

22 W 12 V 5 V SMPS demo board with ICE5GR2280AG

DEMO_5GR2280AG_22W1

About this document

Scope and purpose

This document is an engineering report that describes a universal-input 22 W 12 V 5 V off-line isolated Flyback converter using the latest fifth-generation Infineon Fixed Frequency (FF) CoolSET™ ICE5GR2280AG, which offers high-efficiency, low-standby power with selectable entry and exit standby power options, wide V_{CC} operating range with fast start-up, robust line protection with input Over Voltage Protection (OVP) and various protection modes for a highly reliable system. This demo board is designed for users who wish to evaluate ICE5GR2280AG in terms of 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 off-line SMPS – either auxiliary power supplies for white goods, PCs, servers and TVs, or enclosed adapters for Blu-ray players, set-top boxes, games consoles, etc.

Table of contents

About this document	1
Table of contents	1
1 Abstract.....	3
2 Demo board	4
3 Specifications of the demo board	5
4 Circuit description.....	6
4.1 Line input.....	6
4.2 Start-up.....	6
4.3 Integrated CoolMOS™ with frequency reduction controller	6
4.4 Frequency jittering.....	7
4.5 RCD clamper circuit.....	7
4.6 Output stage.....	7
4.7 Feedback loop	7
4.8 Active Burst Mode (ABM)	8
5 Protection features	9
6 Circuit diagram	10
7 PCB layout.....	11
7.1 Top side	11
7.2 Bottom side	11
8 Bill of Materials (BOM)	12
9 Transformer construction	14
10 Test results.....	15

Abstract

10.1	Efficiency, regulation and output ripple.....	15
10.2	Standby power	16
10.3	Line regulation	17
10.4	Load regulation	17
10.5	Maximum input power	18
10.6	ESD immunity (EN 61000-4-2)	18
10.7	Surge immunity (EN 61000-4-5)	18
10.8	Conducted emissions (EN 55022 class B)	18
10.9	Thermal measurement	21
11	Waveforms and scope plots	22
11.1	Start-up at low/high AC-line input voltage with maximum load.....	22
11.2	Soft-start.....	22
11.3	Drain and CS voltage at maximum load	23
11.4	Frequency jittering.....	23
11.5	Load transient response (dynamic load from 10% to 100%)	24
11.6	Output ripple voltage at maximum load	24
11.7	Output ripple voltage at ABM 1 W load.....	25
11.8	Entering ABM	25
11.9	During ABM	26
11.10	Leaving ABM	26
11.11	Line OVP (non-switch auto restart).....	27
11.12	V _{CC} OVP (odd-skip auto restart)	27
11.13	V _{CC} UVP (auto restart)	28
11.14	Over-load protection (odd-skip auto restart)	28
11.15	V _{CC} short-to-GND protection	29
12	References	30
Revision history		30

Abstract

1 Abstract

This document is an engineering report for a 22 W 12 V 5 V demo board designed in an FF isolated Flyback converter topology using the fifth-generation FF CoolSET™ ICE5GR2280AG. The demo board is operated in Discontinuous Conduction Mode (DCM) and is running at 125 kHz fixed switching frequency. The frequency reduction with soft gate driving and frequency jittering offers lower EMI and better efficiency between medium load and 50% load. The selectable Active Burst Mode (ABM) power enables ultra-low power consumption. In addition, numerous adjustable protection functions have been implemented in ICE5GR2280AG to protect the system and customize the IC for the chosen application. In case of failure modes, like line Over Voltage (OV), V_{CC} OV/Under Voltage (UV), open control-loop or over-load, over-temperature, V_{CC} short-to-GND and CS short-to-GND, the device enters protection mode. By means of the cycle-by-cycle Peak Current Limitation (PCL), the dimension 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. The target applications of ICE5GR2280AG are either auxiliary power supplies for white goods, PCs, servers and TVs, or enclosed adapters for Blu-ray players, set-top boxes, games consoles, etc.

2 Demo board

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

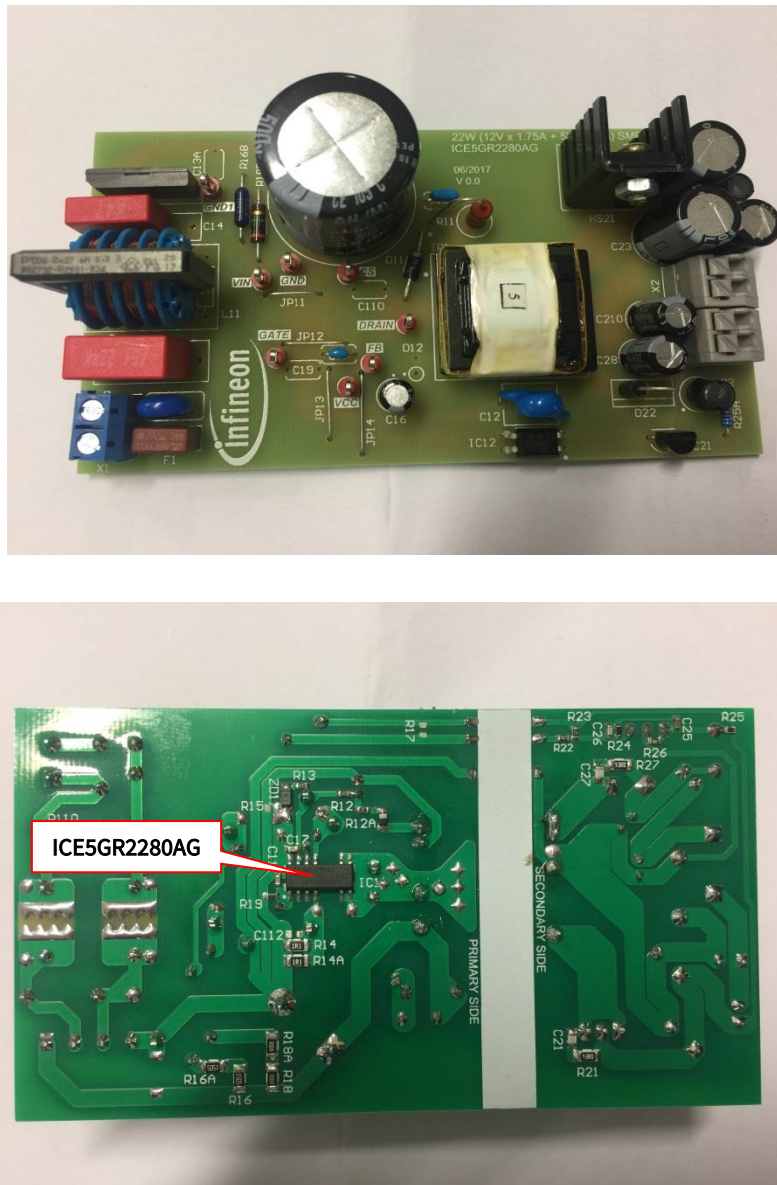


Figure 1 DEMO_5GR2280AG_22W1

3 Specifications of the demo board

Table 1 Specifications of DEMO_5GR2280AG_22W1

Input voltage and frequency	85 V AC (60 Hz) ~ 300 V AC (50 Hz)
Output voltage, current and power	$(12\text{ V} \times 1.75\text{ A}) + (5\text{ V} \times 0.20\text{ A}) = 22\text{ W}$
Regulation	+5 V: less than $\pm 5\%$ +12 V: less than $\pm 5\%$
Output ripple voltage (full load, 85 V AC ~ 300 V AC)	$5\text{ V}_{\text{ripple_p_p}} < 100\text{ mV}$ $12\text{ V}_{\text{ripple_p_p}} < 200\text{ mV}$
Active mode four-point average efficiency (25%, 50%, 75%, 100% load)	> 83% at 115 V AC and 230 V AC
Standby power consumption	No load: $P_{\text{in}} < 100\text{ mW}$ at 230 V AC 60 mW load: $P_{\text{in}} < 180\text{ mW}$ at 230 V AC
Conducted emissions (EN 55022 class B)	Pass with 10 dB margin for 115 V AC and 9.4 dB margin for 230 V AC
ESD immunity (EN 61000-4-2)	Level 4 for contact discharge and level 3 for air discharge ($\pm 8\text{ kV}$ for both contact and air discharge)
Surge immunity (EN 61000-4-5)	Installation class 4 ($\pm 2\text{ kV}$ for line-to-line and $\pm 4\text{ kV}$ for line-to-earth)
Form factor case size (L × W × H)	(110 × 60 × 27) mm

Note: “The demo board is designed for dual-output with cross-regulated loop feedback (FB). It may not regulate properly if loading is applied only to single-output. If the user wants to evaluate for single-output (12 V only) conditions, the following changes are necessary on the board.

1. Remove D22, L22, C28, C210, R25A (to disable 5 V output)
2. Change R26 to 10 k Ω and R25 to 38 k Ω (to disable 5 V FB and enable 100% weighted factor on 12 V output)

Since the board (especially the transformer) is designed for dual-output with optimized cross-regulation, single-output efficiency might not be optimized. It is only for IC functional evaluation under single-output conditions.”

4 Circuit description

4.1 Line input

The AC-line input side comprises the input fuse F1 as Over Current Protection (OCP). The choke L11, X-capacitor C11 and Y-capacitor C12 act as EMI suppressors. Optional spark-gap devices SA1, SA2 and varistor VAR can absorb HV stress during a lightning surge test. A rectified DC voltage (120 ~ 424 V DC) is obtained through the bridge rectifier BR1 together with bulk capacitor C13.

4.2 Start-up

To achieve fast and safe start-up, ICE5GR2280AG is implemented with start-up resistor and V_{CC} short-to-GND protection. When V_{VCC} reaches the turn-on voltage threshold 16 V, the IC begins with a soft-start. The soft-start implemented in ICE5GR2280AG 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 incrementally from 0.3 V to 0.8 V. After IC turn-on, the V_{CC} voltage is supplied by auxiliary windings of the transformer. V_{CC} short-to-GND protection is implemented during the start-up time.

4.3 Integrated CoolMOS™ with frequency reduction controller

ICE5GR1680AG is comprised of a CoolMOS™ and the frequency reduction controller, which enables better efficiency between light load and 50% load. This integrated solution greatly simplifies the circuit layout and reduces the cost of PCB manufacturing. The new CoolSET™ can be operated in either DCM or CCM with frequency reduction mode. This demo board is designed to operate in DCM. When the system is operating at the maximum power, the controller will switch at the FF of 125 kHz. In order to achieve a better efficiency between light load and medium load, frequency reduction is implemented, and the reduction curve is shown in Figure 2. The V_{CS} is clamped by the current limitation threshold or by the PWM op-amp while the switching frequency is reduced. After the maximum frequency reduction, the minimum switching frequency is f_{OSC2_MIN} (53 kHz).

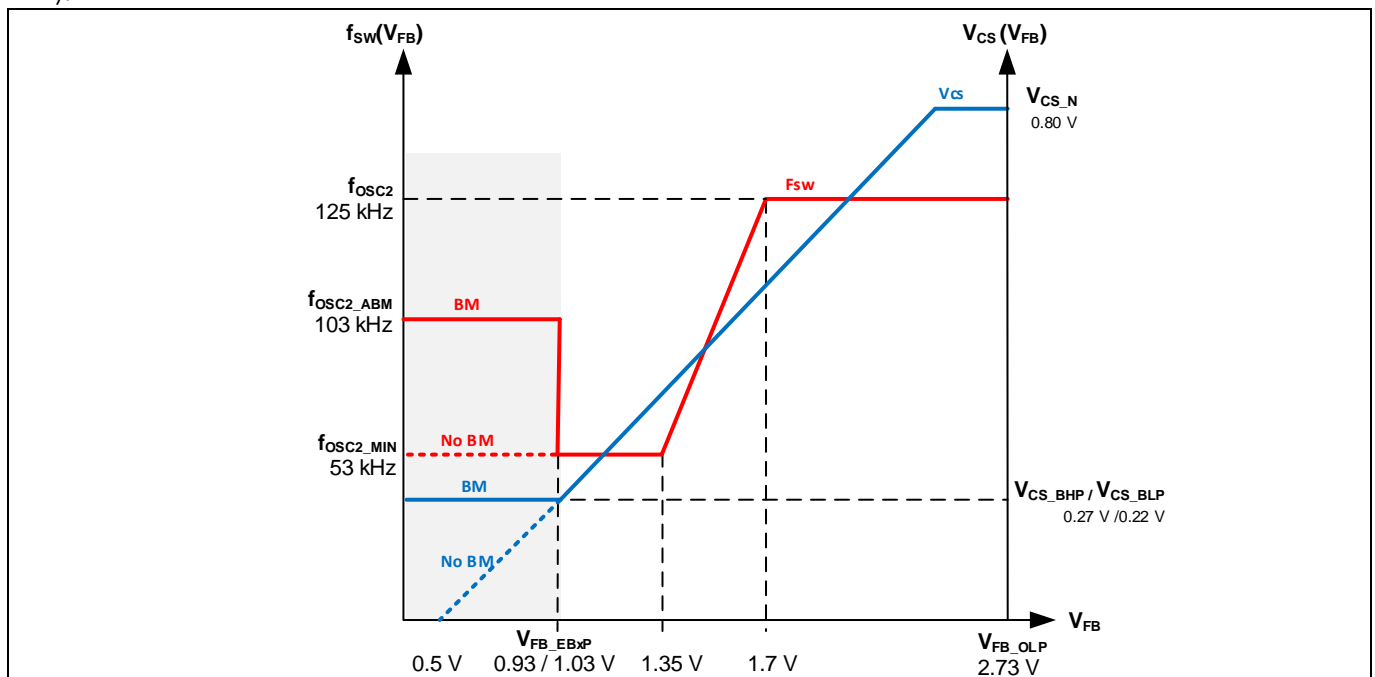


Figure 2 Frequency reduction curve

Circuit description

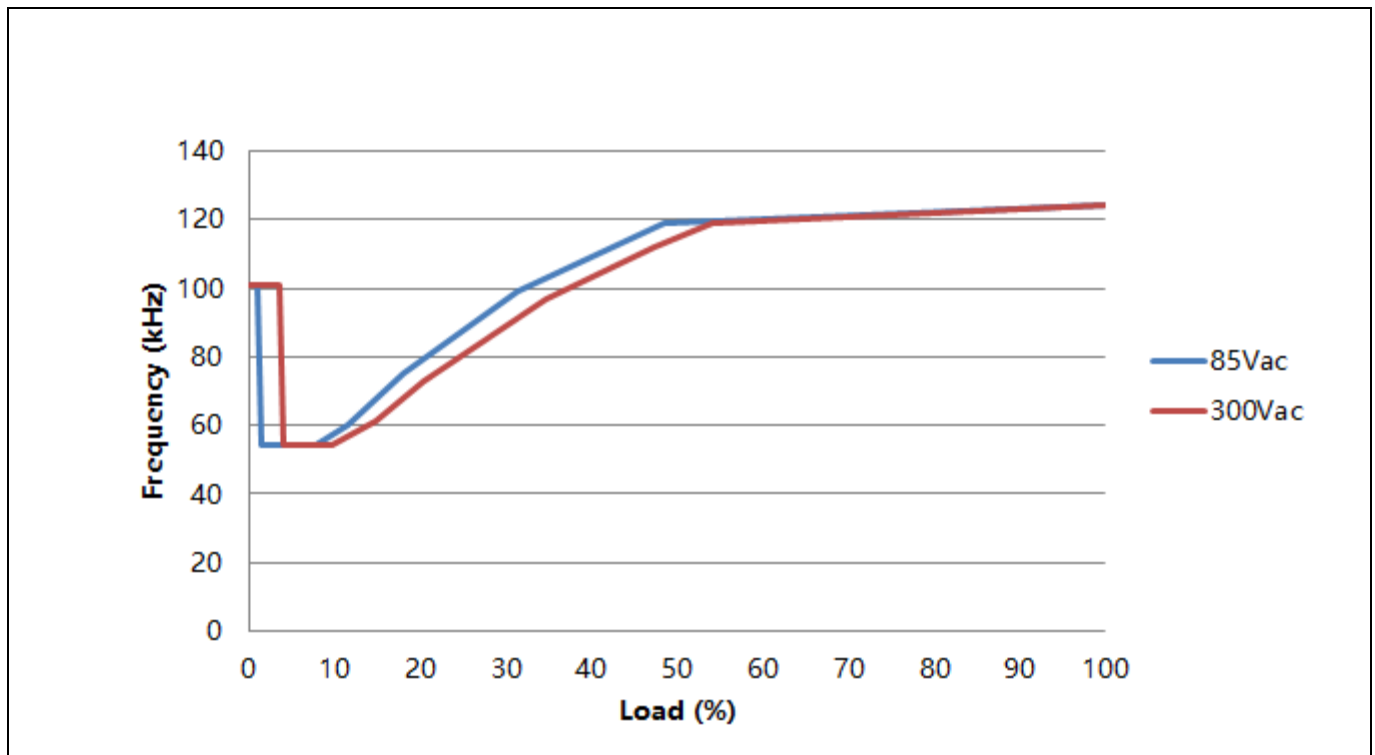


Figure 3 Frequency reduction curve of DEMO_5GR2280AG_22W1

The measured frequency reduction curve of DEMO_5GR2280AG_22W1 is shown in Figure 3.

4.4 Frequency jittering

The ICE5GR2280AG has a frequency jittering feature to reduce the EMI noise. The jitter frequency is internally set at 125 kHz (± 5 kHz) and the jitter period is 4 ms.

4.5 RCD clamper circuit

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

4.6 Output stage

There are two outputs on the secondary side, 12 V and 5 V. The power is coupled out via Schottky diodes D21 and D22. The capacitors C22, C23 and C28 provide energy buffering followed by the L-C filters L21-C24 and L22-C210 to reduce the output ripple and prevent interference between SMPS switching frequency and line frequency. Storage capacitors C22, C23 and C28 are designed to have as small an internal resistance (ESR) as possible to minimize the output voltage ripple caused by the triangular current.

4.7 Feedback loop

For FB, the output is sensed by the voltage divider of R26, R25 and R25A and compared to the IC21 (TL431) internal reference voltage. C25, C26 and R24 comprise the compensation network. The output voltage of IC21 (TL431) is converted to the current signal via optocoupler IC12 and two resistors R22 and R23 for regulation control.

4.8 Active Burst Mode (ABM)

ABM entry and exit power (three levels) can be selected in ICE5GR2280AG. Details are illustrated in the product datasheet. Under light-load conditions, the SMPS enters ABM. At this stage, the controller is always active but the V_{VCC} must be kept above the switch-off threshold. During ABM, the efficiency increases significantly and at the same time it supports low ripple on V_{out} and fast response on load jump.

In order to enter ABM operation, two conditions must apply:

1. The FB voltage must be lower than the threshold of V_{FB_EBXP} .
2. There must be a certain blanking time ($t_{FB_BEB} = 36 \text{ ms}$).

Once both of these conditions are fulfilled, the ABM flip-flop is set and the controller enters ABM operation. This dual-condition determination for entering ABM operation 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 maximum Current Sense (CS) voltage is reduced from V_{CS_N} to V_{CS_BXP} to reduce the conduction loss and the audible noise. In ABM, the FB voltage is changing like a sawtooth between $V_{FB_Bon_NISO}$ and $V_{FB_Boff_NISO}$.

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

5 Protection features

Protection is one of the major factors in determining whether the system is safe and robust. Therefore sufficient protection is necessary. ICE5GR2280AG provides comprehensive protection to ensure the system is operating safely. The protections include line OV, V_{CC} OV and UV, over-load, over-temperature (controller junction), CS short-to-GND and V_{CC} short-to-GND. When those faults are found, the system will enter protection mode until the fault is removed, when it resumes normal operation. A list of protection functions and the failure conditions are shown in the table below.

Table 2 Protection functions of ICE5GR2280AG

Protection function	Failure condition	Protection mode
Line OV	$V_{VIN} > 2.85 \text{ V}$	Non-switch auto restart
V_{CC} OV	$V_{VCC} > 25.5 \text{ V}$	Odd skip auto restart
V_{CC} UV	$V_{VCC} < 10 \text{ V}$	Auto restart
Over-load	$V_{FB} > 2.73 \text{ V}$ and lasts for 54 ms	Odd-skip auto restart
Over-temperature (junction temperature of controller chip only)	$T_J > 140^\circ\text{C}$	Non-switch auto restart
CS short-to-GND	$V_{CS} < 0.1 \text{ V}$, lasts for 0.4 μs and three consecutive pulses	Odd-skip auto restart
V_{CC} short-to-GND ($V_{VCC} = 0 \text{ V}$, $R_{\text{Start-up}} = 50 \text{ M}\Omega$ and $V_{\text{DRAIN}} = 90 \text{ V}$)	$V_{VCC} < 1.2 \text{ V}$, $I_{VCC_Charge1} \approx -0.27 \text{ mA}$	Cannot start up

6 Circuit diagram

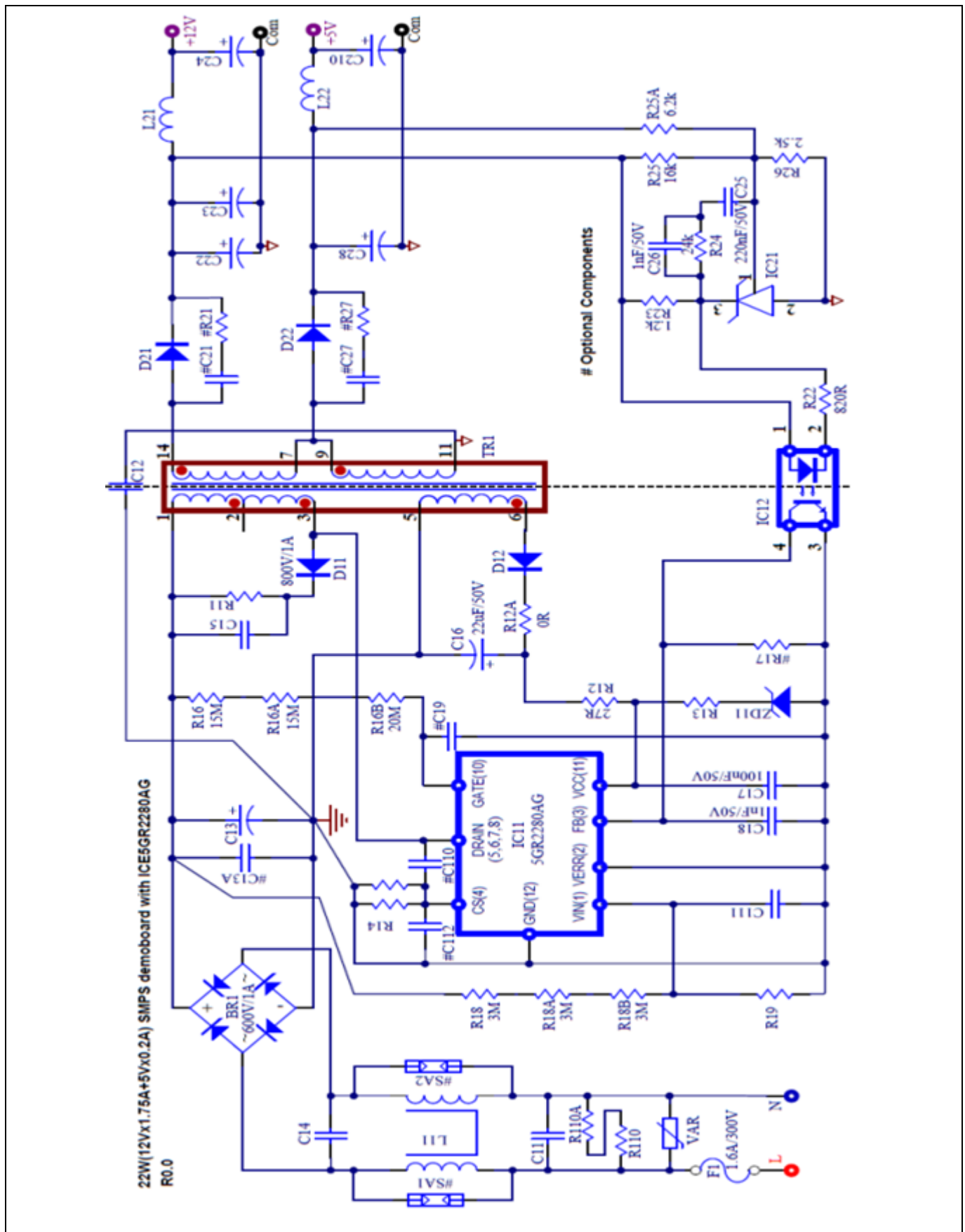


Figure 4 Schematic of DEMO_5GR2280AG_22W1

7 PCB layout

7.1 Top side

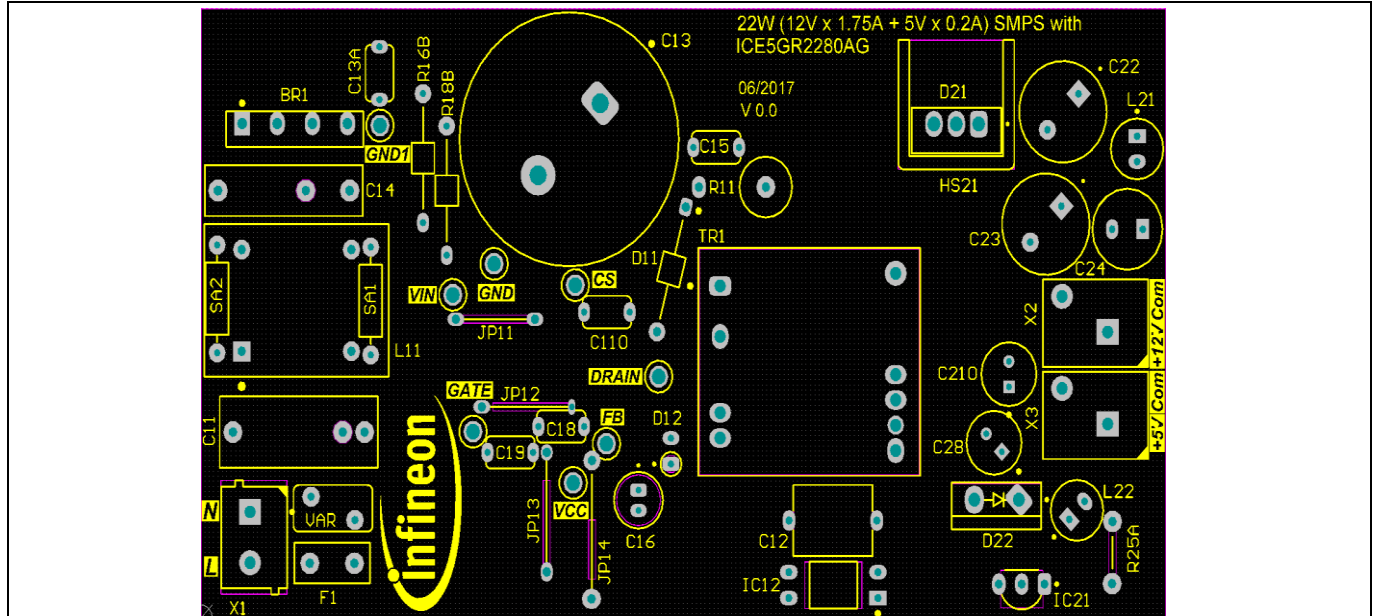


Figure 5 Top side component legend

7.2 Bottom side

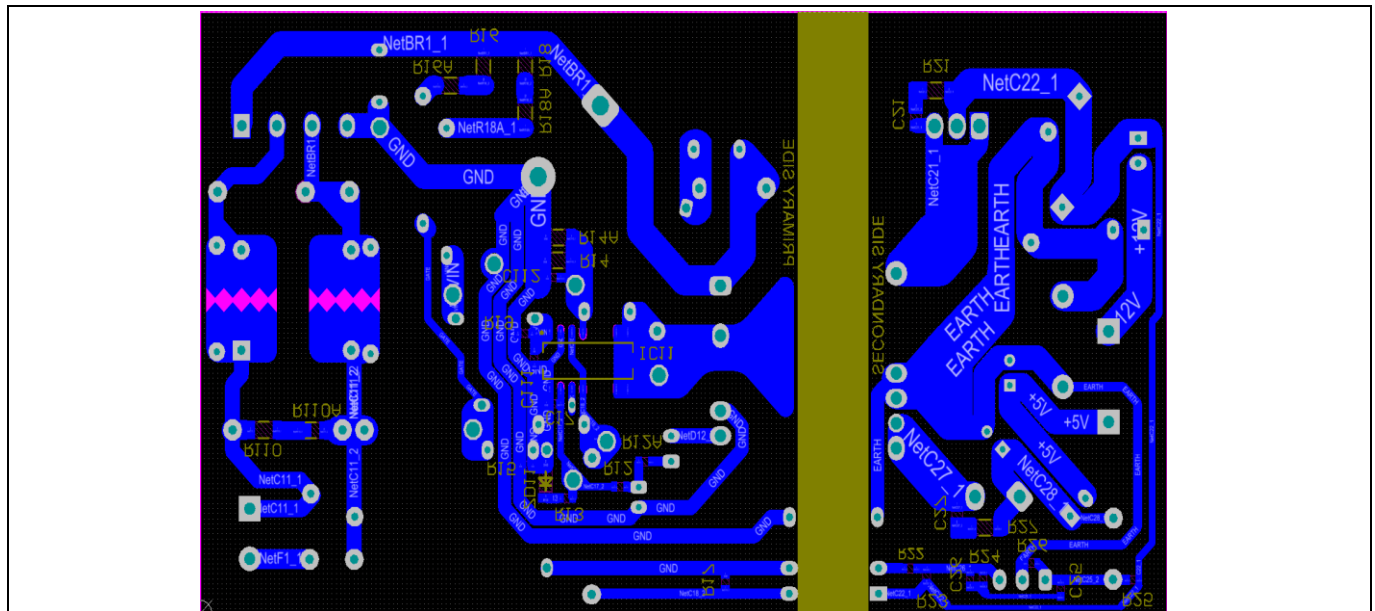


Figure 6 Bottom side copper and component legend

Bill of Materials (BOM)

8 Bill of Materials (BOM)

Table 3 BOM (R 1.5)

No.	Designator	Description	Part number	Manufacturer	Quantity
1	BR1	600 V/1 A	S1VBA60	Shindengen	1
2	C11	0.15 μ F, X-cap	B32932A3154K189	EPCOS/TDK	1
3	C12	1 nF/500 V	DE1E3RA102MA4BQ	Murata	1
4	C13	56 μ F/500 V	LGN2H560MELZ25	Nichicon	1
5	C15	1 nF/1000 V	RDER73A102K2K1H03	Murata	1
6	C16	22 μ F/50 V	50PX22MEFC5X11	Rubycon	1
7	C17	100 nF/50 V	GRM188R71H104KA93D	Murata	1
8	C18	1 nF/50 V	RCE5C1H102J0M1H03A	Murata	1
9	C22, C23	1000 μ F/16 V	16ZLH1000MEFC10X16	Rubycon	2
10	C24	470 μ F/16 V	16ZLH470MEFC8X11.5	Rubycon	1
11	C25	220 nF/50 V	GRM188R71H224KAC4D	Murata	1
12	C26	1 nF/50 V	GRM1885C1H102GA01D	Murata	1
13	C28	330 μ F/10 V	10ZLH330MEFC6.3X11	Rubycon	1
14	C111	22 nF/50 V	GCM188R71H223KA37D	Murata	1
15	C210	330 μ F/10 V	10ZLH330MEFC6.3X11	Rubycon	1
16	D11	800 V/1 A	UF4006-E3/54	Vishay	1
17	D12	0.2 A/200 V	1N485B	Fairchild	1
18	D21	100 V/10 A	MBRF10100CT	Vishay	1
19	D22	50 V/1 A	SB150	Vishay	1
20	F1	1.6 A/300 V	36911600000		1
21	IC11	ICE5GR2280AG	ICE5GR2280AG	Infineon	1
22	IC12	Optocoupler	SFH617A-3		1
23	IC21	Shunt regulator	TL431BVLPG		1
24	JP11, JP12, JP13, JP14	Jumper			4
25	L11	39 mH/0.7 A	B82732R2901B030	Epcos	1
26	L21, L22	4.7 μ H, 4.2 A	7447462047	Würth Electronics	2
27	R11	39 k/2 W/500 V	PR02000206802JR500		1
28	R12, R13	27 R (0603)	RESISTOR		2
29	R14	1.1 R/0.33 W	ERJ8BQF1R1V		1
30	R14A	1.2 R/0.33 W	ERJ8BQF1R2V		1
31	R16, R16A	15 M Ω /0.25 W/5%/1206	RC1206JR-0715ML	Yageo	2
32	R16B	20 M.0.125 W (axial leaded)			1
33	R18, R18A	3 M Ω /0.25 W/5%/1206	RESISTOR		2
34	R18B	3 M/0.125 W (axial leaded)	RESISTOR		1
35	R19	59 k (0603)	ERJ-3RBD5902V		1
36	R22	820 R (0603)			1
37	R23	1.2 k (0603)			1
38	R24	24 k (0603)			1
39	R25	16 k (0603)			1
40	R25A	6.2 k/0.1 W (axial leaded)			1
41	R26	2.5 k (0603)			1
42	R12A	0 R (0603)			1

Bill of Materials (BOM)

43	R110, R110A	2 M/200 V (1206)			2
44	Test point of FB, VIN, CS, gate, drain, V _{cc} , GND, GND1	Test point	5010		8
45	TR1	EF20, 240 uH	750343685 (Rev 02)	Würth Electronics	1
46	ZD11	22 V (SOD123)	MMSZ5251B-7-F		1
47	VAR	320 V/0.25 W	B72207S02321K101	Epcos	1
48	X1	Connector_ Con (L N)	691102710002	Würth Electronics	1
49	X2, X3	Connector_Con (+12 V com), con(+5 V com)	691 412 120 002B	Würth Electronics	2
50	HS21	Heatsink	577202B00000G	AAVID	1

Transformer construction

9 Transformer construction

Core and materials: EE20/10/6, TP4A (TDG)

Bobbin: 070-5643 (14-pin EXT, THT, horizontal version)

Primary inductance: $L_p = 240 \mu\text{H}$ ($\pm 10\%$), measured between pin 1 and pin 3

Manufacturer and part number: Wurth Electronics Midcom (750343685 Rev02)

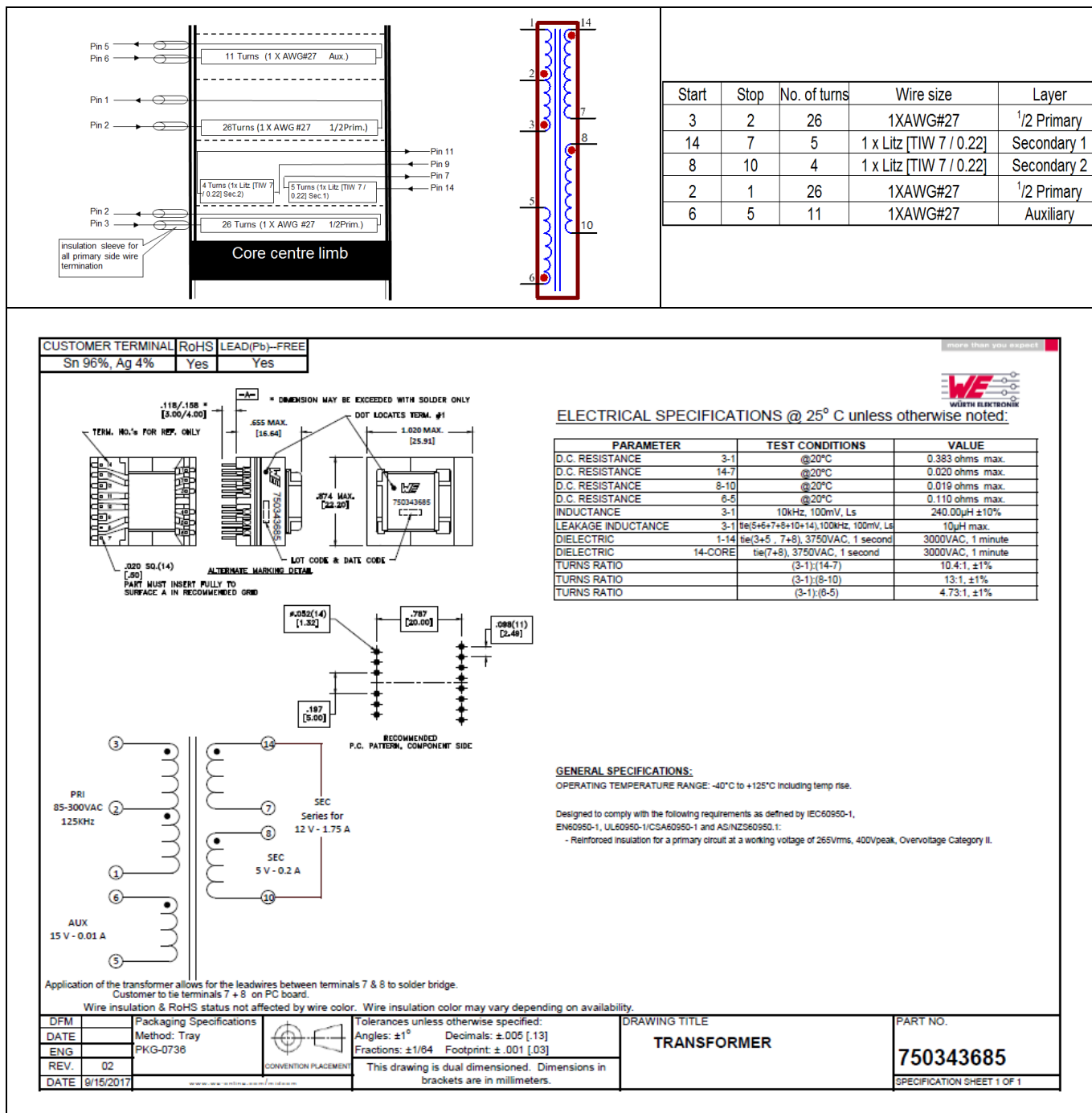


Figure 7 Transformer structure

Test results

10 Test results

10.1 Efficiency, regulation and output ripple

Table 4 Efficiency, regulation and output ripple

Input (V AC/Hz)	P _{in} (W)	12 V (V)	I _{out_12V} (mA)	5 V (V)	I _{out_5V} (mA)	12 V _{RPP} (mV)	5 V _{RPP} (mV)	P _{out} (W)	Efficiency (η) (%)	Average (%)	OLP pin (W)	OLP I _{out} 12 V (Fixed 5 V at 0.2 A) (A)
85 V AC/60 Hz	0.0430	11.72	0	5.07	0	37	25				36.80	2.45
	0.118	12.23	2.5	4.87	6	33	48	0.06				
	6.440	11.68	437.5	5.08	50	37	25	5.36	83.29	82.42		
	12.92	11.68	875	5.07	100	43	25	10.73	83.03			
	19.58	11.69	1312.5	5.06	150	46	30	16.10	82.24			
	26.49	11.70	1750	5.05	200	60	35	21.49	81.11			
115 V AC/60 Hz	0.0480	11.71	0	5.07	0	43	28				37.00	2.55
	0.122	12.23	2.5	4.87	6	40	50	0.06				
	6.370	11.66	437.5	5.08	50	43	25	5.36	84.07	83.81		
	12.72	11.67	875	5.07	100	46	28	10.72	84.26			
	19.19	11.68	1312.5	5.07	150	53	30	16.09	83.85			
	25.83	11.68	1750	5.06	200	63	32	21.45	83.05			
230 V AC/50 Hz	0.072	11.69	0	5.08	0	66	30				38.00	2.70
	0.147	12.24	2.5	4.87	6	66	51	0.06				
	6.380	11.61	437.5	5.10	50	66	27	5.33	83.61	84.4		
	12.63	11.62	875	5.09	100	70	32	10.68	84.53			
	18.90	11.64	1312.5	5.08	150	73	32	16.04	84.87			
	25.30	11.65	1750	5.07	200	73	32	21.40	84.59			
265 V AC/50 Hz	0.086	11.70	0	5.08	0	70	30				39.00	2.76
	0.162	12.27	2.5	4.86	6	63	56	0.06				
	6.430	11.60	437.5	5.11	50	63	28	5.33	82.90	84.01		
	12.67	11.62	875	5.09	100	66	30	10.68	84.27			
	18.98	11.63	1312.5	5.08	150	66	32	16.03	84.44			
	25.32	11.64	1750	5.07	200	66	35	21.38	84.45			
300 V AC/50 Hz	0.112	11.70	0	5.08	0	60	30				39.50	2.83
	0.185	12.27	2.5	4.86	6	63	48	0.06				
	6.510	11.60	437.5	5.11	50	66	27	5.33	81.88	83.31		
	12.78	11.61	875	5.10	100	66	28	10.67	83.48			
	19.09	11.62	1312.5	5.07	150	63	30	16.01	83.88			
	25.45	11.64	1750	5.07	200	66	35	21.38	84.02			

60 mW load condition: 5 V @ 6 mA and 12 V @ 2.5 mA

Maximum load condition: 5 V @ 200 mA and 12 V @ 1750 mA

Test results

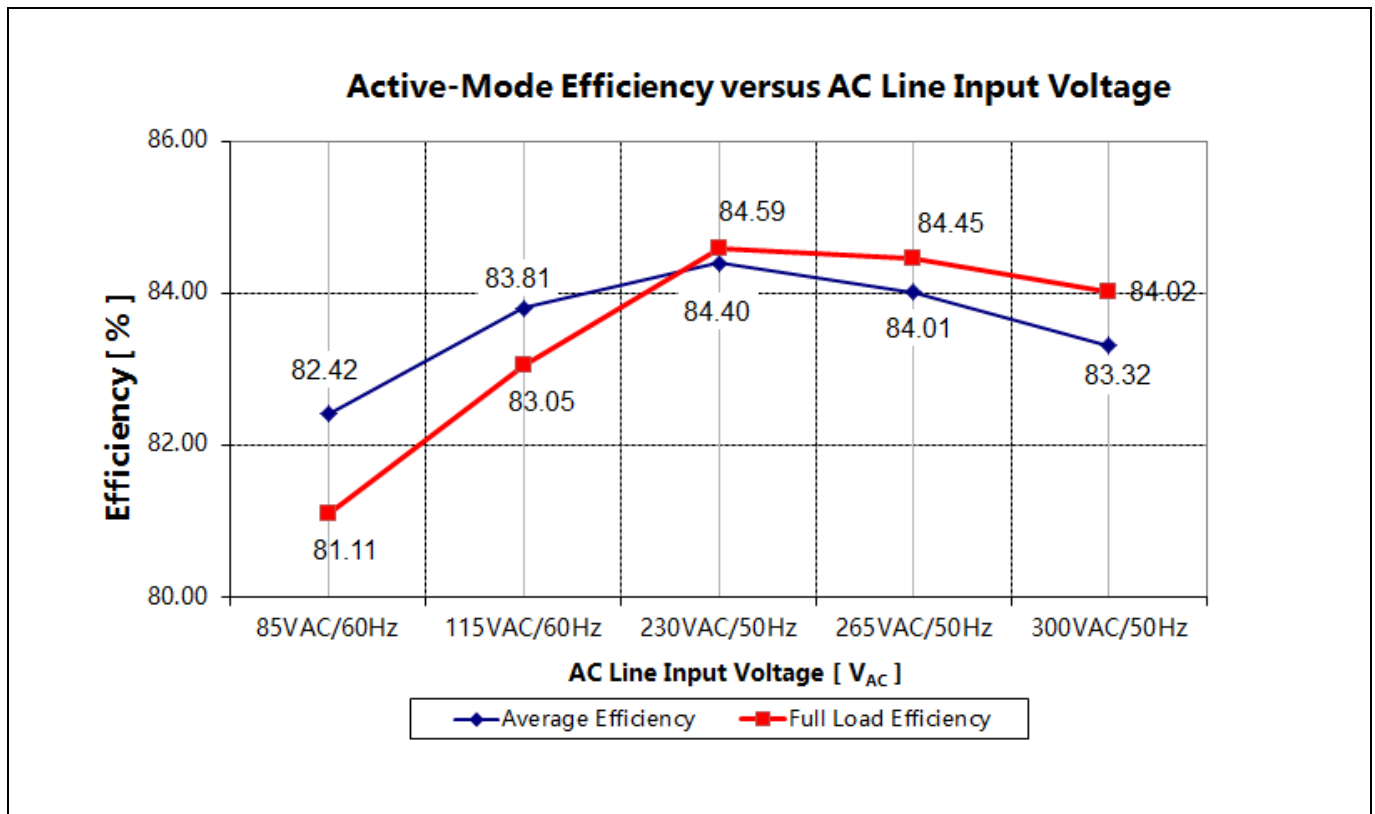


Figure 8 Efficiency vs AC-line input voltage

10.2 Standby power

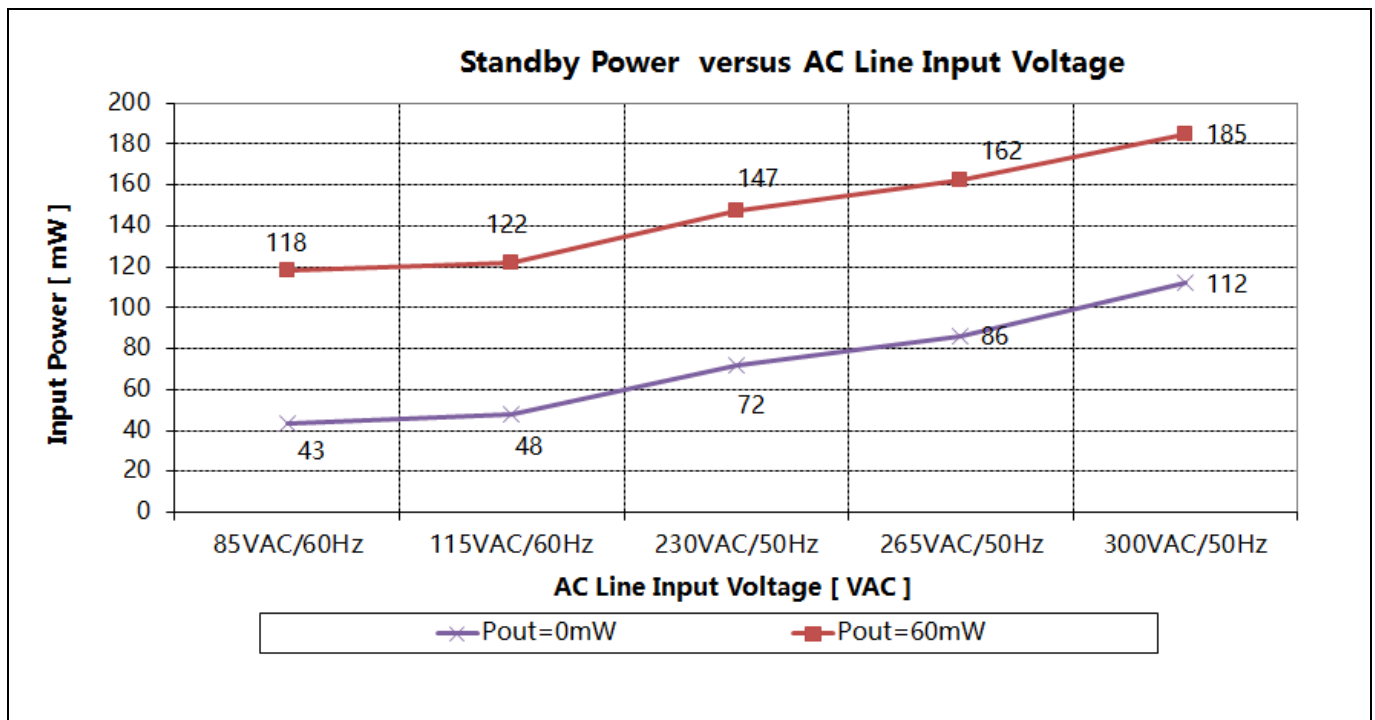
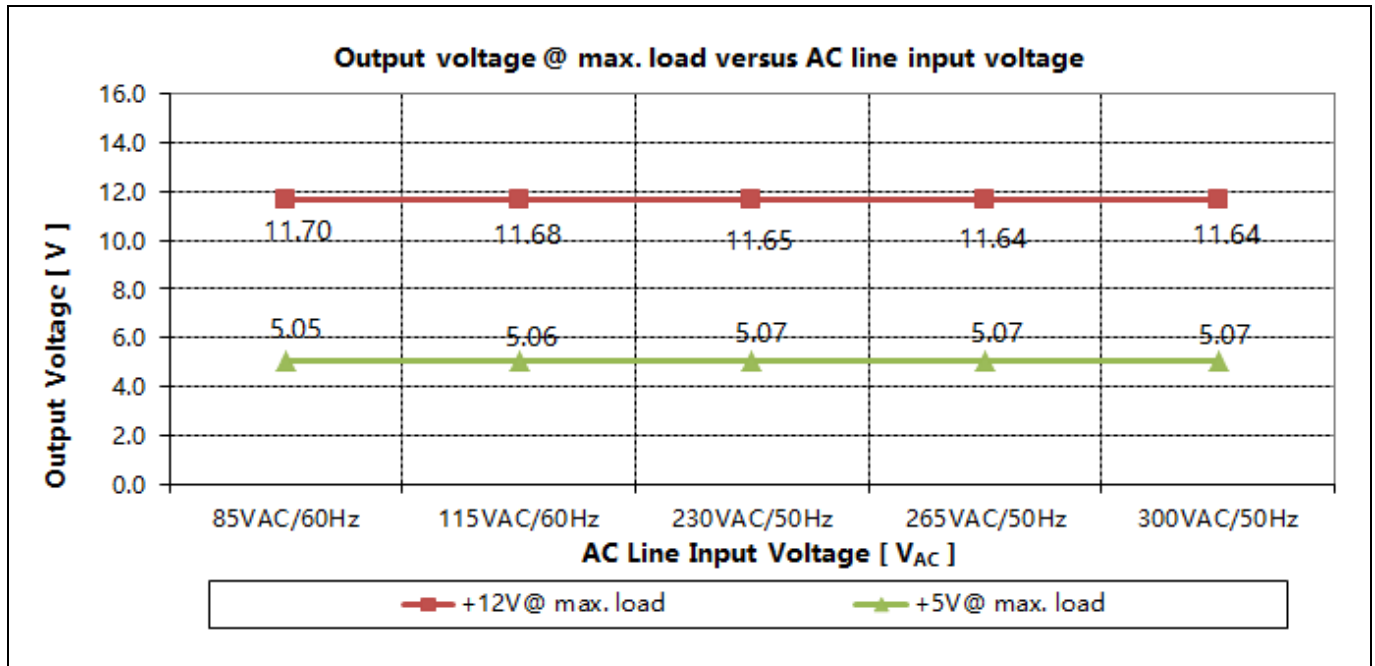


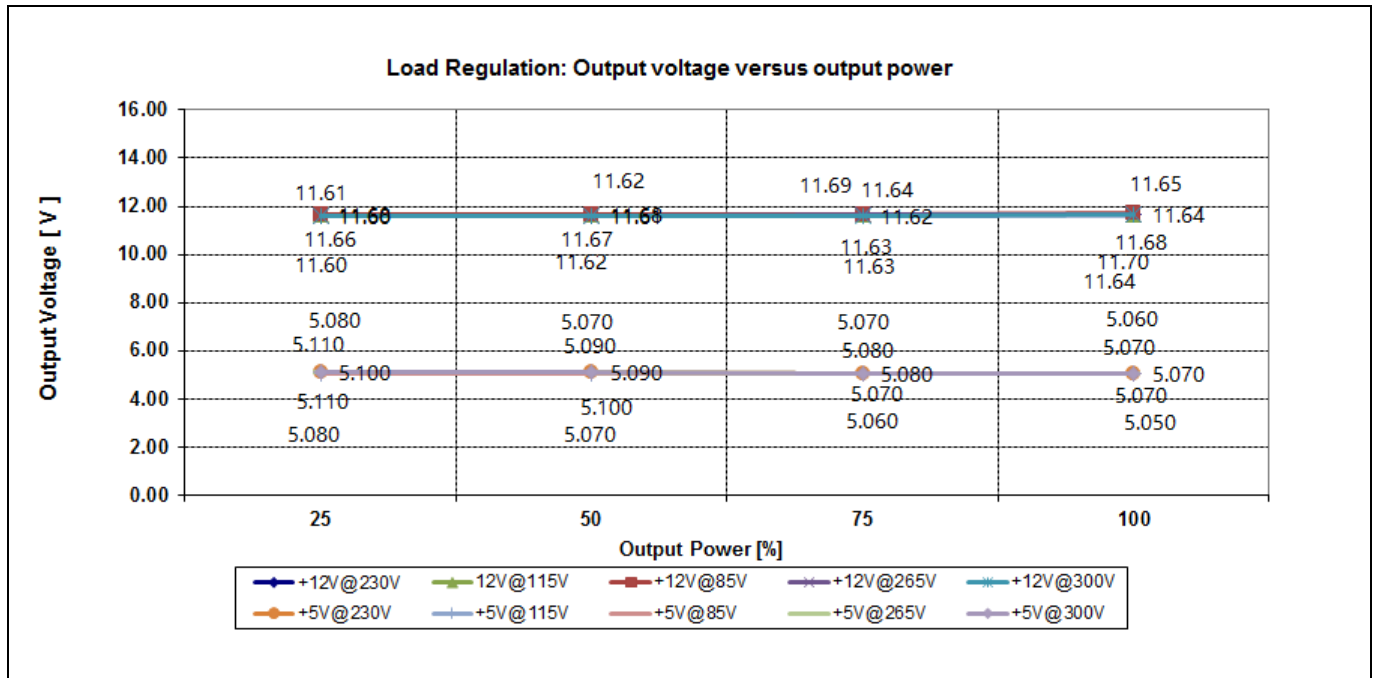
Figure 9 Standby power at no load and 60 mW load vs AC-line input voltage (measured by Yokogawa WT210 power meter – integration mode)

Test results

10.3 Line regulation

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

10.4 Load regulation

Figure 11 Load regulation V_{out} vs output power

Test results

10.5 Maximum input power

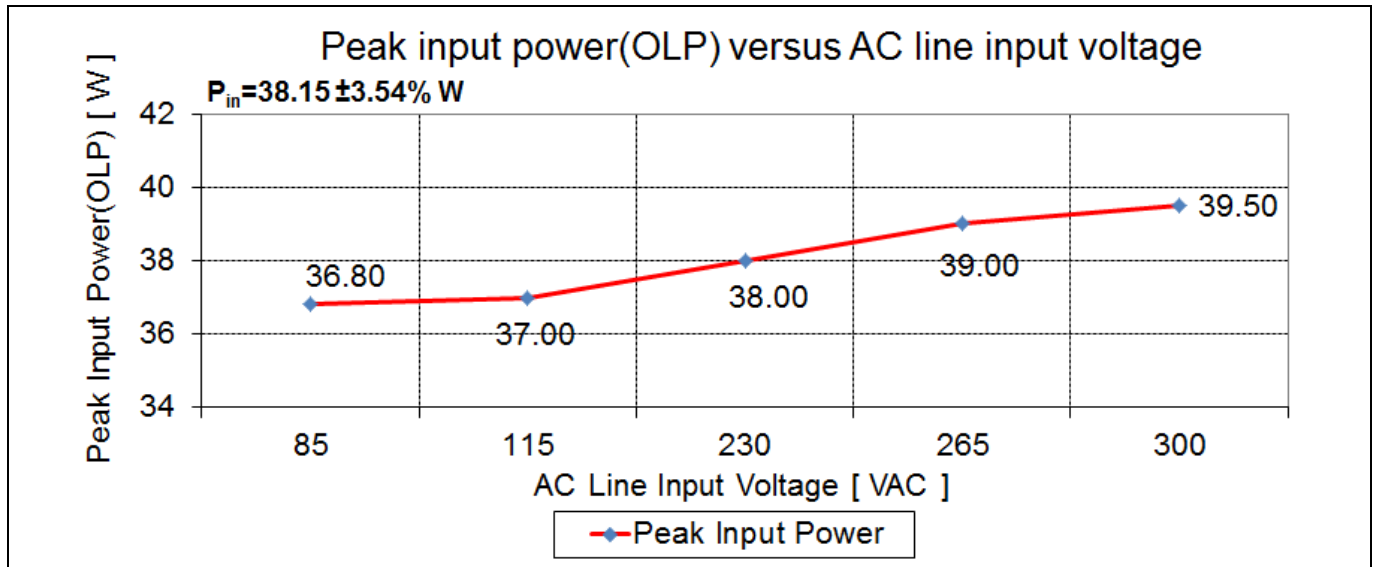


Figure 12 Maximum input power (before over-load protection) vs AC-line input voltage

10.6 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).

10.7 Surge immunity (EN 61000-4-5)

Pass EN 61000-4-5 installation class 4 (± 2 kV for line-to-line and ± 4 kV for line-to-earth).

10.8 Conducted emissions (EN 55022 class B)

The conducted EMI was measured by Schaffner (SMR4503) and followed the test standard of EN 55022 (CISPR 22) class B. The demo board was set up at maximum load (22 W) with an input voltage of 115 V AC and 230 V AC.

Pass conducted emissions EN 55022 (CISPR 22) class B with 10 dB margin at low-line (115 V AC) and with 9.4 dB margin for high-line (230 V AC).

Test results

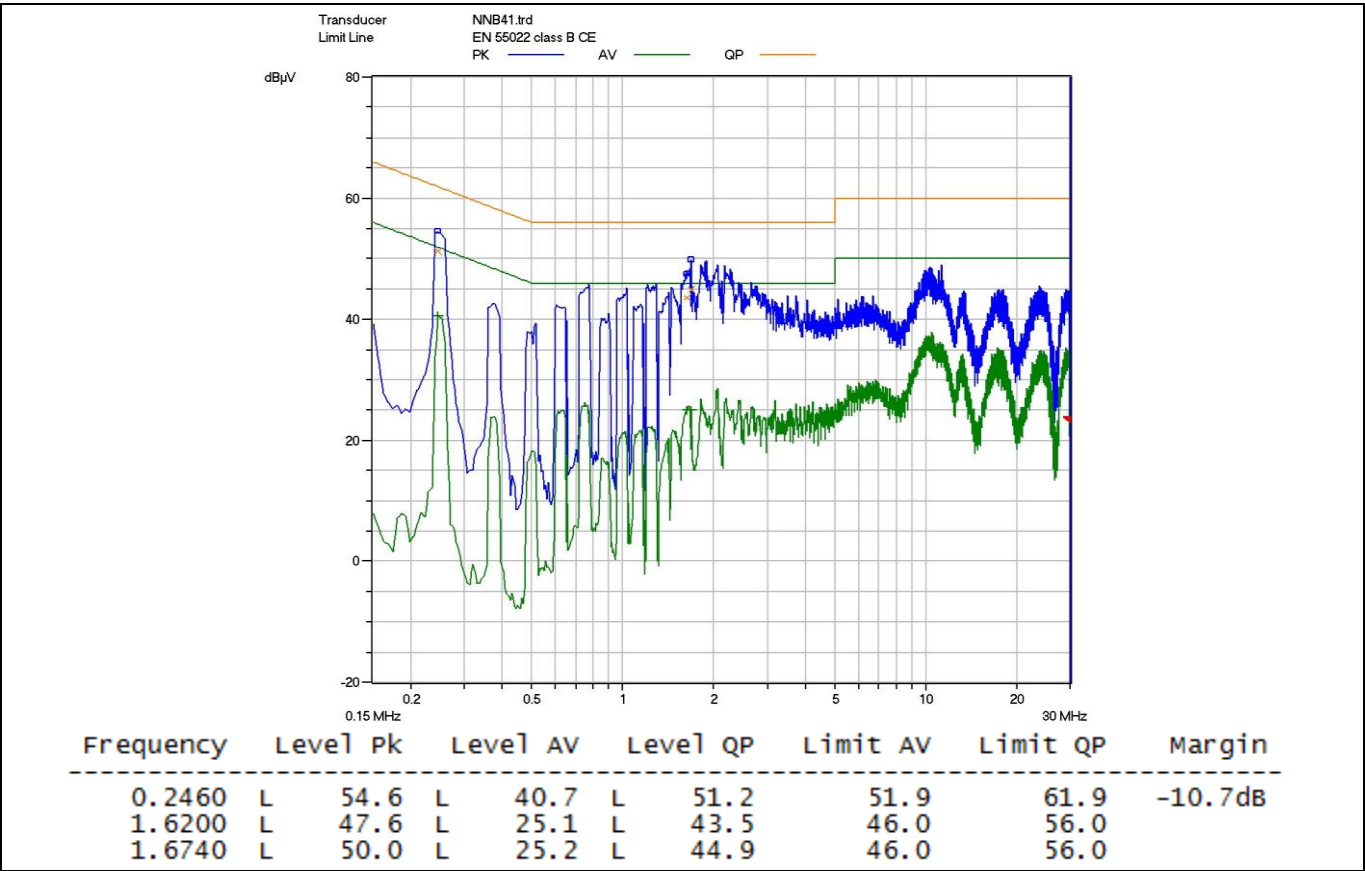


Figure 13 Conducted emissions (line) at 115 V AC and maximum load

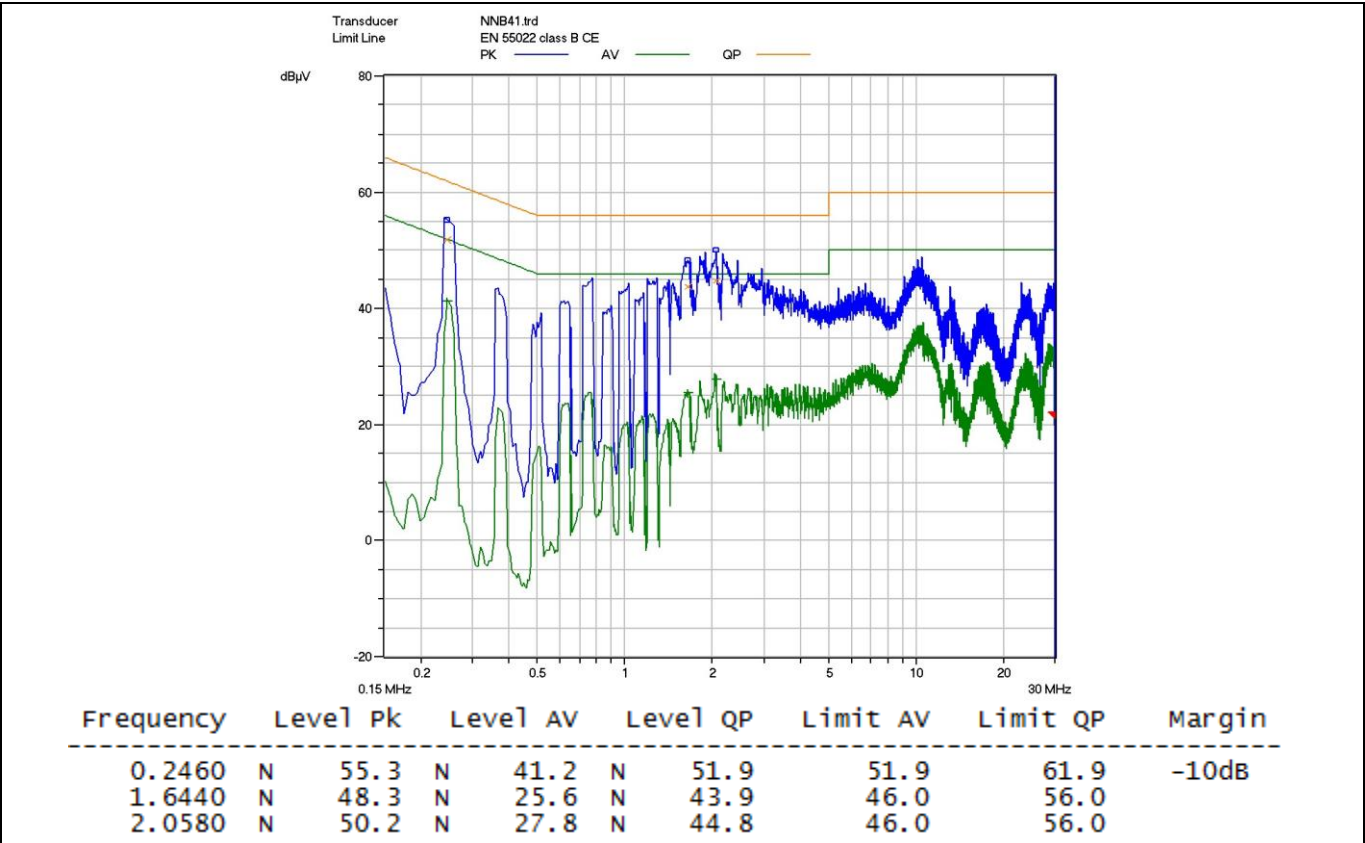


Figure 14 Conducted emissions (neutral) at 115 V AC and maximum load

Test results

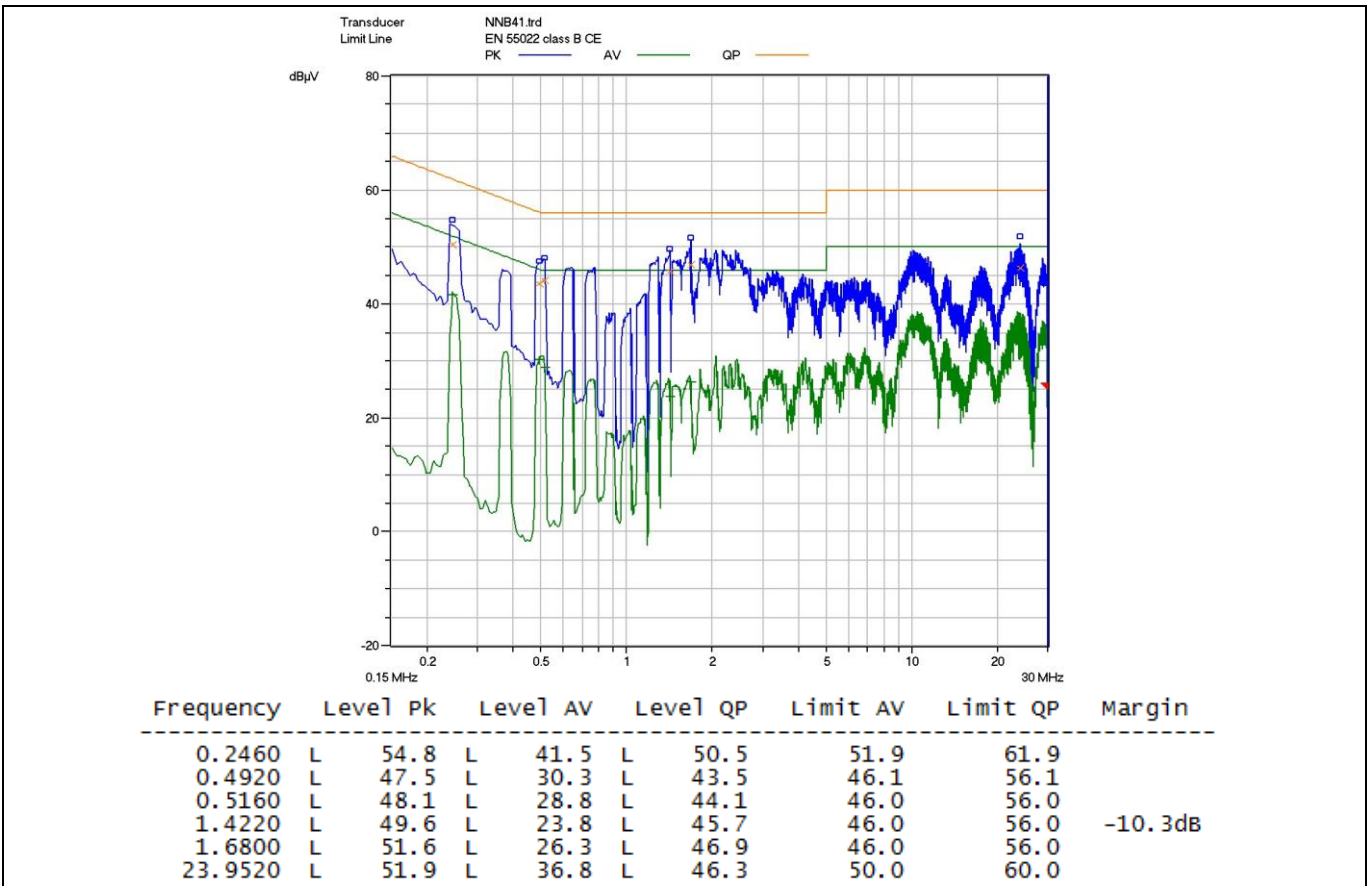


Figure 15 Conducted emissions (line) at 230 V AC and maximum load

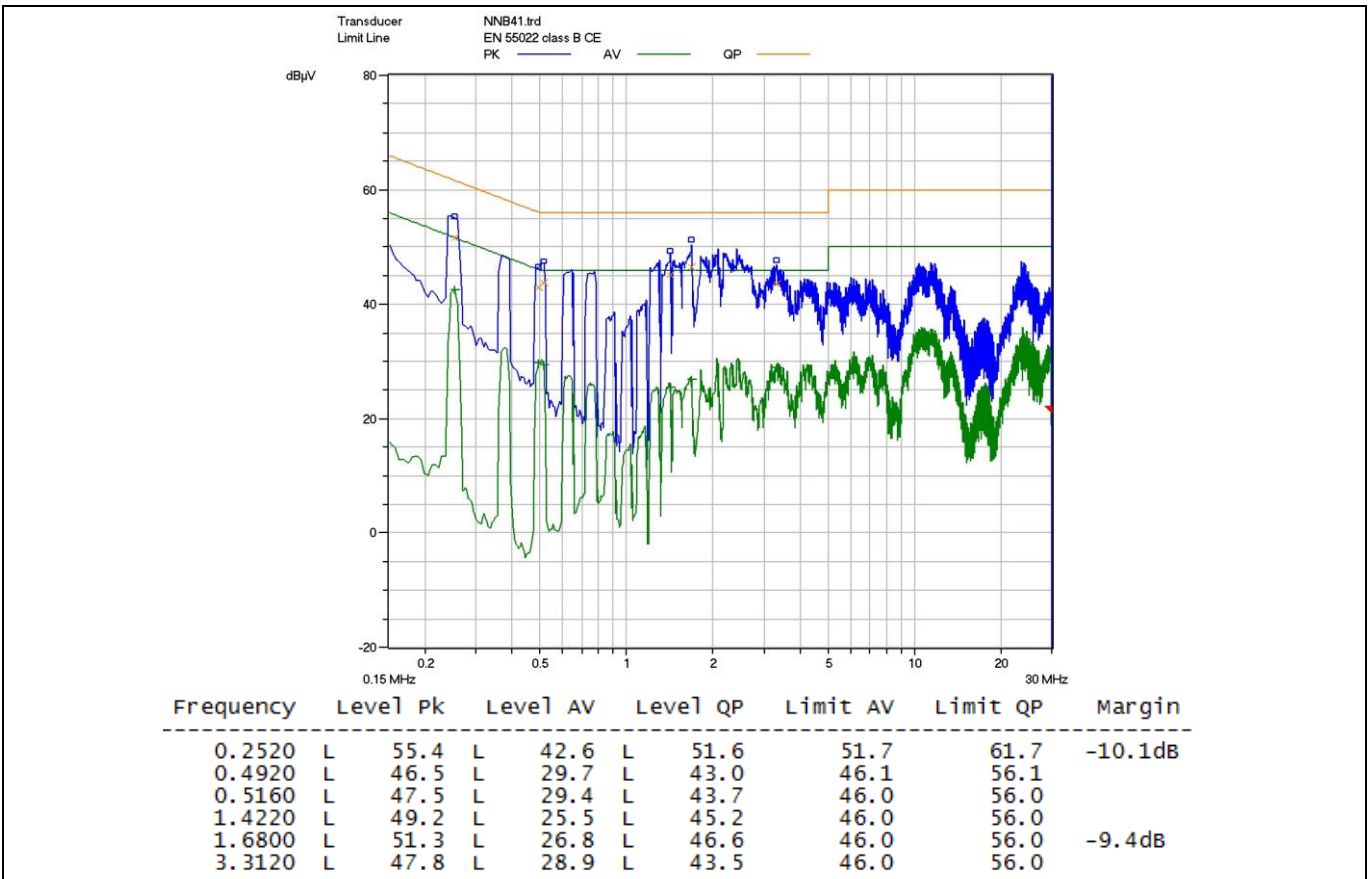


Figure 16 Conducted emissions (neutral) at 230 V AC and maximum load

Test results

10.9 Thermal measurement

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

Table 5 Hottest temperature of demo board

No.	Major component	85 V AC (°C)	300 V AC (°C)
1	IC1 (ICE5GR2280AG)	85.2	67.2
2	L1 (choke)	48.5	32.9
3	T1 (transformer)	68.2	71.9
4	D151 (12 V diode)	64.8	65.3

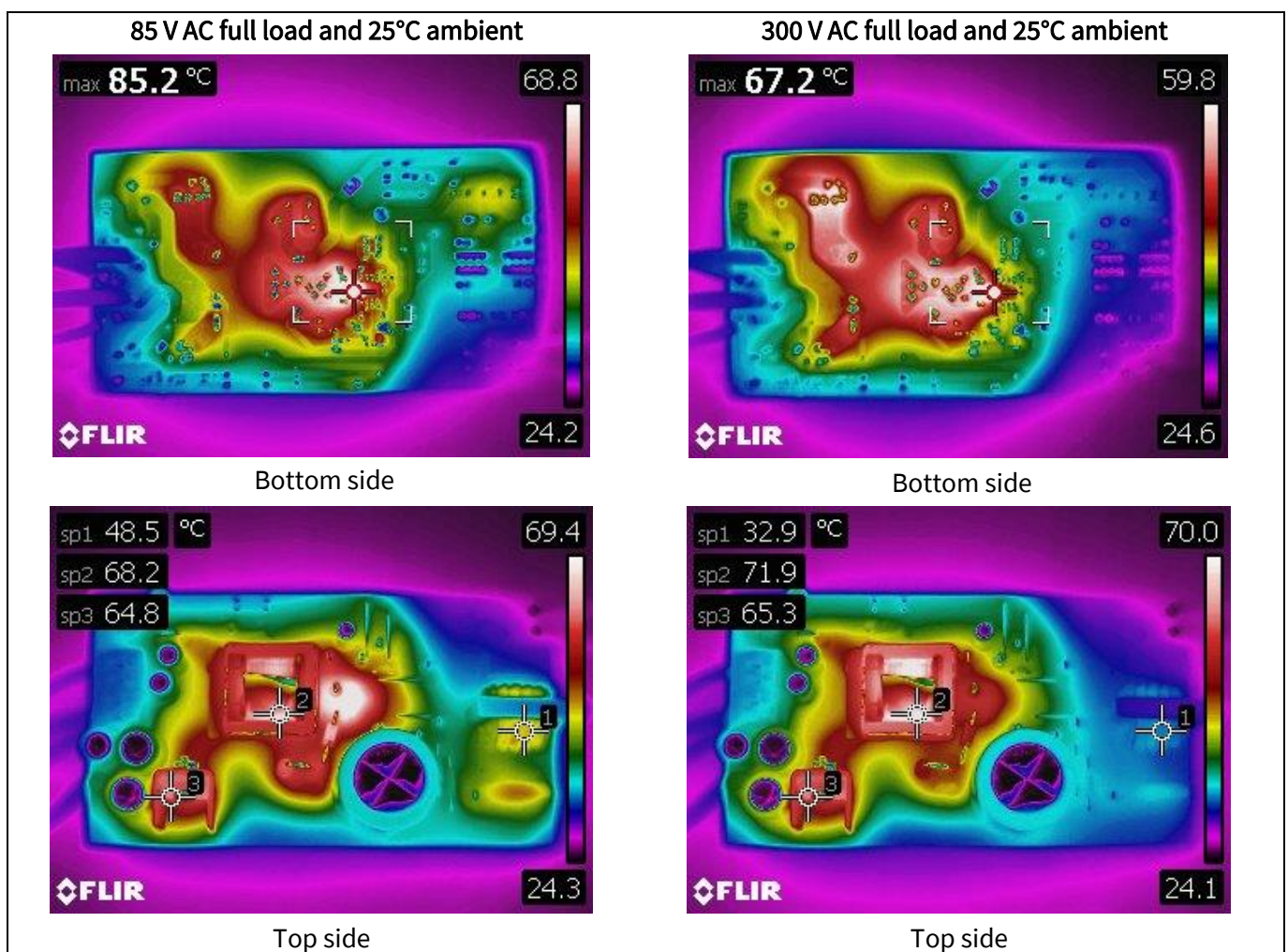


Figure 17 Infrared thermal image of DEMO_5GR2280AG_22W1

11 Waveforms and scope plots

All waveforms and scope plots were recorded with a Teledyne LeCroy 606Zi oscilloscope.

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

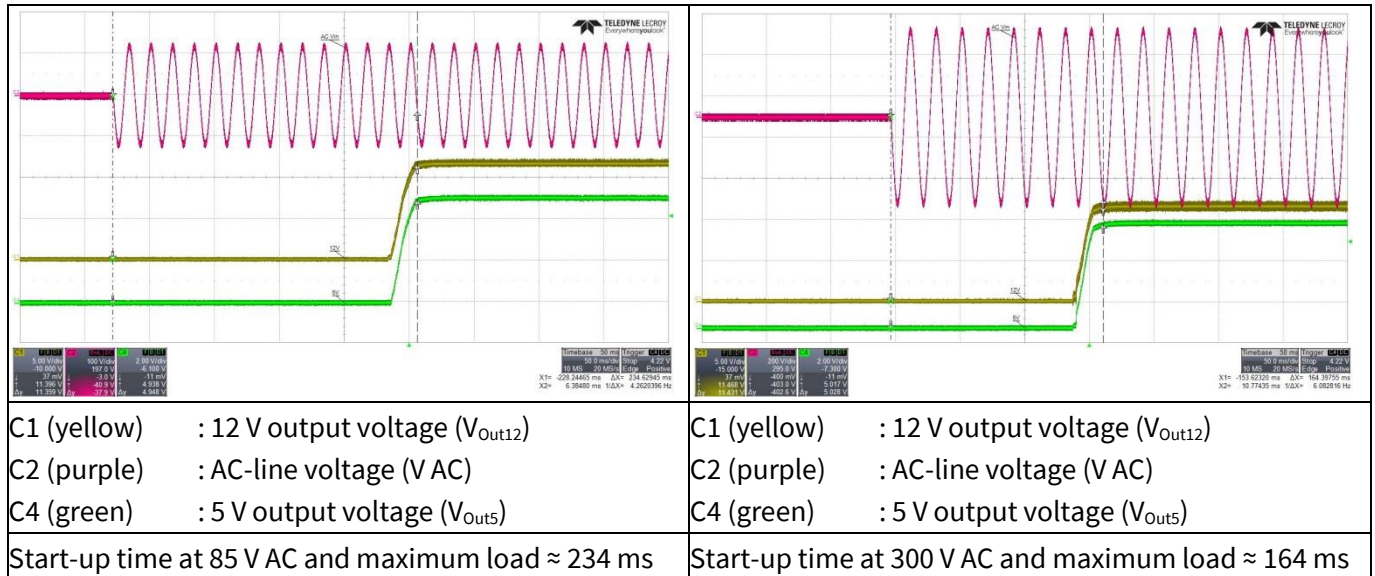


Figure 18 Start-up

11.2 Soft-start

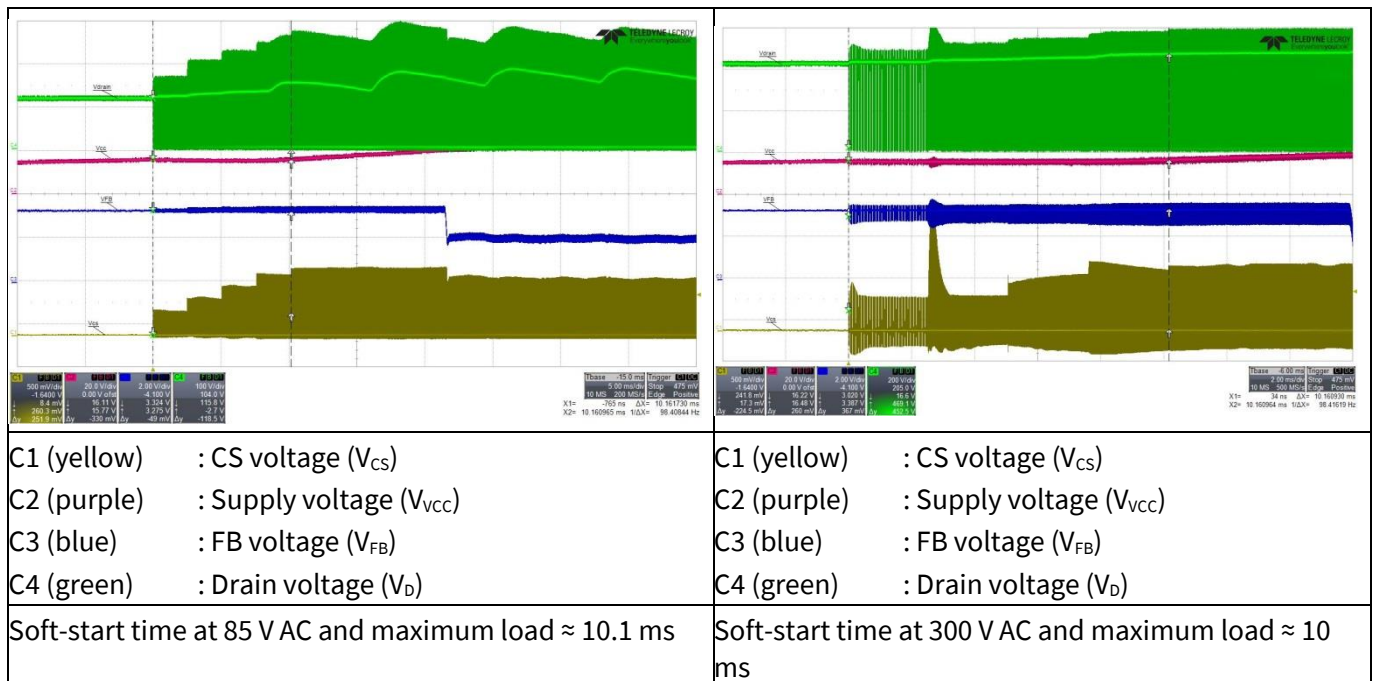


Figure 19 Soft-start

11.3 Drain and CS voltage at maximum load

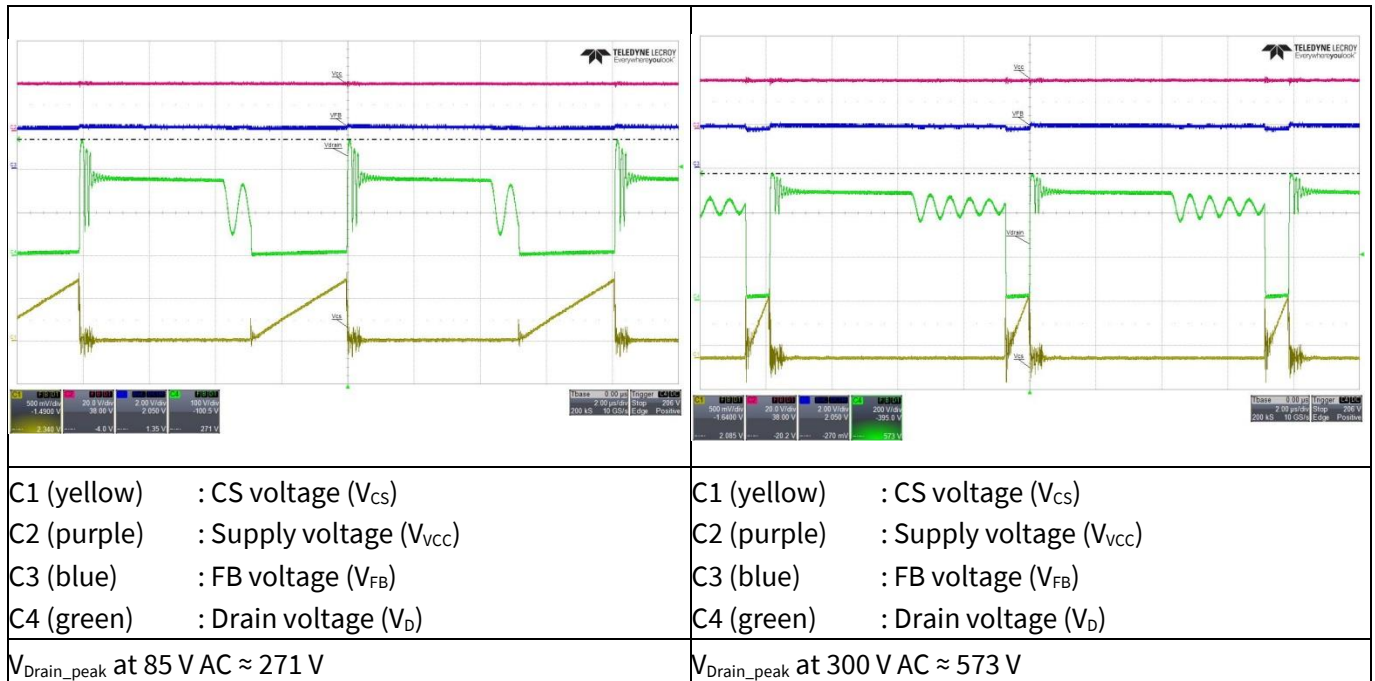


Figure 20 Drain and CS voltage at maximum load

11.4 Frequency jittering

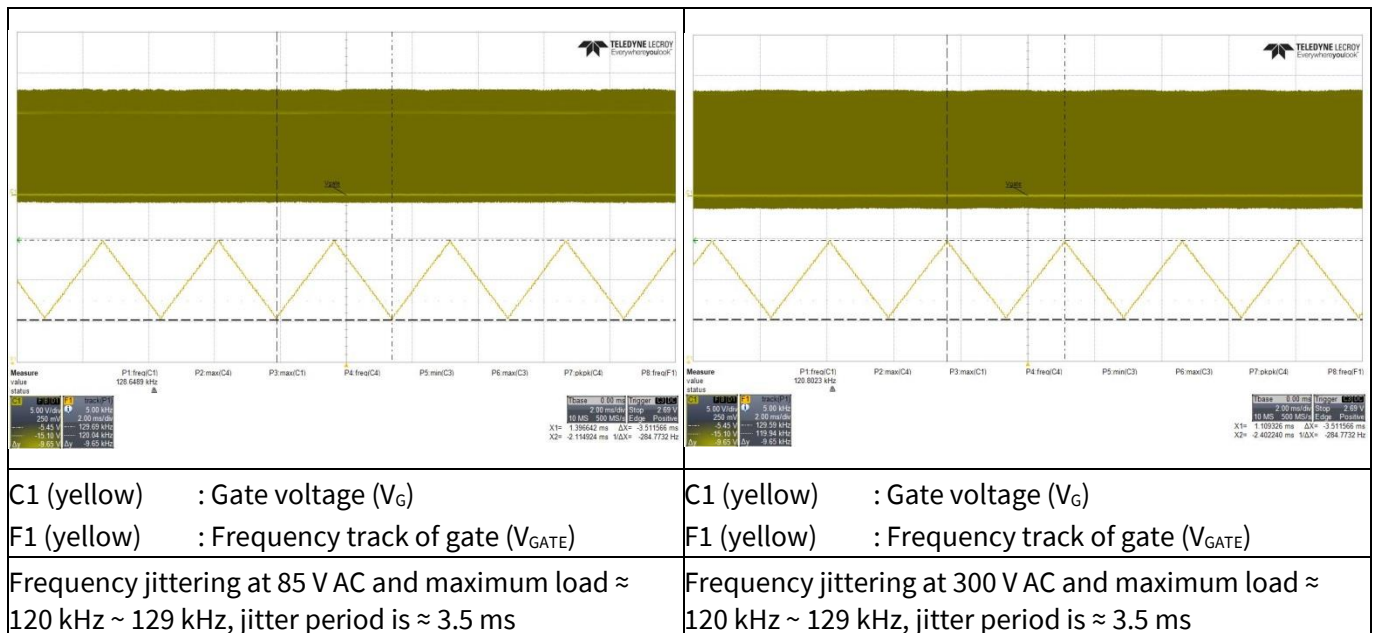


Figure 21 Frequency jittering

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

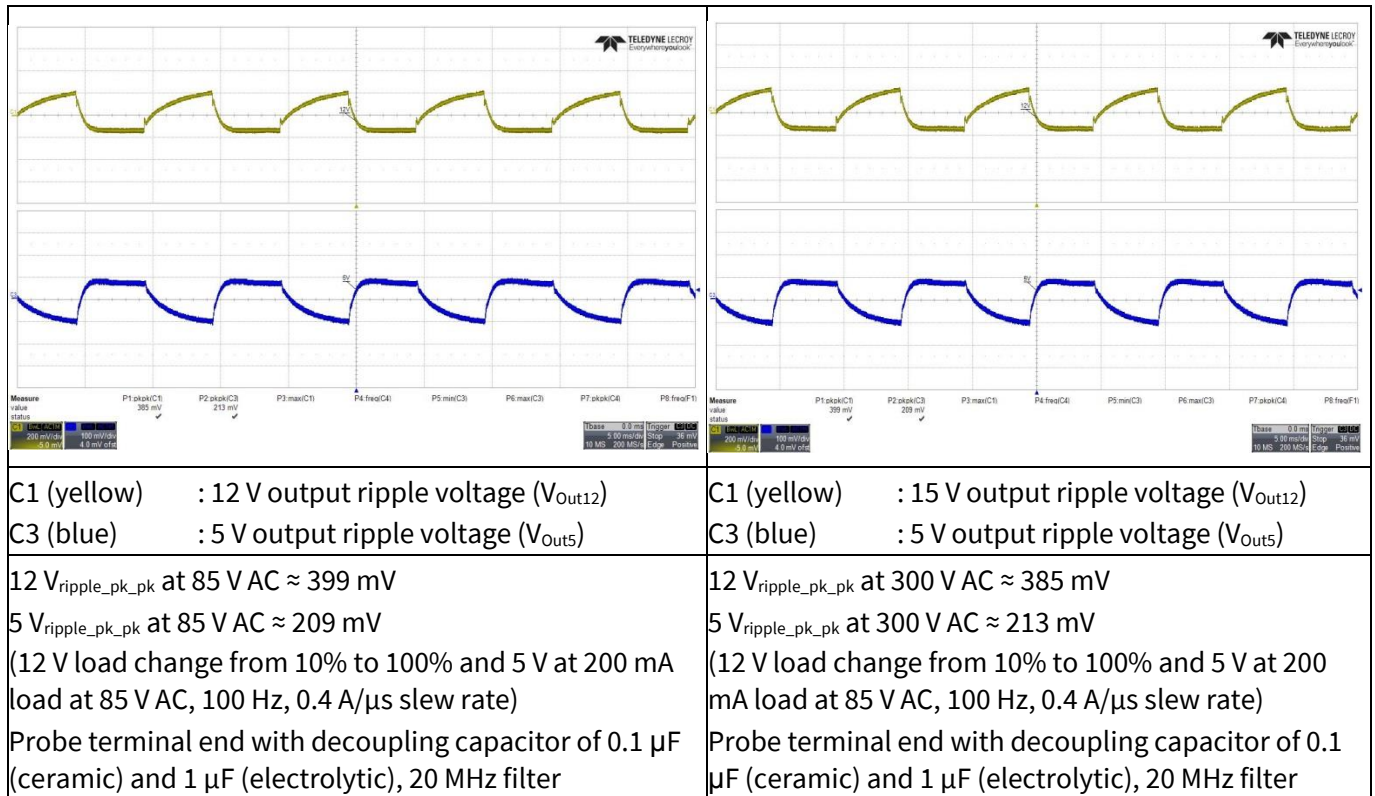


Figure 22 Load transient response

11.6 Output ripple voltage at maximum load

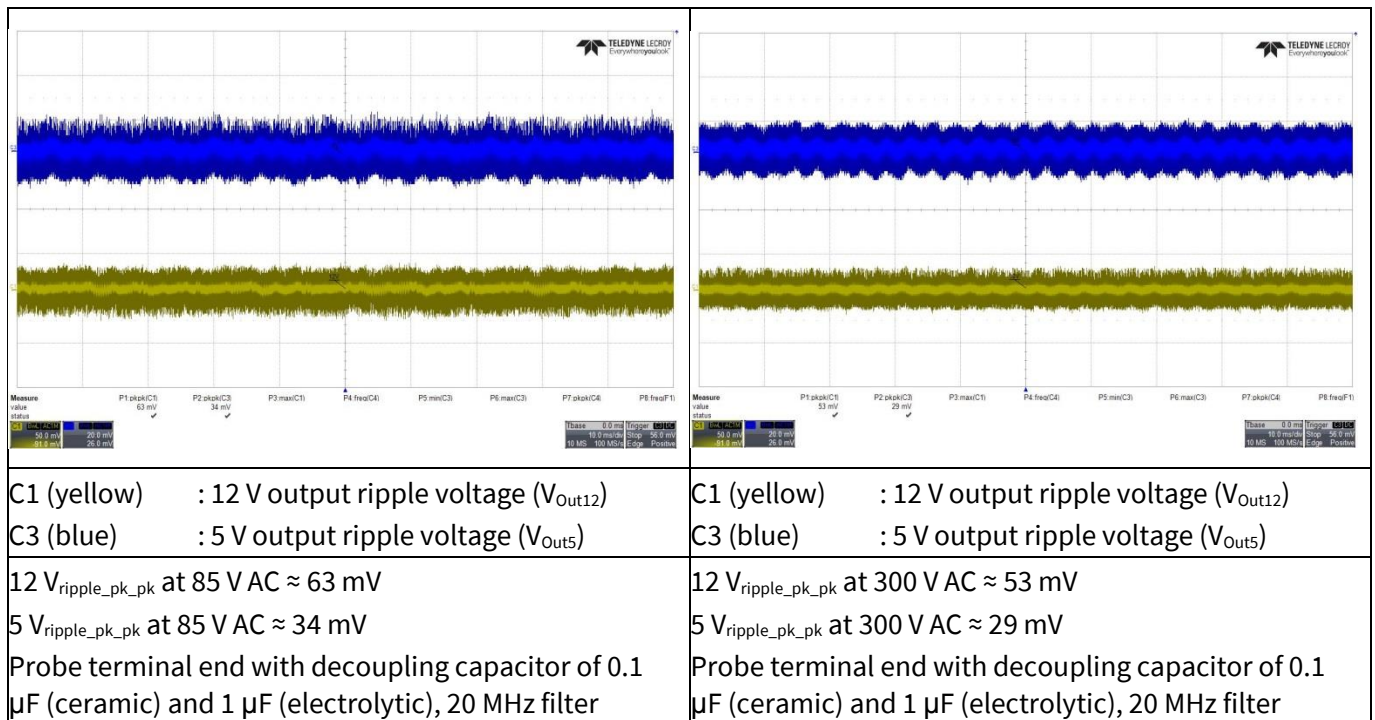


Figure 23 Output ripple voltage at maximum load

11.7 Output ripple voltage at ABM 1 W load

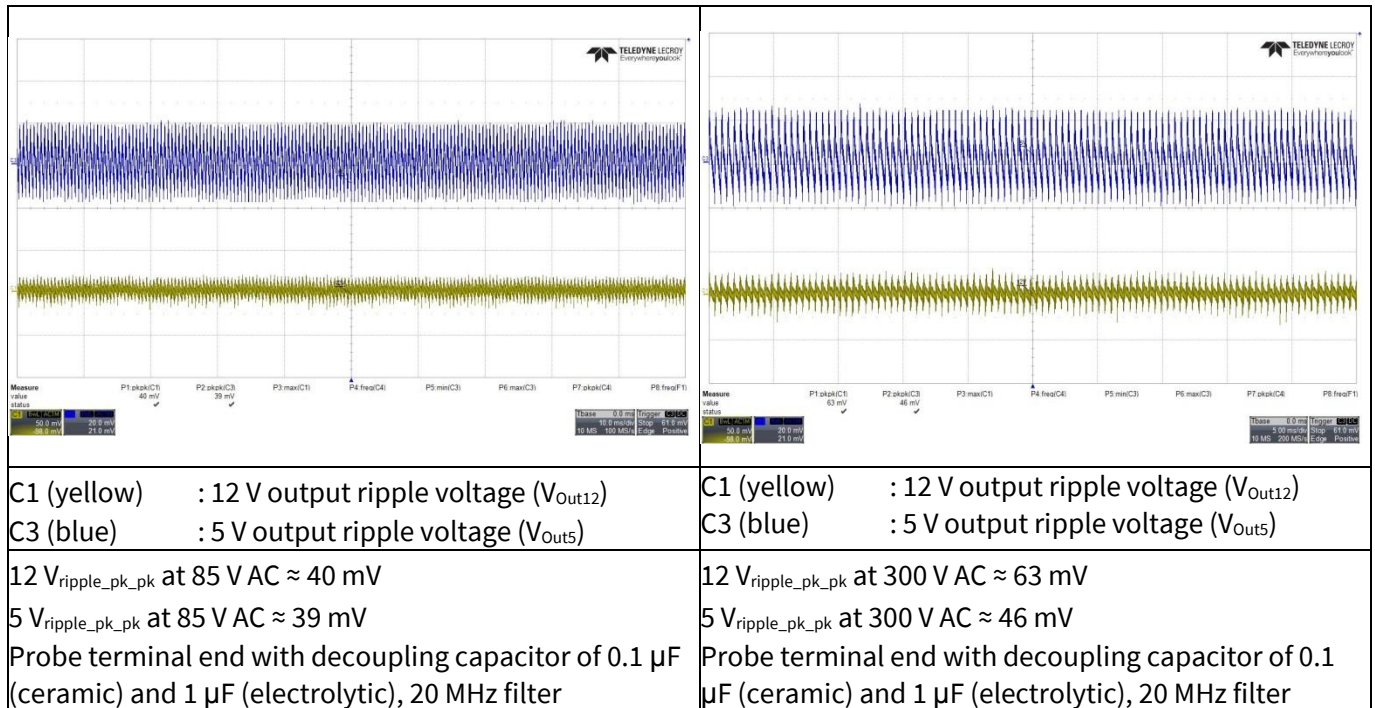


Figure 24 Output ripple voltage at burst mode 1 W load

11.8 Entering ABM

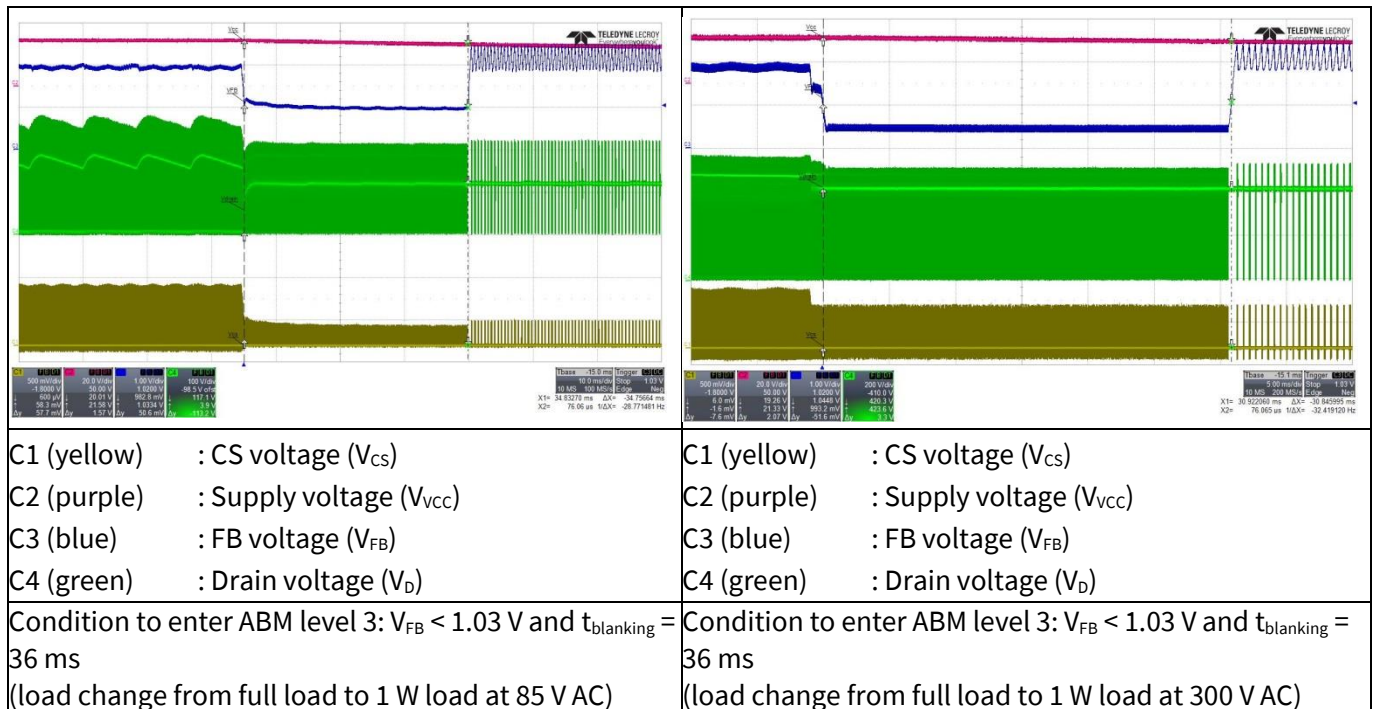


Figure 25 Entering ABM

Waveforms and scope plots

11.9 During ABM

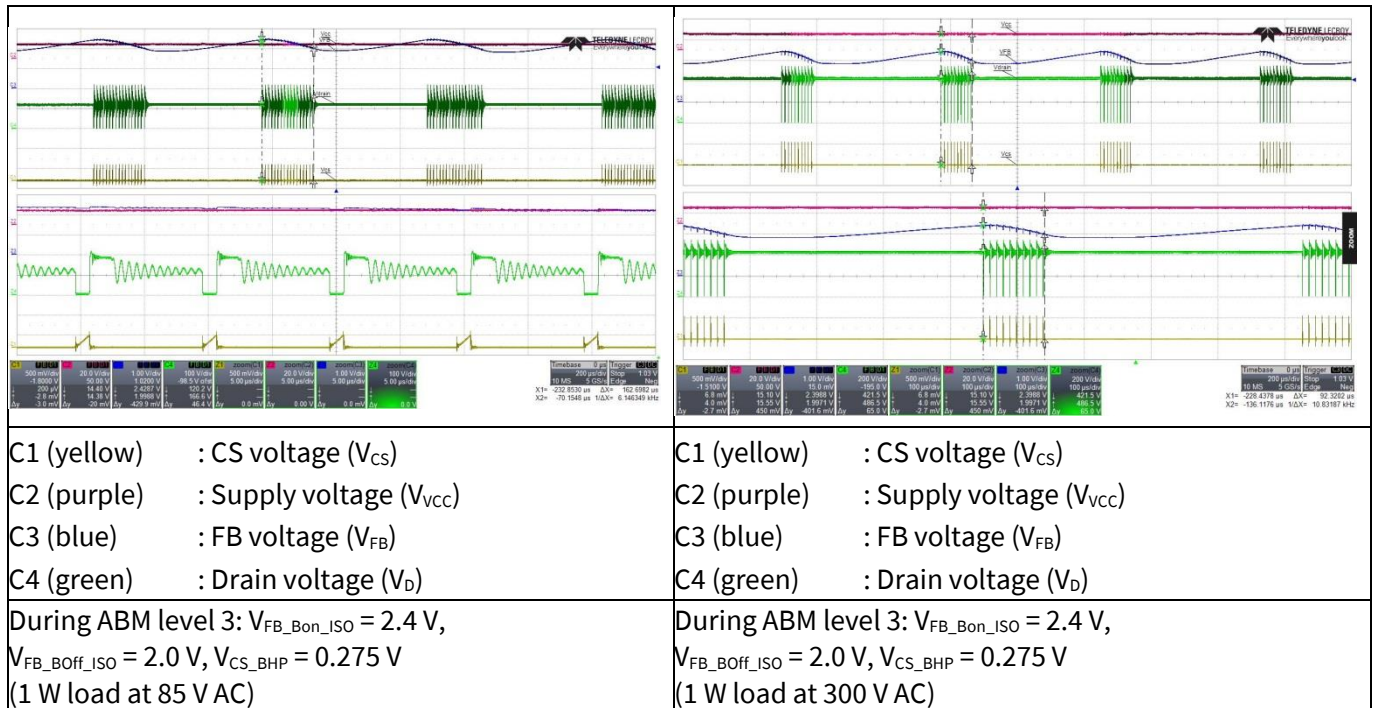


Figure 26 During ABM

11.10 Leaving ABM

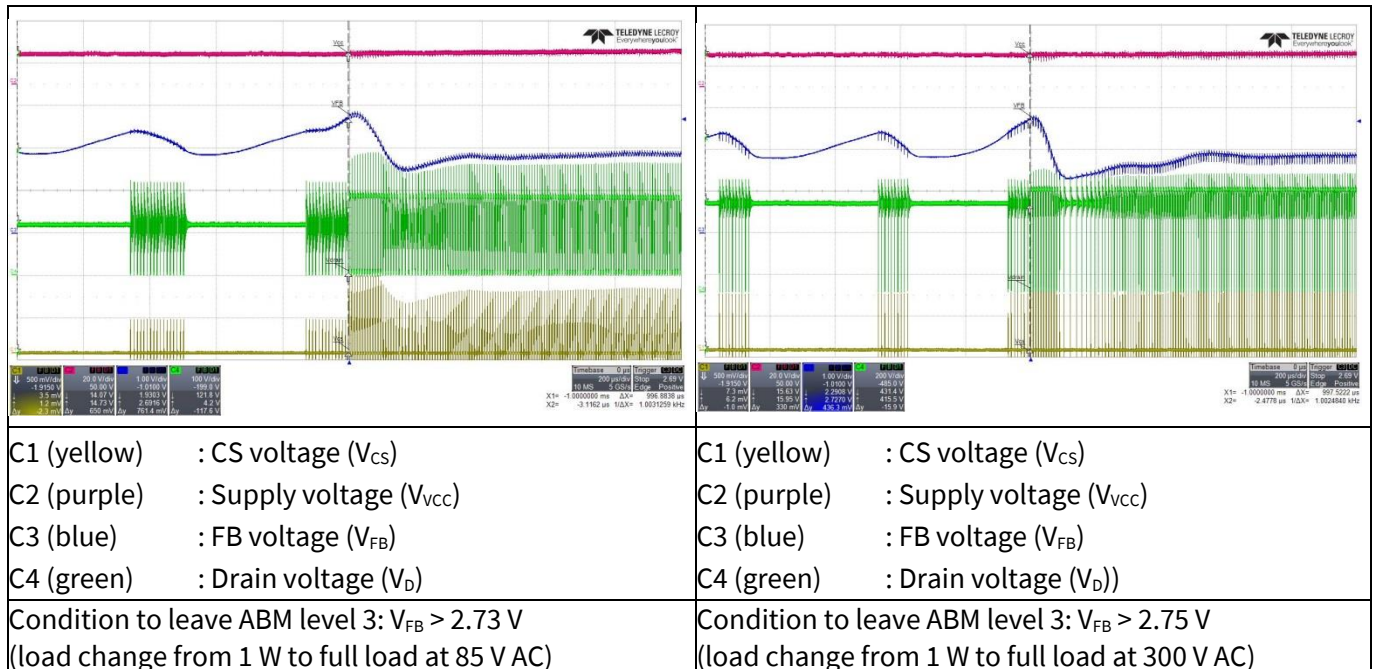


Figure 27 Leaving ABM

Waveforms and scope plots

11.11 Line OVP (non-switch auto restart)

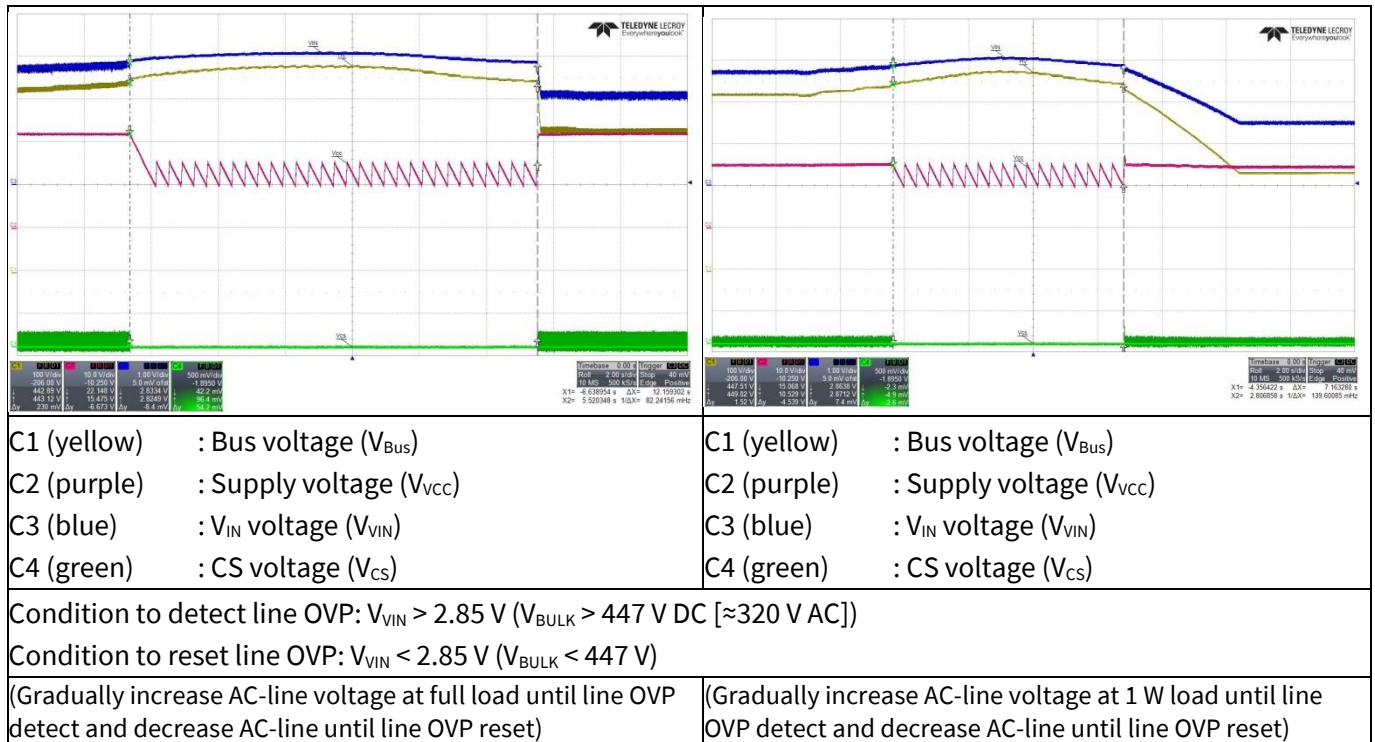
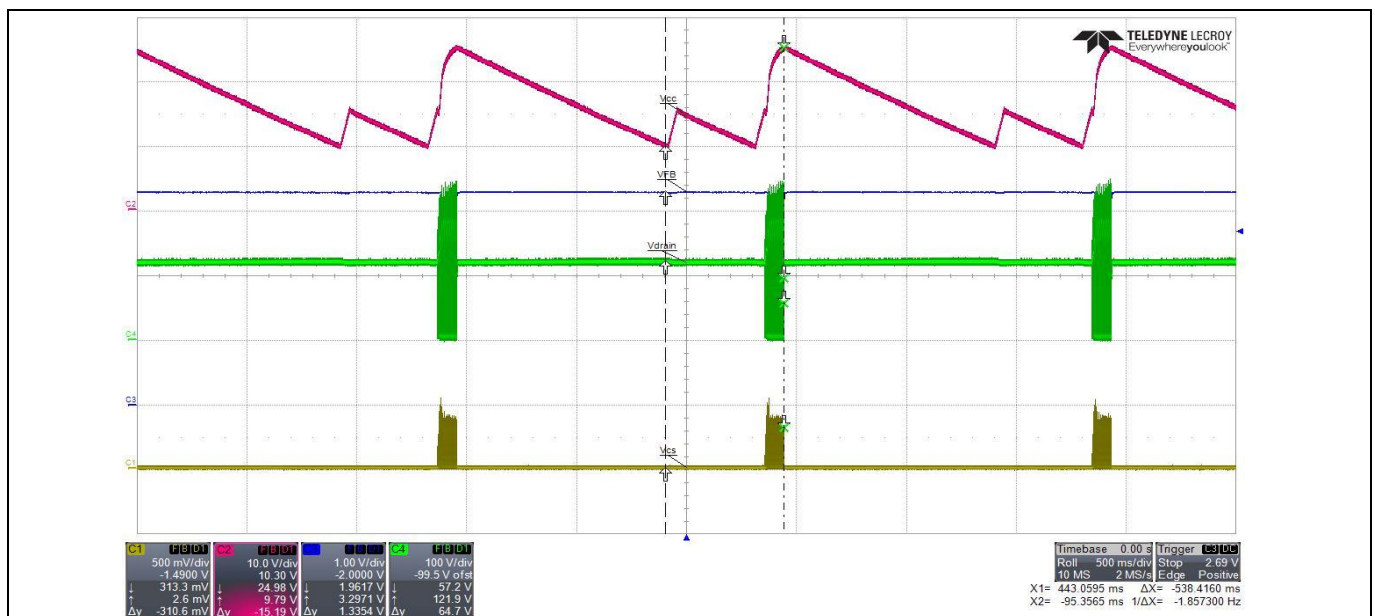
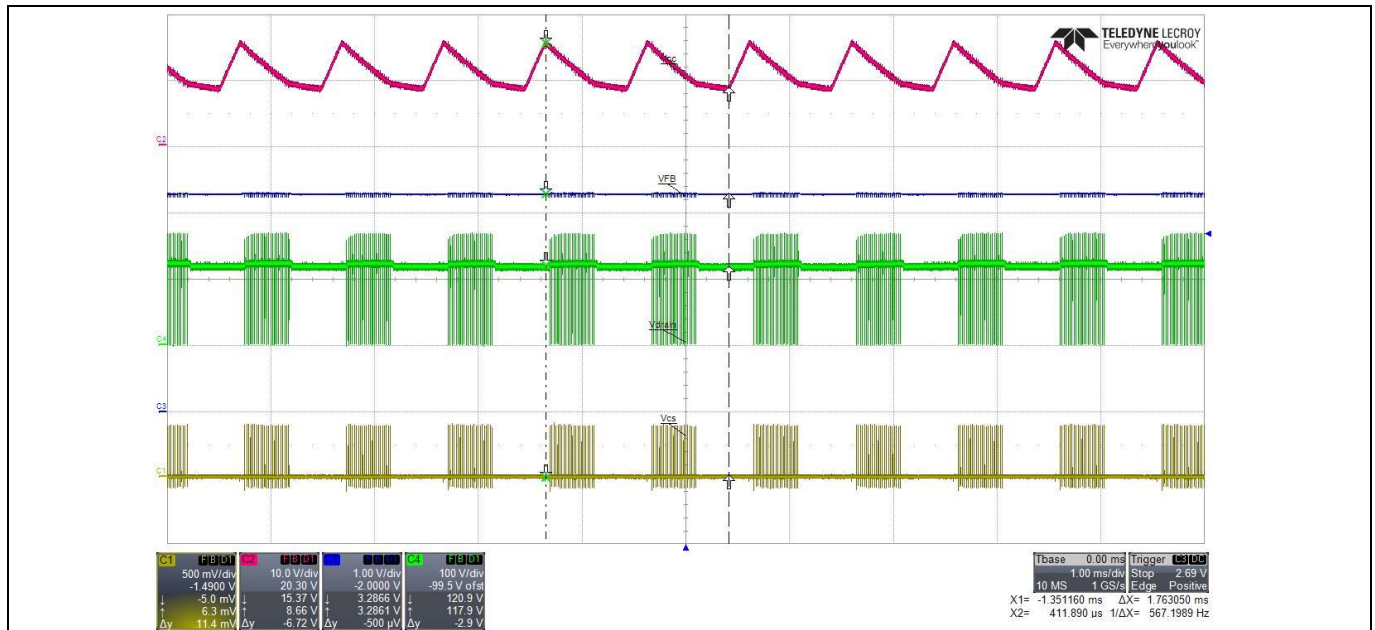


Figure 28 Line OVP

11.12 V_{CC} OVP (odd-skip auto restart)Figure 29 V_{CC} OVP

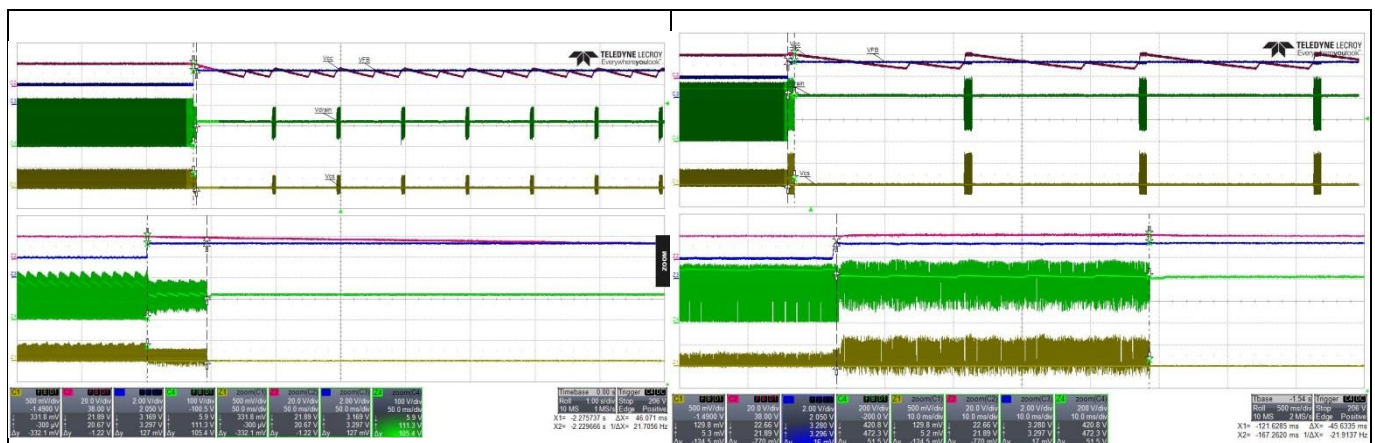
Waveforms and scope plots

11.13 V_{CC} UVP (auto restart)C1 (yellow) : CS voltage (V_{CS})C2 (purple) : Supply voltage (V_{CC})C3 (blue) : FB voltage (V_{FB})C4 (green) : Drain voltage (V_D)Condition to enter V_{CC} UVP: $V_{CC} < 10$ V

(remove R5 and power on the system with full load at 85 V AC)

Figure 30 V_{CC} UVP

11.14 Over-load protection (odd-skip auto restart)

C1 (yellow) : CS voltage (V_{CS})C2 (purple) : Supply voltage (V_{CC})C3 (blue) : FB voltage (V_{FB})C4 (green) : Drain voltage (V_D)Condition to enter over-load protection: $V_{FB} > 2.73$ V
and lasts for 54 ms blanking time

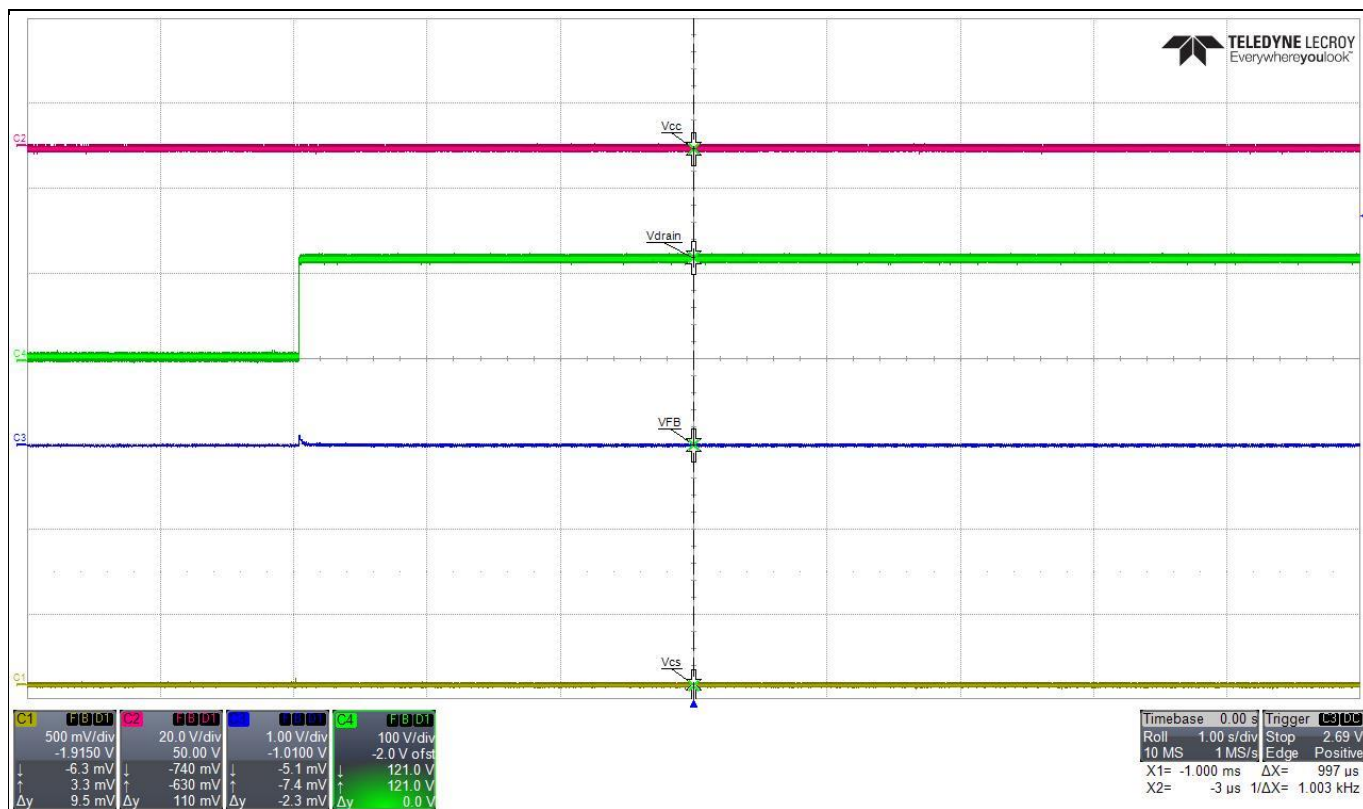
(12 V output load change from full to short at 85 V

C1 (yellow) : CS voltage (V_{CS})C2 (purple) : Supply voltage (V_{CC})C3 (blue) : FB voltage (V_{FB})C4 (green) : Drain voltage (V_D)Condition to enter over-load protection: $V_{FB} > 2.73$ V
and lasts for 54 ms blanking time

(12 V output load change from full to short at 300 V AC)

AC)

Figure 31 Over-load protection

11.15 V_{CC} short-to-GND protectionC1 (yellow) : V_{CS} voltage (V_{CS})C2 (purple) : V_{CC} voltage (V_{CC})C3 (blue) : V_{IN} voltage (V_{IN})C4 (green) : Drain voltage (V_D)Condition to enter V_{CC} short-to-GND: if $V_{CC} < V_{VCC_SCP} \rightarrow I_{VCC} = I_{VCC_Charge1}$ (short V_{CC} pin-to-GND and measure the current with multimeter before system start-up, $I_{VCC} \approx 266 \mu A$ at 85 V AC)Figure 32 V_{CC} short-to-GND protection

References

12 References

- [1] [ICE5xRxxxxAG datasheet, Infineon Technologies AG](#)
- [2] [5th Generation Fixed-Frequency Design Guide](#)
- [3] [Calculation Tool Fixed Frequency CoolSET™ Generation 5](#)

Revision history

Major changes since the last revision

Page or reference	Description of change
–	First release

Trademarks

All referenced product or service names and trademarks are the property of their respective owners.

Edition 2018-02-20

Published by

Infineon Technologies AG

81726 Munich, Germany

**© 2018 Infineon Technologies AG.
All Rights Reserved.**

Do you have a question about this document?

Email: erratum@infineon.com

**Document reference
ER_201707_PL83_015**

IMPORTANT NOTICE

The information contained in this application note is given as a hint for the implementation of the product only and shall in no event be regarded as a description or warranty of a certain functionality, condition or quality of the product. Before implementation of the product, the recipient of this application note must verify any function and other technical information given herein in the real application. Infineon Technologies hereby disclaims any and all warranties and liabilities of any kind (including without limitation warranties of non-infringement of intellectual property rights of any third party) with respect to any and all information given in this application note.

The data contained in this document is exclusively intended for technically trained staff. It is the responsibility of customer's technical departments to evaluate the suitability of the product for the intended application and the completeness of the product information given in this document with respect to such application.

For further information on the product, technology, delivery terms and conditions and prices please contact your nearest Infineon Technologies office (www.infineon.com).

WARNINGS

Due to technical requirements products may contain dangerous substances. For information on the types in question please contact your nearest Infineon Technologies office.

Except as otherwise explicitly approved by Infineon Technologies in a written document signed by authorized representatives of Infineon Technologies, Infineon Technologies' products may not be used in any applications where a failure of the product or any consequences of the use thereof can reasonably be expected to result in personal injury.

Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

[Infineon:](#)

[DEMO5GR2280AG22W1TOBO1](#)