Efficiency and standby measurements of adapted auxiliary SMPS

Introduction

This document shows the measurements of efficiency, standby, and output voltage ripple at full load and different input voltages for the STEVAL-VP26K01F featuring an improved BOM. In particular, we have replaced some passive components to improve its performance in terms of standby and efficiency. Moreover, we have added some different ceramic capacitors in power loops.

This improved board implements a three-output isolated power supply in a flyback topology. For an optimal operation, the converters have been assembled with Würth components.

The key controlling part of the board is the VIPER267KDTR offline high-voltage converter. It features a 1050 V avalanche-rugged power section, fixed frequency operation at 60 kHz with jittering for lower EMI, current limiting with 700 mA fixed set-point, on-board soft start, safe auto-restart after fault conditions, and low standby power consumption. The power supply provides 15 V at 550 mA (700 mA peak operation), a post-regulated 5 V with low noise LDO (LDK220) at 100 mA, and a 3.3 V at 200 mA supplied through a DC-DC converter (PM6644) connected to the 15 V rail to support low voltage devices.

The converter is designed to operate at an extra wide range of input voltages (90 to 440 V_{AC}). This feature allows connecting a power supply through the mains voltage or phase-to-phase connection in a three-phase network.

The converter also provides a triple output voltage: 15 V at 0.55 A_{rms} (0.7 A peak current), 5 V at 100 mA, and 3.3 V at 200 mA.

1 Specifications

1.1 Board electrical specifications

Table 1. STEVAL-VP26K01F electrical specifications

Parameter	Min.	Typ.Author	Max.
Operating AC main input voltage	90 V_{AC}	-	440 V_{AC}
Mains frequency	50 Hz	-	60 Hz
Output voltage 1 – VOUT1	14 V	15 V	16 V
Output current 1 – IOUT1	10 mA	-	550 mA (rms) 700 mA (peak)
Output voltage 2 – VOUT2	4.75 V	5 V	5.25 V
Output current 2 – IOUT2	10 mA	60 mA	100 mA
Output voltage 3 – VOUT3	3.1 V	3.3 V	3.5 V
Output current 3 – IOUT3	-	100 mA	200 mA
Maximum output power	-	-	12.9 W
Efficiency at full load	-	81.2 %	-
Ambient operating temperature	-40˚C	-	85˚C

1.2 Transformer characteristics

Table 2. Transformer characteristics

Parameter	Description
Order code	750316413 rev2
Core	E16
Primary inductance	1.5 mH ± 10%
Saturation current	700 mA
Leakage inductance	50 µH max.
Primary to auxiliary turn ratio	5.38 ± 1%
Primary to sec1 turn ration	7.78 ± 1%
Primary to sec2 turn ration	11.67 ± 1%

Figure 1. **Dimensional drawing, pin placement (distances, bottom view), and electrical diagrams**

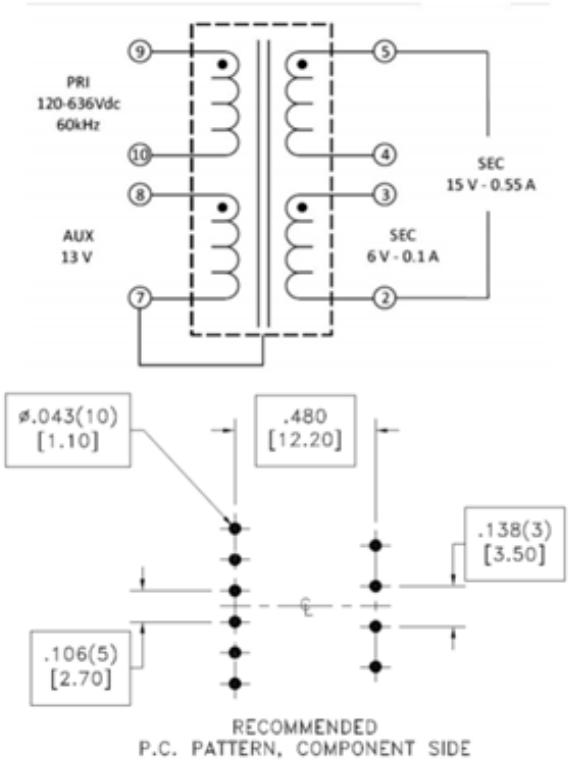
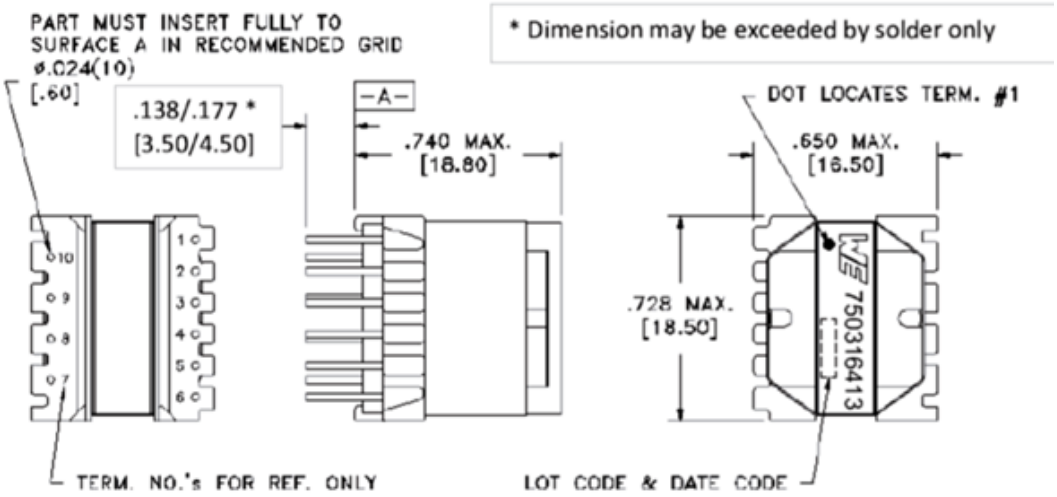


Figure 2. **Dimensional drawing and pin placement diagram (bottom, side, and top view)**



2 Improved BOM

Table 3. **STEVAL-VP26K01F improved BOM**

Item	Q.ty	Reference	Part/value	Description	Manufacturer	Order code
1	1	R1	220 kΩ ±5% - 0.33 W - 200 V	Resistor	Panasonic	ERJ-P08J224V
2	1	R2	220 kΩ ±5% - 0.33 W - 200 V	Resistor	Panasonic	ERJ-P08J224V
3	1	R3	220 kΩ ±5% - 0.33 W - 200 V	Resistor	Panasonic	ERJ-P08J224V
4	1	R4	220 kΩ ±5% - 0.33W - 200V	Resistor	Panasonic	ERJ-P08J224V
5	1	R5	220kΩ ±5% - 0.33W - 200V	Resistor	Panasonic	ERJ-P08J224V
6	1	R6	100 Ω ±5% - 0.33 W - 200 V	Resistor	Panasonic	ERJP08J101V
7	1	R7	47 Ω ±1% - 0.5 W	Resistor	Panasonic	ERJP06F47R0V
8	1	R8	10 Ω ±1 - 0.2 W	Resistor	Panasonic	ERJP03F10R0V
9	1	R9	150 Ω ±1% - 0.1 W	Resistor	TE Connectivity	CRG0603F150R
10	1	R10	0 Ω ±1% - 0.1 W	Resistor	TE Connectivity	CRG0603ZR
11	1	R11	133 kΩ ±1% - 0.1W	Resistor	Vishay	CRCW0603133KFKEA
12	1	R12	-	Resistor (not connected)	-	-
13	1	R13	12 kΩ ±5% - 0.1 W	Resistor	Panasonic	ERJ3GEYJ123V
14	1	R14	12 kΩ ±1% - 0.2 W	Resistor	Panasonic	ERJP03F1202V
15	1	R15	-	Resistor (not connected)	-	-
16	1	R16	680 kΩ ±1 - 1/16 W	Resistor	TE Connectivity	CRG0402F680K
17	1	R17	11.5 kΩ ±0.1 - 0.1 W	Resistor	TE Connectivity	CPF0402B11K5E1
18	1	R18	4.22 kΩ ±0.1 - 0.1 W	Resistor	TE Connectivity	RN73C1E4K22BTG
19	1	C1	220 nF-440 V_{AC}	Film X1 capacitor	Kemet	PHE844RD6220MR06L2
20	1	C2	220 nF-630 V	MLCC capacitor	Murata	GRM55DR72J224KW01L
21	1	C3	33 µF-400 V	Electrolytic capacitor	Wurth Elektronik	860021378014
22	1	C4	33 µF-400 V	Electrolytic capacitor	Wurth Elektronik	860021378014
23	1	C5	1 nF-630 V	MLCC capacitor 1nF-630V	TDK	C3216C0G2J102JT
24	1	C6	100 pF-50 V	MLCC capacitor	Murata	GRM1885C1H101JA01D
25	1	C7	10 µF-25 V	MLCC capacitor	TDK	C2012X5R1E106K125AB
26	1	C9	10 nF-50 V	MLCC capacitor	Murata	GCM188R72A103KA37D

Item	Q.ty	Reference	Part/value	Description	Manufacturer	Order code
27	1	C10	470 µF-25 V low ESR	Electrolytic capacitor	Wurth Elektronik	860040475008
28	1	C11	100 µF-25 V	Electrolytic capacitor	Wurth Elektronik	860040473003
29	1	C12	-	Capacitor (not connected)	-	-
30	1	C13	3.3 µ-10 V	MLCC capacitor	Murata	GRM188R61A335KE15D
31	1	C14	82 nF-50 V	MLCC capacitor	KEMET	C0603C823K5RACTU
32	1	C15	2.2µF-35V	MLCC capacitor	TDK	C1608X5R1V225K080AC
33	1	C16	2.2µF-35V	MLCC capacitor	TDK	C1608X5R1V225K080AC
34	1	C17	100 nF-50 V	MLCC capacitor	Wurth Elektronik	885012205086
35	1	C18	22 pF-50 V	MLCC capacitor	Wurth Elektronik	885012005057
36	1	C19	10 nF-50 V	MLCC capacitor	Wurth Elektronik	885012205067
37	1	C20	22 µF-6.3 V	MLCC capacitor	Wurth Elektronik	885012107005
38	1	C21	1 µF-25 V	MLCC capacitor	Wurth Elektronik	885012106022
39	1	C22	1 µF-25 V	MLCC capacitor	Wurth Elektronik	885012106022
40	1	C23	2.2 nF 250 V_{AC}	Ceramic X1/Y1 capacitor	Murata	DE2E3KY222MA2BM01
41	1	C24	100 pF-5 0V	MLCC capacitor	Wurth Elektronik	885012006057
42	1	C25	100 µF-35 V	Electrolytic capacitor	Wurth Elektronik	860040573004
43	1	D1	1 A-1000 V	Power rectifier diode	ON Semiconductor	MRA4007T3G
44	1	D2	STPS1150, DO 41 PLASTIC	150 V, 1 A power Schottky rectifier	ST	STPS1150
45	1	D3	STPS2200UF, SMB Flat	2A-200V power Schottky	ST	STPS2200UF
46	1	D4	STPS1H100AFN, SMA Flat	100 V, 1 A power Schottky rectifier	ST	STPS1H100AFN
47	1	D5	18 V	Zener diode	Vishay	MMSZ5248B-E3-08
48	1	D6	-	Not connected	-	-
49	1	BR	1200 V-2 A	Bridge rectifier	Taiwan Semiconductor	DBLS208G RD
50	1	TF	-	Flyback transformer	Wurth Elektronik	750316413-R02
51	1	L1	1 mA	Power inductor	Wurth Elektronik	7447713102
52	1	L2	470 µA	Power inductor	Wurth Elektronik	7447713471
53	1	L3	4.7 µA	Power inductor	Wurth Elektronik	74455047

Item	Q.ty	Reference	Part/value	Description	Manufacturer	Order code
54	1	CM	10 mH	Common mode choke	Wurth Elektronik	744821110
55	1	IC1	VIPER267KD, SO-16	1050 V high voltage converter	ST	VIPER267KD
56	1	IC2	LDK220M50R, SOT23-5L	200 mA low quiescent current and low noise LDO	ST	LDK220M50R
57	1	IC3	PM6644, VDFPN 10 3x3x1.0	350 mA adjustable step-down regulator	ST	PM6644
58	1	REF	TS432ILT, SOT23	1.24 V adjustable shunt voltage reference	ST	TS432ILT
59	1	OPTO	-	Optocoupler	Vishay	SFH610A-2
60	1	NTC1	-	16 Ω inrush current limiter	EPCOS	B57236S160M
61	1	NTC2	-	16 Ω inrush current limiter	EPCOS	B57236S160M
62	1	F1	2 A	Fuse	Littlefuse	0461002.ER
63	1	OUT	-	Four-way female connector	Molex	0022152046
64	1	IN	-	Three-way female connector	Molex	0022162030

3 Modified schematic diagrams

Figure 3. **STEVAL-VP26K01F modified schematic - main PSU**

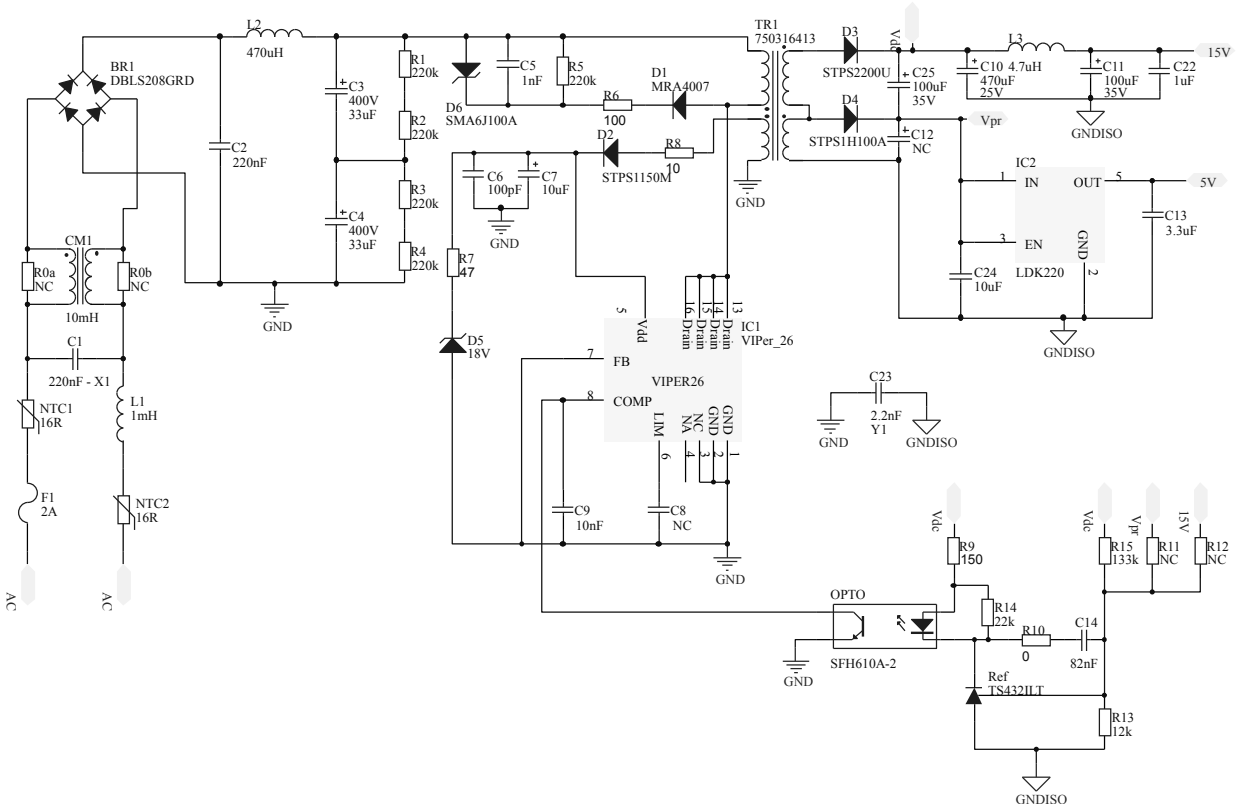
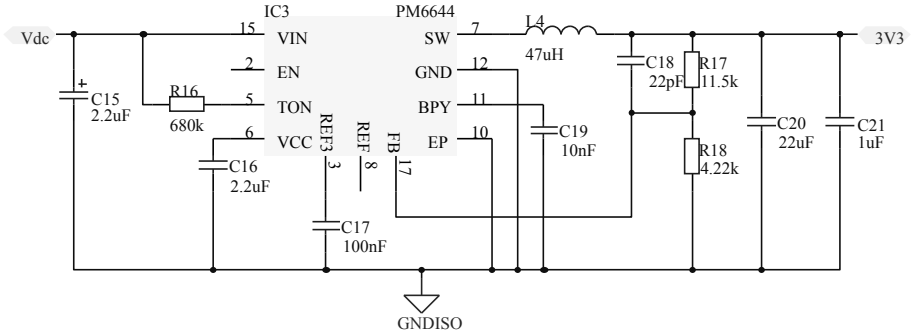


Figure 4. **STEVAL-VP26K01F modified schematic – dedicated DC-DC for 3V3 rail**

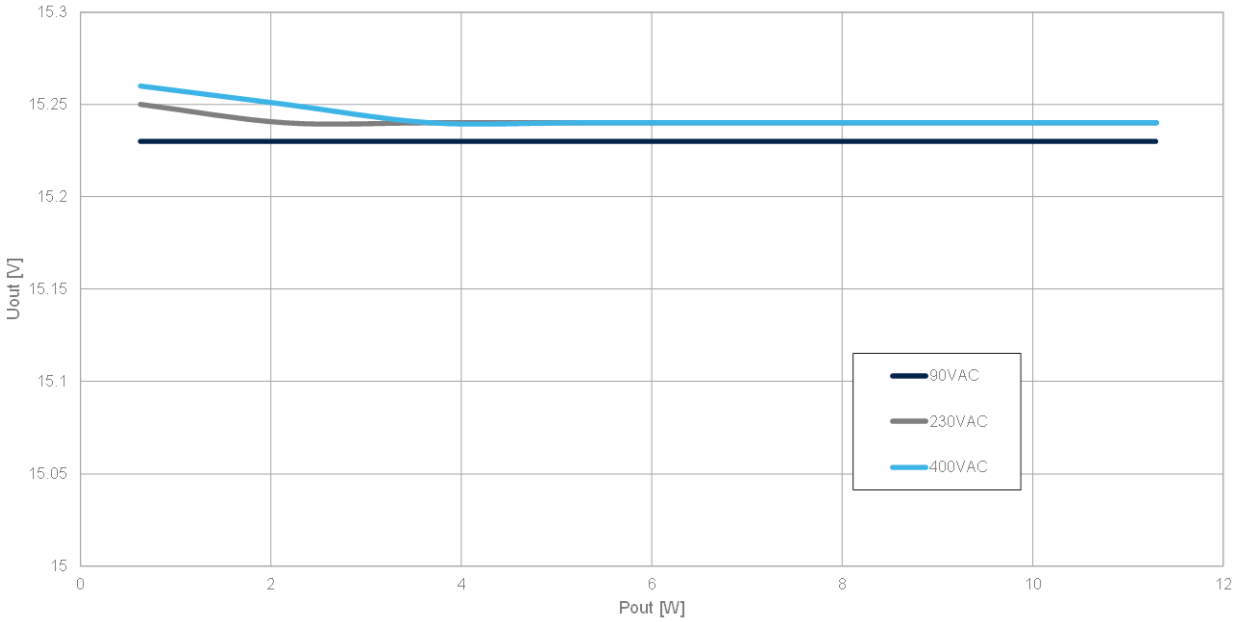


4 Performance data

4.1 Output voltage characteristics

Load characteristic for 15 V output has been tested for different input voltage ranges (90 - 400 V_{AC}).

Figure 5. Output voltage characteristic (V_{IN} = 90 - 400 V_{AC})



4.2 Efficiency characteristics and light load consumption

The efficiency of the converter has been measured in the whole range of the input voltages (90 - 400 V_{AC}), as shown in the table below.

Table 4. Efficiency at typical load

Output condition	Input voltage	Efficiency
15 V@500 mA/5 V@60 mA/3.3 V@100 mA	90 V_{AC}	76.0%
	230 V_{AC}	81.3%
	400 V_{AC}	79.1%

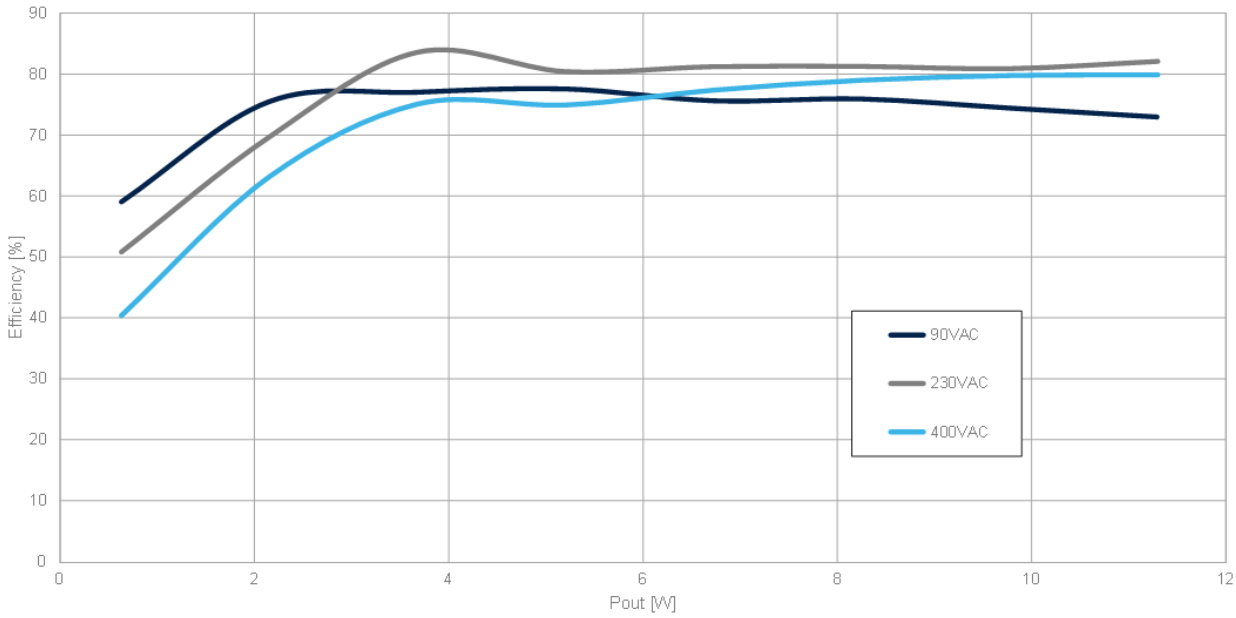
The table below shows the no load consumption measured for different input voltages.

Table 5. Light load power consumption

Input voltage	Input power	Input power @ Pout = 0.16W
90 V_{AC}	48 mW	263 mW
230 V_{AC}	164 mW	370 mW
400 V_{AC}	439 mW	-

The following figure shows a slightly better efficiency and standby consumption compared with the original board measurements. The board efficiency is improved thanks to the lower leakage current and the lower ESR of the input capacitors.

Figure 6. **Efficiency characteristics (V_{IN} = 90 - 400 V_{AC})**



4.3 Output voltage ripple

The output voltage ripple has been measured on the 15 V output for full load. A different input voltage range is shown in a different time scale.

The figures below show the waveforms for the 15 V voltage ripple at full load.

The HF ripple at 60 kHz is shown on the left.

The lower frequency ripple is shown on the right. It is caused by 50 Hz impact for the lowest input voltage, whereas the 250 Hz ripple is caused by jittering (VIPER26K feature to optimize the EMI). The total ripple is in the range of 20 mV p-p.

Figure 7. **Ripple output voltage: 90 V_{AC}**

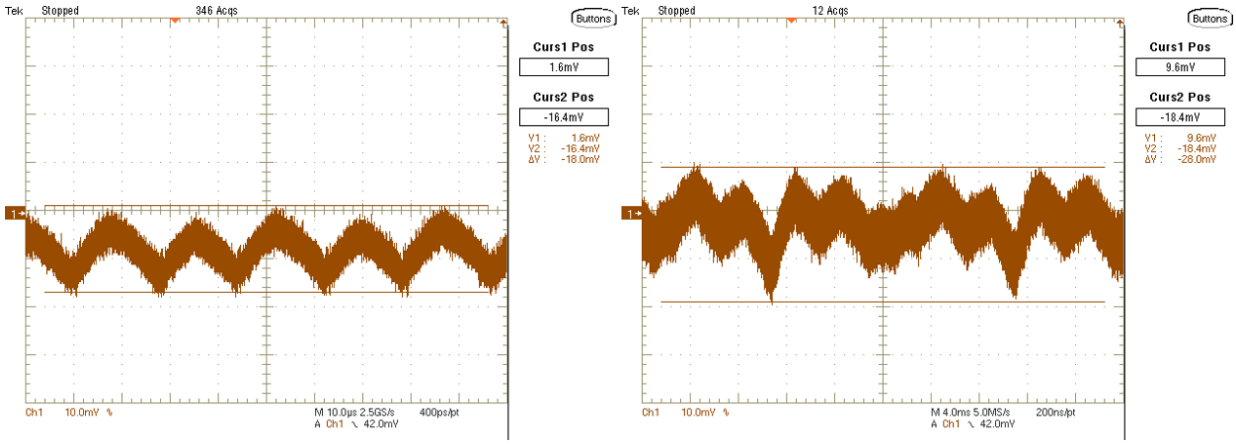


Figure 8. Ripple output voltage: 230 V_{AC}

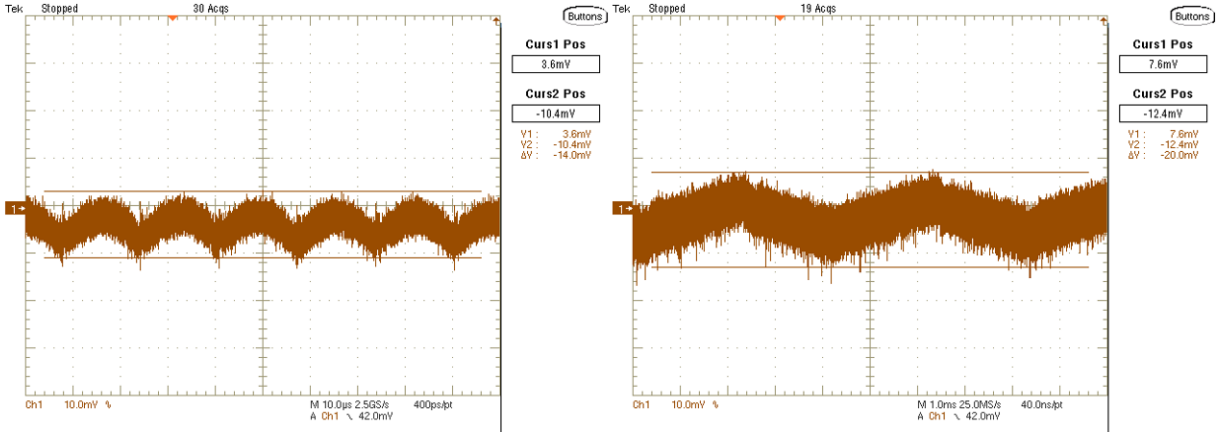
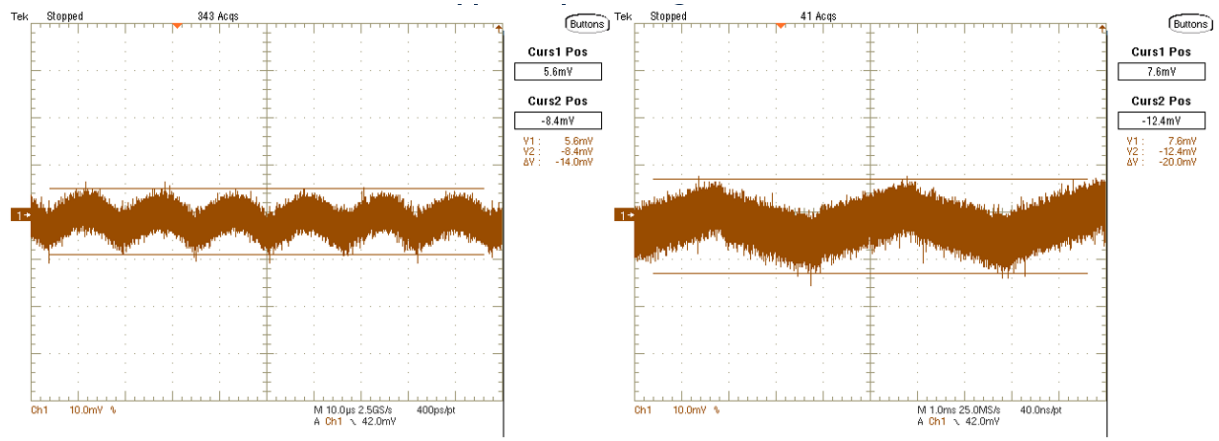


Figure 9. Ripple output voltage: 400 V_{AC}



Revision history

Table 6. **Document revision history**

Date	Revision	Changes
19-Apr-2022	1	Initial release.

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