AN6474

Application note

EVLVIPGAN50WP - 45W USB PD adaptor reference design with VIPERGAN50W

Introduction

This document reports the functional, thermal, and efficiency measurement results for the EVLVIPGAN50WP 45 W QR mode flyback adaptor reference design for USB Type-C™ PD adaptors. This reference design meets CoC Tier 2 and DoE Level 6 efficiency requirements with peak efficiency of 92.4% at full load.

The evaluation board implements at the primary side a quasi-resonant flyback converter based on the VIPerGaN50W controller with optocoupler feedback for voltage regulation. The main devices used in this reference design are:

VIPerGaN50W: this controller combines a high performance low-voltage PWM controller chip with a 700 V HV startup cell in the same package. The advanced power management with low quiescent helps to achieve low standby consumptions.

SRK1001 and STL110N10F7: to increase the system efficiency, the rectification is based on the SRK1001 adaptive synchronous rectification controller. The SRK1001 drives the gate of the 100 V STripFET F7 technology power MOSFET STL110N10F7.

STUSB4761: this controller offers the benefits of a full hardware USB PD stack allowing robust, deterministic, and safe negotiation in line with the USB PD standard.

The EVLVIPGAN50WP is a fully assembled kit intended for performance evaluation only, not an end product for sale.

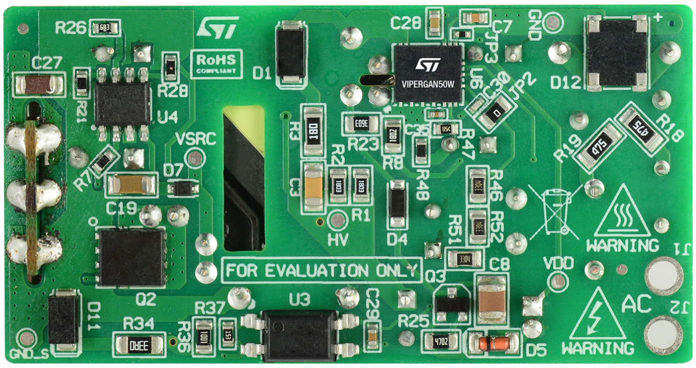
1 Overview

The main features of the EVLVIPGAN50WP 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 2.25 A 45 W max.
- Form factor: 63 mm (L)*32 mm (W)*20 mm (H)
- Efficiency: Meets CoC Tier 2 and DoE Level 6 efficiency requirements, peak efficiency > 92% at 230 V_{AC} 45W
- Quasi-Resonant operations (QR) with dynamic blanking time and adjustable valley synchronization delay functions, to maximize efficiency at any input line and load condition
- Integrated GaN IC VIPerGaN50W results in a compact, simplified PCB layout and bill of material reduction
- Support for USB-PD.

Figure 1. EVLVIPGAN50WP reference design - top

Figure 2. EVLVIPGAN50WP reference design - bottom



2 Specifications

Table 1. **EVLVIPGAN50WP electrical specifications**

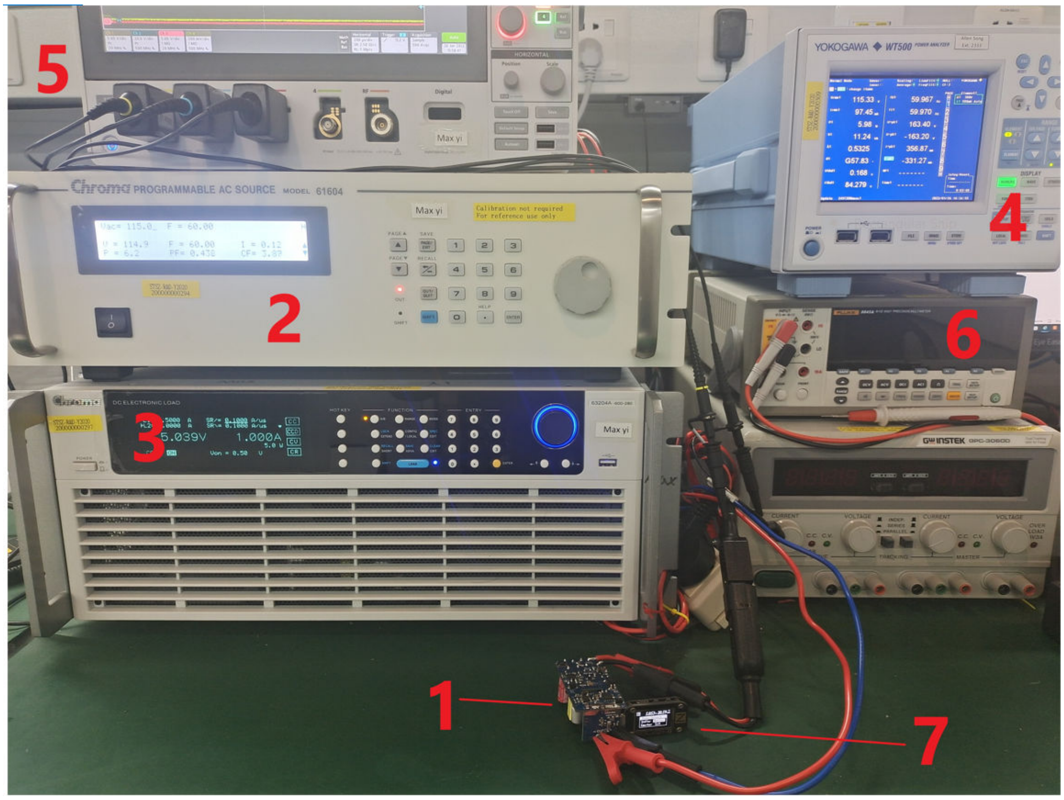
Symbol	Parameter	Test conditions	Min.	Nom.	Max.	Unit
Input parameters						
V_{IN}	Input line voltage		90	115 / 230	264	V_{AC}
f_{LINE}	Input line frequency		47	50 / 60	63	Hz
P_{STBY}	No load input power-5 V_{OUT}			40		mW
P_{STBY}	No load input power-9 V_{OUT}			60		mW
P_{STBY}	No load input power-12 V_{OUT}			80		mW
P_{STBY}	No load input power-15 V_{OUT}			100		mW
P_{STBY}	No load input power-20 V_{OUT}			140		mW
Output parameters-5 V setting						
V_{OUT}	Output voltage	V_{IN} = 90 V_{AC}~264 V_{AC} I_{OUT} = 0 A~3 A		5		V
I_{OUT}	Output current		0		3	A
Output parameters-9 V setting						
V_{OUT}	Output voltage	V_{IN} = 90 V_{AC}~264 V_{AC} I_{OUT} = 0 A~3 A		9		V
I_{OUT}	Output current		0		3	A
Output parameters-12 V setting						
V_{OUT}	Output voltage	V_{IN} = 90 V_{AC}~264 V_{AC} I_{OUT} = 0 A~3 A		12		V
I_{OUT}	Output current		0		3	A
Output parameters-15 V setting						
V_{OUT}	Output voltage	V_{IN} = 90 V_{AC}~264 V_{AC} I_{OUT} = 0 A~3 A		15		V
I_{OUT}	Output current		0		3	A
Output parameters-20 V setting						
V_{OUT}	Output voltage	V_{IN} = 90 V_{AC}~264 V_{AC} I_{OUT} = 0 A~2.25 A		20		V
I_{OUT}	Output current		0		2.25	A
Ambient parameters						
T_{AMB}	Ambient temperature	Free convection	0		40	°C

3 Test setup

3.1 Test conditions and equipment

- 1 x EVLVIPGAN50WP reference design board
- 1 x Chroma programmable AC source 61604A
- 1 x Chroma DC E-load 63204A
- 1 x Power analyzer YOKOGAWA WT500
- 1 x Mixed signal oscilloscope Tektronix MO34
- 1 x FLUKE 8845A 6-1/2 digital precision multimeter
- 1 x POWER-Z KM001, connect to USB Type-C™ output to adjust output voltage
- Ambient temperature = 25 °C.

Figure 3. **EVLVIPGAN50WP test setup**



3.2 Procedure

Description of the steps necessary for the reference design performance test.

Step 1. Connect reference design Type-C output to POWER-Z KM001;

Step 2. Connect the E-load to the reference design output connector;

Step 3. Connect AC source to reference design AC input L/N cables;

Step 4. Power up the reference design with 115 V_{AC} or 230 V_{AC} input to start the test;

Step 5. Adjust the output voltage through POWER-Z KM001;

Step 6. Adjust the output current through the E-load.

4 Measurements / waveforms / test data

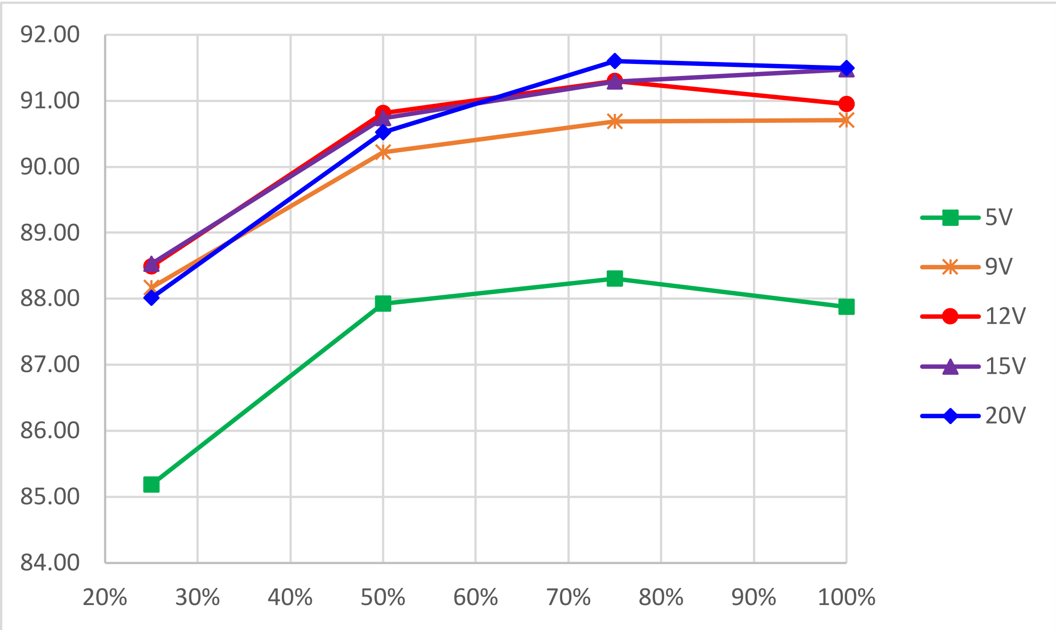
4.1 Efficiency test result

Efficiency at 115 V_{AC} and 230 V_{AC} with different output voltages 5 V/9 V/12 V/15 V/20 V are tested. The result shows that this EVLVIPGAN50WP reference design meets EU CoC Rev.05 tier2 and DoE level 6 requirements with adequate margin.

Efficiency test V_{OUT} sense point at board end.

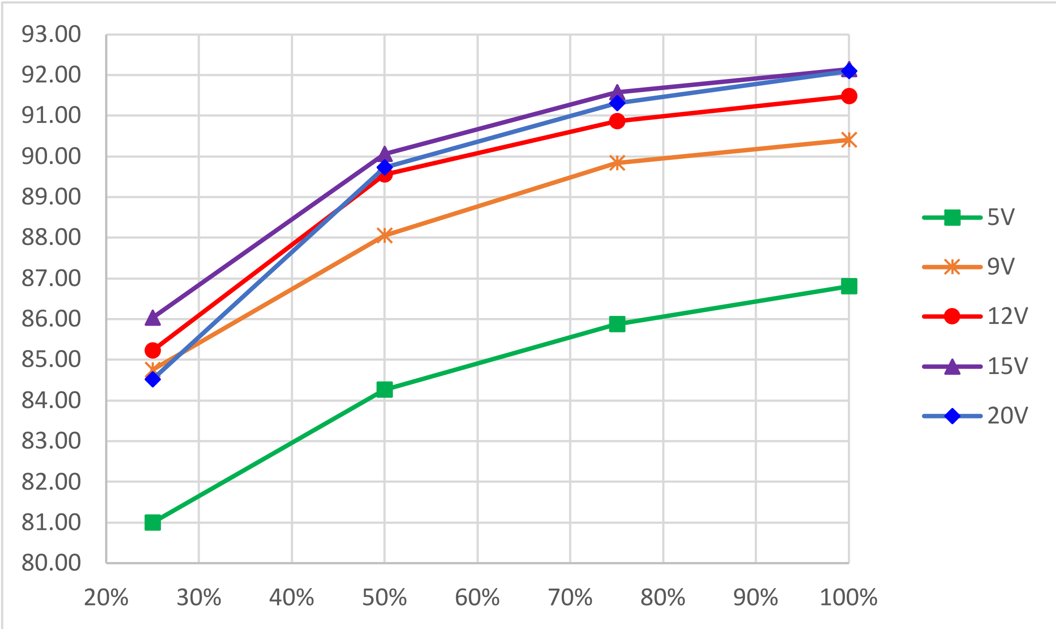
4.1.1 Efficiency at 115 V_{AC} Input

Figure 4. EVLVIPGAN50WP efficiency at 115 V_{AC} input



4.1.2 Efficiency at 230 V_{AC} Input

Figure 5. EVLVIPGAN50WP efficiency at 230 V_{AC} input



4.2 Load and line regulation test result

Figure 6. Load and line regulation at 115 V_{AC}

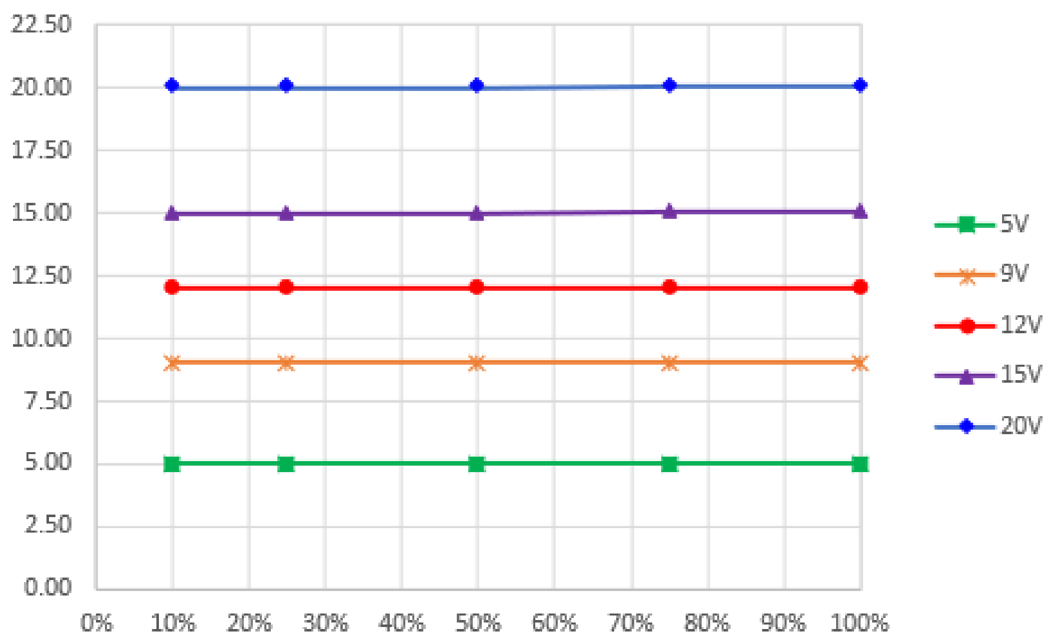
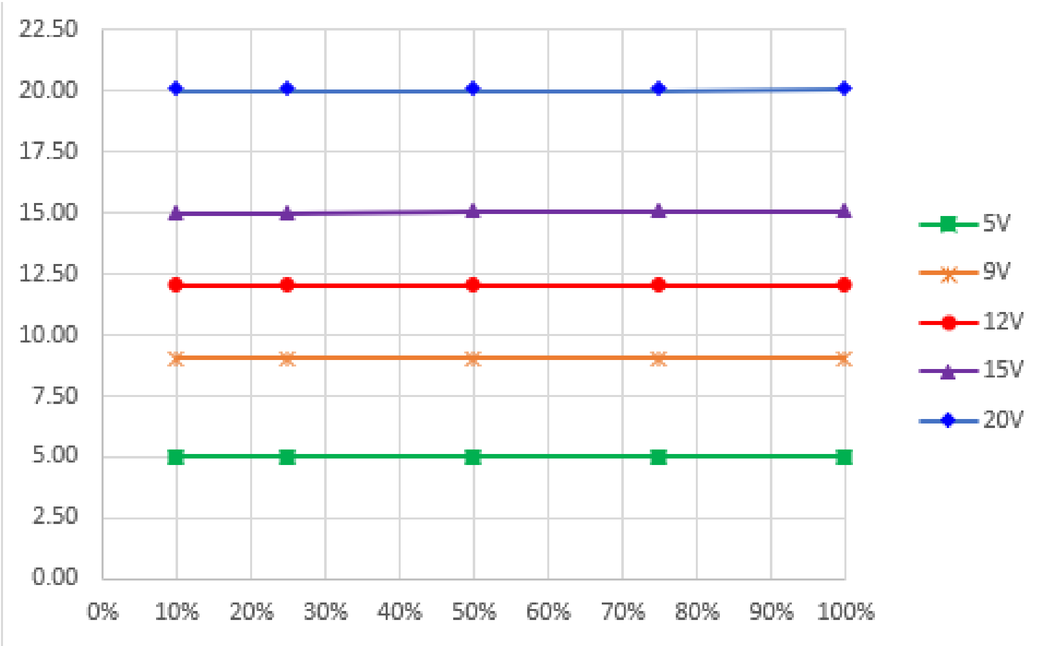


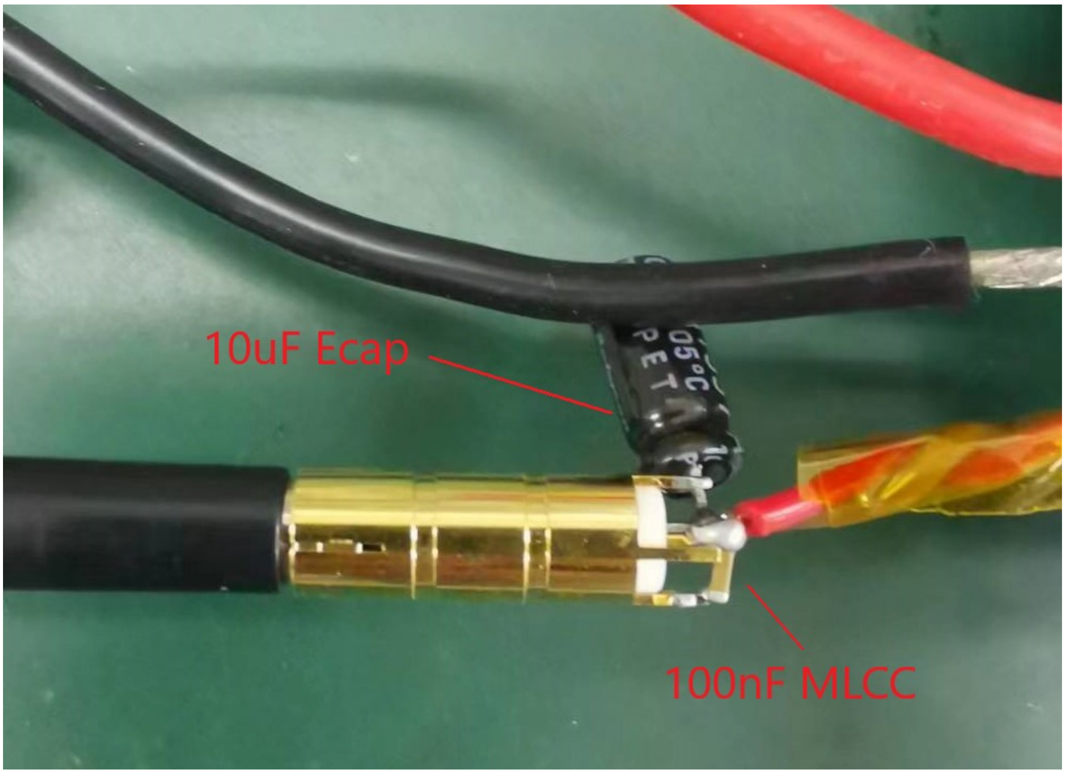
Figure 7. Load and line regulation at 230 V_{AC}



4.3 Ripple & noise

4.3.1 V_{OUT} ripple & noise test setup: test at end of the USB Type-C™ cable

Figure 8. Ripple & noise test setup probe 10 µF E-cap + 100 nF ceramic cap added



4.3.2 Ripple & noise results

Figure 9. Ripple & noise at 115 V_{AC} input 5 V_{OUT} / 3 A $V_{PK\text{-}PK}$ = 68 mV

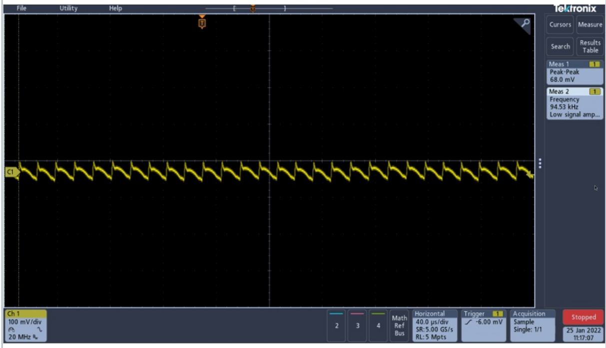


Figure 10. Ripple & noise at 115 V_{AC} input 5 V_{OUT} / 3 A $V_{PK\text{-}PK}$ = 68 mV (nr.2)

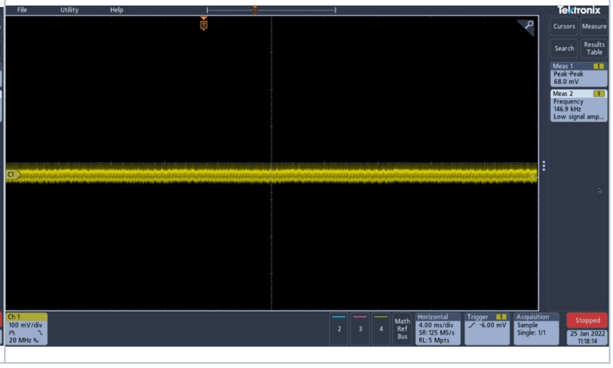


Figure 11. Ripple & noise at 230 V_{AC} input 5 V_{OUT} / 3 A $V_{PK\text{-}PK}$ = 64 mV

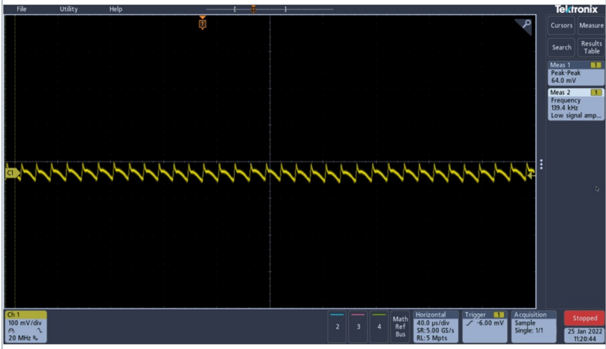


Figure 12. Ripple & noise at 230 V_{AC} input 5 V_{OUT} / 3 A $V_{PK\text{-}PK}$ = 64 mV (nr. 2)

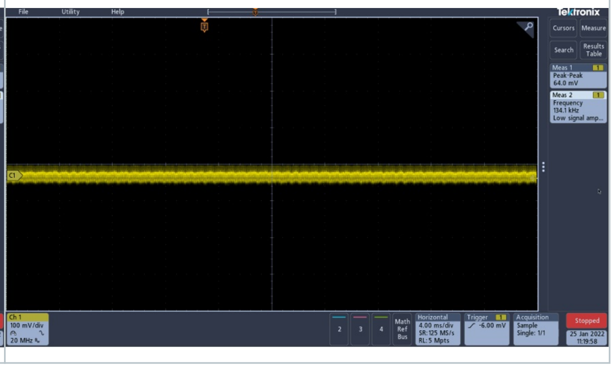


Figure 13. Ripple & noise at 115 V_{AC} input 9 V_{OUT} / 3 A $V_{PK\text{-}PK}$ = 88 mV

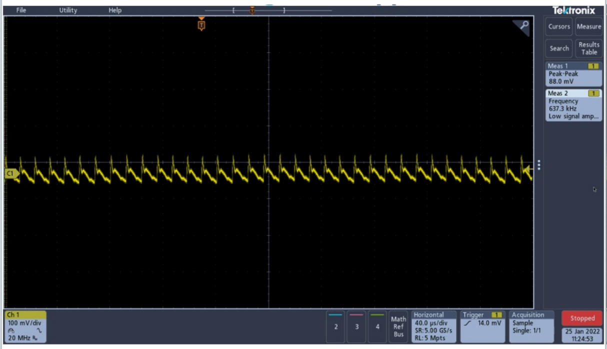


Figure 14. Ripple & noise at 115 V_{AC} input 9 V_{OUT} / 3 A $V_{PK\text{-}PK}$ = 88 mV (nr. 2)

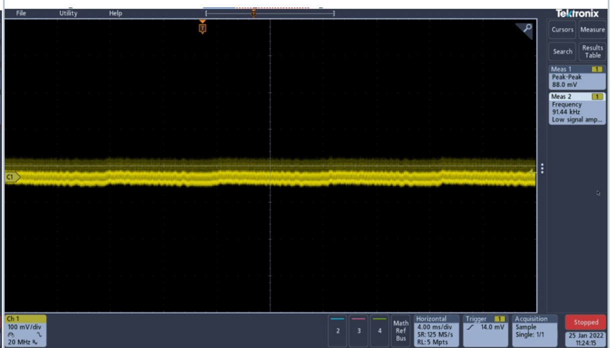


Figure 15. Ripple & noise at 230 V_{AC} input 9 V_{OUT} / 3 A V_{PK-PK} = 76 mV

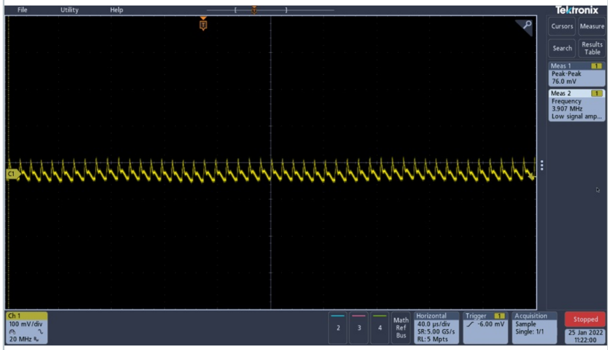


Figure 16. Ripple & noise at 230 V_{AC} input 9 V_{OUT} / 3 A V_{PK-PK} = 76 mV (nr. 2)

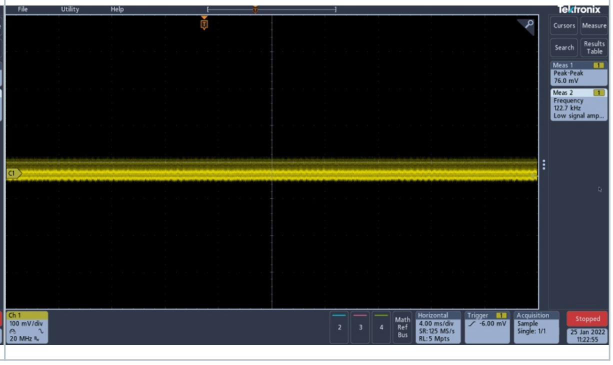


Figure 17. Ripple & noise at 115 V_{AC} input 12 V_{OUT} / 3 A V_{PK-PK} = 112 mV

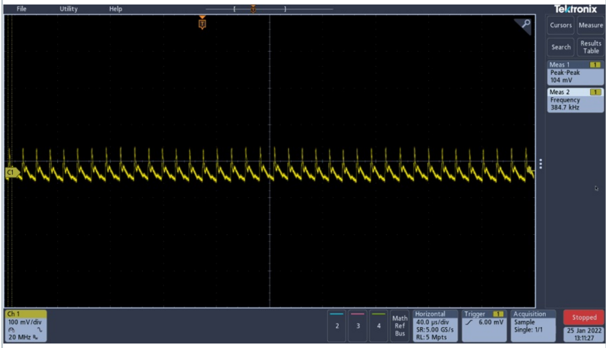


Figure 18. Ripple & noise at 115 V_{AC} input 12 V_{OUT} / 3 A V_{PK-PK} = 112 mV (nr. 2)

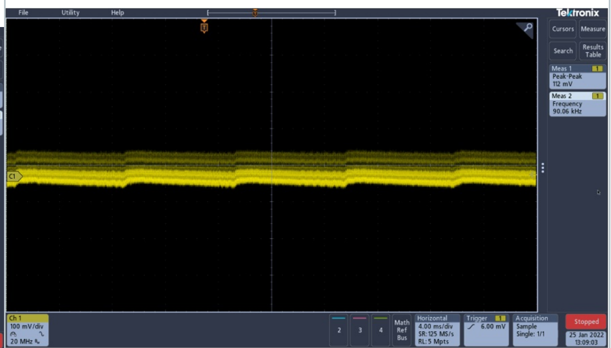


Figure 19. Ripple & noise at 230 V_{AC} input 12 V_{OUT} / 3 A V_{PK-PK} = 84 mV

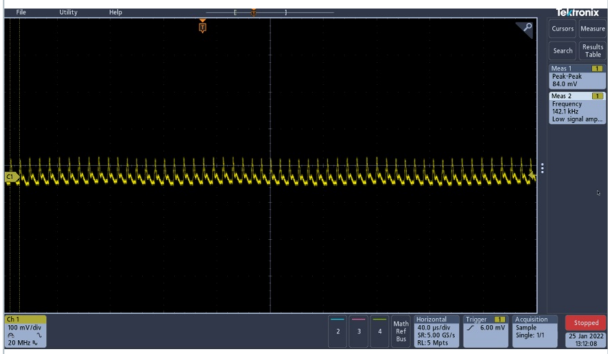
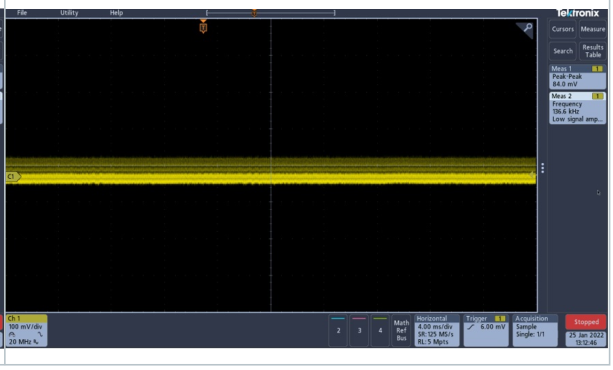


Figure 20. Ripple & noise at 230 V_{AC} input 12 V_{OUT} / 3 A V_{PK-PK} = 84 mV (nr. 2)



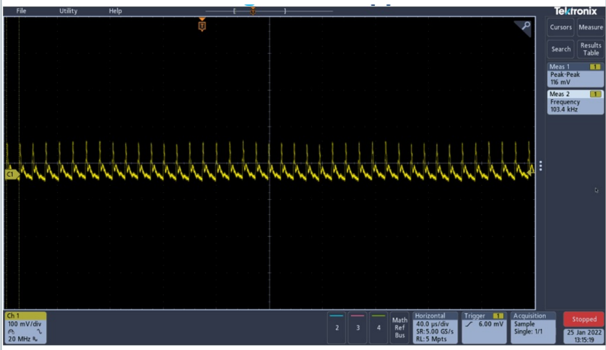


Figure 21. Ripple & noise at 115 V_{AC} input 15 V_{OUT} / 3 A $V_{PK\text{-}PK}$ = 132 mV

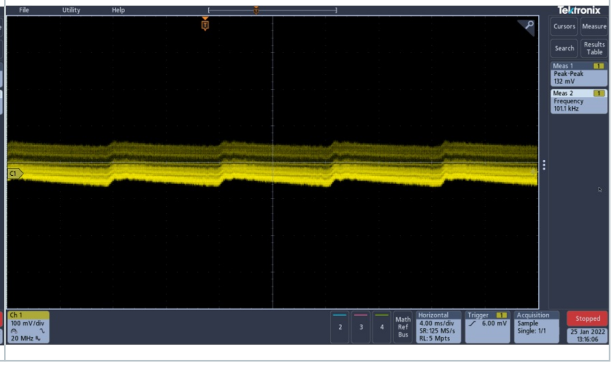


Figure 22. Ripple & noise at 115 V_{AC} input 15 V_{OUT} / 3 A $V_{PK\text{-}PK}$ = 132 mV (nr. 2)

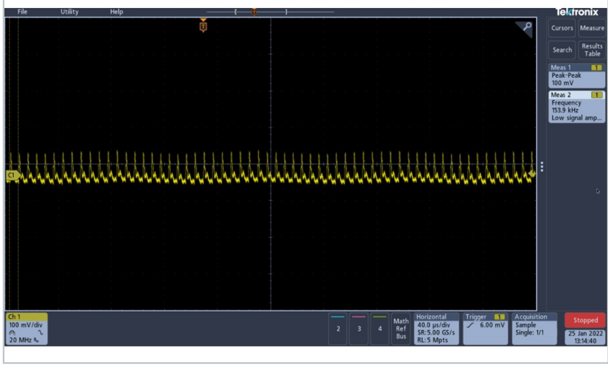


Figure 23. Ripple & noise at 230 V_{AC} input 15 V_{OUT} / 3 A $V_{PK\text{-}PK}$ = 100 mV

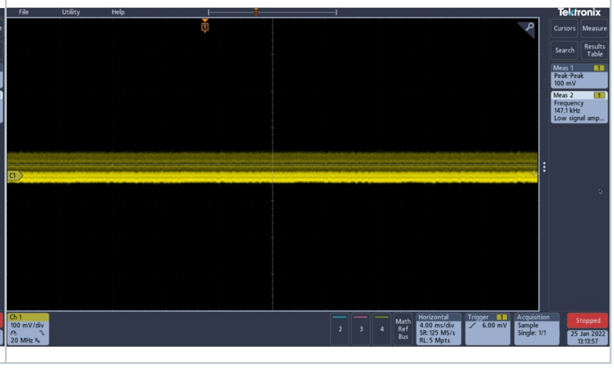


Figure 24. Ripple & noise at 230 V_{AC} input 15 V_{OUT} / 3 A $V_{PK\text{-}PK}$ = 100 mV (nr. 2)

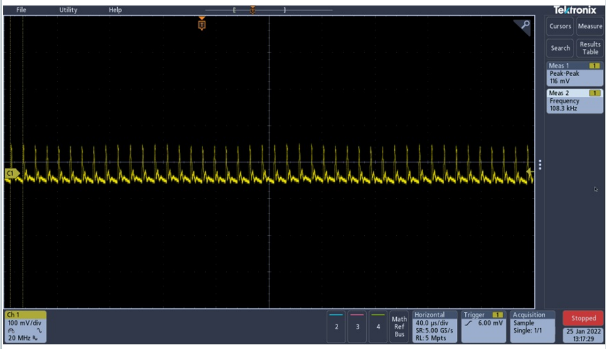


Figure 25. Ripple & noise at 115 V_{AC} input 20 V_{OUT} / 2.25 A $V_{PK\text{-}PK}$ = 124 mV

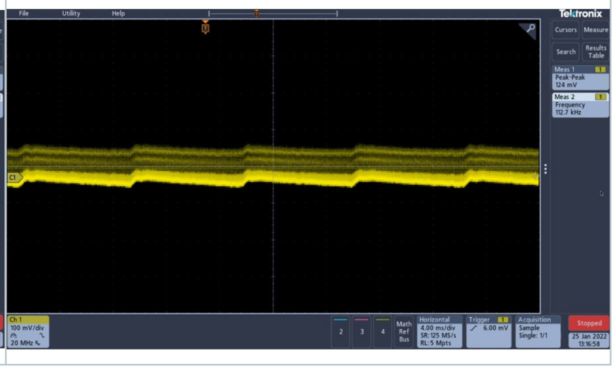


Figure 26. Ripple & noise at 115 V_{AC} input 20 V_{OUT} / 2.25 A $V_{PK\text{-}PK}$ = 124 mV (nr. 2)

Figure 27. Ripple & noise at 230 V_{AC} input 20 V_{OUT} / 2.25 A V_{PK-PK} = 100 mV

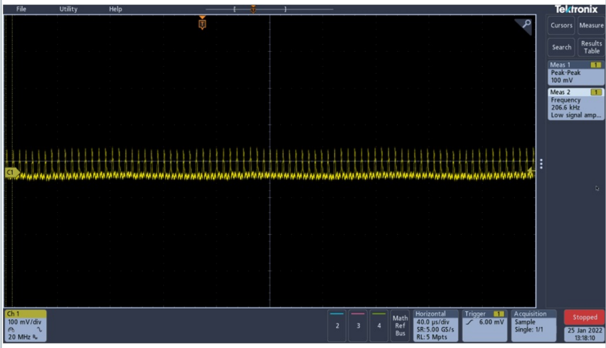
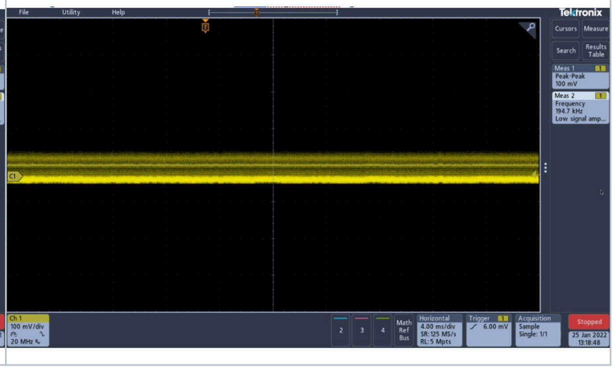


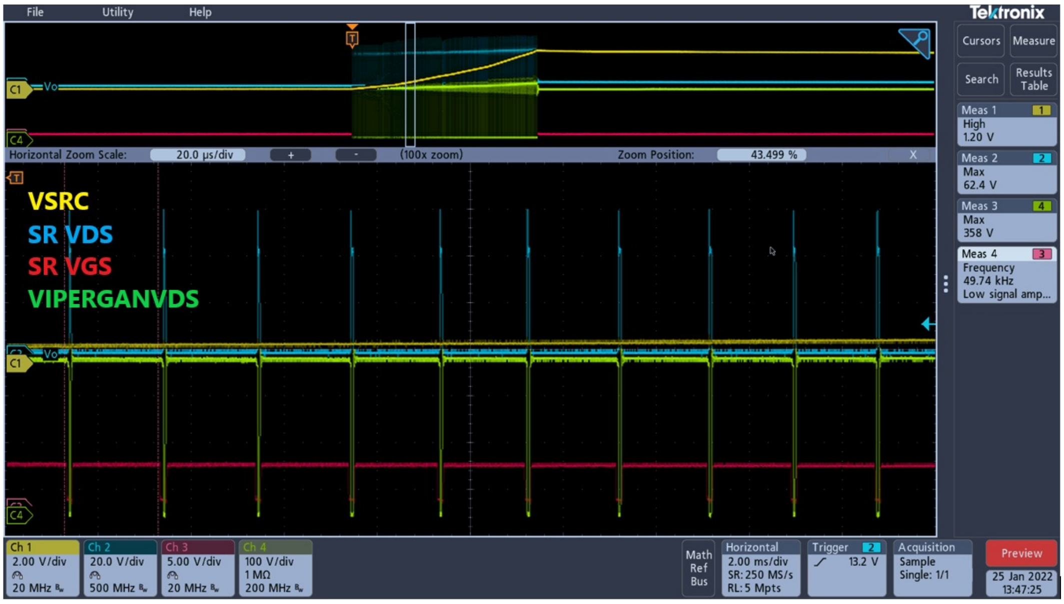
Figure 28. Ripple & noise at 230 V_{AC} input 20 V_{OUT} / 2.25 A V_{PK-PK} = 100 mV (nr. 2)



4.4 Typical waveforms

4.4.1 Startup waveform

Figure 29. Startup waveform



4.4.2 Normal operation waveforms

Figure 30. Primary side typical waveforms-normal operation with 230 V_{AC} 20 V / 0.67 A

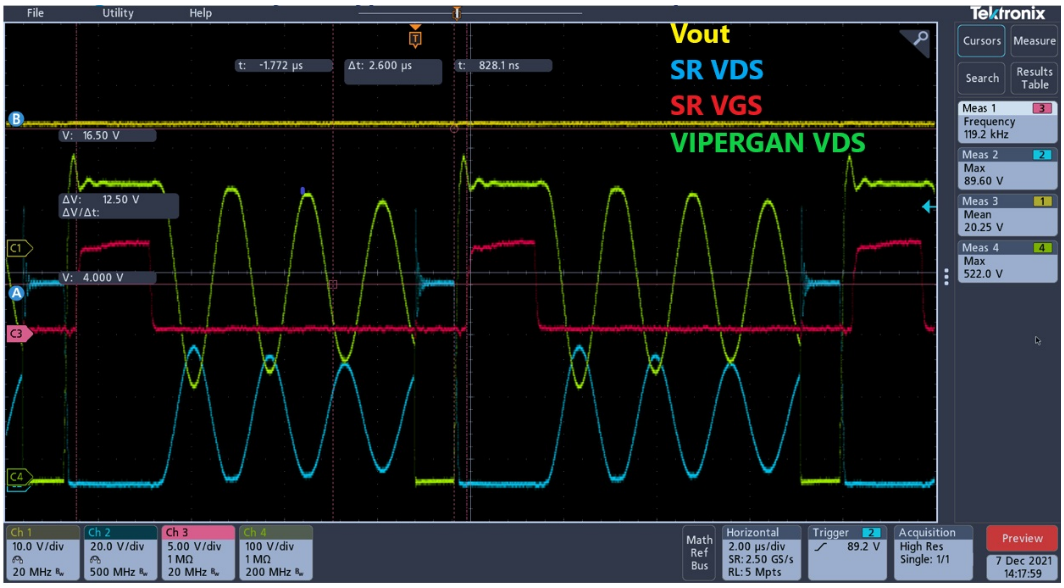
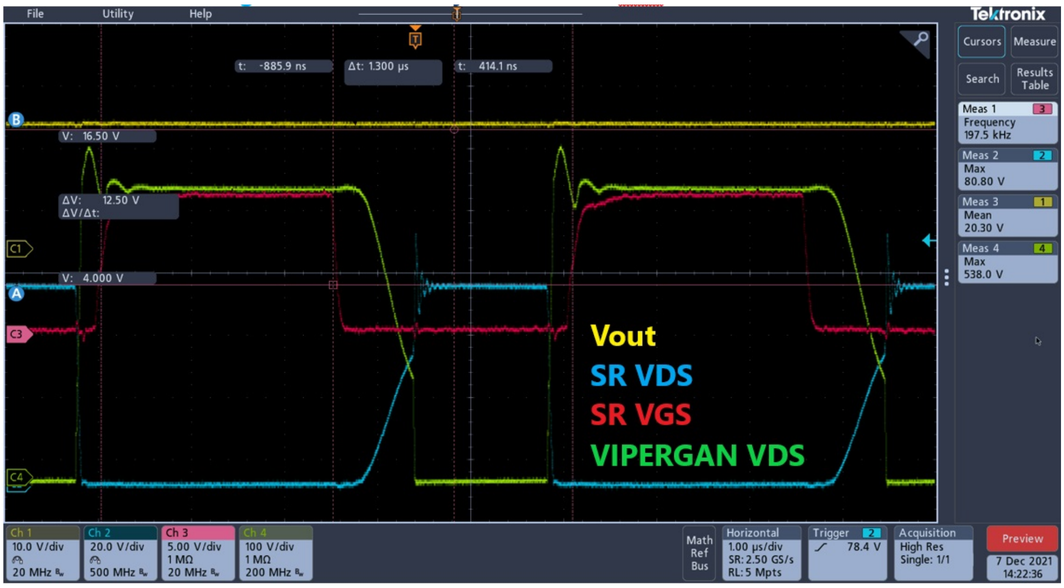


Figure 31. Secondary SR MOSFET V_{DS} at 20 V / 2.25 A



4.4.3 Typical waveforms-normal operation/valley skipping mode/burst mode

In order to improve the efficiency at medium/heavy load, the controller enters valley skipping mode.

While the load is extremely light or disconnected, the converter enters a controlled on/off operation with constant peak current, the system enters burst mode.

Figure 32. **Work in different operation mode: normal operation mode**

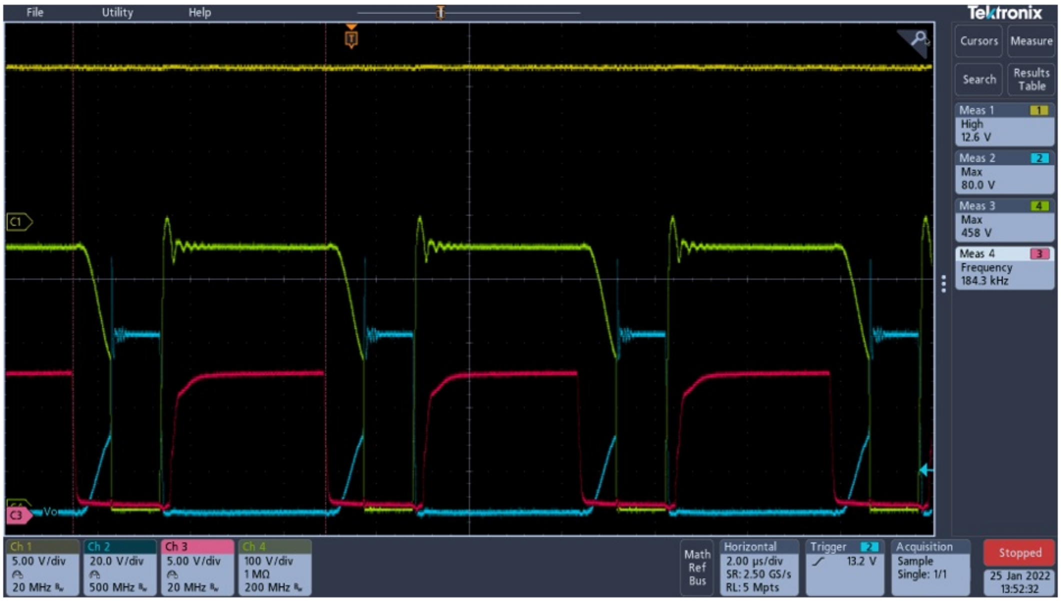
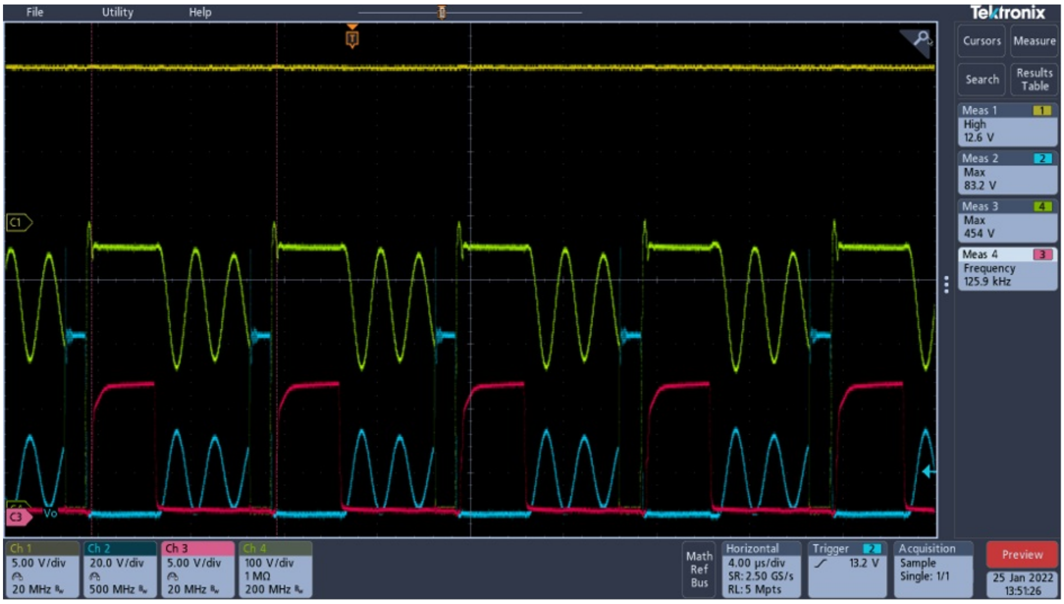


Figure 33. **Work in different operation mode: valley skipping mode**



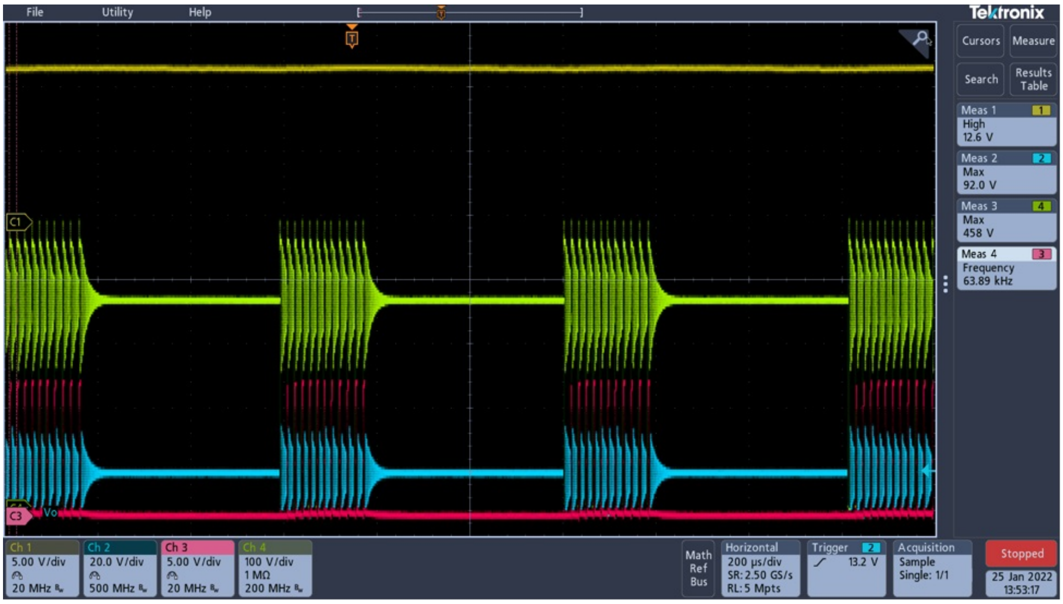


Figure 34. Work in different operation mode: burst mode

4.5 Thermal performance

Table 2. Key components temperature at 20 V / 2.25 A, T_{AMB} = 25 °C

	115 V_{AC}	230 V_{AC}
	Max. Temp.	Max. Temp.
VIPerGaN50W	68.2	69.1
Bridge diode	85	64.9
Transformer	68	78.1
SR MOS	59.3	65.6
SR controller	62.7	69.5
Primary snubber	71.3	78

Figure 35. Key components thermal at 20 V / 2.25 A: 115 V_{AC} input, top

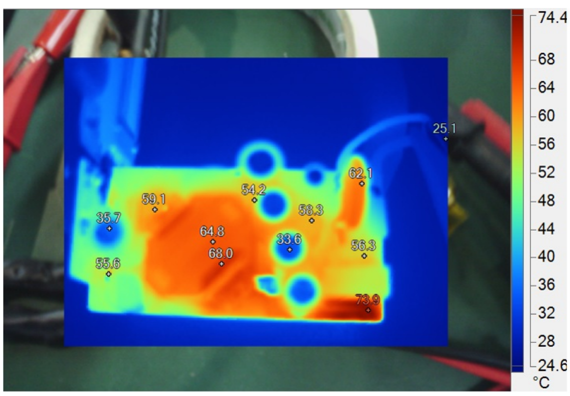


Figure 36. Key components thermal at 20 V / 2.25 A: 230 V_{AC} input, top

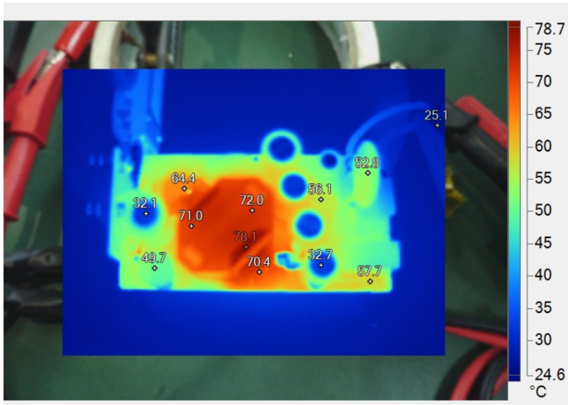


Figure 37. **Key components thermal at 20 V / 2.25 A: 115 V_{AC} input, bottom**

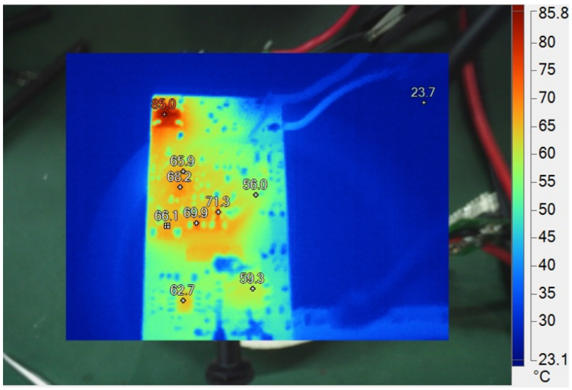
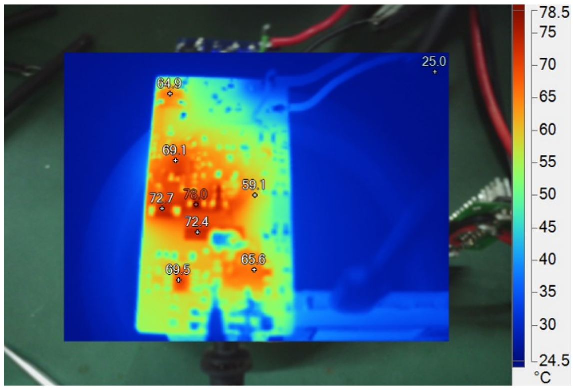


Figure 38. **Key components thermal at 20 V / 2.25 A: 230 V_{AC} input, bottom**



5 Schematic diagrams

Figure 39. Motherboard circuit schematic

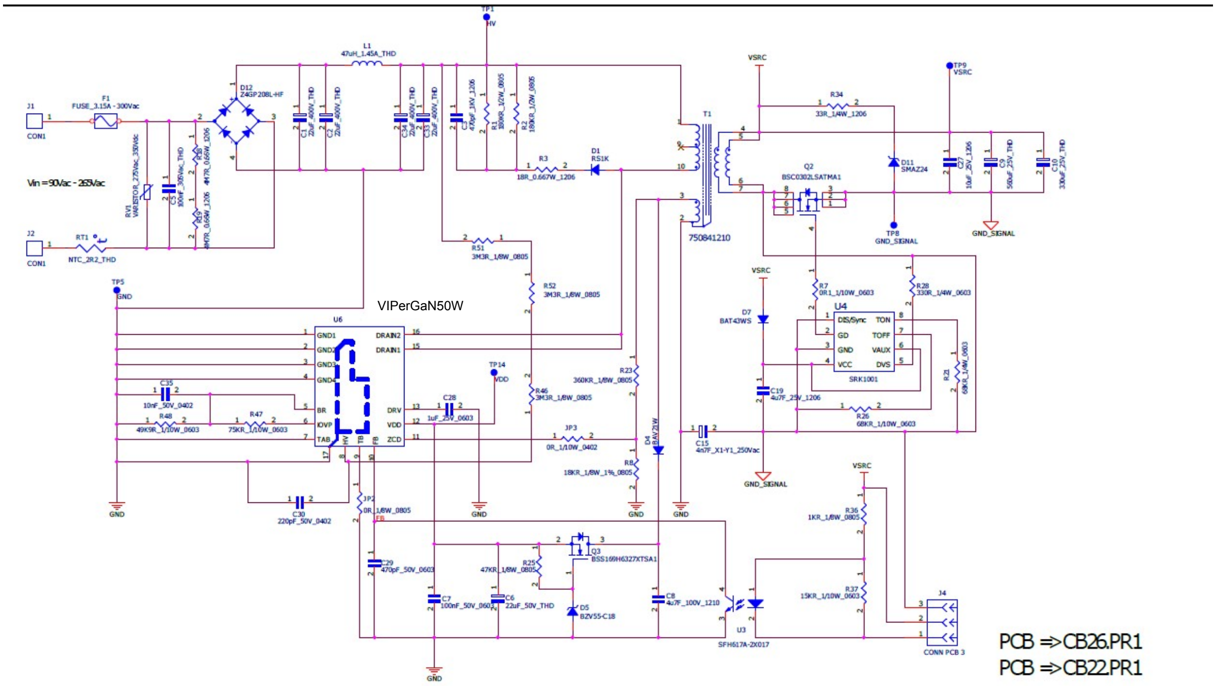
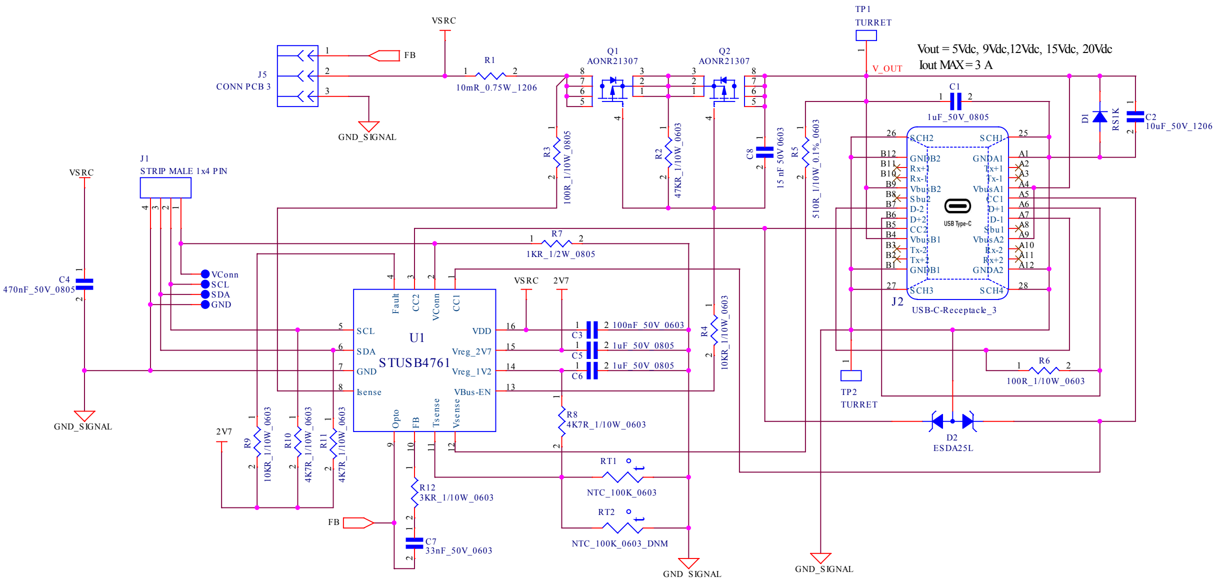


Figure 40. Daughterboard circuit schematic



6 Bill of materials

Table 3. Bill of materials of the reference design - motherboard

Ref.	Part/Value	Description	Manufacture	Order code
C1	22 µF-400 V	ELCap	Wurth Elektronik	860021374027
C2	22 µF-400 V	ELCap	Wurth Elektronik	860021374027
C3	470 pF 10% 1 KV	MLCC	Murata	GRM31BR73A471KW01L
C5	100 nF 20% 305 V_{AC}	Polypropylene X2 capacitor	TDK	B32921C3104M189
C6	22 µF 50 V	ELCap	Rubycon	50YXM22MEFR5X11
C7	100 nF 10% 50 V	MLCC capacitor	Kemet	C0603C104K5RACTU
C8	4.7 µF 10% 100 V	MLCC	AVX	12101C475K4T2A
C9	560 µF-25 V	Solid polymer aluminum capacitors	Kemet	A750MS567M1EAAE015
C10	330 µF-25 V	Solid polymer aluminum capacitors	Kemet	A750KS337M1EAAE018
C15	4.7 nF	Y1 safety ceramic disc capacitors	Murata	DE1E3RA472MA4BN01F
C18	Not connected			
C19	4.7 µF 5% 25 V	MLCC	Murata	GCG31CR71E475JA01L
C27	10 µF 5% 25 V	MLCC	Kemet	C1206C106J3RACAUTO
C28	1 µF 10% 25 V	MLCC	Samsung	CL10A105KA8NNNC
C29	470 pF 5% 50 V	MLCC	Kemet	C0603C471J5RACTU
C30	220 pF 5% 50 V	MLCC	Valsin	0402N221J500CT
C33	22 µF-400 V	ELCap	Wurth Elektronik	860021374027
C34	22 µF-400 V	ELCap	Wurth Elektronik	860021374027
C35	10 nF 10% 50 V	MLCC	Kemet	C0402C103K5REC7411
D2	1 A - 800 V	Fast switching rectifier	VISHAY	RS1K
D4	200 mA - 200 V	Switching diode	Diodes	BAV21W
D5	18 V - 500 mW	Zener diode	Nexperia	BZV55-C18
D7	200 mA - 30 V	Schottky diode	Diodes	BAT43WS
D11	24 V - 1 W	Zener diode	Diodes	SMAZ24
D12	800 V - 2 A	BRIDGE RECT	COMCHIP	Z4GP208L-HF
F1	300 V_{AC} - 3.15 A	Fuse	Copper Bussmann	SS-5H-3-15A-BK
JP2	0 Ω	Resistors	Yageo	RC0805JR-070RL
JP3	0 Ω	Resistors	Yageo	RC0402JR-070RL
L1	47 µH 1.45 A	Power choke	Wurth Elektronik	7447790470
Q2	120 V - 6.5 mΩ	N-channel power MOSFET	Infineon	BSC0302LSATMA1
Q3	100 V 12 Ω	N-channel MOSFET	Infineon	BSS169H6327XTSA1
R1	180 kΩ ± 5% - 0.5 W	Resistors	Panasonic	ERJ-P06D1803V
R2	180 kΩ ± 5% - 0.5 W	Resistors	Panasonic	ERJ-P06D1803V
R3	18 Ω ± 5% - 0.66 W	Resistors	Panasonic	ERJP08J180V
R7	0 Ω	Resistors	Vishay	CRCW06030000JKEA

Ref.	Part/Value	Description	Manufacture	Order code
R8	18 kΩ ± 1% - 0.125 W	Resistors	Yageo	AC0805FR-0718KL
R18	4.7 MΩ ± 5% - 0.66 W - 500 V	Resistors	Panasonic	ERJ-P08J475V
R19	4.7 MΩ ± 5% - 0.66 W - 500 V	Resistors	Panasonic	ERJ-P08J475V
R21	68 kΩ ± 1% - 0.25 W	Resistors	Vishay	RCS060368K0FKEA
R22	Not connected			
R23	360 kΩ ± 1% - 125 mW	Resistors	Yageo	RC0805FR-07360KL
R25	47 kΩ ± 1% - 125 mW	Resistors	Yageo	RC0805FR-0747KL
R26	68 kΩ ± 1% - 100 mW	Resistors	Yageo	RC0603FR-0768KL
R34	33 Ω ± 1% - 250 mW	Resistors	Yageo	RC1206FR-0733RL
R36	1 kΩ ± 1% - 125 mW	Resistors	Yageo	RC0805FR-071KL
R37	15 kΩ ± 5% - 100 mW	Resistors	Vishay	CRCW060315K0JNEAC
R46	3.3 MΩ ± 5% - 125 mW - 500 V	Resistors	ROHM Semi	KTR10EZPF3304
R47	75 kΩ ± 1% - 100 mW	Resistors	Burns	CR0603-FX-7502ELF
R48	49.9 kΩ ± 1% - 100 mW	Resistors	Vishay	RCG060349K9FKEA
R51	3.3 MΩ ± 5% - 125 mW - 500V	Resistors	ROHM Semi	KTR10EZPF3304
R52	3.3 MΩ ± 5% - 125 mW - 500 V	Resistors	ROHM Semi	KTR10EZPF3304
RT1	2.2 Ω	Inrush limiter	Epcos	B57237S0229M000
RV1	275 V_{AC}	Disk varistor	Epcos	B72210S0271K101
T1		Flyback transformer	Wurth Elektronik	750841210
U3	70 V - 100 mA	Optocoupler	Vishay	SFH617A-2X017
U4		Synchronous rectification controller	STMicroelectronics	SRK1001
U6		HV converter	STMicroelectronics	VIPerGaN50W

Table 4. Bill of materials of the reference design - daughterboard

Ref.	Part/Value	Description	Manufacture	Order code
C1	1 µF - 50 V	MLCC capacitor	Kemet	C0805C105J4RACTU
C2	10 µF 5% 25 V	MLCC capacitor	Kemet	C1206C106J3RACAUTO
C3	100 nF 10% 50 V	MLCC capacitor	Kemet	C0603C104K5RACTU
C4	470 nF 10% 50 V	MLCC capacitor	AVX	08055C474K4T2A
C5	1 µF - 50 V	MLCC capacitor	Kemet	C0805C105J4RACTU
C6	1 µF - 50 V	MLCC capacitor	Kemet	C0805C105J4RACTU
C7	33 nF 10% 50 V	MLCC capacitor	Samsung	CL10B333KB8NNND
C8	15 nF 10% 50 V	MLCC capacitor	Kemet	C0603C153K5RACTU
D1	RS1K 1 A - 800 V	Fast switching rectifier	Vishay	RS1K
D2	1.2 V - 10 mA	Dual transil array for ESD protection	STMicroelectronics	ESDA25L
J2	USB-C-MOLEX	Connector USB 3.1, type C	MOLEX	201267-0005
Q1	30 V 4.6 mΩ	P-CHANNEL ENHANCEMENT MOSFET	Vishay	SISS65DN-T1-GE3
Q2	30 V 4.6 mΩ	P-CHANNEL ENHANCEMENT MOSFET	Vishay	SISS65DN-T1-GE3
R1	10 mΩ ± 1% - 0.75 W	Metal foil low resistance chip resistors	Susumu	KRL1632E-C-R010-F-T1
R2	47 kΩ 5%	Resistors	Vishay	CRCW060347K0JKEA
R3	100 Ω 1%	Resistors	Panasonic	ERJP06F1000V
R4	10 kΩ 5%	Resistors	Vishay	CRCW060310K0JKEA
R5	510 Ω 1%	Resistors	Yageo	RC0603FR-07510RL
R6	100 Ω 1%	Resistors	Yageo	RC0603FR-07100RL
R7	0 Ω	Resistors	Vishay	CRCW08050000JKEA
R8	4.7 kΩ 5%	Resistors	Vishay	CRCW06034K70JKEA
R9	10 kΩ 5%	Resistors	Vishay	CRCW060310K0JKEA
R10	4.7 kΩ 5%	Resistors	Vishay	CRCW06034K70JKEA
R11	4.7 kΩ 5%	Resistors	Vishay	CRCW06034K70JKEA
R12	3 kΩ 5%	Resistors	Vishay	CRCW06033K0JKEA
RT1	NTC 100kΩ 1%	Thermal resistors	Ohmite	TX06F104F4100ER
TP1,TP2	TURRET	Test point	Mill_Max	2501-2-00-80-00-00-07-0

7 Conclusions

The test results shown demonstrate the good performances achieved by the EVLVIPGAN50WP.

The reference design shows peak efficiency > 92%, a clear advantage, which was well appreciated. It also meets CoC Tier 2 and DoE Level 6 efficiency requirements for average efficiency. The quasi-resonant topology helps with the low switching losses. The low quiescent current consumption makes it best in class no-load consumption.

The VIPerGaN50W 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 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 VIPerGaN50W IC, enhancing the robustness of the application. The controller is optimized for high frequency driver optimized for GaN for fast, effective and layout simplifications.

All the above features result in smaller power loss and good thermal performance.

Appendix A Reference design warnings, restrictions and disclaimer

Important: *The reference design is not a complete product. It is intended exclusively for evaluation in laboratory/ development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical/mechanical components, systems and subsystems.*

Danger: *Exceeding the specified reference design ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings, contact an STMicroelectronics field representative prior to connecting interface electronics, including input power and intended loads. Any loads applied outside of the specified output range may result in unintended and/or inaccurate operation and/or possible permanent damage to the reference design and/orinterface electronics. During normal operation, some circuit components may reach very high temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified in the reference design schematic diagrams.*

STMicroelectronics reference designs are solely intended to assist designers ("buyers") who are developing systems that incorporate STMicroelectronics semiconductor products (herein, also referred to as "components").

The buyer understands and agrees that he/she is the only responsible for independent analysis, evaluation and judgment in designing his/her own systems and products. STMicroelectronics has conducted only the

measurements and tests specifically described in the published documentation for the specified reference design. STMicroelectronics may correct, enhance, improve its reference designs for future development.

STMicroelectronics reference designs are provided "as is". STMicroelectronics does not promise that reference designs are accurate or error free. STMicroelectronics makes no warranties or representations with regard to the reference designs or use of the reference designs, express, implied or statutory, and specifically disclaims all warranties, express or implied, as to the accuracy or completeness of the information contained therein.

STMicroelectronics disclaims any warranty of title and any implied warranties of merchantability, fitness for a particular purpose and non-infringement of any third-party intellectual property rights concerning STMicroelectronics reference designs or their use. STMicroelectronics shall not be liable for and shall not

defend or indemnify buyers against third-party infringement claim that relates to or is based on a combination of components provided in an STMicroelectronics reference design.

In no event shall STMicroelectronics be liable for any actual, special, incidental, consequential or indirect damages, however caused, on any theory of liability and whether or not STMicroelectronics has been advised of the possibility of such damages, arising in any way out of STMicroelectronics reference designs or buyer's use of STMicroelectronics reference designs.

You further acknowledge and agree that the reference designs may not be used in or in connection with any legal or administrative proceeding in any court, arbitration, agency, commission or other tribunal or in connection with any action, cause of action, litigation, claim, allegation, demand or dispute of any kind.

Revision history

Table 5. **Document revision history**

Date	Version	Changes
19-Mar-2026	1	Initial release.

Contents

List of tables

List of figures