44 W, 12 V SMPS reference board with CoolSET™ ICE5AR0680BZS-1

REF_5AR0680BZS-1_44W1

About this document

Scope and purpose

This document describes a universal-input 44 W, 12 V offline flyback converter using the latest CoolSET™ 5th Generation Fixed Frequency Plus ICE5AR0680BZS-1 switching controller from Infineon, which offers high efficiency, low standby power with selectable entry and exit standby power options, wide V_{CC} operating range with fast startup, and various modes of protection for a highly reliable system.

This reference board is designed to evaluate the performance of CoolSET™ ICE5AR0680BZS-1 switching controller for optimized efficiency, thermal performance, and EMI.

Intended audience

This document is intended for power supply design/application engineers, students, etc. who wish to design low-cost and highly reliable systems of offline SMPS, such as auxiliary power supplies for white goods, PCs, servers, and TVs, or enclosed adapters for gaming consoles.

CoolSET™

Infineon's CoolSET™ AC-DC integrated power stages in fixed-frequency switching scheme offers increased robustness and outstanding performance. This family offers superior energy efficiency, comprehensive protective features, and reduced system costs and is ideally suited for auxiliary power supply applications in a wide variety of potential applications such as:

- SMPS
- Home appliances
- Server
- Telecom

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1 Introduction

This document describes a 44 W 12 V reference board designed in a Fixed Frequency flyback converter topology using the CoolSET™ 5th Generation Fixed Frequency Plus ICE5AR0680BZS-1 switching controller.

The reference board is operated in continuous conduction mode (CCM) and is running at 100 kHz fixed switching frequency to optimize low-line full-load efficiency. The frequency reduction with soft gate driving and frequency jittering offers lower EMI and better efficiency between light load and 50 percent load conditions. The selectable active burst mode (ABM) enables ultra-low power consumption.

In addition, numerous adjustable protection functions have been implemented in the ICE5AR0680BZS-1 switching controller to protect the system and customize the IC for the chosen application. In case of failure modes, such as VCC overvoltage (OV)/undervoltage (UV), open control loop or overload, overtemperature, V_{CC} short-to-GND and CS short-to-GND, the device enters into protection mode.

By cycle-by-cycle peak current limitation (PCL), the dimensions of the transformer and current rating of the secondary diode can both be optimized. In this way, a cost-effective solution can easily be achieved. Target applications of ICE5AR0680BZS-1 switching controller are either auxiliary power supplies for white goods, PCs, servers, and TVs, or enclosed adapters for gaming consoles.

This document contains the list of features, power supply specifications, schematics, bill of materials (BOM), and transformer construction. Typical operating characteristics such as performance curves and scope waveforms are shown at the end of the document.

2 Reference board

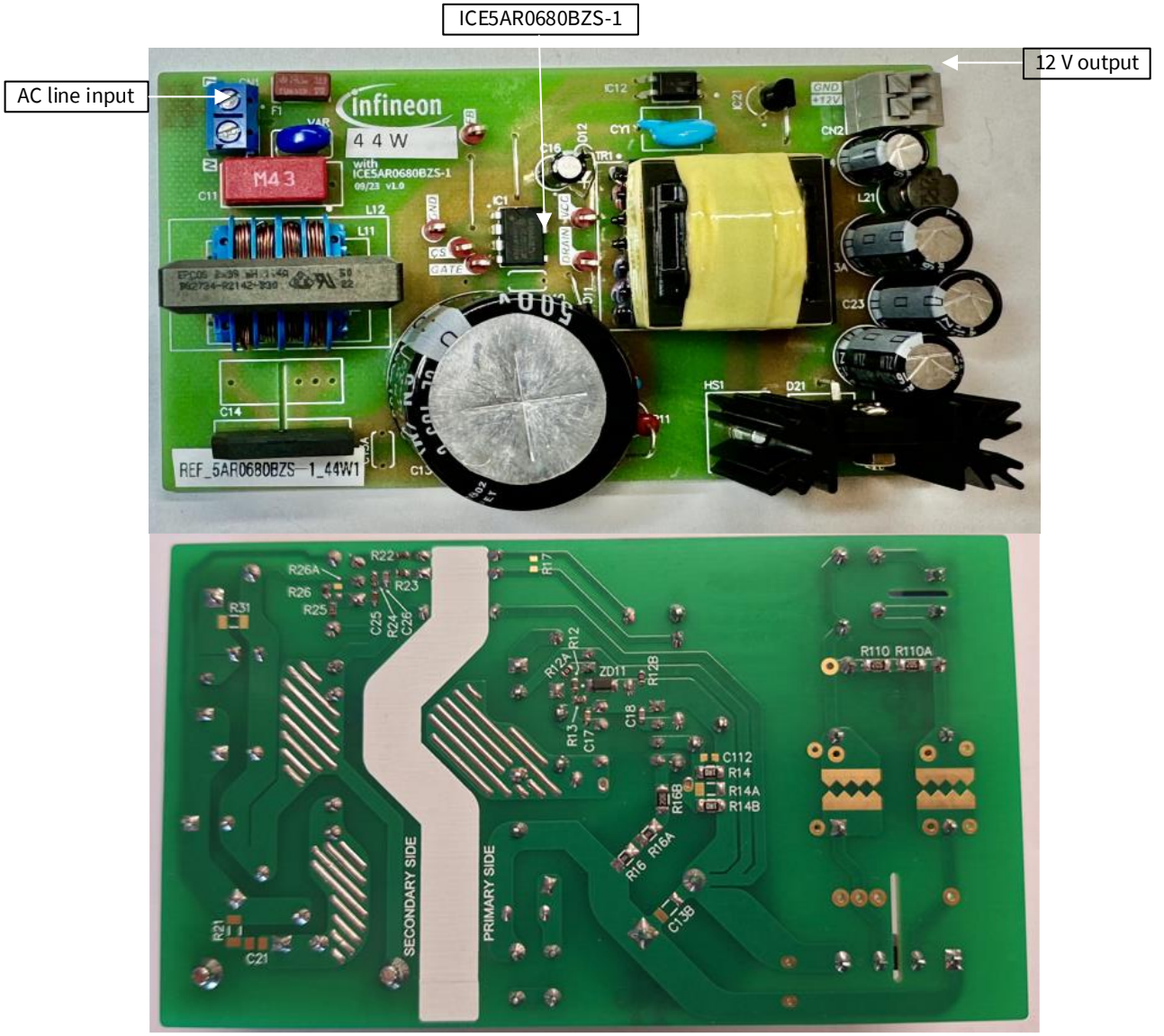


Figure 1 REF_5AR0680BZS-1_44W1

2.1 Reference board specifications

Table 1 REF_5AR0680BZS-1_44W1 specifications

Input voltage and frequency	85 V AC (60 Hz) ~ 300 V AC (50 Hz)
Output voltage, current, and power	12 V x 3.66 A = 44 W
Dynamic load response (12 V load change from 10% to 100%, slew rate at 0.4 A/µs, 100 Hz)	±3% of nominal output voltage
Output ripple voltage (full load, 85 V AC ~ 300 V AC)	12 $V_{ripple\_p\_p}$ < 100 mV
Active mode four-point average efficiency (25%, 50%, 75%, 100% load)	> 87% at 115 V AC and 230 V AC
No-load power consumption	< 100 mW at 300 V AC
Conducted emissions (EN 55022 Class-B)	Pass with 8 dB margin for 115 V AC and 6 dB margin for 230 V AC
ESD immunity (EN 61000-4-2)	Level 4 for contact discharge and Level 3 for air discharge (±8 kV for both contact and air discharge)
Surge immunity (EN 61000-4-5)	Installation Class 4 (±2 kV for line-to-line and ±4 kV for line-to-earth)
Form factor case size (L x W x H)	118 mm x 67 mm x 35 mm

3 Circuit description

3.1 Line input

The AC line input side comprises the input fuse (F1) as overcurrent protection. The choke (L11), X-capacitor (C11), and Y-capacitor (CY1) act as EMI suppressors. Optional spark-gap devices (SA1 and SA2) and varistor (VAR) can absorb the high voltage (HV) stress during a lightning surge test. A rectified DC voltage (120 ~ 424 V DC) is obtained through the bridge rectifier (BR1) together with the bulk capacitor (C13).

3.2 Startup

To achieve fast and safe startup, the ICE5AR0680BZS-1 switching controller is implemented with a startup resistor and V_{CC} short-to-GND protection. When V_{VCC} reaches the turn-on voltage threshold of 16 V, the IC begins with a soft start.

The soft start implemented in ICE5AR0680BZS-1 is a digital time-based function. The preset soft-start time is 12 ms with four steps. If not limited by other functions, the peak voltage on the CS pin will increase in increments from 0.3 V to 0.8 V. After the IC turn-on, the VCC voltage is supplied by the auxiliary windings of the transformer. V_{CC} short-to-GND protection is implemented during the startup time.

3.3 Integrated CoolMOS™ MOSFET with frequency reduction control

ICE5AR0680BZS-1 switching controller comprises a CoolMOS™ superjunction MOSFET and the frequency reduction control, which enables better efficiency between light load and 50% load conditions. This integrated solution greatly simplifies the circuit layout and reduces the cost of PCB manufacturing.

The latest CoolSET™ switching controller can be operated in either discontinuous conduction mode (DCM) or CCM with frequency reduction mode. This reference board is designed to operate in CCM to increase the efficiency under low-line full-load conditions. When the system is operating at maximum power, the controller will switch at the Fixed Frequency of 100 kHz. To achieve a better efficiency between light load and medium load, frequency reduction is implemented; the reduction curve is shown in Figure 2. V_{CS} is clamped by the current limitation threshold or by the PWM opamp while the switching frequency is reduced. After maximum frequency reduction, the minimum switching frequency is f_{OSC4_MIN} (43 kHz).

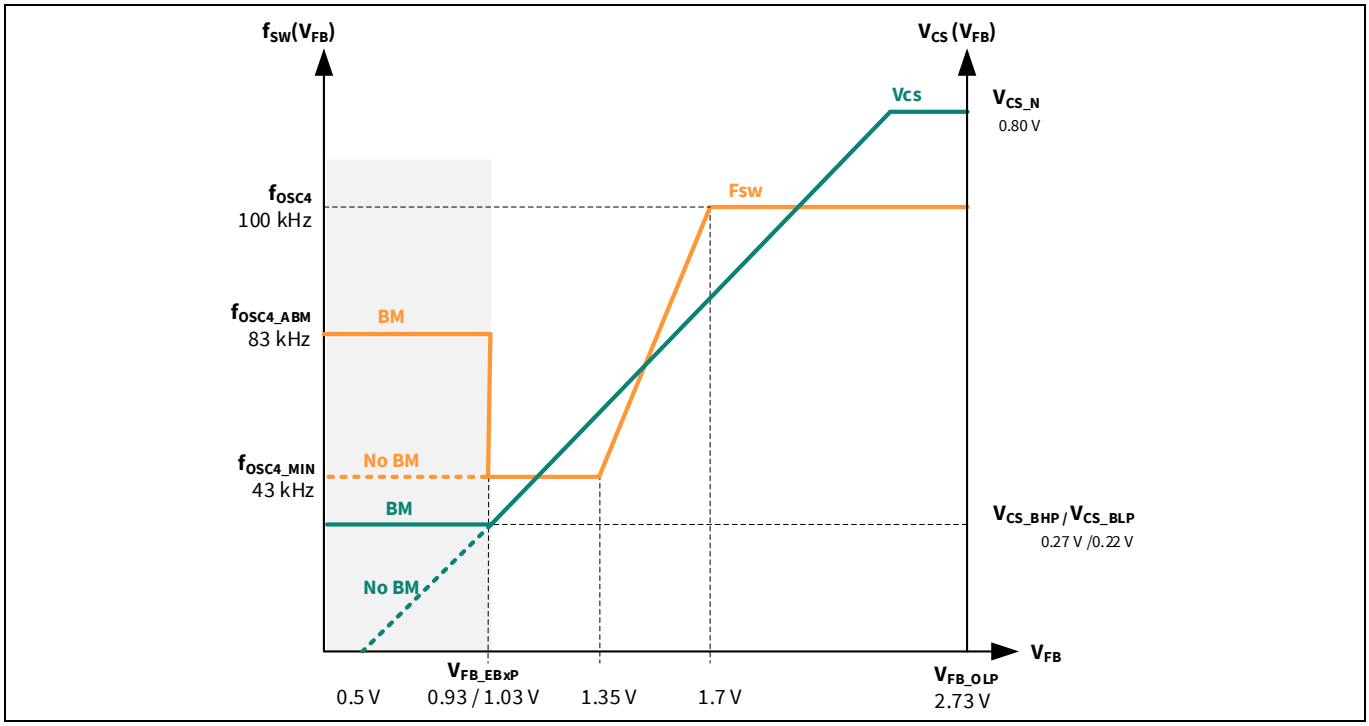


Figure 2 Frequency reduction curve

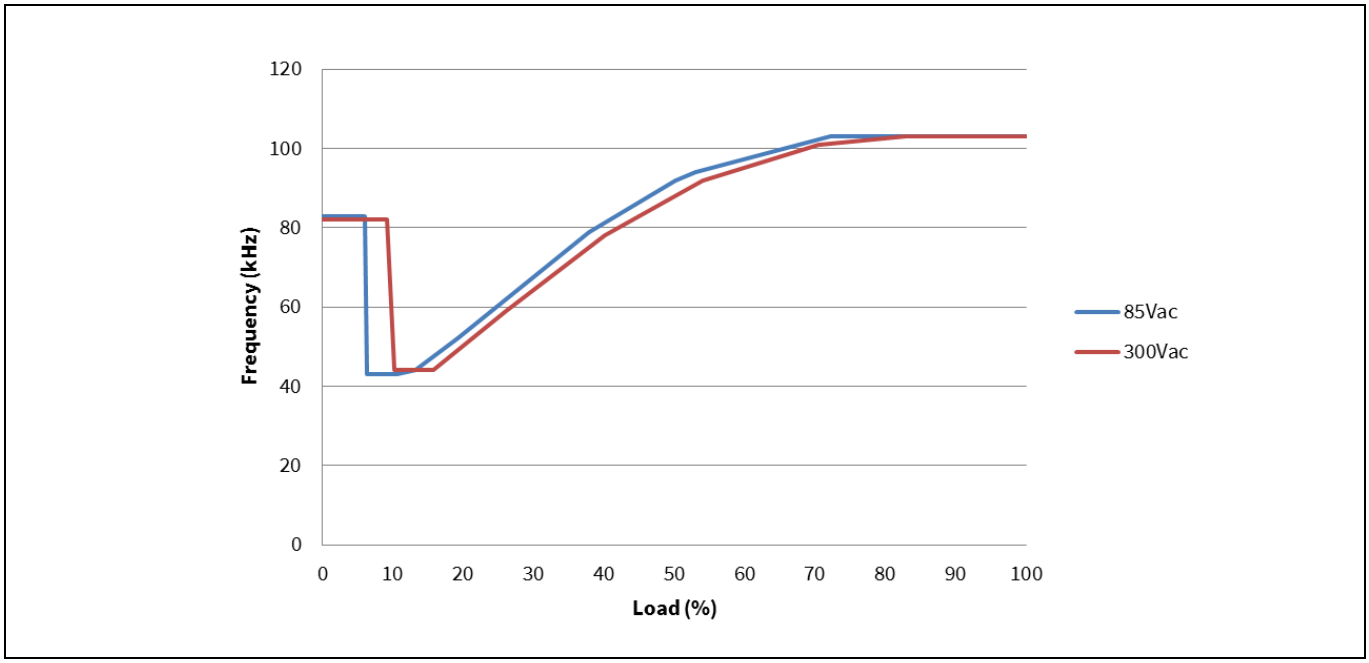


Figure 3 Frequency reduction curve of REF_5AR0680BZS-1_44W1

The measured frequency reduction curve of REF_5AR0680BZS-1_44W1 is shown in Figure 3.

3.4 Frequency jittering

ICE5AR0680BZS-1 has a frequency jittering feature to reduce EMI noise. The jitter frequency is internally set at 100 kHz (±4 kHz) and the jitter period is 4 ms.

3.5 RCD clamper circuit

A clamper network (R11, R11A, C15, and D11) dissipates the energy of the leakage inductance and suppresses the ringing on the SMPS transformer.

3.6 Output stage

There is a single output on the secondary side, 12 V. The power is coupled out via the Schottky diode (D21). The capacitors (C22, C23, and C23A) provide energy buffering followed by the L-C filters (L21-C24) to reduce the output ripple and considerably reduce the interference between SMPS switching frequency and line frequency. Storage capacitors (C22, C23, and C23A) are designed to have an internal resistance (ESR) as low as possible to minimize the output voltage ripple caused by the triangular current.

3.7 Feedback loop

For feedback (FB), the output is sensed by the voltage dividers (R26 and R25) and compared to the IC21 (TL431) internal reference voltage. The capacitors and resistor (C25, C26, and R24) form the compensation network. The output voltage of IC21 (TL431) is converted to the current signal via the optocoupler IC12 and two resistors (R22 and R23) for regulation control.

3.8 Active burst mode (ABM)

The ABM entry and exit power can be selected from three options, including no ABM. This reference board is set to option 3; details are shown in the product datasheet [1]. Under light-load conditions, the SMPS enters ABM operation. At this stage, the controller is always active but keeps V_{VCC} above the switch-off threshold. During ABM, the efficiency increases significantly; at the same time it supports low ripple on V_{out} and fast response on load jump.

To enter ABM operation, two conditions apply:

- The FB voltage must be lower than the threshold of V_{FB_EBXP}.
- A certain blanking time (t_{FB_BEB} = 36 ms) is required.

Once all these conditions are fulfilled, the ABM flip-flop is set and the controller enters ABM operation. This dual condition determines entering ABM operation and prevents mis-triggering of ABM so that the controller enters ABM operation only when the output power is really low during the preset blanking time.

During ABM, the switching frequency is reduced to 83 kHz for level 2 and 3 selections and 43 kHz for level 1 (no ABM) to improve the efficiency during standby power measurement. The maximum current sense (CS) voltage is reduced from V_{CS_N} to V_{CS_BXP} to reduce the conduction loss and audible noise. During ABM operation, the FB voltage changes like a sawtooth between $V_{FB\_Bon\_ISO}$ and $V_{FB\_Boff\_ISO}$.

The FB voltage immediately increases if there is a high load jump, as observed by one comparator. As the current limit is 27/33% during ABM operation, a certain load is required so that FB voltage can exceed V_{FB_LB} (2.73 V). After leaving ABM, the maximum current can be provided to stabilize V_{out}.

4 Protection features

Protection is one of the major factors in determining whether the system is safe and robust. Therefore, sufficient protection is necessary. ICE5AR0680BZS-1 provides comprehensive protection features to ensure the system is operating safely. This includes VCC OV and UV, overload, overtemperature (controller junction), and VCC short-to-GND. When those faults are detected, the system will enter protection mode. Once the fault is removed, the system resumes normal operation. The following table lists the protections and failure conditions.

Table 2 Protection functions of ICE5AR0680BZS-1 switching controller

Protection function	Failure condition	Protection mode
V_{CC} OV	$V_{VCC} > V_{VCC\_OVP}$	Extended cycle skip auto-restart
V_{CC} UV	$V_{VCC} < V_{VCCoff}$	Auto-restart
Overload	$V_{FB} > V_{FB\_OLP}$ and lasts for $t_{FB\_OLP\_B}$	Extended cycle skip auto-restart
Overtemperature	T_J > 140°C (40°C hysteresis)	Non-switch auto-restart
V_{CC} short-to-GND (V_{VCC} = 0 V, $R_{StartUp}$ = 50 MΩ and V_{DRAIN} = 90 V)	$V_{VCC} < V_{CC\_SCP}$, $I_{VCC\_Charge1} \approx$ -0.2 mA	Cannot start up

5 Schematic

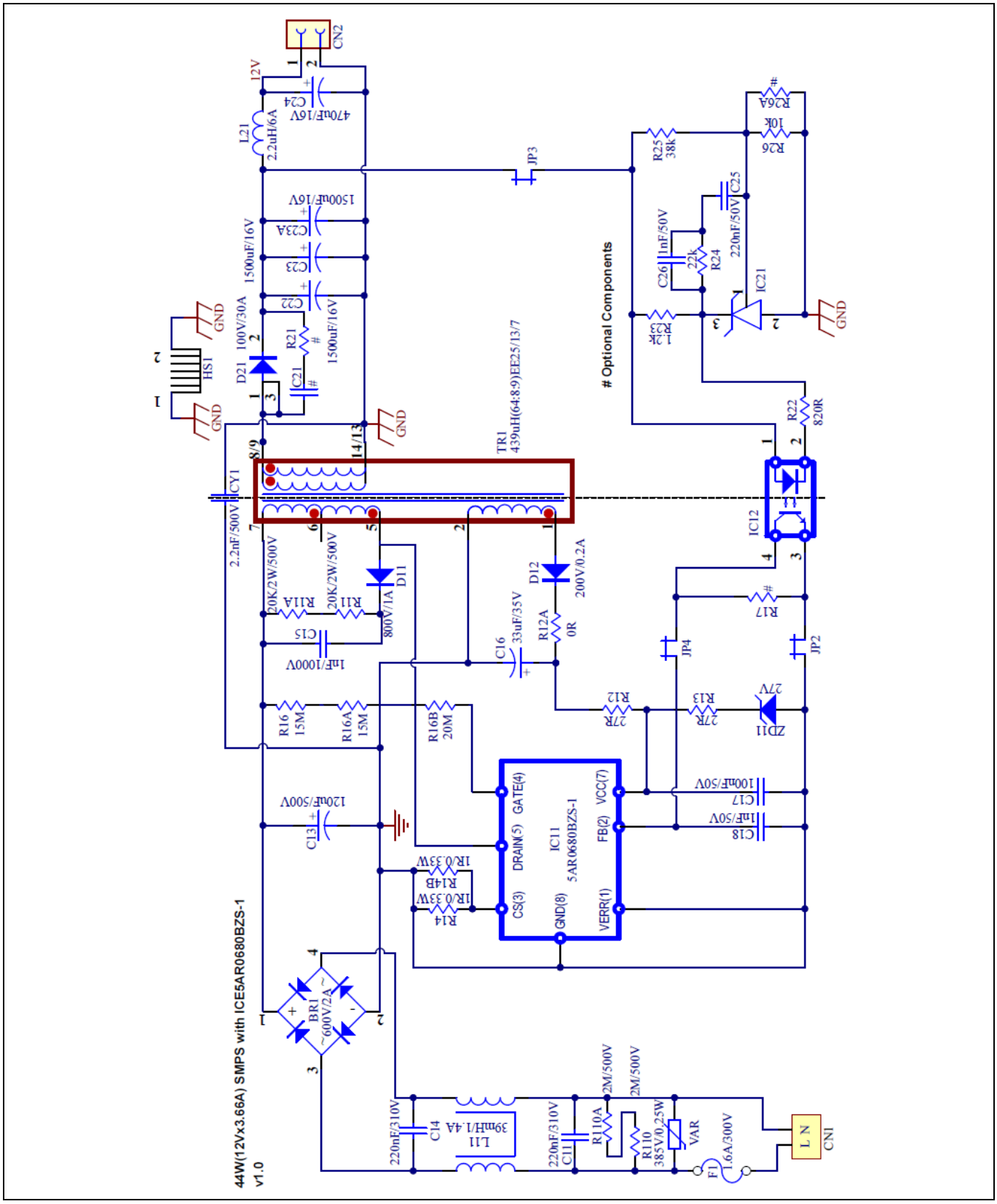


Figure 4 REF_5AR0680BZS-1_44W1

6 PCB layout

6.1 Top side

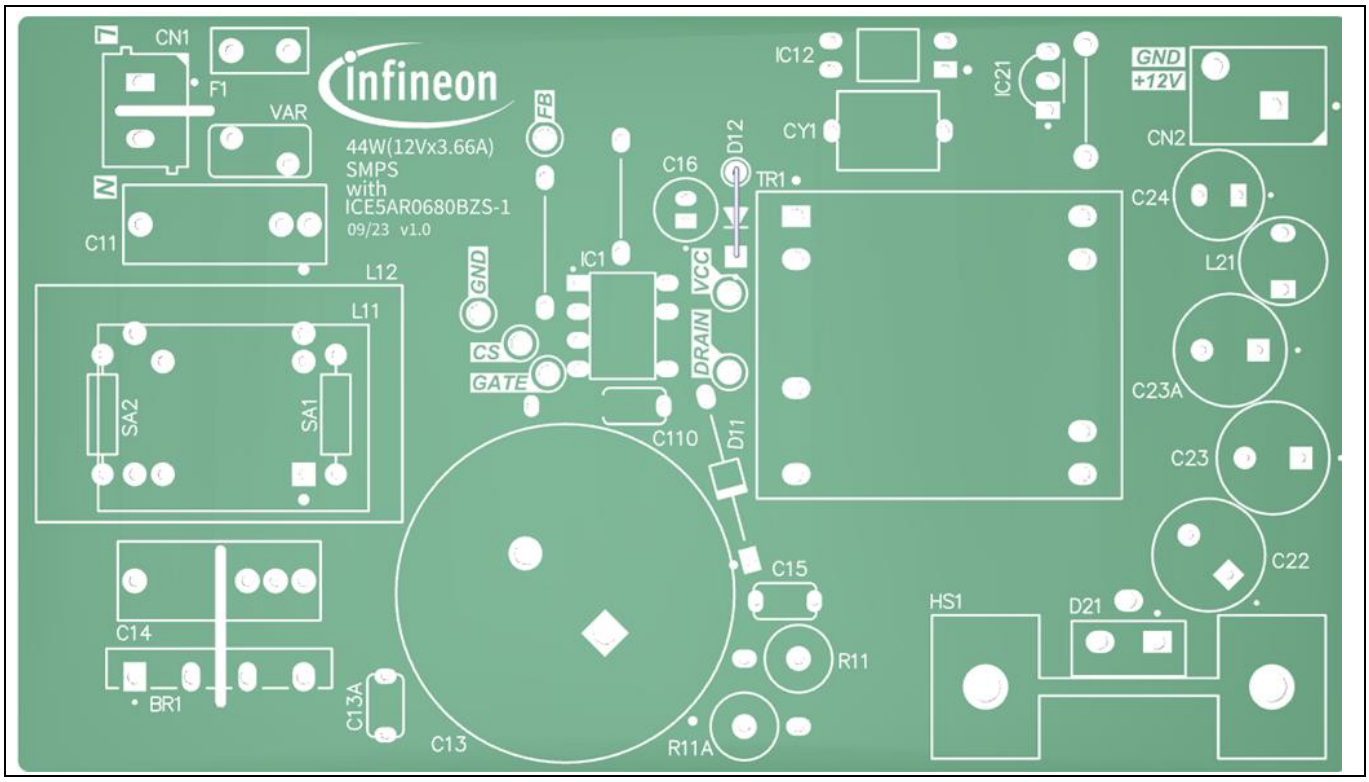


Figure 5 Top side component legend

6.2 Bottom side

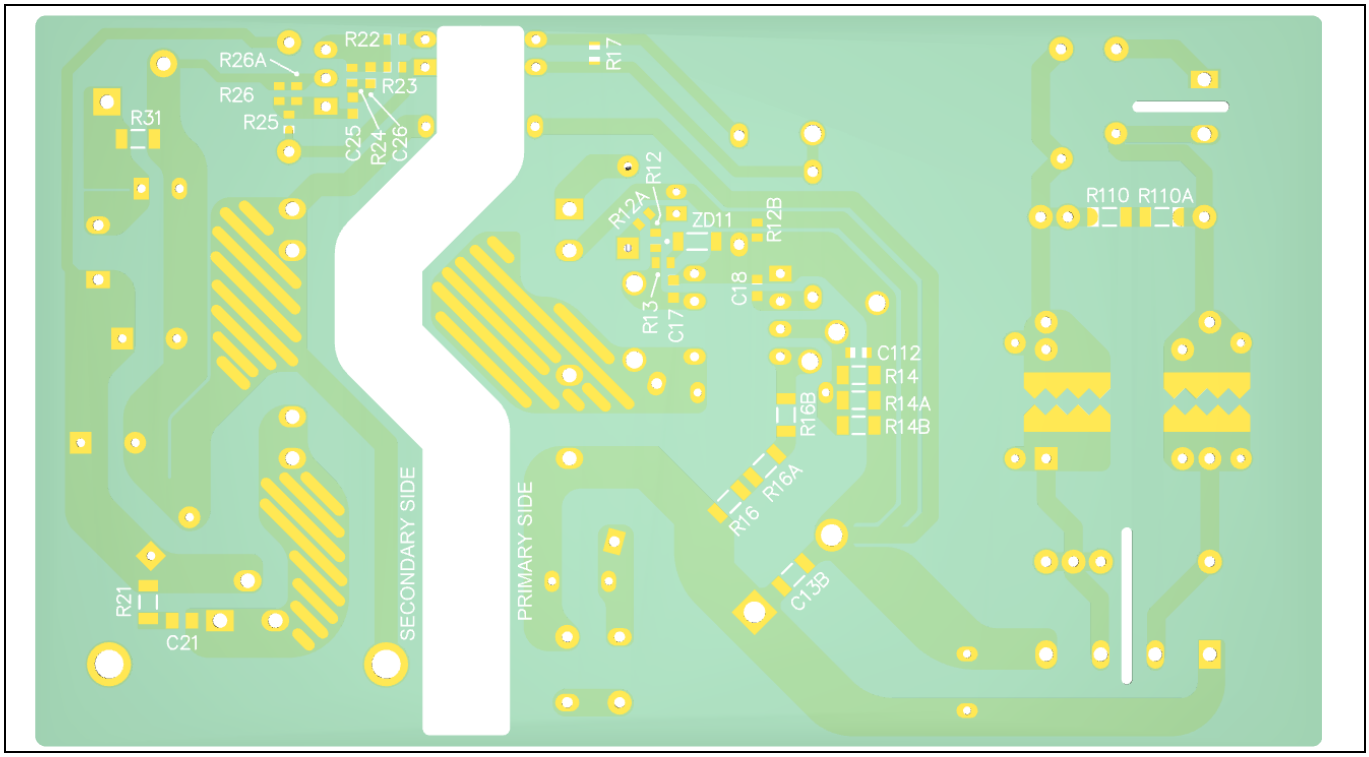


Figure 6 Bottom side copper and component legend

7 Bill of materials

Table 3 BOM (R 0.1)

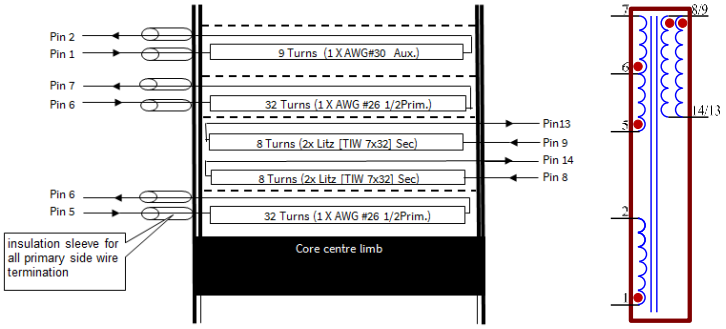
No.	Designator	Description	Part number	Manufacturer	Quantity
1	BR1	600 V/2 A	D2SB60A	Shindengen	1
2	C11	220 nF/310 V	890334024002	Würth Elektronik	1
3	CY1	2.2 nF/1000 V	DE1E3RA222MA4BQ	Murata	1
4	C13	120 uF/500 V	LGN2H121MELB30	–	1
5	C15	1 nF/1000 V	RDER7U3A102K2K1H03B	Murata	1
6	C16	33 uF/35 V	50PX33MEFC5X11	Rubycon	1
7	C17	100 nF/50 V	GRM188R71H104KA93D	Murata	1
8	C18, C26	1 nF/50 V	GRM1885C1H102GA01D	Murata	2
9	C22, C23, C23A	1500 uF/16 V	16ZLH1500MEFC10X20	Rubycon	3
10	C24	470 uF/16 V	16ZLH470MEFC8X11.5	Rubycon	1
11	C25	220 nF/50 V	GRM188R71H224KAC4D	Murata	1
12	D11	800 V/1 A	UF4006	–	1
13	D12	200 V/0.2 A	1N485B	–	1
14	D21	100 V/30 A	VF30100SG	–	1
15	F1	1.6 A/300 V	36911600000	–	1
16	FB @ pins 5 and 7 of TR1	Ferrite bead	B64290P0035X038	Epcos	2
17	HS21	Heatsink	513002B02500G	–	1
18	IC1	CoolSET™	ICE5AR0680BZS-1	Infineon	1
19	IC12	Optocoupler	SFH617A-3	–	1
20	IC21	Shunt regulator	TL431BVLPG	–	1
21	JP11, JP12, J21	Jumper	–	–	3
22	L11	39 mH/1.4 A	B82734R2142B030	Epcos	1
23	L21	2.2 uH/6 A	744772022	Würth Elektronik	1
24	R11, R11A	33 k/2 W/500 V	PR02000203302JR500	–	2
25	R12, R13	27 R	0603 Resistor	–	2
26	R12A	0 R	0603 Resistor	–	1
27	R14, R14B	1 R/0.33 W	ERJ8BQF1R0 V	–	2
28	R16, R16A	15 M	1206 Resistor	–	2
29	R16B	20 M	1206 Resistor	–	1
30	R22	820 R	0603 Resistor	–	1
31	R23	1.2 k	0603 Resistor	–	1
32	R24	22 k	0603 Resistor	–	1
33	R25	38 k	0603 Resistor	–	1

Bill of materials

No.	Designator	Description	Part number	Manufacturer	Quantity
34	R26	10 k	0603 Resistor	–	1
35	R110, R110A	2 M/500 V	1206 Resistor	–	2
36	TR1	439 uH (64:8:9)EE25/13/7	750343659(R00)	Würth Elektronik	1
37	Test point for FB, VCC, CS, DRAIN, GATE, and GND	Test point	5010	–	6
38	VAR	385 V/0.25 W	B72207S0381K101	Epcos	1
39	CN1	Connector	691102710002	Würth Elektronik	1
40	CN2	Connector	691412120002B	Würth Elektronik	1
41	ZD11	DIODE ZENER 27 V 500 MW 1206	Taiwan Semiconductor Corporation	BZS55B27 RXG	1

8 Transformer construction

- **Core and material**: EE25/13/7(EF25), TP4A (TDG)
- **Bobbin**: 070-5644 (14-pin, THT, horizontal version)
- **Primary inductance**: Lp = 439 µH (±10%), measured between pin 5 and pin 7
- **Manufacturer and part number**: Würth Elektronik (750343659 R00)



Start	Stop	No. of turns	Wire size	Layer
5	6	32	1XAWG#26	1/2 Primary
8	14	8	2x Litz [TIW 7x32]	1/2 Secondary
9	13	8	2x Litz [TIW 7x32]	1/2 Secondary
6	7	32	1XAWG#26	1/2 Primary
1	2	9	1XAWG#30	Auxiliary

Horizontal and vertical external shields are added and tied to pin 2

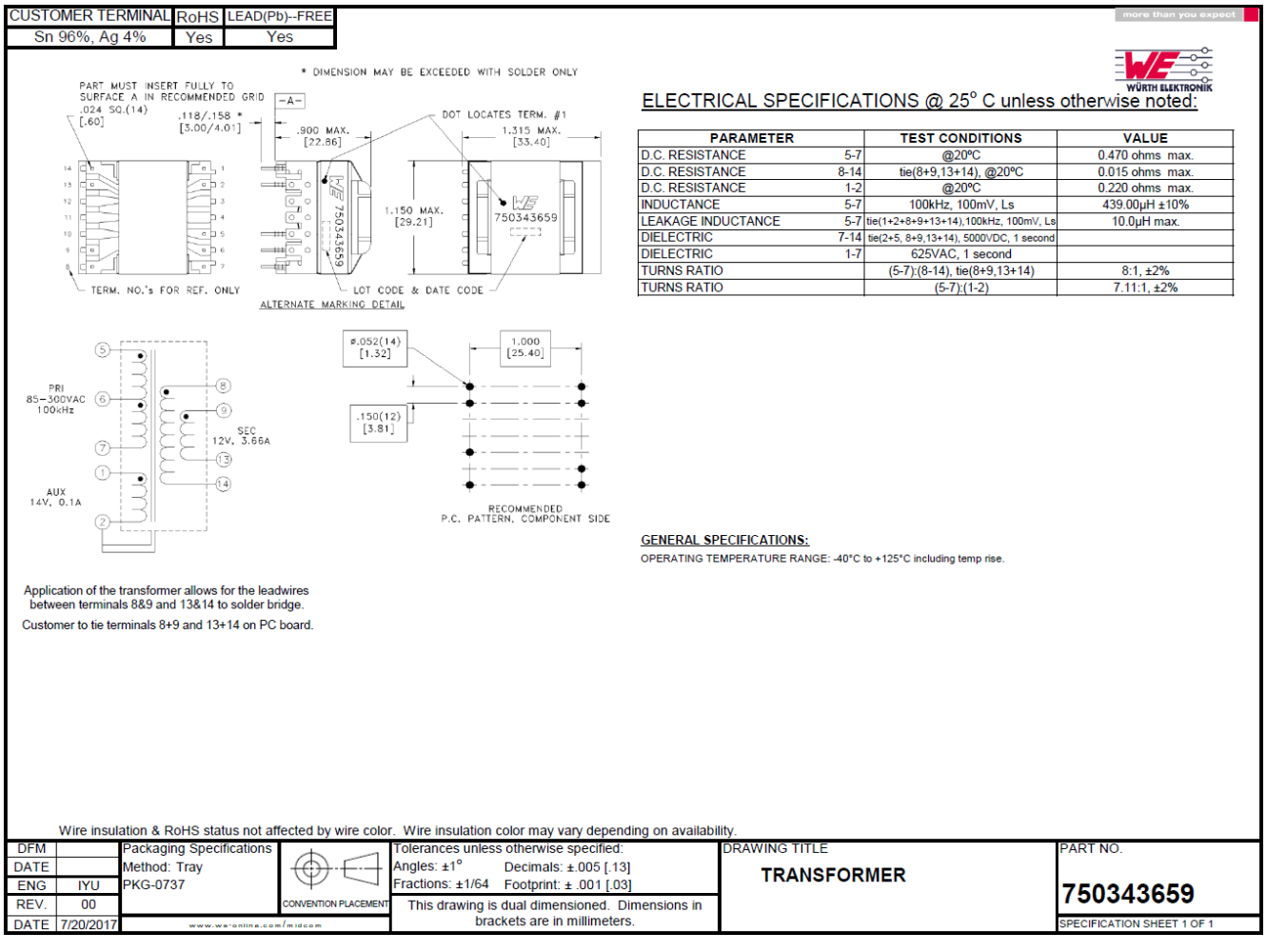


Figure 7 Transformer structure

9 Test results

9.1 Efficiency, regulation, and output ripple

Table 4 Efficiency, regulation, and output ripple

Input (V AC/Hz)	P_{in} (W)	V_{12} (V DC)	I_{12} (A)	V_{12RPP} (mV)	P_{out} (W)	Efficiency η (%)	Average η (%)	OLP P_{in} (W)	OLP I_{out12V} (A)
85 V AC/ 60 Hz	0.03614	12.04	0.000	58				60.80	4.20
	12.64	12.03	0.913	14	10.98	86.89	85.74		
	25.51	12.02	1.833	17	22.03	86.37			
	38.51	12.01	2.743	24	32.94	85.55			
	52.19	12.00	3.660	33	43.92	84.15			
115 V AC/ 60 Hz	0.03895	12.04	0.000	58				65.20	4.60
	12.56	12.03	0.913	14	10.98	87.45	87.07		
	25.18	12.02	1.833	16	22.03	87.50			
	37.81	12.01	2.743	20	32.94	87.13			
	50.95	12.00	3.660	22	43.92	86.20			
230 V AC/ 50 Hz	0.05925	12.04	0.000	61				71.50	5.10
	12.63	12.03	0.913	14	10.98	86.96	87.75		
	25.05	12.02	1.833	16	22.03	87.95			
	37.42	12.01	2.743	20	32.94	88.04			
	49.89	12.00	3.660	22	43.92	88.03			
265 V AC/ 50 Hz	0.06063	12.04	0.000	63				72.00	5.26
	12.69	12.03	0.913	13	10.98	86.55	87.39		
	25.18	12.02	1.833	16	22.03	87.50			
	37.54	12.01	2.743	20	32.94	87.76			
	50.05	12.00	3.660	22	43.92	87.75			
300 V AC/ 50 Hz	0.06563	12.04	0.000	63				72.70	5.31
	12.80	12.03	0.913	14	10.98	85.81	87.00		
	25.34	12.02	1.833	15	22.03	86.95			
	37.56	12.01	2.743	19	32.94	87.71			
	50.18	12.00	3.660	22	43.92	87.52			

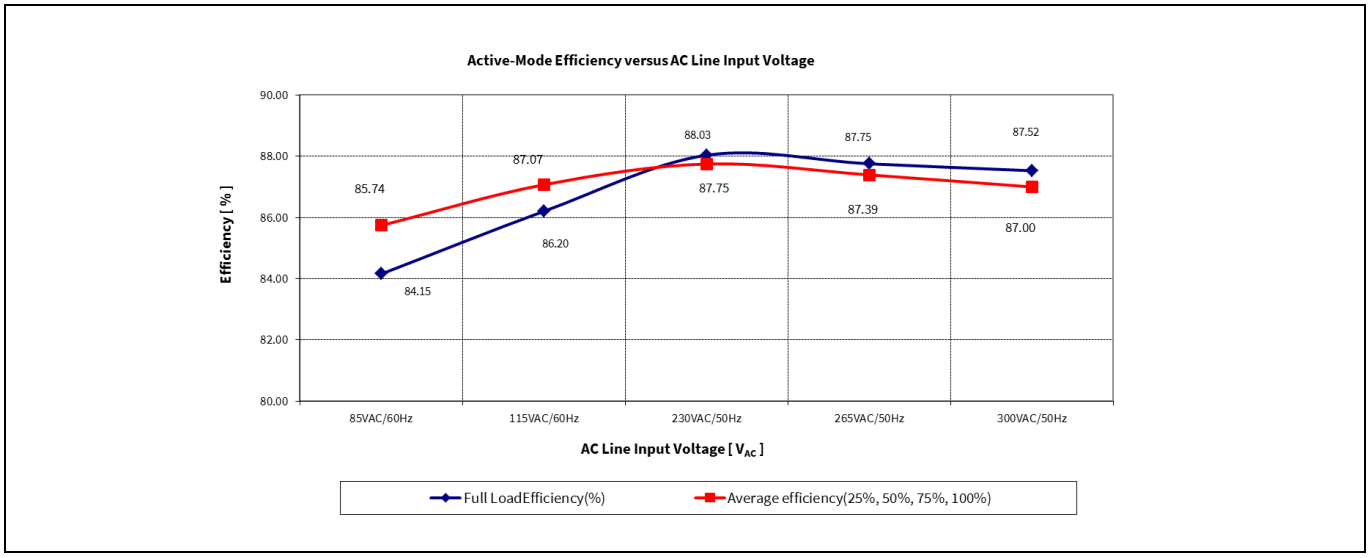


Figure 8 Efficiency vs. AC-line input voltage

9.2 Standby power

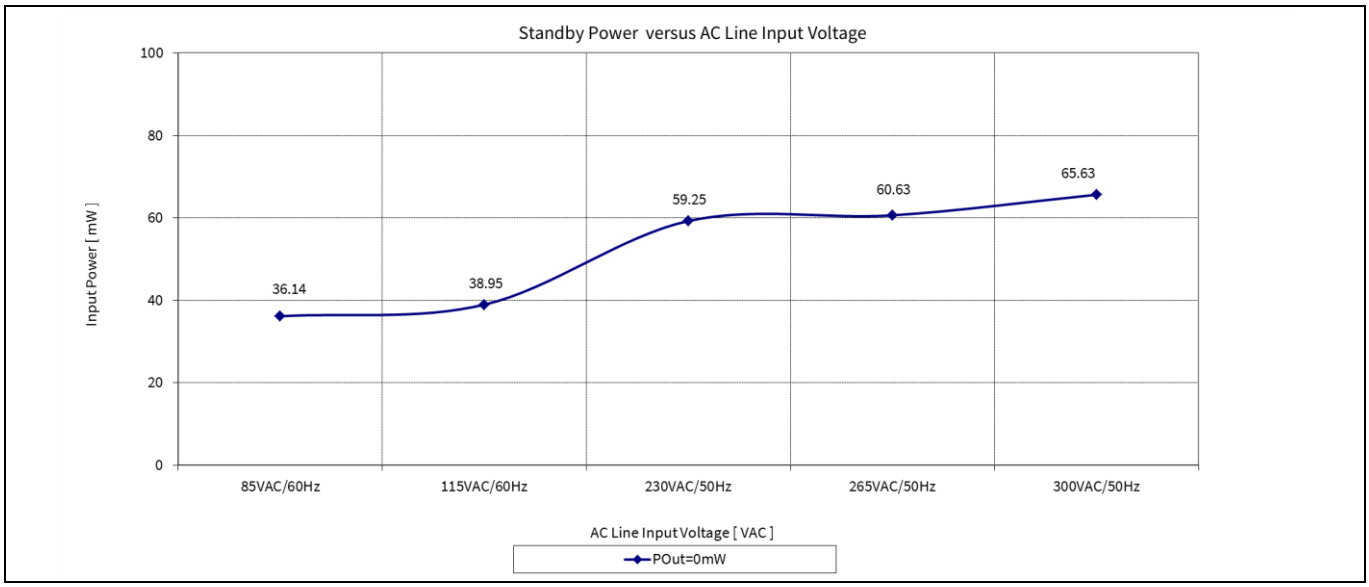


Figure 9 Standby power at no load vs. AC-line input voltage (measured by WT210 power meter from Yokogawa – integration mode)

9.3 Line regulation

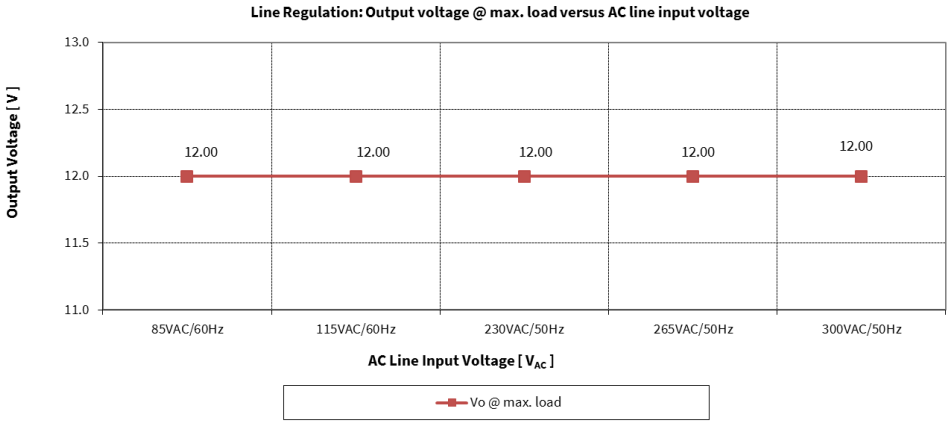


Figure 10 Line regulation V_{Out} at full load vs. AC-line input voltage

9.4 Load regulation

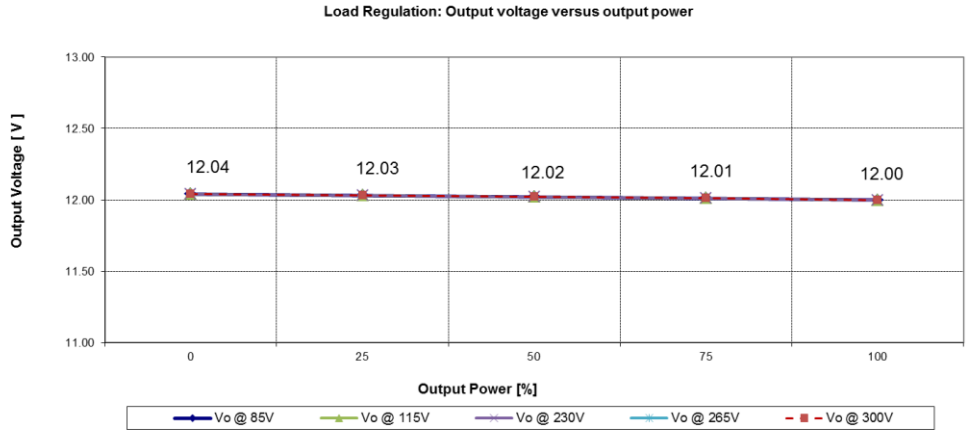


Figure 11 Load regulation V_{Out} vs. output power

9.5 Maximum input power

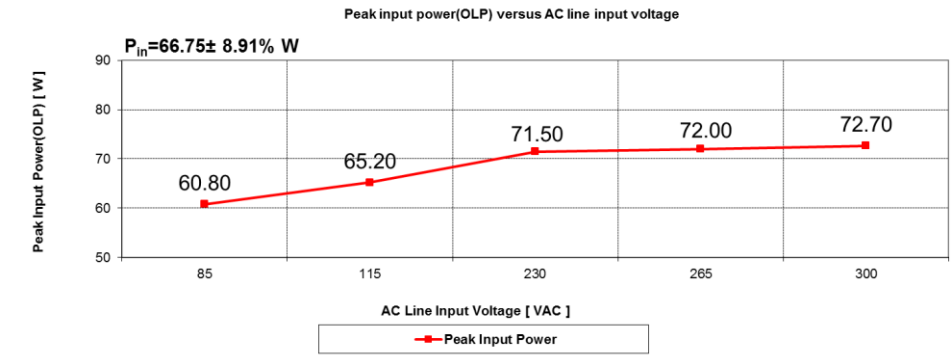


Figure 12 Maximum input power (before over-load protection) vs. AC-line input voltage

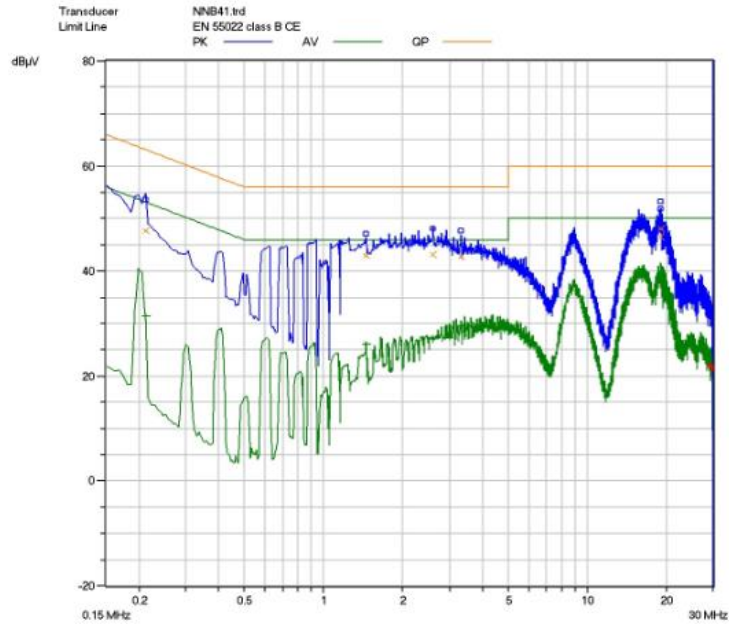
9.6 Surge immunity (EN 61000-4-5)

Pass EN61000-4-5 installation Class 4 (±2 kV for line-to-line and ±4 kV for line-to-earth).

9.7 Conducted emissions (EN 55022 Class-B)

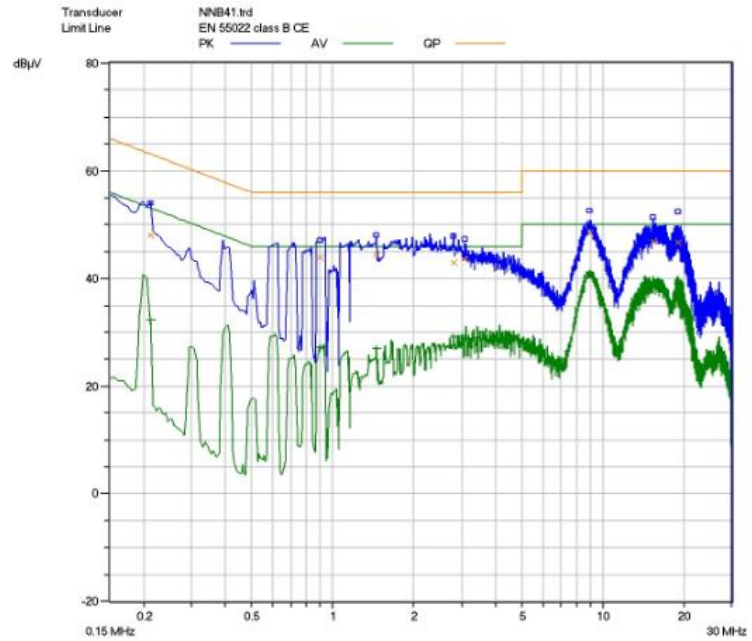
The conducted EMI is measured by Schaffner (SMR4503) and followed the test standard of EN 55022 (CISPR 22) Class-B. The reference board is set up at maximum load (44 W) with input voltage of 115 V AC and 230 V AC.

Pass conducted emissions EN 55022 (CISPR 22) Class-B with 8 dB margin for low-line (115 V AC) and 6 dB margin for high-line (230 V AC).



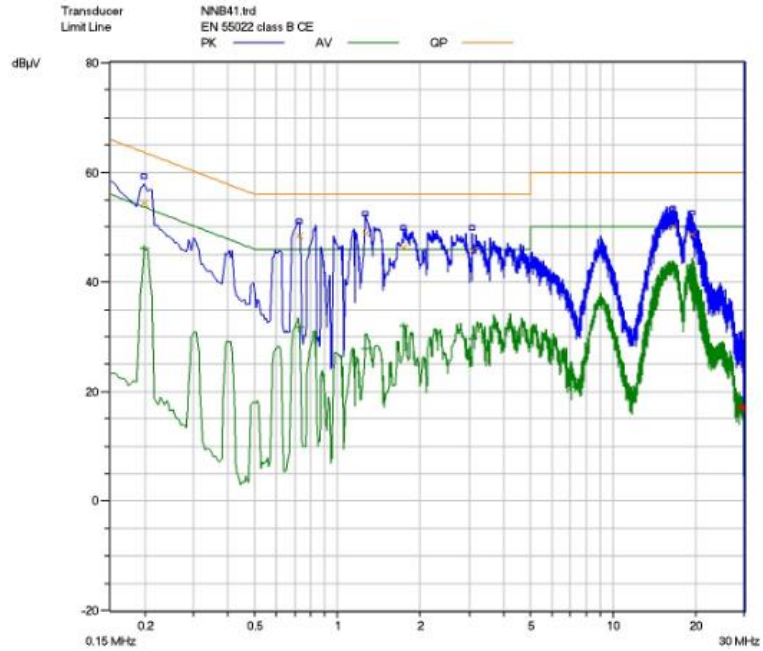
Frequency		Level Pk		Level AV		Level QP	Limit AV	Limit QP
0.2100	L	53.5	L	31.3	L	47.8	53.2	63.2
1.4520	L	47.1	L	26.1	L	43.1	46.0	56.0
2.5980	L	48.2	L	27.2	L	43.2	46.0	56.0
3.3200	L	47.6	L	29.7	L	42.8	46.0	56.0
18.9040	L	51.8	L	37.7	L	46.5	50.0	60.0
19.0720	L	53.2	L	39.7	L	48.1	50.0	60.0

Figure 13 Conducted emissions (line) at 115 V AC and maximum load



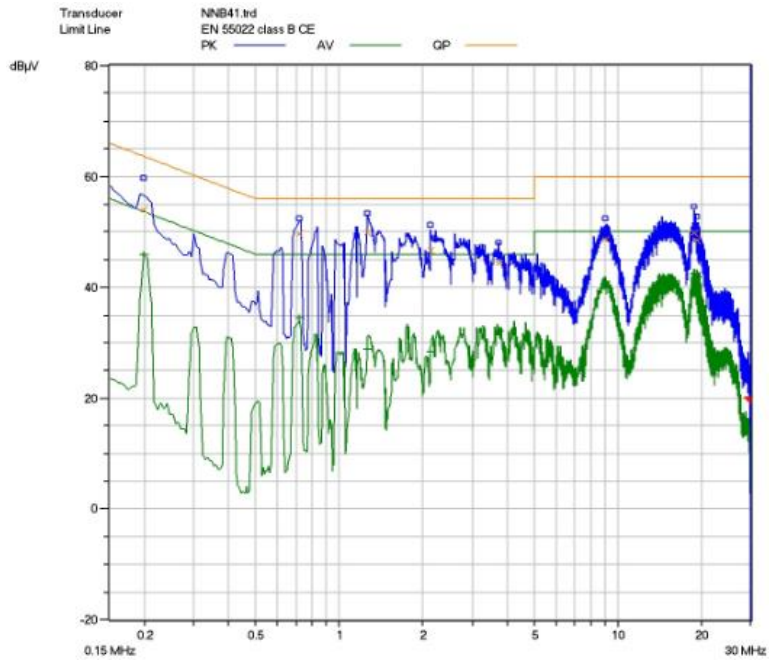
Frequency		Level Pk		Level AV		Level QP	Limit AV	Limit QP
0.2100	N	54.1	N	32.4	N	48.2	53.2	63.2
0.9000	N	47.2	N	27.2	N	44.0	46.0	56.0
1.4520	N	48.1	N	27.1	N	44.3	46.0	56.0
2.8080	N	48.0	N	29.3	N	43.1	46.0	56.0
3.0880	N	47.3	N	28.9	N	43.5	46.0	56.0
8.8880	N	52.6	N	41.1	N	48.5	50.0	60.0
15.3600	N	51.4	N	39.0	N	47.0	50.0	60.0
19.0240	N	52.4	N	39.0	N	46.7	50.0	60.0

Figure 14 Conducted emissions (neutral) at 115 V AC and maximum load



Frequency		Level Pk		Level AV		Level QP	Limit AV	Limit QP
0.1980	L	59.3	L	46.1	L	54.4	53.7	63.7
0.7260	L	51.1	L	31.7	L	48.6	46.0	56.0
1.2540	L	52.5	L	27.9	L	48.8	46.0	56.0
1.7400	L	50.0	L	32.0	L	46.4	46.0	56.0
3.0880	L	49.9	L	29.7	L	45.8	46.0	56.0
16.4640	L	53.5	L	43.0	L	50.0	50.0	60.0
19.4160	L	52.6	L	41.3	L	48.8	50.0	60.0

Figure 15 Conducted emissions (line) at 230 V AC and maximum load



Frequency		Level Pk		Level AV		Level QP	Limit AV	Limit QP
0.1980	N	59.8	N	46.0	N	54.0	53.7	63.7
0.7200	N	52.4	N	34.5	N	49.7	46.0	56.0
1.2540	N	53.5	N	28.7	N	50.0	46.0	56.0
2.1240	N	51.3	N	28.4	N	46.8	46.0	56.0
3.7360	N	48.1	N	32.2	N	44.5	46.0	56.0
9.0480	N	52.5	N	41.0	N	48.6	50.0	60.0
18.7360	N	54.5	N	42.4	N	49.8	50.0	60.0
19.2640	N	52.9	N	41.7	N	48.5	50.0	60.0

Figure 16 Conducted emissions (neutral) at 230 V AC and maximum load

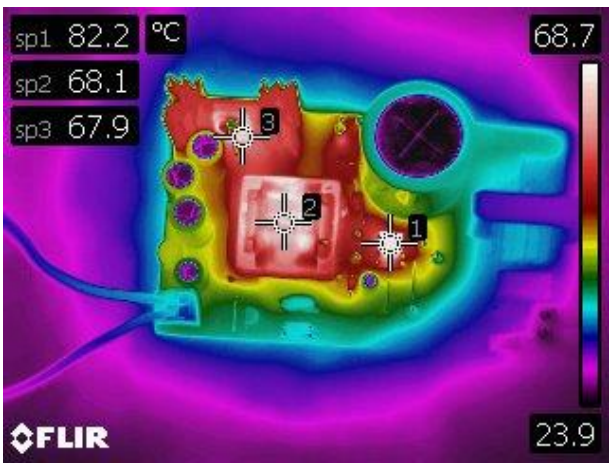
9.8 Thermal measurement

The thermal testing of the open-frame reference board is done using an infrared thermography camera (FLIR-T62101) at an ambient temperature of 25°C. The measurements are taken after one hour running at full load.

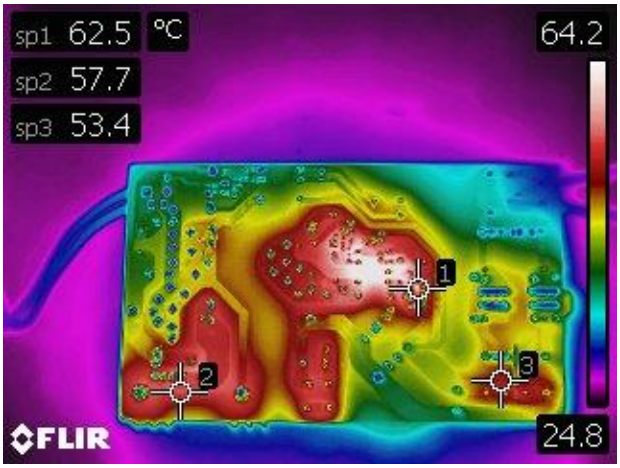
Table 5 Hottest temperature of reference board

No.	Major component	85 V AC (°C)	300 V AC (°C)
1	IC11 (ICE5AR0680BZS-1)	85.3	82.2
2	R14 (CS resistor)	62.5	47.6
3	TR1 (transformer)	60.1	68.1
4	BR1 (bridge diode)	61.7	36.0
5	R11 (clamper resistor)	67.6	64.0
6	L11 (choke)	68.3	35.0
7	D21 (secondary diode)	67.6	67.9
8	Ambient	25.0	25.0

Top side



Top side



Bottom side

Bottom side

Figure 17 Infrared thermal image of REF_5AR0680BZS-1_44W1

9.9 ESD immunity (EN 61000-4-2)

Pass EN 61000-4-2 level 4 for contact discharge and level 3 for air discharge (±8 kV for both contact and air discharge).

10 Waveforms and scope plots

10.1 Start-up at low/high AC-line input voltage with maximum load

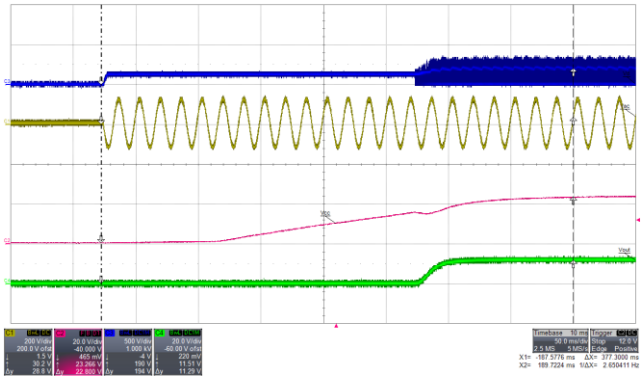
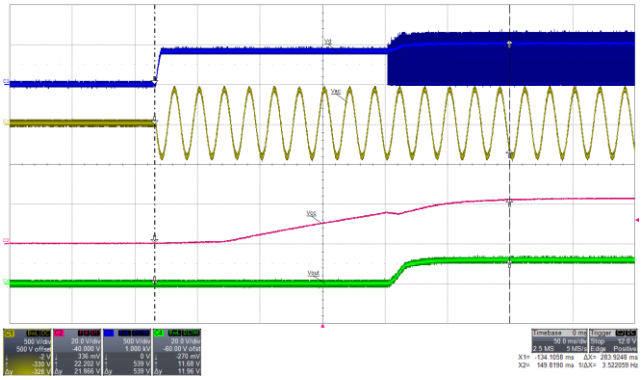
	
C1: AC Line C2:VCC C3:V_{DS} C4:12Vout	C1: AC Line C2:VCC C3:V_{DS} C4:12Vout
Start-up time at 85 V AC and maximum load ≈ 377 ms	Start-up time at 300 V AC and maximum load ≈ 284 ms

Figure 18 Start-up

10.2 Soft-start

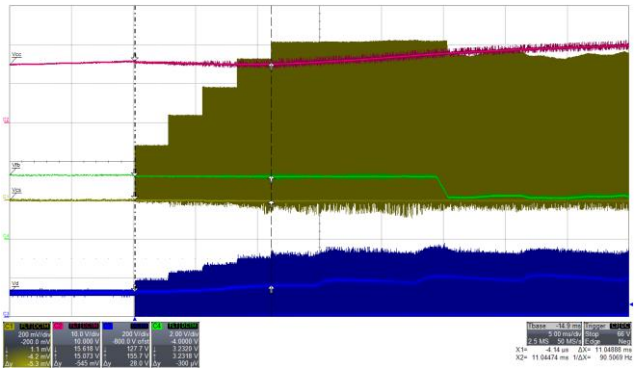
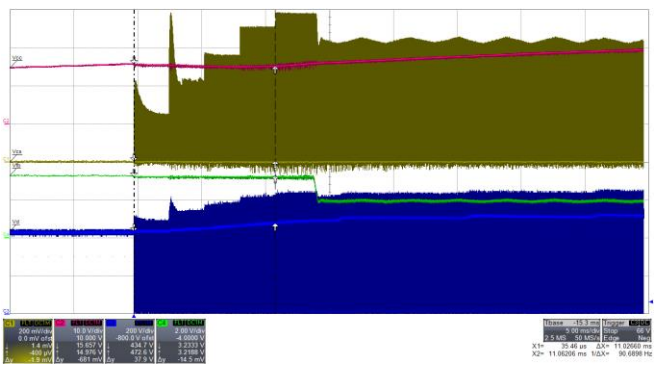
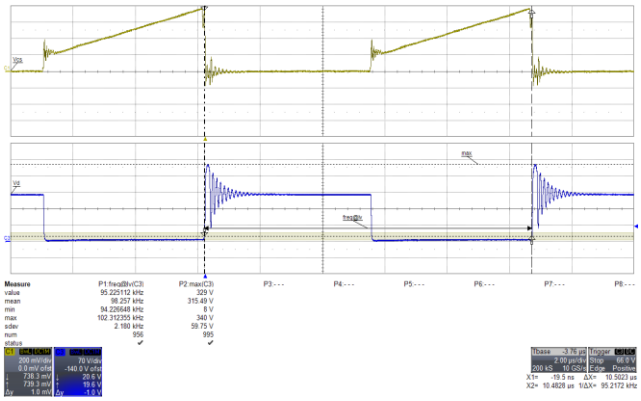
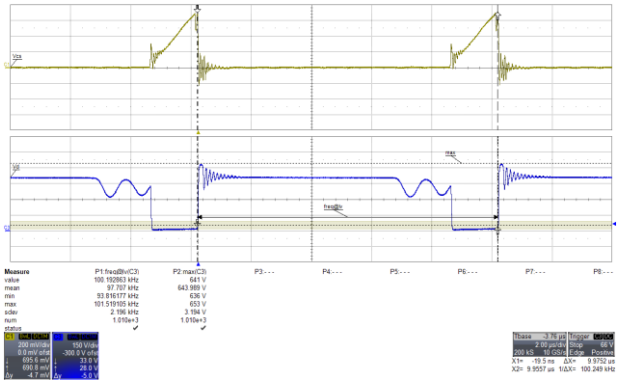
	
C1: CS C2:VCC C3:V_{DS} C4:V_{FB}	C1: CS C2:VCC C3:V_{DS} C4:V_{FB}
Soft-start time at 85 V AC and maximum load ≈ 11 ms	Soft-start time at 300 V AC and maximum load ≈ 11 ms

Figure 19 Soft-start

10.3 Drain and CS voltage at maximum load

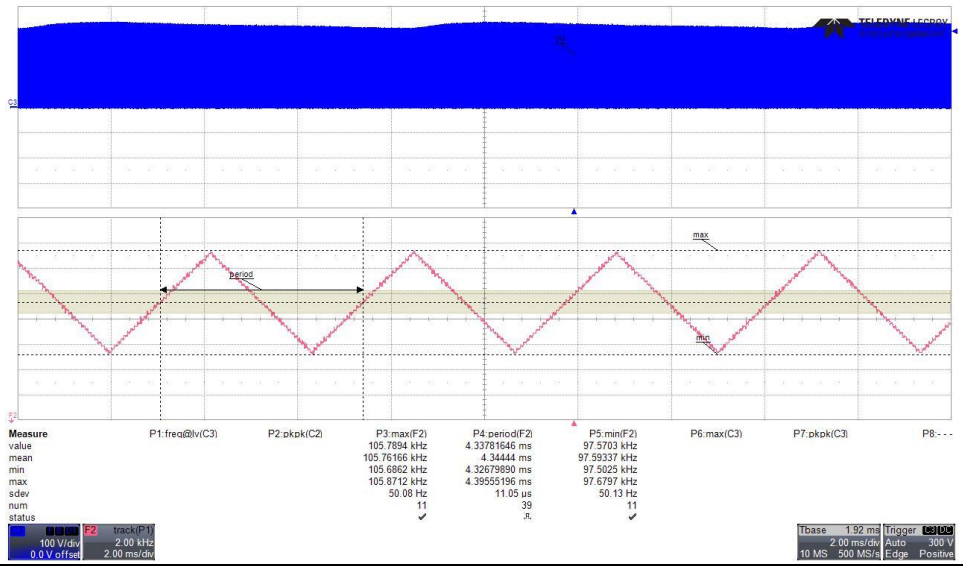




C1: CS C3:V_{DS}	C1: CS C3:V_{DS}
V_{Drain_peak} at 85 V AC ≈ 340 V	V_{Drain_peak} at 300 V AC ≈ 653 V

Figure 20 Drain and CS voltage at maximum load

10.4 Frequency jittering



F2: Frequency Trend C3:V_{DS}
Frequency jittering at 85 V AC and maximum load is ≈ 97 kHz ~ 105 kHz, jitter period is ≈ 4.3 ms

Figure 21 Frequency jittering

10.5 Load transient response (dynamic load from 10% to 100%)

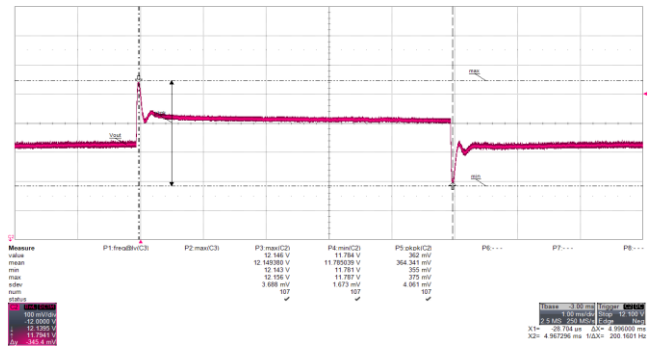
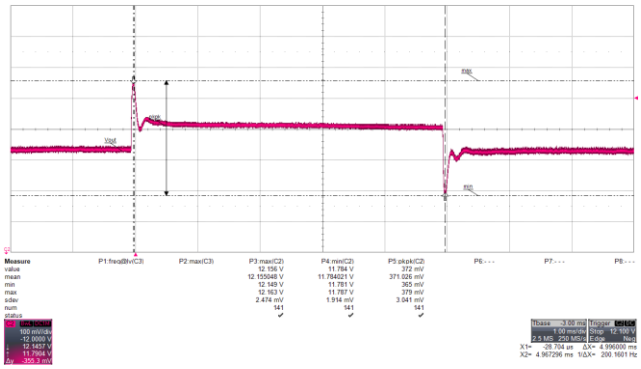
	
C2:12Vout	**C2:12Vout**
12 $V_{ripple\_pk\_pk}$ at 85 V AC ≈ 345 mV (85 V AC, 12 V load change from 10% to 100%, 100 Hz, 0.4 A/µs slew rate) Probe terminal end with decoupling capacitor of 0.1 µF (ceramic) and 10 µF (electrolytic), 20 MHz filter	12 $V_{ripple\_pk\_pk}$ at 85 V AC ≈ 355 mV (300 V AC, 12 V load change from 10% to 100%, 100 Hz, 0.4 A/µs slew rate) Probe terminal end with decoupling capacitor of 0.1 µF (ceramic) and 10 µF (electrolytic), 20 MHz filter

Figure 22 Load transient response

10.6 Output ripple voltage at maximum load

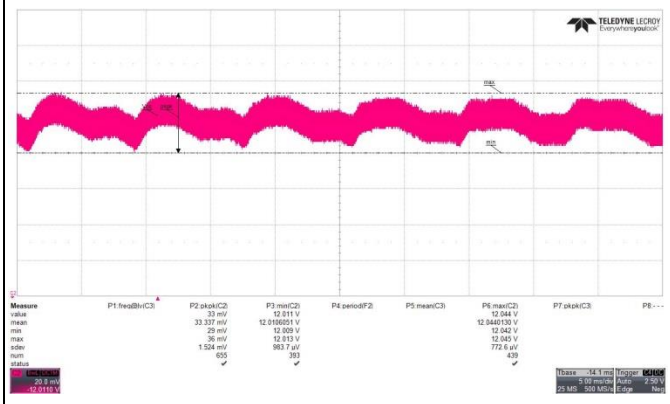
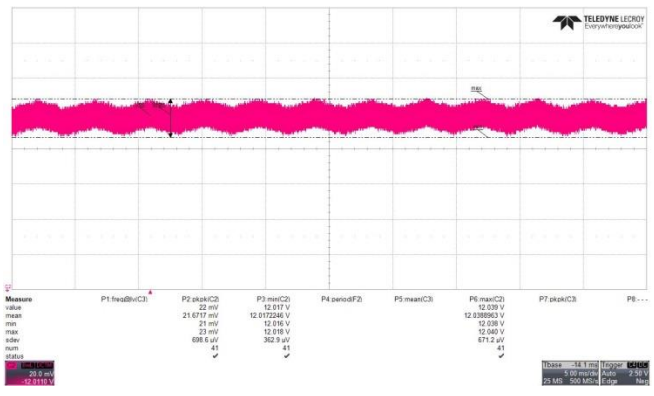
	
C2:12Vout	**C2:12Vout**
12 $V_{ripple\_pk\_pk}$ at 85 V AC ≈ 36 mV Probe terminal end with decoupling capacitor of 0.1 µF (ceramic) and 10 µF (electrolytic), 20 MHz filter	12 $V_{ripple\_pk\_pk}$ at 300 V AC ≈ 23 mV Probe terminal end with decoupling capacitor of 0.1 µF (ceramic) and 10 µF (electrolytic), 20 MHz filter

Figure 23 Output ripple voltage at maximum load

10.7 Output ripple voltage at ABM 1 W load

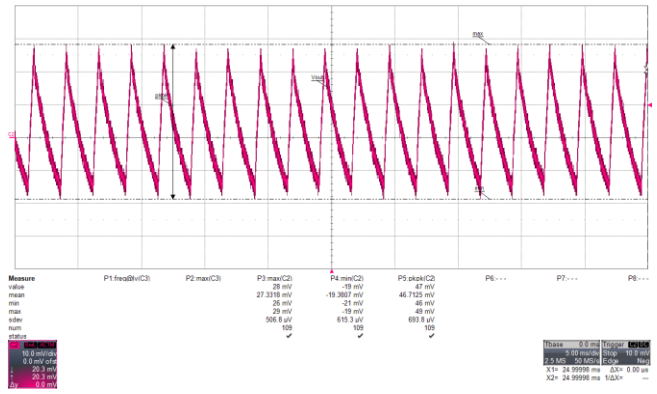
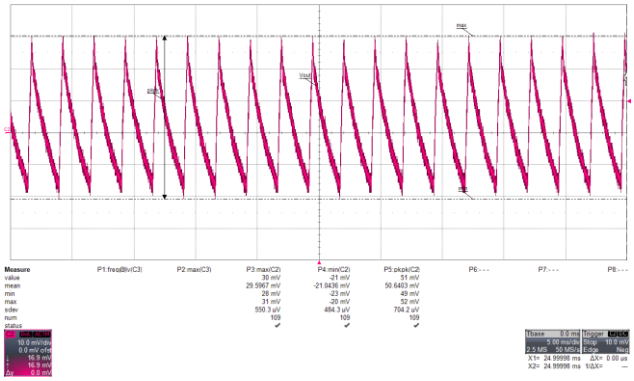
	
C2:12Vout(AC Coupled)	**C2:12Vout(AC Coupled)**
12 $V_{ripple\_pk\_pk}$ at 85 V AC ≈ 49 mV Load: 12 V at 83 mA Probe terminal end with decoupling capacitor of 0.1 µF (ceramic) and 10 µF (electrolytic), 20 MHz filter	12 $V_{ripple\_pk\_pk}$ at 300 V AC ≈ 52 mV Load: 12 V at 83 mA Probe terminal end with decoupling capacitor of 0.1 µF (ceramic) and 10 µF (electrolytic), 20 MHz filter

Figure 24 Output ripple voltage at ABM 1 W load

10.8 Entering ABM

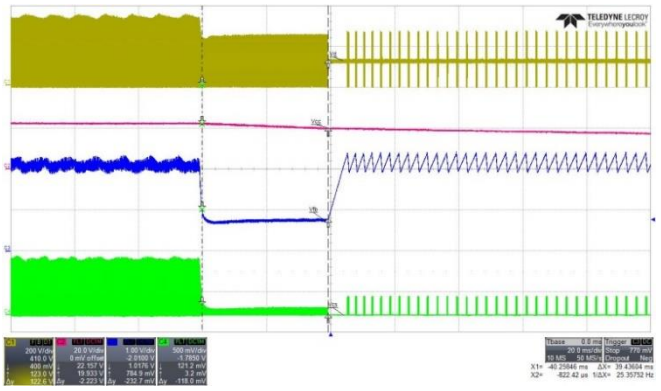
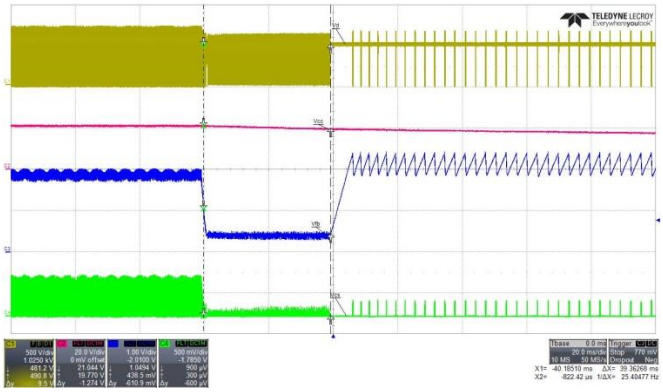
	
C1: V_{DS} C2:VCC C3:V_{FB} C4:CS	**C1: V_{DS} C2:VCC C3:V_{FB} C4:CS**
Condition to enter ABM level 3: V_{FB} < 1.03 V and $t_{blanking}$ = 36 ms (load change from full load to 1 W load at 85 V AC)	Condition to enter ABM level 3: V_{FB} < 1.03 V and $t_{blanking}$ = 36 ms (load change from full load to 1 W load at 300 V AC)

Figure 25 Entering ABM

10.9 During ABM

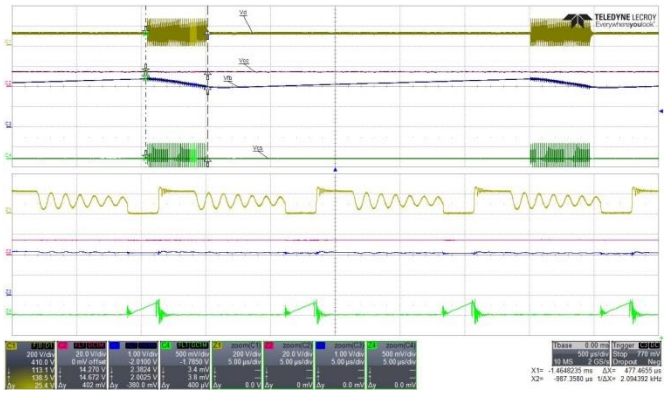
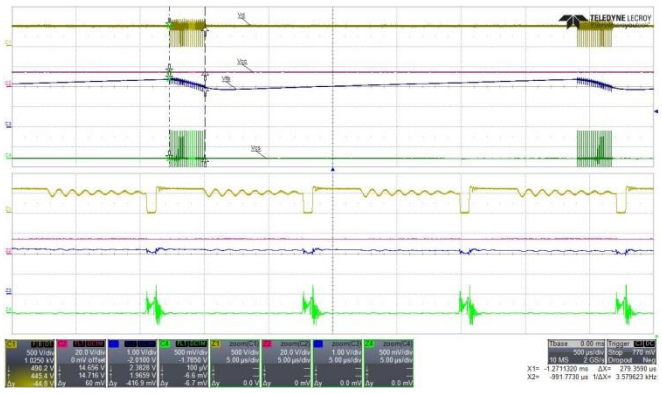
	
C1: V_{DS} C2:VCC C3:V_{FB} C4:CS	C1: V_{DS} C2:VCC C3:V_{FB} C4:CS
During ABM level 1: $V_{FB\_Bon\_ISO}$ = 2.35 V, $V_{FB\_BOff\_ISO}$ = 2.0 V, V_{CS_BHP} = 0.27 V (1 W load at 85 V AC)	During ABM level 1: $V_{FB\_Bon\_ISO}$ = 2.35 V, $V_{FB\_BOff\_ISO}$ = 2.0 V, V_{CS_BHP} = 0.27 V (1 W load at 300 V AC)

Figure 26 During ABM

10.10 Leaving ABM

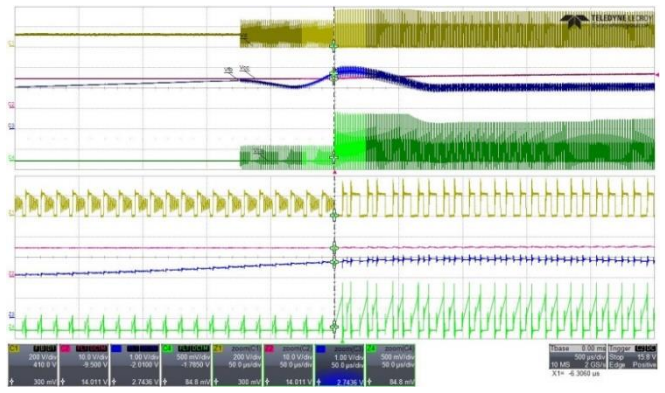
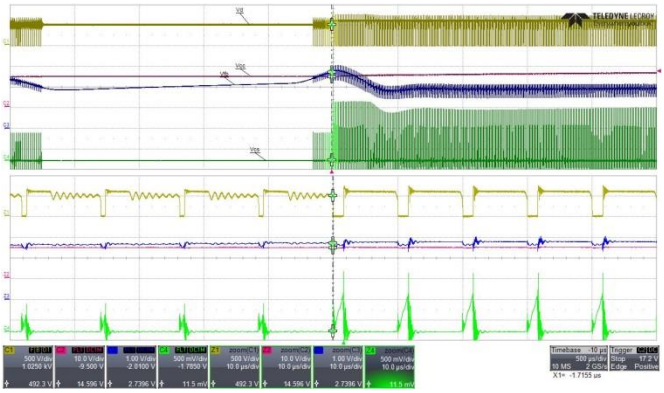
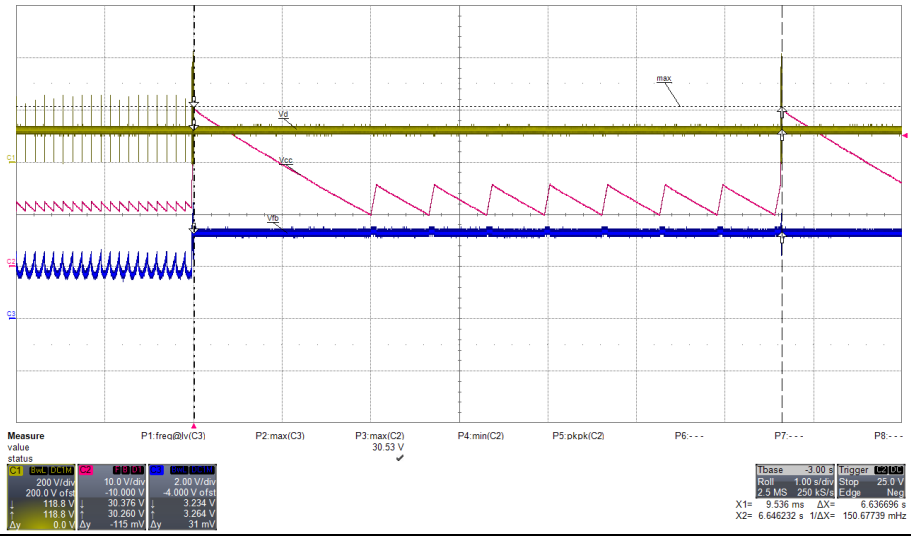
	
C1: V_{DS} C2:VCC C3:V_{FB} C4:CS	C1: V_{DS} C2:VCC C3:V_{FB} C4:CS)
Condition to leave ABM level 3: V_{FB} > 2.73 V (load change from 1 W to full load at 85 V AC)	Condition to leave ABM level 3: V_{FB} > 2.73 V (load change from 1 W to full load at 300 V AC)

Figure 27 Leaving ABM

10.11 V_{CC} OVP

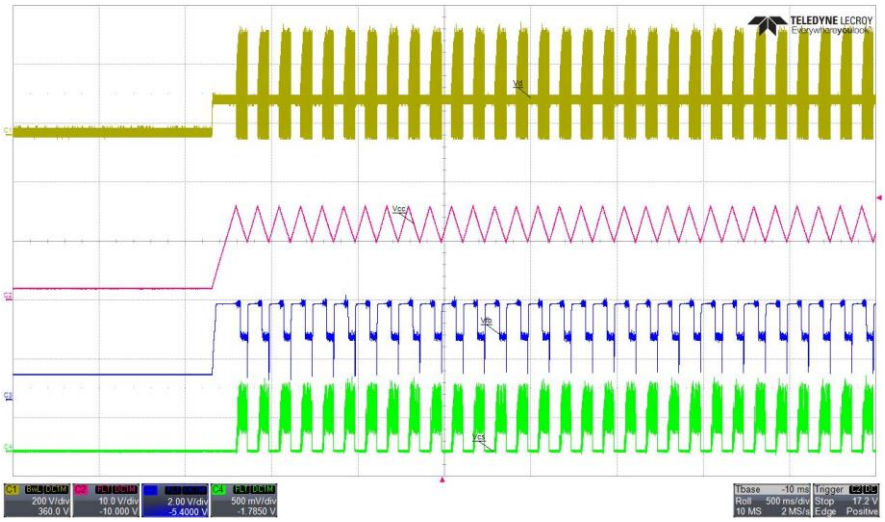


C1: V_{DS} C2:VCC C3:V_{FB}

Condition to enter V_{VCC} Overvoltage protection (OVP): V_{VCC} > 30.5 V
(short R26 while system operating at 85 V AC and no load). Part enters extended cycle skip auto-restart.

Figure 28 V_{CC} OVP

10.12 V_{CC} UVP

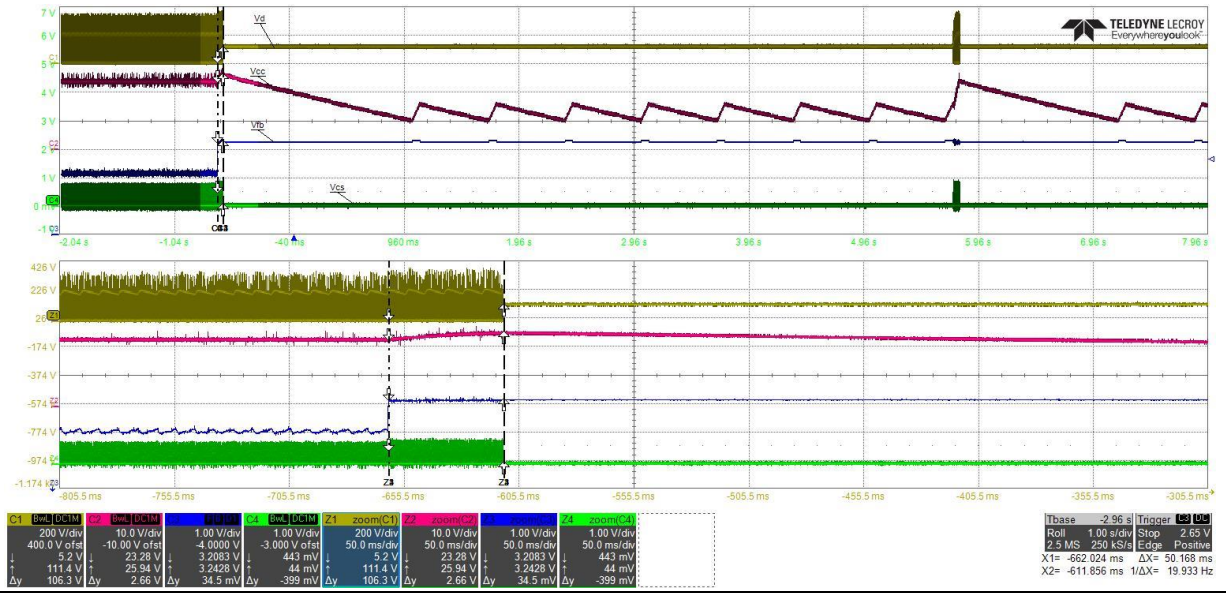


C1: V_{DS} C2:VCC C3:V_{FB} C4:CS

Condition to enter VCC Under Voltage Protection (UVP): V_{CC} < 10 V
(remove R12A and power on the system with full load at 85 V AC). Part enters auto-restart.

Figure 29 V_{CC} UVP

10.13 Over-load protection

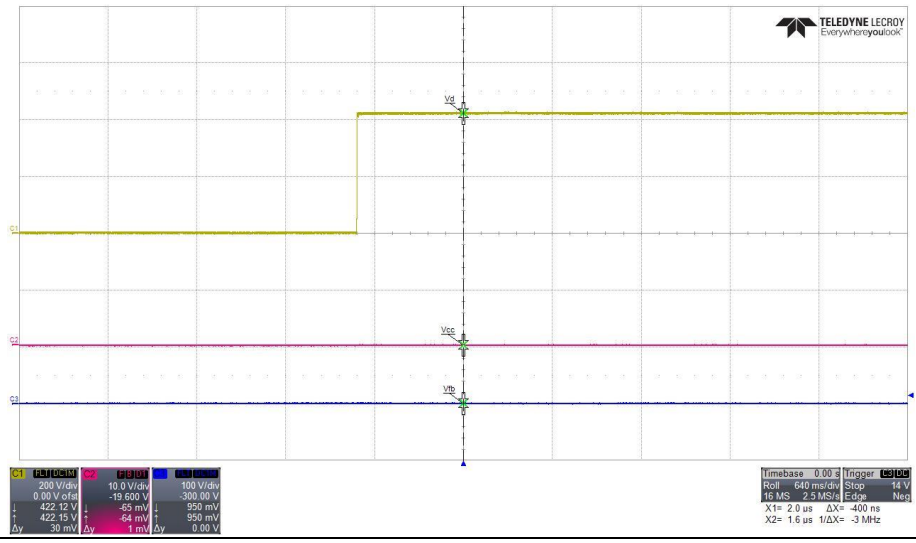


C1: V_{DS} C2:VCC C3:V_{FB} C4:CS

Condition to enter over-load protection: V_{FB} > 2.73 V and lasts for 54 ms blanking time
(load change from full to short load at 85 V AC). Part enters extended cycle skip auto-restart.

Figure 30 Over-load protection

10.14 V_{CC} short-to-GND protection



C1: V_{DS} C2:VCC C3:V_{FB}

Condition to enter V_{CC} short-to-GND: if $V_{CC} < V_{VCC\_SCP}$ → $I_{VCC} = I_{VCC\_Charge1}$
(short VCC pin-to-GND and measure the current with multimeter before system start-up, I_{VCC} ≈ 500 µA and input power is ≈ 450 mW at 300 V AC)

Figure 31 V_{CC} short-to-GND protection

References

[1] Infineon Technologies AG: *ICE5xRxxxxBZx-1 datasheet*; Available online

[2] Infineon Technologies AG: *CoolSET™ 5th Generation Fixed Frequency Plus flyback design guide*; Available online

[3] Infineon Technologies AG: *CoolSET™ 5th Generation Fixed Frequency Plus calculation tool for flyback*; Available online

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Document revision	Date	Description of changes
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