

## Test results

## 10 Test results

## 10.1 Efficiency, regulation and output ripple

Table 4 Efficiency, regulation and output ripple

Input (V AC/Hz)	P <sub>in</sub> (W)	V <sub>out</sub> (V DC)	I <sub>out</sub> (A)	V <sub>RPP</sub> (mV)	P <sub>out</sub> (W)	Efficiency $\eta$ (%)	Average $\eta$ (%)	OLP P <sub>in</sub> (W)	OLP I <sub>out</sub> (A)
85 V AC/60 Hz	0.05670	19.05	0.000	115				81.00	3.51
	17.47	19.05	0.793	32	15.10	86.42	85.30		
	35.01	19.05	1.581	58	30.12	86.04			
	53.06	19.05	2.370	70	45.15	85.09			
	71.95	19.05	3.160	97	60.20	83.67			
115 V AC/60 Hz	0.06249	19.05	0.000	118				80.60	3.60
	17.32	19.05	0.793	44	15.10	87.17	86.85		
	34.49	19.05	1.581	58	30.12	87.34			
	51.90	19.05	2.370	76	45.15	86.99			
	70.06	19.05	3.160	90	60.20	85.92			
230 V AC/50 Hz	0.09808	19.05	0.000	113				82.00	3.79
	17.45	19.05	0.793	36	15.10	86.52	87.41		
	34.40	19.05	1.581	43	30.12	87.56			
	51.36	19.05	2.370	63	45.15	87.91			
	68.68	19.05	3.160	86	60.20	87.65			
265 V AC/50 Hz	0.11717	19.05	0.000	121				86.00	3.94
	17.59	19.05	0.793	33	15.10	85.83	87.02		
	34.59	19.05	1.581	40	30.12	87.08			
	51.50	19.05	2.370	55	45.15	87.67			
	68.80	19.05	3.160	78	60.20	87.50			
300 V AC/50 Hz	0.14020	19.05	0.000	123				89.00	4.00
	17.73	19.05	0.793	36	15.10	85.15	86.39		
	34.91	19.05	1.581	40	30.12	86.28			
	51.90	19.05	2.370	50	45.15	86.99			
	69.08	19.05	3.160	70	60.20	87.14			

## Test results

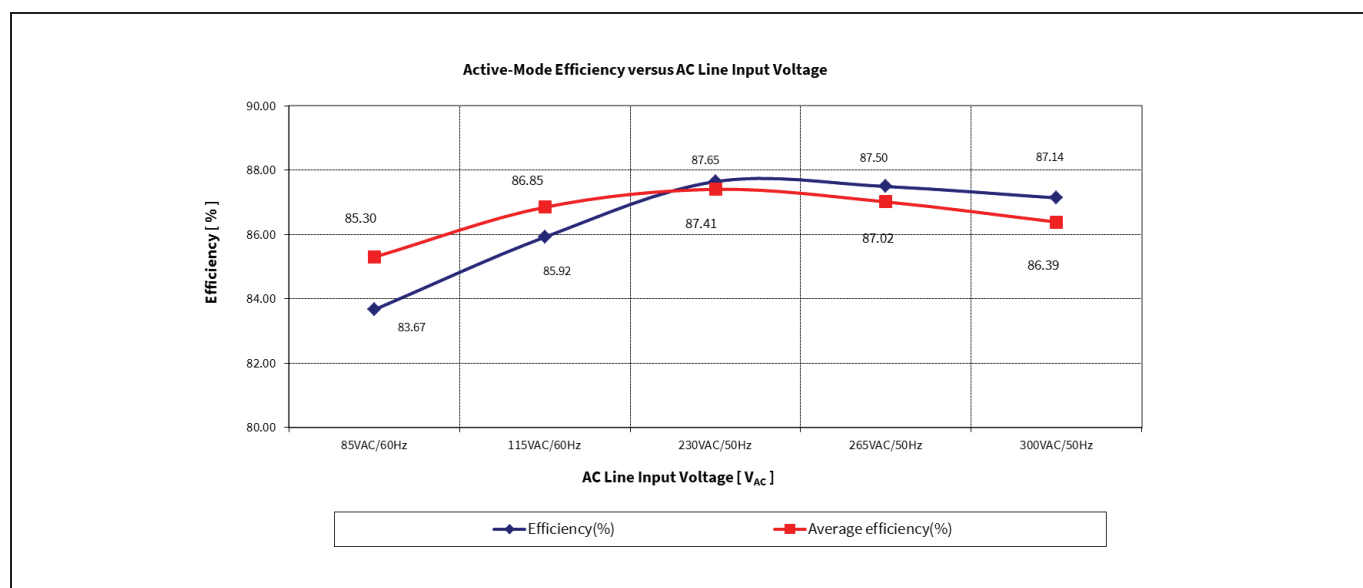


Figure 8 Efficiency vs AC-line input voltage

## 10.2 Standby power

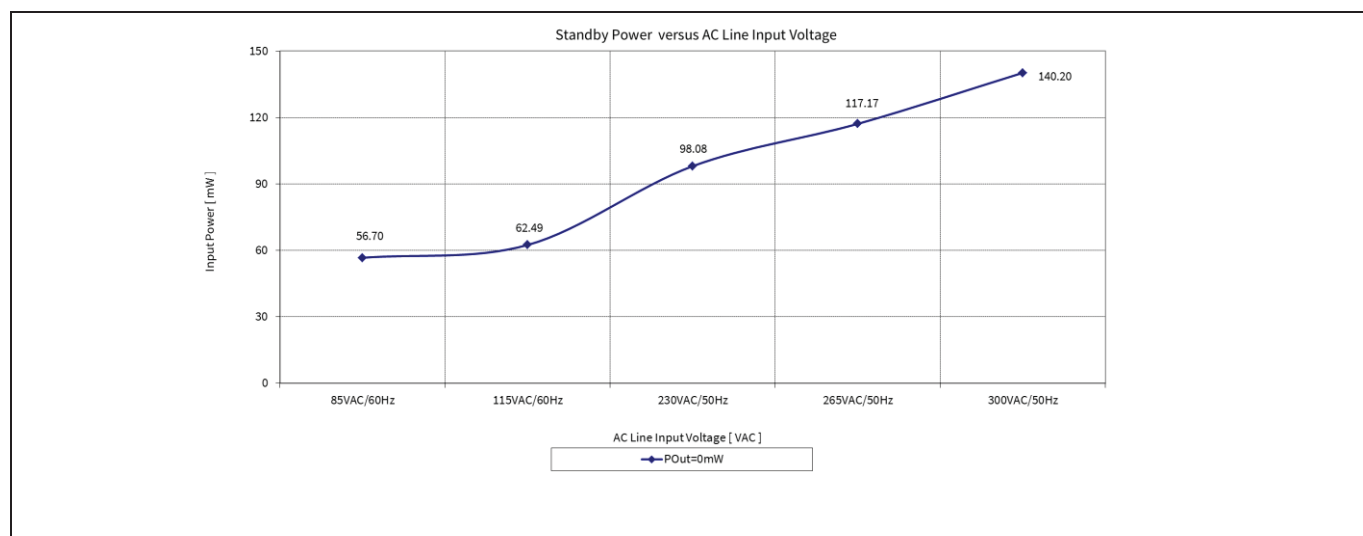


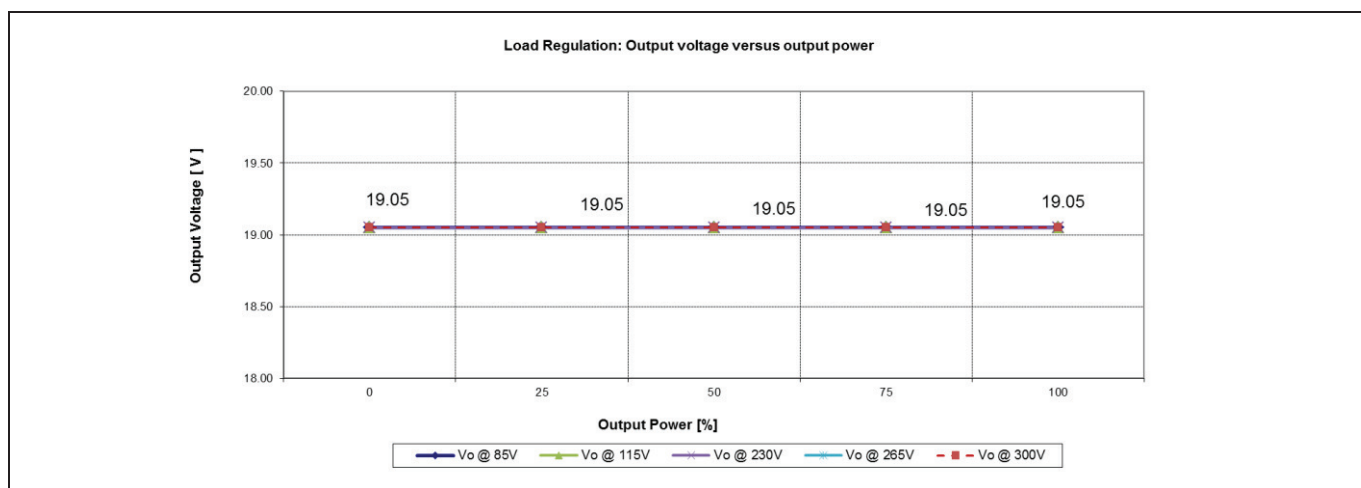
Figure 9 Standby power at no-load vs AC-line input voltage (measured by Yokogawa WT210 power meter – integration mode)

## 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

## 10.5 Maximum input power

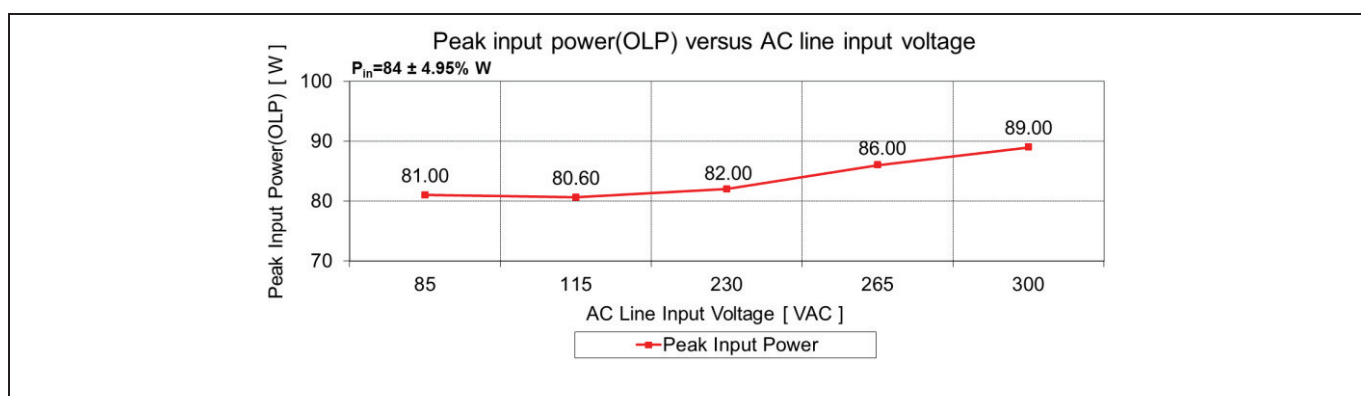


Figure 12 Maximum input power (before over-load protection) vs AC-line input voltage

## Test results

## 10.6 ESD immunity (EN 61000-4-2)

Pass EN 61000-4-2 special level ( $\pm 10$  kV for both contact and air discharge).

## 10.7 Surge immunity (EN 61000-4-5)

Pass EN 61000-4-5 installation class 4 ( $\pm 2$  kV for line-to-line and  $\pm 4$  kV for line-to-earth).<sup>1</sup>

## 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 (60 W) with input voltage of 115 V AC and 230 V AC.

Pass conducted emissions EN 55022 (CISPR 22) class B with 7 dB margin for quasi peak measurement at low-line (115 V AC) and high-line (230 V AC).

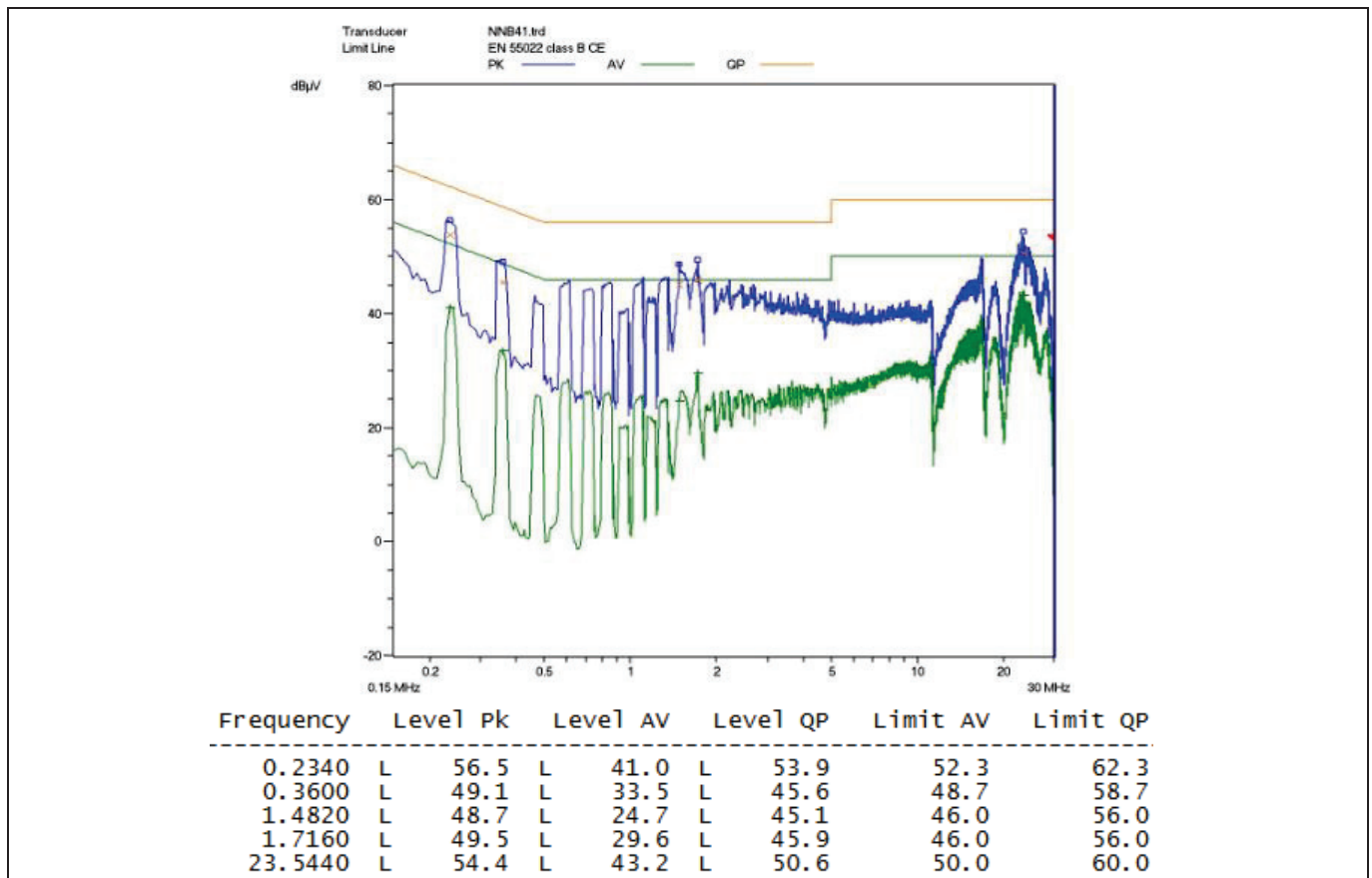


Figure 13 Conducted emissions (line) at 115 V AC and maximum load

<sup>1</sup> PCB spark-gap distance needs to reduce to 0.5 mm.

## Test results

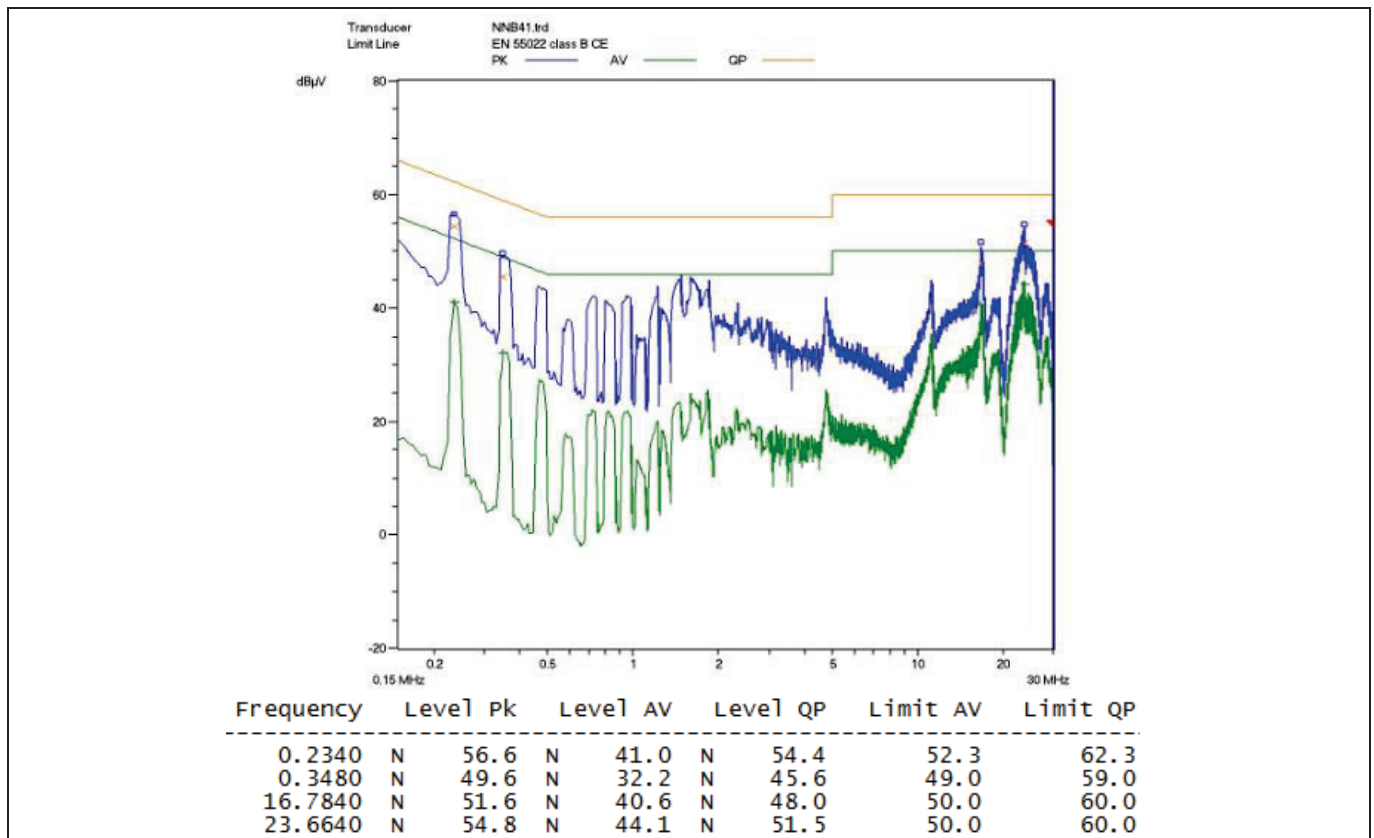


Figure 14 Conducted emissions (neutral) at 115 V AC and maximum load

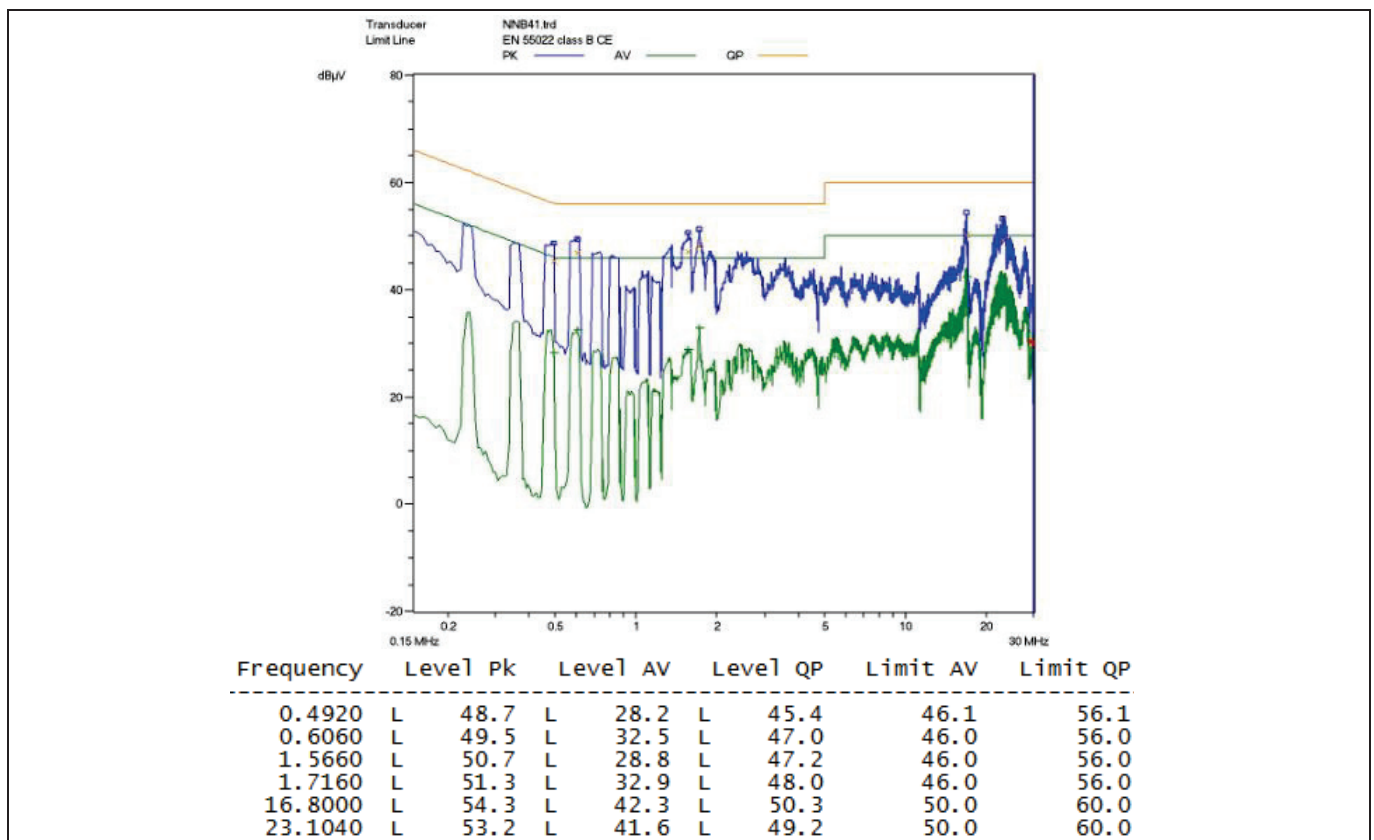


Figure 15 Conducted emissions (line) at 230 V AC and maximum load

## Test results

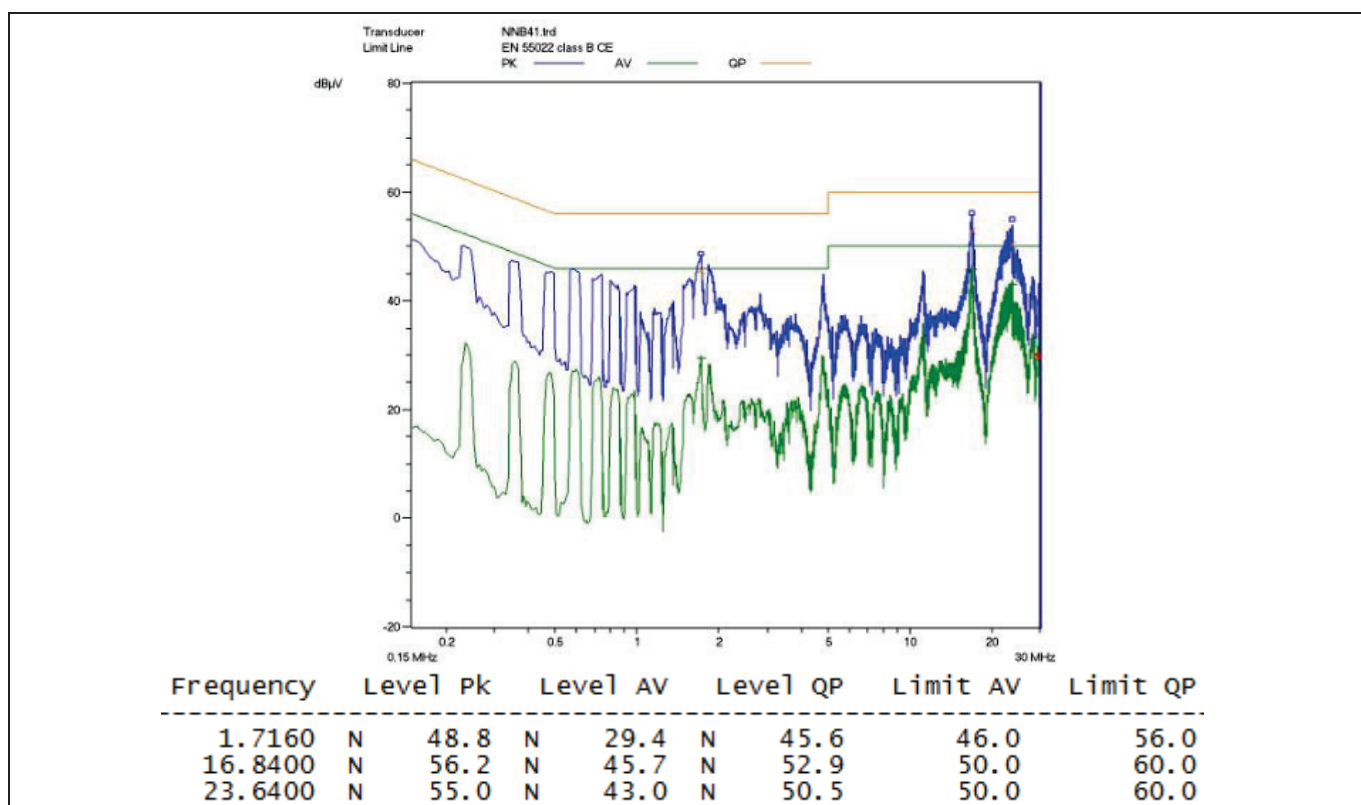


Figure 16 Conducted emissions (neutral) at 230 V AC and maximum load

## 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	IC11 (ICE5GSAG)	85.5	56.2
2	Q11 (IPA80R650CE)	58.9	60.5
3	R14A (CS resistor)	79.0	48.2
4	TR1 (transformer)	70.4	82.0
5	BR1 (bridge diode)	63.3	38.0
6	R11A (clammer resistor)	54.8	55.0
7	L11 (choke)	85.0	42.0
8	D21 (secondary diode)	61.8	60.6
9	Ambient	25.0	25.0



## Test results

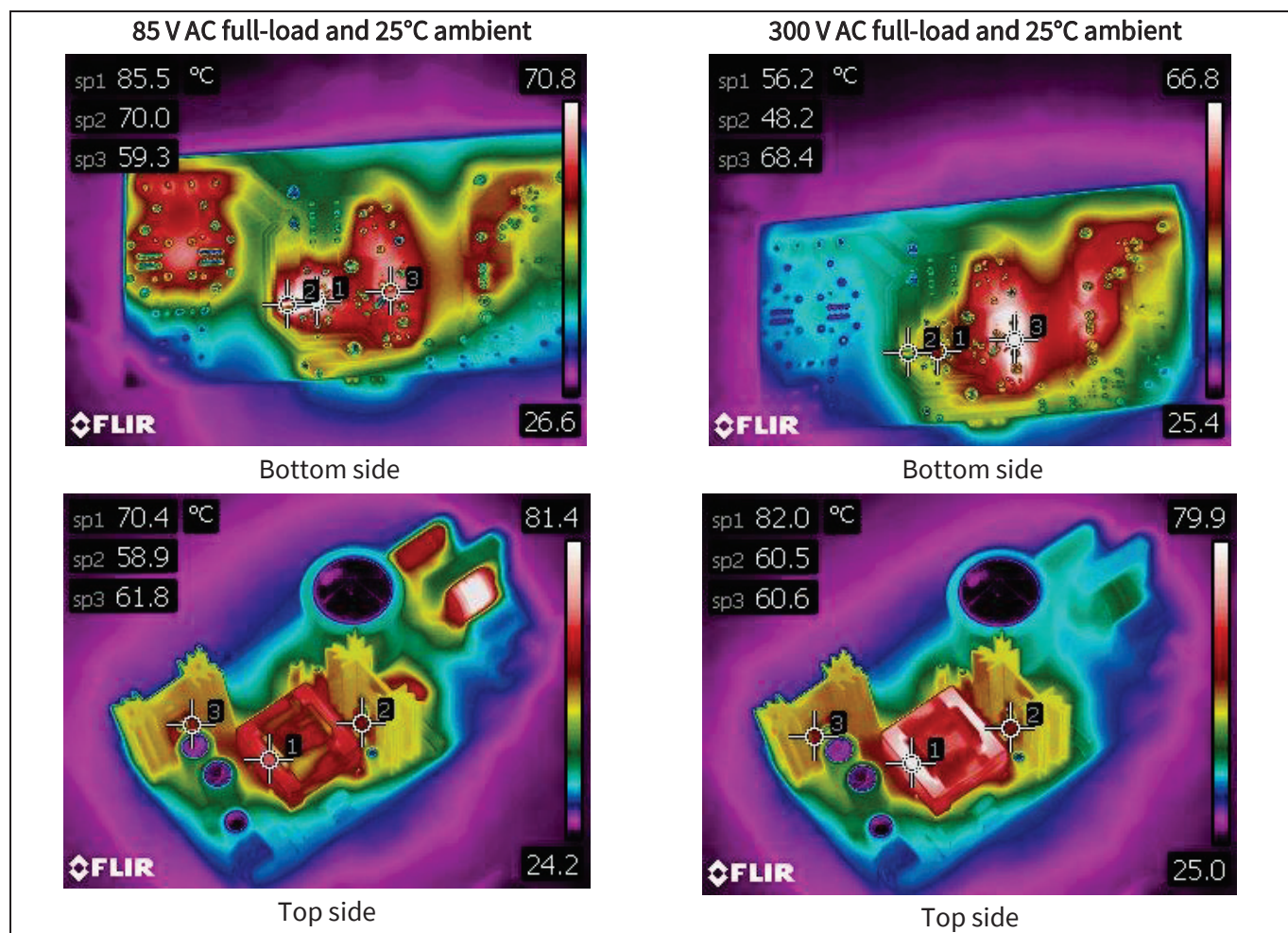


Figure 17 Infrared thermal image of DEMO\_5GSAG\_60W1

## Waveforms and scope plots

## 11 Waveforms and scope plots

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

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

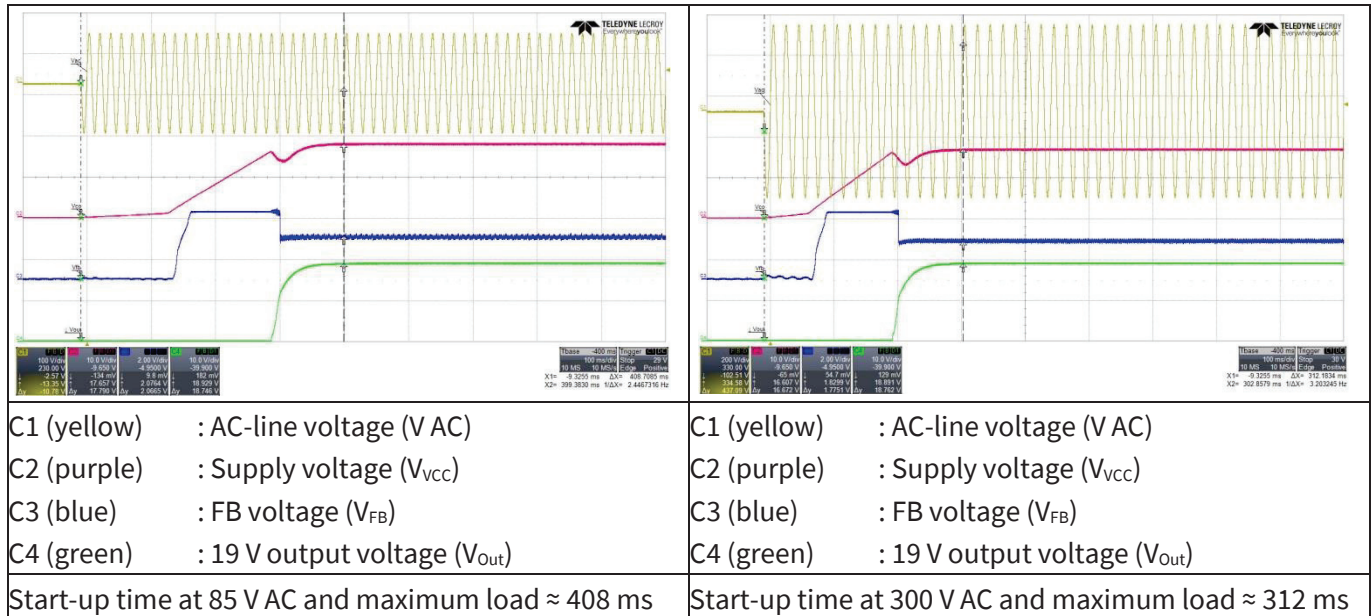


Figure 18 Start-up

### 11.2 Soft-start

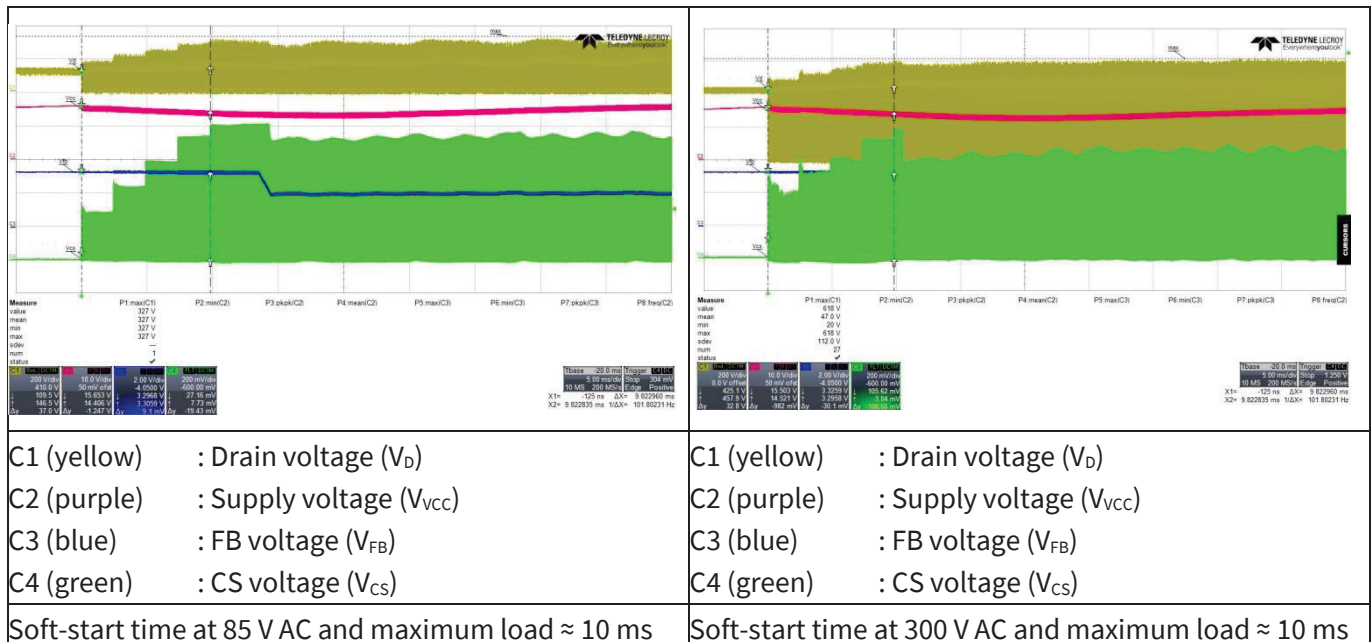


Figure 19 Soft-start



## Waveforms and scope plots

### 11.3 Drain and CS voltage at maximum load

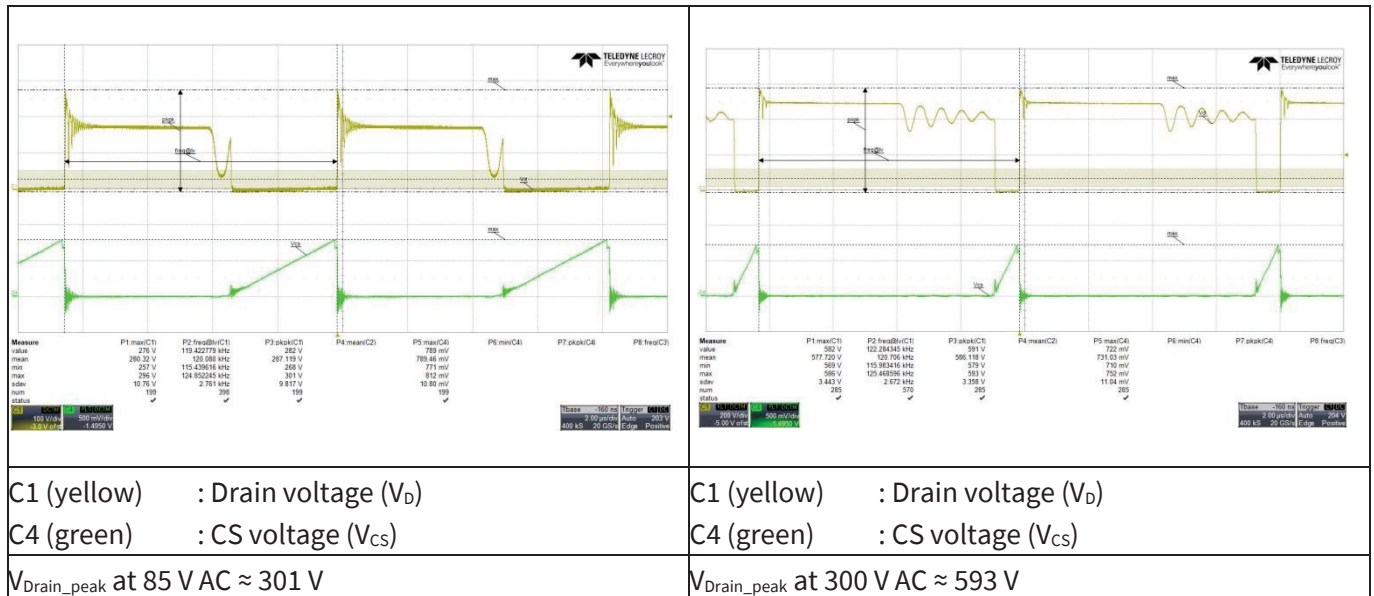


Figure 20 Drain and CS voltage at maximum load

### 11.4 Frequency jittering

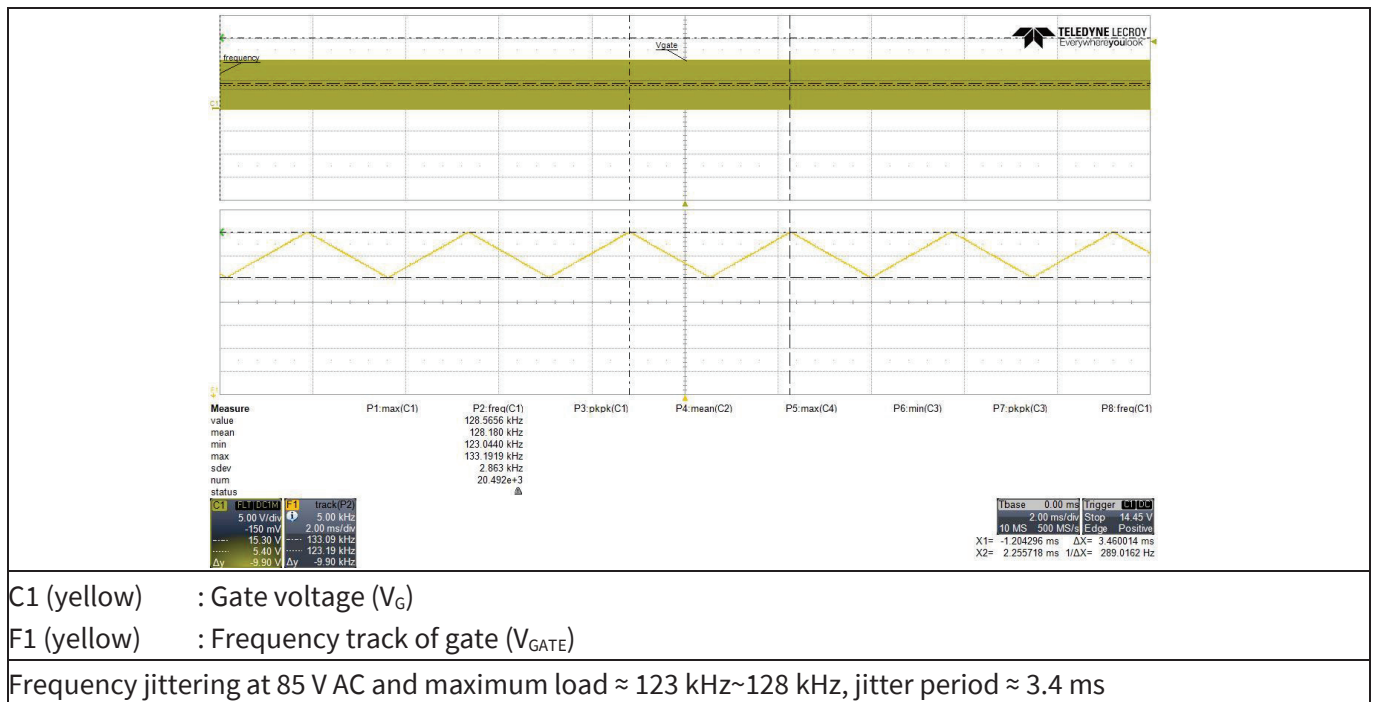


Figure 21 Frequency jittering

## Waveforms and scope plots

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

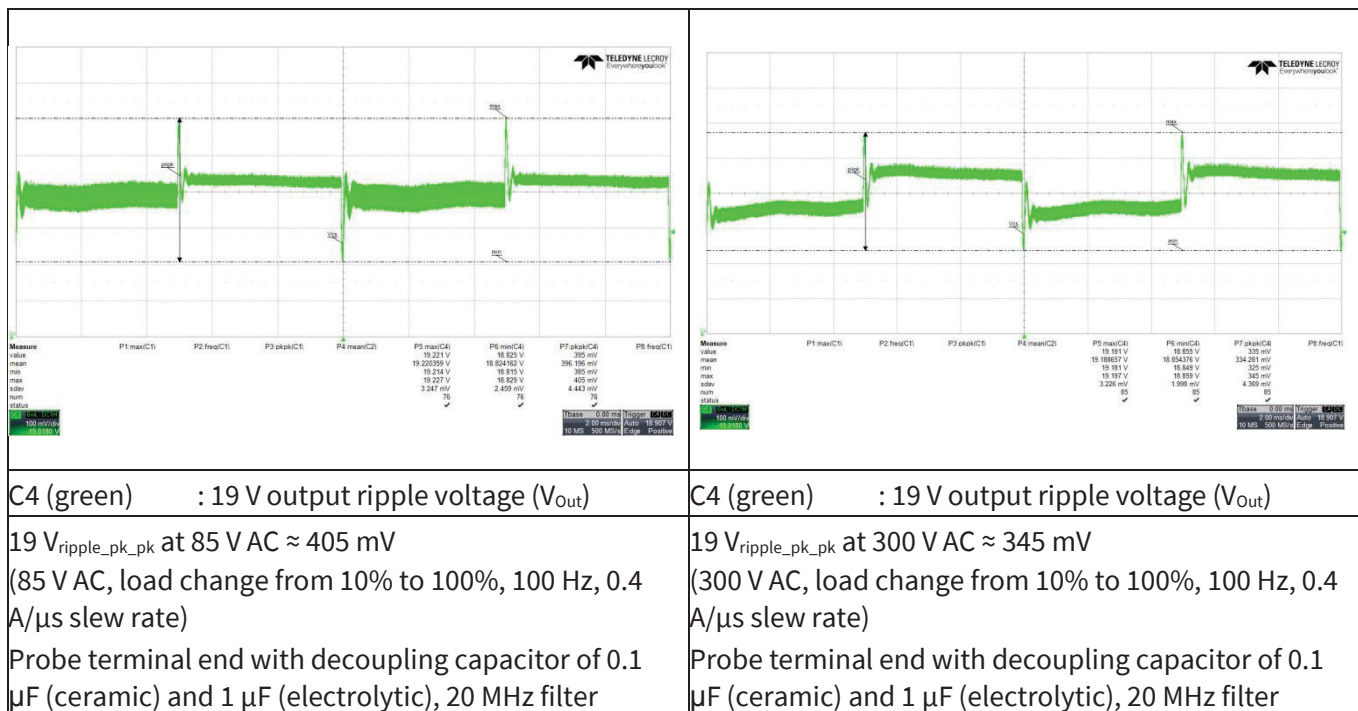


Figure 22 Load transient response

## 11.6 Output ripple voltage at maximum load

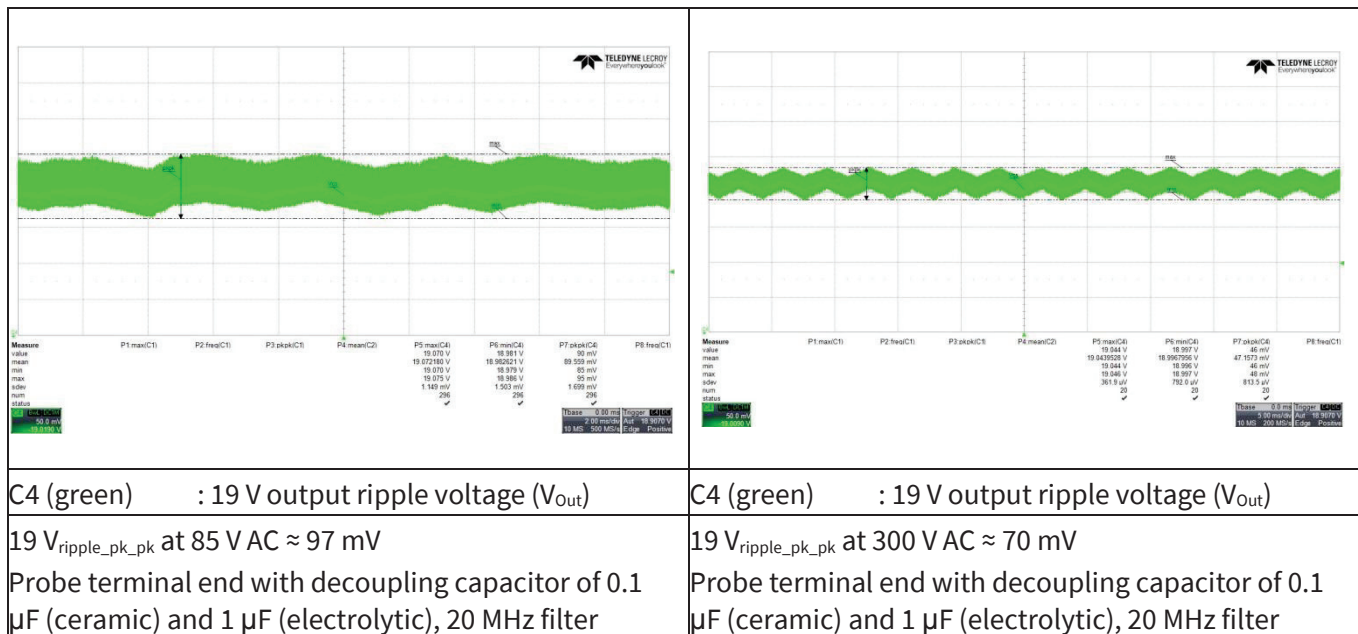


Figure 23 Output ripple voltage at maximum load

## Waveforms and scope plots

## 11.7 Output ripple voltage at ABM 1 W load

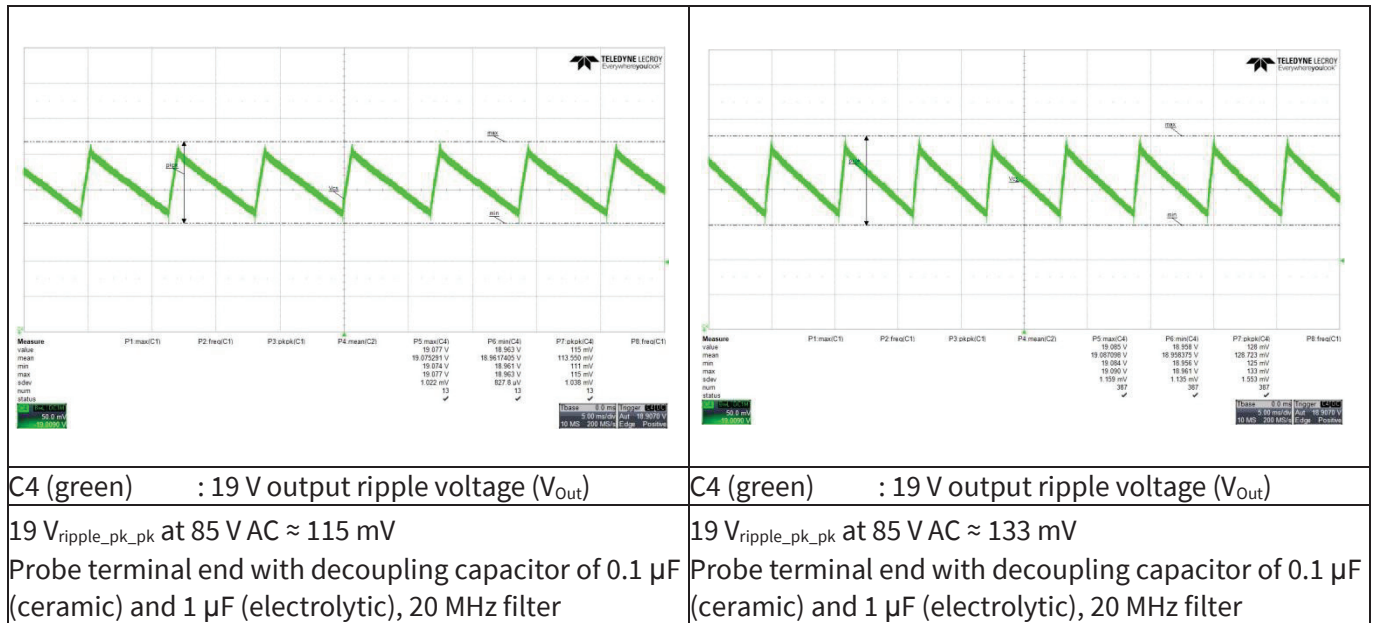


Figure 24 Output ripple voltage at burst mode 1 W load

## 11.8 Entering ABM

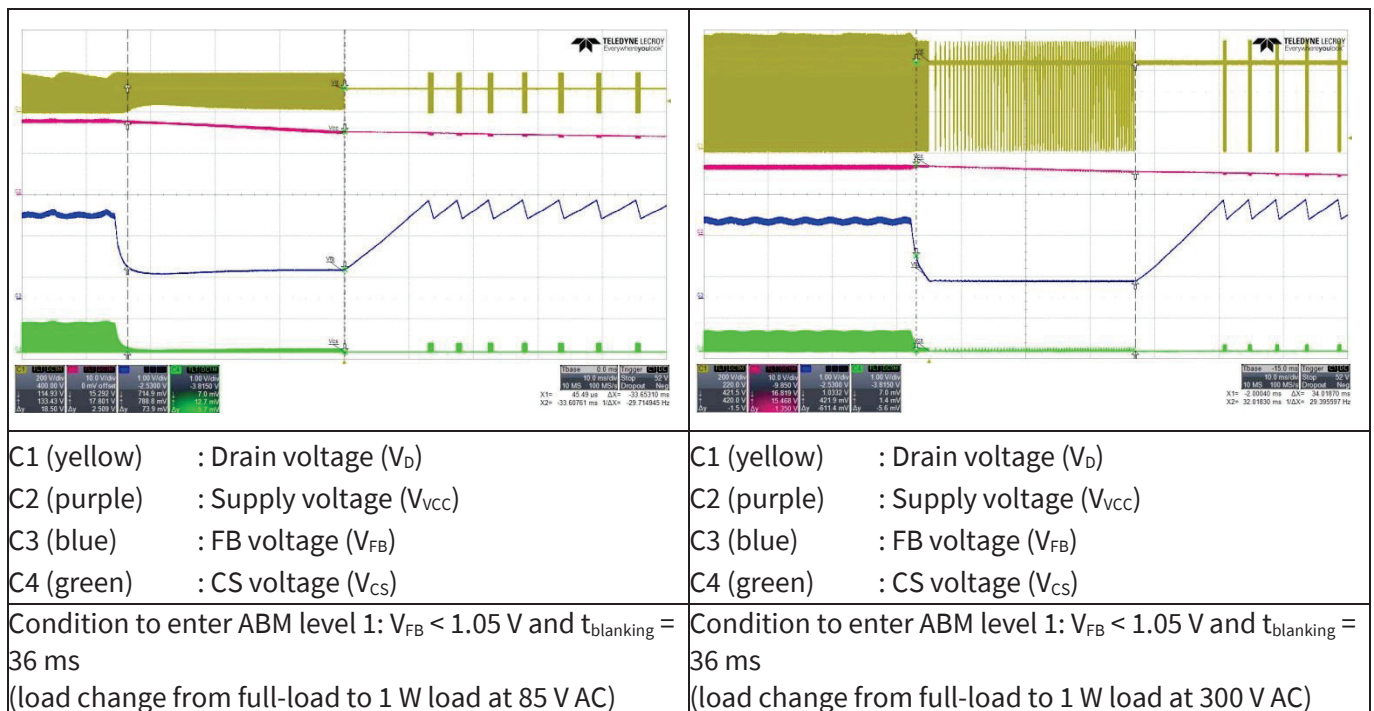


Figure 25 Entering ABM

## Waveforms and scope plots

## 11.9 During ABM

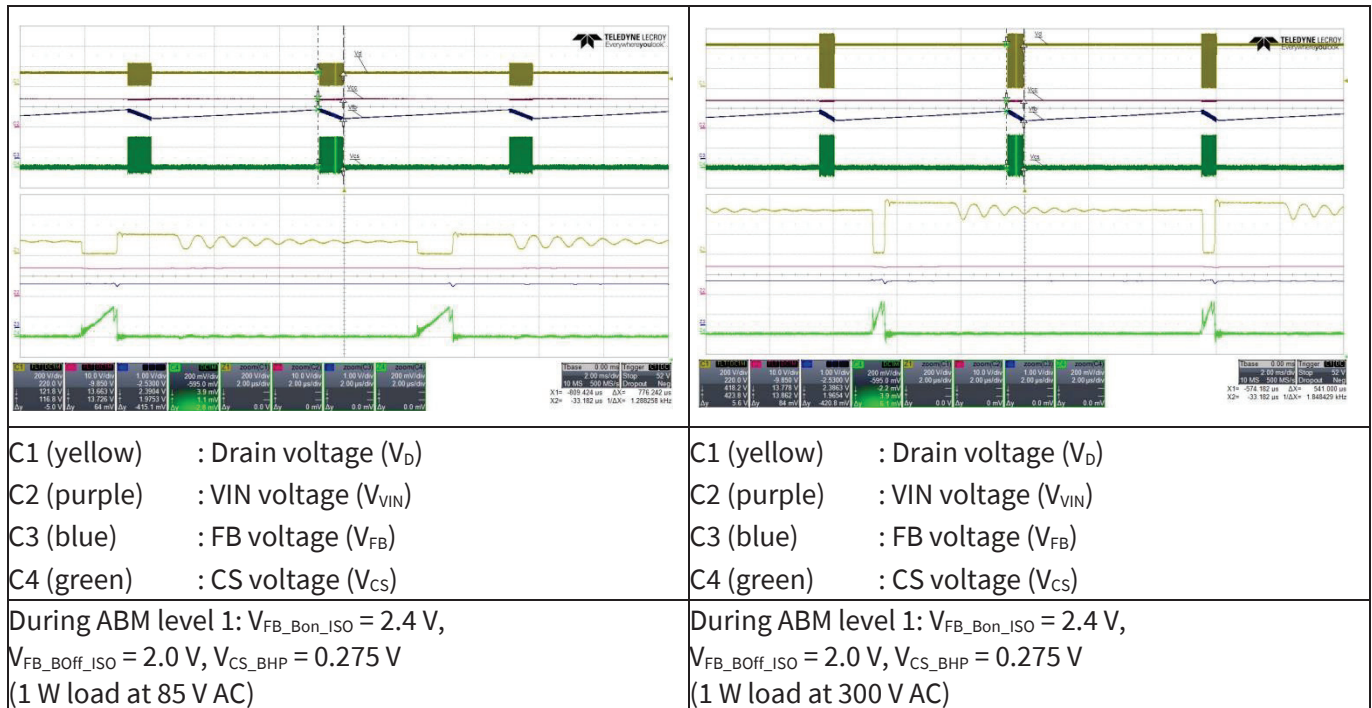


Figure 26 During ABM

## 11.10 Leaving ABM

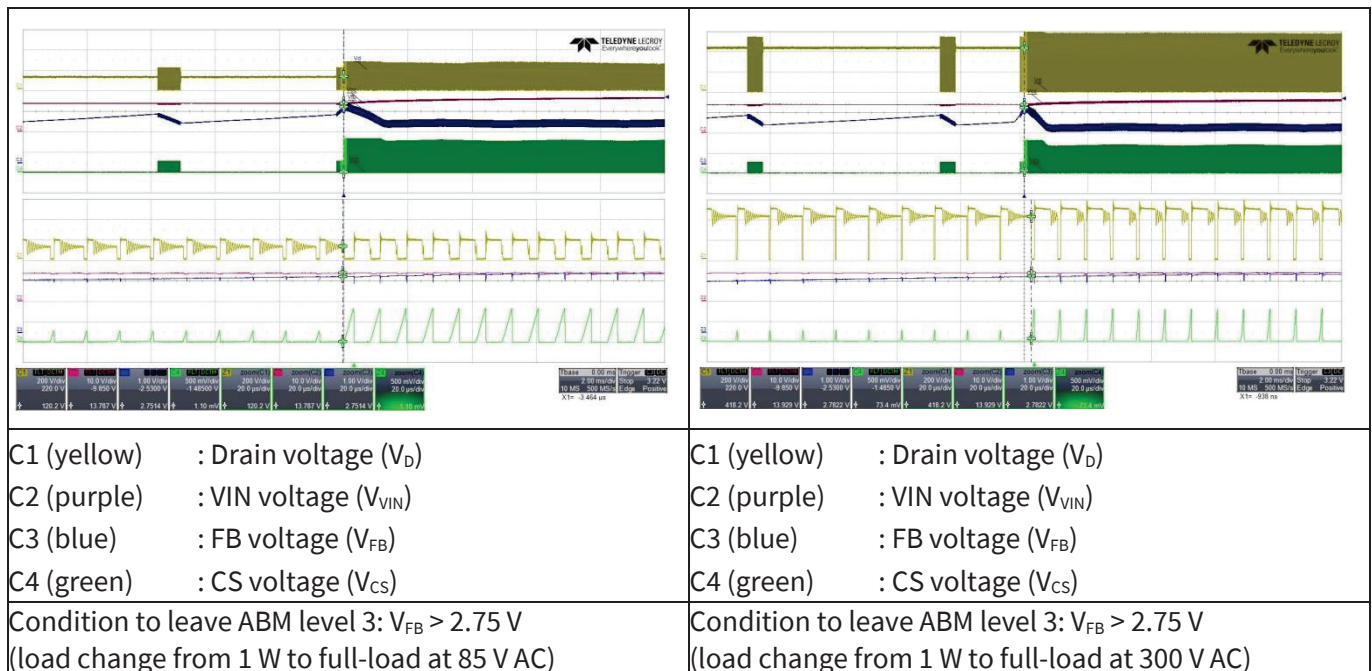


Figure 27 Leaving ABM



## Waveforms and scope plots

## 11.11 Line OVP (non-switch auto restart)

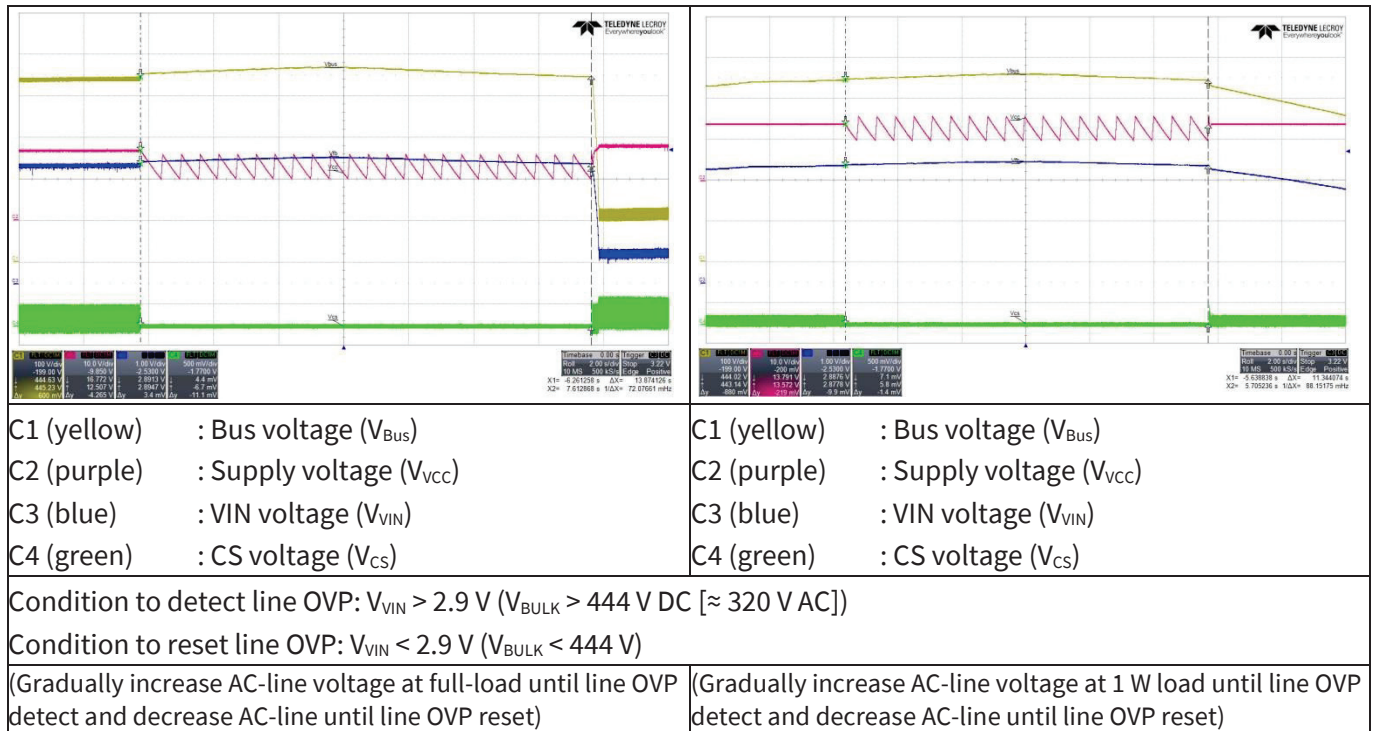
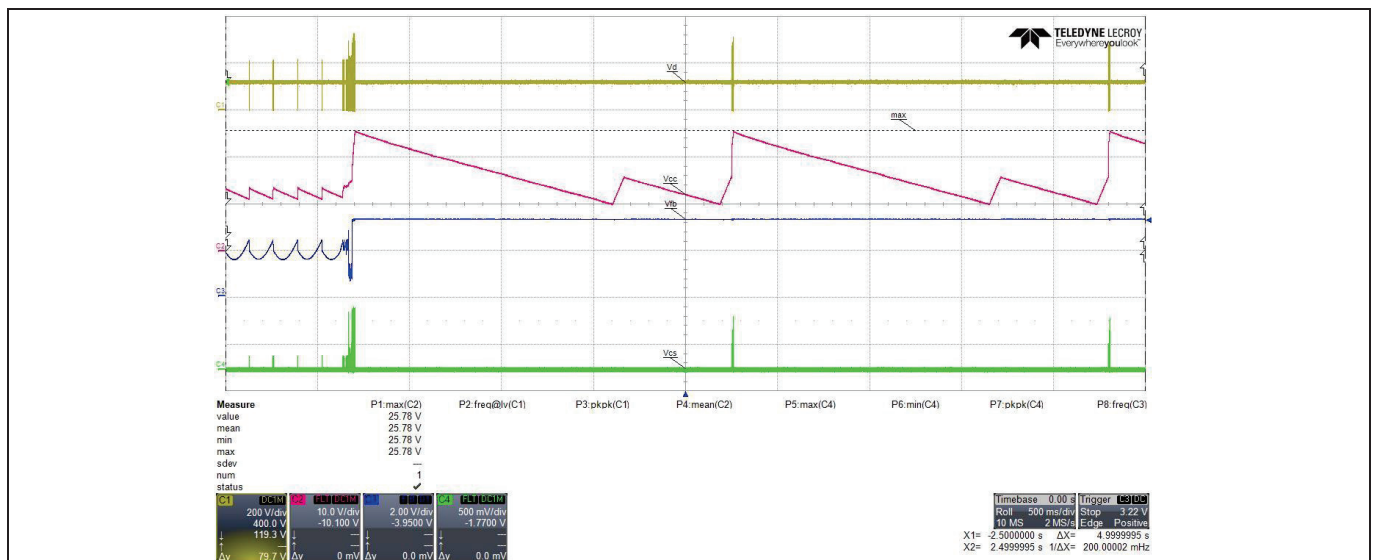


Figure 28 Line OVP

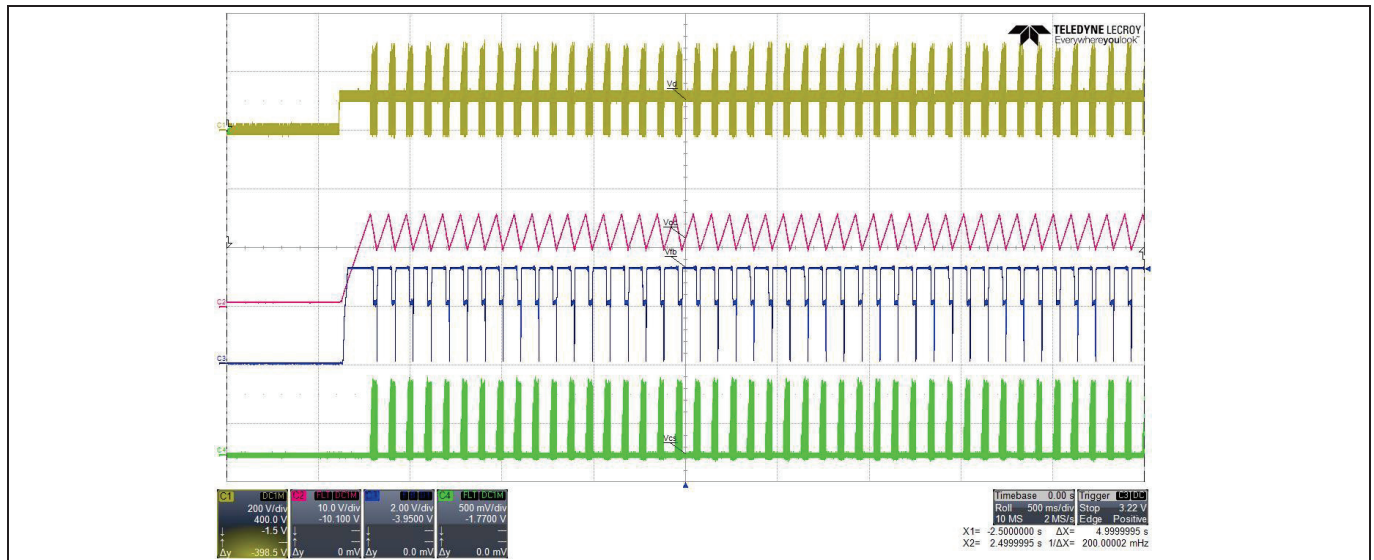
11.12  $V_{CC}$  OVP (odd-skip auto restart)

- C1 (yellow) : Drain voltage ( $V_D$ )  
 C2 (purple) : Supply voltage ( $V_{CC}$ )  
 C3 (blue) : FB voltage ( $V_{FB}$ )  
 C4 (green) : CS voltage ( $V_{CS}$ )

Condition to enter  $V_{CC}$  OVP:  $V_{CC} > 25.5 \text{ V}$   
 (short R16A while system operating at 85 V AC and no-load)

Figure 29  $V_{CC}$  OVP

## Waveforms and scope plots

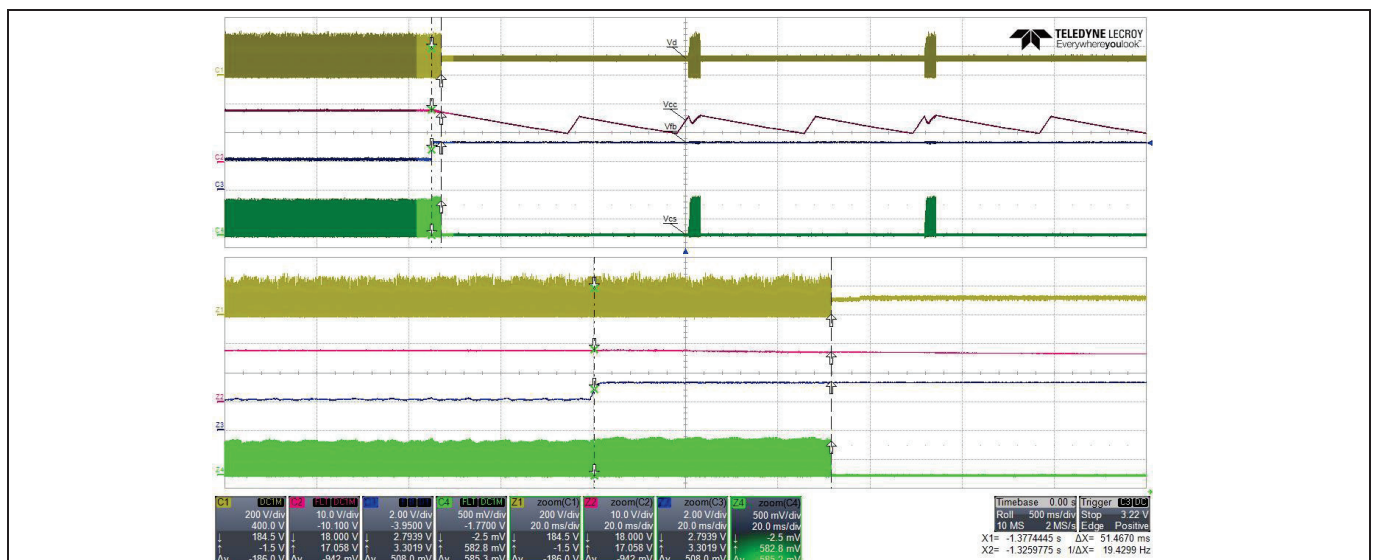
11.13  $V_{CC}$  under-voltage protection (auto restart)

- C1 (yellow) : Drain voltage ( $V_D$ )  
 C2 (purple) : Supply voltage ( $V_{CC}$ )  
 C3 (blue) : FB voltage ( $V_{FB}$ )  
 C4 (green) : CS voltage ( $V_{CS}$ )

Condition to enter  $V_{CC}$  under-voltage protection:  $V_{CC} < 10$  V  
 (Remove R5 and power on the system with full-load at 85 V AC)

Figure 30  $V_{CC}$  under voltage protection

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



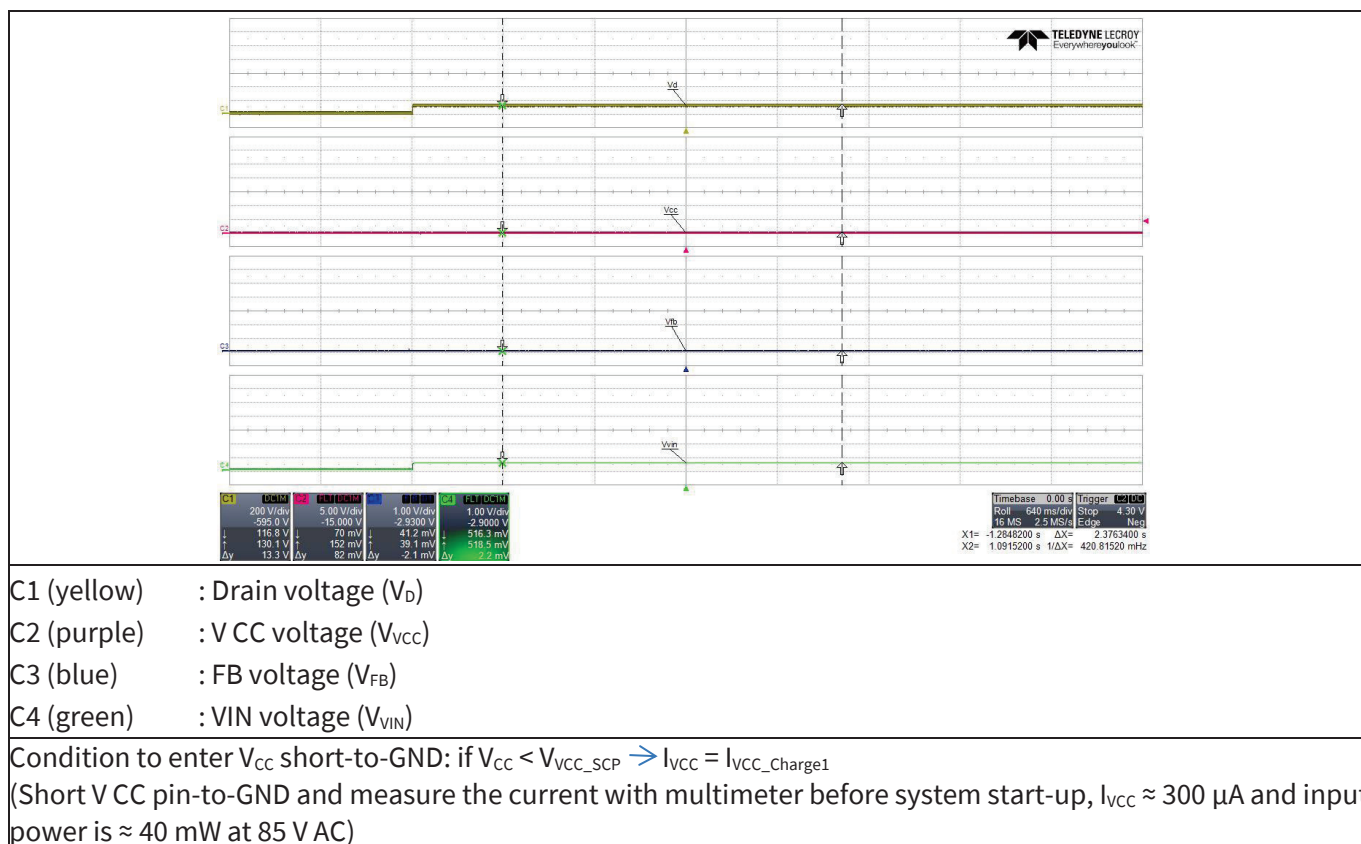
- C1 (yellow) : Drain voltage ( $V_D$ )  
 C2 (purple) : Supply voltage ( $V_{CC}$ )  
 C3 (blue) : FB voltage ( $V_{FB}$ )  
 C4 (green) : CS voltage ( $V_{CS}$ )

Condition to enter over-load protection:  $V_{FB} > 2.75$  V and lasts for 54 ms blanking time  
 (load change from full- to short-load at 85 V AC)

Figure 31 Over-load protection



## Waveforms and scope plots

11.15  $V_{CC}$  short-to-GND protectionFigure 32  $V_{CC}$  short-to-GND protection