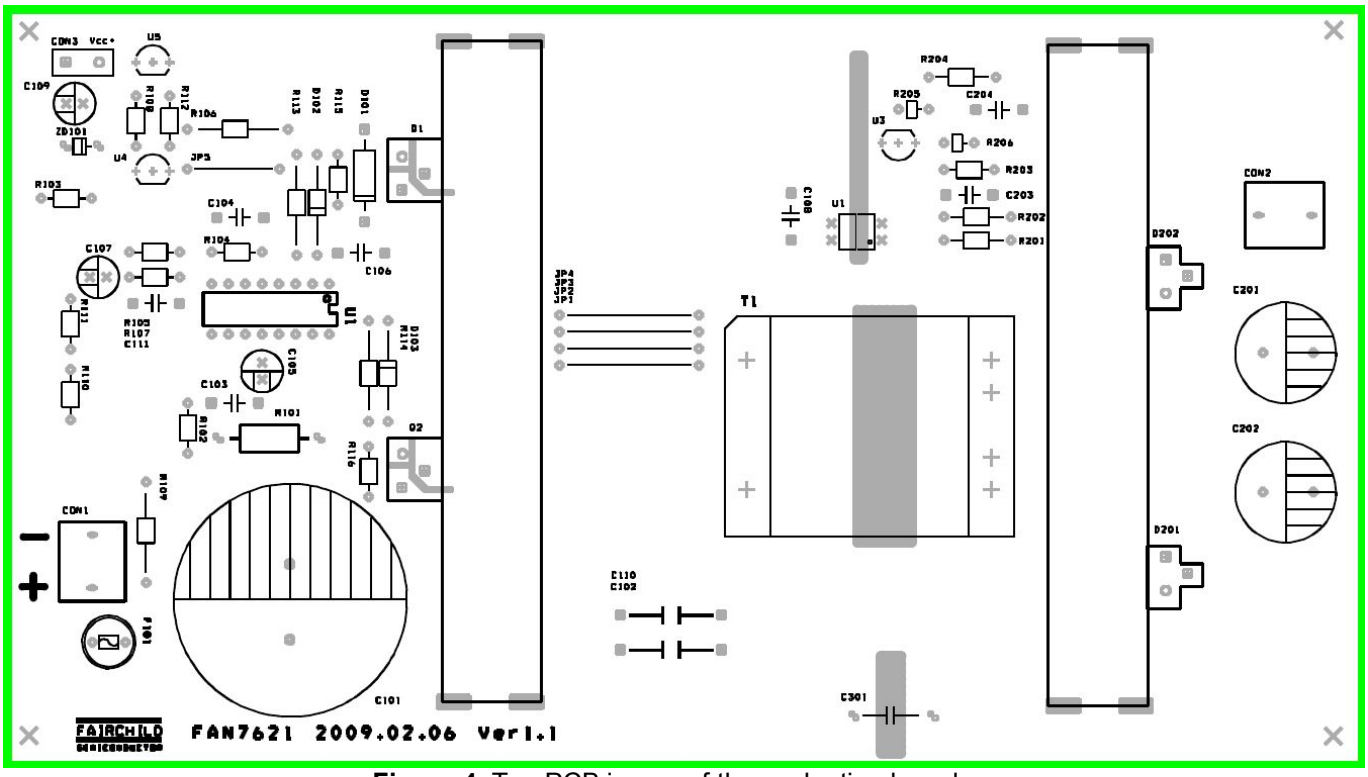

Figure 4. Top PCB image of the evaluation board.

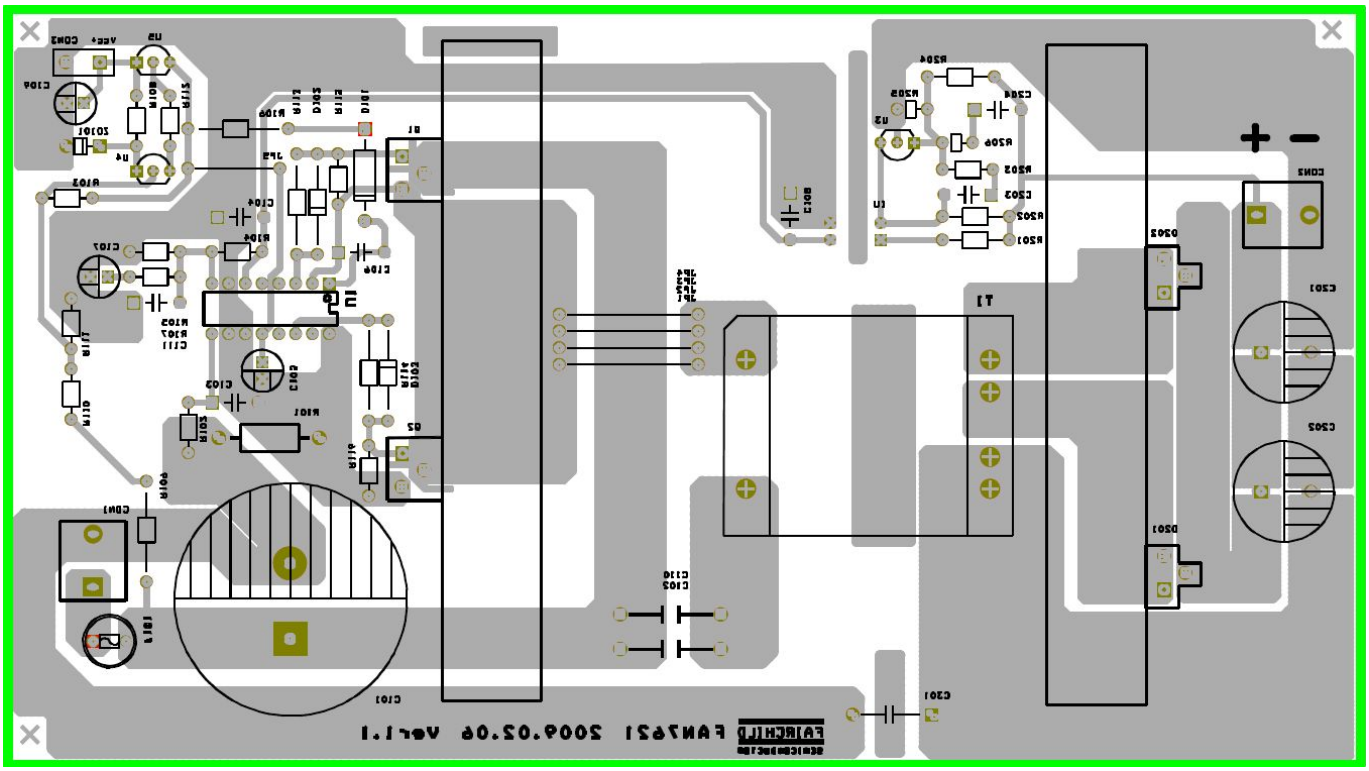

Figure 5. Bottom PCB image of the evaluation board.

1.4 200W FAN7621 Evaluation Board Schematic

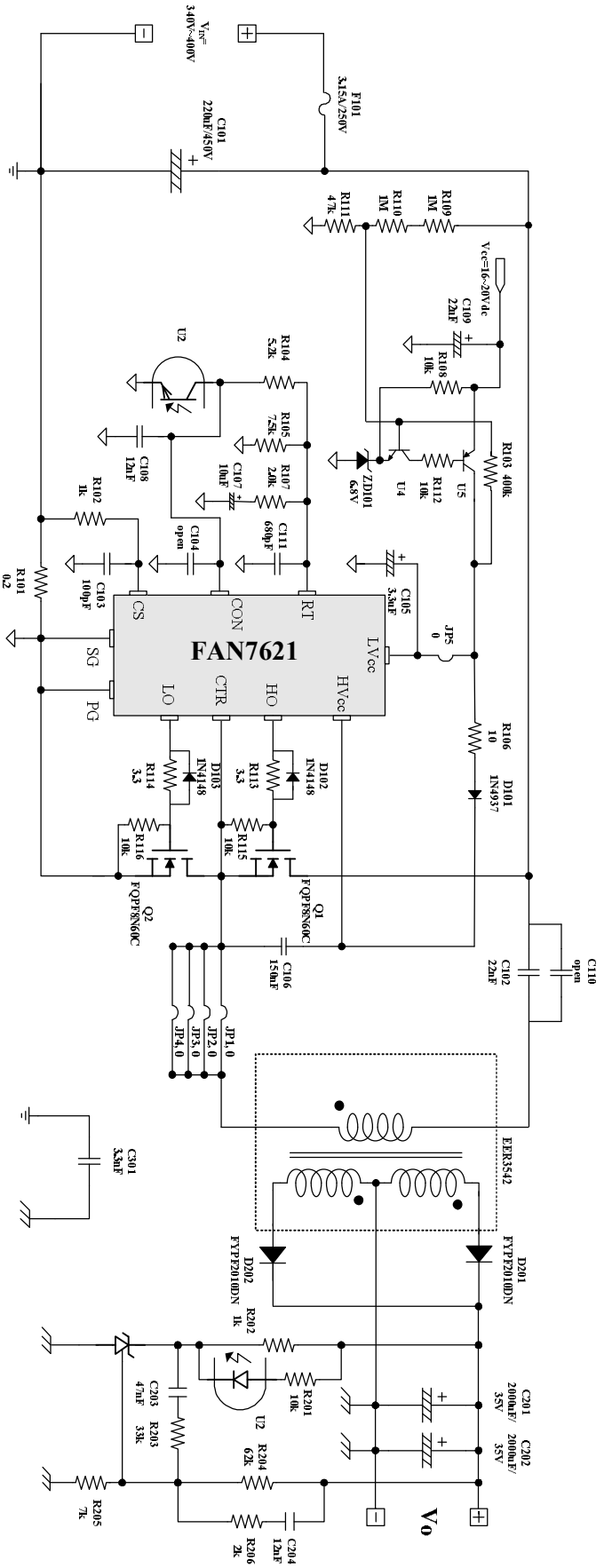

Figure 6. Schematic of FAN7621 Evaluation Board (LLC Resonant Converter)

1.5 Bill of Materials

Table 2. Bill of materials used for evaluation board

Item Number	Part Reference	Value	Note	Manufacturer	Digi-Key
1	C101	220u/450V	Electrolytic	Samyoung Electronics	
2	C102	22nF/630V	Film	Wima	
3	C103	100pF	Film	Samwha Electronics	
4	C104	Not use	-		
5	C105	3.3uF/50V	Electrolytic	Samyoung Electronics	
6	C106	150nF	Film	Samwha Electronics	
7	C107	10uF/50V	Electrolytic	Samyoung Electronics	
8	C108	12nF	Film	Samwha Electronics	
9	C109	22uF/35V	Electrolytic	Samyoung Electronics	
10	C110	Not use	-		
11	C111	680pF	Film	Samwha Electronics	
12	C201	2200uF/35V	Electrolytic	Samyoung Electronics	
13	C202	2200uF/35V	Electrolytic	Samyoung Electronics	
14	C203	47nF	Film	Samwha Electronics	
15	C204	12nF	Film	Samwha Electronics	
16	C301	4.7nF	AC ceramic	Samyoung Electronics	
17	R101	0.2Ω	2W	Stackpole Electronics Inc	RS20.2FA-ND
18	R102	1kΩ	1/4W	Panasonic - ECG	P1.00KCATB-ND
19	R103	400kΩ	1/4W	Panasonic - ECG	ERO-S2PHF4023-ND
20	R104	5.2kΩ	1/4W	Panasonic - ECG	ERO-S2PHF5232-ND
21	R105	7.5kΩ	1/4W	Panasonic - ECG	P7.50KCATB-ND
22	R106	10Ω	1/4W	Panasonic - ECG	P10.0CACT-ND
23	R107	2.0kΩ	1/4W	Panasonic - ECG	P2.00KCATB-ND
24	R108	10kΩ	1/4W	Panasonic - ECG	P10.0KCATB-ND
25	R109	1MΩ	1/4W	Panasonic - ECG	P1.00MCATB-ND
26	R110	1MΩ	1/4W	Panasonic - ECG	P1.00MCATB-ND
27	R111	47kΩ	1/4W	Panasonic - ECG	P47.0KCATB-ND
28	R112	10kΩ	1/4W	Panasonic - ECG	P10.0KCATB-ND
29	R113	3.3Ω	1/4W	Panasonic - ECG	ERO-S2PHF3R30-ND
30	R114	3.3Ω	1/4W	Panasonic - ECG	ERO-S2PHF3R30-ND
31	R115	10kΩ	1/4W	Panasonic - ECG	P1.00MCATB-ND
32	R116	10kΩ	1/4W	Panasonic - ECG	P1.00MCATB-ND
33	R201	10kΩ	1/4W	Panasonic - ECG	P1.00MCATB-ND
34	R202	1kΩ	1/4W	Panasonic - ECG	P1.00KCATB-ND
35	R203	33kΩ	1/4W	Panasonic - ECG	P33.0KCATB-ND
36	R204	62kΩ	1/4W	Panasonic - ECG	P62.0KCATB-ND
37	R205	7KΩ	1/4W	Panasonic - ECG	ERO-S2PHF6981-ND
38	R206	2kΩ	1/4W	Panasonic - ECG	P2.00KCATB-ND
39	U1	FAN7621	Control IC	Fairchild Semiconductor	
40	U2	FOD817B	Opto-Coupler	Fairchild Semiconductor	FOD817B-ND
41	U3	KA431	Voltage reference	Fairchild Semiconductor	KA431AZBU-ND
42	U4	2N2222	NPN transistor	Fairchild Semiconductor	2N2222A-ND
43	U5	2N3906	PNP transistor	Fairchild Semiconductor	2N3906FS-ND
44	Q1	FQPF8N60C	600V/11A	Fairchild Semiconductor	FQPF8N60C-ND
45	Q2	FQPF8N60C	600V/11A	Fairchild Semiconductor	FQPF8N60C-ND
46	D101	1N4937	600V/1A	Fairchild Semiconductor	1N4937-ND
47	D102	1N4148	100V/0.2A	Fairchild Semiconductor	1N4148FS-ND
48	D103	1N4148	100V/0.2A	Fairchild Semiconductor	1N4148FS-ND
49	D201	FYPF2010DN	100V/20A	Fairchild Semiconductor	FYPF2010DNTU-ND
50	D202	FYPF2010DN	100V/20A	Fairchild Semiconductor	FYPF2010DNTU-ND
51	ZD101	1N4736	6.8V	Fairchild Semiconductor	1N4736A-ND
52	F101	3.15A/250V	FUSE		
53	T1	SNX-2468-1	Transformer	Santronics	

1.6 Transformer Specification

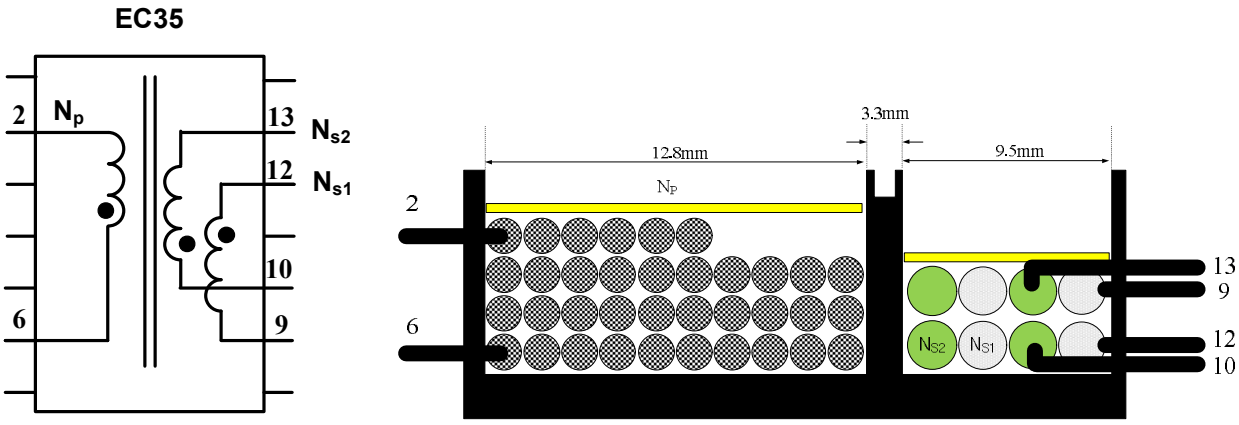

Figure 7. Transformer specification.

	Pin(S → F)	Wire	Turns	Note
N_p	6 → 2	0.08φ×88 (Litz wire)	36	-
N_{s1}	12 → 9	0.08φ×234 (Litz wire)	4	Bifilar winding
N_{s2}	10 → 13	0.08φ×234 (Litz wire)	4	Bifilar winding

Table 3. Winding Specification

Core: EC35 (Ae=106 mm^2)
Bobbin: EC35 (Horizontal)
Transformer model number: SNX-2468-1

Electrical Characteristics

	Pin	Spec.	Remark
Primary side Inductance (Lp)	2 – 6	550μH ± 10%	100kHz, 1V
Primary side effective leakage (Lr)	2 – 6	110μH ± 10%	Short one of the secondary windings

Table 4. Electrical Characteristics

This transformer can be supplied by Santronics. If you want to get this transformer, please visit the website www.santronics-usa.com

2. Test Results

2.1 Primary side MOSFET voltage and current waveforms

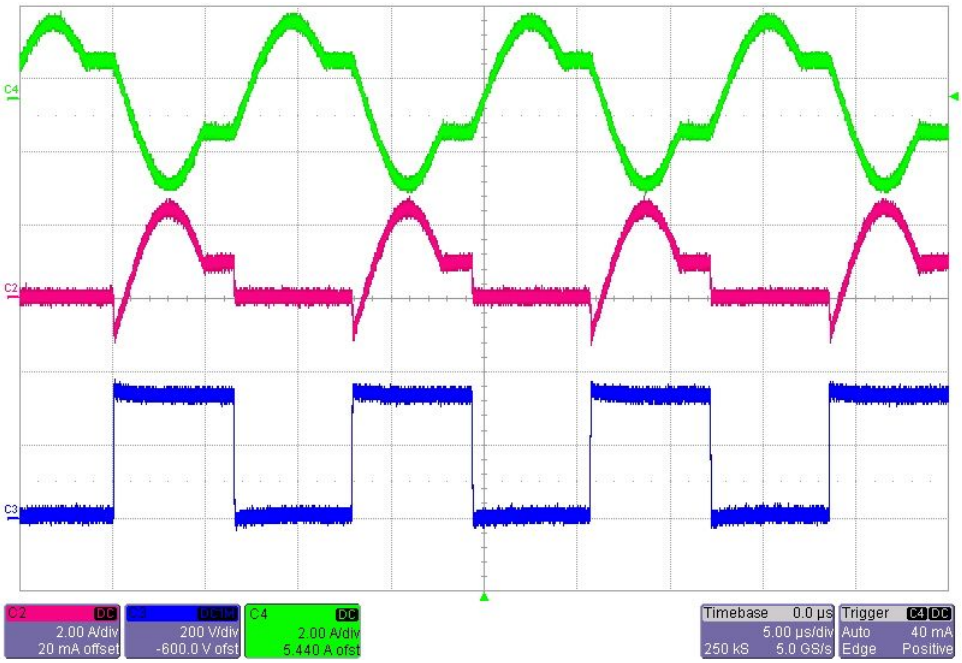

Figure 8. Operation waveforms at minimum input voltage [V_{IN}=340V_{DC}, Po=200W (24V/8.3A)]
C2: High side MOSFET current ($HI_{DS,}$) (2A/div), **C3**: Low side MOSFET V_{DS} (LV_{DS}) (200V/div),
C4: Transformer Primary side current (I_P) (2A/div), time: 5us/div

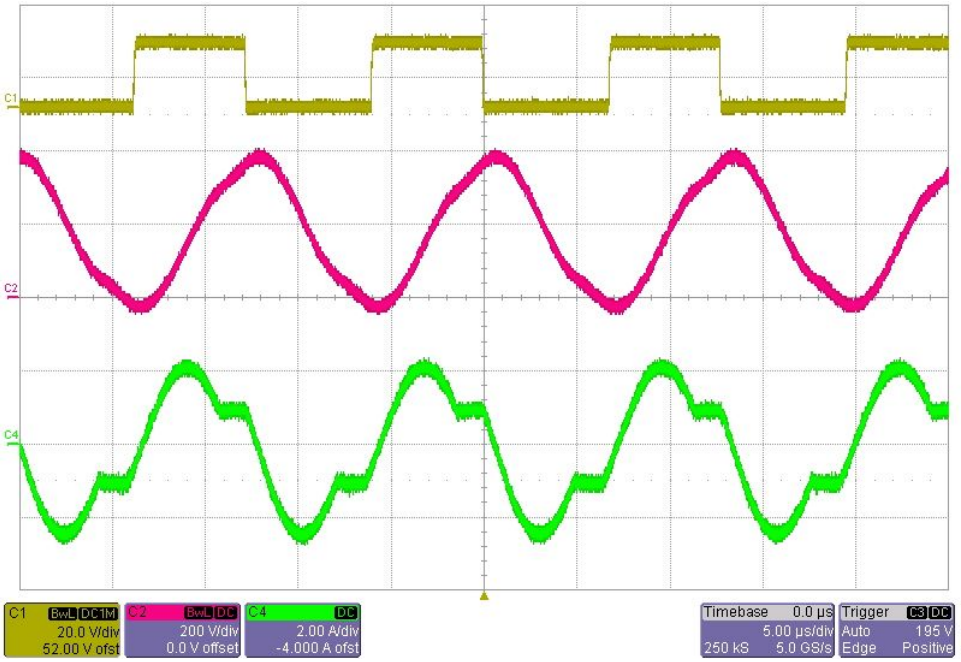

Figure 9. Operation waveforms at minimum input voltage [V_{IN}=340V_{DC}, Po=200W (24V/8.3A)]
C1: Low side V_{GS} (V_{LO}) (20V/div), **C2**: Resonant capacitor voltage (V_{Cr}) (200V/div)
C4: Transformer Primary side current (I_P) (2A/div), time: 5us/div

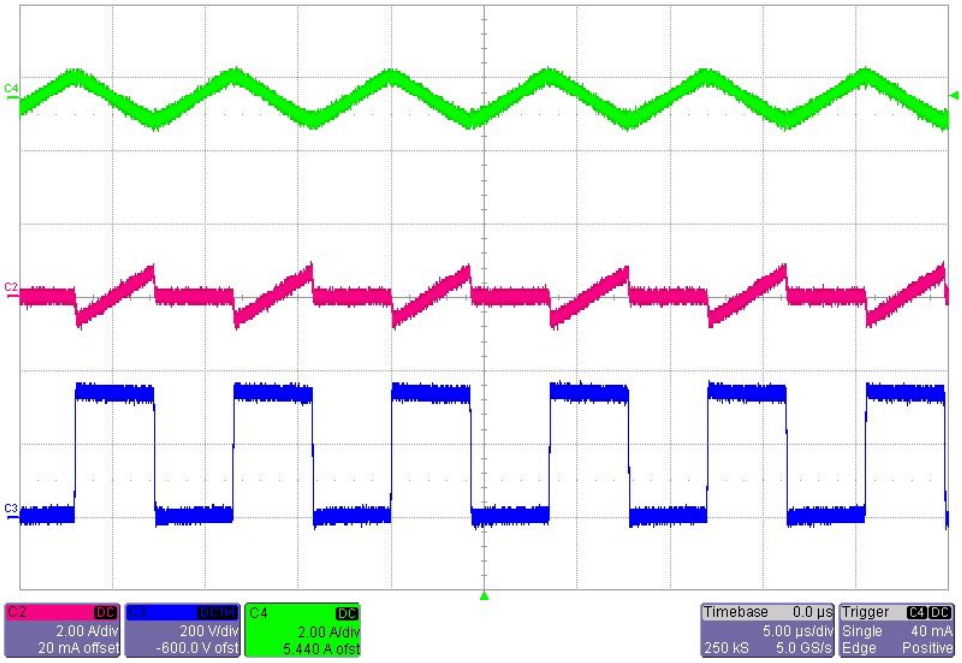

Figure 10. Operation waveforms at minimum input voltage [V_{IN}=340V_{DC}, Po=0W (24V/0A)]
C2: High side MOSFET current ($HI_{DS,}$) (2A/div), **C3**: Low side MOSFET V_{DS} (LV_{DS}) (200V/div),
C4: Transformer Primary side current (I_P) (2A/div), time: 5us/div

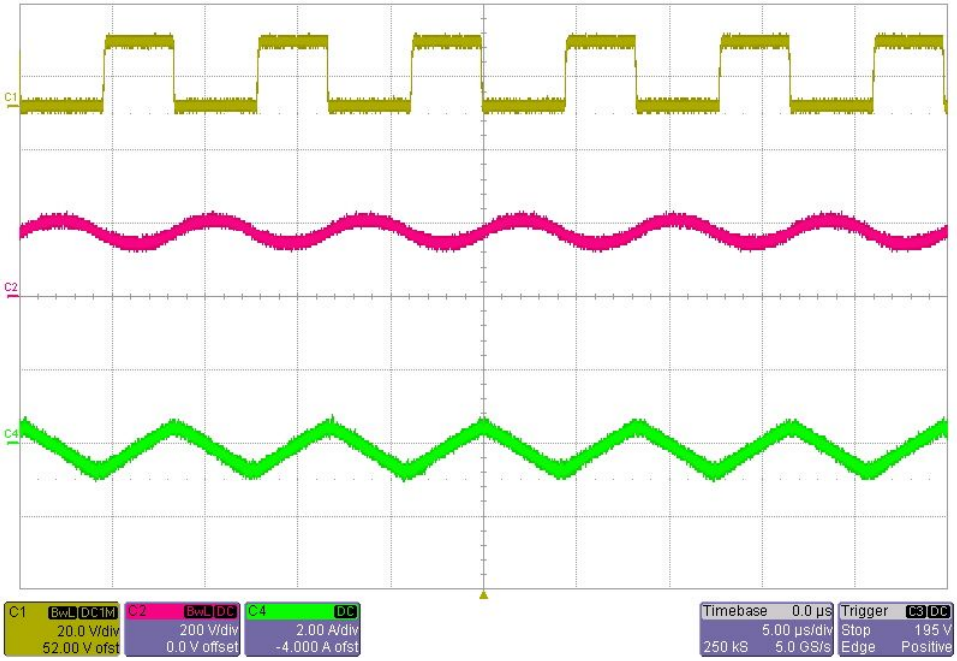

Figure 11. Operation waveforms at minimum input voltage [V_{IN}=340V_{DC}, Po=0W (24V/0A)]
C1: Low side V_{GS} (V_{LO}) (20V/div), **C2**: Resonant capacitor voltage (V_{Cr}) (200V/div)
C4: Transformer Primary side current (I_P) (2A/div), time: 5us/div

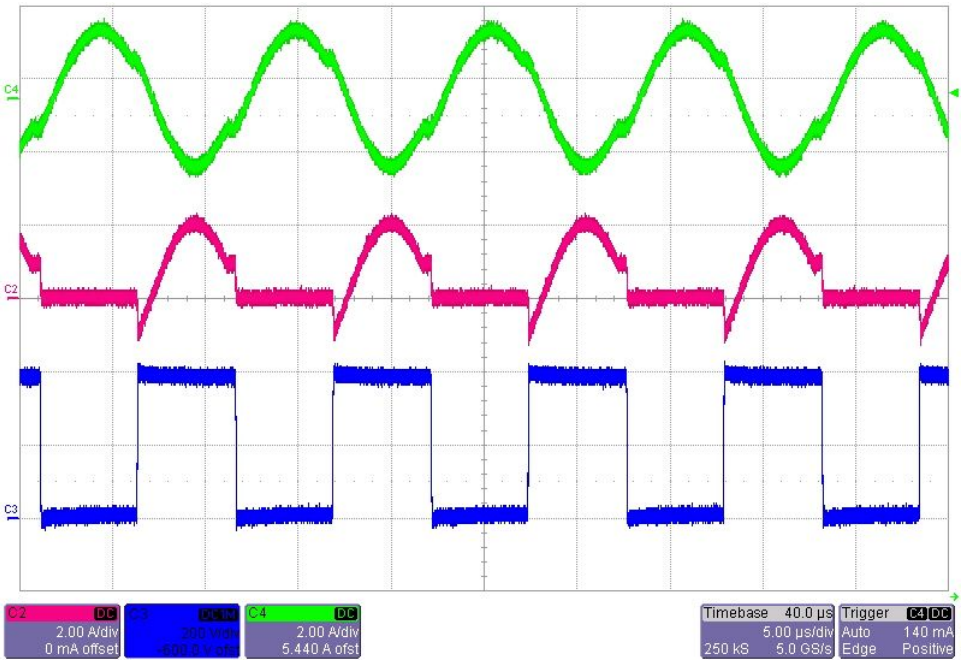

Figure 12. Operation waveforms at nominal input voltage [V_{IN}=390V_{DC}, Po=200W (24V/8.3A)]
C2: High side MOSFET current ($HI_{DS,}$) (2A/div), **C3**: Low side MOSFET V_{DS} (LV_{DS}) (200V/div),
C4: Transformer Primary side current (I_P) (2A/div), time: 5us/div

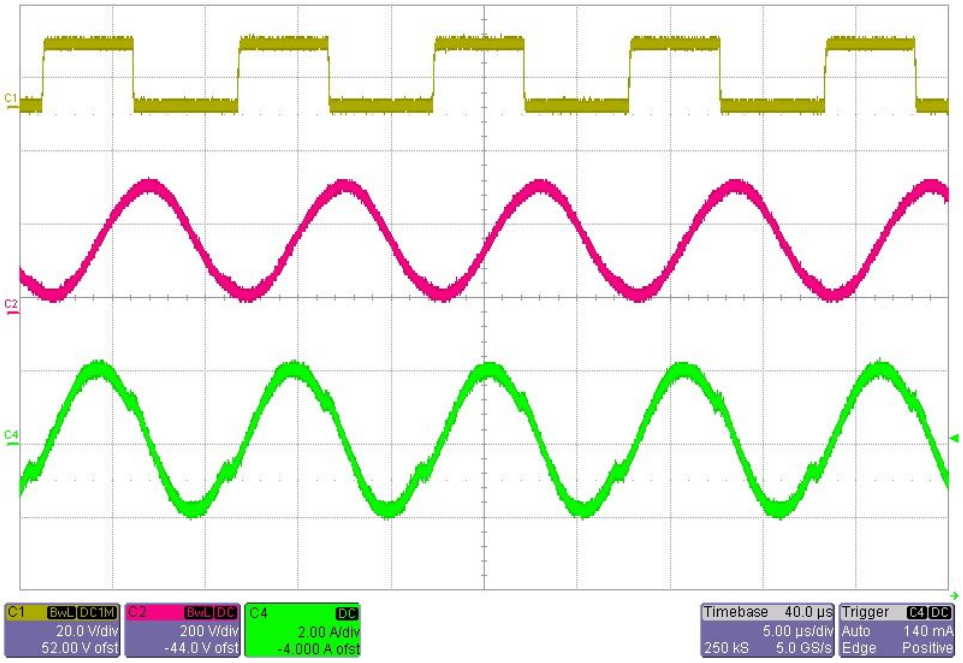

Figure 13. Operation waveforms at nominal input voltage [V_{IN}=390V_{DC}, Po=200W (24V/8.3A)]
C1: Low side V_{GS} (V_{LO}) (20V/div), **C2**: Resonant capacitor voltage (V_{Cr}) (200V/div)
C4: Transformer Primary side current (I_P) (2A/div), time: 5us/div

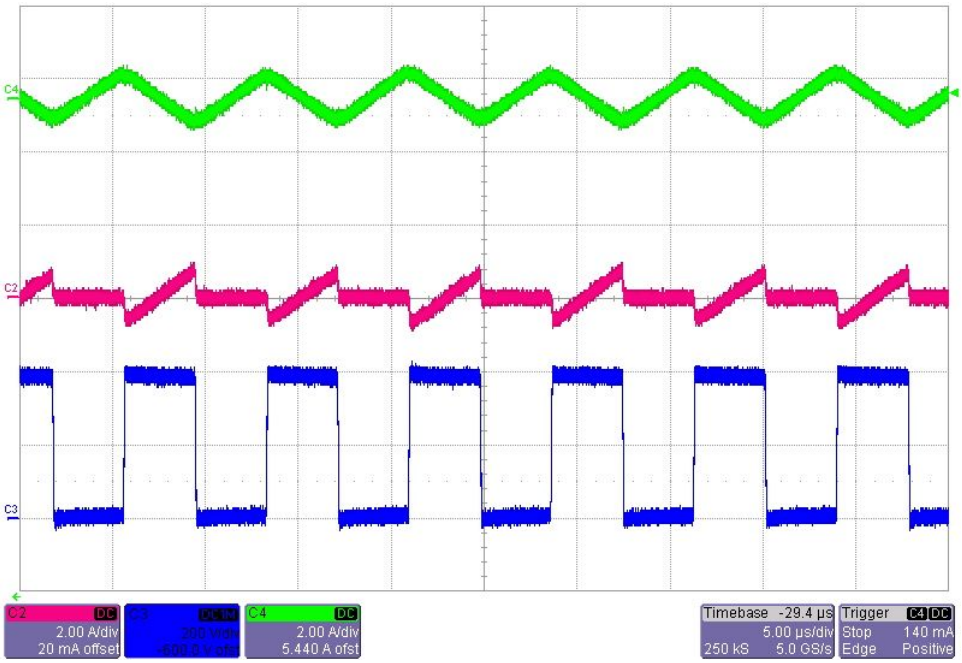

Figure 14. Operation waveforms at nominal input voltage [V_{IN}=390V_{DC}, Po=0W (24V/0A)]
C2: High side MOSFET current ($HI_{DS,}$) (2A/div), **C3**: Low side MOSFET V_{DS} (LV_{DS}) (200V/div),
C4: Transformer Primary side current (I_P) (2A/div), time: 5us/div

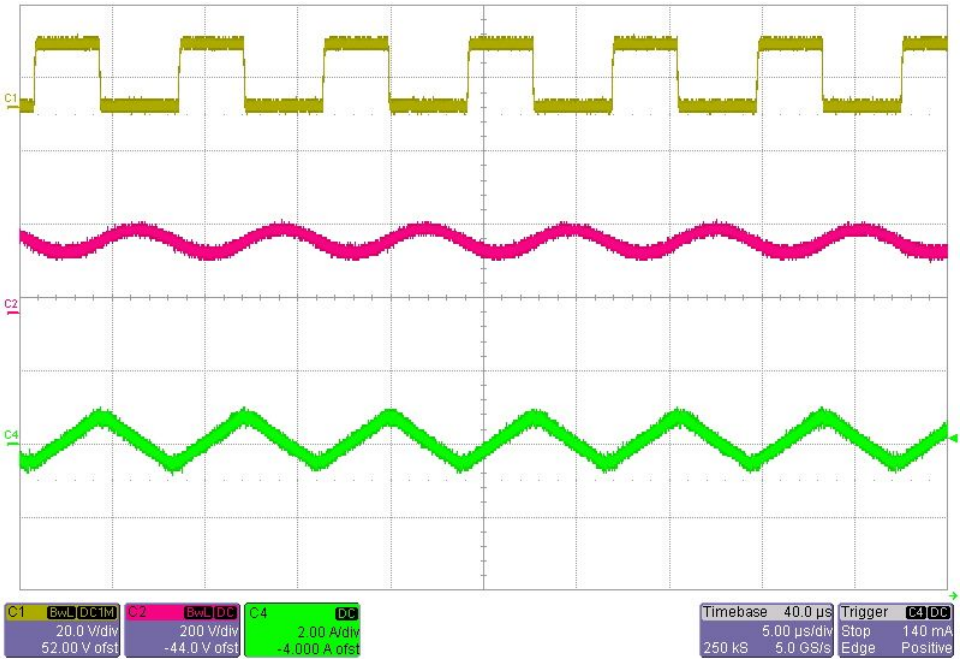

Figure 15. Operation waveforms at nominal input voltage [V_{IN}=390V_{DC}, Po=0W (24V/0A)]
C1: Low side V_{GS} (V_{LO}) (20V/div), **C2**: Resonant capacitor voltage (V_{Cr}) (200V/div)
C4: Transformer Primary side current (I_P) (2A/div), time: 5us/div

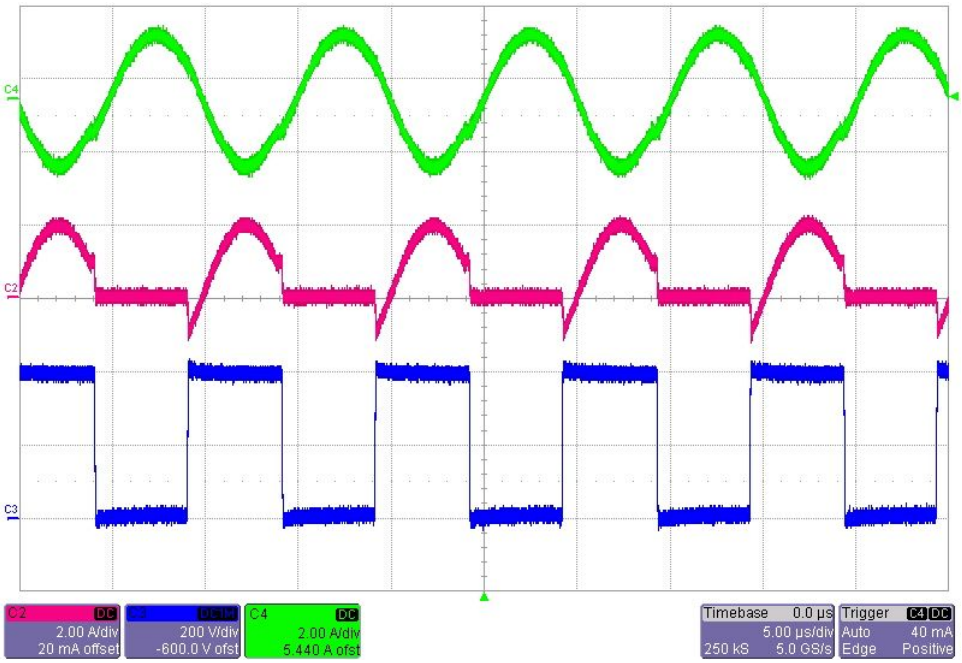

Figure 16. Operation waveforms at maximum input voltage [V_{IN}=400V_{DC}, Po=200W (24V/8.3A)]
C2: High side MOSFET current ($HI_{DS,}$) (2A/div), **C3**: Low side MOSFET V_{DS} (LV_{DS}) (200V/div),
C4: Transformer Primary side current (I_P) (2A/div), time: 5us/div

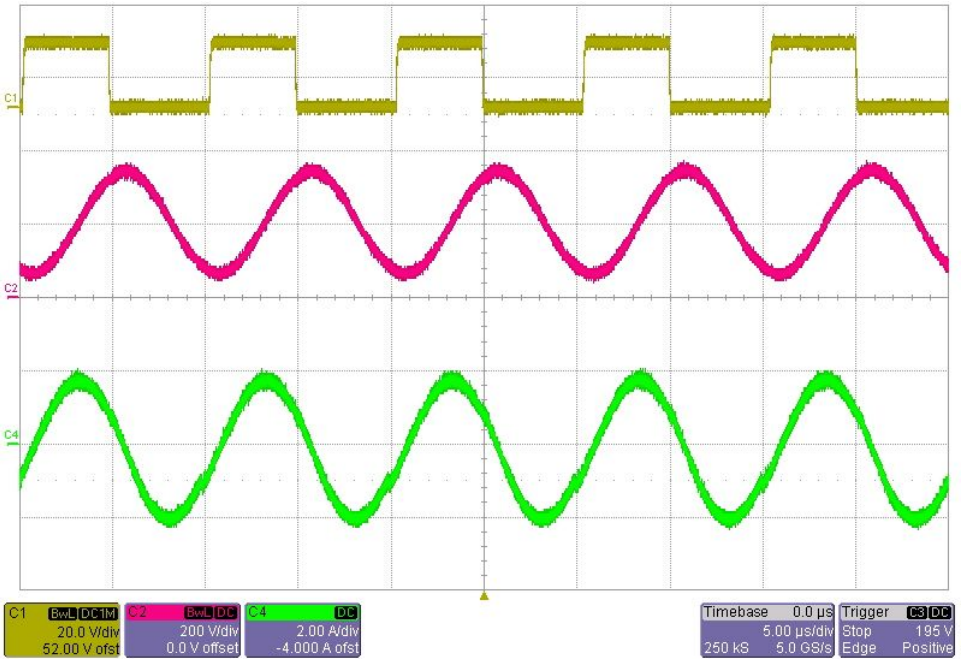

Figure 17. Operation waveforms at maximum input voltage [V_{IN}=400V_{DC}, Po=200W (24V/8.3A)]
C1: Low side V_{GS} (V_{LO}) (20V/div), **C2**: Resonant capacitor voltage (V_{Cr}) (200V/div)
C4: Transformer Primary side current (I_P) (2A/div), time: 5us/div

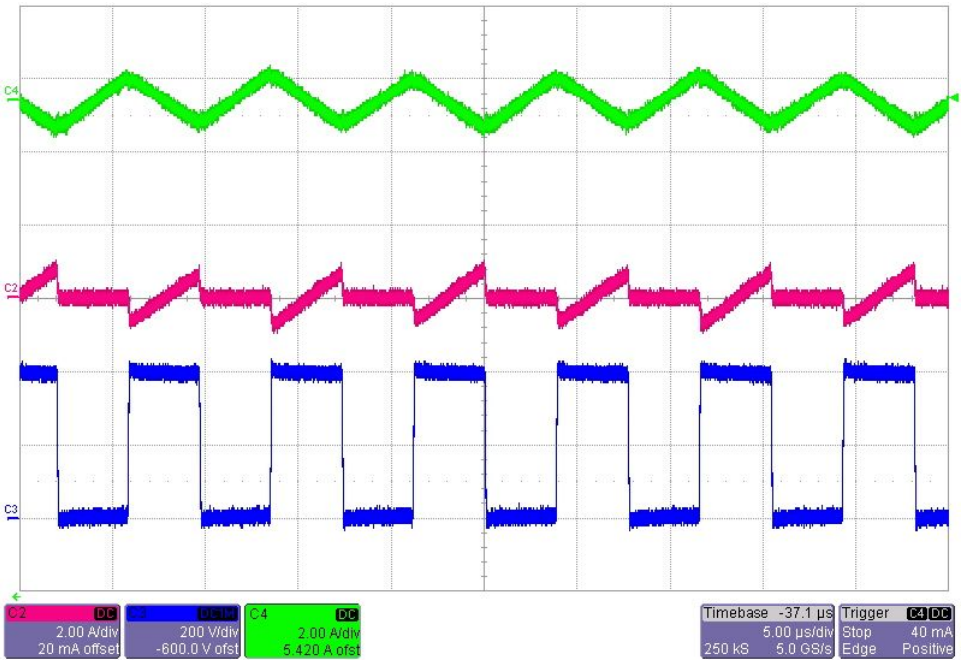

Figure 18. Operation waveforms at maximum input voltage [V_{IN}=400V_{DC}, Po=0W (24V/0A)]
C2: High side MOSFET current ($HI_{DS,}$) (2A/div), **C3**: Low side MOSFET V_{DS} (LV_{DS}) (200V/div),
C4: Transformer Primary side current (I_P) (2A/div), time: 5us/div

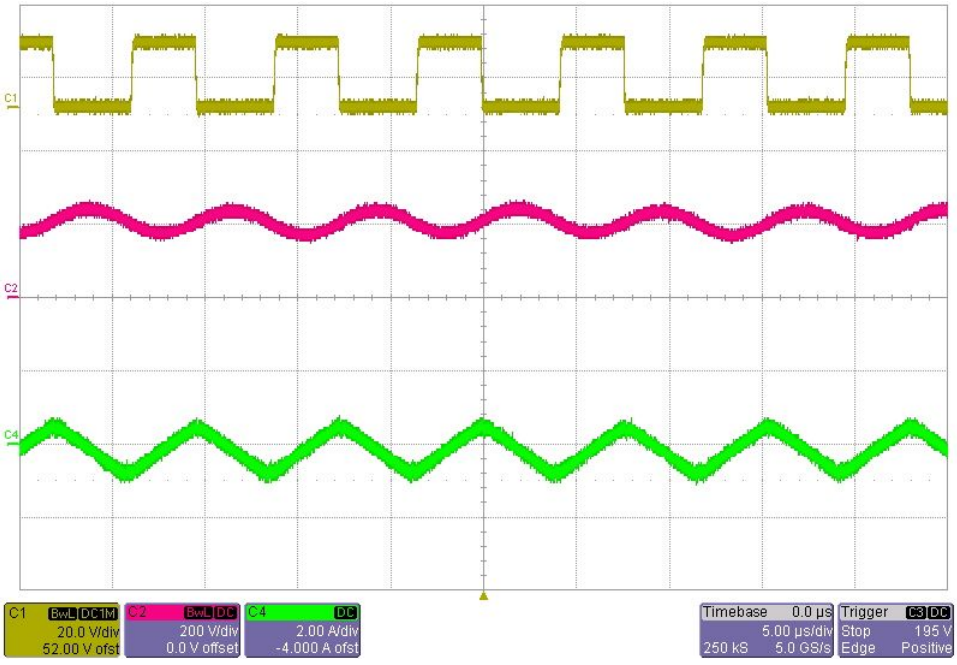

Figure 19. Operation waveforms at maximum input voltage [V_{IN}=400V_{DC}, Po=0W (24V/0A)]
C1: Low side V_{GS} (V_{LO}) (20V/div), **C2**: Resonant capacitor voltage (V_{Cr}) (200V/div)
C4: Transformer Primary side current (I_P) (2A/div), time: 5us/div

2.2 Secondary side rectifier diodes voltage and current waveforms

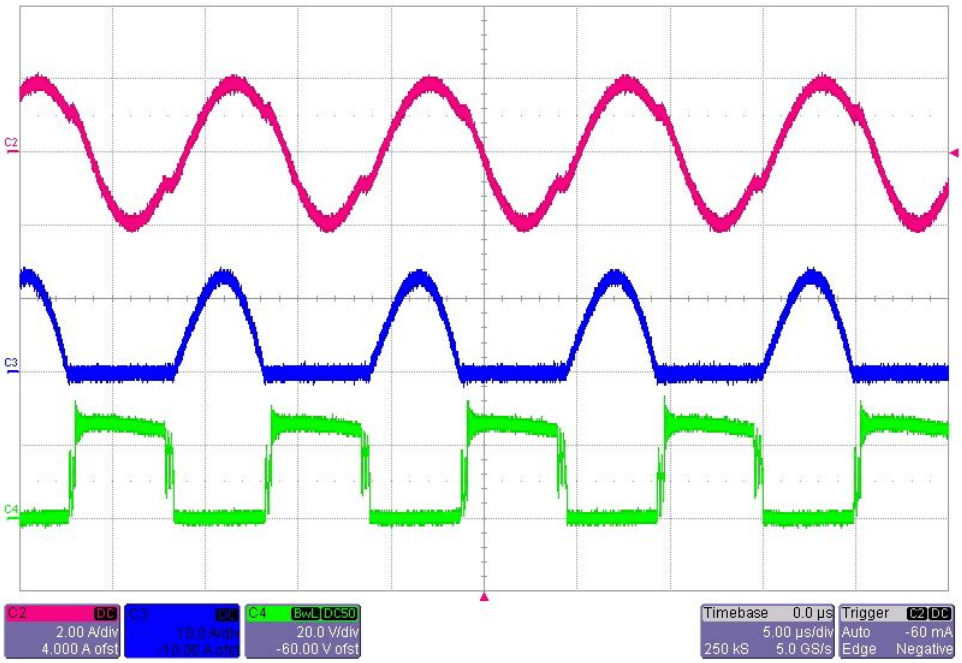

Figure 20. Operation waveforms at nominal input voltage [V_{IN}=390V_{DC}, Po=200W (24V/8.3A)]
C2: Transformer Primary side current (I_P) (2A/div), **C3**: Rectifier diode (D201) current (I_{D1}) (10A/div),
C4: Rectifier diode (D201) voltage (V_{D1}) (50V/div), time: 5us/div

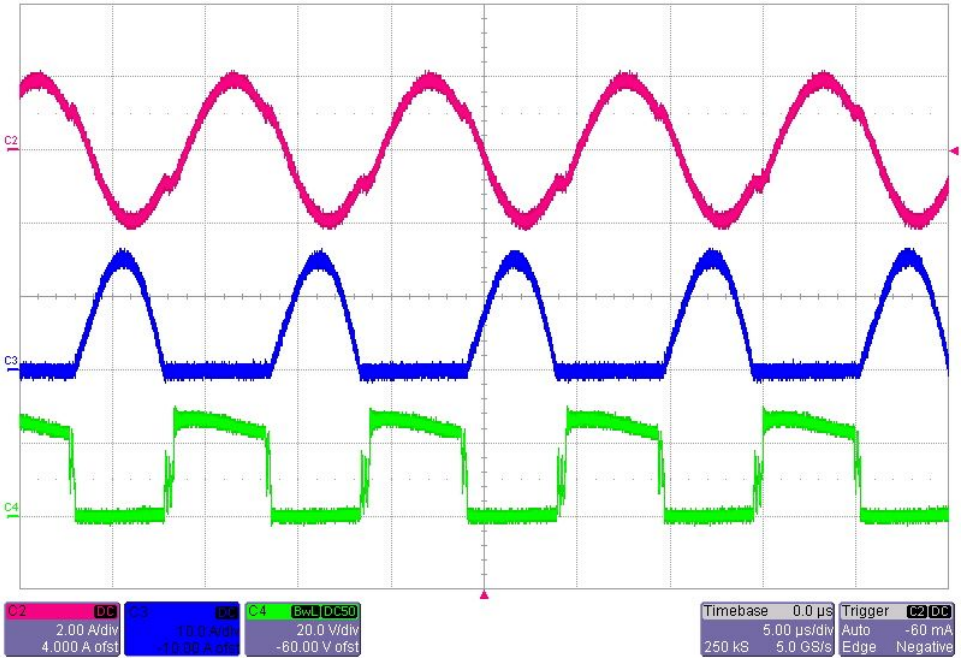

Figure 21. Operation waveforms at nominal input voltage [V_{IN}=390V_{DC}, Po=200W (24V/8.3A)]
C2: Transformer Primary side current (I_P) (2A/div), **C3**: Rectifier diode (D202) current (I_{D1}) (10A/div),
C4: Rectifier diode (D202) voltage (V_{D1}) (50V/div), time: 5us/div

2.3 On/Off waveforms

Figures 22 and 23 show the soft-start waveforms at full load and no load condition, respectively for nominal V_{IN}. To guarantee soft-start, the V_{IN} is applied first and then LVcc for FAN7621 is supplied.

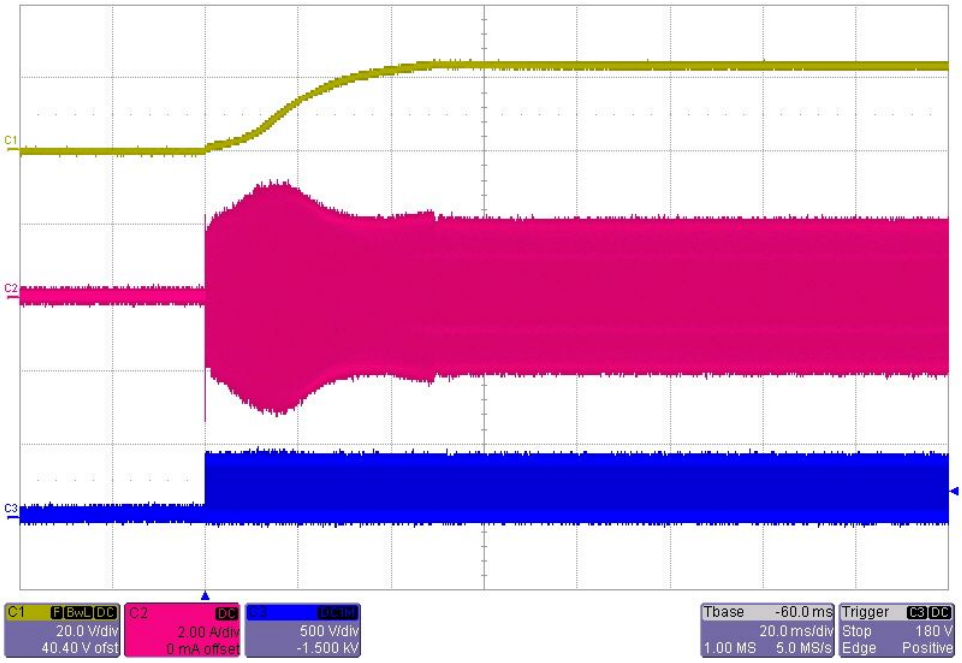

Figure 22. Startup waveforms at nominal input voltage [V_{IN}=390V_{DC}, Po=200W (24V/8.3A)]
C1: Output voltage (V_{OUT}) (20V/div), **C2**: Transformer Primary side current (I_P) (2A/div)
C3: Low side MOSFET V_{DS} (LV_{DS}) (500V/div), time: 20ms/div

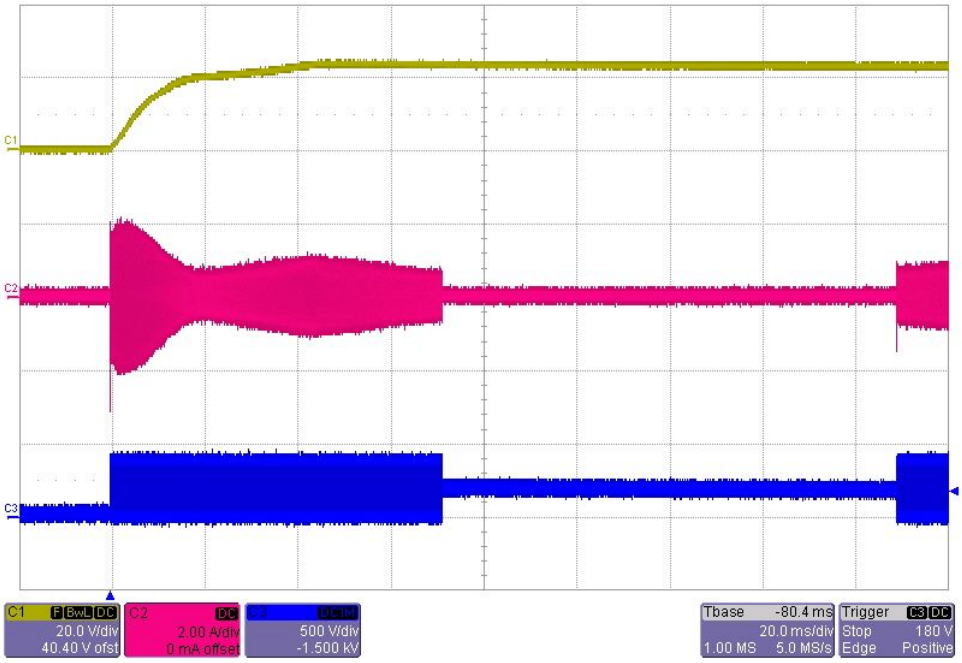

Figure 23. Startup waveforms at nominal input voltage [V_{IN}=390V_{DC}, Po=0W (24V/0A)]
C1: Output voltage (V_{OUT}) (20V/div), **C2**: Transformer Primary side current (I_P) (2A/div)
C3: Low side MOSFET V_{DS} (LV_{DS}) (500V/div), time: 20ms/div

Figure 24 shows the soft-start waveforms at nominal V_{IN} and full load condition. At startup, the switching frequency starts from 340kHz for soft-start. The switching frequency is decreased gradually to generate V_{OUT}. After V_{OUT} reaches its rated voltage, the control pin voltage decreases to regulate output voltage and the switching frequency is controlled.

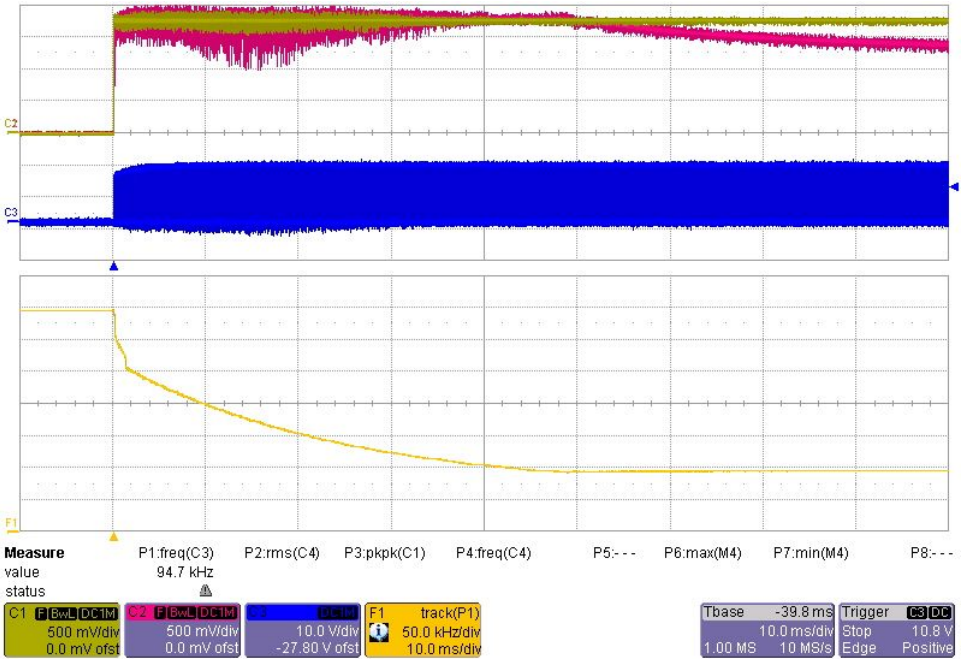

Figure 24. Startup waveforms at nominal input voltage [V_{IN}=390V_{DC}, Po=200W (24V/8.3A)]
C1: RT pin voltage (V_{RT}) (500mV/div), **C2**: Control pin voltage (V_{con}) (500mV/div)
C3: Low side V_{GS} (V_{LO}) (10V/div), **F1**: Low side V_{GS} (V_{LO}) frequency (50kHz/div), time: 10ms/div

Figure 25 shows the startup waveforms at nominal V_{IN} and full load condition. At start up, the low side MOSFET is turned on and the HV_{CC} voltage is increased. After two switching of low side MOSFET, HV_{CC} voltage reaches HV_{CC}UV+(HV_{CC} start threshold), and then the high side MOSFET operates.

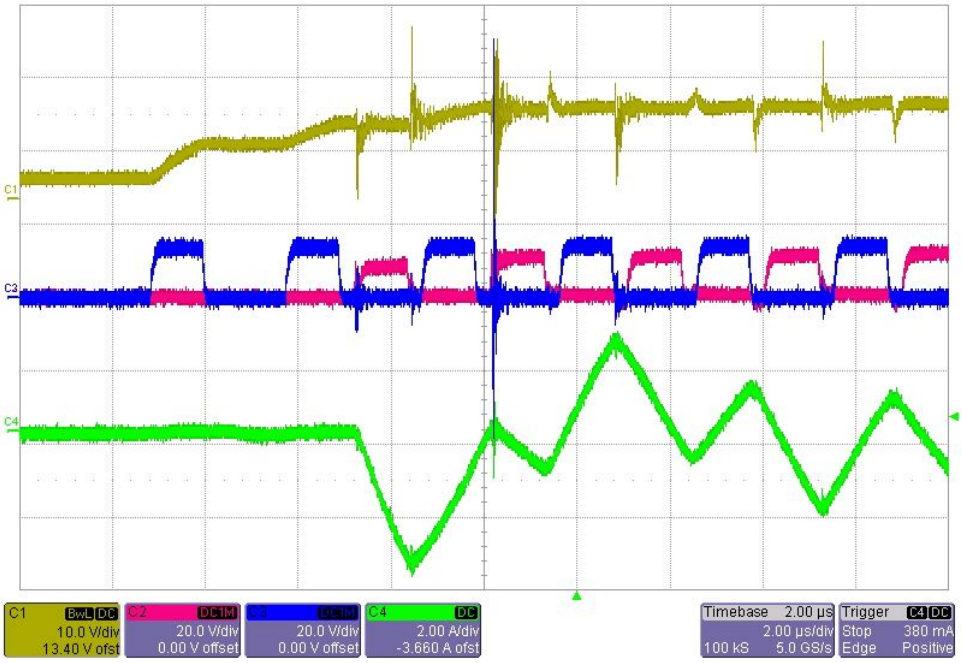

Figure 25. Startup waveforms at nominal input voltage [V_{IN}=390V_{DC}, Po=200W (24V/8.3A)]
C1: High side V_{CC} to Center voltage (HV_{CC}) (10V/div), **C2**: High side V_{GS} (V_{HO}) (20V/div),
C3: Low side V_{GS} (V_{LO}) (20V/div), **C4**: Transformer Primary side current (I_P) (2A/div), time: 2us/div

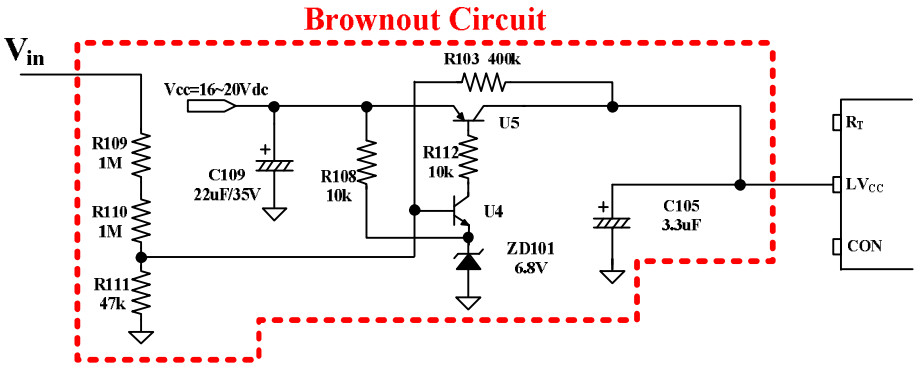

Figure 26. Brownout Circuit in The Evaluation Board

For Line-UVLO, the evaluation board employs an external brownout circuit as shown in Figure 26. The brownout circuit connects V_{CC} to LV_{CC} when the voltage between R110 and R111 reaches to the sum of U4 base-emitter saturation voltage ($V_{BE,sat}$) and ZD101 voltage (V_Z). At this moment, the input voltage is

$$V_{in,start} = \left(V_{BE,sat} + V_Z\right)\frac{R109 + R110 + R111}{R111}$$

After FAN7621 starts operating, U4 base voltage is maintained by the current through R103 as well as the current through R109 and R110. The brownout circuit disconnects V_{CC} from LV_{CC} when U4 base voltage decreases under the sum of U4 base-emitter saturation voltage ($V_{BE,sat}$) and ZD101 voltage (V_Z). At this point, the input voltage can be obtained as below.

$$V_{in,stop} = V_{BE,sat} + V_Z + \left(R109 + R110\right)\left(\frac{V_{BE,sat} + V_Z}{R111} - \frac{V_{CC} - \left(V_{BE,sat} + V_Z\right)}{R103}\right)$$

$$Hysteresis = V_{in,start} - V_{in,stop} = \frac{R109 + R110}{R103}\left(V_{CC} - \left(V_{BE,sat} + V_Z\right)\right)$$

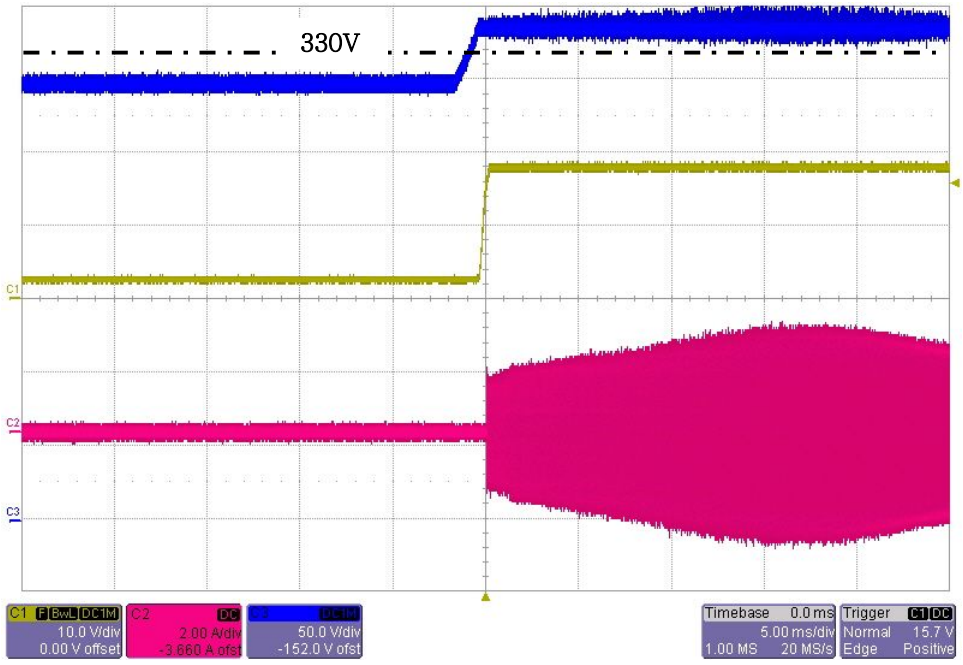

Figure 27. Power on waveforms at nominal input voltage [V_{IN}=390V_{DC}, Po=200W (24V/8.3A)]
C1: V_{CC} supply voltage (LV_{CC}) (10V/div), **C2**: Transformer Primary side current (I_P) (2A/div),
C3: Input voltage (V_{IN}) (50V/div), time: 5ms/div

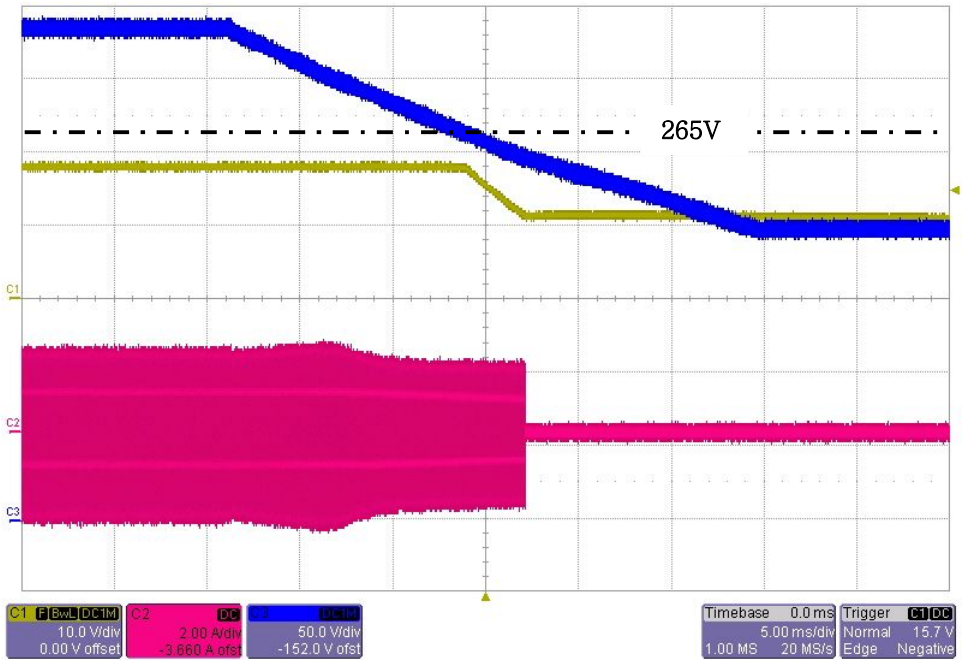

Figure 28. Power off waveforms at nominal input voltage [V_{IN}=390V_{DC}, Po=200W (24V/8.3A)]
C1: V_{CC} supply voltage (10V/div), **C2**: Transformer Primary side current (I_P) (2A/div),
C3: Input voltage (V_{IN}) (50V/div), time: 5ms/div

2.4 Output voltage ripple

Figure 29 shows $V_{O,ripple}$ at nominal V_{IN} and full load condition. The peak-to-peak $V_{O,ripple}$ is 0.35V, which is about 1.5% of V_{OUT}. Figure 30 shows $V_{O,ripple}$ under the load transient condition at nominal V_{IN}. The peak-to-peak $V_{O,ripple}$ is 0.55V, which is about 2.3% of V_{OUT}.

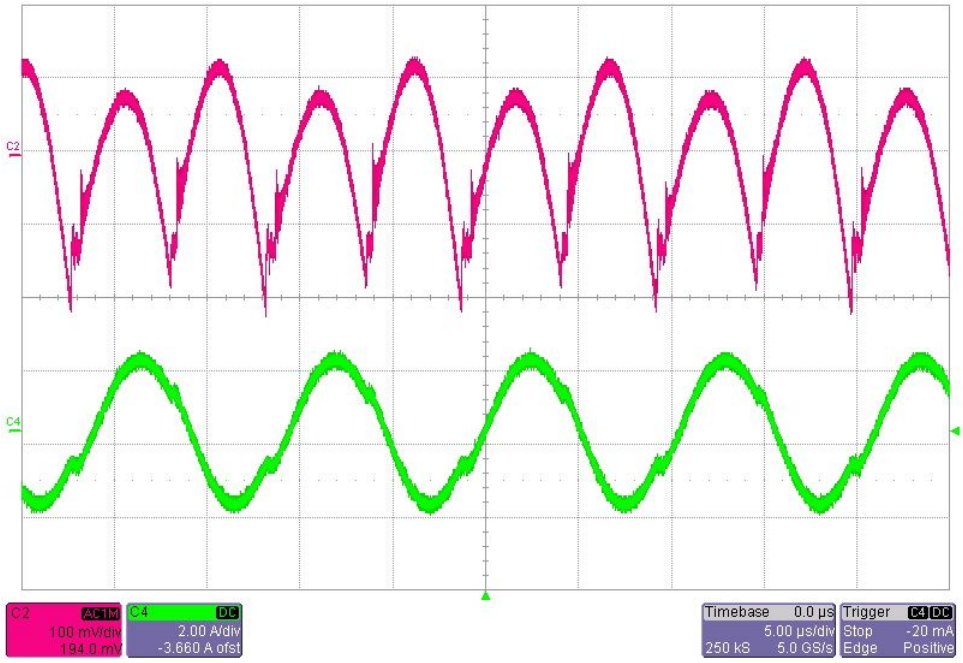

Figure 29. Output voltage ripple at nominal input voltage [V_{IN}=390V_{DC}, Po=200W (24V/8.3A)]
C2: Output voltage ripple ($V_{O,ripple}$) (100mV/div), **C4**: Transformer Primary side current (I_P) (2A/div), time: 5us/div

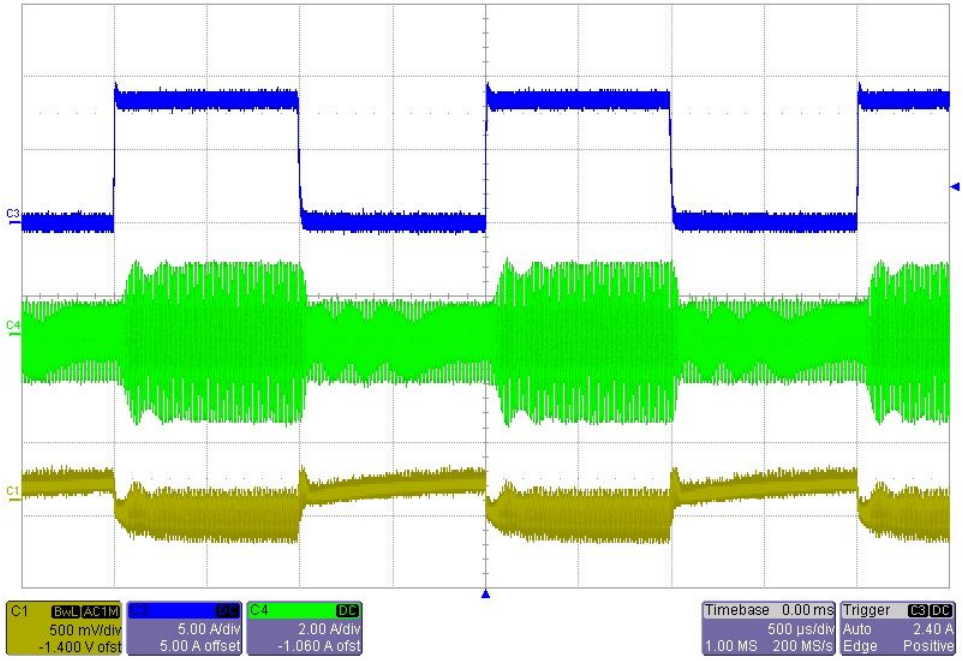

Figure 30. Output voltage ripple with transient load current at nominal input voltage [V_{IN}=390V_{DC}, (Io=0A ↔ 8.3A, slew rate=2A/us, duty=50%, freq=500Hz)]
C1: Output voltage ripple ($V_{O,ripple}$) (500mV/div), **C3**: Output load current (I_{OUT}) (5A/div),
C4: Transformer Primary side current (I_P) (2A/div), time: 500us/div

2.5 Hold up time test

In order to see the holdup time, V_{IN} is disconnected while the converter operates at full load condition. It is observed V_{OUT} is maintained for 30ms when V_{IN} is disconnected.

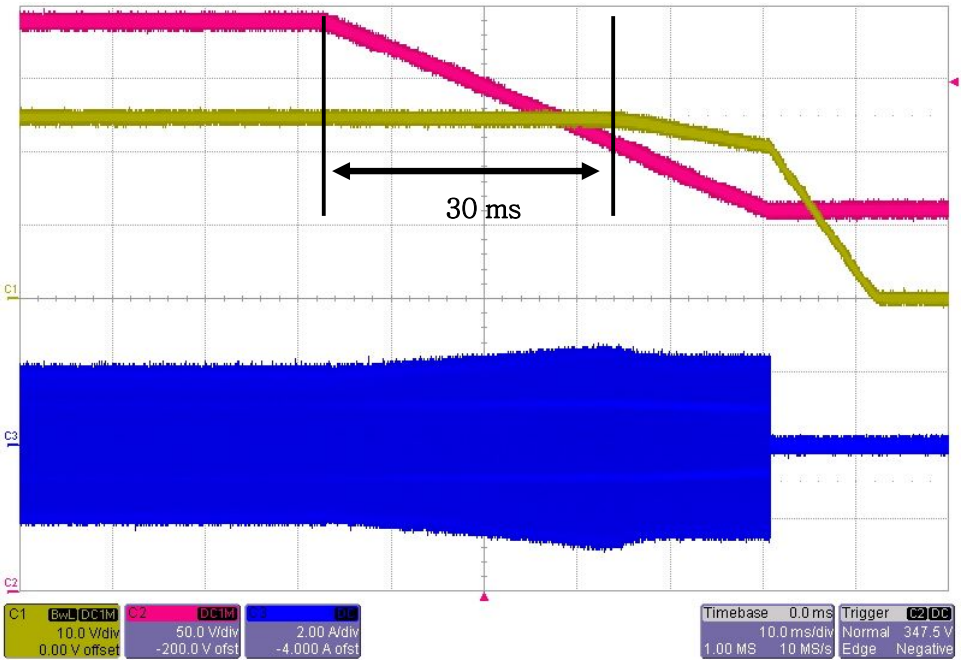

Figure 31. Output voltage waveform after turning off input voltage [V_{IN}=390V_{DC}, Po=200W (24V/8.3A)]
C1: Output voltage (V_{OUT}) (10V/div), **C2**: Input voltage (V_{IN}) (50V/div),
C3: Transformer Primary side current (I_P) (2A/div), time: 10ms/div

2.6 Protection operation waveforms

Figure 32 shows the over load condition. I_{OUT} increases from 8.3A to 16.6A. When I_P reaches over its trip point of 3A for the OCP blanking time of 1.5us, the over current protection is triggered.

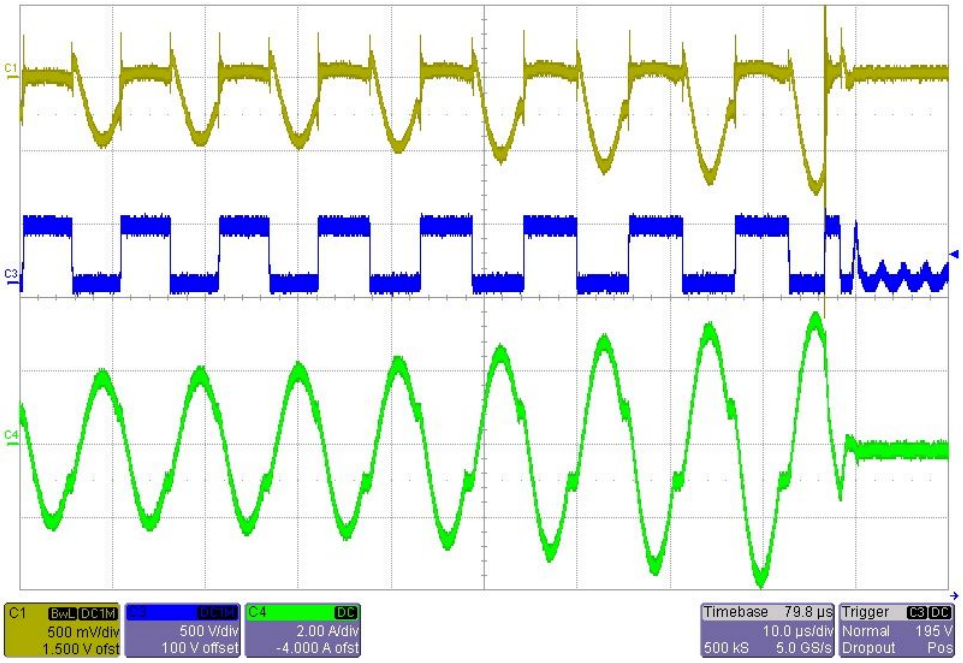

Figure 32. Protection waveform at over load condition [V_{IN}=390V_{DC}, (Io=8.3A → 16.6A)]
C1: Current sensing pin voltage (V_{CS}) (500mV/div), **C3**: Low side MOSFET V_{DS} (LV_{DS}) (500V/div),
C4: Transformer Primary side current (I_P) (2A/div), time: 10us/div

Figure 33 shows the output short condition. When I_P reaches over its trip point of 3A for the OCP blanking time of 1.5us, the over current protection is triggered.

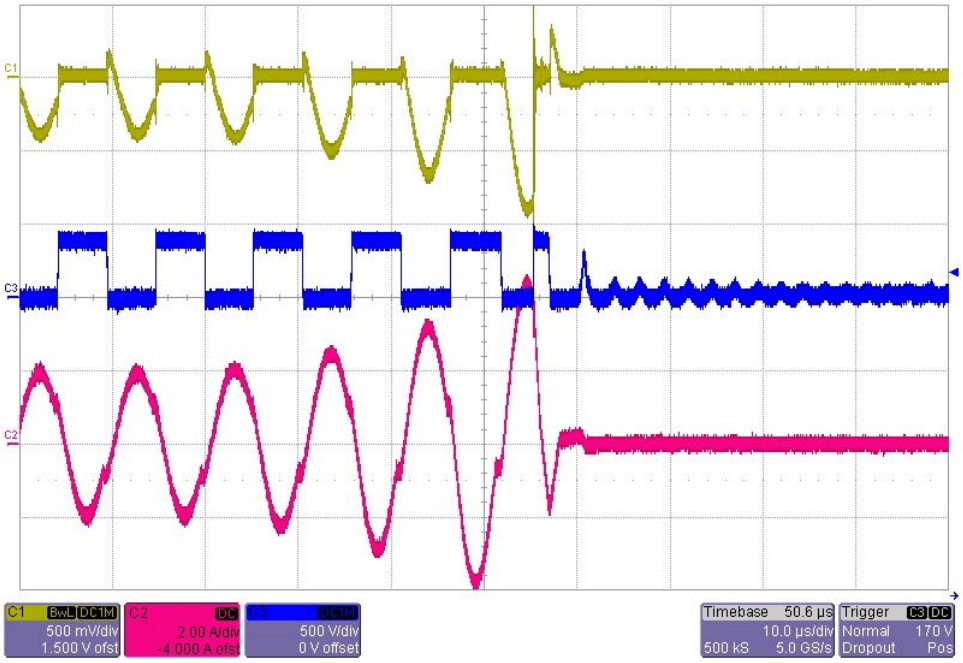

Figure 33. Protection waveform at output short condition [V_{IN}=390V_{DC}, (Io=8.3A → short)]
C1: Current sensing pin voltage (V_{CS}) (500mV/div), **C2**: Transformer Primary side current (I_P) (2A/div),
C3: Low side MOSFET V_{DS} (LV_{DS}) (500V/div), time: 10us/div

Figure 34 shows the secondary rectifier short protection waveforms. When I_P reaches its trip point of 5A, the abnormal over current protection is triggered.

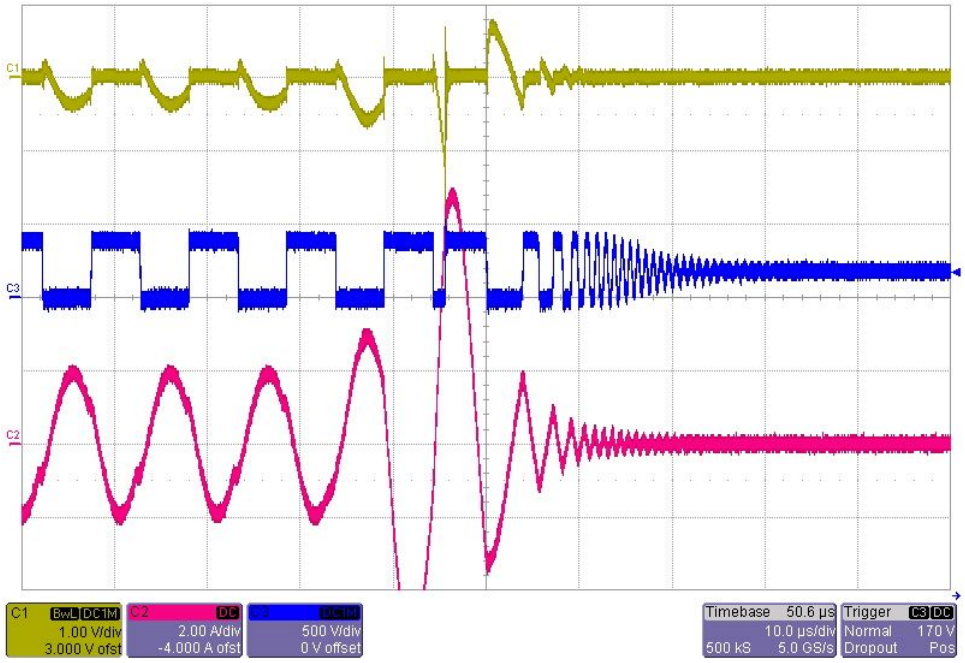

Figure 34. Protection waveform at secondary rectifier (D201) short condition [V_{IN}=390V_{DC}, Io=8.3A]
C1: Current sensing pin voltage (V_{CS}) (1V/div), **C2**: Transformer Primary side current (I_P) (2A/div),
C3: Low side MOSFET V_{DS} (LV_{DS}) (500V/div), time: 10us/div

2.7 Efficiency

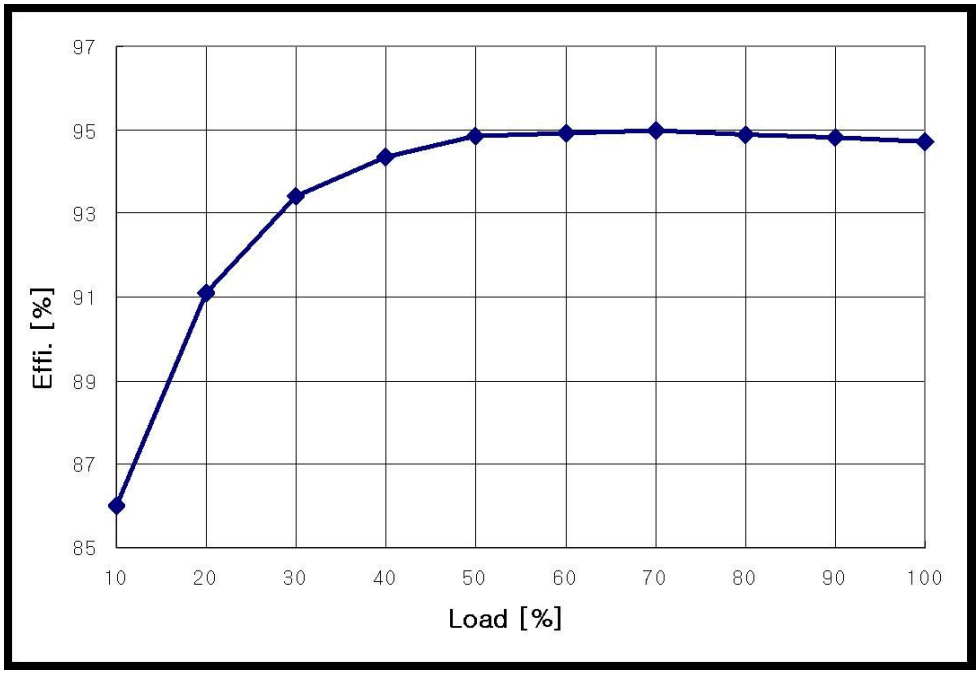

Figure 35. Measured efficiency [V_{IN}=390V_{DC}, Io=8.3A]

2.8 Temperature

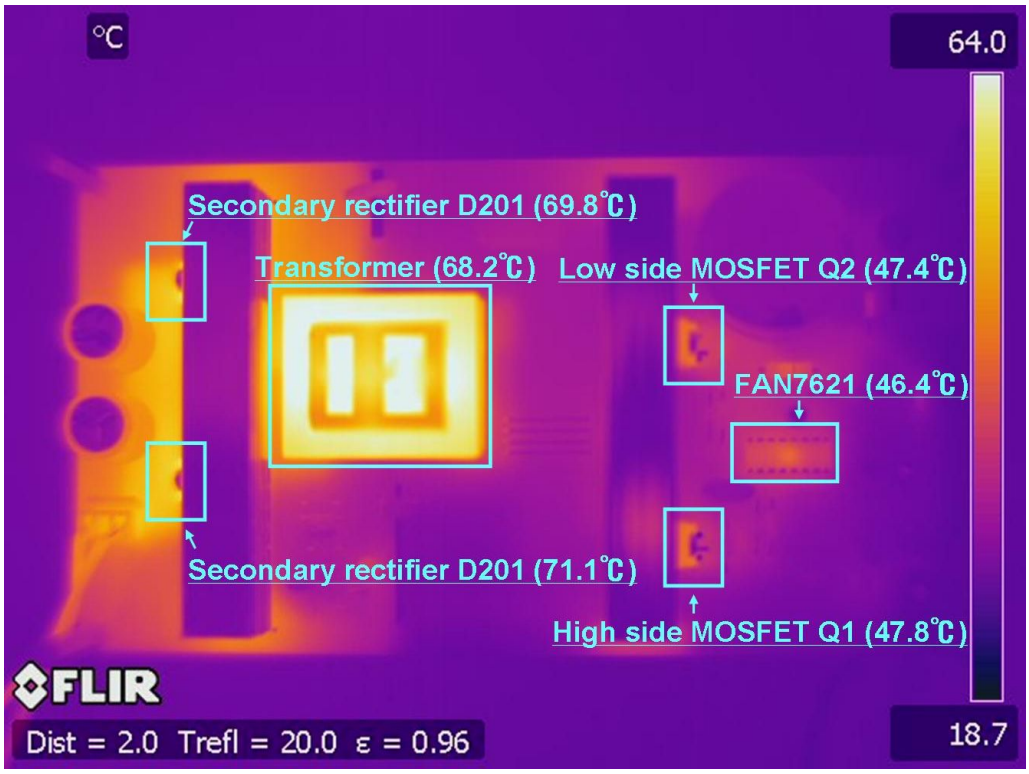

Figure 36. Temperature [V_{IN}=390V_{DC}, Io=8.3A]

Warning and Disclaimer:

This Evaluation Board may employ high voltages so appropriate safety precautions should be used when operating this board. Replace components on the Evaluation Board only with those parts shown on the parts list in the User's Guide. Contact an authorized Fairchild representative with any questions.

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