EVLVIPGAN65PD – 65W USB PD adaptor reference design with VIPERGAN65

Introduction

This document describes the EVLVIPGAN65PD, a 65 W QR mode flyback adaptor reference design for USB Type-C^{TM} PD adaptors with the following characteristics:

- 4-point average active mode efficiency at full load: > 92%
- Input power consumption in no load condition: < 50 mW (@230 V_{AC})
- Compliant with IEC55022 Class B conducted EMI, even with reduced EMI filter
- RoHS compliant

The evaluation board has been developed using the VIPERGAN65, a new advanced offline HV converter by STMicroelectronics, having the following features:

- 650 V power GaN with embedded senseFET (Si) and HV startup
- QR operation with dynamic blanking time and adjustable valley synchronization delay functions to maximize efficiency at any input line and load condition
- Valley-lock to ensure constant valley skipping
- Input voltage feedforward compensation for mains-independent OPP intervention
- Adaptive burst mode for advanced power management in light load conditions
- Frequency jittering for EMI suppression

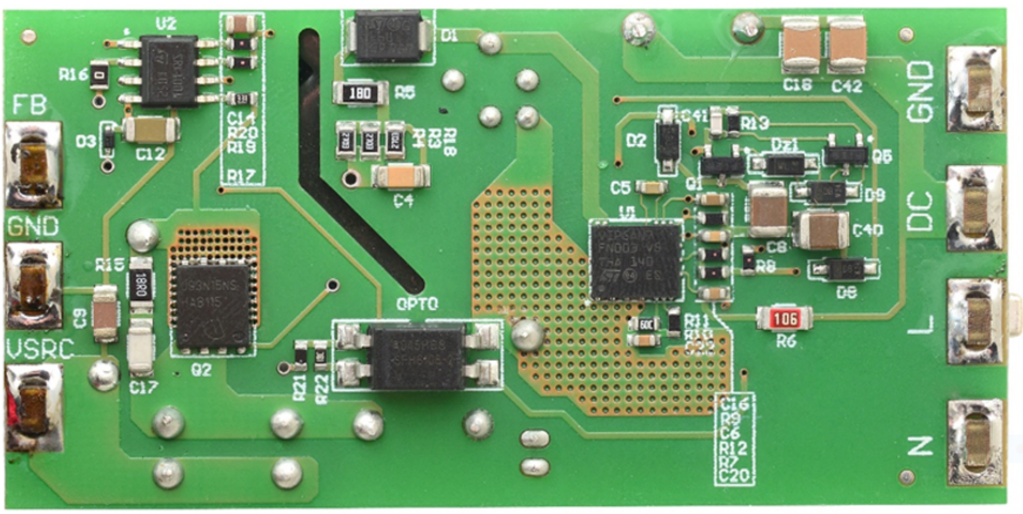
1 Overview

The main features of the EVLVIPGAN65PD are:

- Input voltage: Universal AC from 90 V_{AC} to 264 V_{AC} with 47 Hz to 63 Hz frequency
- Output voltage: Single Type-C output 5 V_{DC} – 20 V_{DC}
- Output power: 20 V 3.25 A 65 W max.
- Size: 70 x 35 x 25 mm (L x W x H)
- Power density: > 22 W/in^3
- Efficiency: Meets EU CoC Tier 2 and DoE Level 6 efficiency requirements, peak efficiency >93% at 230 V_{AC} 65W
- Quasi-resonant operations with dynamic blanking time and adjustable valley synchronization delay functions, to maximize efficiency at any input line and load condition
- Integrated GaN IC VIPERGAN65 results in a compact, simplified PCB layout and bill of material reduction
- Support for USB Power Delivery

Figure 1. EVLVIPGAN65PD reference design – top

Figure 2. EVLVIPGAN65PD reference design – bottom



2 Test board: design and evaluation

The electrical specifications of the evaluation board are listed in Table 1 according USB Power Delivery Specification Rev. 3.1.

Table 1. Electrical specifications

Parameter	Min.	Typ.	Max.	Unit
AC main input voltage	90		264	V_{AC}
Main frequency (f_L)	47		63	Hz
Standby input power – 5 V_{OUT} @230 V_{AC}			45	mW
Ambient operating temperature			60	ºC
Output parameters – 5 V setting				
Output voltage	4.75	5	5.25	V
Output current	2.85	3	3.15	A
Output parameters – 9 V setting				
Output voltage	8.55	9	9.45	V
Output current	2.85	3	3.15	A
Output parameters – 12 V setting				
Output voltage	11.4	12	12.6	V
Output current	2.85	3	3.15	A
Output parameters – 15 V setting				
Output voltage	14.25	15	15.75	V
Output current	2.85	3	3.15	A
Output parameters – 20 V setting				
Output voltage	19	20	21	V
Output current	3.0875	3.25	3.4125	A

3 Schematic and bill of materials

Figure 3. Input board circuit schematic

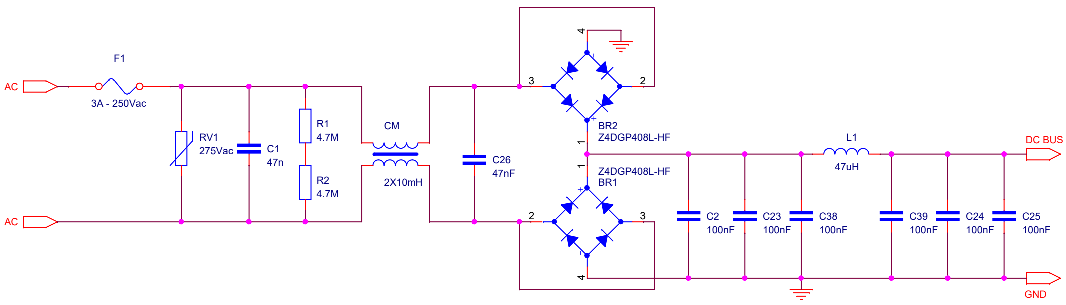


Figure 4. Main board circuit schematic

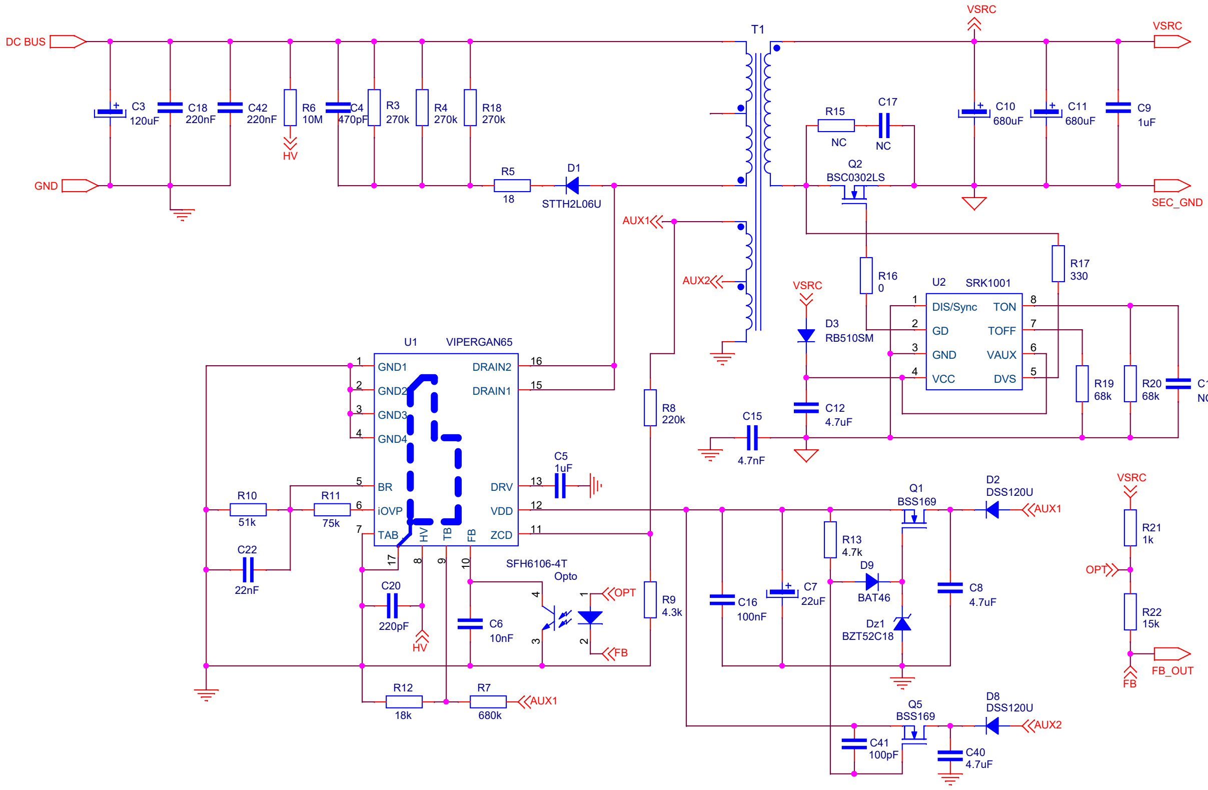


Figure 5. Daughterboard circuit schematic

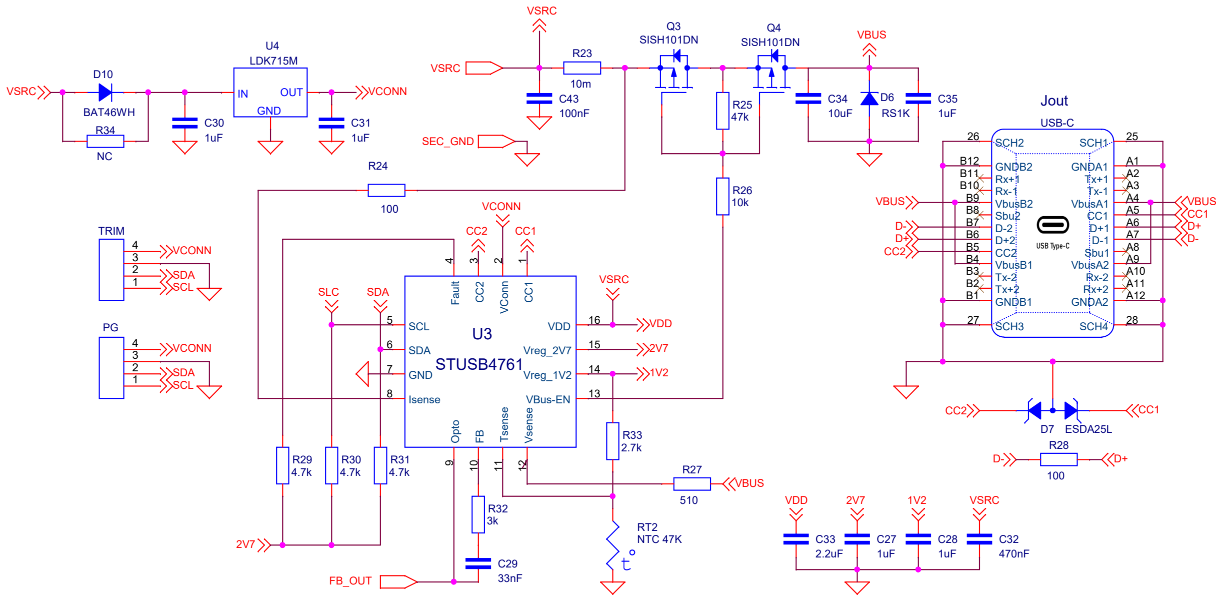


Table 2. Bill of materials of the reference design – input board

Reference	Part/Value	Description	Manufacturer	Order code
BR1	600V - 2A	Bridge rectifier	Comchip Technology	Z4DGP408L-HF
BR2	600V - 2A	Bridge rectifier	Comchip Technology	Z4DGP408L-HF
C1	47nF - 275Vac	Polypropylene X2 capacitor	Wurth Elektronik	890334023015
C2	100nF ±10% - 450Vcc	MLCC capacitor	TDK	C3216X7T2W104K160AE
C23	100nF ±10% - 450Vcc	MLCC capacitor	TDK	C3216X7T2W104K160AE
C24	100nF ±10% - 450Vcc	MLCC capacitor	TDK	C3216X7T2W104K160AE
C25	100nF ±10% - 450Vcc	MLCC capacitor	TDK	C3216X7T2W104K160AE
C26	47nF - 275Vac	Polypropylene X2 capacitor	Wurth Elektronik	890334023015
C38	100nF ±10% - 450Vcc	MLCC capacitor	TDK	C3216X7T2W104K160AE
C39	100nF ±10% - 450Vcc	MLCC capacitor	TDK	C3216X7T2W104K160AE
CM	10mH - 1.2A	Common Mode Choke	Coilcraft	CJ5094-CL
F1	3A - 250Vac	FUSE	Littelfuse	0443003.DR
L1	47uH	Power choke	Burns	SRN8040TA-470M
R1	4.7MΩ±5% - 0.25W	Resistor	Vishay Dale	CRCW12064M70JNEA
R2	4.7MΩ±5% - 0.25W	Resistor	Vishay Dale	CRCW12064M70JNEA
RV1	275Vac	Disk varistor	Wurth Elektronik	820572711

Table 3. Bill of materials of the reference design – main board

Reference	Part/Value	Description	Manufacturer	Order code
C3	120uF - 400V	Electrolytic capacitor	Rubycon	400HXW120MEFR16X30
C4	470pF - 1000V	MLCC	Wurth Elektronik	885342208017
C5	1uF - 50V	MLCC	TDK	CGA3E3X5R1H105K080AB

Reference	Part/Value	Description	Manufacturer	Order code
C6	10nF - 100V	MLCC	TDK	C1608X7R2A103K080AA
C7	22uF - 50V	Electrolytic capacitor	Rubycon	860160672011
C8	4.7uF - 100V	MLCC capacitor	TDK	CNC6P1X7R2A475K2
C9	1uF - 100V	MLCC capacitor	TDK	C3216X7R2A105K160AA
C10	680uF - 25V	Conductive Polymer hybrid ECAP	KEMET	EEH-AZS1E561B
C11	680uF - 25V	Conductive Polymer hybrid ECAP	KEMET	EEH-AZS1E561B
C12	4.7uF - 50V	MLCC capacitor	Wurth Elektronik	885012208094
C14	NC			
C15	4.7nF - 250Vac	Y1 Safety ceramic disc capacitors	Murata	DE1E3RA472MA4BN1F
C16	100nF - 50V	MLCC capacitor	Wurth Elektronik	885012206095
C17	NC			
C18	220nF - 450V	MLCC capacitor	TDK	C3225X7T2W224M200AE
C20	220pF - 100V	MLCC capacitor	Murata	GCM1885C2A221FA16D
C22	22nF - 100V	MLCC capacitor	KEMET	C0603C223K1RACTU
C40	4.7uF - 100V	MLCC capacitor	TDK	CNC6P1X7R2A475K2
C41	100pF - 50V	MLCC capacitor	Wurth Elektronik	710-885012006057
C42	220nF - 450V	MLCC capacitor	TDK	C3225X7T2W224M200AE
D1	2A - 600V	Fast switching rectifier	STMicroelectronics	STTH2L06U
D2	1A - 200V	Small signal switching diode	SMC Diode Solutions	DSS120U
D3	100mA - 40V	Small signal Schottky diode	Rohm	RB510SM-40FHT2R
D8	1A - 200V	Small signal switching diode	SMC Diode Solutions	DSS120U
D9	250mA - 100V	Small signal switching diode	NXP	BAT46WH,115
Dz1	18V - 500mW	Zener diode	Diodes	BZT52C18
OPTO	70V - 100mA	Optocoupler	Vishay	SFH6106-4T
Q1	100V - 12Ω	N-channel - Small signal MOSFET	Infineon	BSS169IXTSA1
Q2	120V - 8mΩ - Logic Level	N-channel Power MOSFET	Infineon	BSC0302LS
Q5	100V - 12Ω	N-channel - Small signal MOSFET	Infineon	BSS169IXTSA1
R3	270kΩ±1% - 0.5W - 400V	Anti-surge thick film chip resistor	Panasonic	ERJ-P06F2703V
R4	270kΩ±1% - 0.5W - 400V	Anti-surge thick film chip resistor	Panasonic	ERJ-P06F2703V
R5	18Ω±5% - 0.66W - 500V	Anti-surge thick film chip resistor	Panasonic	ERJP08J180V
R6	10MΩ±5% - 0.25W - 800V	Thick film high voltage chip resistors	Burns	CHV1206-JW-106ELF

Reference	Part/Value	Description	Manufacturer	Order code
R7	680kΩ±1% - 0.25W	Thick film chip resistors	Panasonic	ERJ-UP3F6803V
R8	220kΩ±1% - 0.25W	Thick film chip resistors	Panasonic	ERJ-UP3F2203V
R9	4.3kΩ±1% - 0.25W	Thick film chip resistors	Panasonic	ERJ-UP3F4301V
R10	51kΩ±1% - 0.1W	Thick film chip resistors	Yageo	RT0603FRE1051KL
R11	75kΩ±1% - 0.25W	Thick film chip resistors	Yageo	RT0603FRE1075KL
R12	18kΩ±1% - 0.25W	Thick film chip resistors	Panasonic	667-ERJ-UP3F1802V
R13	4.7kΩ±1% - 0.25W	Thick film chip resistors	Panasonic	ERJPA3F4701V
R15	NC			
R16	0Ω	Thick film chip resistors	Panasonic	ERJ-H3G0R00V
R17	330Ω±1% - 0.25W	Thick film chip resistors	Panasonic	ERJ-UP3F3300V
R18	270kΩ±1% - 0.5W - 400V	Anti-surge thick film chip resistor	Panasonic	ERJ-P06F2703V
R19	68kΩ±1% - 0.25W	Thick film chip resistors	Panasonic	ERJ-UP3F6802V
R20	68kΩ±1% - 0.25W	Thick film chip resistors	Panasonic	ERJ-UP3F6802V
R21	1kΩ±1% - 0.25W	Thick film chip resistors	Panasonic	ERJ-UP3F1001V
R22	15kΩ±1% - 0.25W	Thick film chip resistors	Panasonic	ERJ-UP3F1502V
TF1	500uH	Flyback transformer	Wurth Elektronik	750320045 rev.02
U1		HV Converter	STMicroelectronics	VIPERGAN65
U2		Synchronous rectification controller	STMicroelectronics	SRK1001

Table 4. **Bill of materials of the reference design – daughterboard**

Reference	Part/Value	Description	Manufacturer	Order code
C27	1uF - 50V	MLCC capacitor	Wurth Elektronik	885012207103
C28	1uF - 50V	MLCC capacitor	Wurth Elektronik	885012207103
C29	33nF - 50V	MLCC capacitor	Wurth Elektronik	885012206092
C30	1uF - 100V	MLCC capacitor	TDK	C3216X7R2A105K160AA
C31	1uF - 100V	MLCC capacitor	TDK	C3216X7R2A105K160AA
C32	470nF - 100V	MLCC capacitor	AVX	08051C474KAT2A
C33	2.2uF - 50V	MLCC capacitor	Murata	GRM188R61H225KE11D
C34	10uF - 50V	MLCC capacitor	Murata	81-GRT31CR61H106KE1L
C35	1uF - 100V	MLCC capacitor	Murata	GCM21BC72A105KE36L
C43	100nF - 100V	MLCC capacitor	Murata	GCM21BR72A104KA7K

Reference	Part/Value	Description	Manufacturer	Order code
D6	1A - 800V	Fast switching rectifier	VISHAY	RS1K
D7	1.2V - 10mA	Dual TRANSIL array for ESD protection	STMicroelectronics	ESDA25LY
D10	250mA - 100V	Small Signal Switching Diode	NXP	BAT46WH,115
Jout		Connector USB 3.1,type C, 90°	Molex	201267-0005
Q3	30V - 10m	P-channel Power MOSFET	Vishay	SISH101DN-T1-GE3
Q4	30V - 10m	P-channel Power MOSFET	Vishay	SISH101DN-T1-GE3
R23	10mΩ±1% - 0.75W	Metal foil low resistance chip resistors	Susumu	KRL1632E-C-R010-F-T1
R24	100Ω±1% - 0.5W	Thick film chip resistors	Panasonic	ERJP06F1000V
R25	47kΩ±1% - 0.1W	Thick film chip resistors	Vishay	CRCW060347K0FKEA
R26	10kΩ±1% - 0.25W	Thick film chip resistors	Panasonic	ERJ-UP3F1002V
R27	510Ω±1% - 0.25W	Thick film chip resistors	Panasonic	ERJ-PA3F5100V
R28	100Ω±1% - 0.25W	Thick film chip resistors	Panasonic	ERJ-UP3F1000V
R29	4.7kΩ±1% - 0.1W	Thick film chip resistors	Panasonic	ERJ-3EKF4701V
R30	4.7kΩ±1% - 0.1W	Thick film chip resistors	Panasonic	ERJ-3EKF4701V
R31	4.7kΩ±1% - 0.1W	Thick film chip resistors	Panasonic	ERJ-3EKF4701V
R32	3kΩ±1% - 0.25W	Thick film chip resistors	Panasonic	ERJ-UP3F3001V
R33	2.7kΩ±1% - 0.1W	Thick film chip resistors	Panasonic	ERJ-3EKF2701V
R34	NC			
RT2	47kΩ±5% - 0.125W	NTC thermistor	Vishay	NTCS0603E3473JHT
U3		Standalone USB PD controller	STMicroelectronics	STUSB4761QTR
U4	5V - 85mA	LDO regulator	STMicroelectronics	LDK715M50R
TRIM	1uF - 50V	SMT vertical header	Wurth Elektronik	665104131822

The transformer characteristics are listed in the table below.

Table 5. Transformer characteristics

Parameter	Value
Manufacturer	Wurth Elektronik
Part number	750320045 rev.02
Primary inductance	500µH ± 10%
Leakage inductance	7.5µH max.
Primary (12 - 1) to Aux1 (10 - 2) turns ratio	2.53
Primary (12 - 1) to Aux2 (3 - 2) turns ratio	3.43
Primary (12 - 1) to Secondary (FL1 – FL2) turns ratio	6

Another transformer version with extended rail (Wurth Elektronik 750320431, www.we-online.com) is available for applications where customers prefer having a drop-in component with similar characteristics and performance

Figure 6. **Dimensional drawing and pin placement diagram – distances (bottom view)**

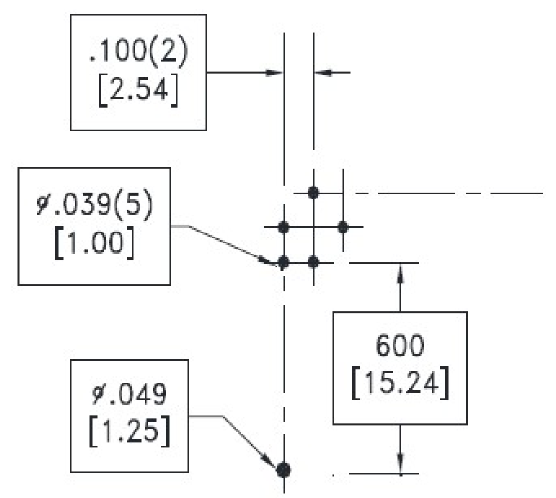


Figure 7. **Dimensional drawing and pin placement diagram – electrical diagram**

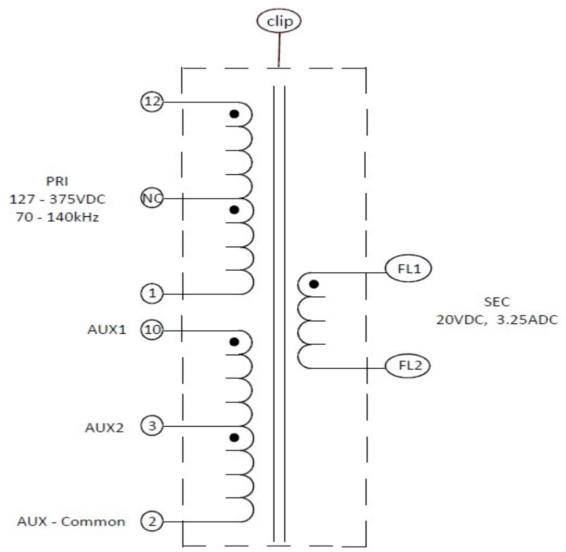
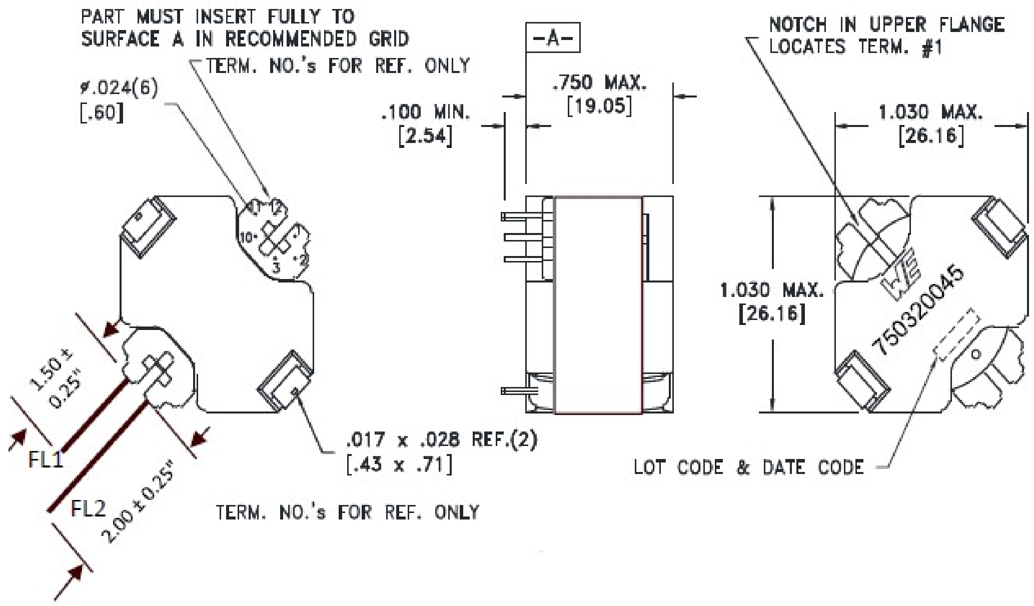


Figure 8. **Dimensional drawing and pin placement diagram – bottom, side, and top view**



4 Efficiency measurements

The active mode efficiency is defined as the average of the efficiencies measured at 25%, 50%, 75%, and 100% of the rated output power, at nominal input voltages (V_{IN} = 115 V_{AC} and V_{IN} = 230 V_{AC}).

External power supplies (the power supplies which are contained in a separate housing from the end-use devices that they are powering) need to comply with the European Code of Conduct, version 5 “Active mode efficiency” criterion, which states that an SMPS with power throughput of 65 W should have an active mode efficiency higher than 89%.

Another standard to be applied is the DoE Level 6 Efficiency Standards recommendation, whose active mode efficiency requirement for the same power throughput is 88%.

Table 6 to Table 7 show the efficiency measurement results.

Table 6. Average efficiency at 115 V_{AC}

Output load (%)	I_{OUT} (A)	V_{OUT} (V)	P_{IN} (W)	P_{OUT} (W)	Efficiency (%)
5 V output					
25%	0.7523	5.052	4.218	3.8006	90.10
50%	1.5014	5.042	8.31	7.57	91.10
75%	2.251	5.032	12.46	11.327	90.91
100%	3	5.031	16.74	15.093	90.16
Average efficiency					90.567
9 V output					
25%	0.7523	9.044	7.453	6.8038	91.29
50%	1.5014	9.041	14.67	13.574	92.53
75%	2.251	9.039	21.95	20.347	92.70
100%	3	9.037	29.41	27.111	92.18
Average efficiency					92.175
12 V output					
25%	0.7523	12.05	9.898	9.0652	91.59
50%	1.5014	12.046	19.51	18.086	92.70
75%	2.251	12.044	29.17	27.111	92.94
100%	3	12.043	39.12	36.129	92.35
Average efficiency					92.395
15 V output					
25%	0.7523	15.053	12.37	11.324	91.54
50%	1.5014	15.05	24.35	22.596	92.80
75%	2.251	15.05	36.44	33.878	92.97
100%	3	15.047	48.86	45.141	92.39
Average efficiency					92.425
20 V output					
25%	0.8121	20.059	17.79	16.290	91.57
50%	1.6263	20.055	35.16	32.615	92.76
75%	2.4358	20.053	52.69	48.845	92.70
100%	3.25	20.049	70.81	65.159	92.02
Average efficiency					92.263

Table 7. Average efficiency at 230 V_{AC}

Output Load (%)	I_{OUT} (A)	V_{OUT} (V)	P_{IN} (W)	P_{OUT} (W)	Efficiency (%)
5 V output					
25%	0.7523	5.048	4.381	3.798	86.69
50%	1.5014	5.04	8.66	7.567	87.38
75%	2.251	5.035	12.75	11.334	88.89
100%	3	5.031	16.88	15.093	89.41
Average efficiency					88.09
9 V output					
25%	0.7523	9.048	7.773	6.8068	87.57
50%	1.5014	9.048	15.34	13.585	88.56
75%	2.251	9.042	22.28	20.354	91.36
100%	3	9.039	29.44	27.117	92.11
Average efficiency					89.90
12 V output					
25%	0.7523	12.054	10.23	9.0682	88.64
50%	1.5014	12.053	20.13	18.096	89.90
75%	2.251	12.049	29.46	27.122	92.06
100%	3	12.044	38.95	36.132	92.77
Average efficiency					90.84
15 V output					
25%	0.7523	15.058	12.66	11.328	89.48
50%	1.5014	15.054	24.75	22.602	91.32
75%	2.251	15.05	36.55	33.878	92.69
100%	3	15.046	48.40	45.138	93.26
Average efficiency					91.69
20 V output					
25%	0.8121	20.062	18.25	16.292	89.27
50%	1.6263	20.059	35.36	32.622	92.26
75%	2.4358	20.055	52.38	48.850	93.26
100%	3.25	20.051	69.69	65.166	93.51
Average efficiency					92.08

Table 8 shows the efficiency measured at 10% of the rated output power.

Table 8. Average efficiency at 10% of the max. output load

V_{IN} [V_{AC}]	I_{OUT} (A)	V_{OUT} (V)	P_{IN} (W)	P_{OUT} (W)	Efficiency (%)
5 V output					
115	0.30117	5.057	1.718	1.523	88.65
230	0.30117	5.048	1.808	1.520	84.07
9 V output					
115	0.30117	9.045	3.054	2.724	89.19

V_{IN} [V_{AC}]	I_{OUT} (A)	V_{OUT} (V)	P_{IN} (W)	P_{OUT} (W)	Efficiency (%)
230	0.30117	9.046	3.198	2.724	85.18
12 V output					
115	0.30117	12.05	4.062	3.629	89.34
230	0.30117	12.053	4.245	3.630	85.51
15 V output					
115	0.30117	15.056	5.101	4.534	88.88
230	0.30117	15.058	5.308	4.535	85.44
20 V output					
115	0.3284	20.063	7.491	6.589	87.96
230	0.3284	20.066	7.738	6.590	85.16

Figure 9. **Efficiency at 115 V_{AC}**

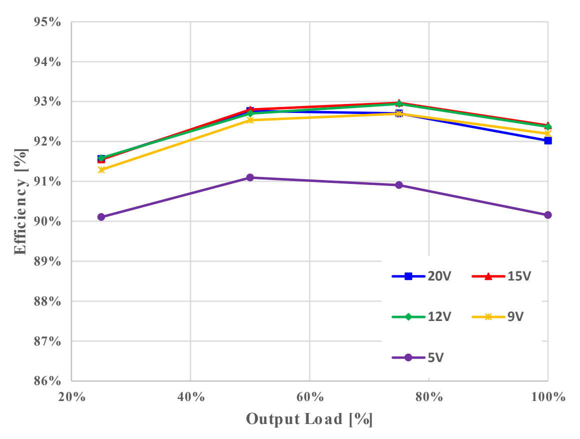
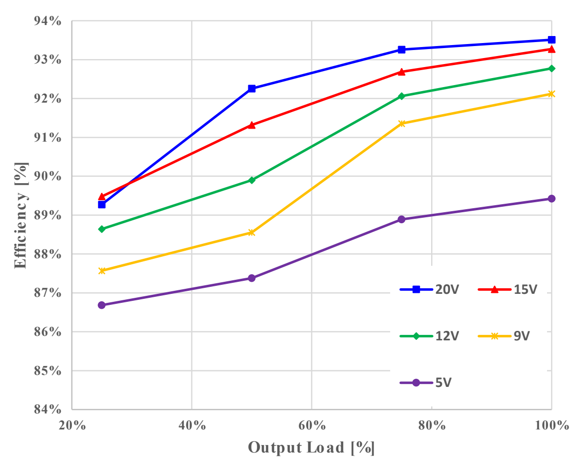


Figure 10. **Efficiency at 230 V_{AC}**



4.1 No load consumptions

The input power of the converter has been measured in no load; in this condition, the converter works in burst mode so that the average switching frequency is reduced, thus minimizing the frequency related losses. The no load condition is realized with nothing connected to the USB Type-C® port, which opens the by-pass MOSFETs Q3 and Q4 in the daughterboard and sets the output voltage of the converter to 5V.

Table 9. **No load consumptions**

V_{IN} [V_{AC}]	P_{IN} (mW)
5 V output	
115	26.11
230	40.79

5 Typical waveforms

The following figures show the GaN (primary side) and SR MOSFET (secondary side) drain to source voltage for minimum and maximum AC input voltage at maximum output power.

Figure 11. VIPerGaN and SR MOSFET V_{DS} at 90 V_{AC} (20 V – 3.25 A)

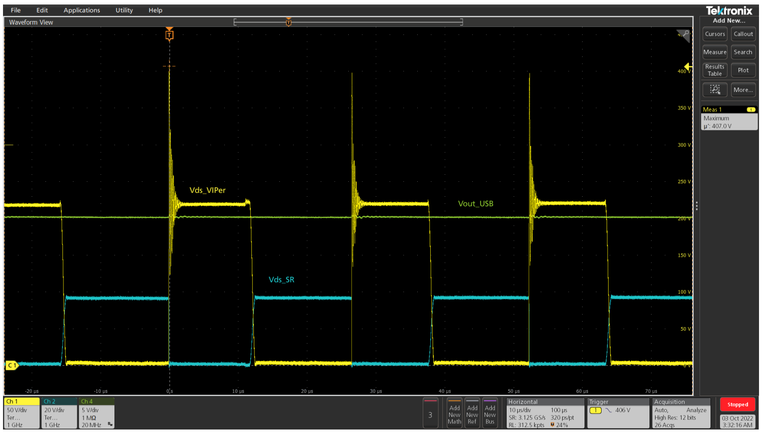
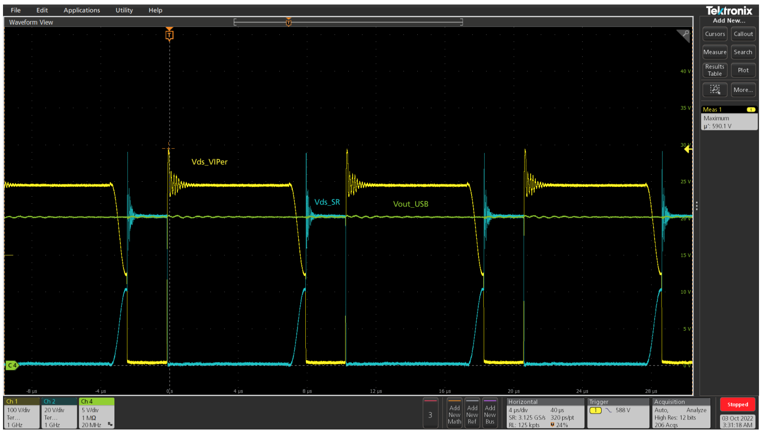


Figure 12. VIPerGaN and SR MOSFET V_{DS} at 265 V_{AC} (20 V – 3.25 A)



The output voltage ripple has been measured at different output voltages with two different loads (0 A and maximum available current). Tests have been performed at the nominal input voltages (115 V_{AC} and 230 V_{AC}).

Figure 13. Ripple at 115 V_{AC}, 5 V – 0 A

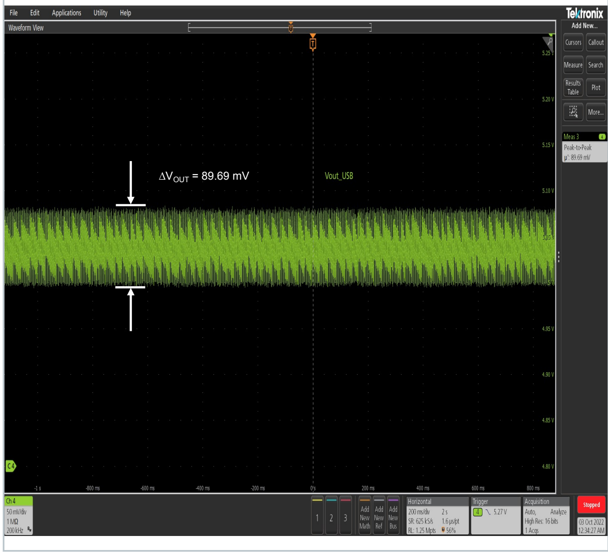


Figure 14. Ripple at 230 V_{AC}, 5 V – 0 A

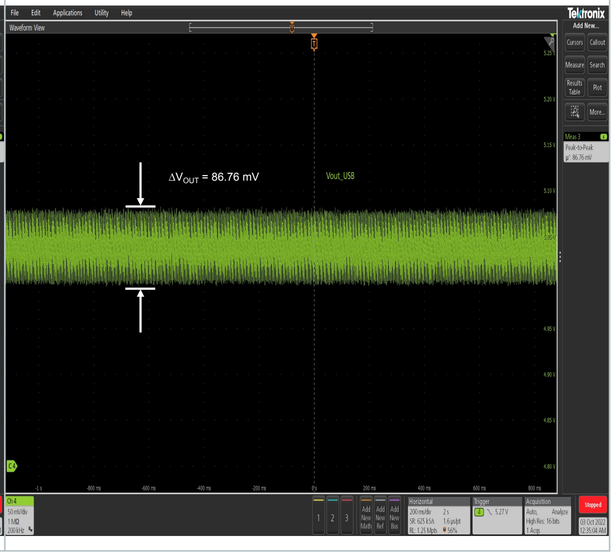


Figure 15. Ripple at 115 V_{AC}, 5 V – 3 A

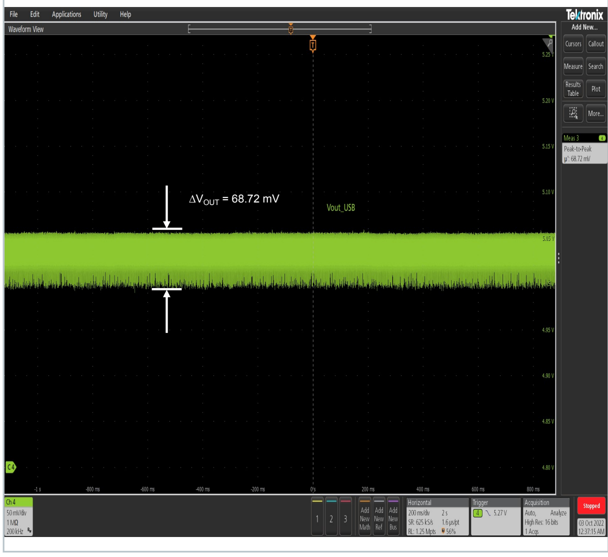


Figure 16. Ripple at 230 V_{AC}, 5 V – 3 A

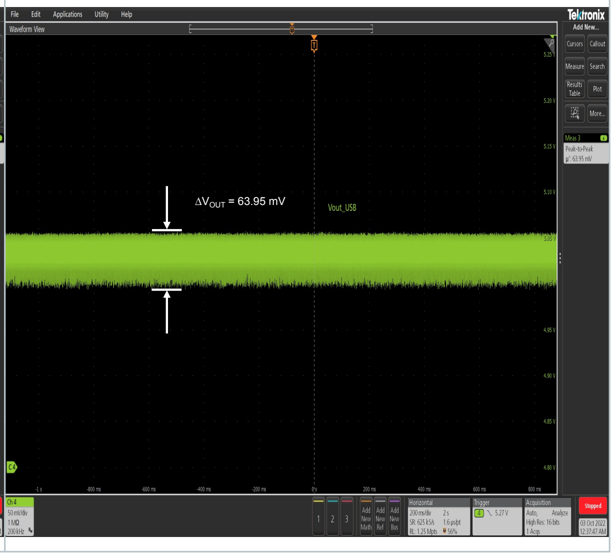


Figure 17. Ripple at 115 V_{AC}, 9 V – 0 A

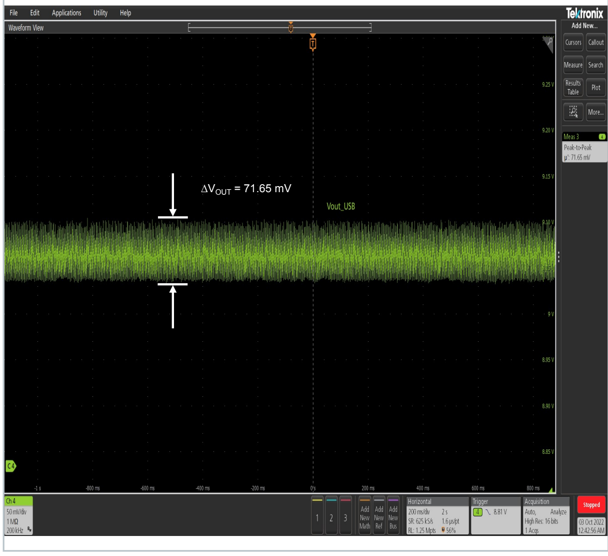


Figure 18. Ripple at 230 V_{AC}, 9 V – 0 A

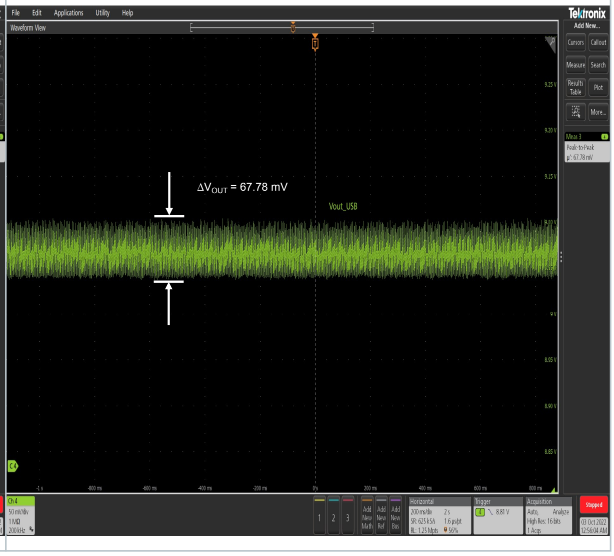


Figure 19. Ripple at 115 V_{AC}, 9 V – 3 A

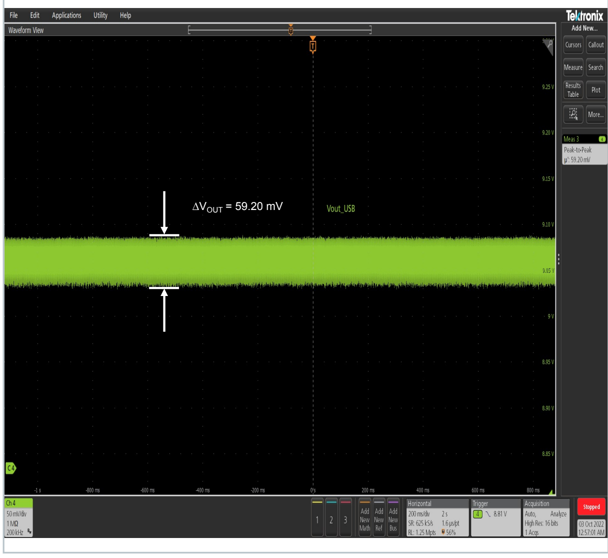


Figure 20. Ripple at 230 V_{AC}, 9 V – 3 A

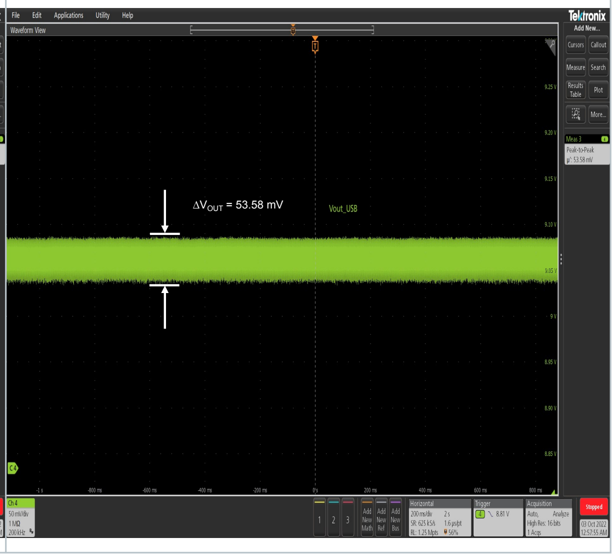


Figure 21. Ripple at 115 V_{AC}, 12 V – 0 A

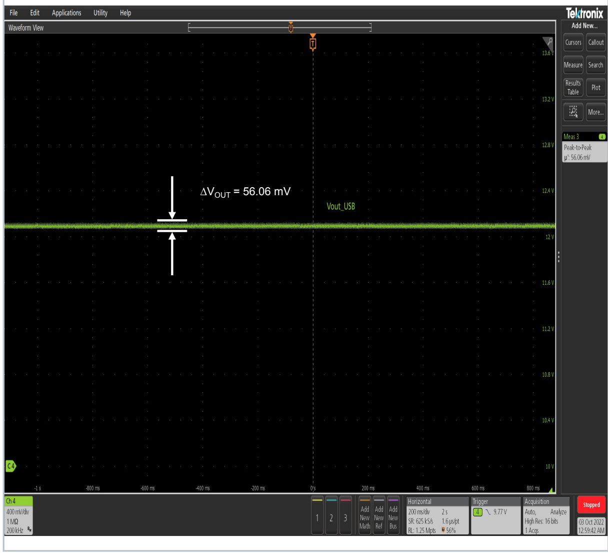


Figure 22. Ripple at 230 V_{AC}, 12 V – 0 A

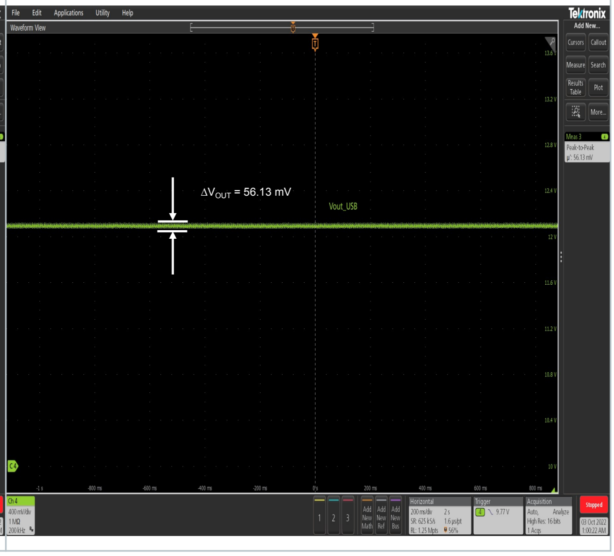


Figure 23. Ripple at 115 V_{AC}, 12 V – 3 A

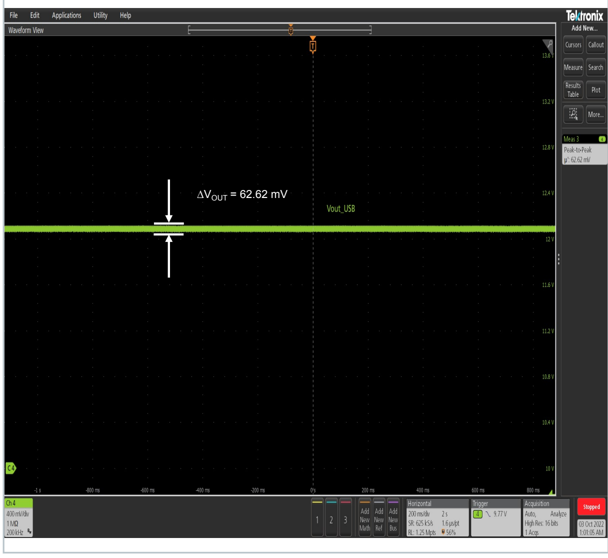


Figure 24. Ripple at 230 V_{AC}, 12 V – 3 A

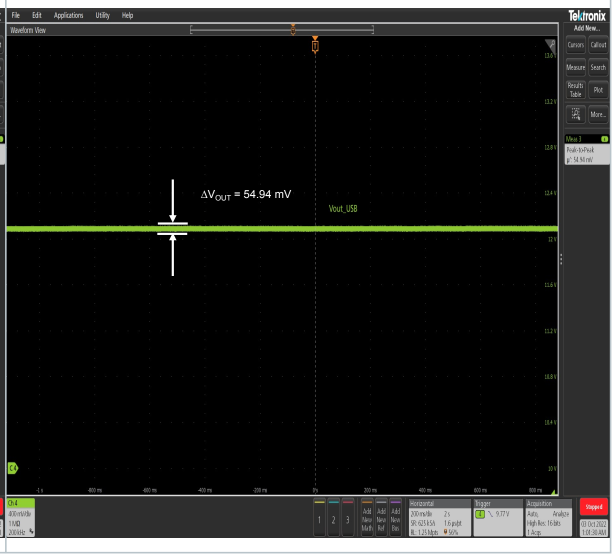


Figure 25. Ripple at 115 V_{AC}, 15 V – 0 A

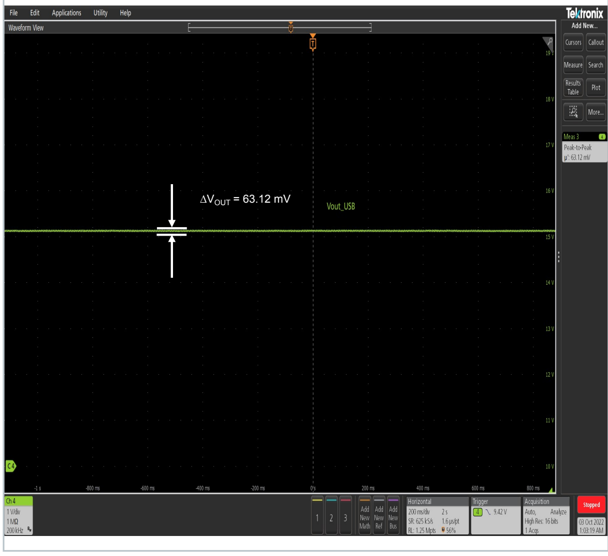


Figure 26. Ripple at 230 V_{AC}, 15 V – 0 A

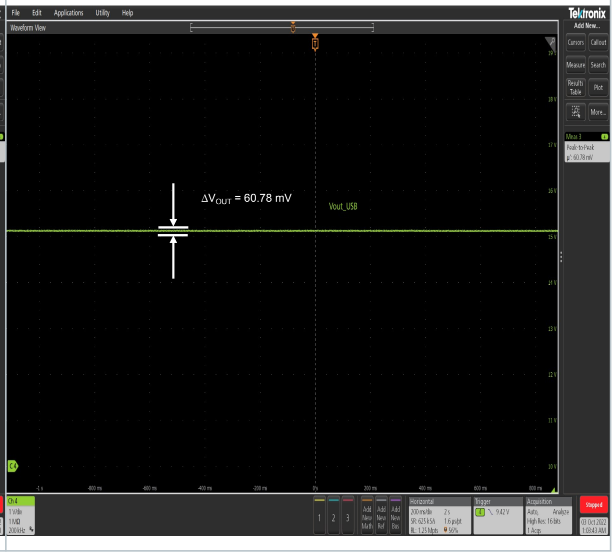


Figure 27. Ripple at 115 V_{AC}, 15 V – 3 A

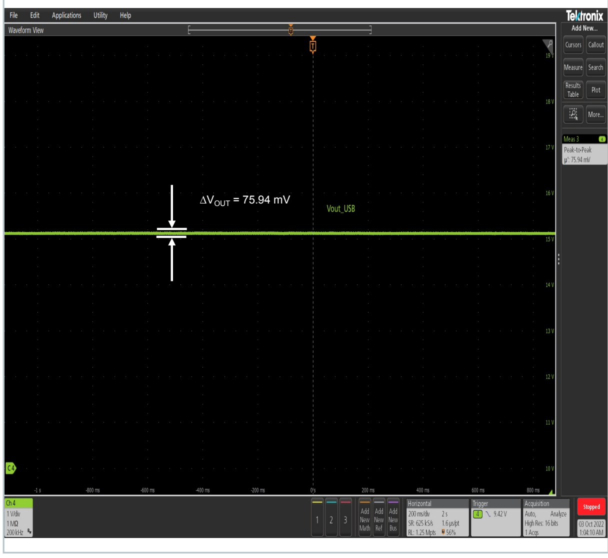


Figure 28. Ripple at 230 V_{AC}, 15 V – 3 A

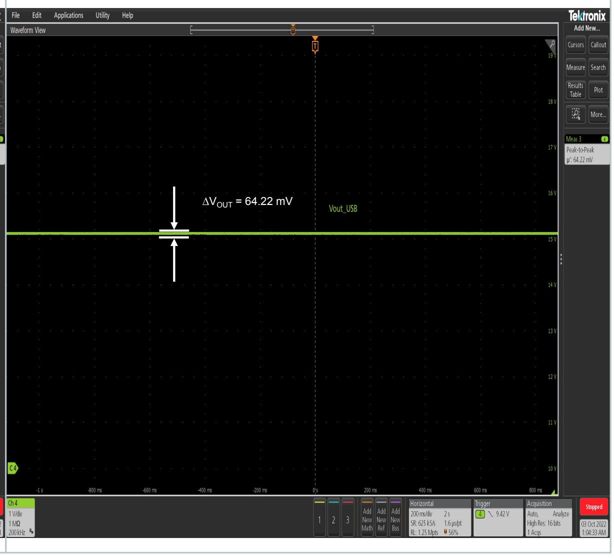


Figure 29. Ripple at 115 V_{AC}, 20 V – 0 A

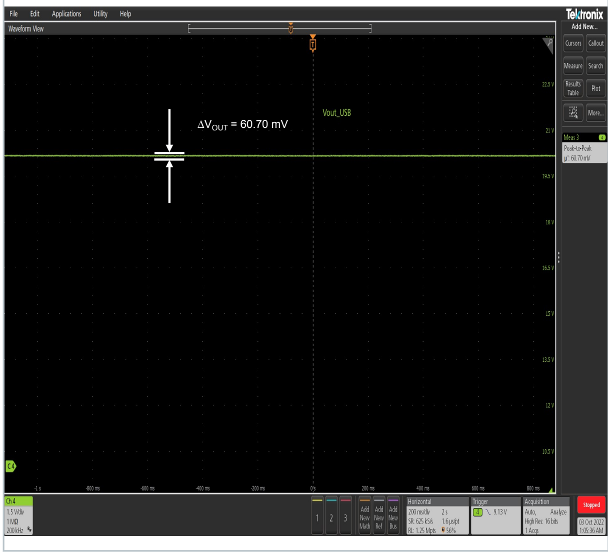


Figure 30. Ripple at 230 V_{AC}, 20 V – 0 A

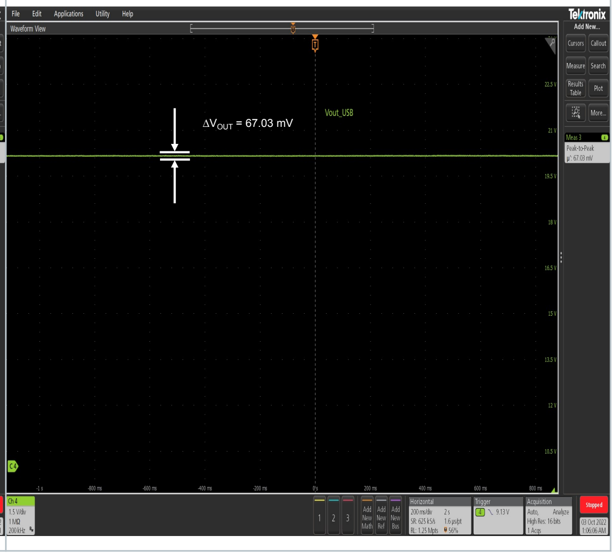


Figure 31. Ripple at 115 V_{AC}, 20 V – 3.25 A

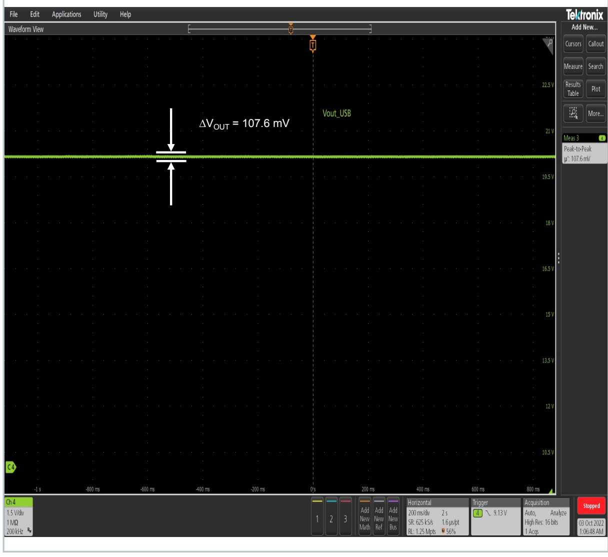


Figure 32. Ripple at 230 V_{AC}, 20 V – 3.25 A

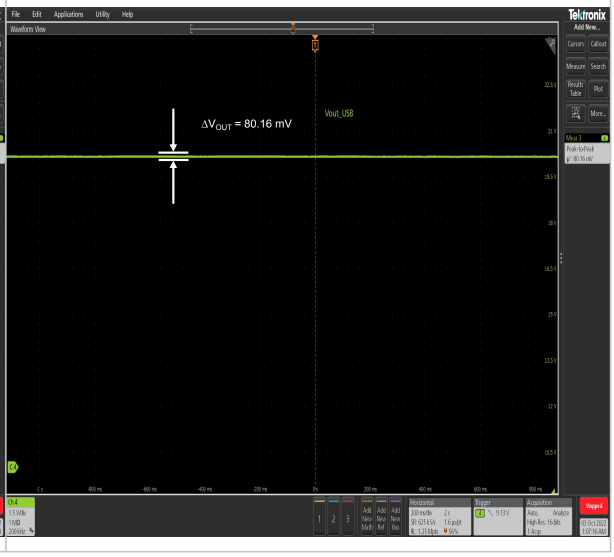


Table 10. Output voltage ripple test results

V_{IN} [V_{AC}]	V_{OUT} (V)	I_{OUT} (A)	Ripple (mV)	Max. ripple (mV) as per USB PD Specification Rev. 3.1
115V_{AC}	5	0	± 89.69	± 250
	5	3	± 68.72	± 250
	9	0	± 71.65	± 450
	9	3	± 59.20	± 450
	12	0	± 56.06	± 600
	12	3	± 62.62	± 600
	15	0	± 63.12	± 750
	15	3	± 75.94	± 750
	20	0	± 60.70	± 1000

V_{IN} [V_{AC}]	V_{OUT} (V)	I_{OUT} (A)	Ripple (mV)	Max. ripple (mV) as per USB PD Specification Rev. 3.1
115V_{AC}	20	3.25	± 107.6	± 1000
230V_{AC}	5	0	± 86.76	± 250
	5	3	± 63.95	± 250
	9	0	± 67.68	± 450
	9	3	± 53.58	± 450
	12	0	± 56.13	± 600
	12	3	± 54.94	± 600
	15	0	± 60.78	± 750
	15	3	± 64.22	± 750
	20	0	± 67.03	± 1000
	20	3.25	± 80.16	± 1000

5.1 Dynamic step load regulation

The following figures show the load transient response when the converter is subjected to repetitive dynamic load transitions from zero to full load at 115 V_{AC} and 230 V_{AC}.

The transition period is 200 ms with a 50% duty cycle and slew rate of 150 mA/µs.

There are no abnormal oscillations in the output voltage and the overshoot and undershoot are within the limits defined by the specification.

Figure 33. Dynamic step load (V_{OUT} = 5 V, I_{OUT} from 0 to 3 A) at 115 V_{AC}

Figure 34. Dynamic step load (V_{OUT} = 5 V, I_{OUT} from 0 to 3 A) at 230 V_{AC}

Figure 35. Dynamic step load (V_{OUT} = 9 V, I_{OUT} from 0 to 3 A) at 115 V_{AC}

Figure 36. Dynamic step load (V_{OUT} = 9 V, I_{OUT} from 0 to 3 A) at 230 V_{AC}

Figure 37. **Dynamic step load (V_{OUT} = 12 V, I_{OUT} from 0 to 3 A) at 115 V_{AC}**

Figure 38. **Dynamic step load (V_{OUT} = 12 V, I_{OUT} from 0 to 3 A) at 230 V_{AC}**

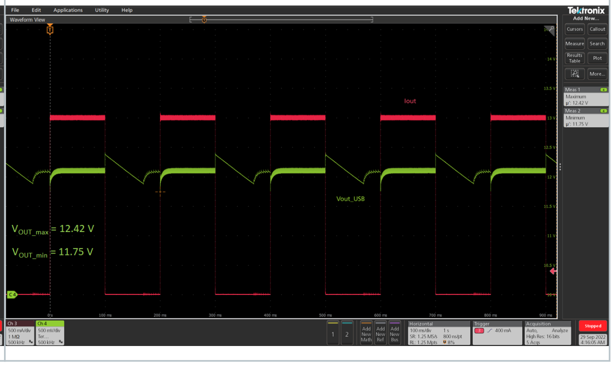


Figure 39. **Dynamic step load (V_{OUT} = 15 V, I_{OUT} from 0 to 3 A) at 115 V_{AC}**

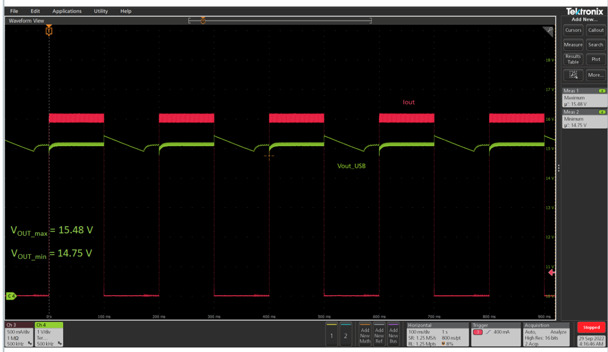


Figure 40. **Dynamic step load (V_{OUT} = 15 V, I_{OUT} from 0 to 3 A) at 230 V_{AC}**

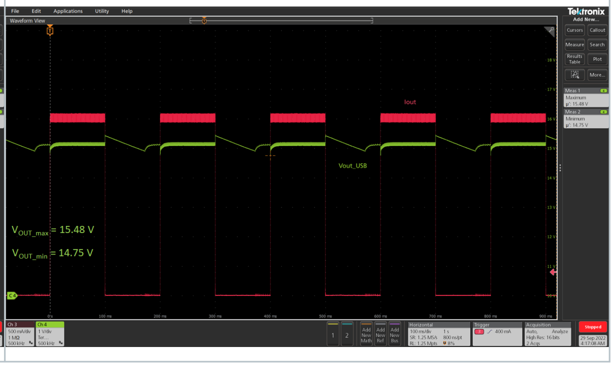


Figure 41. **Dynamic step load (V_{OUT} = 20 V, I_{OUT} from 0 to 3.25 A) at 115 V_{AC}**

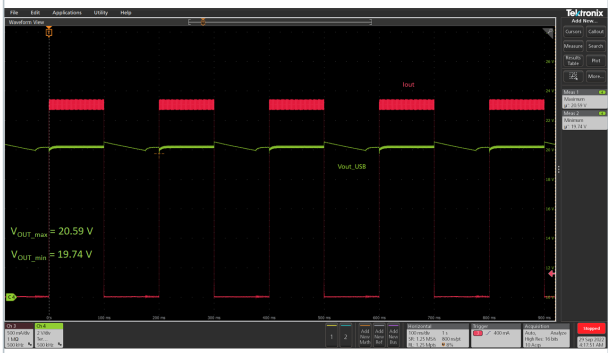
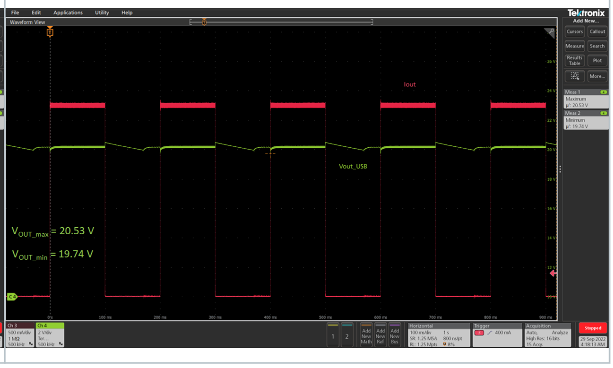


Figure 42. **Dynamic step load (V_{OUT} = 20 V, I_{OUT} from 0 to 3.25 A) at 230 V_{AC}**



6 Conducted noise measurements

The VIPERGAN65 frequency jittering feature allows the spectrum to be spread over frequency bands rather than being concentrated on single frequency value. Especially when measuring conducted emission with the average detection method, the level reduction can be several dBµV.

A pre-compliance test for the EN55022 (Class B) European normative was performed and average measurements of the conducted noise emissions at nominal mains voltages and with output set to 20 V and maximum load (3.25 A) are shown in the following figures.

Figure 43. CE average measurement at 115 V_{AC} (V_{OUT} = 20 V, I_{OUT} = 3.25 A)

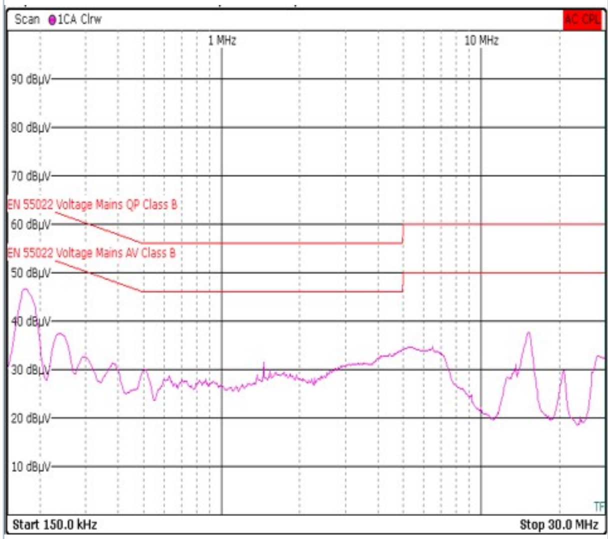
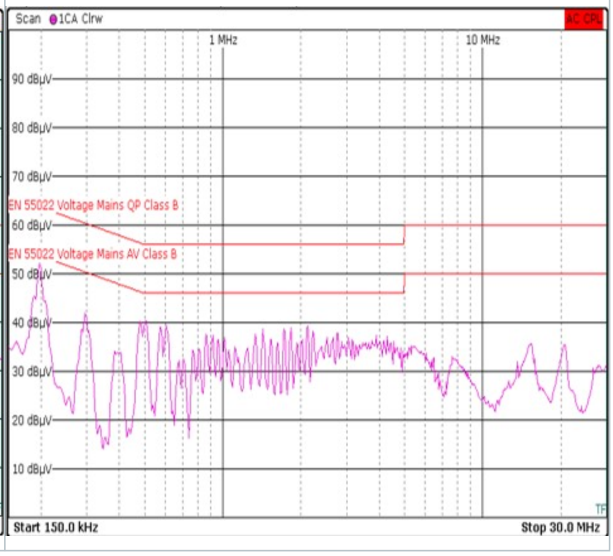


Figure 44. CE average measurement at 230 V_{AC} (V_{OUT} = 20 V, I_{OUT} = 3.25 A)



7 Thermal measurements

A thermal analysis of the board has been performed using an IR image sensor. The test was performed with the output voltage set to 20 V under full load condition for the two nominal input voltages (115 V_{AC} and 230 V_{AC}). The results are shown below.

Figure 45. Thermal map at 115 V_{AC} (20 V – 3.25 A). Bottom layer

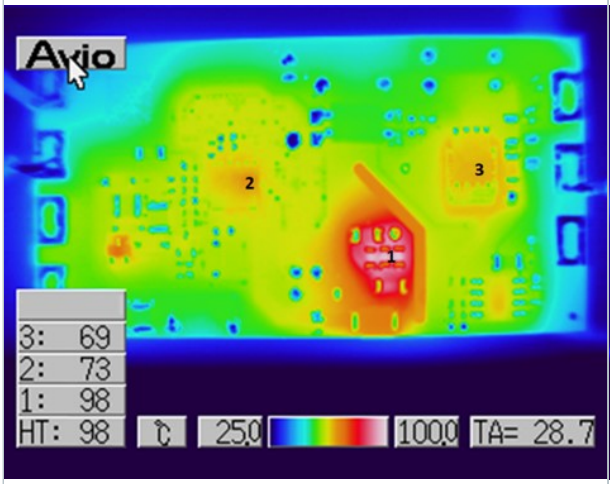


Figure 46. Thermal map at 115 V_{AC} (20 V – 3.25 A). Top layer

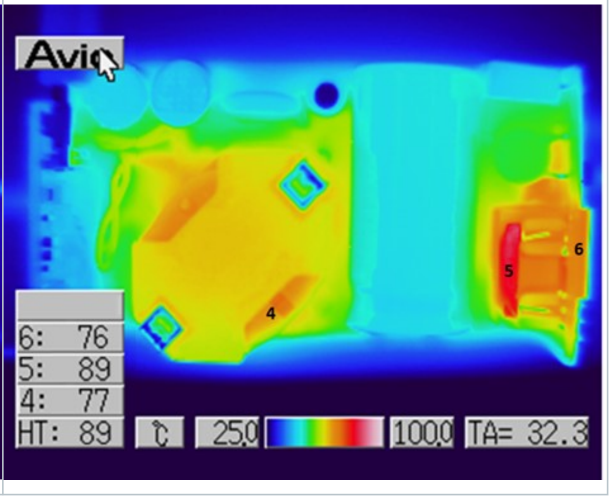


Figure 47. Thermal map at 230 V_{AC} (20 V – 3.25 A). Bottom layer

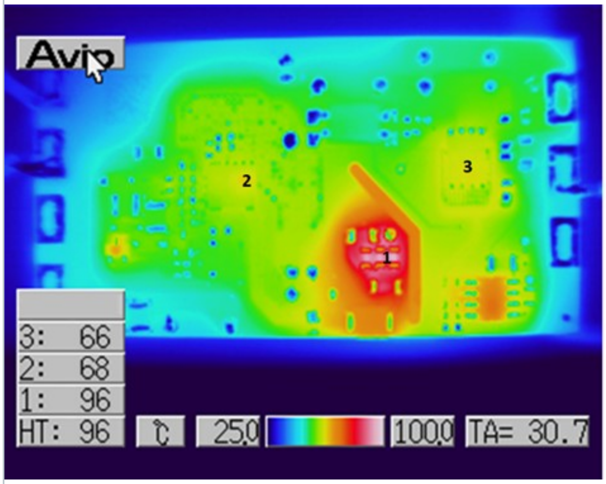


Figure 48. Thermal map at 230 V_{AC} (20 V – 3.25 A). Top layer

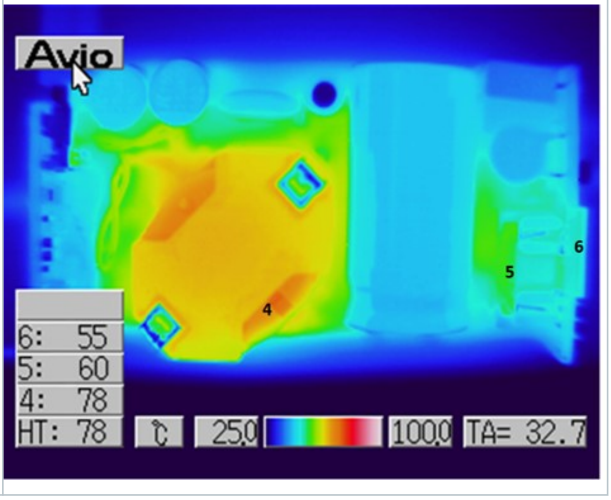


Table 11. Temperature of key components (T_{AMB} = 25°C, emissivity = 0.95 for all points)

Point	Temp (°C)		Reference
	115 V_{AC}	230 V_{AC}	
1	98	96	Snubber resistors
2	73	68	VIPERGAN
3	69	66	SR MOSFET
4	77	78	Transformer
5	89	60	Choke
6	76	55	Bridge diode

8 Conclusions

The test results shown demonstrate the good performances achieved by EVLVIPGAN65PD.

The reference design shows peak efficiency > 93%. It also meets EU CoC Tier 2 and DoE Level 6 efficiency requirements for average efficiency. The quasi-resonant topology helps to minimize the switching losses. The low quiescent current consumption makes it best-in-class no load consumption.

The VIPERGAN65 is an offline quasi-resonant (valley switching at switch turn-on) flyback converter. Depending on the converter's load condition, the device is able to work in different modes. Based on the quasi-resonant, the primary switching losses are minimized. The secondary losses are minimized by using the highly efficient and optimized synchronous rectification controller.

Users no longer need to take care of GaN driving complexity to enjoy the benefits of GaN technology thanks to the highly integrated VIPERGAN65 IC, enhancing the robustness of the application.

Revision history

Table 12. Document revision history

Date	Version	Changes
10-Feb-2023	1	Initial release.

Contents

List of tables

List of figures