

UCG28828, 120W QR Flyback Converter with Integrated GaN Evaluation Module



Description

The UCG28828 evaluation module (EVM) enables designers to evaluate the operation and performance of the UCG28828 aux-less QR-flyback controller. This evaluation module demonstrates how the UCG28828 drives a quasi-resonant flyback converter to achieve high efficiency throughout the load and the universal line input.

Get Started

1. Read and study this user's guide completely before evaluating.
2. Order the [UCG28828EVM-094](#) for evaluation if step 1 met.
3. Setup and test the [UCG28828EVM-094](#) per user's guide instruction.

Features

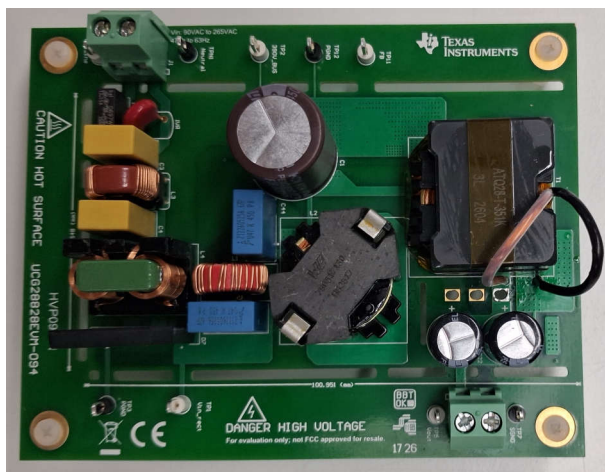
- Integrated 750V GaN with 170mΩ Rds(on), dynamic QR/DCM/CCM modes of operation and peak current mode controlled QR flyback converter
- Supports AC input voltage 90VAC to 264VAC at 43Hz - 63Hz line frequency and output power of 20V/5A, 24V/5A and 28V/4.3A. Also, this EVM

can be configured for 5V/3A, 9V/3A, 12V/3A and 15V/3A with PFC disabled for all this output voltage.

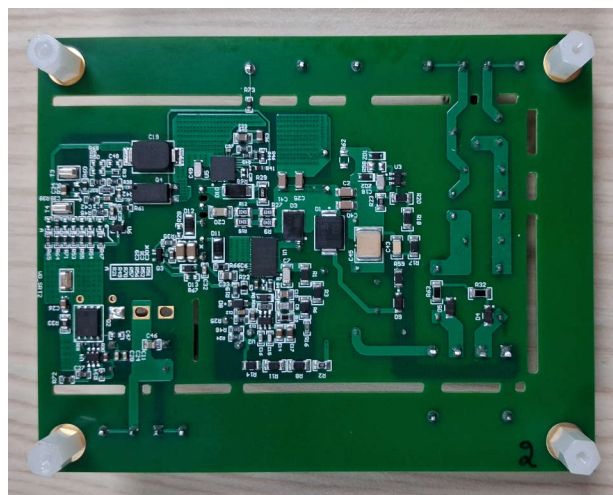
- High efficiency and low-standby power and two stage (PFC + Flyback) peak efficiency: > 93% efficiency at 115VAC input and approx. 95% efficiency at 230VAC input
- PFC need minimum 20mA at 20V output setting to enable PFC circuit across the input voltage
- Self-bias and auxless-sense, integrated current sense, Integrated HV startup and Integrated X-cap discharge enable lowest BOM cost by integration
- Complete sets of protection feature which includes OVP, OTP, Short circuit, overcurrent protection and brown-in and out protection.
- Discrete brown-out circuit is implemented for UCC28056 PFC transition mode controller.
- This EVM includes TI parts which are UCG28828, UCC28056, LMG3622, LM8364 and ATL431.

Applications

- [USB wall power adapter](#)
- [USB AC/DC adapter](#)
- [Battery charger](#)
- [Docking station](#)



UCG28828EVM-094 Top View



UCG28828EVM-094 Bottom View

1 Evaluation Module Overview

1.1 Introduction

This user guide describes the design, operation, and performance of the 120W two-stage AC/DC power supply evaluation module (EVM). The EVM demonstrates a high-efficiency, high-density isolated power supply design for AC-DC adapter, consumer electronics, industrial, and medical power supply applications.

This EVM implements a two-stage power conversion topology. The first stage uses the UCC28056 transition-mode PFC controller with an LMG3622 GaN FET switch to achieve near-unity power factor and low total harmonic distortion (THD) across a universal AC input range of 90VAC to 264VAC. The second stage uses the UCG28828 auxless quasi-resonant (QR) flyback controller with an integrated 750V GaN HEMT to deliver a regulated DC output of 20V, 24V, or 28V and 120W output power. The UCG28828 auxless architecture eliminates the need for an auxiliary winding on the transformer for flyback bias supply, reducing transformer complexity and overall bill of materials (BOM) cost. Valley switching operation minimizes switching losses, enabling high power density while maintaining greater than 92% efficiency across the load range. The EVM is designed to meet the following industry standards:

- Efficiency: DoE Level VI average efficiency
- Standby Power: CoC Tier 2 (<210mW at no load)
- EMC: CISPR 32 Class B conducted emissions
- Input: Universal AC, 90 VAC to 264 VAC, 47Hz to 63Hz
- Output: 20V, 24V, or 28V and 120W maximum power.

This user guide covers the EVM schematic, bill of materials, test setup, and measured performance data including efficiency, load regulation, startup, switching frequency across load, line transient, load transient, output voltage ripple, thermal performance, conducted EMI and PFC stage test data. The user's guide provides basic evaluation instructions from a system viewpoint of QR flyback converter operation. Please read this user's guide thoroughly before applying power to this board.

1.2 Kit Contents

Item	Description	Quantity
UCG28828EVM-094	PCB (evaluation module)	1

1.3 Specification

Input	Output	Max Output Power
90VAC-264VAC47-63Hz	28V/4.3A, 24V/5A and 20V/5A [Can set output to 15V/3A, 12V/3A, 9V/3A, 5V/3A (PFC will be disabled)]	120W

1.4 Device Information

The UCG28828 is a high-frequency, quasi-resonant (QR) AC/DC flyback converter with an integrated 750V primary-side GaN high electron mobility transistor (HEMT) with as low as 170mΩ RDS(on), designed for AC-to-DC power conversion of 120W with switching frequency up to 500kHz for high power density designs. The device features the industry's first auxless flyback architecture with self-bias, eliminating the need for a transformer auxiliary winding to deliver a compact, lower-cost power supply design with higher efficiency — particularly in wide output voltage applications such as USB-PD chargers. Integration of input voltage sensing, output voltage sensing, current sense, HV start-up, and X-cap discharge significantly reduces external component count and BoM cost. The UCG28828 supports dynamic mode transition across CCM, QR, and DCM operating modes for high efficiency across the full power range, achieving less than 30mW standby power consumption, with built-in EMI mitigation through frequency dithering, valley locking, frequency foldback, burst mode, and switching slew rate control. A comprehensive protection suite — OVP, SCP, two-level over-power protection with LPS, OTP, brownin and brownout, open feedback protection, and cycle-by-cycle current limit — combined with flexible resistor-programmable configuration pins in a compact 5mm × 5mm QFN package, makes the UCG28828 a fully integrated, platform-capable design for USB-PD adapters, USB wall outlets, industrial DIN rail supplies, and server auxiliary power supplies.

1.5 General Texas Instruments High Voltage Evaluation (TI HV EVM) User Safety Guidelines



Always follow TI's setup and application instructions, including use of all interface components within the recommended electrical rated voltage and power limits. Always use electrical safety precautions to help ensure your personal safety and those working around you. Contact TI's Product Information Center <http://support/ti.com> for further information.

Save all warnings and instructions for future reference.

WARNING

Failure to follow warnings and instructions can result in personal injury, property damage or death due to electrical shock and burn hazards.

The term TI HV EVM refers to an electronic device typically provided as an open framed, unenclosed printed circuit board assembly. It is *intended strictly for use in development laboratory environments, solely for qualified professional users having training, expertise and knowledge of electrical safety risks in development and application of high voltage electrical circuits. Any other use and/or application are strictly prohibited by Texas Instruments.* If you are not qualified, then you should immediately stop from further use of the HV EVM.

1. Work Area Safety

- a. Keep work area clean and orderly.
- b. Qualified observers must be present anytime circuits are energized.
- c. Effective barriers and signage must be present in the area where the TI HV EVM and the interface electronics are energized, indicating operation of accessible high voltages can be present, for the purpose of protecting inadvertent access.
- d. All interface circuits, power supplies, evaluation modules, instruments, meters, scopes and other related apparatus used in a development environment exceeding 50Vrms/75VDC must be electrically located within a protected Emergency Power Off EPO protected power strip.
- e. Use stable and nonconductive work surface.
- f. Use adequately insulated clamps and wires to attach measurement probes and instruments. No freehand testing whenever possible.

2. Electrical Safety

As a precautionary measure, a good engineering practice is to assume that the entire EVM can have fully accessible and active high voltages.

- a. De-energize the TI HV EVM and all the inputs, outputs and electrical loads before performing any electrical or other diagnostic measurements. Revalidate that TI HV EVM power has been safely de-energized.
- b. With the EVM confirmed de-energized, proceed with required electrical circuit configurations, wiring, measurement equipment connection, and other application needs, while still assuming the EVM circuit and measuring instruments are electrically live.
- c. After EVM readiness is complete, energize the EVM as intended.

WARNING

While the EVM is energized, never touch the EVM or the electrical circuits, as the EVM or the electrical circuits can be at high voltages capable of causing electrical shock hazard.

3. Personal Safety

- a. Wear personal protective equipment (for example, latex gloves or safety glasses with side shields) or protect EVM in an adequate lucent plastic box with interlocks to protect from accidental touch.

Limitation for safe use: EVMs are not to be used as all or part of a production unit.

2 Hardware

2.1 Test Setup Requirements

Safety: This evaluation module is not encapsulated and there are accessible voltages that are greater than 50V_{DC}.

Isolation Input Transformer: An appropriately rated 1:1 isolation transformer shall be used on the inputs to this EVM and be constructed in a manner in which the primary winding are separated from the secondary windings by reinforced insulation, double insulation, or a screen connected to the protective conductor terminal.



WARNING

- If the user is not trained in the proper safety of handling and testing power electronics, then please do not test this evaluation module.
- While the EVM is energized, never touch the EVM or the electrical circuits, as the EVM or the electrical circuits can be at high voltages capable of causing electrical shock hazard.
- Caution: Hot surface. Contact can cause burns. Do not touch!
- Read this user's guide thoroughly before making test.

Voltage Source: Isolated AC source or variable AC transformer capable of 264V_{RMS} and capable of handling 100W power level.

Voltmeter: Digital voltage meter

Power Analyzer: Capable of measuring 1mW to 100W of input power and capable of handling 264V_{RMS} input voltage. Some power analyzers may require a precision shunt resistor for measuring input current to measure input power of 5W or less. Please read the power analyzer's user manual for proper measurement setups for full power and for stand-by power.

Oscilloscope:

- 4 Channel, 500MHz bandwidth.
- Probes capable of handling 600V.

Output Load: Resistive or electronic load capable of handling 130W at 20V.

Recommended Wire Gauge: Insulated 22AWG to 18AWG.



WARNING

Caution: Do not leave EVM powered when unattended.

2.2 Recommended Test Setups

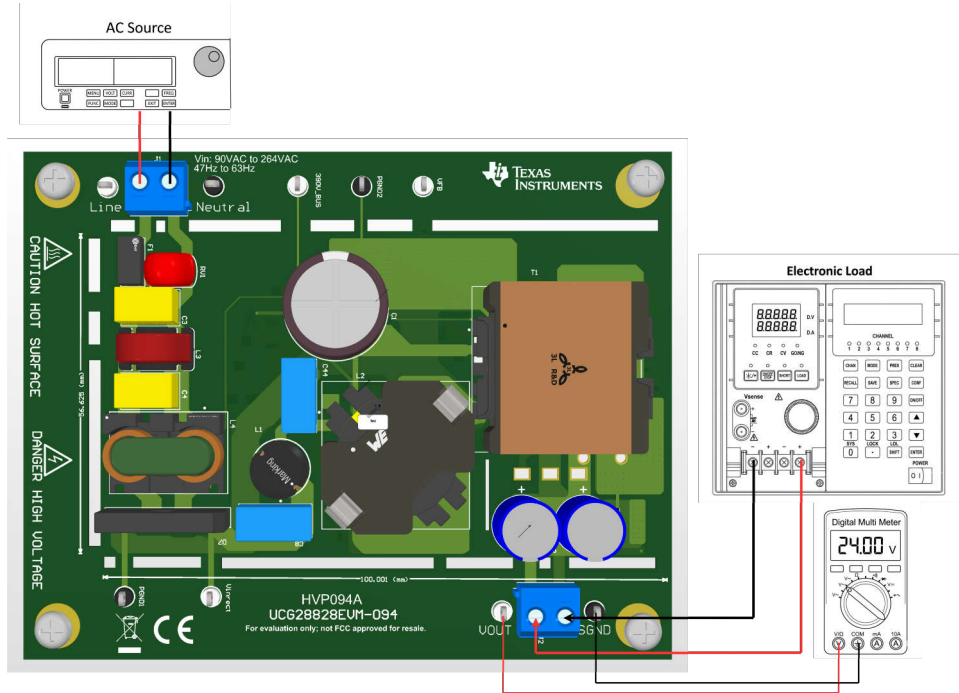


Figure 2-1. UCG28828EVM-094 Test Setup Diagram

2.3 Test Points

Table 2-1. Test Points

Test Points	Description
Line	AC input line terminal
Neutral	AC input neutral terminal
Vinrect	Rectified input voltage
390V_BUS	PFC output voltage
PGND1, PGND2	Primary side ground
VFB	UCG28828 feedback pin voltage
VD_SR	SR FET drain pin voltage
VOUT	Flyback output voltage
SGND	Secondary side ground
T2, T3	Test pin across 50Ω resistor for stability analysis (R36)

2.4 Terminals

Table 2-2. Table list EVM terminal

Terminals	Description
J1	AC input terminal
J2	Flyback output terminal

3 Performance Data and Typical Characteristic Curves

The 120W two-stage AC/DC power supply combines a UCC28056-controlled PFC front-end stage utilizing the LMG3622 700V GaN FET as the power switch, followed by a UCG28828 (750V integrated GaN FETauxless flyback conversion stage). This power supply consistently delivers high efficiency across all three programmable output voltages — 28V, 24V, and 20V ; over the full universal input range of 90VAC to 264VAC.

The LMG3622 GaN-based PFC switch enables high-frequency, low-loss switching in the PFC stage, contributing directly to the overall system efficiency gains observed across all line and load conditions. At 28V output, peak efficiency reaches 95.23% at 264VAC full load, with 4-point average efficiency ranging from 92.13% at 90VAC to 94.05% at 264VAC. At 24V output, peak efficiency reaches 95.00% at 264VAC full load, with 4-point average efficiency ranging from 91.92% at 90VAC to 94.00% at 264VAC. At 20V output, peak efficiency reaches 94.82% at 264VAC full load, with 4-point average efficiency ranging from 91.82% at 90VAC to 93.71% at 264VAC.

Across all output voltage settings, system efficiency consistently exceeds 92% at 50% load and above for all line conditions, with all results meeting DoE Level VI and CoC Tier 2 requirements for 120W external power supplies.

These measurements confirm that the combination of UCC28056, LMG3622, and UCG28828 sustains high conversion efficiency across the full output voltage range, load range, and universal input voltage range — validating the design for high-power-density adapter applications.

3.1 Efficiency Test Data for 28V Output Voltage

V _{IN} and F _{line}	P _{IN} (W)	V _{OUT} (V)	I _{OUT} (A)	P _{OUT} (W)	P _{out} %	Efficiency	4-points Average Efficiency
90VAC and 60Hz	0.22733	27.89	0.00489	0.13624	0.11%	59.93%	
90VAC and 60Hz	0.32208	27.89	0.0070	0.1963	0.16%	60.94%	
90VAC and 60Hz	0.44436	27.89	0.0108	0.3023	0.25%	68.02%	
90VAC and 60Hz	0.5901	27.89	0.0153	0.4264	0.35%	72.26%	
90VAC and 60Hz	0.6722	27.89	0.0178	0.4951	0.41%	73.66%	
90VAC and 60Hz	1.2286	27.89	0.0350	0.9756	0.81%	79.41%	
90VAC and 60Hz	5.6506	27.89	0.1769	4.9340	4.11%	87.32%	
90VAC and 60Hz	13.5907	27.88	0.4290	11.9605	10%	88.01%	
90VAC and 60Hz	33.38	27.87	1.084	30.2111	25%	90.51%	92.13%
90VAC and 60Hz	64.75	27.86	2.147	59.8154	50%	92.38%	
90VAC and 60Hz	96.41	27.84	3.216	89.5334	75%	92.87%	
90VAC and 60Hz	128.68	27.84	4.288	119.3779	100%	92.46%	
115VAC and 60Hz	0.355	27.89	0.00654	0.182	0.15%	51.39%	
115VAC and 60Hz	0.349	27.89	0.007	0.202	0.17%	57.93%	
115VAC and 60Hz	0.465	27.89	0.011	0.317	0.26%	68.26%	
115VAC and 60Hz	0.604	27.89	0.016	0.437	0.36%	72.32%	
115VAC and 60Hz	0.677	27.89	0.018	0.502	0.42%	74.10%	
115VAC and 60Hz	1.278	27.89	0.037	1.026	0.86%	80.23%	
115VAC and 60Hz	5.726	27.89	0.18	5.014	4.17%	87.56%	
115VAC and 60Hz	13.704	27.87	0.434	12.096	10%	88.26%	
115VAC and 60Hz	33.26	27.87	1.086	30.267	25%	91.00%	92.81%
115VAC and 60Hz	64.436	27.86	2.146	59.788	50%	92.79%	
115VAC and 60Hz	95.767	27.85	3.220	89.677	75%	93.64%	
115VAC and 60Hz	127.332	27.84	4.291	119.461	100%	93.82%	
230VAC and 50Hz	0.303	27.88	0.006	0.156	0.13%	51.41%	
230VAC and 50Hz	0.365	27.88	0.008	0.215	0.18%	58.76%	
230VAC and 50Hz	0.478	27.88	0.012	0.325	0.27%	68.12%	
230VAC and 50Hz	0.620	27.88	0.016	0.444	0.37%	71.65%	
230VAC and 50Hz	0.703	27.88	0.018	0.509	0.42%	72.37%	

V _{IN} and F _{line}	P _{IN} (W)	V _{OUT} (V)	I _{OUT} (A)	P _{OUT} (W)	P _{out} %	Efficiency	4-points Average Efficiency
230VAC and 50Hz	1.275	27.88	0.037	1.029	0.86%	80.71%	
230VAC and 50Hz	5.607	27.88	0.179	4.982	4.15%	88.85%	
230VAC and 50Hz	13.519	27.88	0.430	11.988	10%	88.68%	
230VAC and 50Hz	32.796	27.87	1.081	30.138	25%	91.90%	93.83%
230VAC and 50Hz	63.898	27.86	2.149	59.871	50%	93.70%	
230VAC and 50Hz	95.026	27.85	3.230	89.956	75%	94.66%	
230VAC and 50Hz	125.914	27.84	4.3	119.712	100%	95.07%	
264VAC and 50Hz	0.285	27.89	0.005	0.145	0.12%	50.99%	
264VAC and 50Hz	0.366	27.89	0.007	0.208	0.17%	56.81%	
264VAC and 50Hz	0.479	27.89	0.011	0.317	0.26%	66.26%	
264VAC and 50Hz	0.619	27.89	0.016	0.437	0.36%	70.54%	
264VAC and 50Hz	0.695	27.88	0.018	0.504	0.42%	72.56%	
264VAC and 50Hz	1.234	27.88	0.035	0.982	0.82%	79.61%	
264VAC and 50Hz	5.611	27.88	0.179	4.980	4.15%	88.76%	
264VAC and 50Hz	13.75	27.86	0.439	12.231	10%	88.95%	
264VAC and 50Hz	32.591	27.85	1.078	30.022	25%	92.12%	94.049%
264VAC and 50Hz	63.611	27.85	2.146	59.766	50%	93.96%	
264VAC and 50Hz	94.356	27.84	3.216	89.533	75%	94.89%	
264VAC and 50Hz	125.533	27.83	4.2990.145	119.641	100%	95.23%	

3.2 Efficiency Test Data for 24V Output Voltage

V _{IN} and F _{line}	P _{IN} (W)	V _{OUT} (V)	I _{OUT} (A)	P _{OUT} (W)	P _{out} %	Efficiency	4-ponits Average Efficiency
90VAC and 60Hz	0.199	24.02	0.005	0.116	0.09%	58.08%	
90VAC and 60Hz	0.317	24.02	0.008	0.196	0.16%	61.83%	
90VAC and 60Hz	0.426	24.02	0.012	0.293	0.24%	68.84%	
90VAC and 60Hz	0.542	24.02	0.016	0.392	0.33%	72.27%	
90VAC and 60Hz	0.646	24.02	0.020	0.485	0.40%	75.10%	
90VAC and 60Hz	1.267	24.02	0.043	1.028	0.86%	81.09%	
90VAC and 60Hz	5.714	24.02	0.208	4.992	4.15%	87.37%	
90VAC and 60Hz	13.874	24.02	0.508	12.202	10%	87.95%	
90VAC and 60Hz	33.330	24.01	1.253	30.085	25%	90.26%	91.92%
90VAC and 60Hz	65.040	24.00	2.500	60.000	50%	92.25%	
90VAC and 60Hz	97.060	24.00	3.750	90.000	75%	92.73%	
90VAC and 60Hz	129.700	23.99	4.997	119.878	100%	92.43%	
115VAC and 60Hz	0.246	24.02	0.006	0.113	0.09%	54.10%	
115VAC and 60Hz	0.336	24.02	0.009	0.218	0.18%	65.05%	
115VAC and 60Hz	0.442	24.02	0.013	0.304	0.25%	68.77%	
115VAC and 60Hz	0.550	24.02	0.017	0.403	0.34%	73.34%	
115VAC and 60Hz	0.642	24.02	0.020	0.480	0.40%	74.76%	
115VAC and 60Hz	1.252	24.02	0.042	1.019	0.85%	81.39%	
115VAC and 60Hz	5.518	24.02	0.201	4.838	4.03%	87.68%	
115VAC and 60Hz	13.710	24.01	0.505	12.125	10%	88.44%	

V _{IN} and F _{line}	P _{IN} (W)	V _{OUT} (V)	I _{OUT} (A)	P _{OUT} (W)	P _{out} %	Efficiency	4-points Average Efficiency
115VAC and 60Hz	33.176	24.01	1.253	30.085	25%	90.68%	92.64%
115VAC and 60Hz	64.662	24.00	2.500	60.000	50%	92.79%	
115VAC and 60Hz	96.178	24.00	3.750	90.000	75%	93.58%	
115VAC and 60Hz	128.203	23.99	4.998	119.902	100%	93.52%	
230VAC and 50Hz	0.265	24.02	0.006	0.132	0.11%	49.94%	93.79%
230VAC and 50Hz	0.354	24.02	0.009	0.212	0.17%	59.87%	
230VAC and 50Hz	0.453	24.02	0.013	0.303	0.25%	67.02%	
230VAC and 50Hz	0.558	24.02	0.017	0.402	0.33%	72.01%	
230VAC and 50Hz	0.665	24.02	0.021	0.493	0.41%	74.14%	94.00%
230VAC and 50Hz	1.230	24.02	0.042	1.003	0.84%	81.52%	
230VAC and 50Hz	5.515	24.02	0.204	4.897	4.08%	88.81%	
230VAC and 50Hz	13.514	24.02	0.505	12.130	10%	89.76%	
230VAC and 50Hz	32.732	24.02	1.253	30.097	25%	91.95%	93.79%
230VAC and 50Hz	63.984	24.01	2.500	60.025	50%	93.81%	
230VAC and 50Hz	95.105	24.00	3.749	89.976	75%	94.61%	
230VAC and 50Hz	126.432	23.98	4.998	119.852	100%	94.80%	
264VAC and 50Hz	0.261	24.02	0.005	0.117	0.10%	44.83%	94.00%
264VAC and 50Hz	0.350	24.02	0.008	0.198	0.17%	56.56%	
264VAC and 50Hz	0.451	24.02	0.012	0.296	0.25%	65.60%	
264VAC and 50Hz	0.564	24.02	0.016	0.395	0.33%	70.01%	
264VAC and 50Hz	0.680	24.02	0.020	0.489	0.41%	71.87%	94.00%
264VAC and 50Hz	1.203	24.02	0.040	0.967	0.81%	80.38%	
264VAC and 50Hz	5.513	24.02	0.205	4.924	4.10%	89.31%	
264VAC and 50Hz	13.521	24.02	0.505	12.130	10%	89.71%	
264VAC and 50Hz	32.687	24.01	1.254	30.109	25%	92.11%	94.00%
264VAC and 50Hz	63.840	24.01	2.501	60.049	50%	94.06%	
264VAC and 50Hz	94.860	24.00	3.749	89.976	75%	94.85%	
264VAC and 50Hz	126.166	23.98	4.998	119.852	100%	95.00%	

3.3 Efficiency Test Data for 20V Output Voltage

V _{IN} and F _{line}	P _{IN} (W)	V _{OUT} (V)	I _{OUT} (A)	P _{OUT} (W)	P _{out} %	Efficiency	4-points Average Efficiency
90VAC and 60Hz	0.309	20.034	0.010	0.199	0.20%	64.26%	91.82%
90VAC and 60Hz	0.440	20.034	0.015	0.310	0.31%	70.54%	
90VAC and 60Hz	0.551	20.034	0.021	0.412	0.41%	74.88%	
90VAC and 60Hz	0.677	20.033	0.026	0.517	0.52%	76.35%	
90VAC and 60Hz	1.251	20.033	0.051	1.019	1.02%	81.47%	91.82%
90VAC and 60Hz	5.796	20.029	0.255	5.017	5.02%	88.12%	
90VAC and 60Hz	11.501	20.028	0.505	10.114	10.11%	87.94%	
90VAC and 60Hz	27.889	20.023	1.254	25.109	25.00%	90.03%	
90VAC and 60Hz	54.447	20.017	2.502	50.083	50.00%	91.98%	91.82%
90VAC and 60Hz	81.000	20.009	3.751	75.054	75.00%	92.66%	
90VAC and 60Hz	108.014	20.001	5.001	100.025	100.00%	92.60%	
115VAC and 60Hz	0.312	20.034	0.010	0.199	0.20%	63.91%	
115VAC and 60Hz	0.437	20.033	0.016	0.311	0.31%	71.25%	

V_{IN} and Fline	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	P_{OUT} (W)	P_{out} %	Efficiency	4-points Average Efficiency
115VAC and 60Hz	0.544	20.033	0.021	0.412	0.41%	75.76%	
115VAC and 60Hz	0.677	20.033	0.026	0.517	0.52%	76.36%	
115VAC and 60Hz	1.247	20.033	0.051	1.020	1.02%	81.77%	
115VAC and 60Hz	5.790	20.020	0.257	5.145	5.14%	88.86%	
115VAC and 60Hz	11.510	20.021	0.508	10.171	10.17%	88.36%	
115VAC and 60Hz	27.770	20.018	1.257	25.163	25.00%	90.61%	92.47%
115VAC and 60Hz	54.196	20.013	2.504	50.113	50.00%	92.47%	
115VAC and 60Hz	80.417	20.006	3.752	75.063	75.00%	93.34%	
115VAC and 60Hz	107.014	19.997	5.001	100.005	100.00%	93.45%	
230VAC and 50Hz	0.315	20.034	0.010	0.200	0.20%	63.53%	
230VAC and 50Hz	0.446	20.033	0.016	0.313	0.31%	70.20%	
230VAC and 50Hz	0.555	20.033	0.021	0.414	0.41%	74.59%	
230VAC and 50Hz	0.674	20.033	0.026	0.517	0.52%	76.78%	
230VAC and 50Hz	1.224	20.033	0.050	0.994	1.00%	81.23%	
230VAC and 50Hz	5.705	20.025	0.257	5.146	5.15%	90.21%	
230VAC and 50Hz	11.336	20.025	0.506	10.133	10.13%	89.38%	
230VAC and 50Hz	27.336	20.022	1.256	25.148	25.00%	92.00%	93.62%
230VAC and 50Hz	53.584	20.016	2.503	50.100	50.00%	93.50%	
230VAC and 50Hz	79.567	20.012	3.752	75.085	75.00%	94.37%	
230VAC and 50Hz	105.710	20.001	5.001	100.025	100.00%	94.62%	
264VAC and 50Hz	0.341	20.034	0.010	0.200	0.20%	58.69%	
264VAC and 50Hz	0.448	20.034	0.016	0.314	0.31%	69.93%	
264VAC and 50Hz	0.561	20.033	0.021	0.415	0.42%	74.03%	
264VAC and 50Hz	0.651	20.033	0.024	0.490	0.50%	75.37%	
264VAC and 50Hz	1.266	20.033	0.051	1.022	1.00%	80.71%	
264VAC and 50Hz	5.611	20.032	0.251	5.028	5.00%	89.61%	
264VAC and 50Hz	11.231	20.030	0.502	10.055	10.00%	89.53%	
264VAC and 50Hz	27.302	20.026	1.253	25.093	25.00%	91.91%	93.71%
264VAC and 50Hz	53.514	20.024	2.502	50.100	50.00%	93.62%	
264VAC and 50Hz	79.438	20.015	3.751	75.076	75.00%	94.51%	
264VAC and 50Hz	105.516	20.005	5.001	100.045	100.00%	94.82%	

3.4 Efficiency Curve: Efficiency vs Output Power

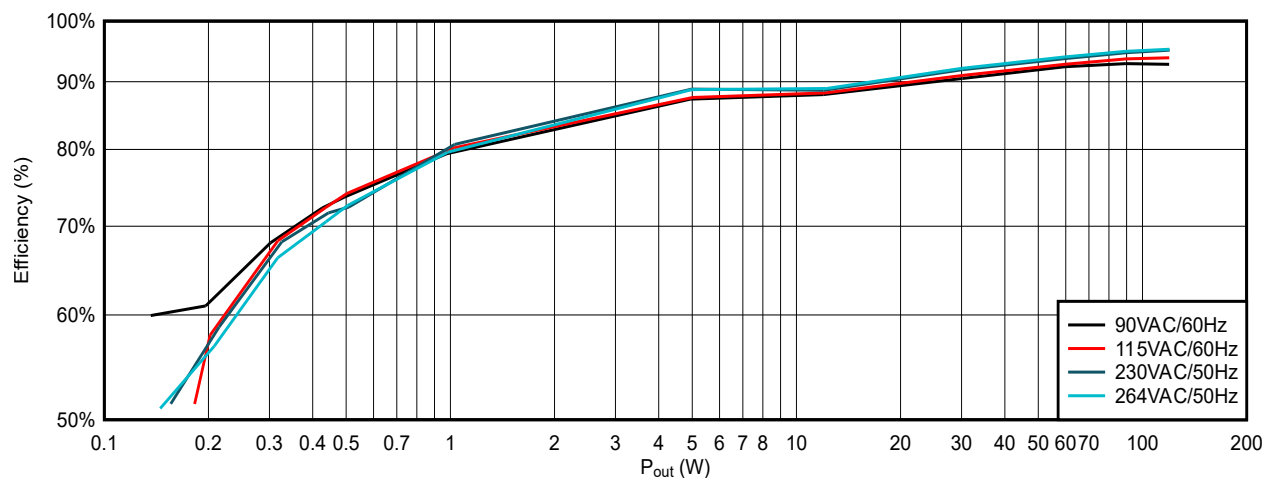


Figure 3-1. Efficiency vs P_{out} (28V V_{out})

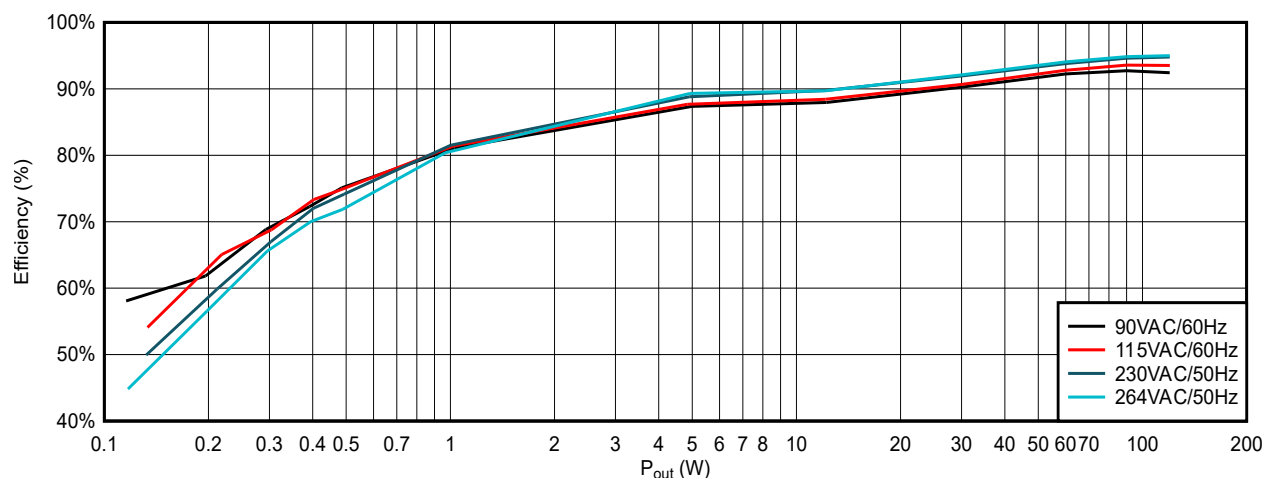


Figure 3-2. Efficiency vs P_{out} (24V V_{out})

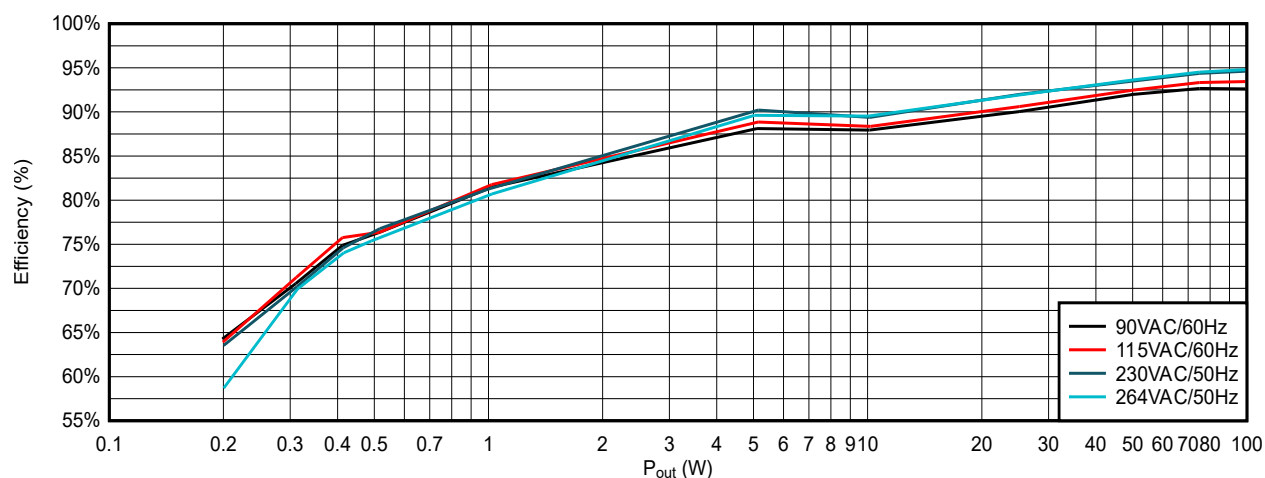


Figure 3-3. Efficiency vs P_{out} (20V V_{out})

3.5 Load Regulation

This sections shows the output voltage regulation across the load for AC input voltage of 90VAC/60Hz, 115VAC/60Hz, 230VAC/50Hz and 264VAC/50Hz.

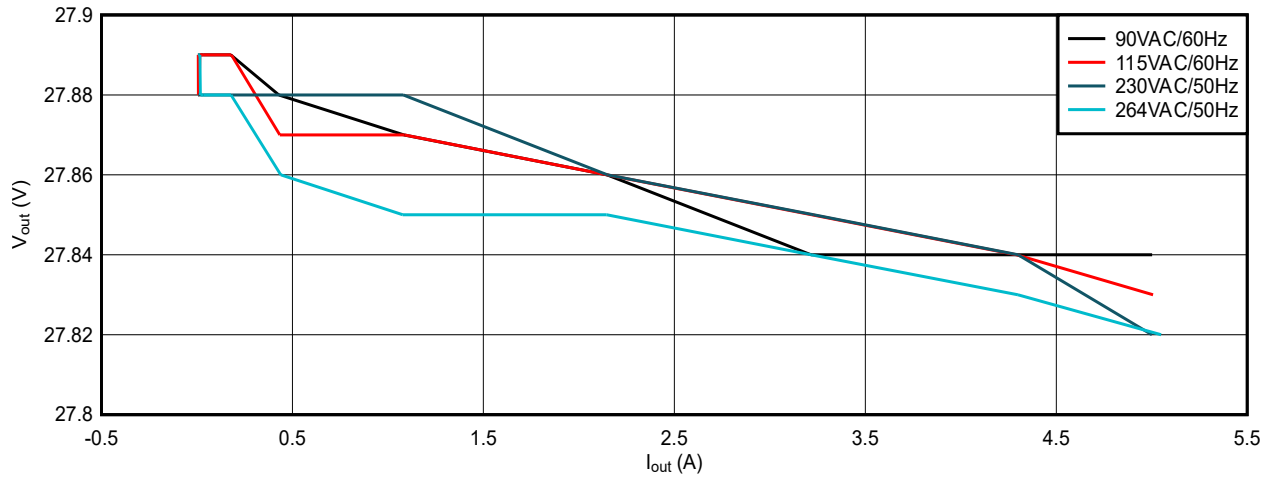


Figure 3-4. Load Regulation: at 28V Output Voltage

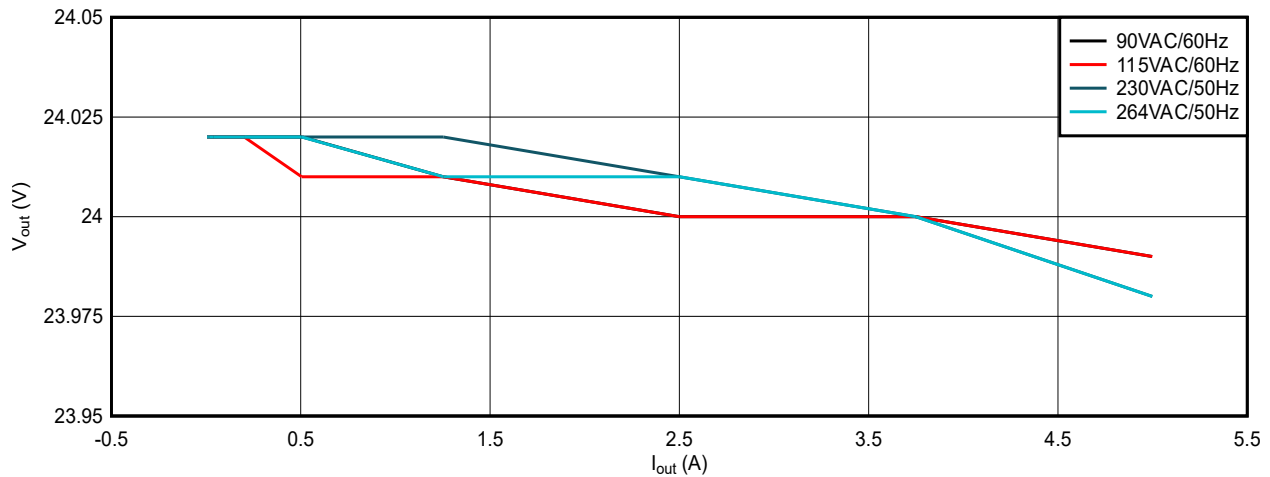


Figure 3-5. Load Regulation: at 24V Output Voltage

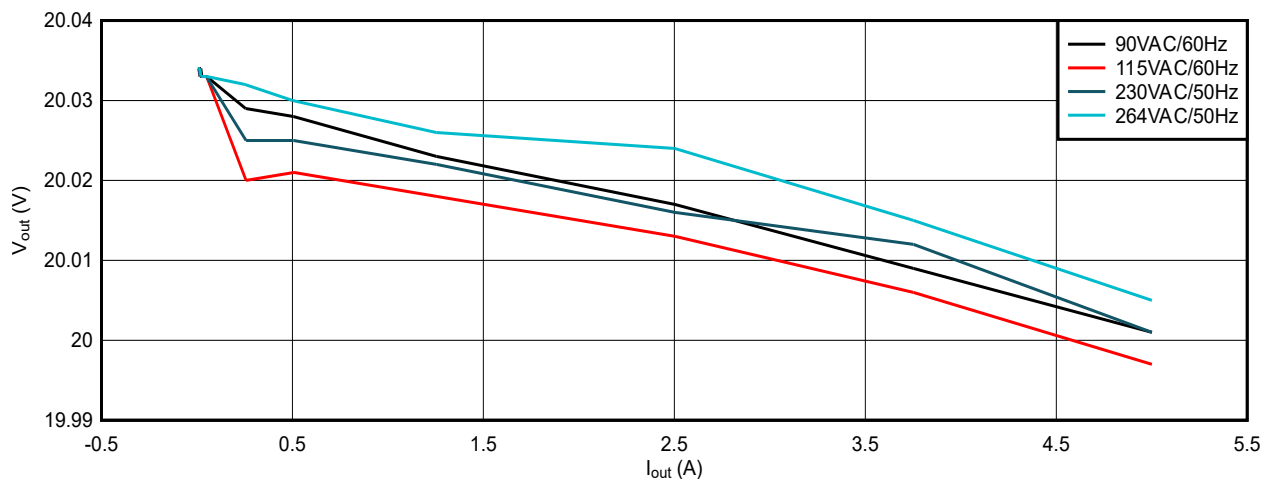


Figure 3-6. Load Regulation: at 20V Output Voltage

3.6 Startup Waveforms

The following waveforms shows the AC input voltage, output voltage and load current during start-up at no-load and full-load. The test condition is listed in the figure description.

Note

This EVM do not support full power startup at any output voltage settings (20V/24V/28V) below 115VAC, as PFC bias supply is dependent on flyback.

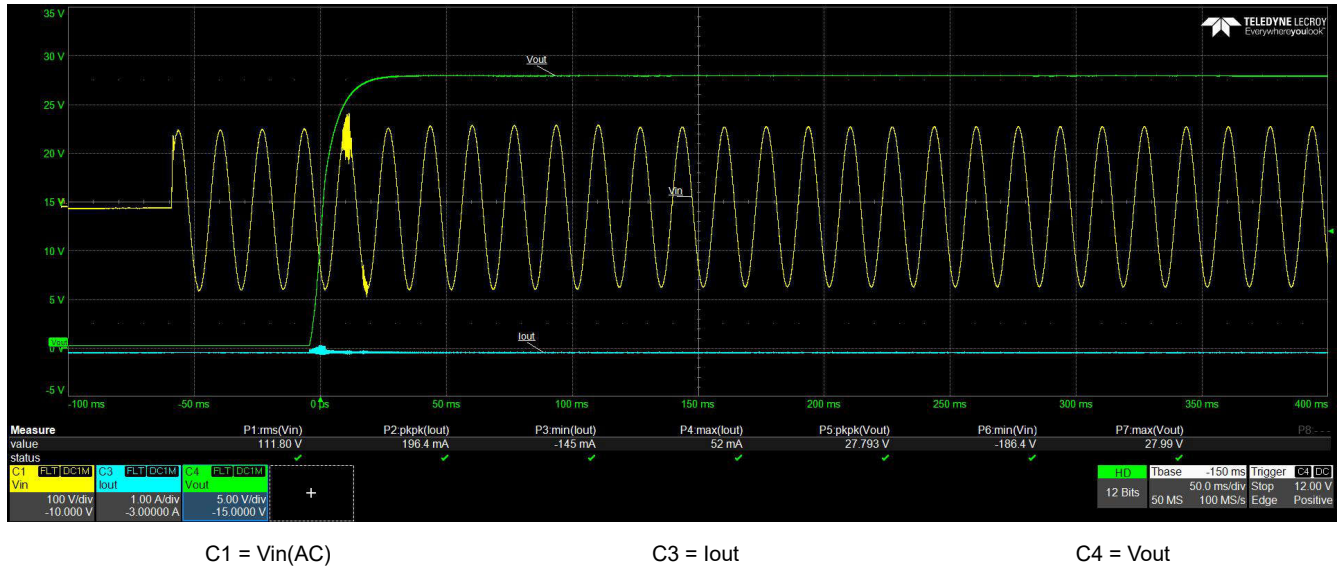


Figure 3-7. Startup Waveform at 115VAC/60Hz, 28V/0A

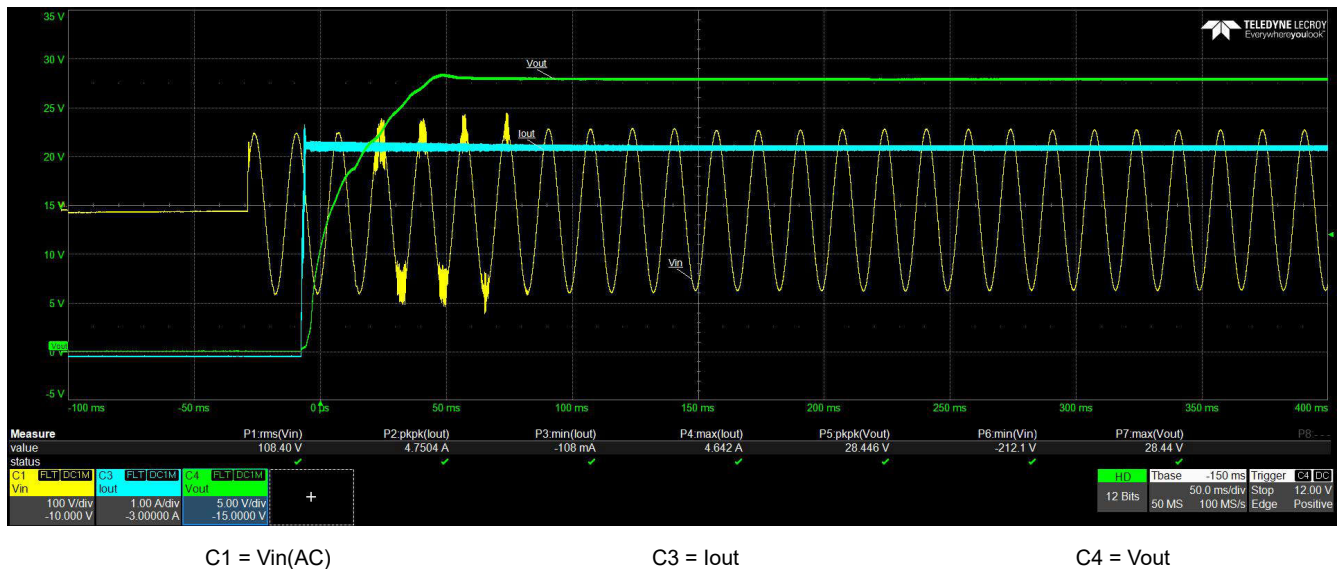
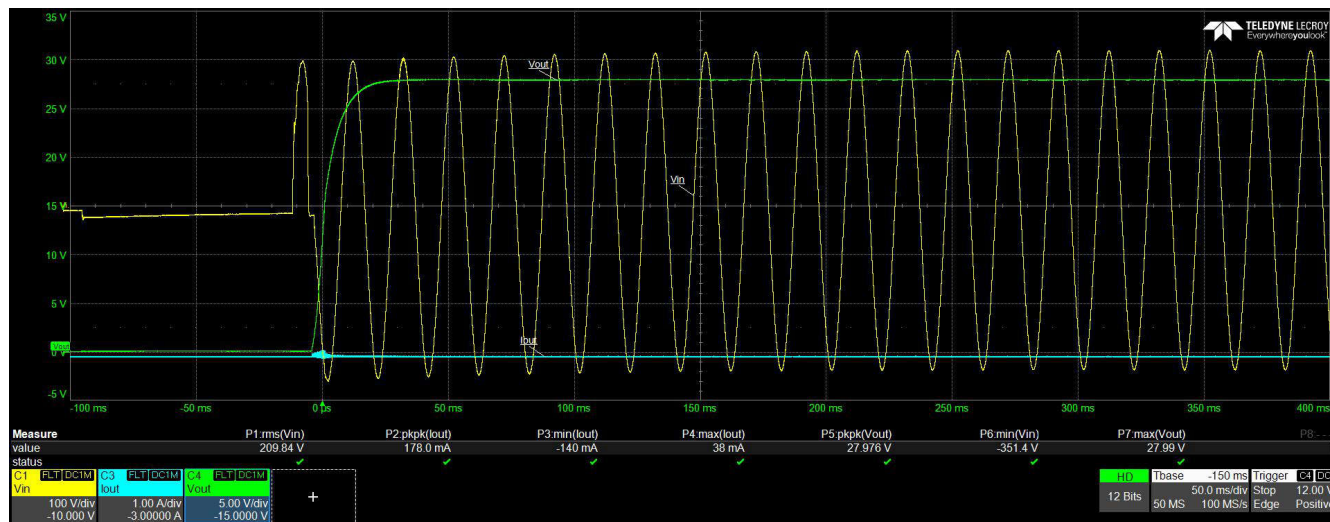


Figure 3-8. Startup Waveform at 115VAC/60Hz, 28V/4.3A



C1 = Vin(AC)

C3 = Iout

C4 = Vout

Figure 3-9. Startup Waveform at 230VAC/50Hz, 28V/0A

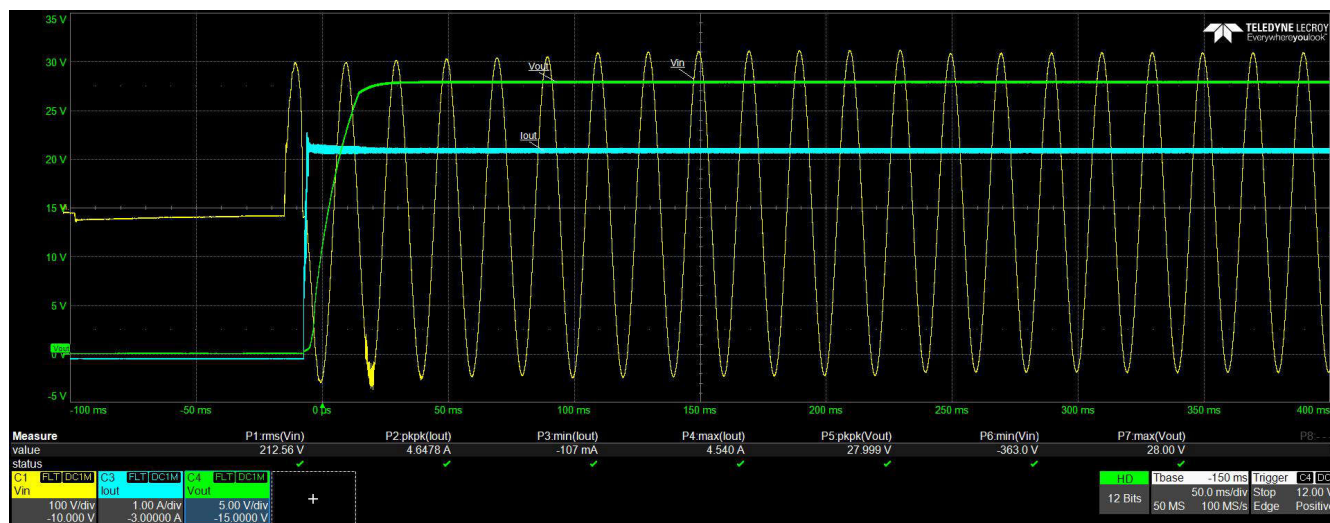


Figure 3-10. Startup Waveform at 230VAC/50Hz, 28V/4.3A

C1 = Vin(AC)

C3 = Iout

C4 = Vout

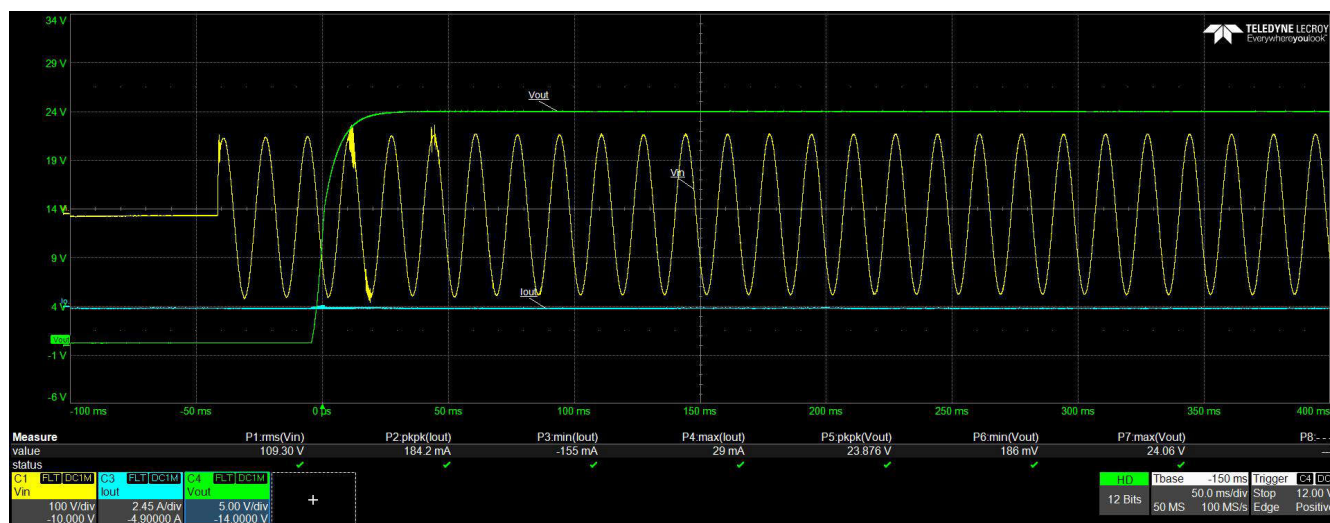


Figure 3-11. Startup Waveform at 115VAC/60Hz, 24V/0A

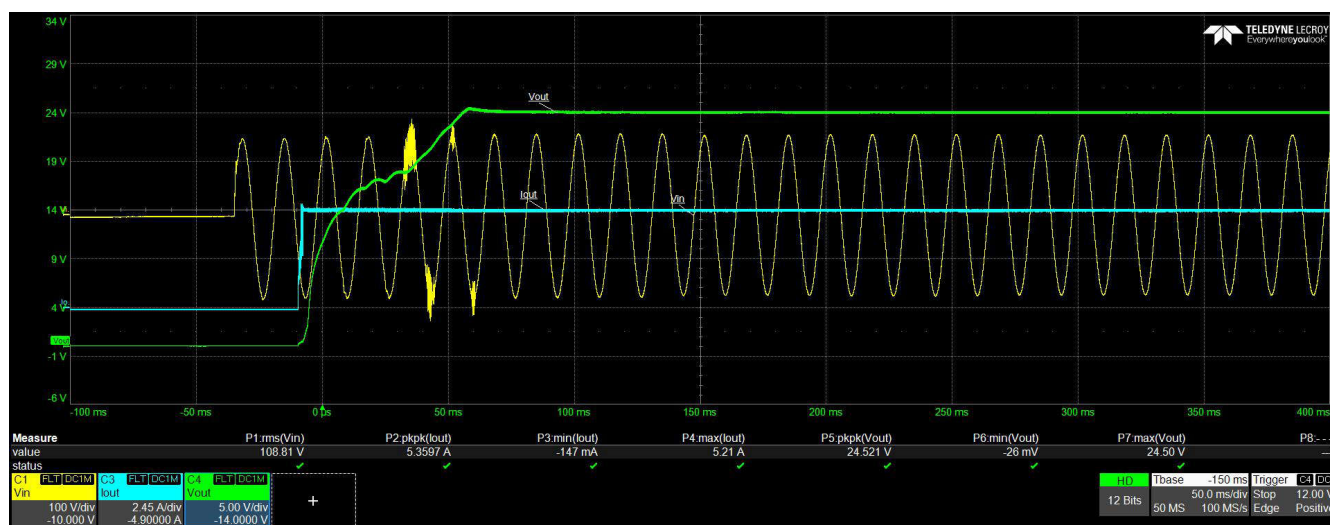
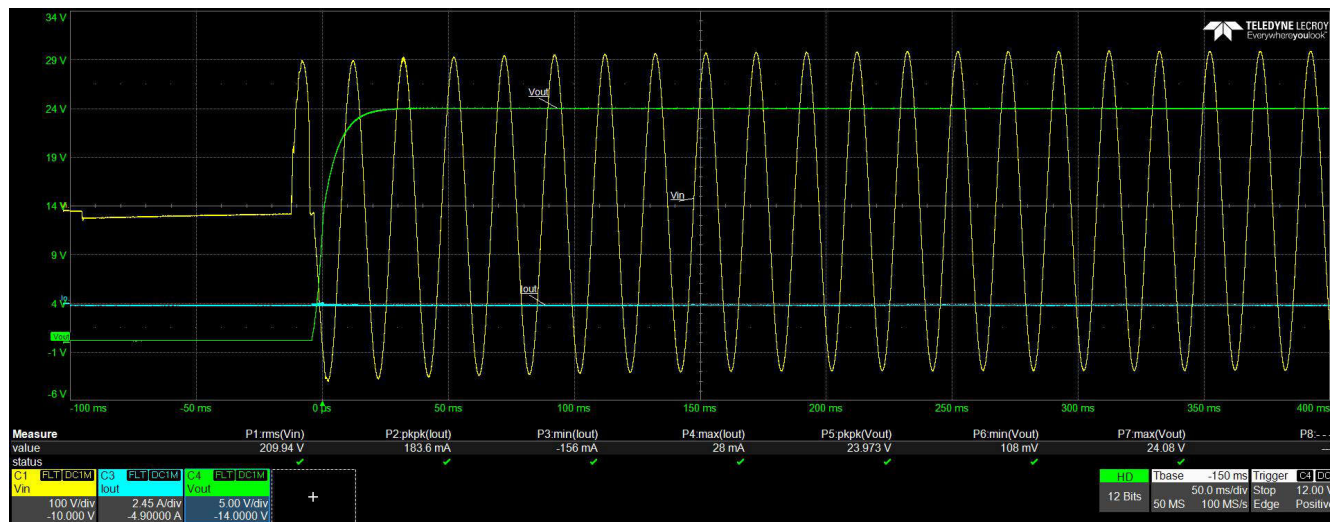


Figure 3-12. Startup Waveform at 115VAC/60Hz, 24V/5A

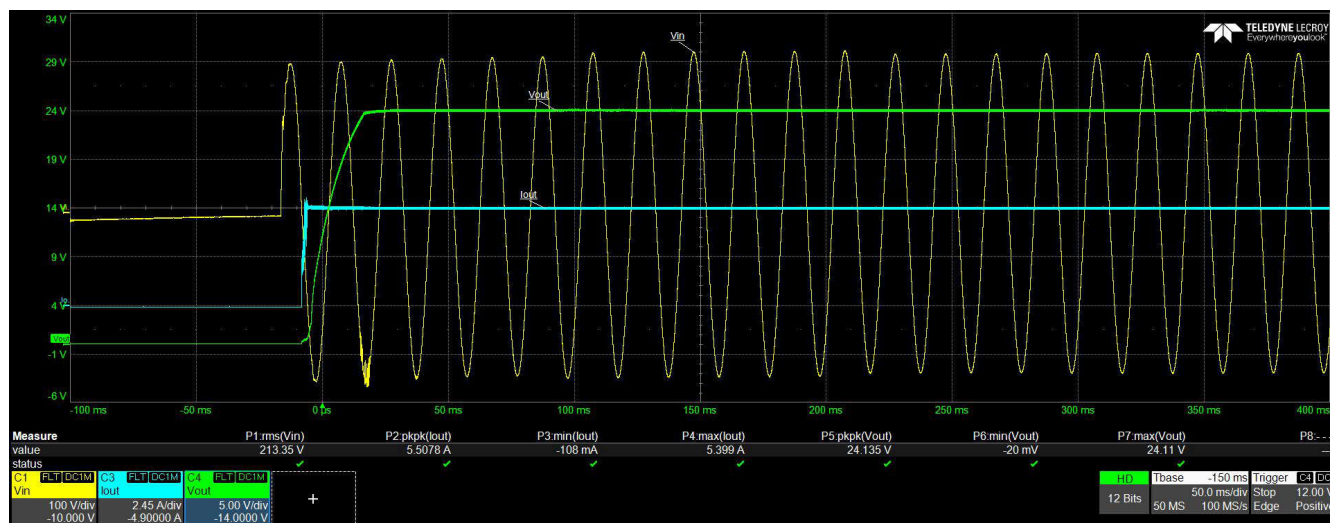


C1 = Vin(AC)

C3 = Iout

C4 = Vout

Figure 3-13. Startup Waveform at 230VAC/50Hz, 24V/0A

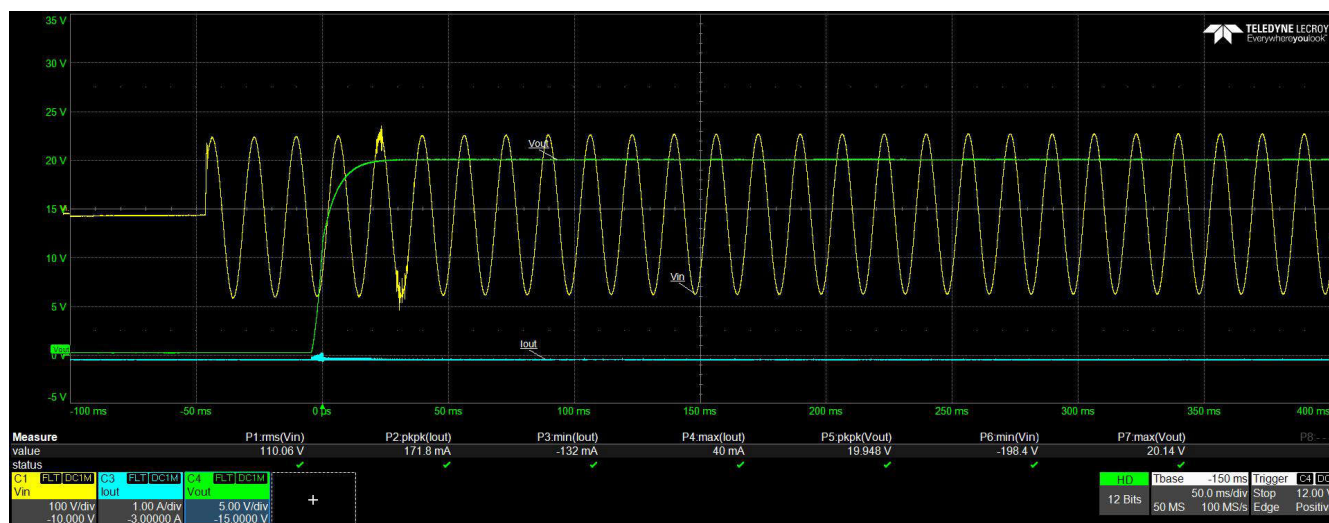


C1 = Vin(AC)

C3 = Iout

C4 = Vout

Figure 3-14. Startup Waveform at 230VAC/50Hz, 24V/5A

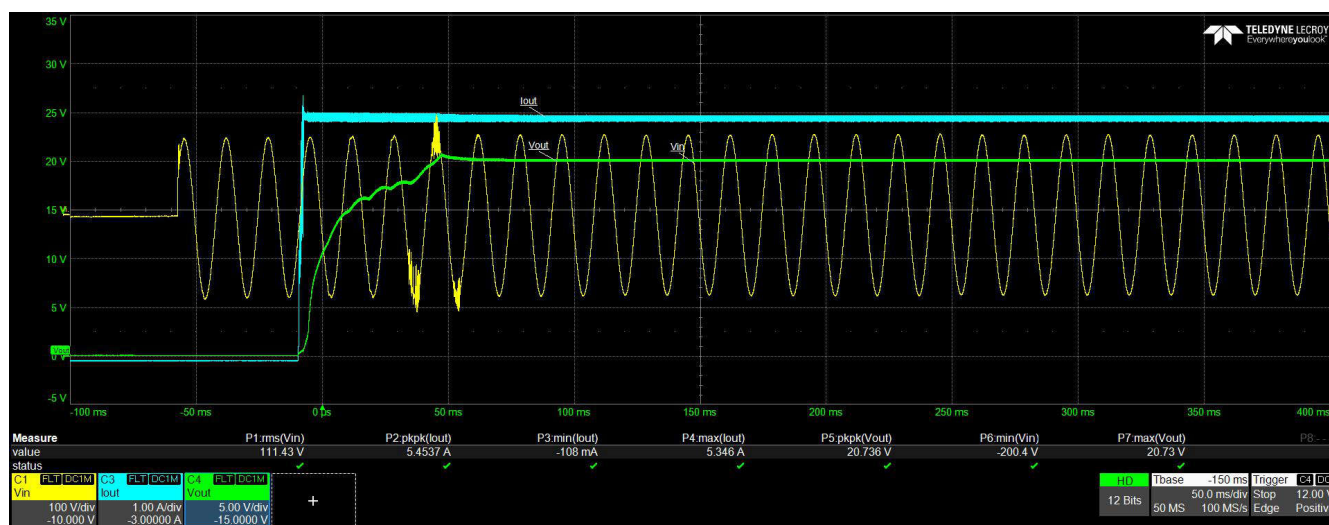


C1 = Vin(AC)

C3 = Iout

C4 = Vout

Figure 3-15. Startup Waveform at 115VAC/60Hz, 20V/0A

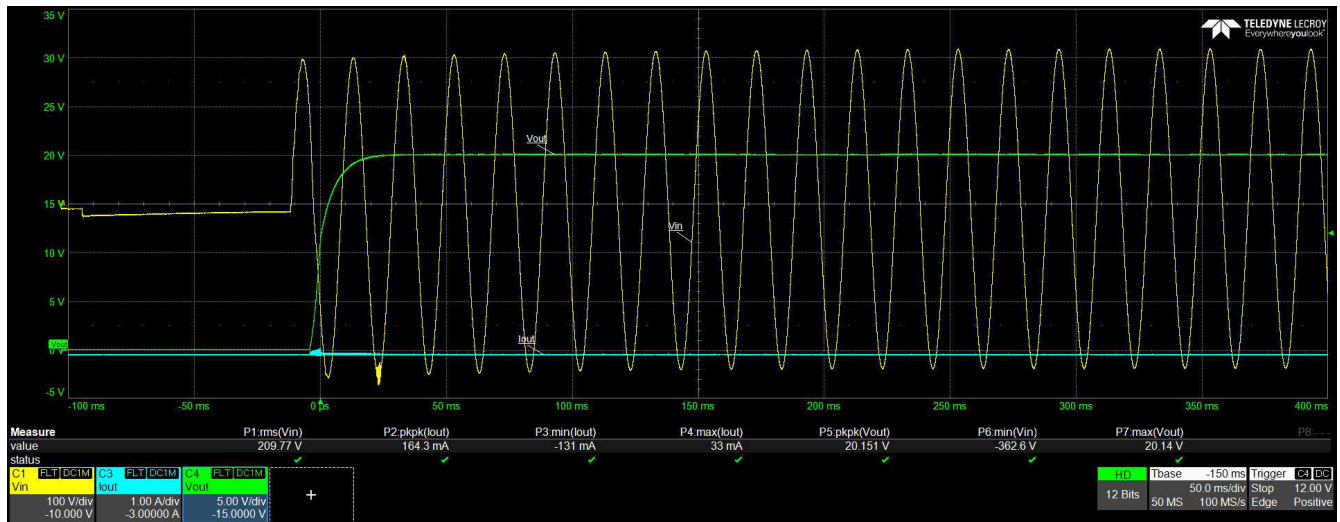


C1 = Vin(AC)

C3 = Iout

C4 = Vout

Figure 3-16. Startup Waveform at 115VAC/60Hz, 20V/5A

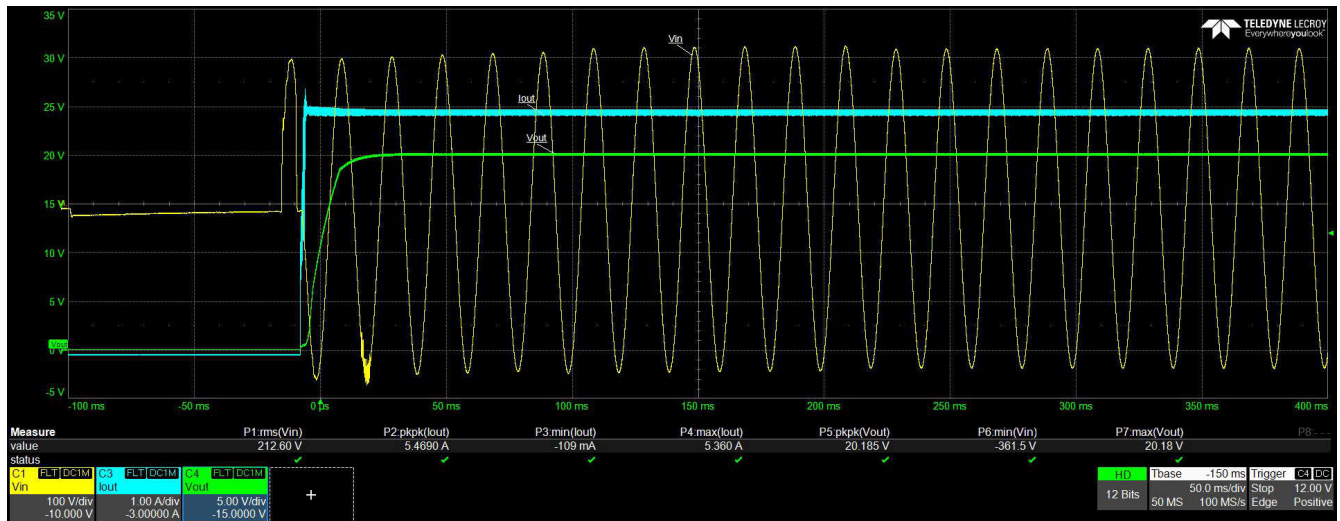


C1 = Vin(AC)

C3 = Iout

C4 = Vout

Figure 3-17. Startup Waveform at 230VAC/50Hz, 20V/0A



C1 = Vin(AC)

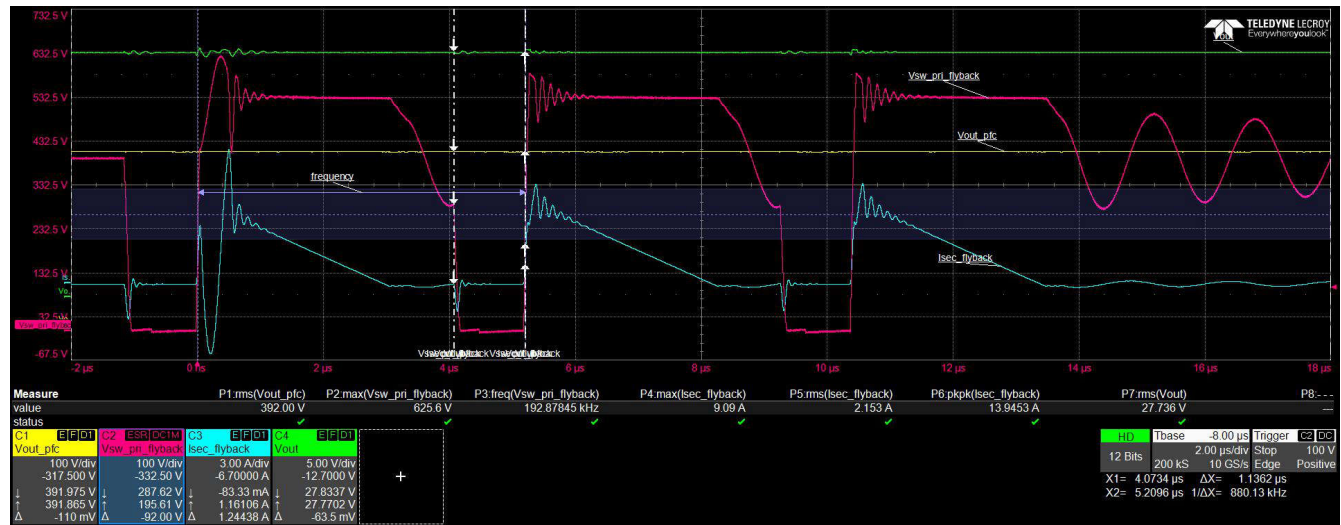
C3 = Iout

C4 = Vout

Figure 3-18. Startup Waveform at 230VAC/50Hz, 20V/5A

3.7 Switching Frequency Across Load

Following waveforms shows the switching behavior of UCG28828-1REZR at operating points of 115VAC/60Hz and 230VAC/50Hz across the load for output settings of 20V, 24V and 28V.



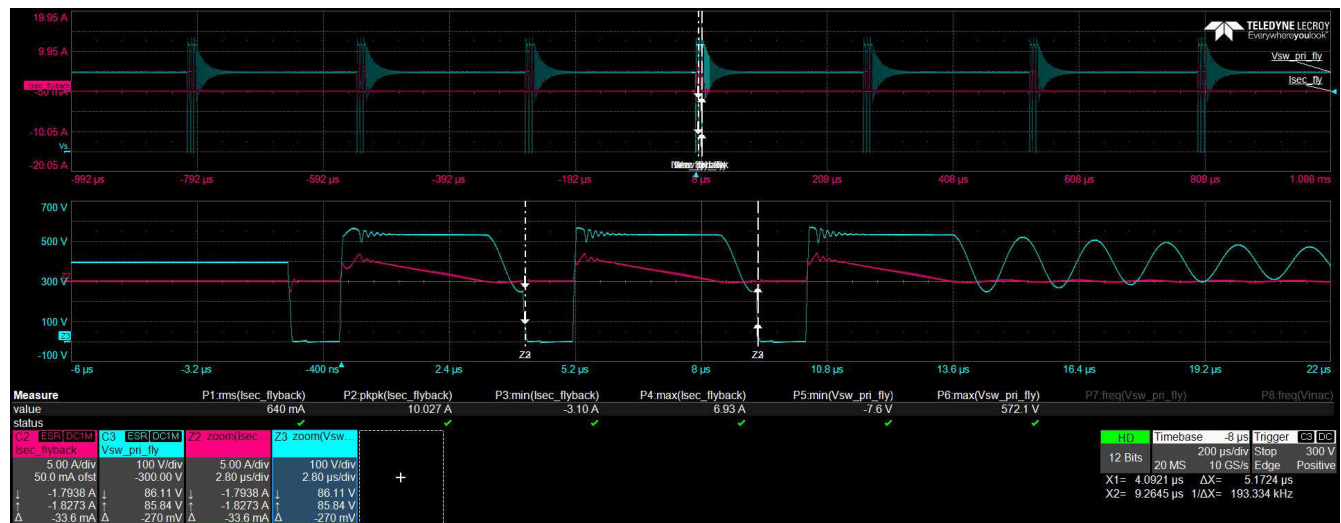
C1 = PFC output voltage

C2 = Flyback primary side
switch node voltage

C3 = flyback secondary side
current

C4 = output voltage

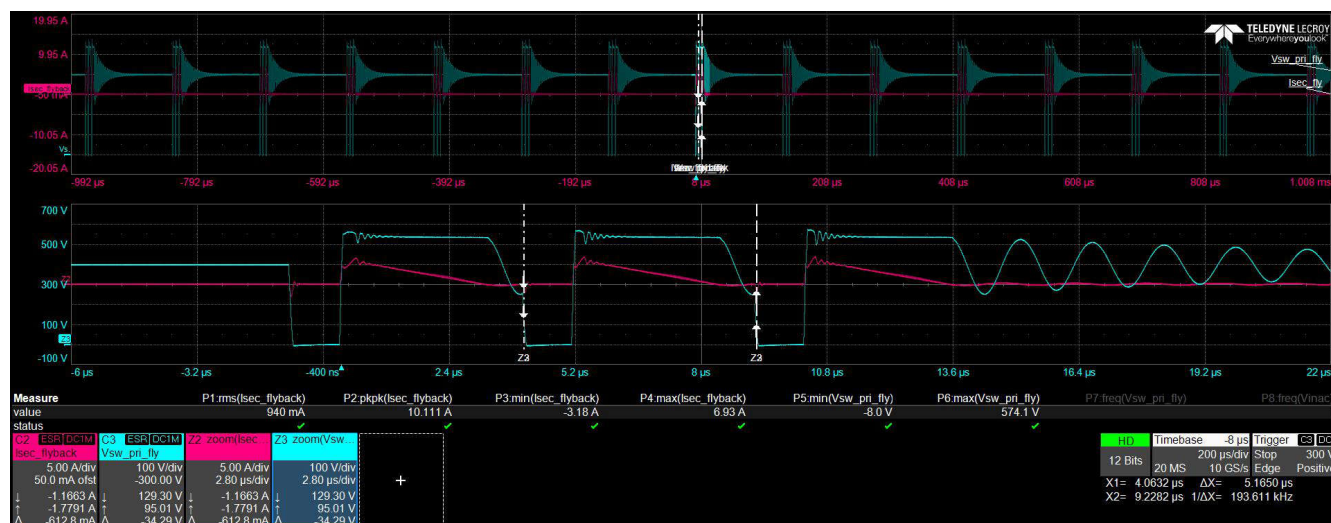
Figure 3-19. Switching Behavior at $V_{out} = 28V$ and $I_{out} = 0A$



C2 = Flyback secondary side current

C3 = Flyback primary side switch node voltage

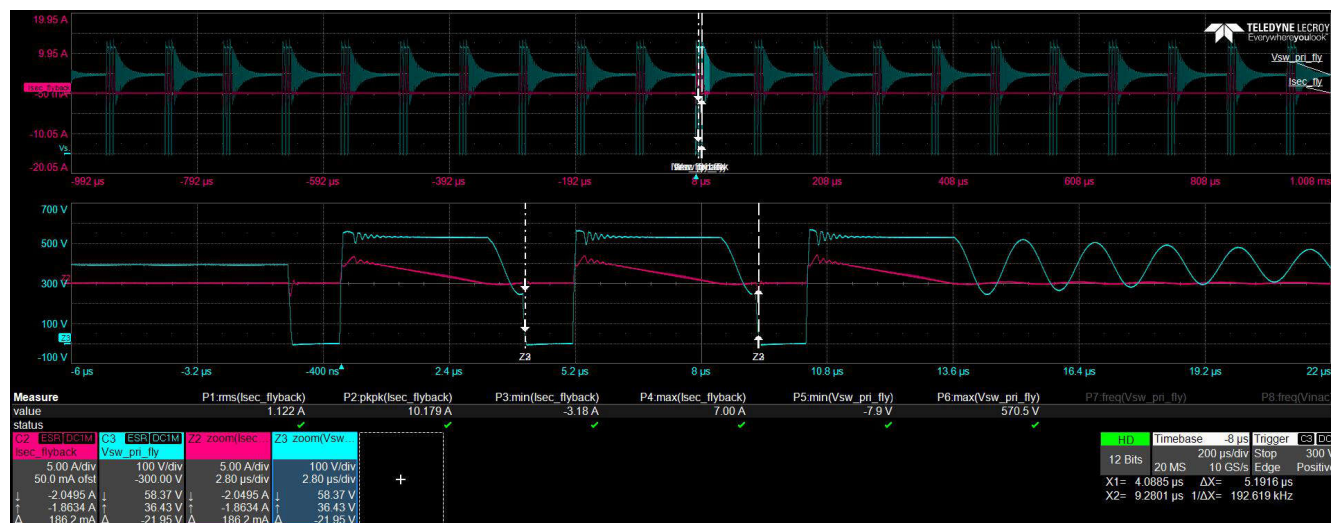
Figure 3-20. Switching Behavior at $V_{out} = 28V$ and $I_{out} = 0.1A$



C2 = Flyback secondary side current

C3 = Flyback primary side switch node voltage

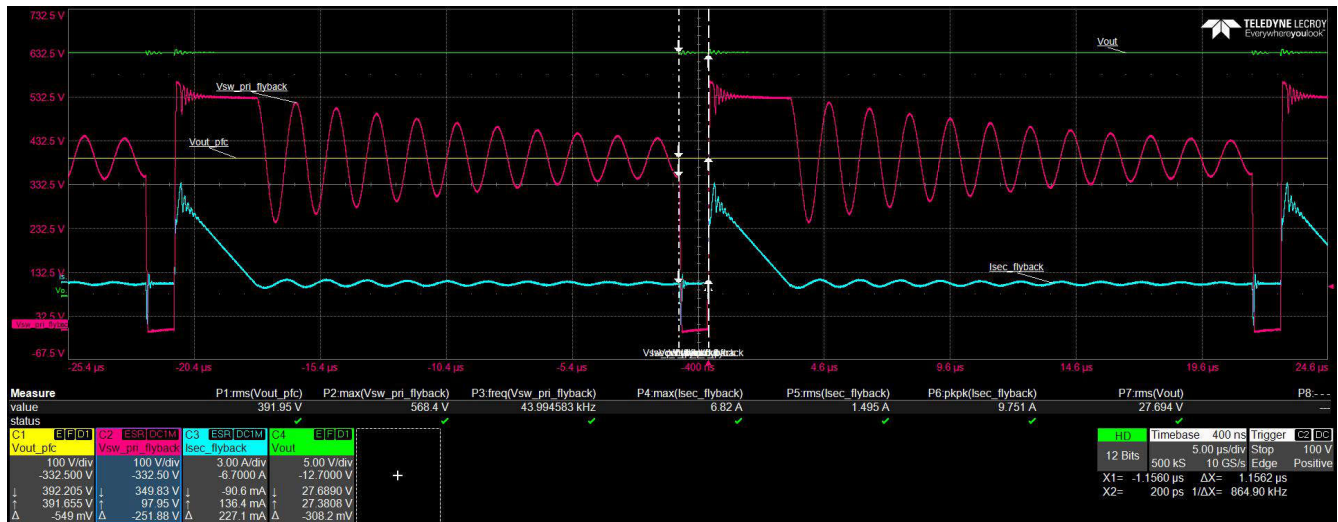
Figure 3-21. Switching Behavior at $V_{out} = 28V$ and $I_{out} = 0.2A$



C2 = Flyback secondary side current

C3 = Flyback primary side switch node voltage

Figure 3-22. Switching Behavior at $V_{out} = 28V$ and $I_{out} = 0.3A$



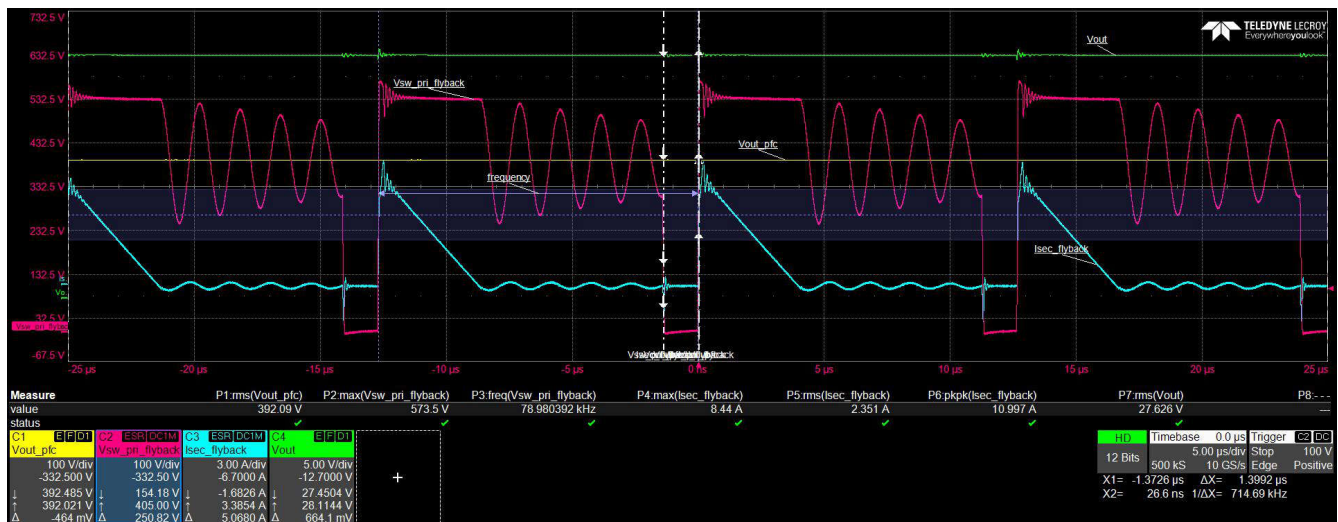
C1 = PFC output voltage

C2 = Flyback primary side
switch node voltage

C3 = flyback secondary side
current

C4 = output voltage

Figure 3-23. Switching Behavior at $V_{out} = 28V$ and $I_{out} = 0.43A$



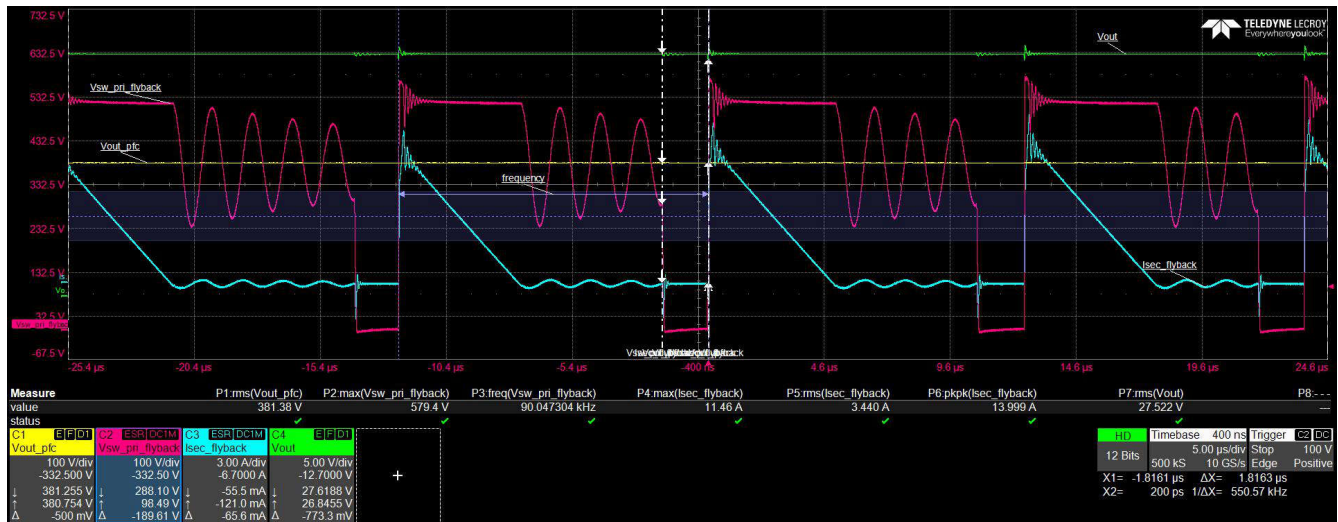
C1 = PFC output voltage

C2 = Flyback primary side
switch node voltage

C3 = flyback secondary side
current

C4 = output voltage

Figure 3-24. Switching Behavior at $V_{out} = 28V$ and $I_{out} = 1.075A$



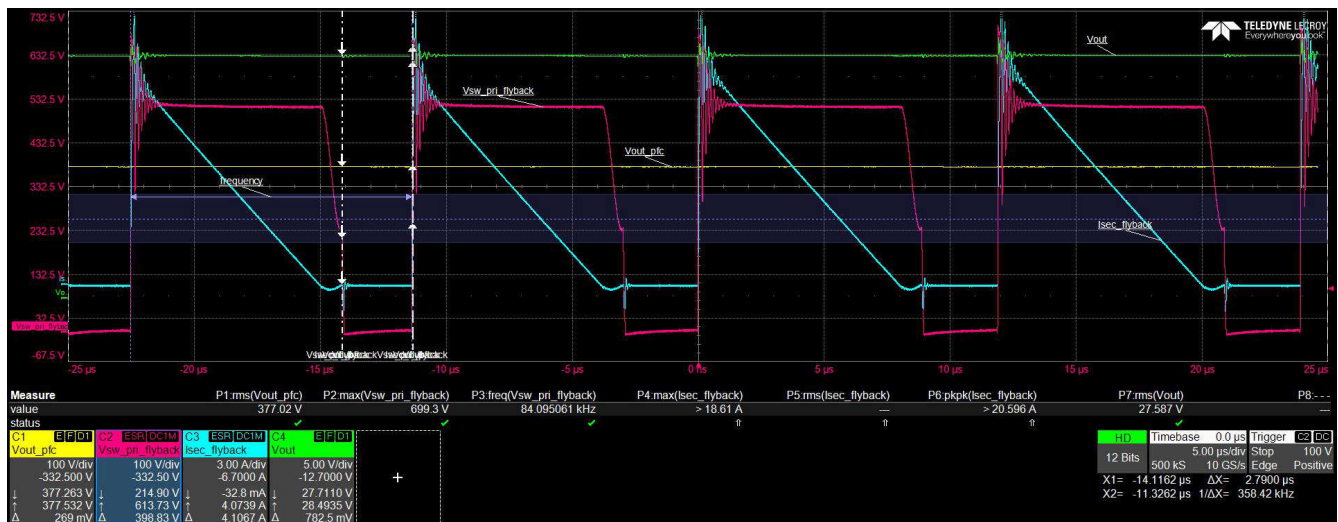
C1 = PFC output voltage

C2 = Flyback primary side
switch node voltage

C3 = flyback secondary side
current

C4 = output voltage

Figure 3-25. Switching Behavior at $V_{out} = 28V$ and $I_{out} = 2.15A$



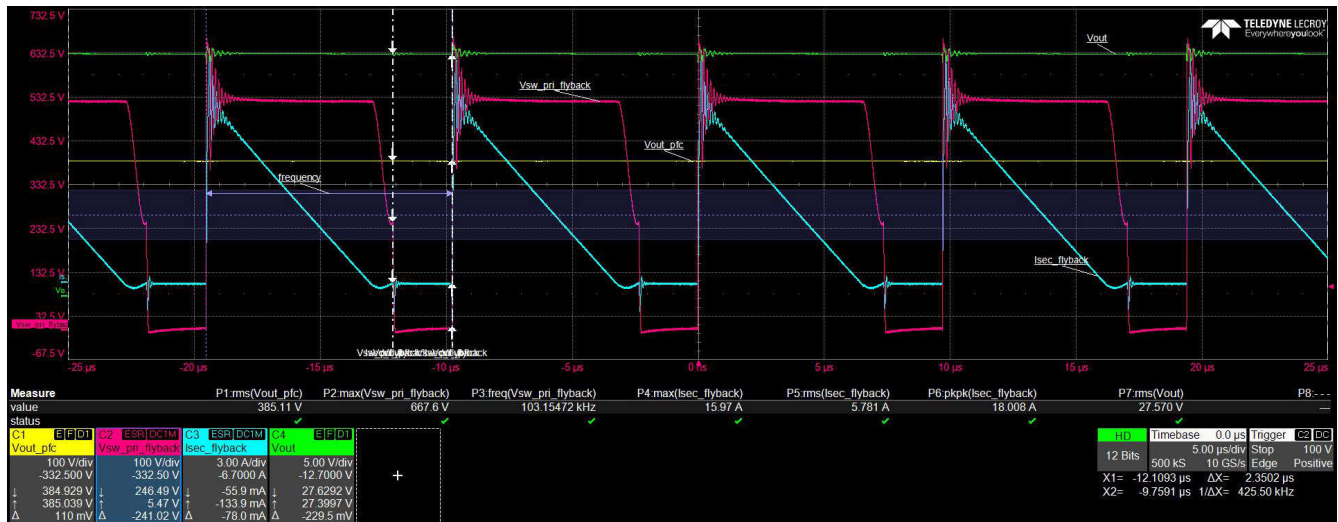
C1 = PFC output voltage

C2 = Flyback primary side
switch node voltage

C3 = flyback secondary side
current

C4 = output voltage

Figure 3-26. Switching Behavior at $V_{out} = 28V$ and $I_{out} = 3.225A$



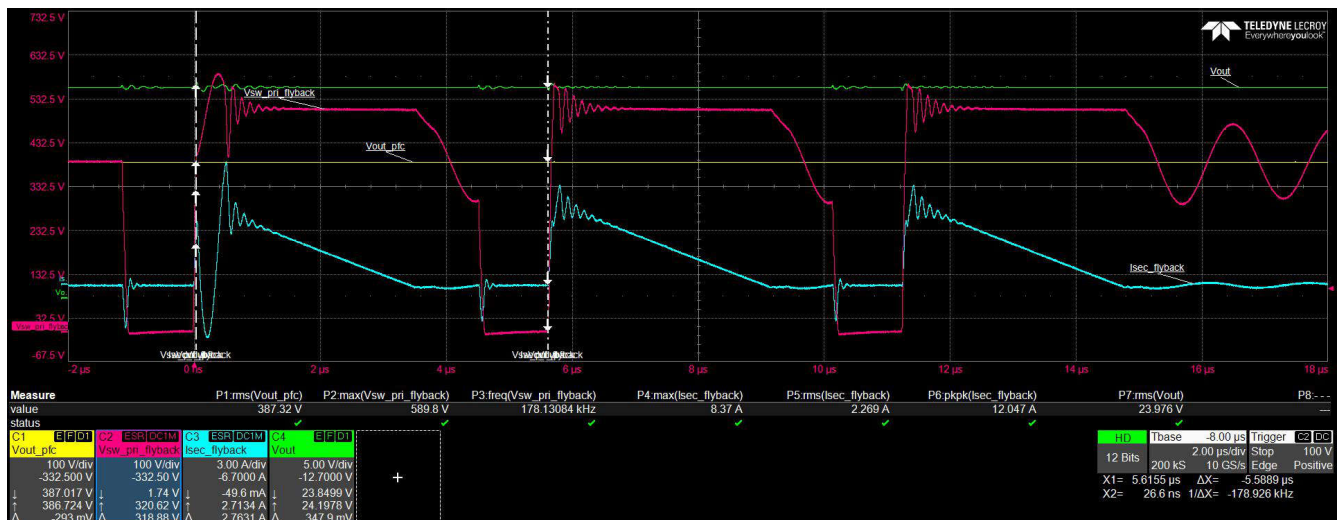
C1 = PFC output voltage

C2 = Flyback primary side
switch node voltage

C3 = flyback secondary side
current

C4 = output voltage

Figure 3-27. Switching Behavior at $V_{out} = 28V$ and $I_{out} = 4.3A$



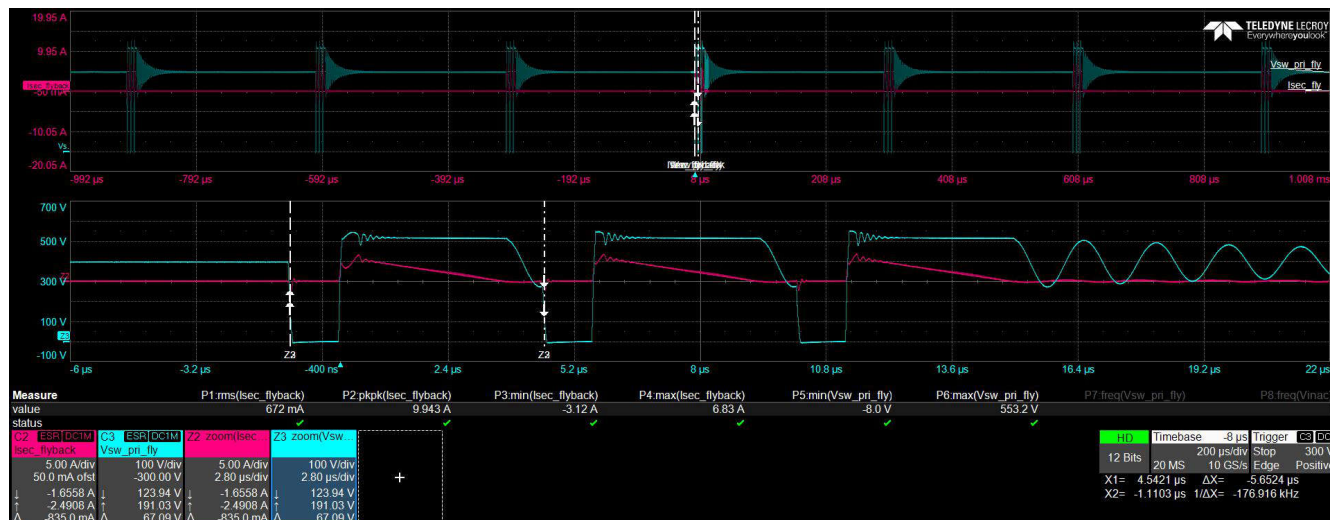
C1 = PFC output voltage

C2 = Flyback primary side
switch node voltage

C3 = flyback secondary side
current

C4 = output voltage

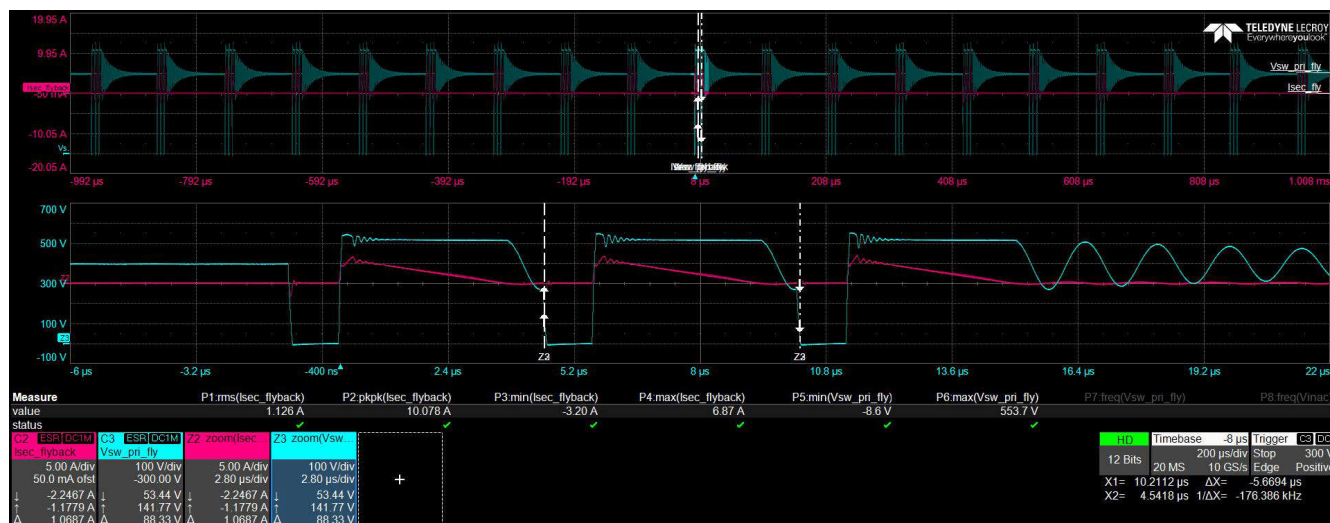
Figure 3-28. Switching Behavior at $V_{out} = 24V$ and $I_{out} = 0A$



C2 = Flyback secondary side current

C3 = Flyback primary side switch node voltage

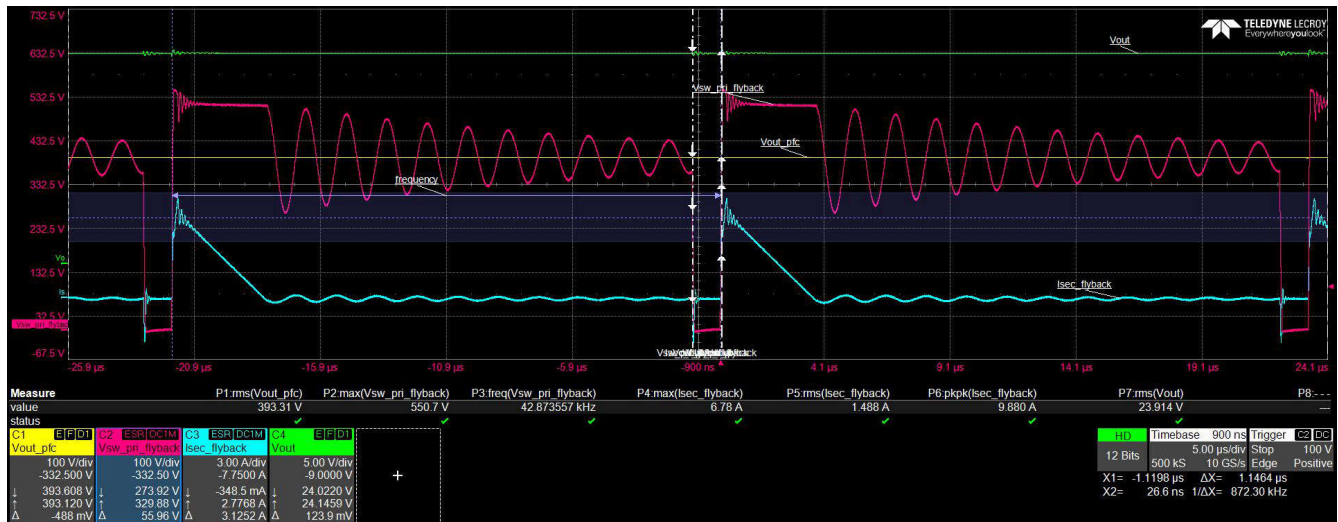
Figure 3-29. Switching Behavior at $V_{out} = 24V$ and $I_{out} = 0.1A$



C2 = Flyback secondary side current

C3 = Flyback primary side switch node voltage

Figure 3-30. Switching Behavior at $V_{out} = 24V$ and $I_{out} = 0.3A$



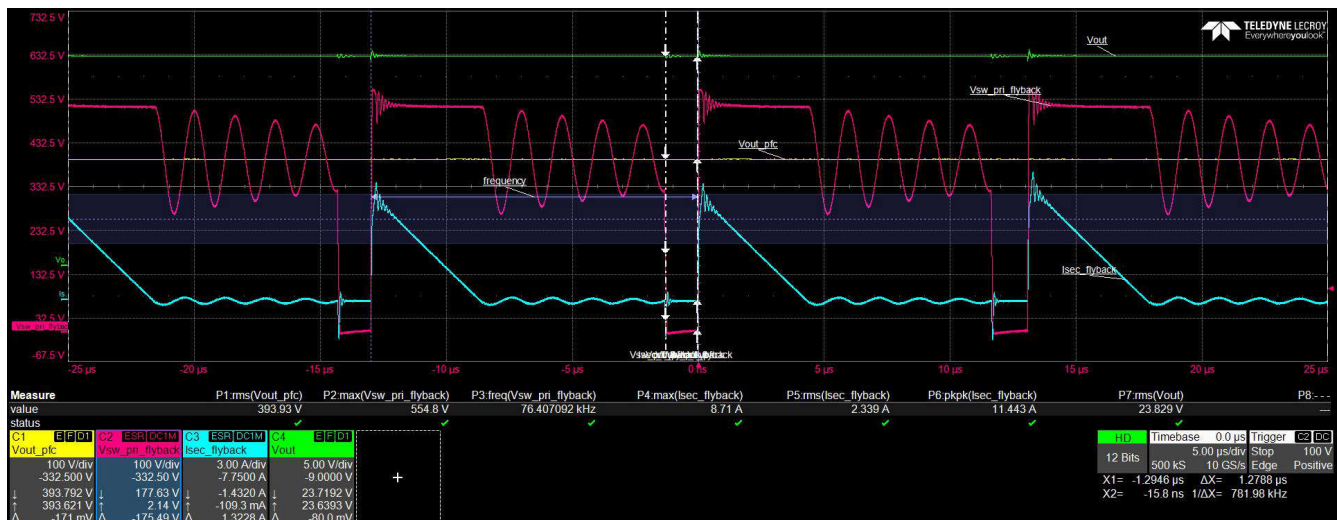
C1 = PFC output voltage

C2 = Flyback primary side
switch node voltage

C3 = flyback secondary side
current

C4 = output voltage

Figure 3-31. Switching Behavior at $V_{out} = 24V$ and $I_{out} = 0.5A$



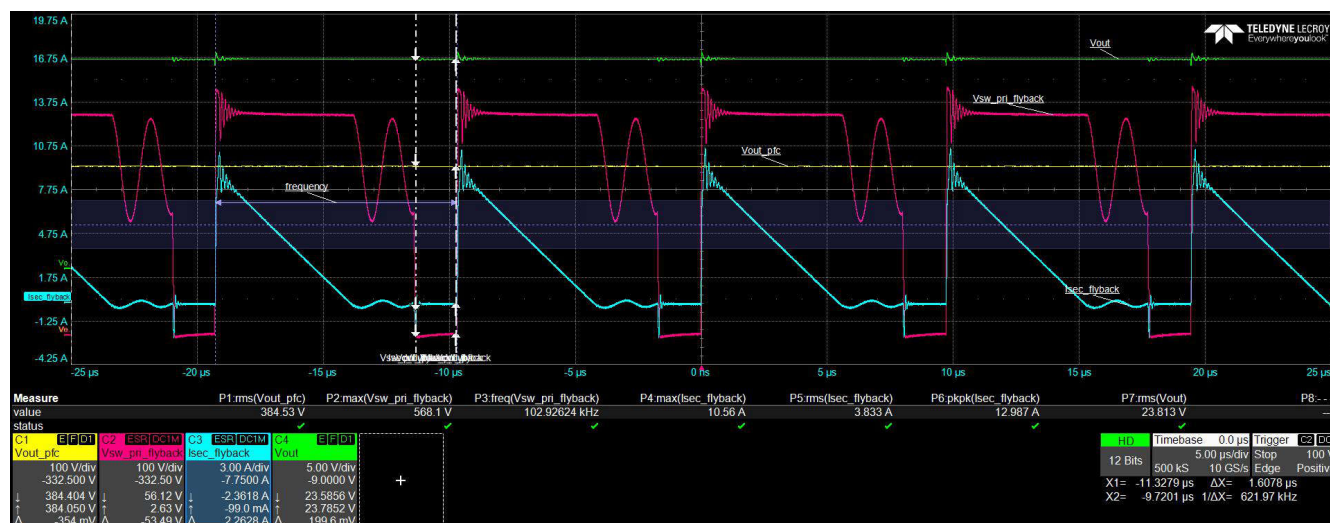
C1 = PFC output voltage

C2 = Flyback primary side
switch node voltage

C3 = flyback secondary side
current

C4 = output voltage

Figure 3-32. Switching Behavior at $V_{out} = 24V$ and $I_{out} = 1.25A$



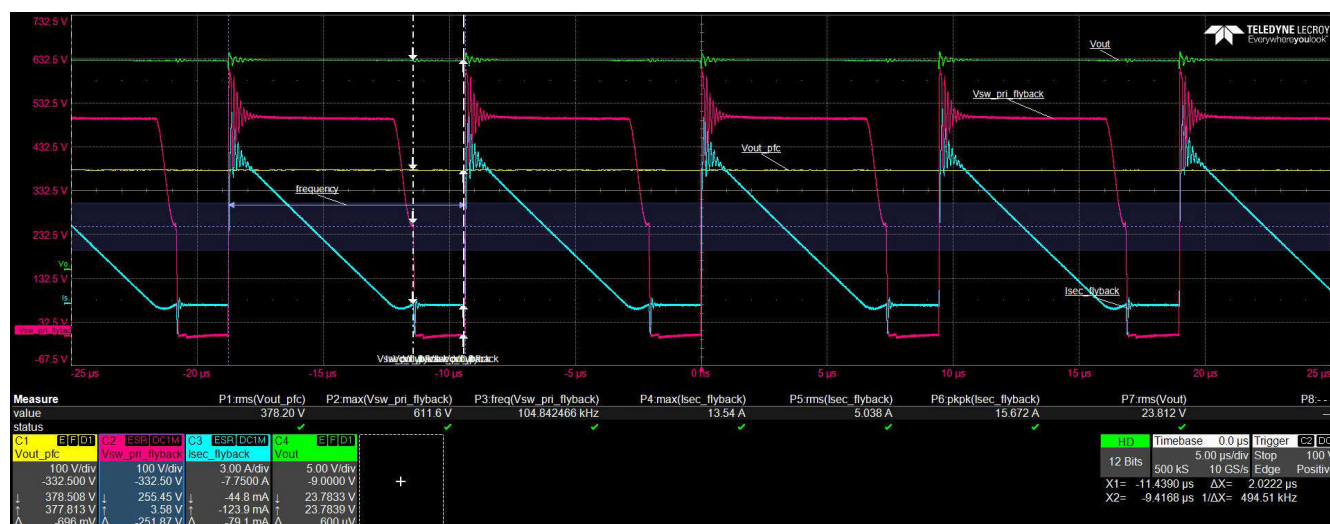
C1 = PFC output voltage

C2 = Flyback primary side
switch node voltage

C3 = flyback secondary side
current

C4 = output voltage

Figure 3-33. Switching Behavior at $V_{out} = 24V$ and $I_{out} = 2.5A$



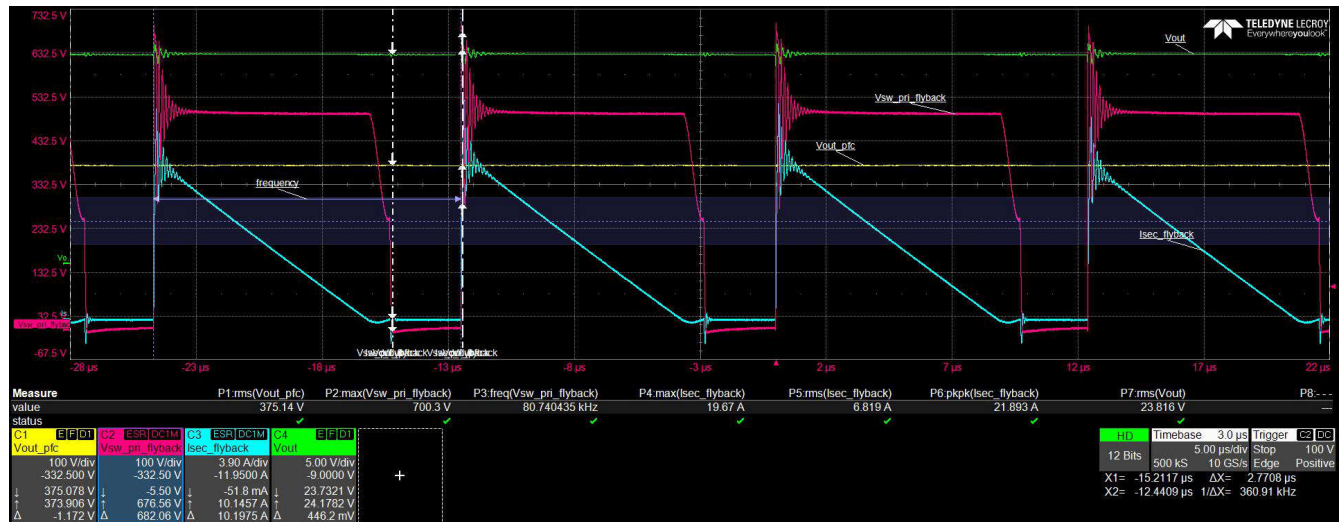
C1 = PFC output voltage

C2 = Flyback primary side
switch node voltage

C3 = flyback secondary side
current

C4 = output voltage

Figure 3-34. Switching Behavior at $V_{out} = 24V$ and $I_{out} = 3.75A$



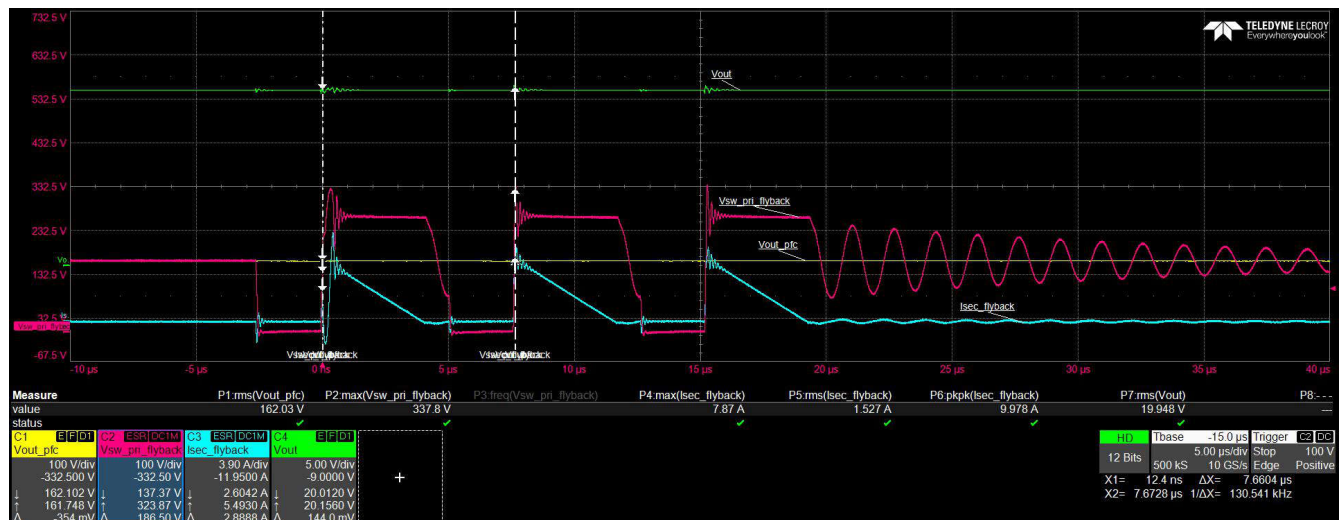
C1 = PFC output voltage

C2 = Flyback primary side
switch node voltage

C3 = flyback secondary side
current

C4 = output voltage

Figure 3-35. Switching Behavior at $V_{out} = 24V$ and $I_{out} = 5A$



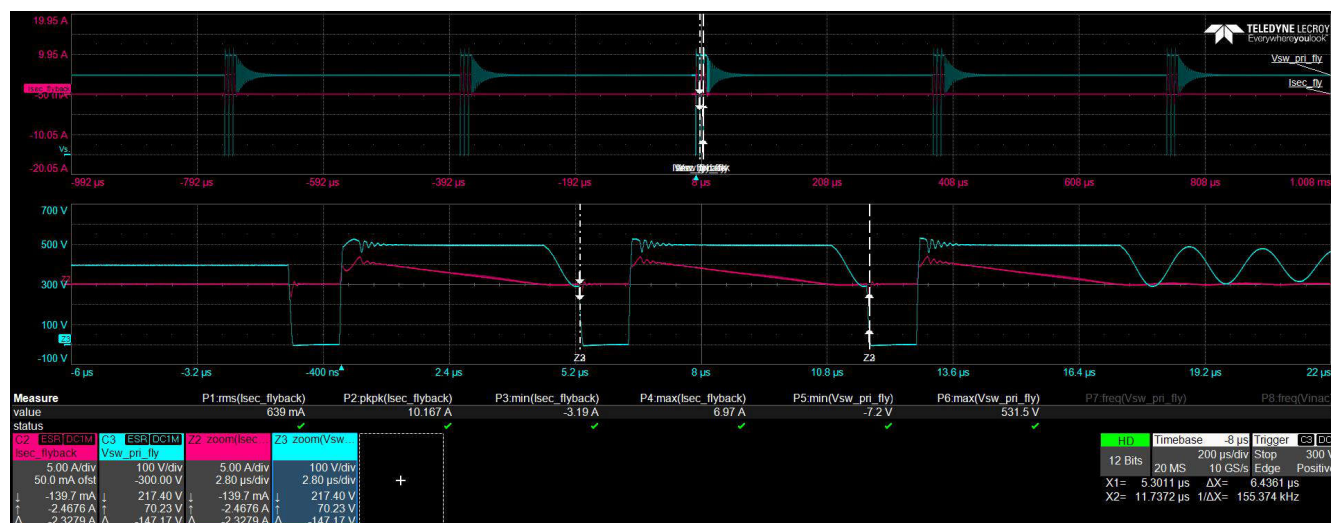
C1 = PFC output voltage

C2 = Flyback primary side
switch node voltage

C3 = flyback secondary side
current

C4 = output voltage

Figure 3-36. Switching Behavior at $V_{out} = 20V$ and $I_{out} = 0A$



C1 = PFC output voltage

C2 = Flyback primary side
switch node voltage

C3 = flyback secondary side
current

C4 = output voltage

Figure 3-37. Switching Behavior at $V_{out} = 20V$ and $I_{out} = 0.1A$

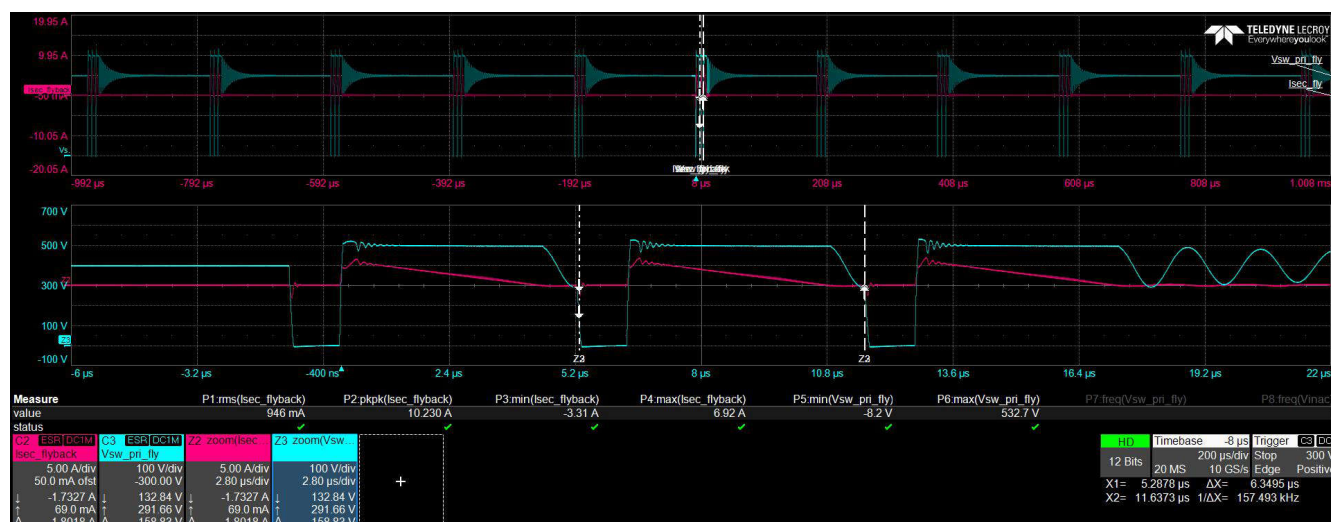


Figure 3-38. Switching Behavior at $V_{out} = 20V$ and $I_{out} = 0.2A$

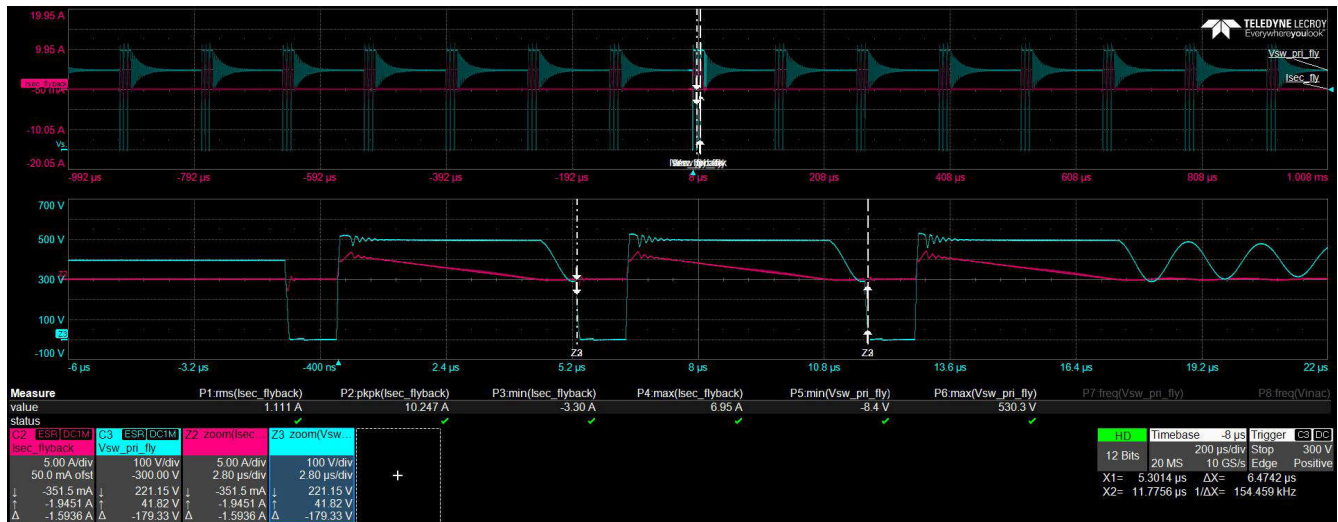
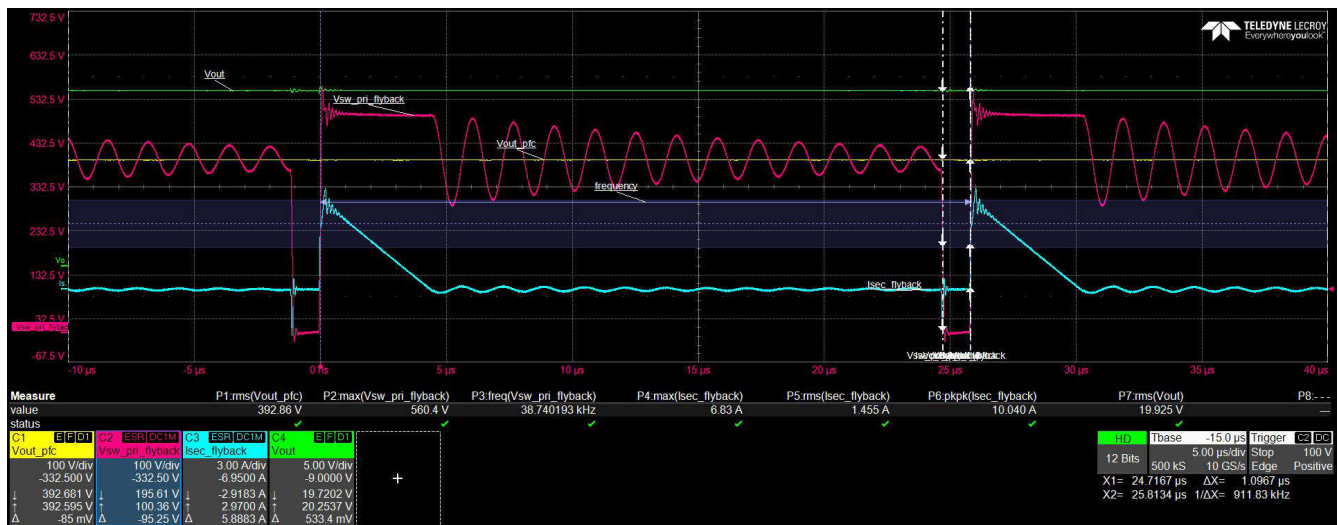


Figure 3-39. Switching Behavior at $V_{out} = 20V$ and $I_{out} = 0.3A$



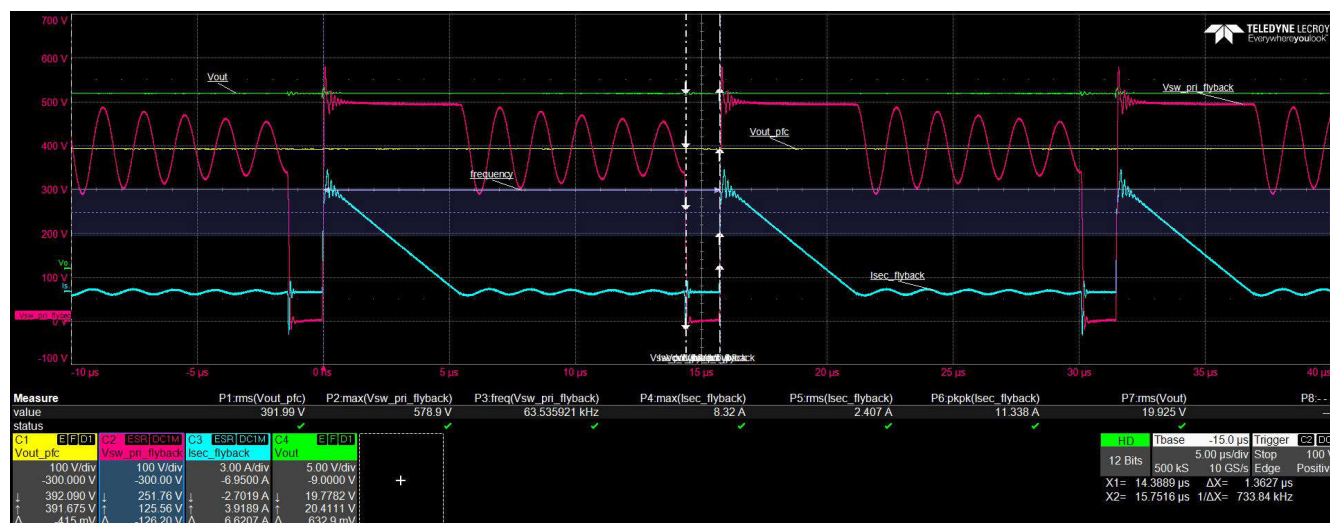
C1 = PFC output voltage

C2 = Flyback primary side
switch node voltage

C3 = flyback secondary side
current

C4 = output voltage

Figure 3-40. Switching Behavior at $V_{out} = 20V$ and $I_{out} = 0.5A$



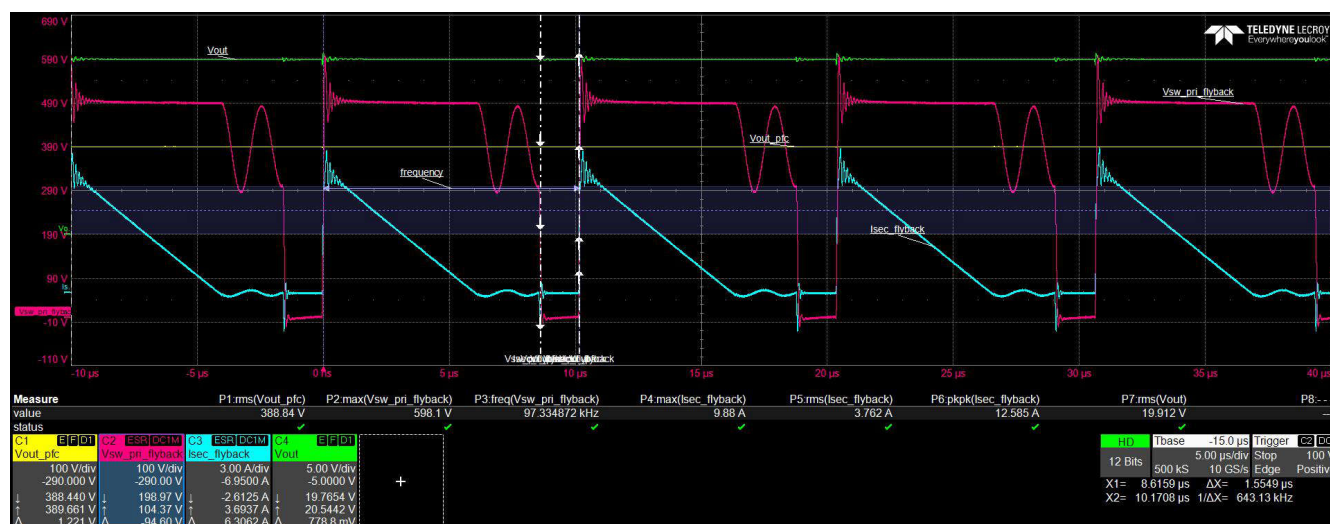
C1 = PFC output voltage

C2 = Flyback primary side
switch node voltage

C3 = flyback secondary side
current

C4 = output voltage

Figure 3-41. Switching Behavior at $V_{out} = 20V$ and $I_{out} = 1.25A$



C1 = PFC output voltage

C2 = Flyback primary side
switch node voltage

C3 = flyback secondary side
current

C4 = output voltage

Figure 3-42. Switching Behavior at $V_{out} = 20V$ and $I_{out} = 2.5A$

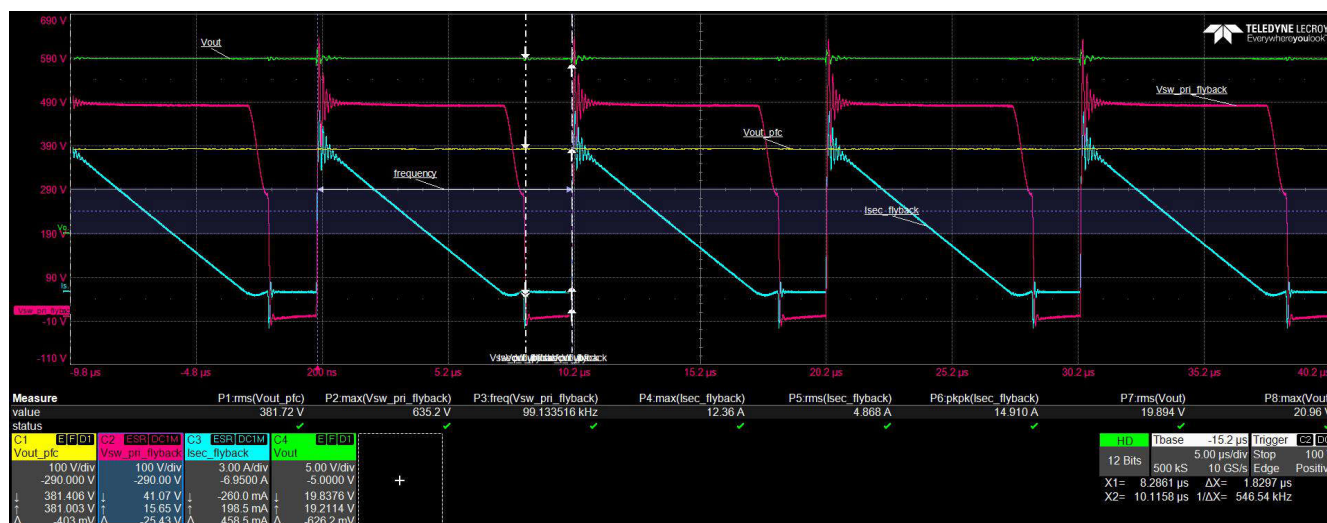
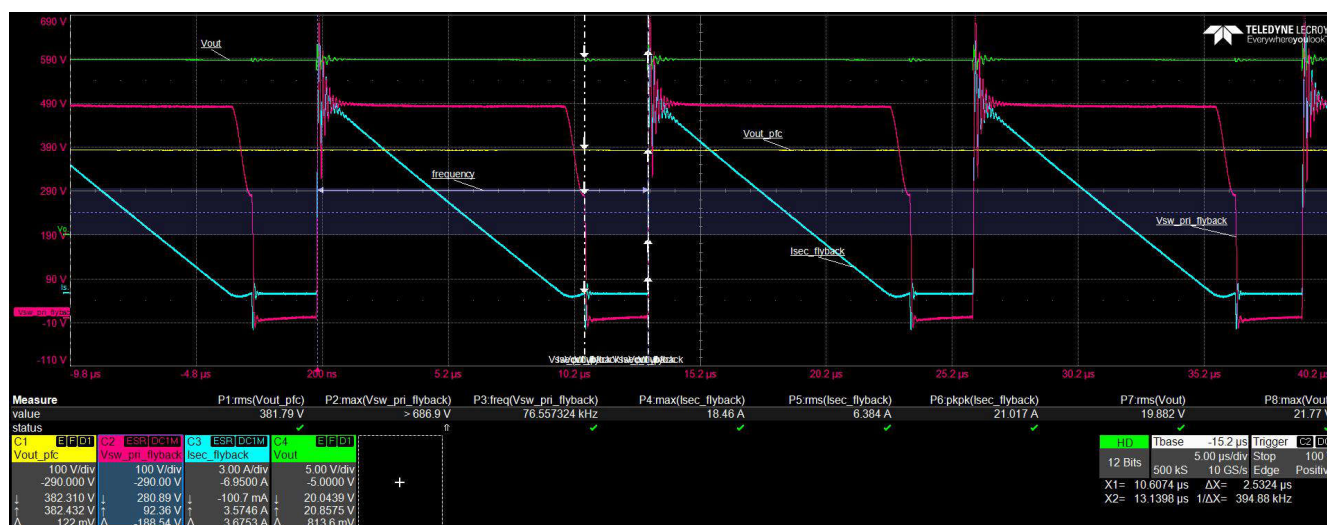


Figure 3-43. Switching Behavior at $V_{out} = 20V$ and $I_{out} = 3.75A$



C1 = PFC output voltage

C2 = Flyback primary side
switch node voltage

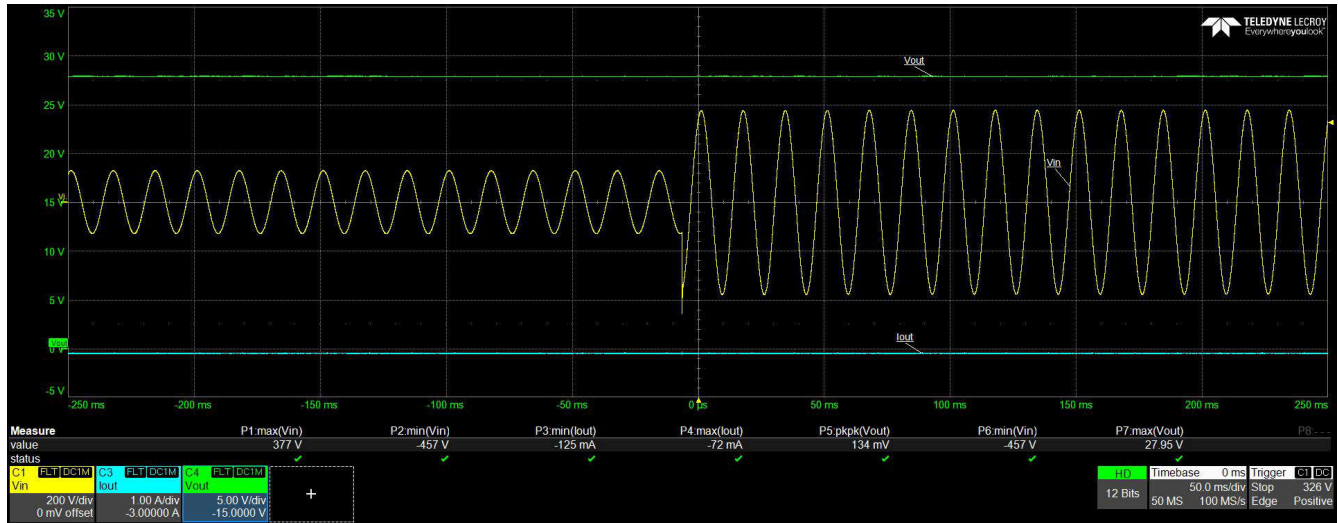
C3 = flyback secondary side
current

C4 = output voltage

Figure 3-44. Switching Behavior at $V_{out} = 20V$ and $I_{out} = 5A$

3.8 Line Transient Response

This section demonstrates the ability of the EVM to maintain a stable DC output voltage during large variations in the AC input voltage. The waveforms show the system response as the input voltage is stepped from a minimum of 90 VAC to a maximum of 264 VAC at 60Hz.

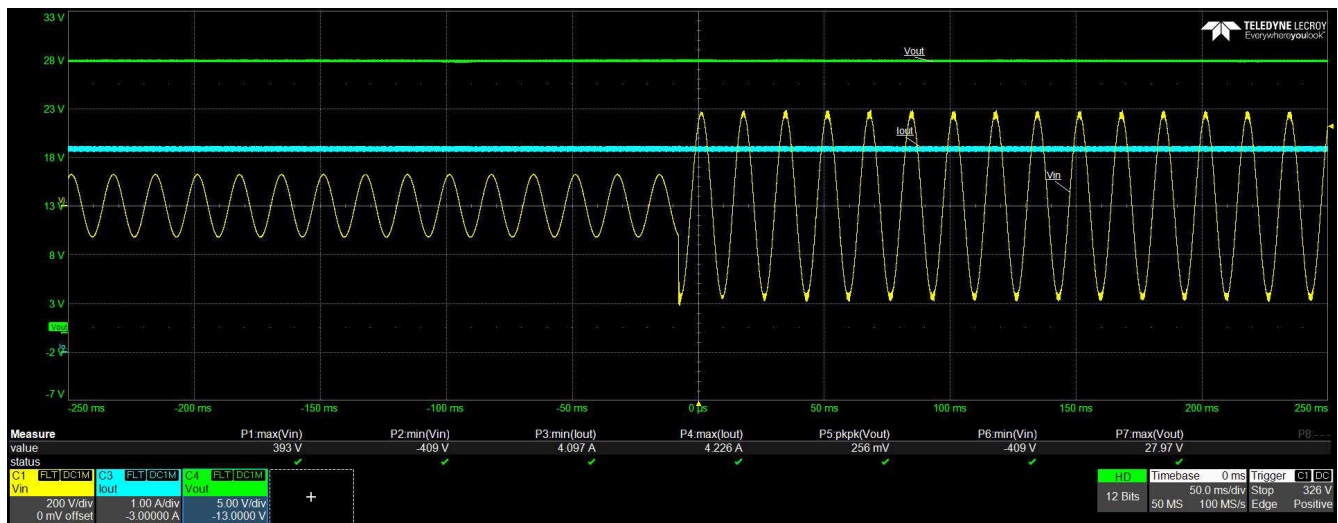


C1= AC input voltage

C3 = Flyback output Current

C4 = Flyback output voltage

Figure 3-45. Line Transient Waveform: $V_{in} = 90\text{VAC}$ to $264\text{VAC}/60\text{Hz}$, $V_{out} = 28\text{V}$, and $I_{out} = 0\text{A}$



C1= AC input voltage

C3 = Flyback output Current

C4 = Flyback output voltage

Figure 3-46. Line Transient Waveform: $V_{in} = 90\text{VAC}$ to $264\text{VAC}/60\text{Hz}$, $V_{out} = 28\text{V}$, and $I_{out} = 4.3\text{A}$

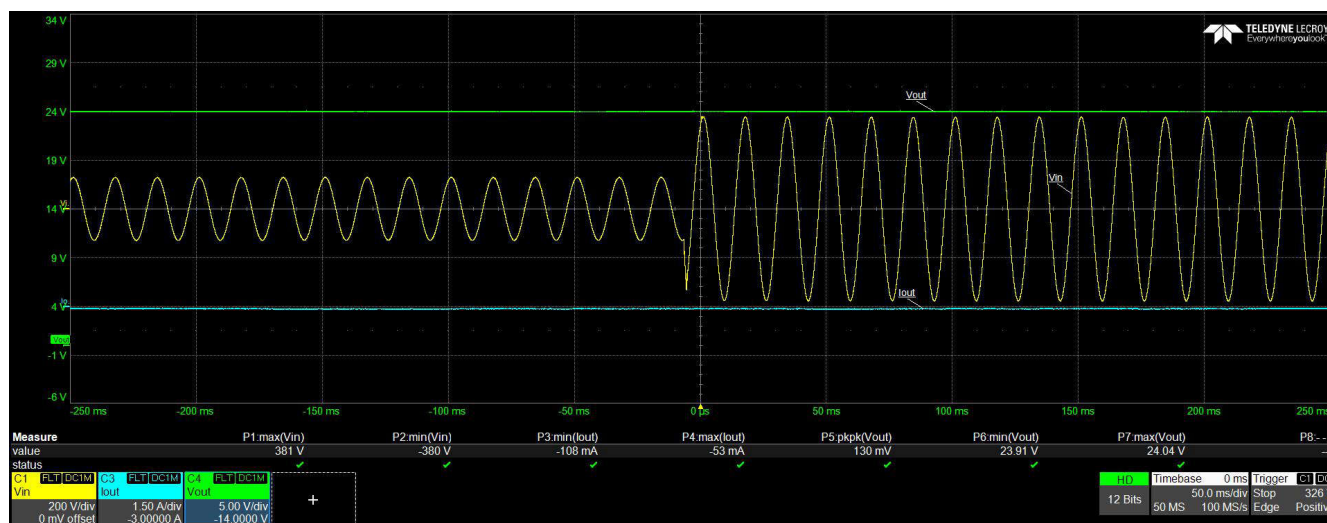


Figure 3-47. Line Transient Waveform: $V_{in} = 90\text{VAC}$ to $264\text{VAC}/60\text{Hz}$, $V_{out} = 24\text{V}$, and $I_{out} = 0\text{A}$

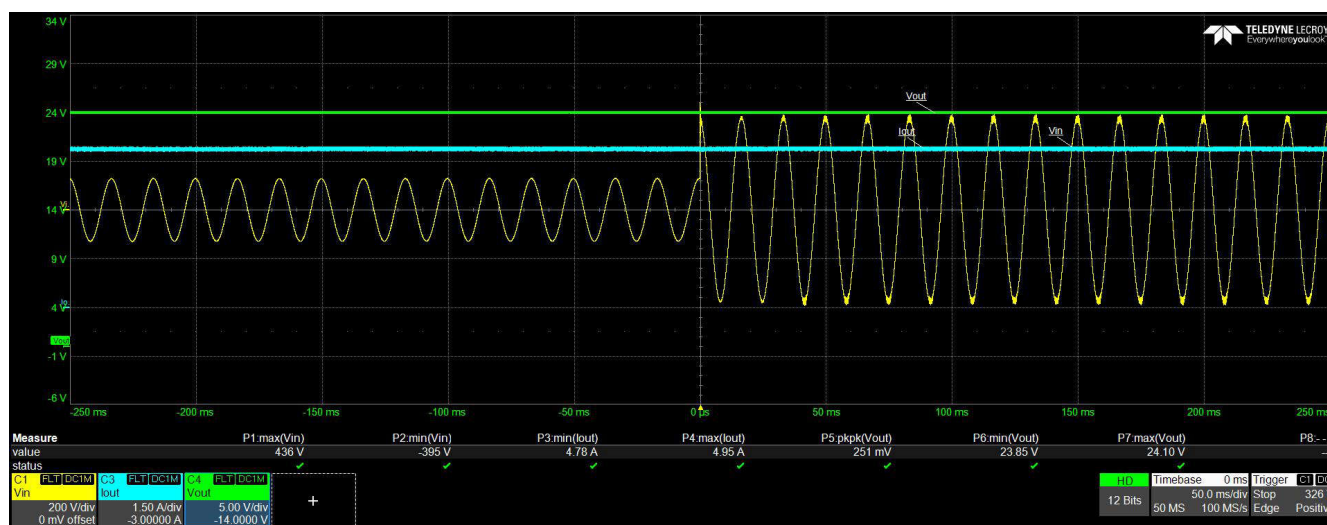
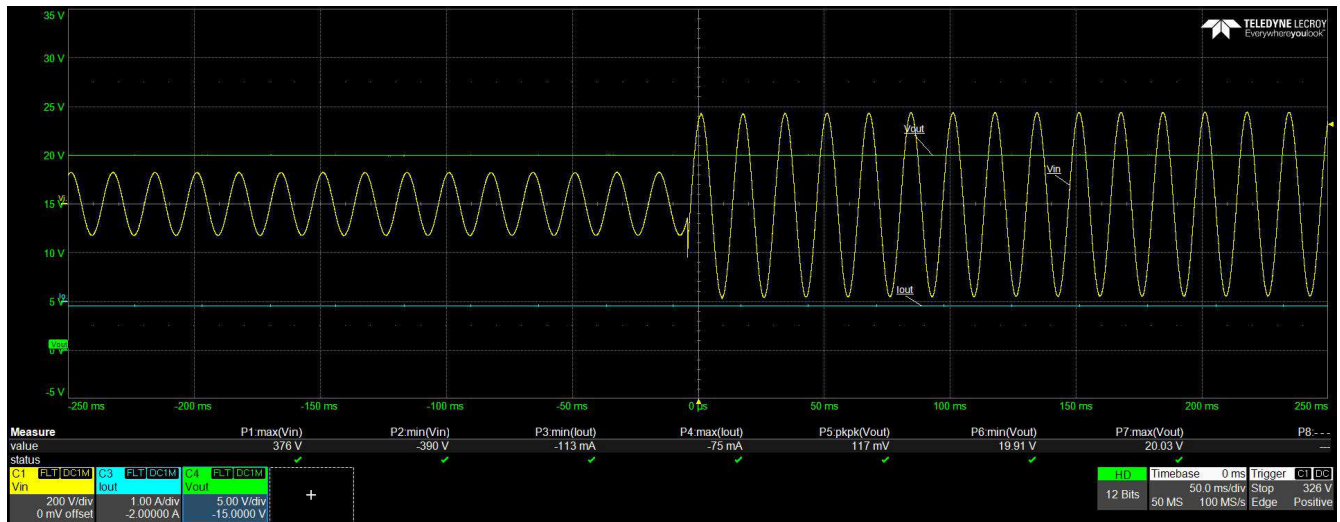


Figure 3-48. Line Transient Waveform: $V_{in} = 90\text{VAC}$ to $264\text{VAC}/60\text{Hz}$, $V_{out} = 24\text{V}$, and $I_{out} = 5\text{A}$

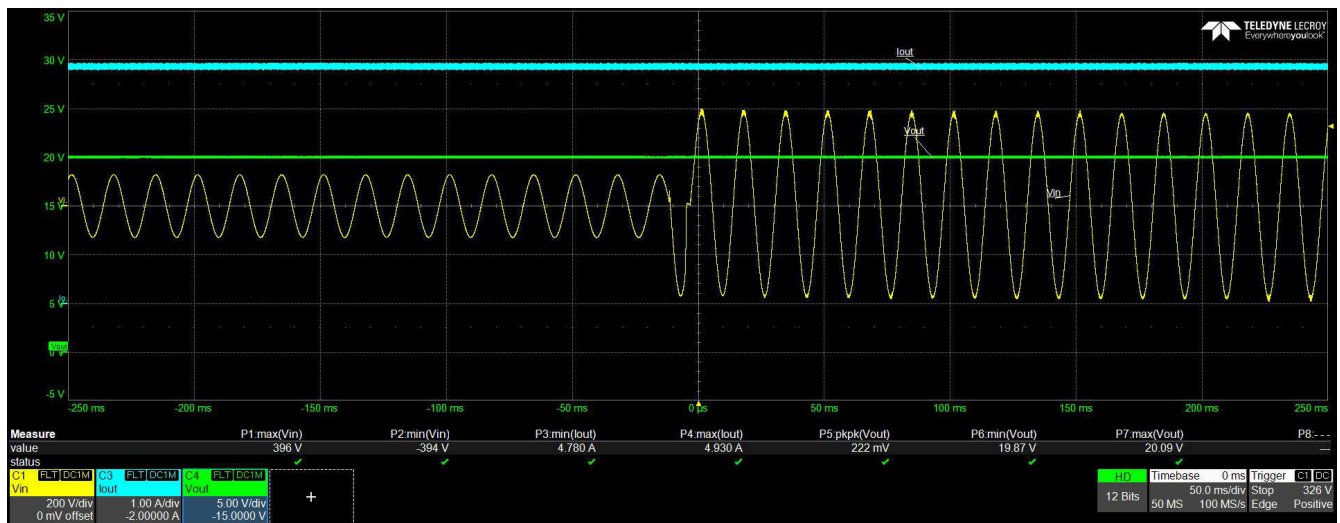


C1= AC input voltage

C3 = Flyback output Current

C4 = Flyback output voltage

Figure 3-49. Line Transient Waveform: $V_{in} = 90\text{VAC}$ to $264\text{VAC}/60\text{Hz}$, $V_{out} = 20\text{V}$, and $I_{out} = 0\text{A}$



C1= AC input voltage

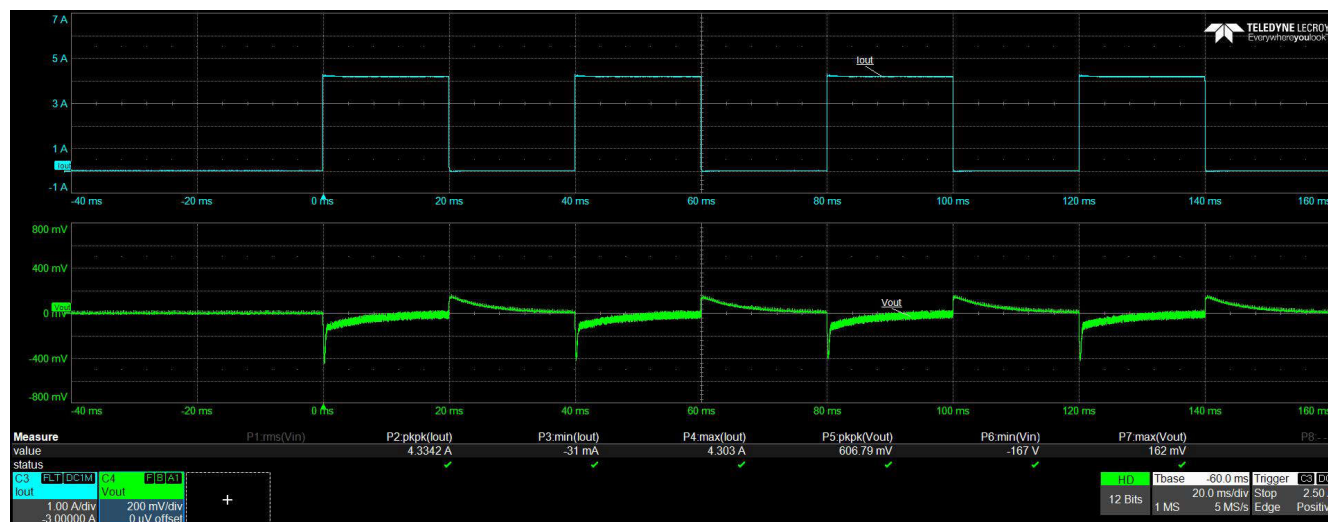
C3 = Flyback output Current

C4 = Flyback output voltage

Figure 3-50. Line Transient Waveform: $V_{in} = 90\text{VAC}$ to $264\text{VAC}/60\text{Hz}$, $V_{out} = 20\text{V}$, and $I_{out} = 5\text{A}$

3.9 Load Transient Waveform

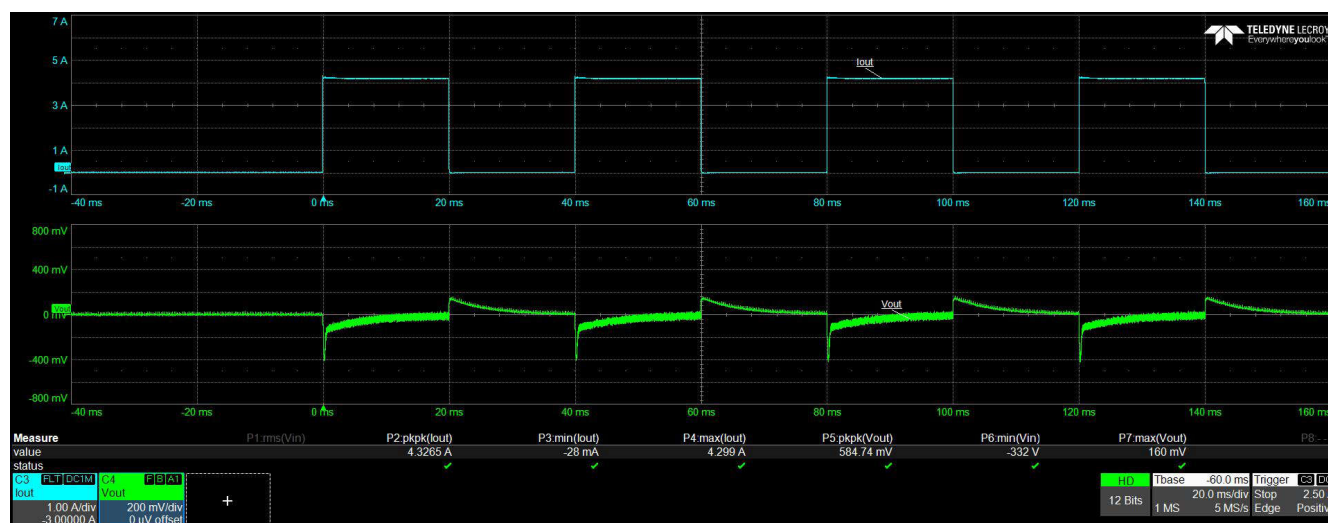
This section demonstrates the ability of the EVM to maintain a stable DC output voltage during step load transient for 2% to 100% load with slew rate of $2.5\text{A}/\mu\text{s}$ (both rising and falling edge) at frequency of 25Hz. Below waveforms are for input 115VAC/60Hz and 230VAC/50Hz and output 28V/24V/20V.



C3 = Flyback Output Current

C4 = Flyback Output Voltage

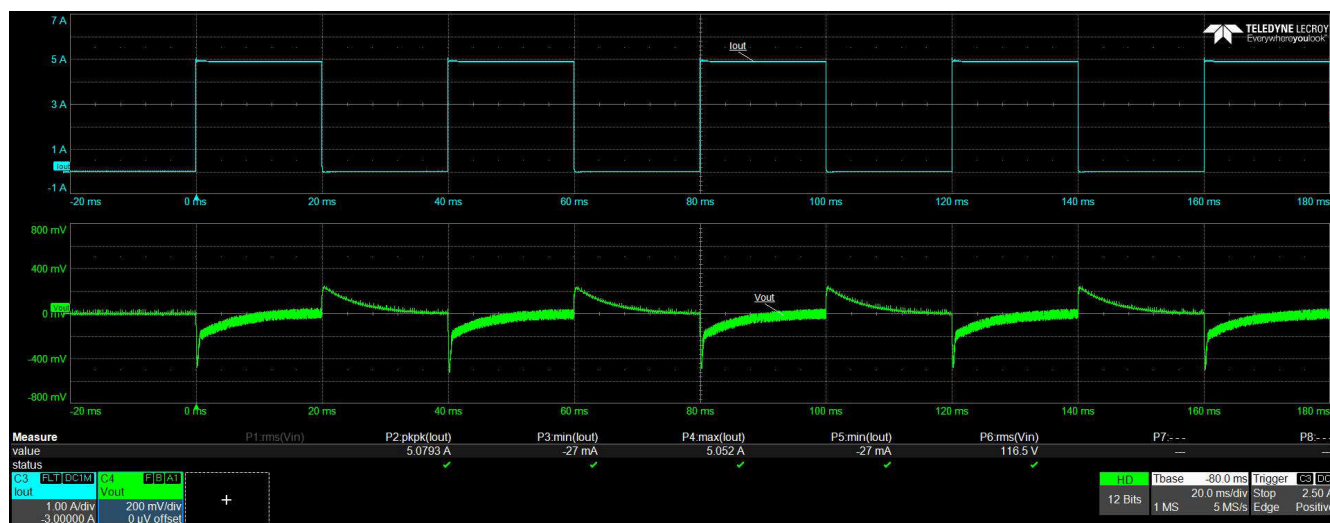
Figure 3-51. Transient Waveform at 115VAC/60Hz and Output 28V/0.1A to 4.3A



C3 = Flyback Output Current

C4 = Flyback Output Voltage

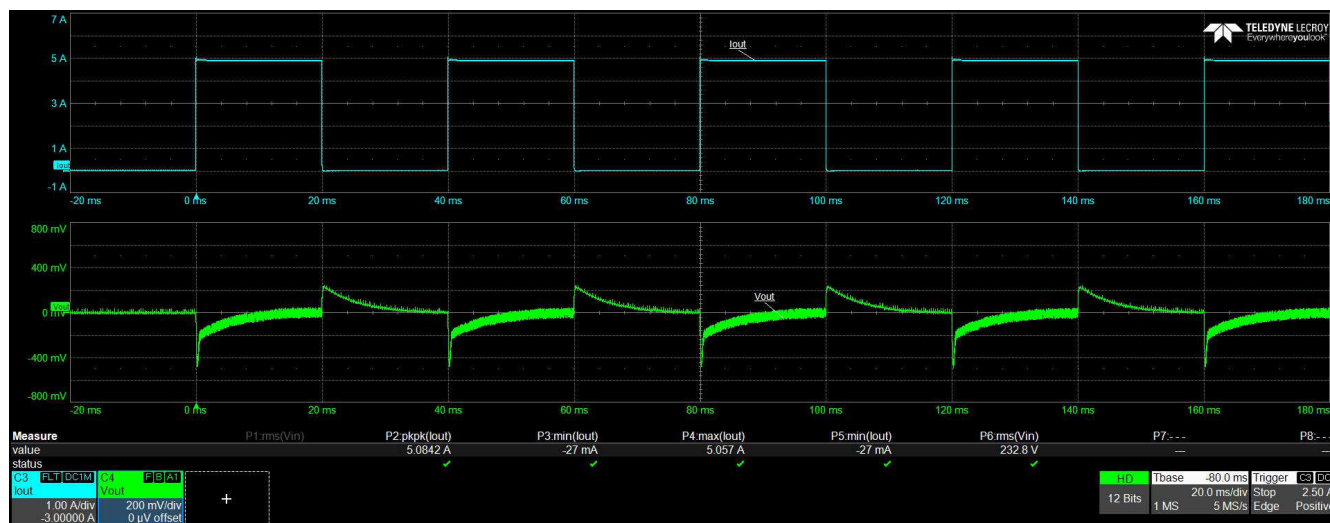
Figure 3-52. Transient Waveform at 230VAC/50Hz and Output 28V/0.1A to 4.3A



C3 = Flyback Output Current

C4 = Flyback Output Voltage

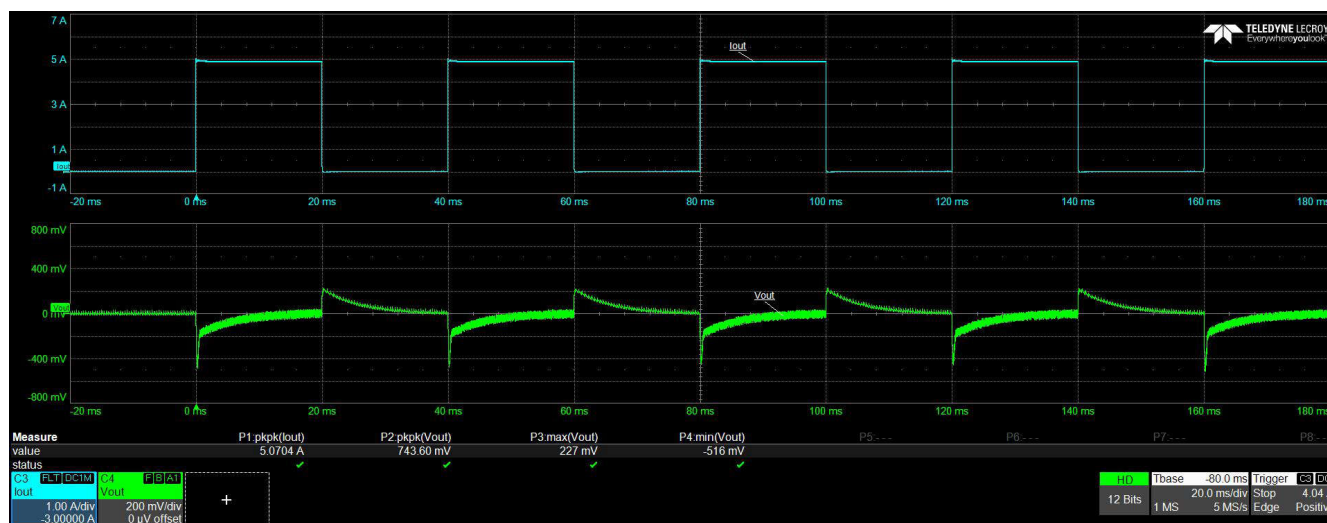
Figure 3-53. Transient Waveform at 115VAC/60Hz and Output 24V/0.1A to 5A



C3 = Flyback Output Current

C4 = Flyback Output Voltage

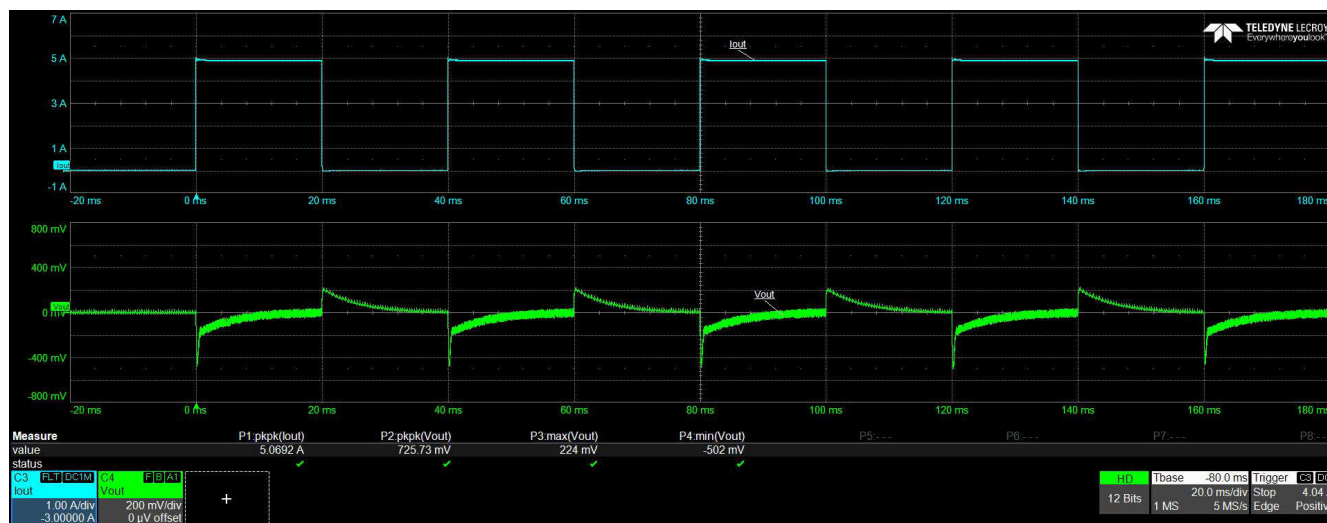
Figure 3-54. Transient Waveform at 230VAC/50Hz and Output 24V/0.1A to 5A



C3 = Flyback Output Current

C4 = Flyback Output Voltage

Figure 3-55. Transient Waveform at 115VAC/60Hz and Output 20V/0.1A to 5A



C3 = Flyback Output Current

C4 = Flyback Output Voltage

Figure 3-56. Transient Waveform at 230VAC/50Hz and Output 20V/0.1A to 5A

3.10 Output Ripple Voltage

The following waveforms show the output voltage ripple for 115 VAC/60Hz and 230VAC/50Hz at no-load and full-load for output settings of 20V, 24V and 28V. Here, C4 - Output Voltage Ripple, oscilloscope channel bandwidth = 20MHz and oscilloscope probe is AC coupled.

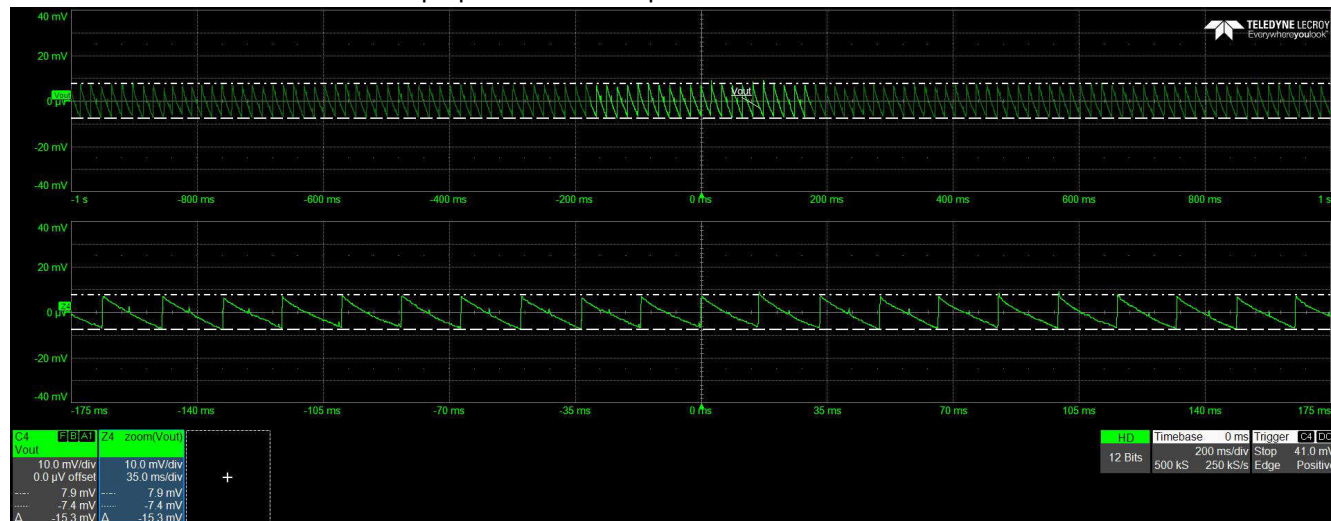


Figure 3-57. Output Voltage Ripple at Input = 115VAC/60Hz and Output = 28V/0A

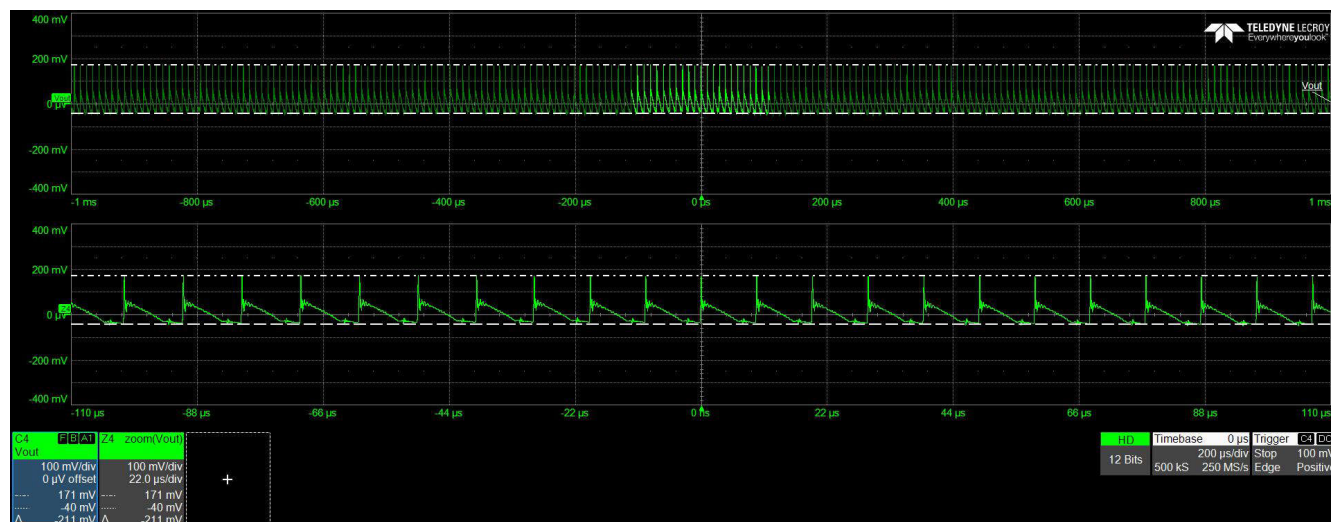


Figure 3-58. Output Voltage Ripple at Input = 115VAC/60Hz and Output = 28V/4.3A

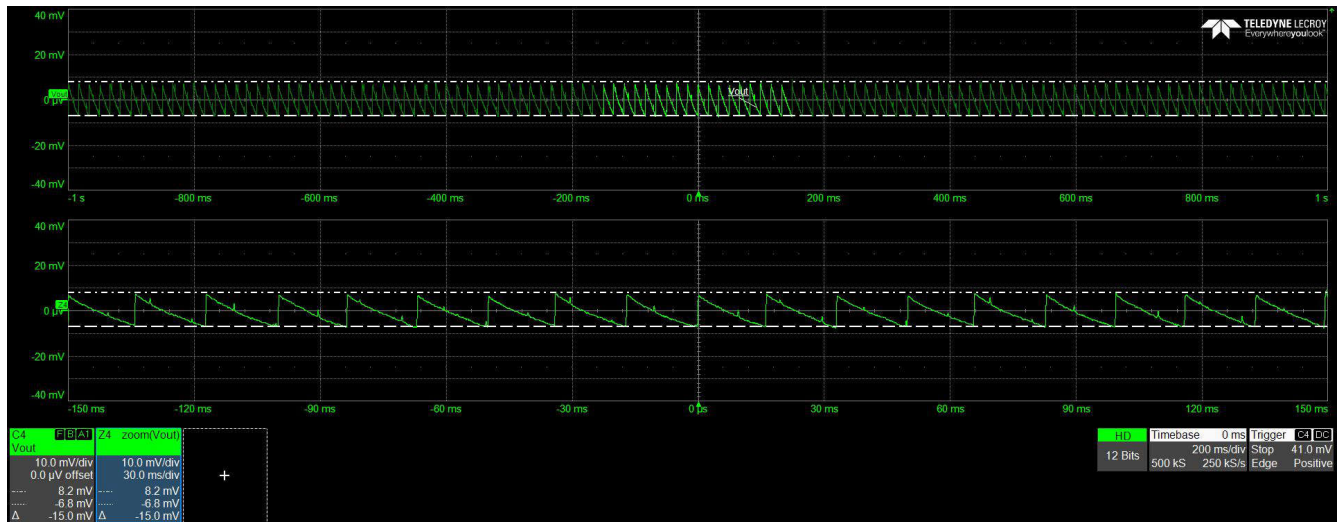


Figure 3-59. Output Voltage Ripple at Input = 230VAC/50Hz and Output = 28V/0A

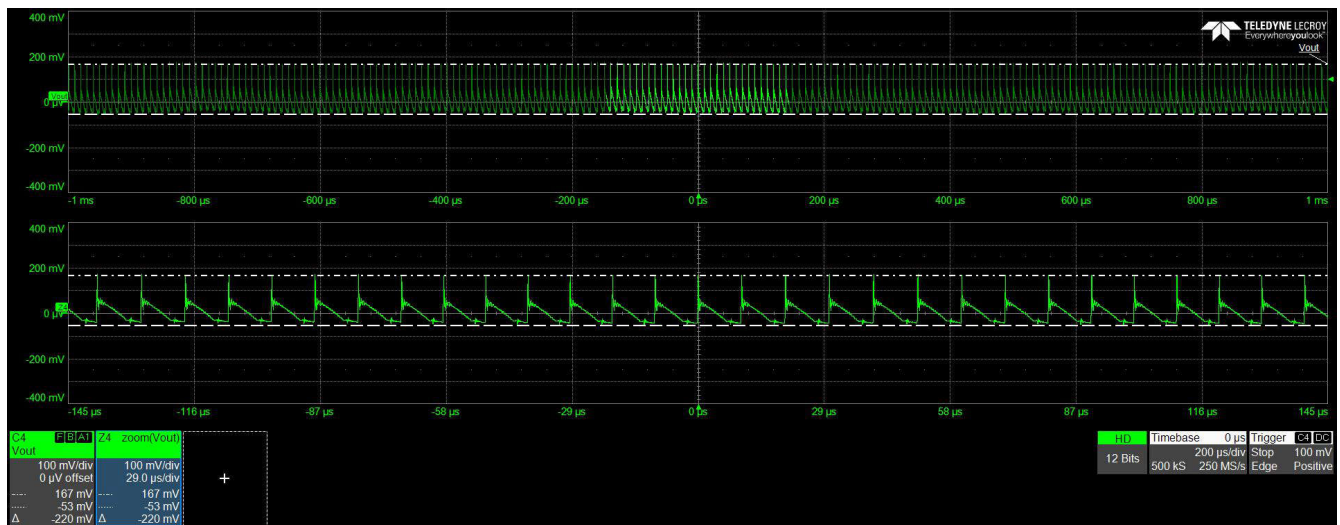


Figure 3-60. Output Voltage Ripple at Input = 230VAC/50Hz and Output = 28V/4.3A

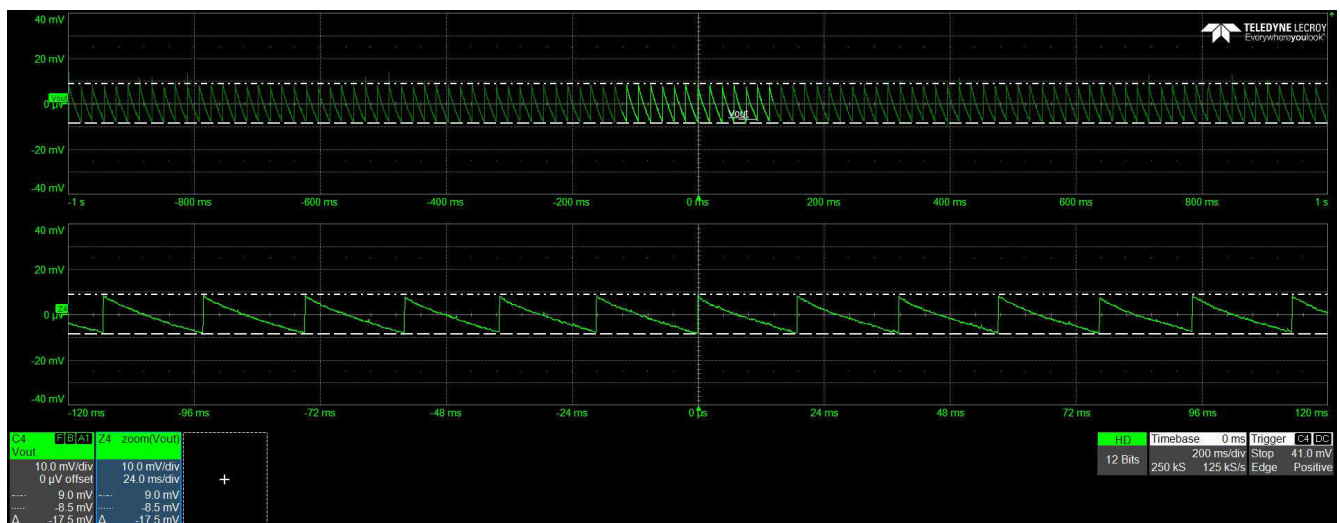


Figure 3-61. Output Voltage Ripple at Input = 115VAC/60Hz and Output = 24V/0A

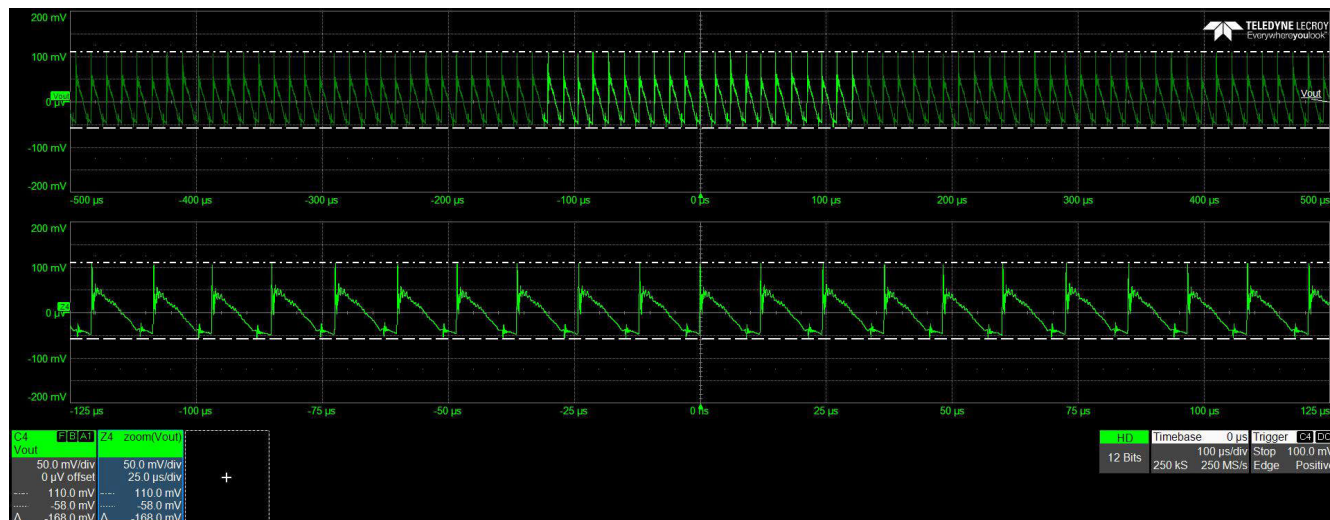


Figure 3-62. Output Voltage Ripple at Input = 1150VAC/60Hz and Output = 24V/5A

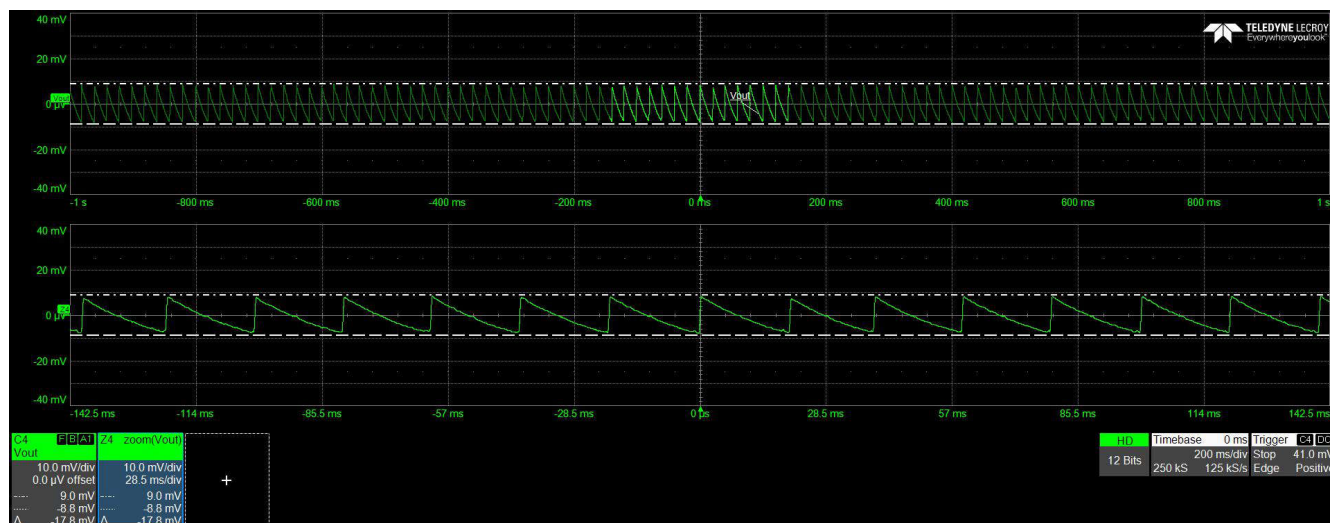


Figure 3-63. Output Voltage Ripple at Input = 230VAC/50Hz and Output = 24V/0A

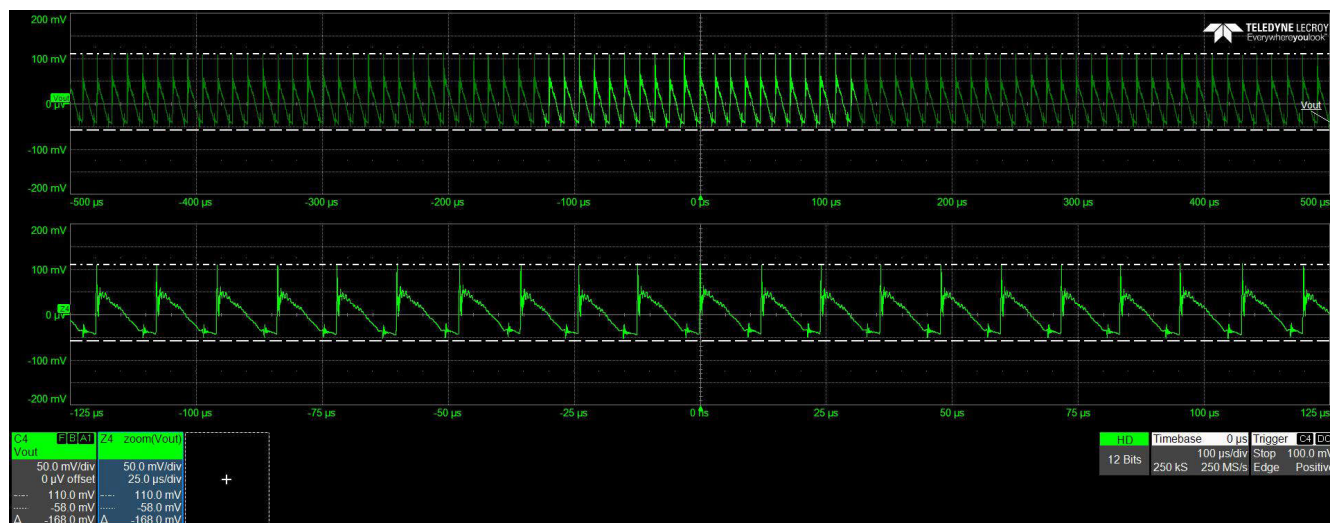


Figure 3-64. Output Voltage Ripple at Input = 230VAC/50Hz and Output = 24V/5A

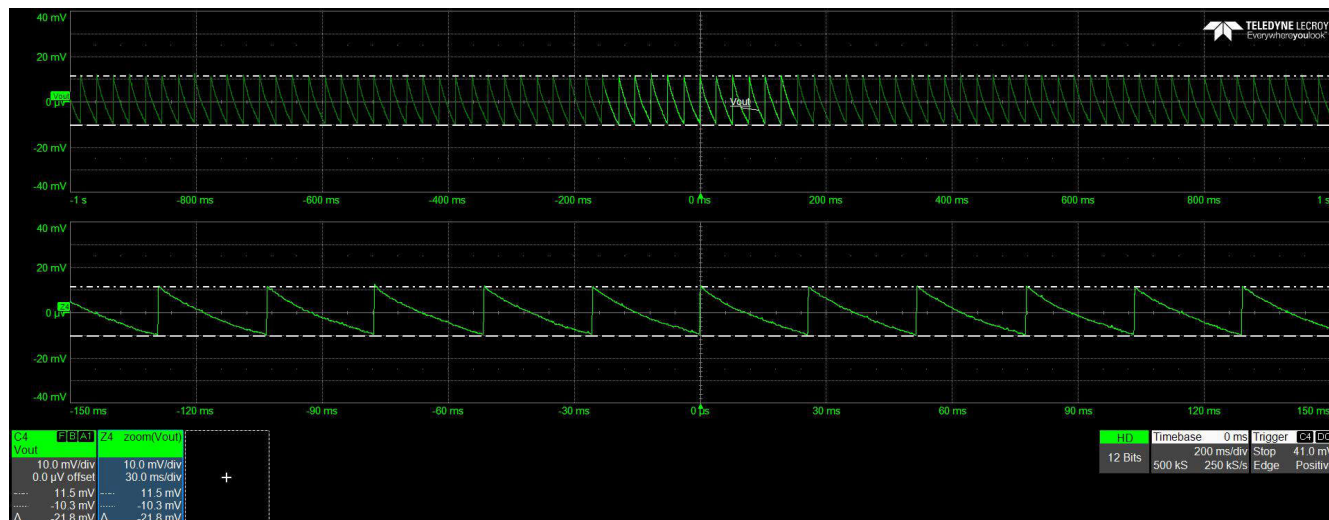


Figure 3-65. Output Voltage Ripple at Input = 115VAC/60Hz and Output = 20V/0A

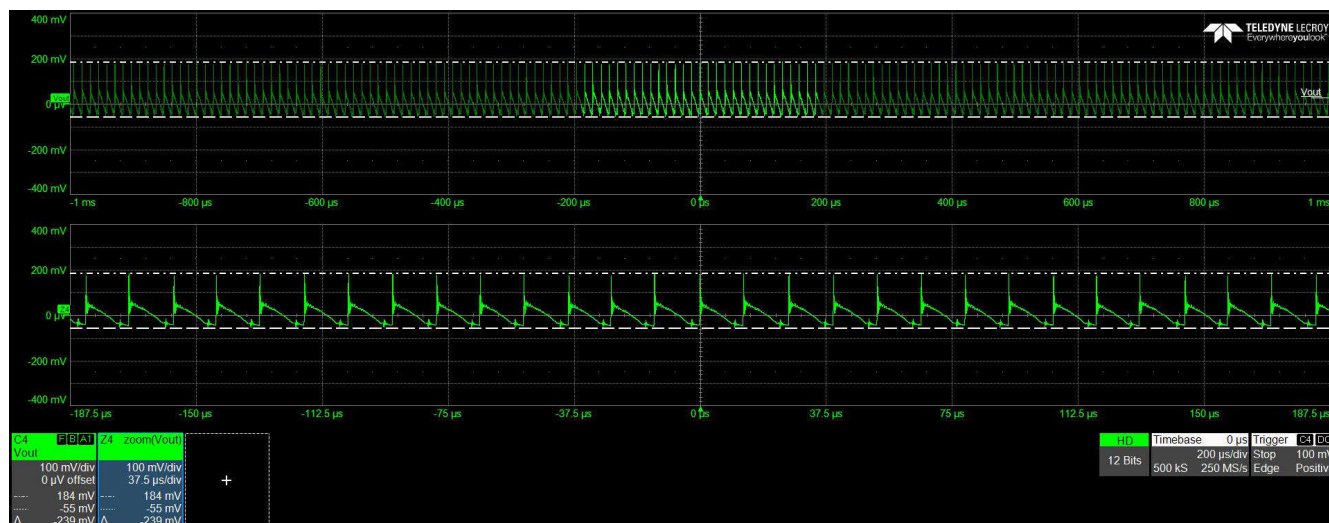


Figure 3-66. Output Voltage Ripple at Input = 115VAC/60Hz and Output = 20V/5A

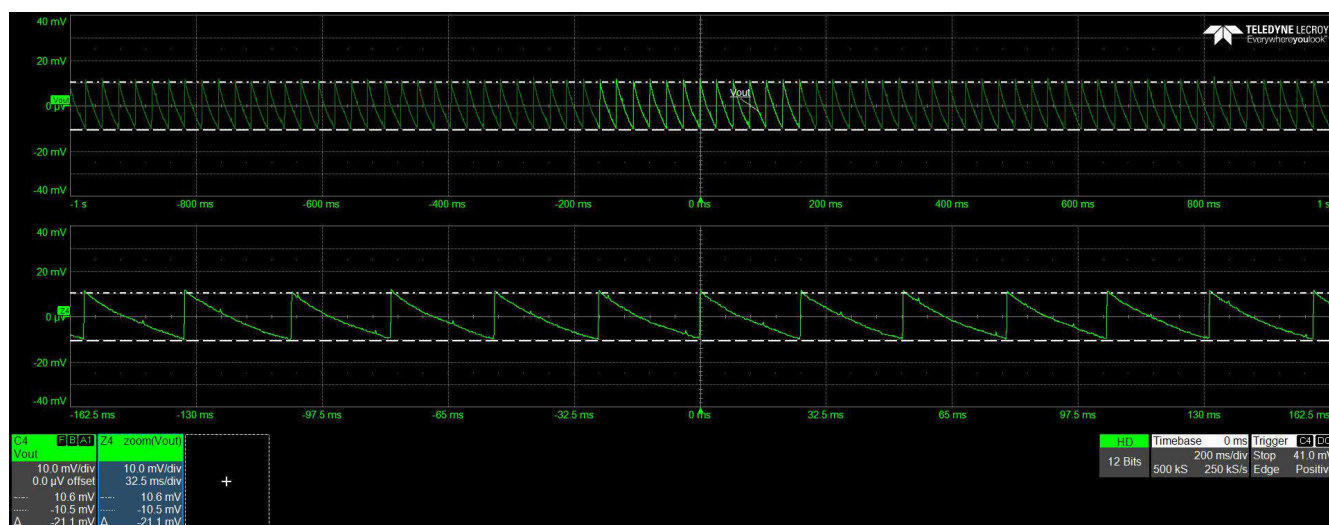


Figure 3-67. Output Voltage Ripple at Input = 230VAC/50Hz and Output = 20V/0A

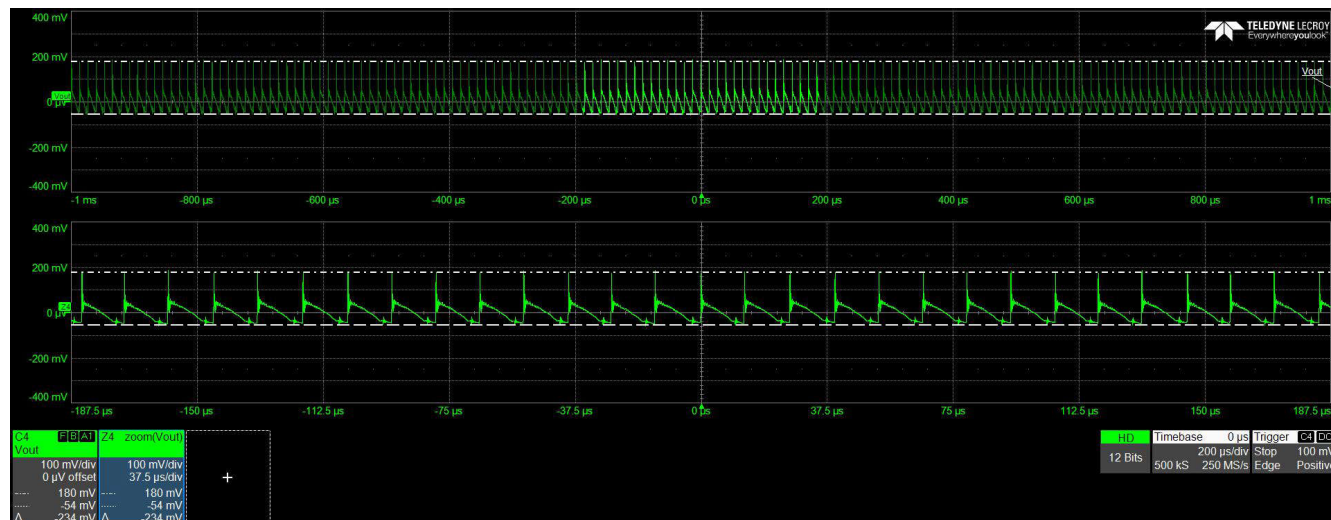
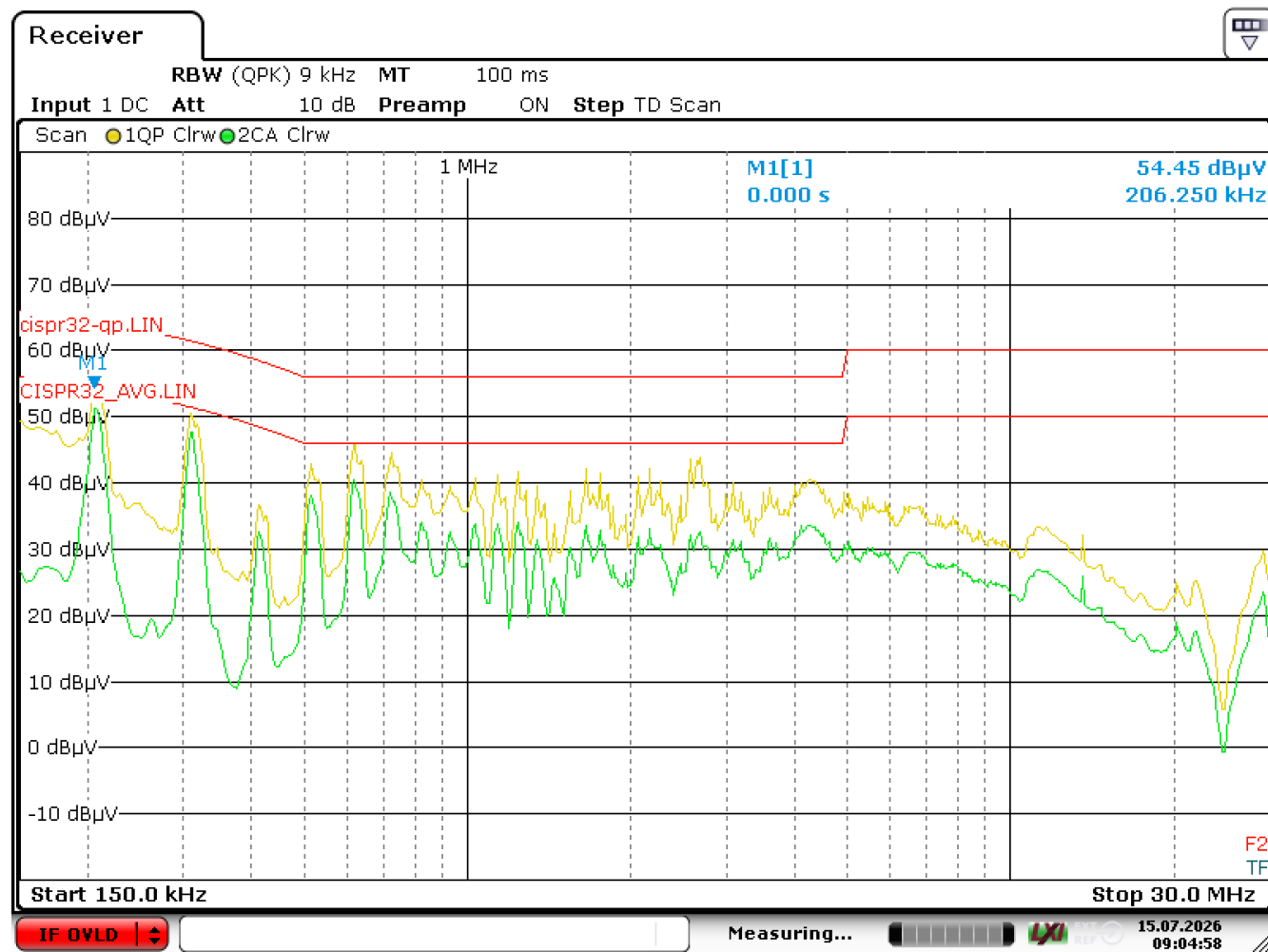


Figure 3-68. Output Voltage Ripple at Input = 230VAC/50Hz and Output = 20V/5A

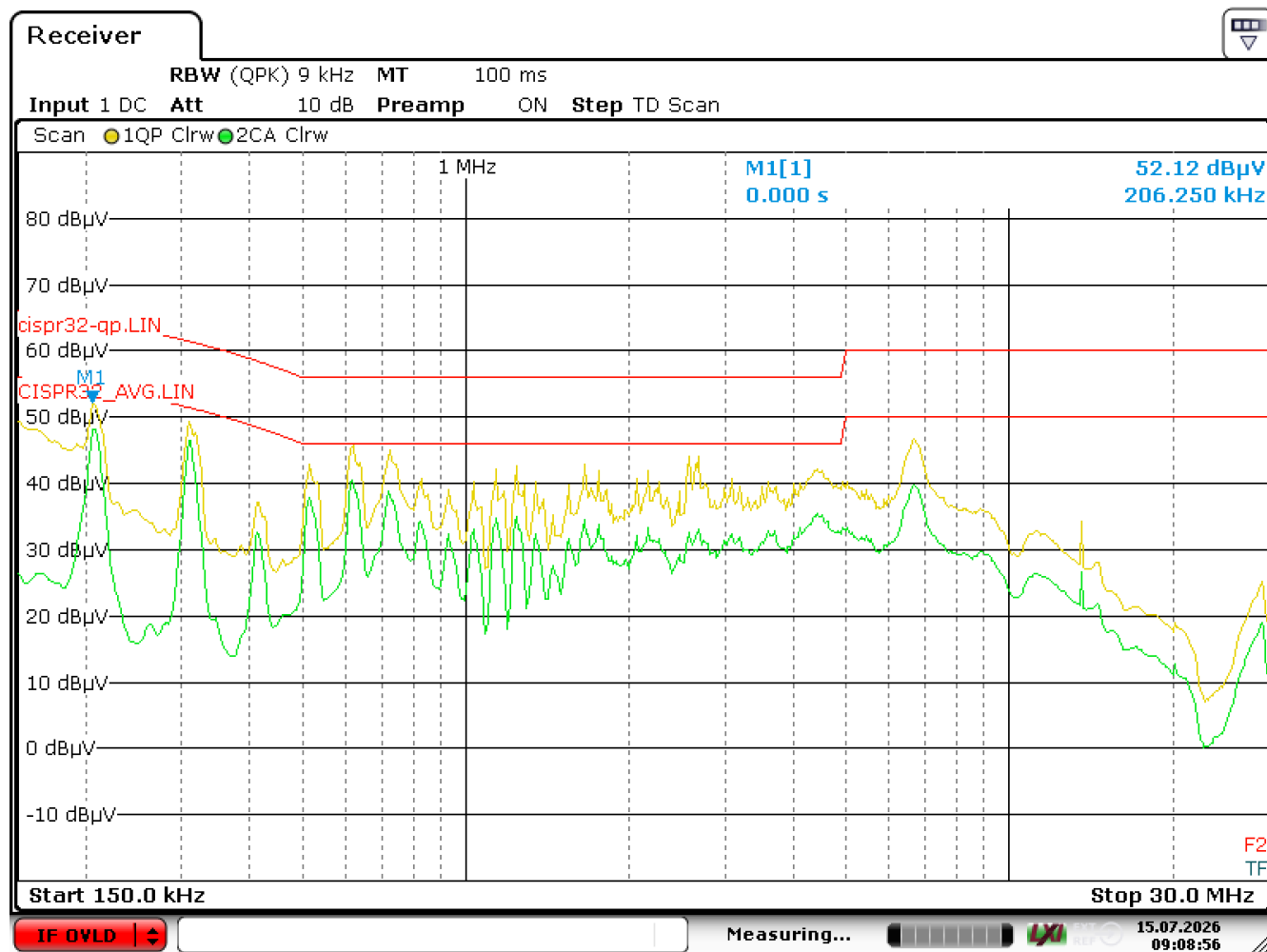
3.11 EN55022 Class B Conducted EMI Test Result

Please note this device was evaluated in pre-compliance EMI lab. TI recommends that all final designs need to be verified by an agency-qualified EMI test house. Test conditions is mentioned in figure description.



Date: 15.JUL.2026 09:04:59

Figure 3-69. Input = 230VAC/50Hz, Output = 28V/4.3A, Line Scan and Neutral Terminated



Date: 15.JUL.2026 09:08:57

Figure 3-70. Input = 230VAC/50Hz, Output = 28V/4.3A, Neutral Scan and Line Terminated



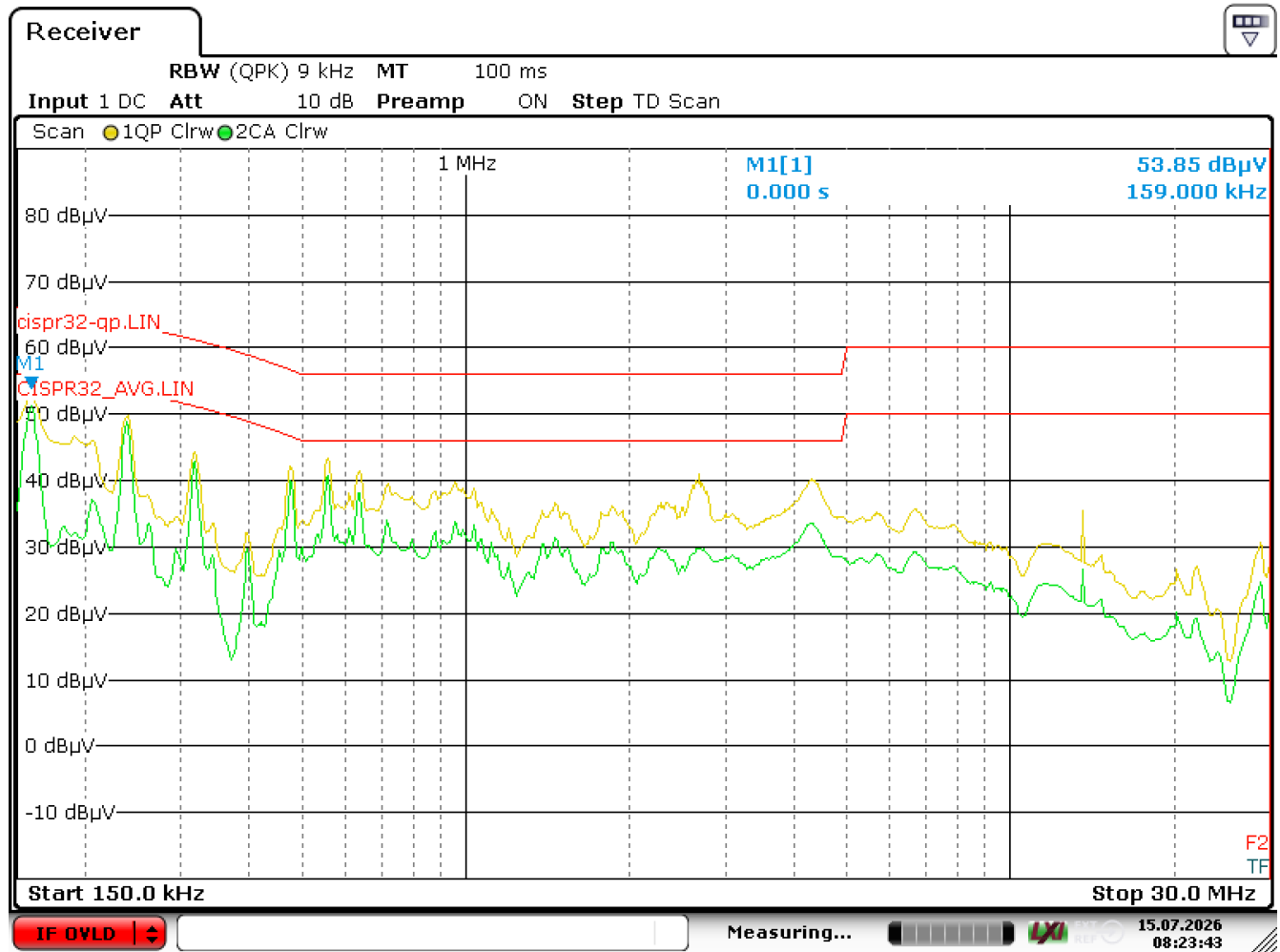
Date: 7.JUL.2026 13:04:35

Figure 3-71. Input = 230VAC/50Hz, Output = 24V/5A, Line Scan and Neutral Terminated



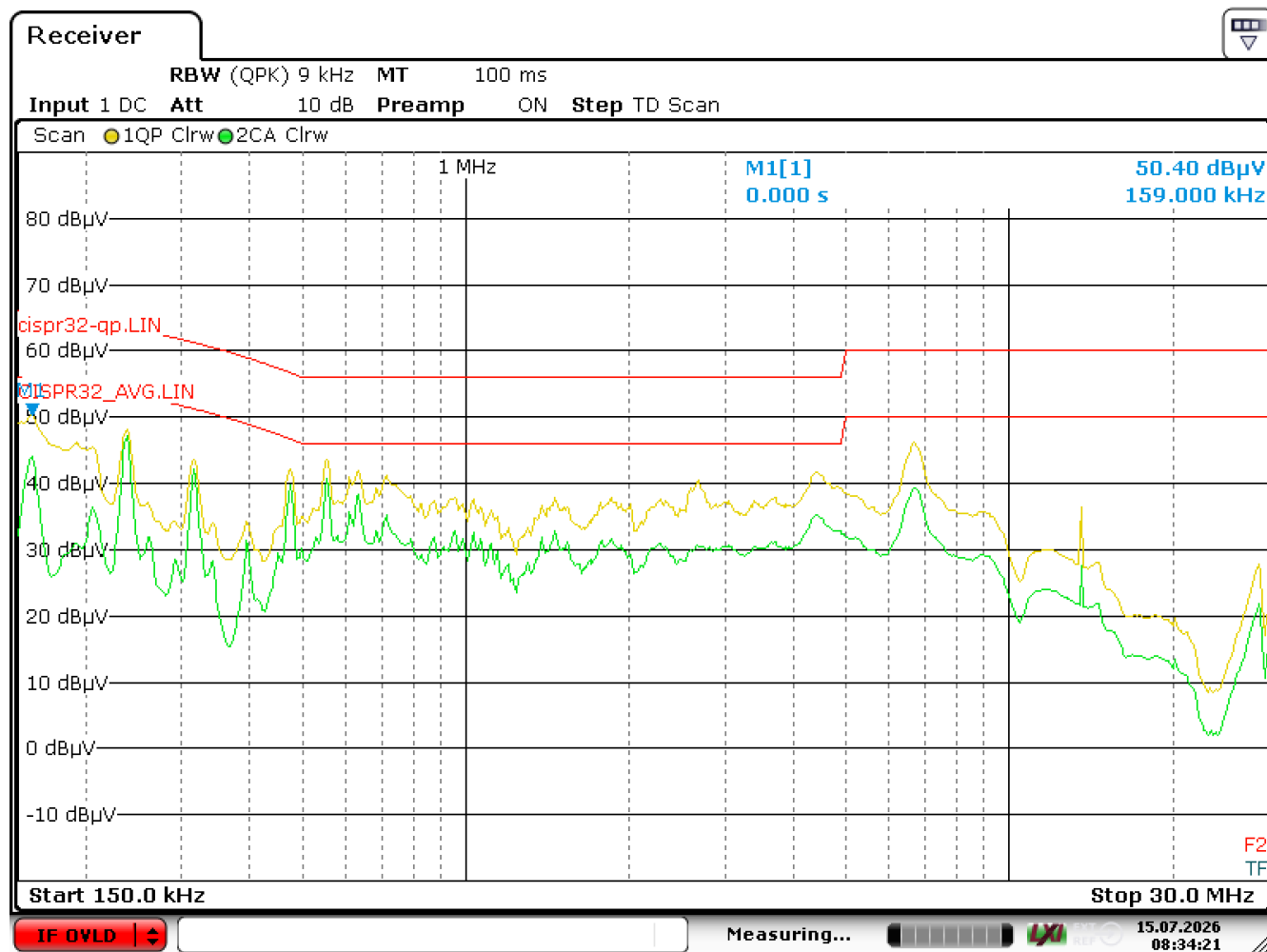
Date: 7.JUL.2026 13:19:40

Figure 3-72. Input = 230VAC/50Hz, Output = 24V/5A, Neutral Scan and Line Terminated



Date: 15.JUL.2026 08:23:44

Figure 3-73. Input = 230VAC/50Hz, Output = 20V/5A, Line Scan and Neutral Terminated



Date: 15.JUL.2026 08:34:22

Figure 3-74. Input = 230VAC/50Hz, Output = 20V/5A, Neutral Scan and Line Terminated

3.12 Thermal Performance at Maximum Load

The following images show the EVM temperature after 1 hour, 2 hour and 3 hour soak at 90VAC/60Hz, output set to 24V, full load and no forced air.

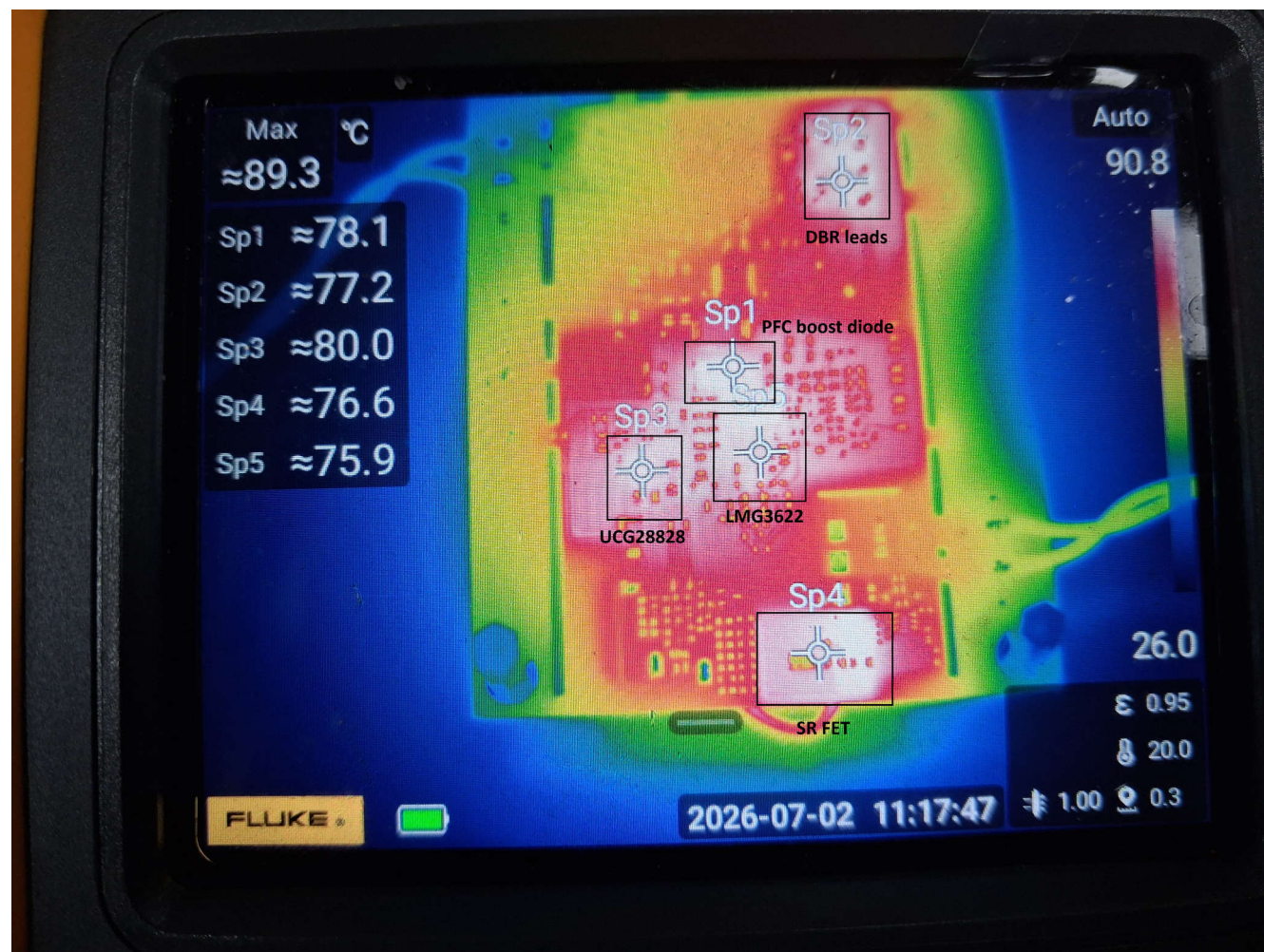


Figure 3-75. Input = 90VAC/60Hz, Output = 24V/5A and Scan After 1 Hour Run (Bottom Side)

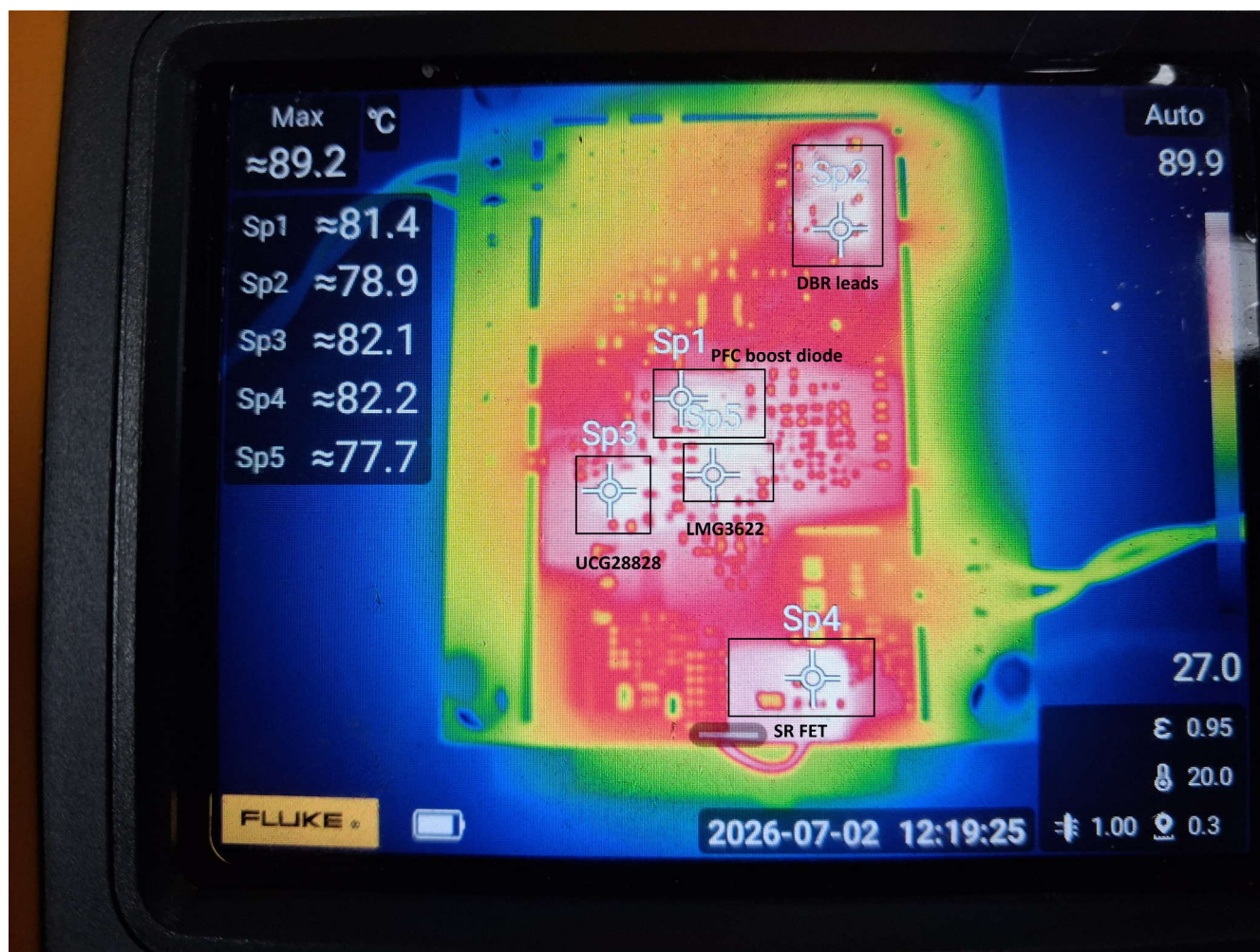


Figure 3-76. Input = 90VAC/60Hz, Output = 24V/5A and Scan After 2 Hour Run (Bottom Side)

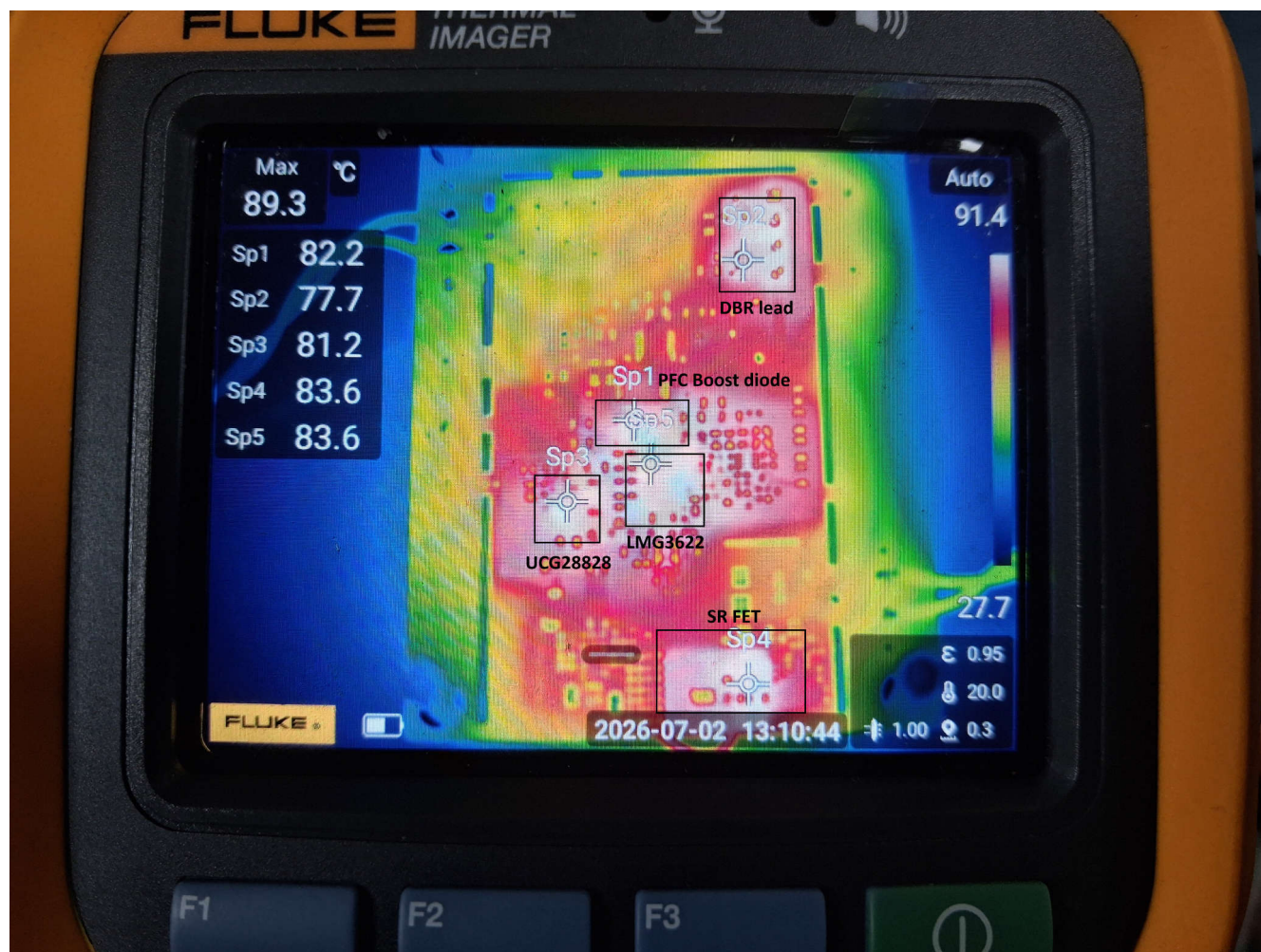


Figure 3-77. Input = 90VAC/60Hz, Output = 24V/5A and Scan After 3 Hour Run (Bottom Side)

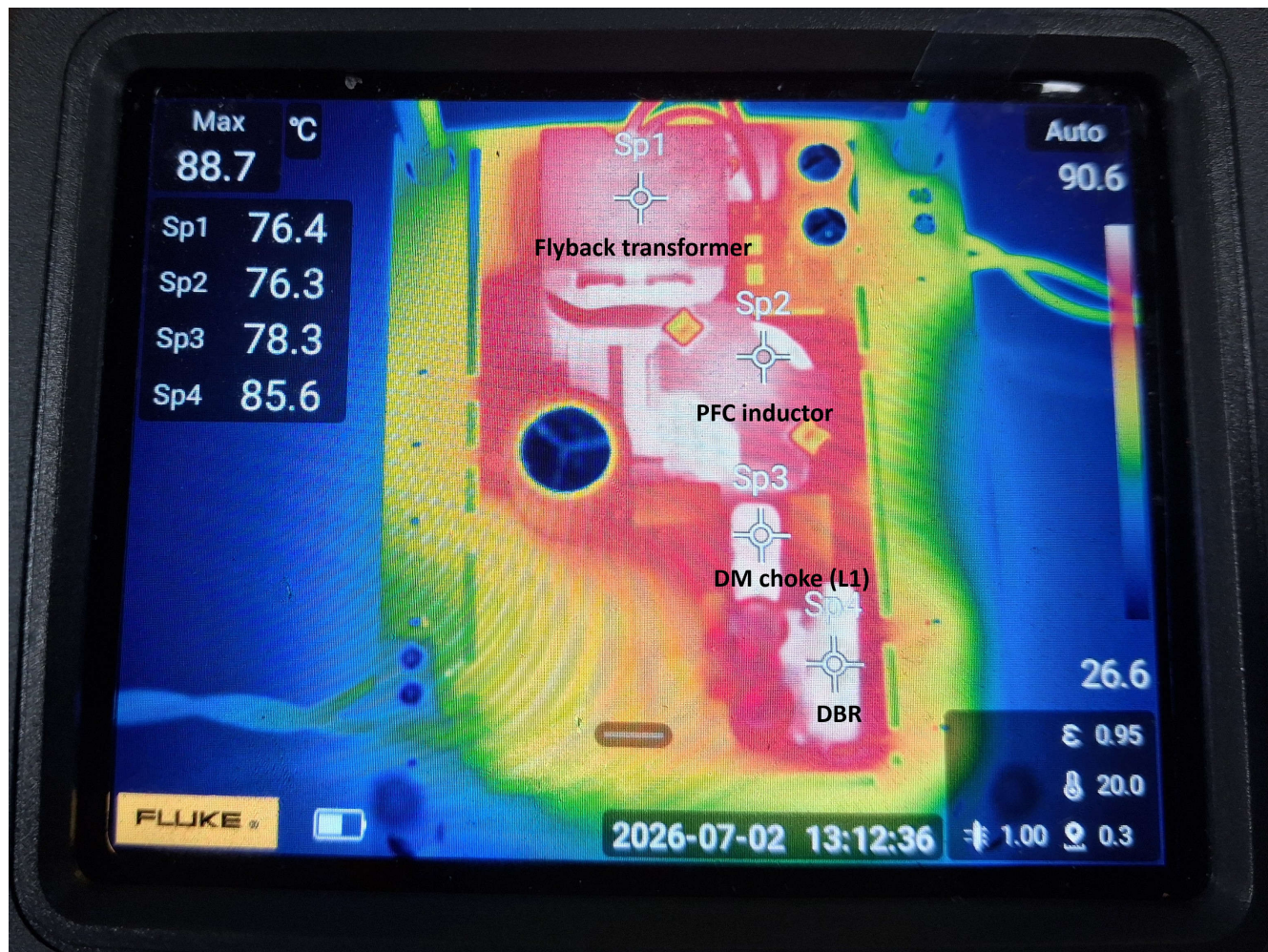


Figure 3-78. Input = 90VAC/60Hz, Output = 24V/5A and Scan After 3 Hour Run (top Side)

3.13 PFC Test Results: V_{in} vs I_{in}

The following waveforms show the input current behavior at different load conditions for 24V output setting at input voltage of 115VAC/60Hz and 230VAC/50Hz.

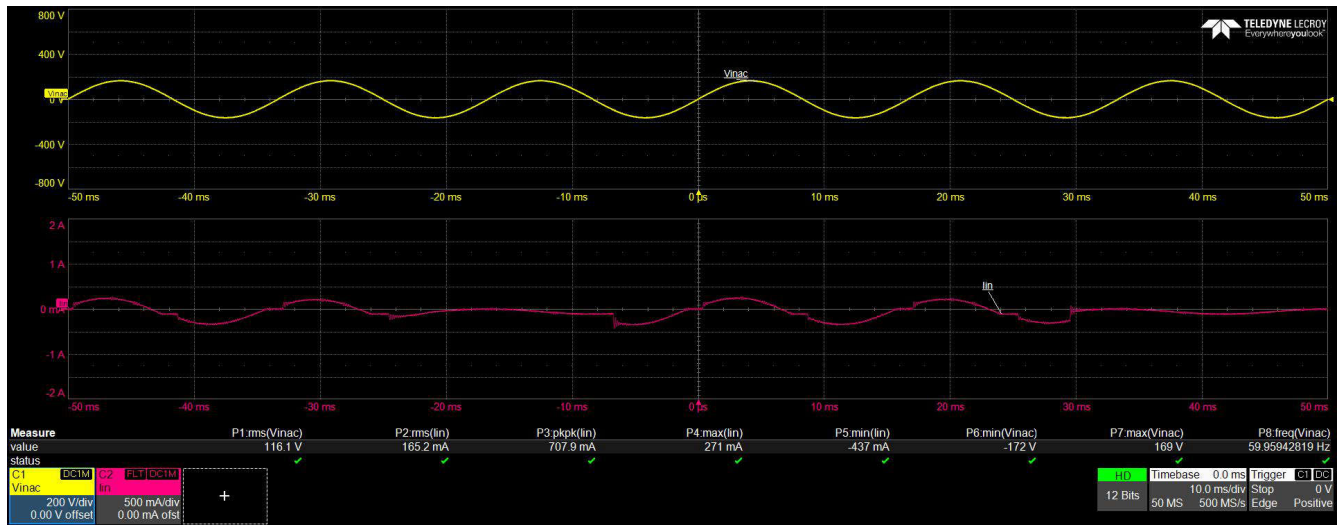


Figure 3-79. $V_{in} = 115\text{VAC}/60\text{Hz}$, $V_{out_fly} = 24\text{V}$ and $I_{out} = 0.5\text{A}$

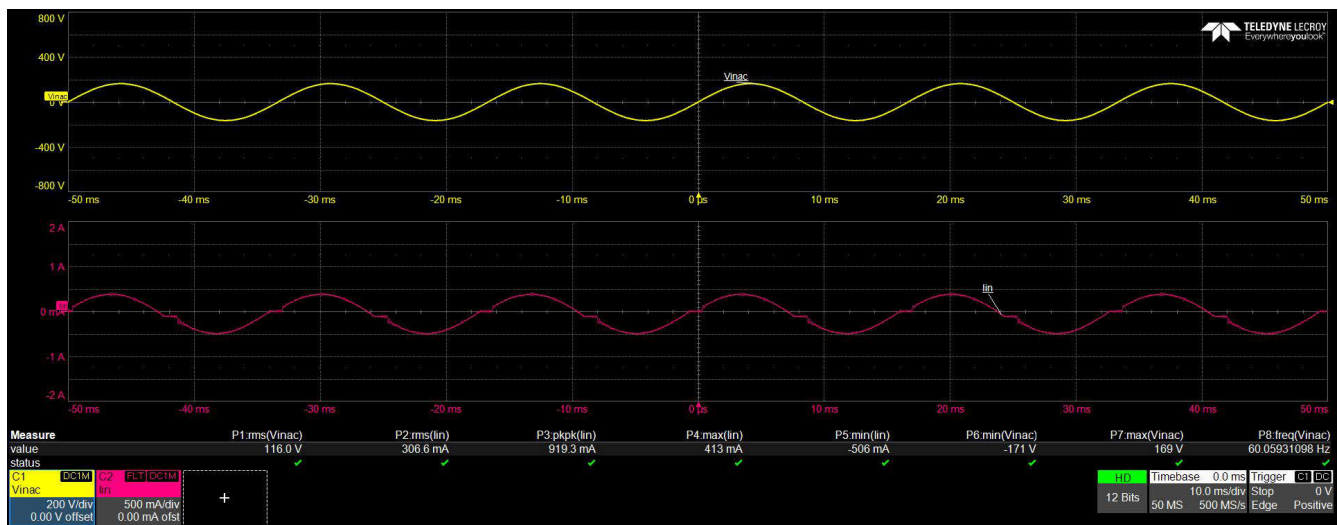


Figure 3-80. $V_{in} = 115\text{VAC}/60\text{Hz}$, $V_{out_fly} = 24\text{V}$ and $I_{out} = 1.25\text{A}$

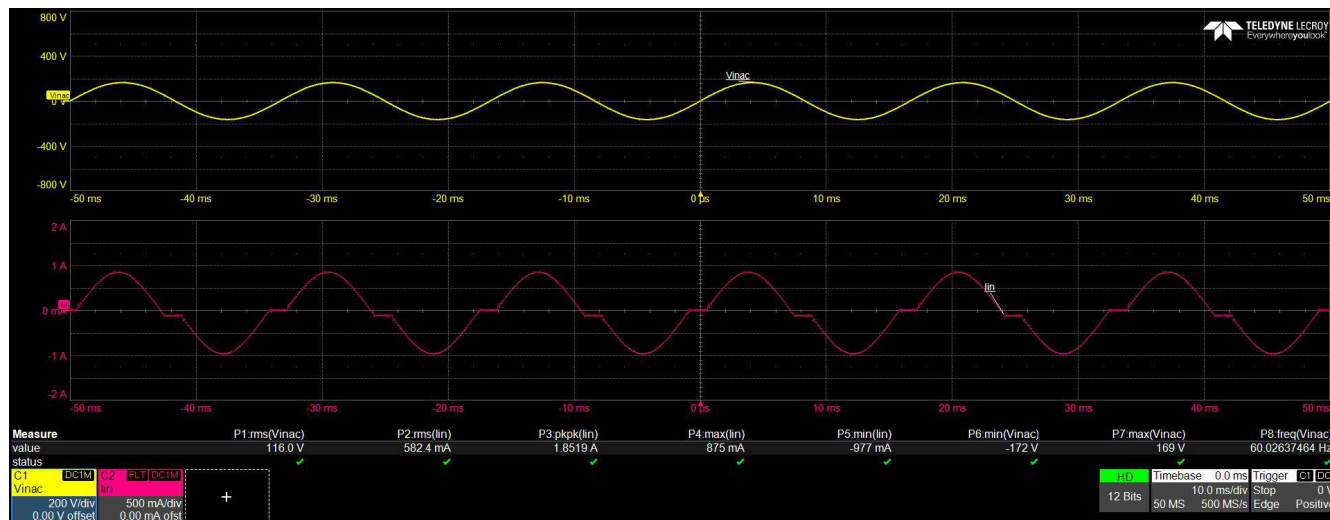


Figure 3-81. $V_{in} = 115\text{VAC}/60\text{Hz}$, $V_{out_fly} = 24\text{V}$ and $I_{out} = 2.5\text{A}$

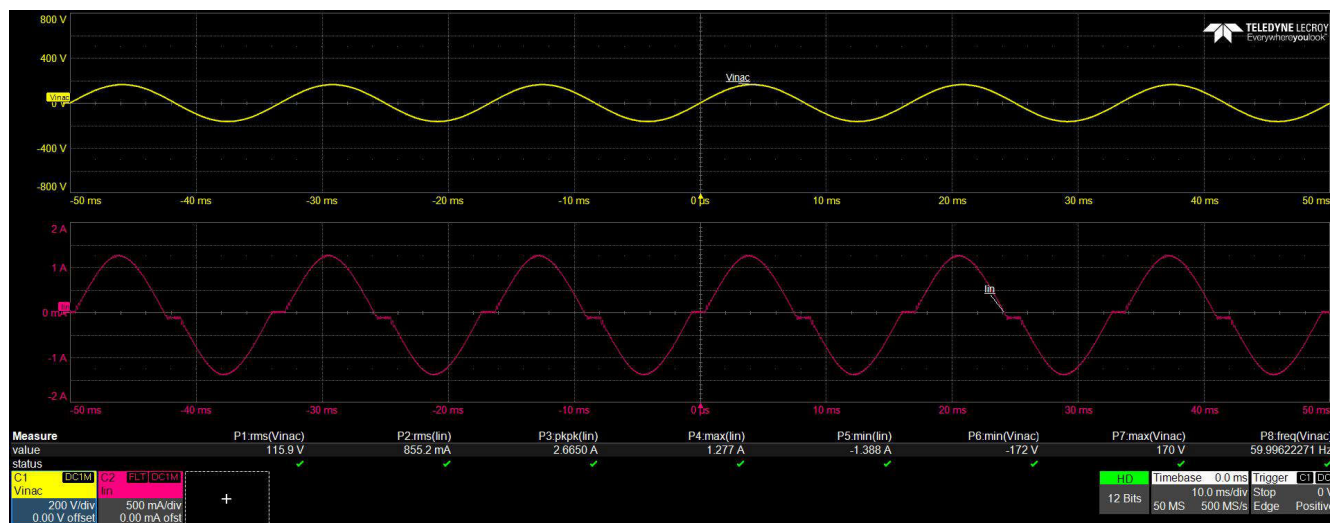


Figure 3-82. $V_{in} = 115\text{VAC}/60\text{Hz}$, $V_{out_fly} = 24\text{V}$ and $I_{out} = 3.75\text{A}$

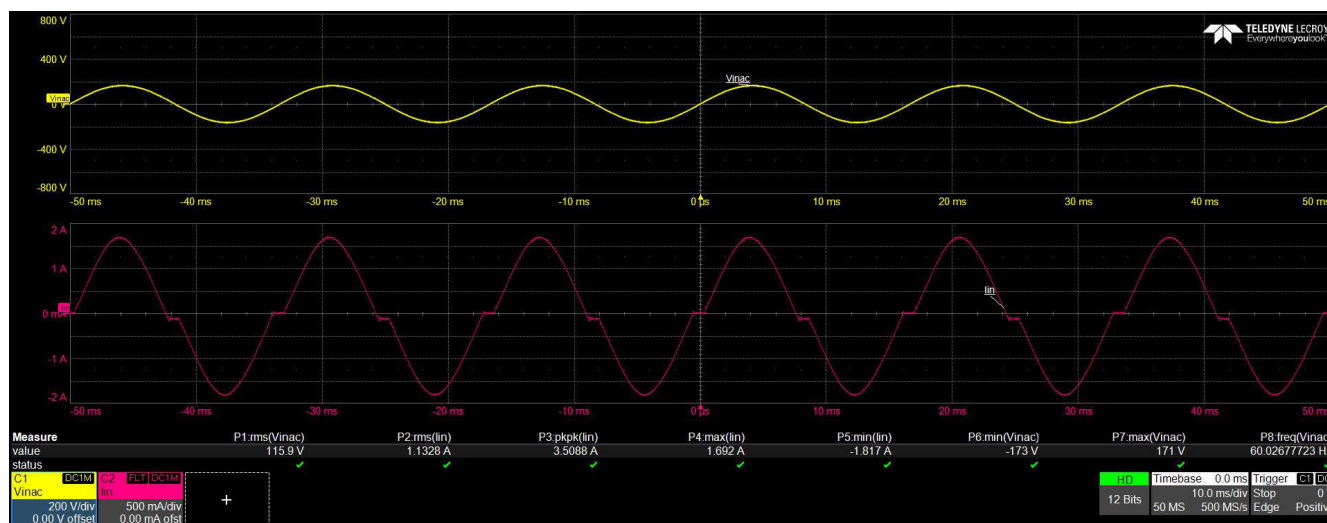


Figure 3-83. $V_{in} = 115\text{VAC}/60\text{Hz}$, $V_{out_fly} = 24\text{V}$ and $I_{out} = 5\text{A}$

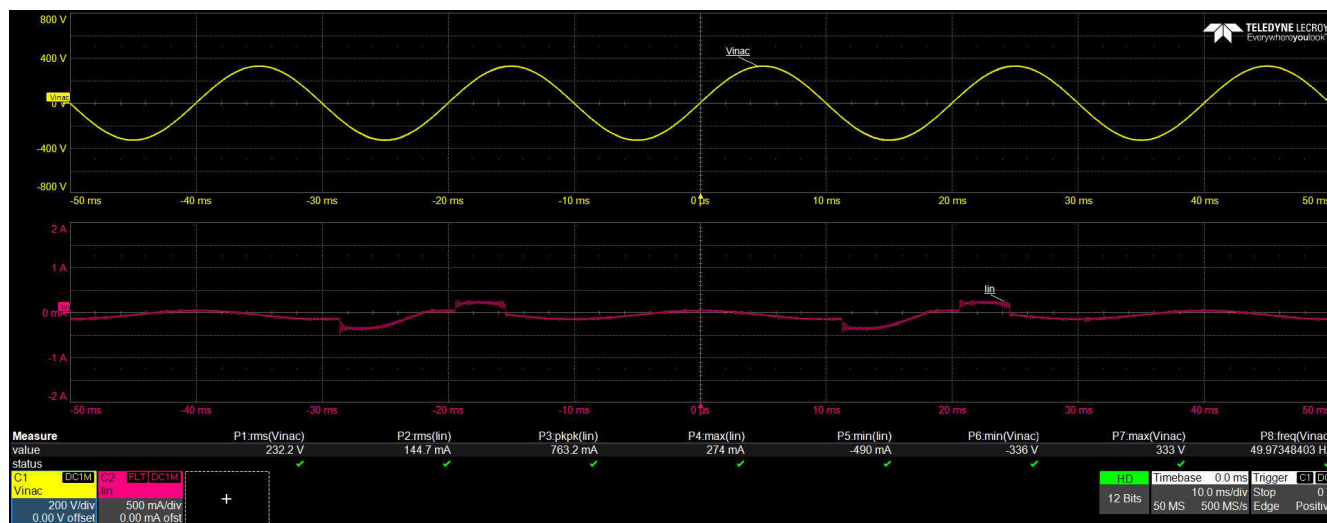


Figure 3-84. $V_{in} = 230\text{VAC}/50\text{Hz}$, $V_{out_fly} = 24\text{V}$ and $I_{out} = 0.5\text{A}$

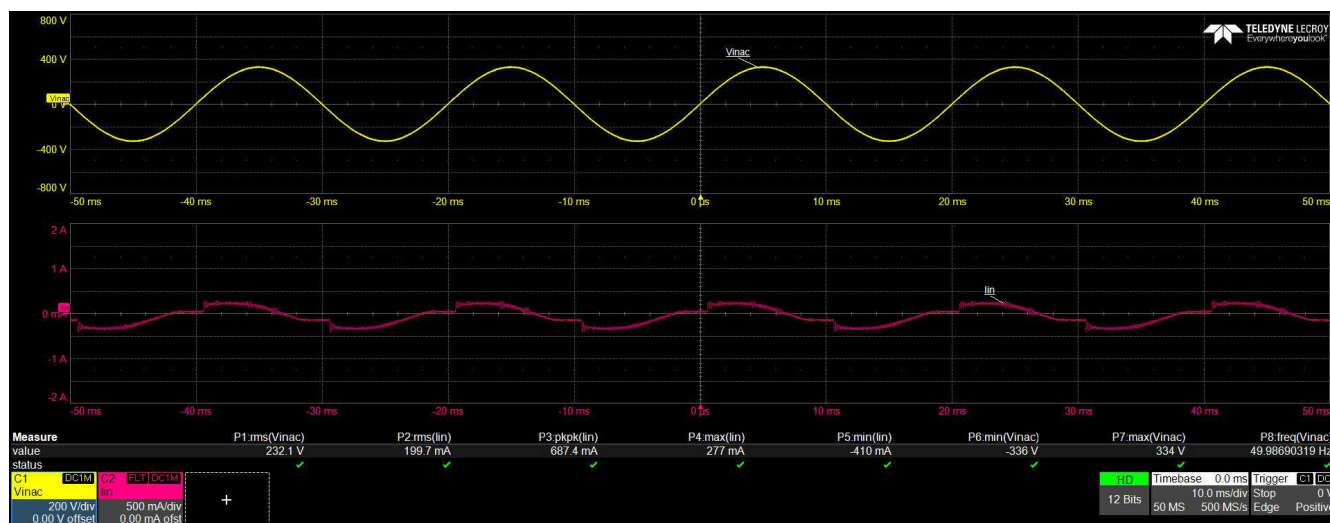


Figure 3-85. $V_{in} = 230\text{VAC}/50\text{Hz}$, $V_{out_fly} = 24\text{V}$ and $I_{out} = 1.25\text{A}$

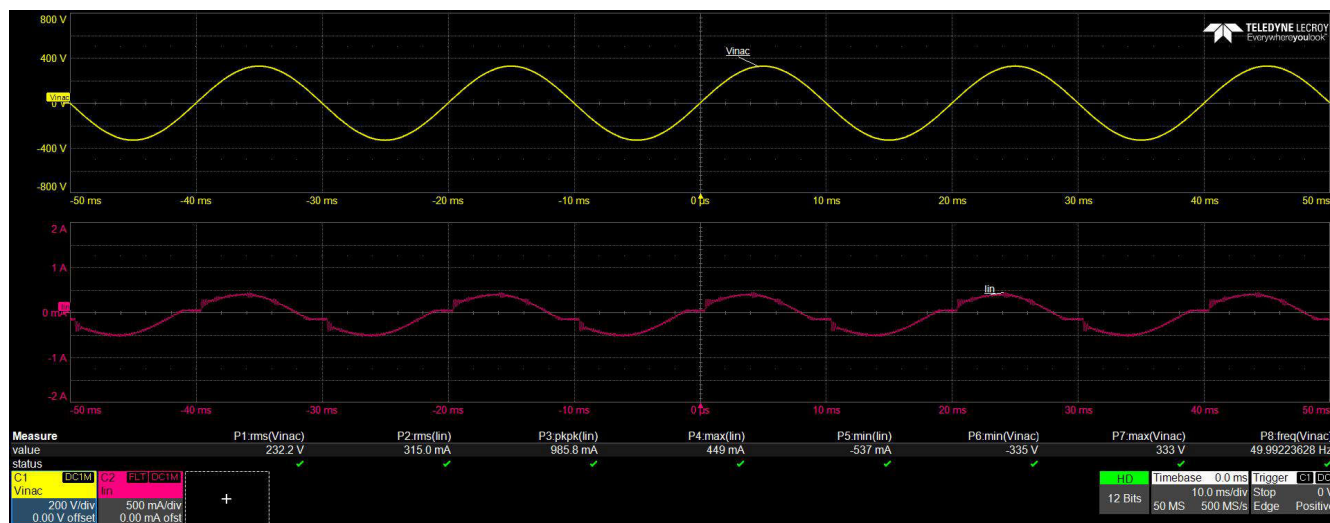


Figure 3-86. $V_{in} = 230\text{VAC}/50\text{Hz}$, $V_{out_fly} = 24\text{V}$ and $I_{out} = 2.5\text{A}$

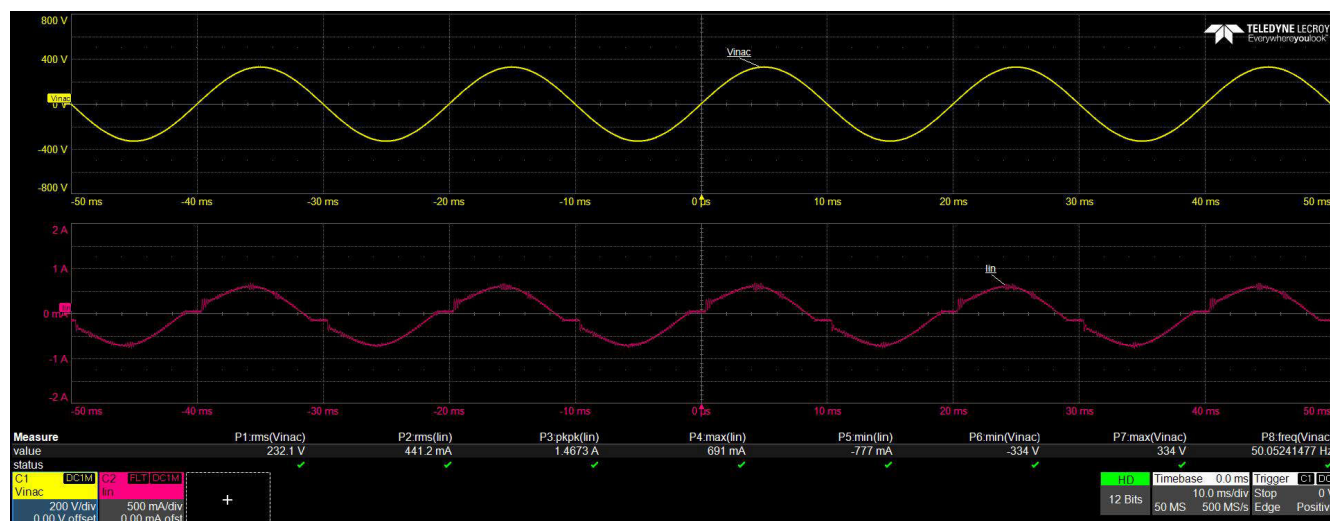


Figure 3-87. $V_{in} = 230VAC/50Hz$, $V_{out_fly} = 24V$ and $I_{out} = 3.75A$

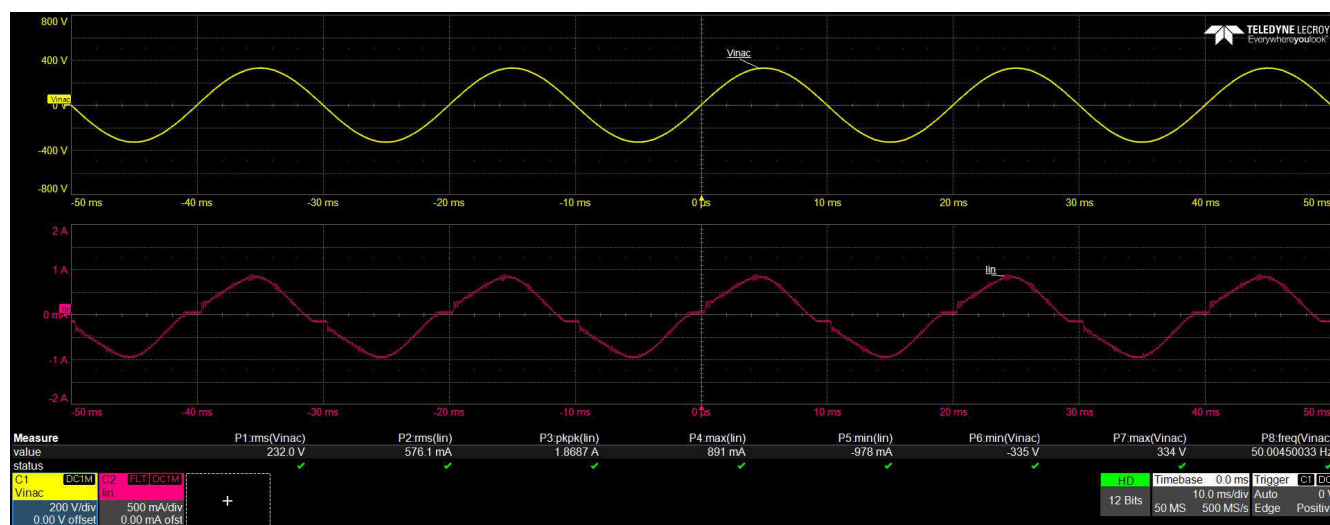
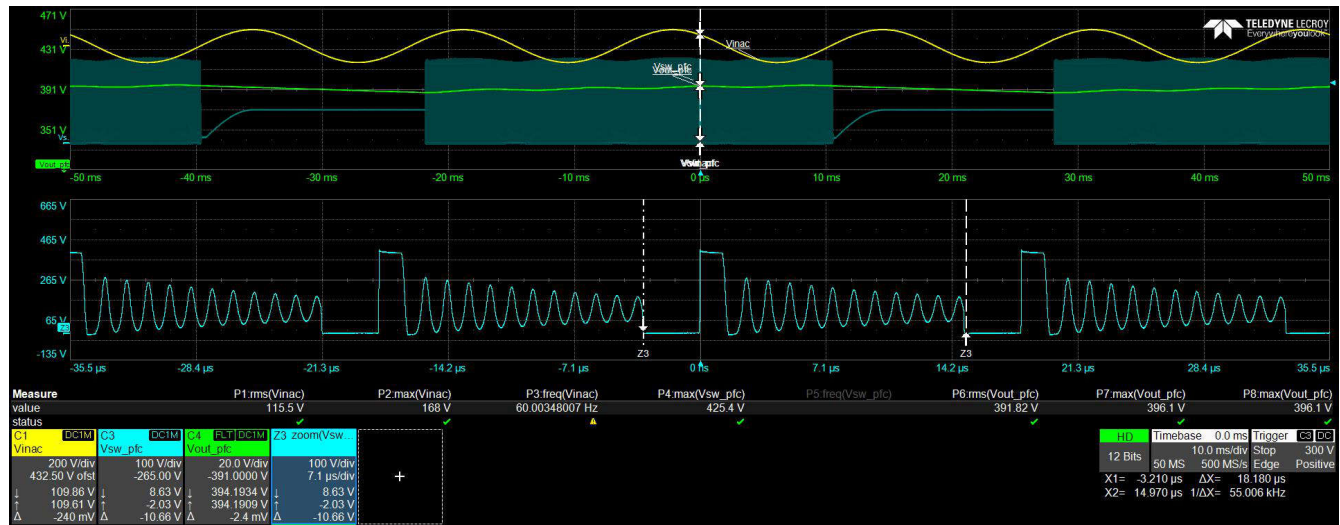


Figure 3-88. $V_{in} = 230VAC/50Hz$, $V_{out_fly} = 24V$ and $I_{out} = 5A$

3.14 PFC Test Results: Switch node Waveforms across load

The following waveforms shows the switch-node behavior at different load condition for 24V output setting at input voltage of 115VAC/60Hz and 230VAC/50Hz.

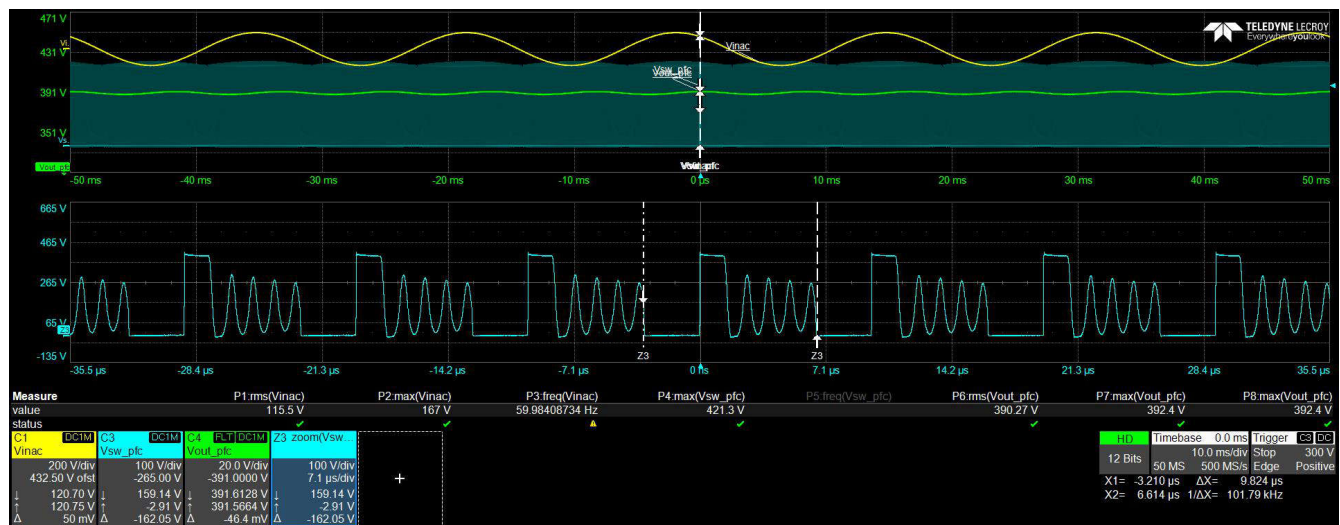


C1 = AC input voltage

C3 = PFC switch node voltage

C4 = PFC output voltage

Figure 3-89. $V_{in} = 115\text{VAC}/60\text{Hz}$, $V_{out_fly} = 24\text{V}$ and $I_{out} = 0.5\text{A}$



C1 = AC input voltage

C3 = PFC switch node voltage

C4 = PFC output voltage

Figure 3-90. $V_{in} = 115\text{VAC}/60\text{Hz}$, $V_{out_fly} = 24\text{V}$ and $I_{out} = 1.25\text{A}$

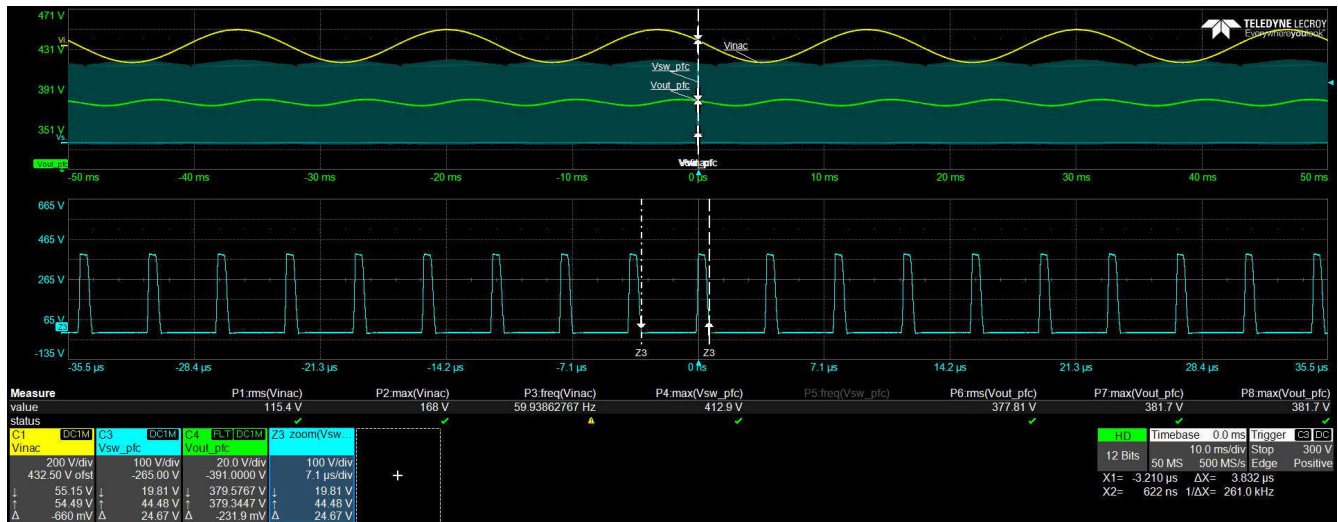


Figure 3-91. $V_{in} = 115\text{VAC}/60\text{Hz}$, $V_{out_fly} = 24\text{V}$ and $I_{out} = 2.5\text{A}$

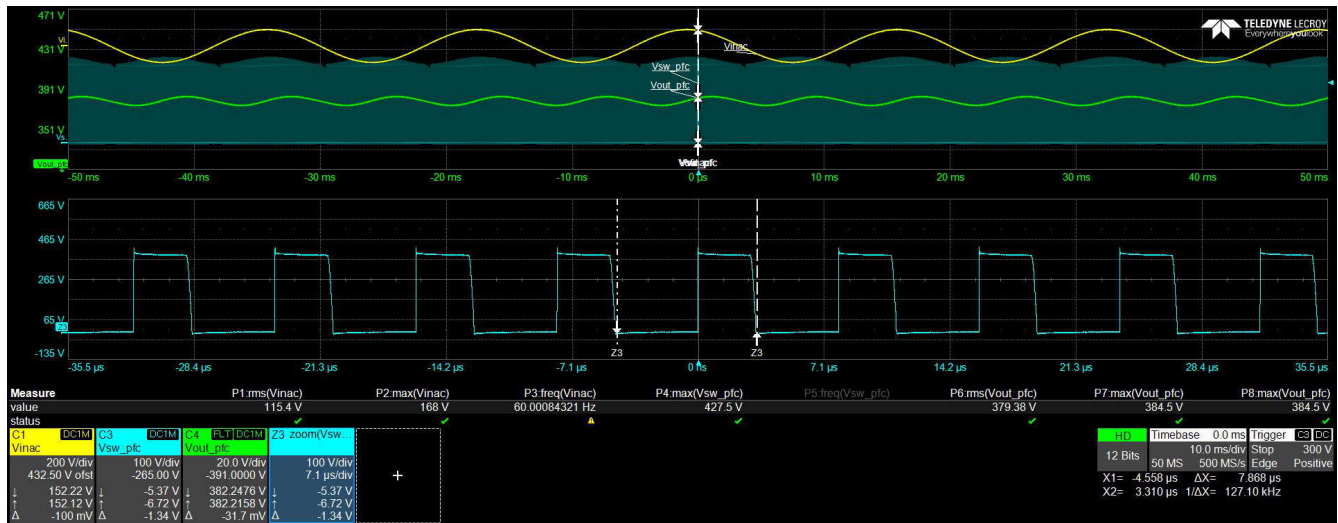


Figure 3-92. $V_{in} = 115\text{VAC}/60\text{Hz}$, $V_{out_fly} = 24\text{V}$ and $I_{out} = 3.75\text{A}$

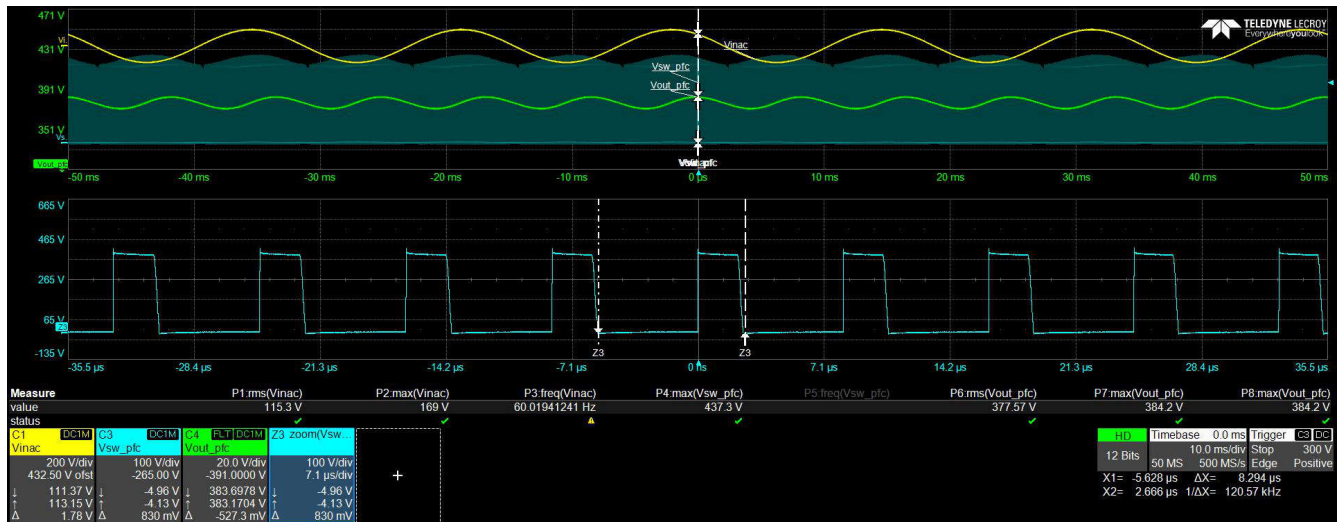


Figure 3-93. $V_{in} = 115\text{VAC}/60\text{Hz}$, $V_{out_fly} = 24\text{V}$ and $I_{out} = 5\text{A}$

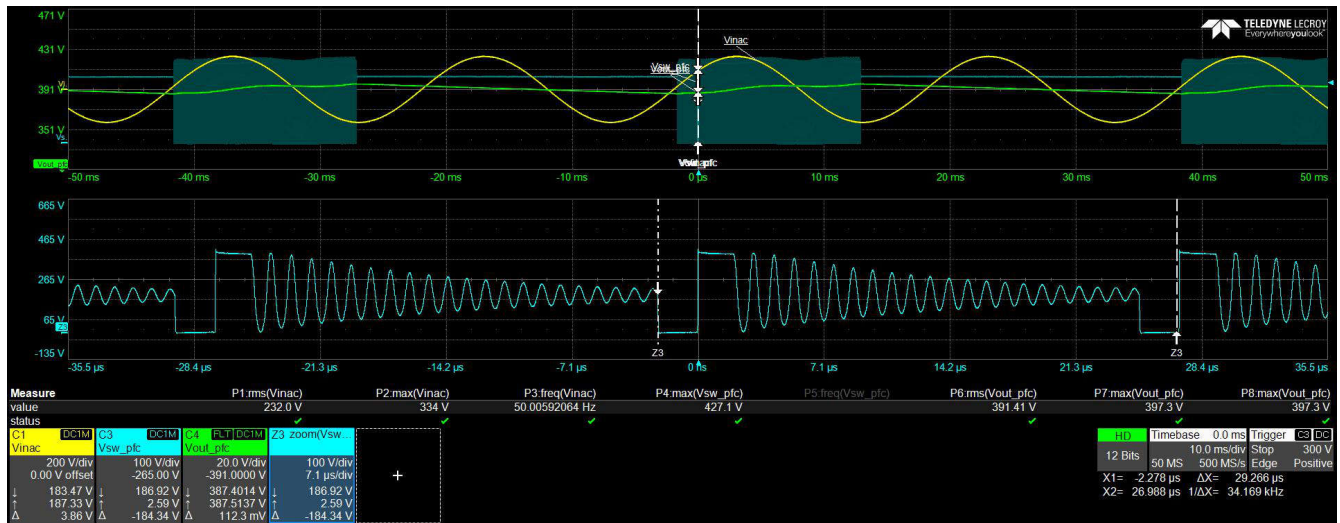


Figure 3-94. $V_{in} = 230\text{VAC}/50\text{Hz}$, $V_{out_fly} = 24\text{V}$ and $I_{out} = 0.5\text{A}$

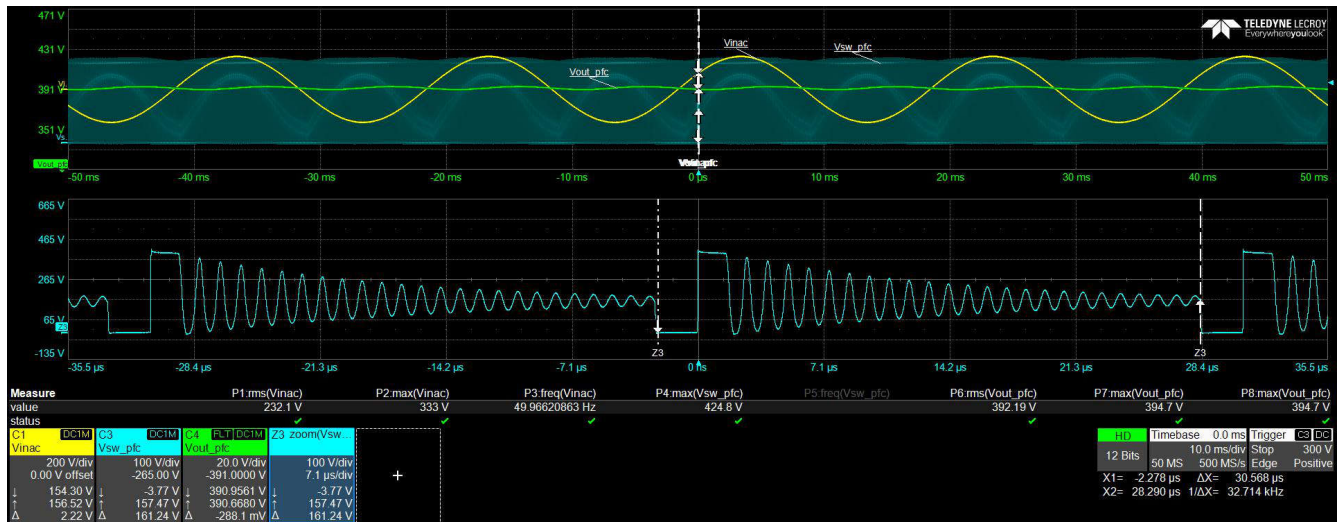


Figure 3-95. $V_{in} = 230\text{VAC}/50\text{Hz}$, $V_{out_fly} = 24\text{V}$ and $I_{out} = 1.25\text{A}$

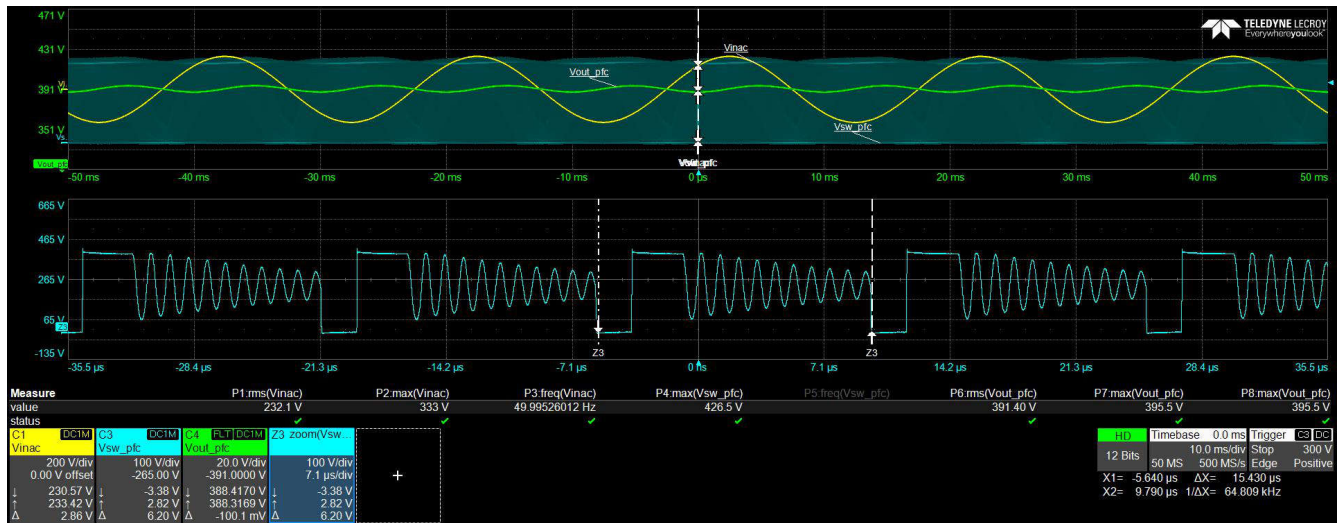
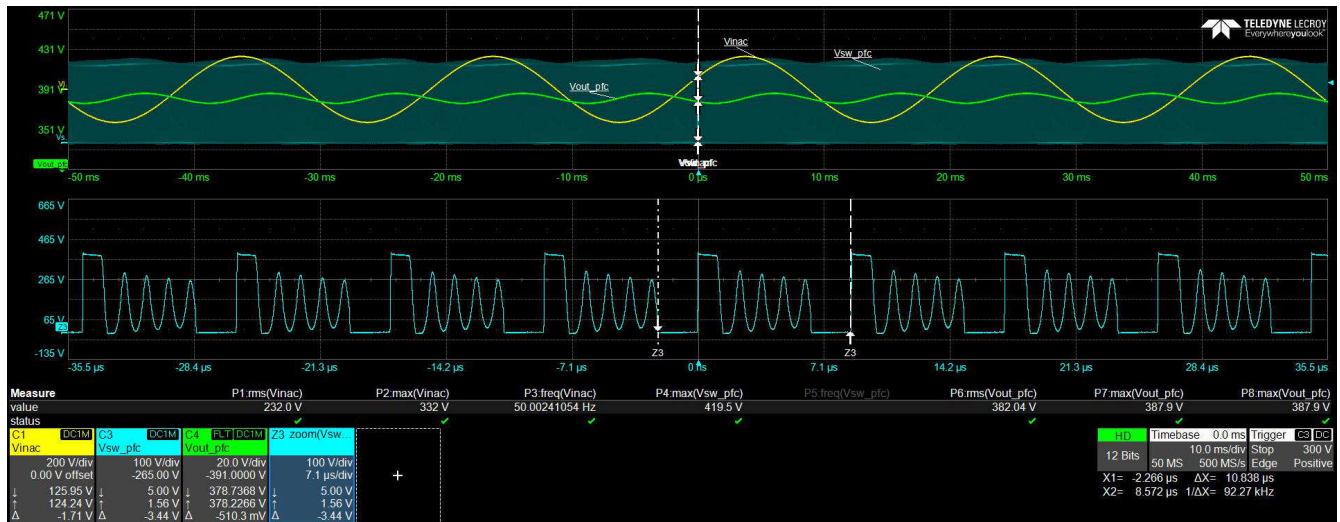


Figure 3-96. $V_{in} = 230\text{VAC}/50\text{Hz}$, $V_{out_fly} = 24\text{V}$ and $I_{out} = 2.5\text{A}$

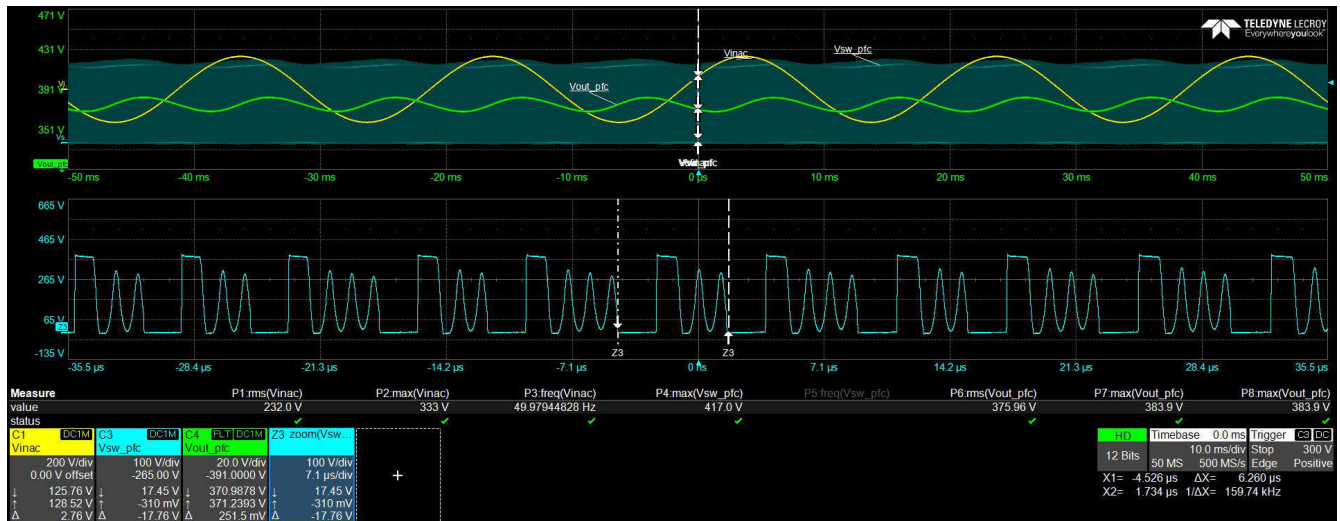


C1 = AC input voltage

C3 = PFC switch node voltage

C4 = PFC output voltage

Figure 3-97. $V_{in} = 230\text{VAC}/50\text{Hz}$, $V_{out_fly} = 24\text{V}$ and $I_{out} = 3.75\text{A}$



C1 = AC input voltage

C3 = PFC switch node voltage

C4 = PFC output voltage

Figure 3-98. $V_{in} = 230\text{VAC}/50\text{Hz}$, $V_{out_fly} = 24\text{V}$ and $I_{out} = 5\text{A}$

3.15 PFC Test Results: Efficiency (only PFC With External Vcc)

This section shows the PFC stage efficiency with external bias supply to PFC of 15V and power dissipation (for example, $V_{cc} \times I_{V_{cc}}$) have been taken into account while calculating efficiency across each operating point. Below table show front-end PFC efficiency at 115VAC and 60Hz and 230VAC and 50Hz.

V_{IN} and Fline	P_{IN} (W)	Vout(V)	I_{out} (A)	P_{OUT} (W)	Efficiency
115VAC and 60Hz	3.273	390.3	0.008	3.111	94.19%
115VAC and 60Hz	10.483	390.4	0.026	9.963	95.04%
115VAC and 60Hz	21.075	391.1	0.051	20.126	95.50%
115VAC and 60Hz	31.406	390	0.077	29.956	95.38%
115VAC and 60Hz	41.315	385.8	0.103	39.626	95.91%
115VAC and 60Hz	51.992	387.1	0.129	49.948	96.07%
115VAC and 60Hz	61.257	380.6	0.155	58.909	96.17%
115VAC and 60Hz	71.763	382.5	0.181	69.076	96.26%
115VAC and 60Hz	81.864	380.4	0.207	78.815	96.28%
115VAC and 60Hz	94.327	379.2	0.239	90.629	96.08%
115VAC and 60Hz	104.839	378.4	0.266	100.654	96.01%
115VAC and 60Hz	114.869	377.6	0.292	110.259	95.99%
115VAC and 60Hz	125.244	376.9	0.318	119.854	95.70%
115VAC and 60Hz	135.382	376.4	0.347	130.611	95.77%
230VAC and 50Hz	3.238	390	0.008	3.026	93.01%
230VAC and 50Hz	10.761	390.2	0.027	10.352	96.06%
230VAC and 50Hz	20.675	390.2	0.051	19.916	96.19%
230VAC and 50Hz	30.980	390.5	0.077	29.971	96.65%
230VAC and 50Hz	41.318	391.3	0.102	40.093	96.93%
230VAC and 50Hz	51.273	391.3	0.127	49.781	97.01%
230VAC and 50Hz	61.579	391.1	0.153	59.827	97.08%
230VAC and 50Hz	72.130	390.1	0.180	70.124	97.16%
230VAC and 50Hz	83.268	386.9	0.209	80.986	97.19%
230VAC and 50Hz	93.290	382.4	0.238	91.011	97.49%
230VAC and 50Hz	103.479	380.4	0.265	100.806	97.28%
230VAC and 50Hz	113.479	378.7	0.292	110.580	97.39%
230VAC and 50Hz	123.912	376.5	0.321	120.857	97.49%
230VAC and 50Hz	133.826	374.3	0.348	130.256	97.29%

Efficiency curve:

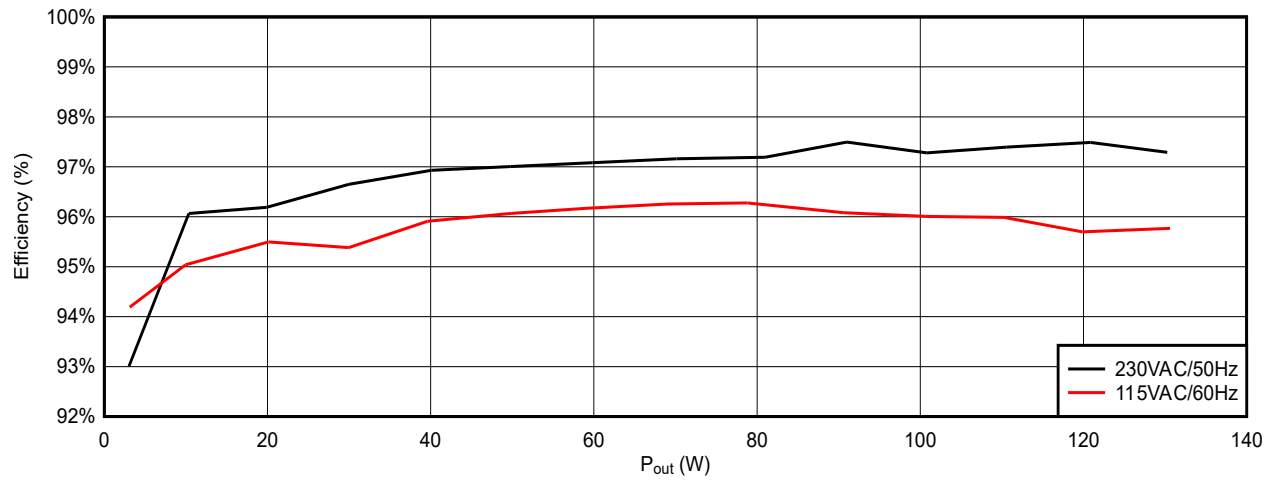


Figure 3-99. Efficiency Curves for Front-end PFC With External Vcc = 15V

4.1 Schematics

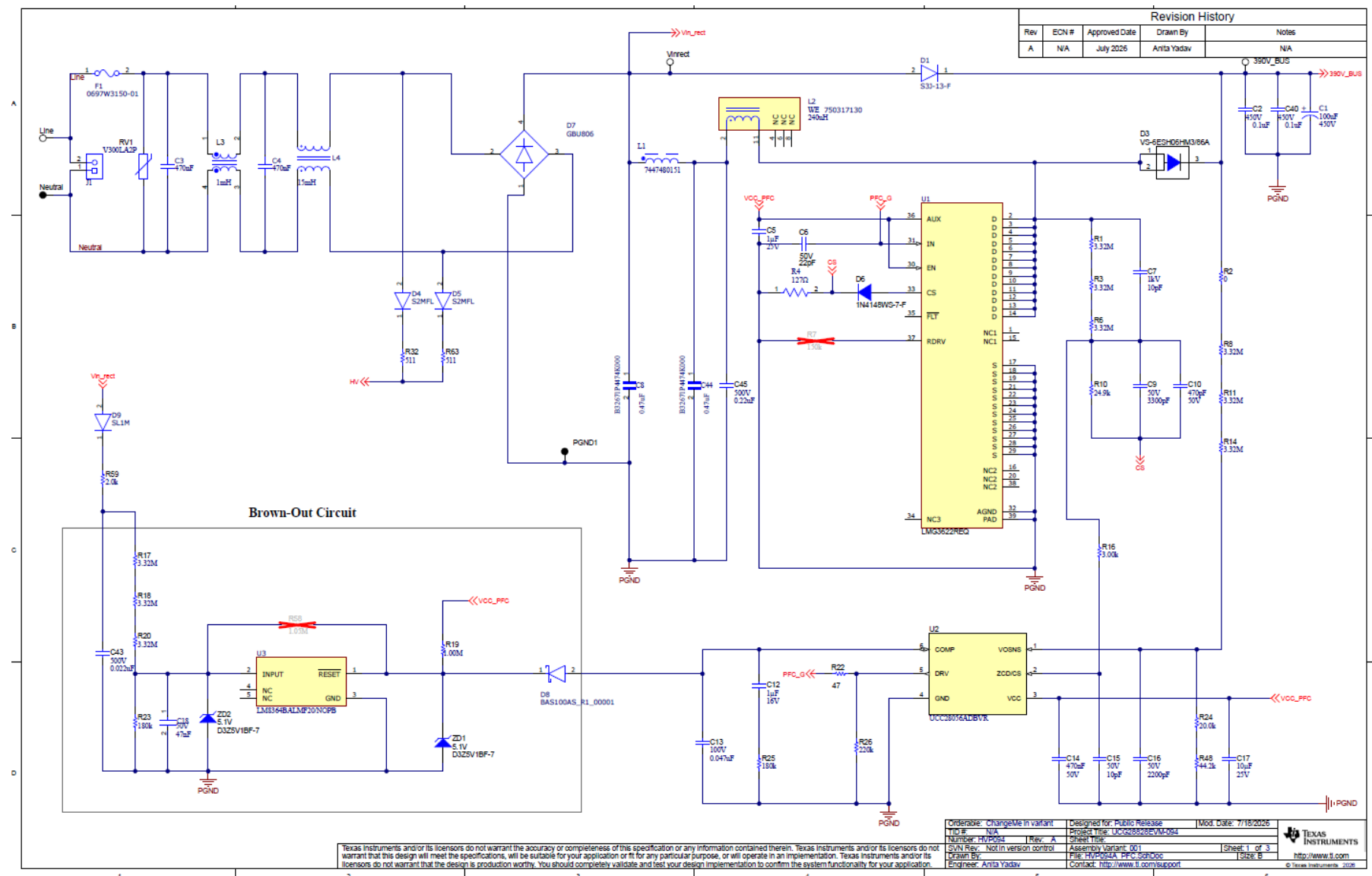


Figure 4-1. UCG28828EVM-094: PFC Schematic

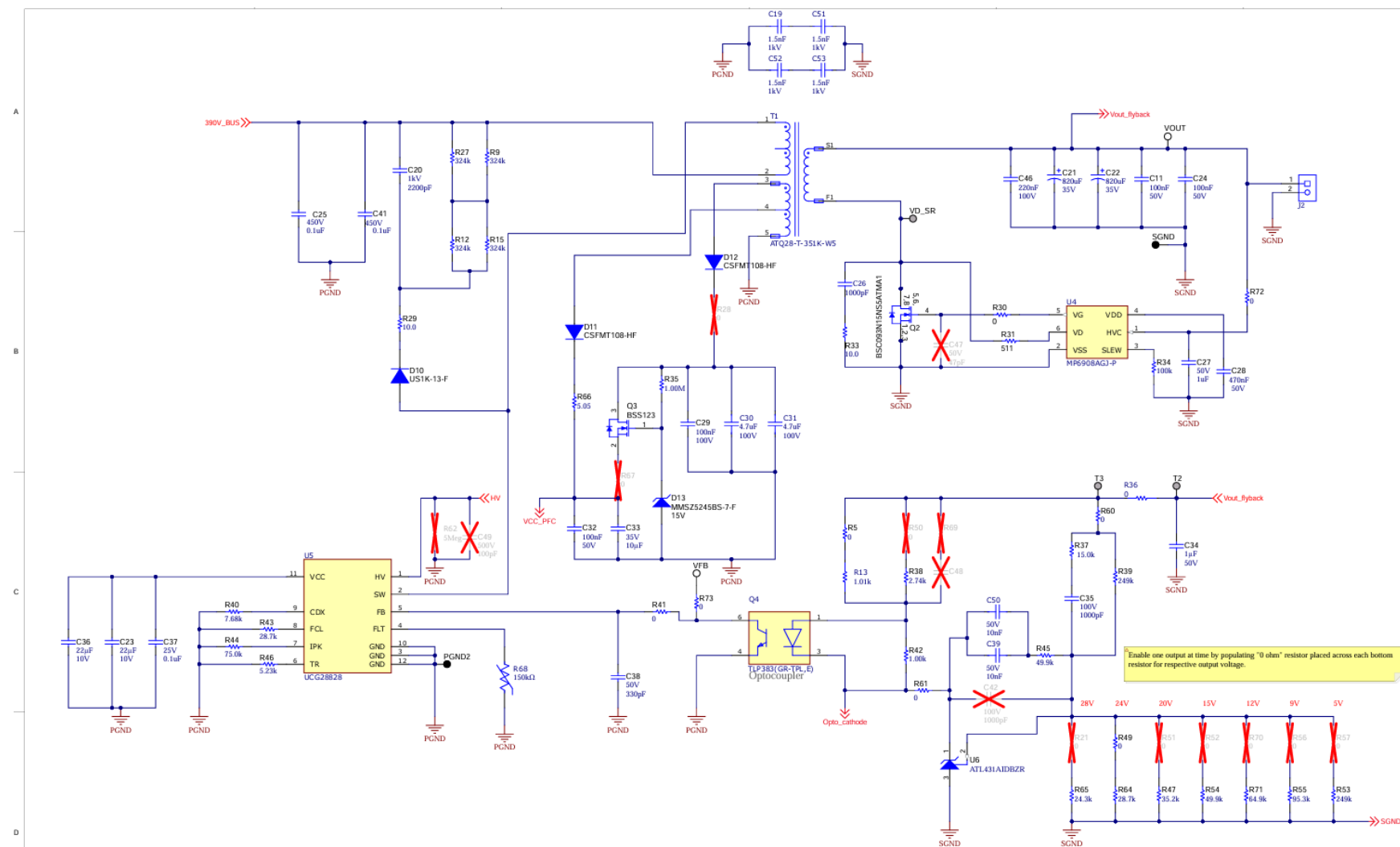


Figure 4-2. UCG2882EVM-094: Flyback Schematic

4.2 PCB Layouts

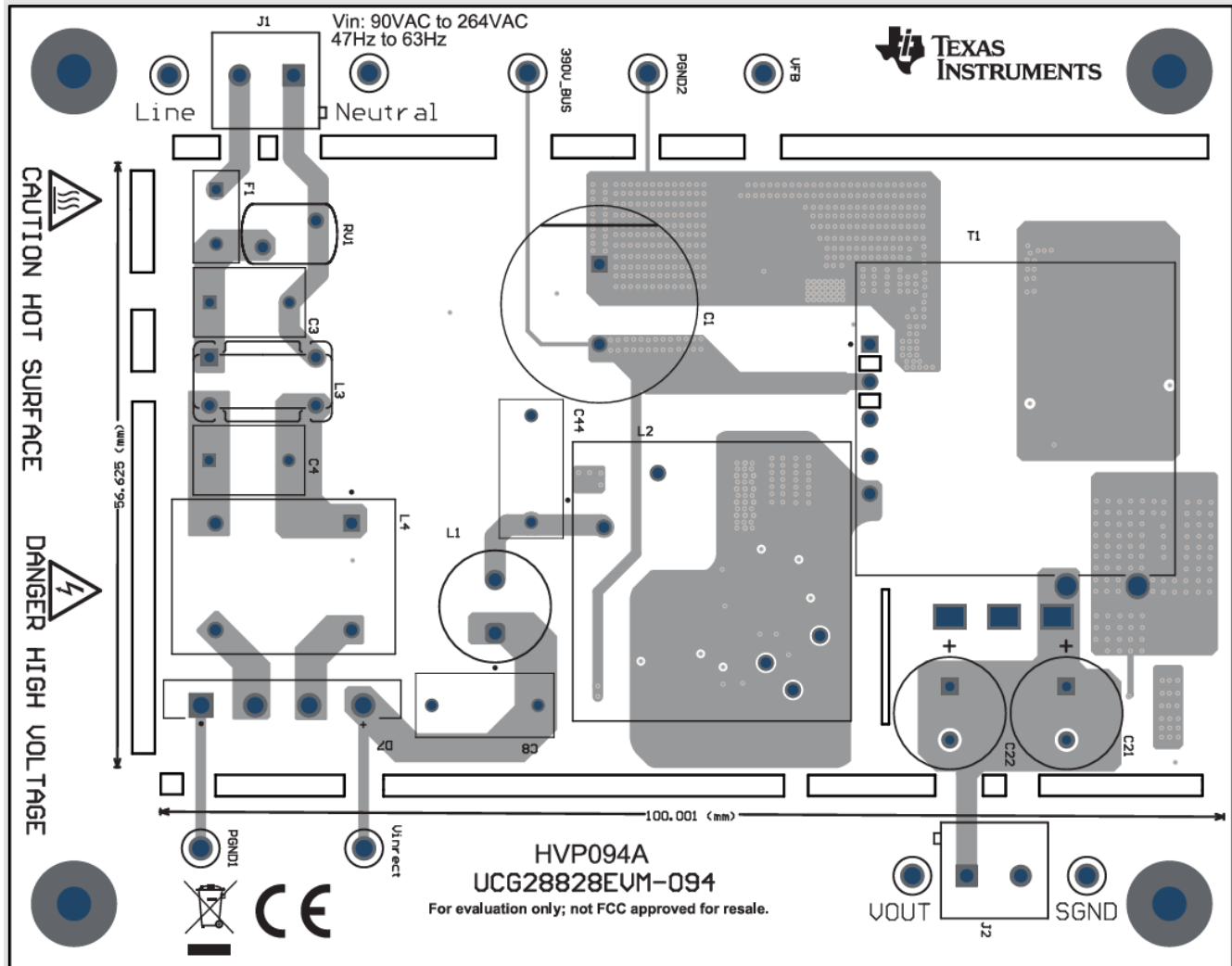


Figure 4-3. EVM Assembly (Top View)

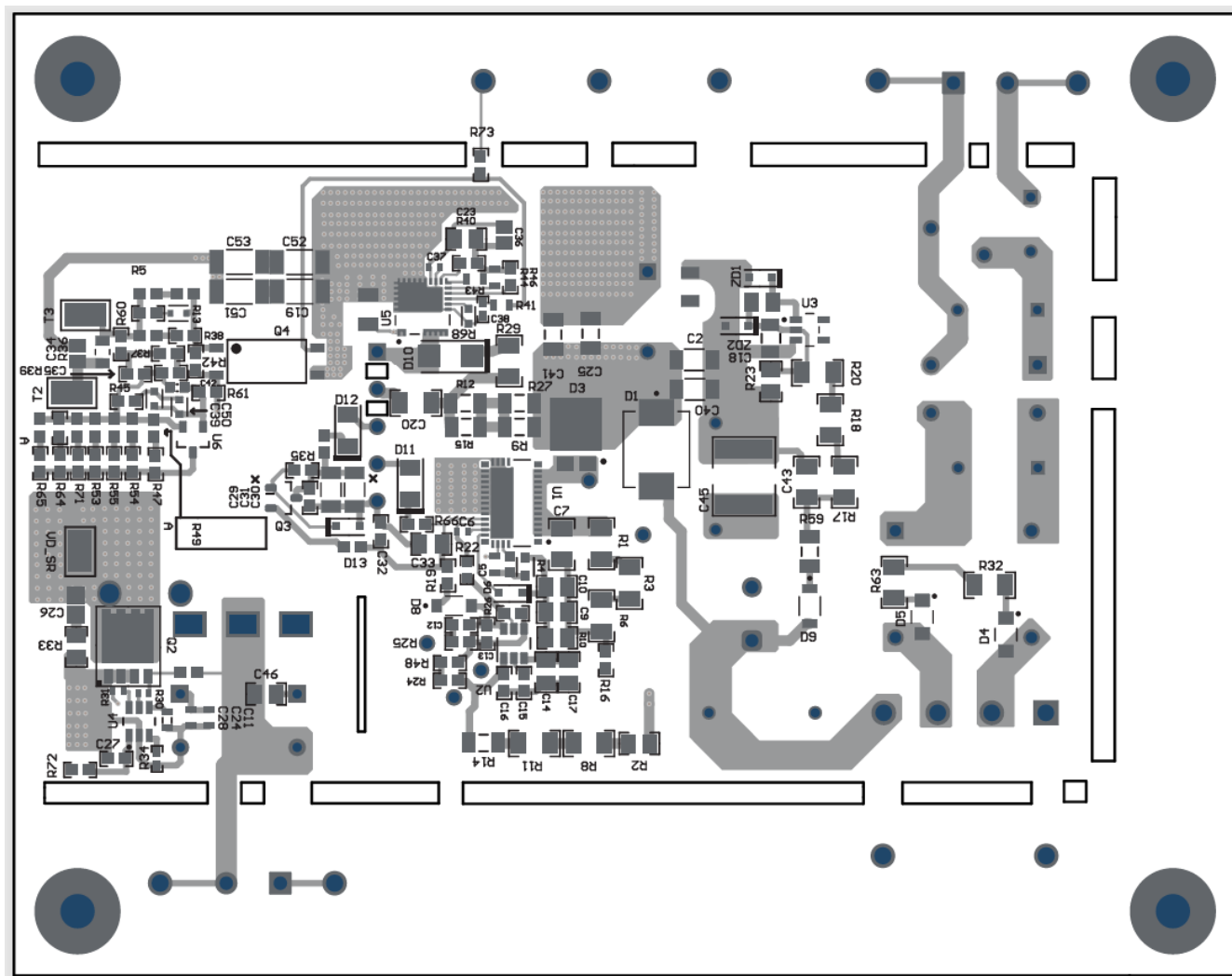


Figure 4-4. EVM Assembly (Bottom View)

4.3 Transformer Details

This design uses transformer from 3L Coils and the specifications are mentioned below. This transformer has good balance between leakage inductance and interturn capacitance. The details of the ATQ28-T-351K-W5 transformer are given below.

PARAMETER	TYPICAL VALUE	PINS/LEADS
Inductance (μH)	$350 \pm 10\%$	1 – 2
Leakage Inductance (μH)	3.76	1 – 2
D.C. resistance ($\text{m}\Omega$)	97.17	1 – 2
D.C. resistance ($\text{m}\Omega$)	9.57	S - F
Parasitic capacitance (pF)	47.8	1 - S
Turns-ratio	25T:5T:3T:10T $\pm$ 0.5TS	(1-2):(S-F):(4-5):(3-4)

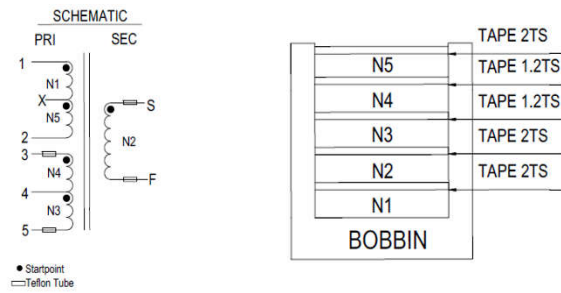
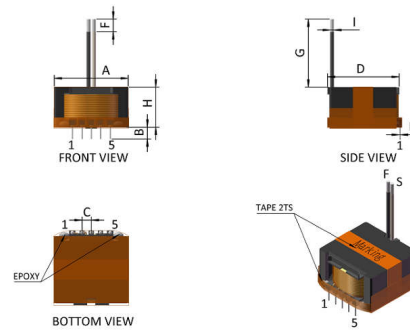


Figure 4-5. ATQ28-T-351K-W5: Schematic

1. Mechanical Dimension:



Item	Spec.(mm)	Typ.(mm)	Item	Spec.(mm)	Typ.(mm)
A	29.3 MAX	28.56	F	5.0 ± 0.5	5.1
B	3.8 ± 0.5	3.87	G	50 ± 2.0	50.3
C	3.5 ± 0.5	3.51	H	20.0 MAX	19.1
D	30.5 MAX	29.71	I	1.8 MAX	1.6
E	0.8 ± 0.1	0.80	J		

Notes:

Marking :ATQ28-T-351K

Figure 4-6. ATQ28-T-351K-W5: Mechanical Dimensions

3、DC-BIAS CURVE.

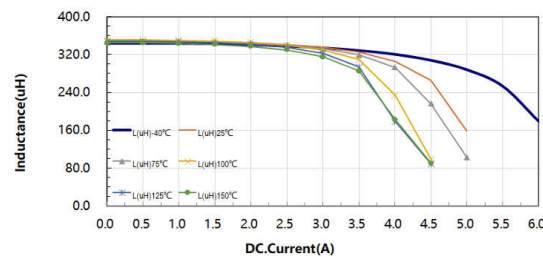


Figure 4-7. ATQ28-T-351K-W5: DC Bias Curve

4.4 Bill of Materials

The table below lists the bill of materials for UCG28828EVM-098.

Table 4-1. Bill of Materials

Designator	Quantity	Description	Part Number
390V_BUS, Line, VFB, Vinrect, Vout	5	Test Point, Multipurpose, White, TH	5012
C1	1	100µF 450V Aluminum Electrolytic Capacitors Radial, Can 3000 Hrs at 105°C	KCMJ2002W101MF
C2, C25, C40, C41	4	CAP, CERM, 0.1µF, 450V, ± 10%, X7T, AEC-Q200 Grade 1, 1206_190	CGA5L4X7T2W104K160AE
C3, C4	2	470nF ±10% X2 Plugin,P=7.5mm Suppression Capacitors ROHS	MPX474K31B9KN20600
C5	1	CAP, CERM, 1µF, 25V,± 10%, X7R, AEC-Q200 Grade 1, 0603	CGA3E1X7R1E105K080AC
C6	1	CAP, CERM, 22pF, 50V,± 5%, C0G/NP0, 0402	CC0402JRNPO9BN220
C7	1	CAP, CERM, 10pF, 1000V, ± 5%, C0G/NP0, 1206	VJ1206A100JXGAT5Z
C8, C44	2	0.47 µF Film Capacitor 160V 450V Polypropylene (PP), Metallized Radial	B32671P4474K000
C9	1	CAP, CERM, 3300pF, 50V, ± 5%, C0G/NP0, 0805	GRM2165C1H332JA01D
C10	1	CAP, CERM, 470pF, 50V, ± 10%, X7R, 0805	C0805C471K5RACTU

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Description	Part Number
C11, C24	2	CAP, CERM, 0.1µF, 50V, ± 10%, X7R, AEC-Q200 Grade 1, 0603	06035C104KAZ2A
C12	1	CAP, CERM, 1µF, 16V, ± 10%, X7R, AEC-Q200 Grade 1, 0603	GCM188R71C105KA64J
C13	1	CAP, CERM, 0.047µF, 100V, ± 10%, X7S, 0603	C1608X7S2A473K080AB
C14	1	CAP, CERM, 0.47µF, 50V, ± 10%, X7R, 0805	GRM21BR71H474KA88L
C15	1	CAP, CERM, 10pF, 50V, ± 5%, C0G/NP0, 0603	C0603C100J5GACTU
C16	1	CAP, CERM, 2200pF, 50V, ± 5%, C0G/NP0, 0603	GRM1885C1H222JA01D
C17	1	CAP, CERM, 10µF, 25V, ± 10%, X7R, 0805	GRM21BZ71E106KE15L
C18	1	Chip Multilayer Ceramic Capacitors for General Purpose, 1206, 47000pF, C0G, 30ppm/°C, 5%, 50V	GRM31M5C1H473JA01K
C19, C51, C52, C53	4	1500pF ±10% 250VAC Ceramic Capacitor X7R 1808 (4520 Metric)	1808YA250152KJTSYX
C20	1	CAP, CERM, 2200pF, 1000V, ± 10%, X7R, 1206	GRM31BR73A222KW01L
C21, C23	2	Aluminum Electrolytic Capacitors (Radial Lead Type) 820µF ± 20% 35V	EEUFS1V821
C23, C36	2	CAP, CERM, 22µF, 10V, ± 20%, X7R, 0805	GRM21BZ71A226ME15L
C26	1	CAP CER 1000PF 1KV X7R 0805	C0805X102KDRACTU
C27	1	CAP, CERM, 1µF, 50V, ± 10%, X5R, 0603	C1608X5R1H105K080AB
C28	1	CAP, CERM, 0.47µF, 50V, ± 10%, X7R, 0603	C1608X7R1H474K080AC
C29	1	CAP, CERM, 0.1µF, 100V, ± 10%, X7R, AEC-Q200 Grade 1, 0603	HMK107B7104KAHT
C30, C31	2	Chip Multilayer Ceramic Capacitors for General Purpose, 1206, 4.7µF, X7R, 15%, 10%, 100V	GRM31CZ72A475KE11L
C32	1	CAP, CERM, 0.1µF, 50V, ± 10%, X7R, 0603	C1608X7R1H104K080AA
C33	1	CAP, CERM, 10µF, 35V, ± 10%, X5R, 0805	GMK212BBJ106KG-T
C34	1	CAP, CERM, 1µF, 50V, ± 10%, X7R, AEC-Q200 Grade 1, 0805	08055C105K4Z2A
C35	1	CAP, CERM, 1000pF, 100V, ± 5%, C0G/NP0, 0603	C1608C0G2A102J080AA
C37	1	CAP, CERM, 0.1µF, 25V, ± 10%, X7R, 0402	GRM155R71E104KE14D
C38	1	CAP, CERM, 330pF, 50V, ± 1%, C0G/NP0, 0402	GRM1555C1H331FA01J
C39, C50	2	Multi-Layer Ceramic Capacitor 10nF 50V C0G ± 5% 0603 Paper T/R	GRT1885C1H103JA02D
C43	1	CAP, CERM, 0.022µF, 500V, ± 10%, X7R, 1206	VJ1206Y223KXEAT5Z
C45	1	CAP, CERM, 0.22µF, 500V, ± 10%, X7R, 2220	VJ2220Y224KBEAT4X
C46	1	CAP, CERM, 0.22µF, 100V, ± 10%, X7R, 0805	CL21B224KCFNSWE
D1	1	Rectifier, Single, 600V, 3A, Smc Rohs Compliant: Yes	S3J-13F
D3	1	Diode, Hyperfast, 600V, 6A, AEC-Q101, TO-277A	VS-6ESH06HM3/86A
D4, D5	2	Diode 1000V 2A Surface Mount SOD-123F	S2MFL
D6	1	Diode, Switching, 75V, 0.15A, AEC-Q101, SOD-323	1N4148WS-7F
D7	1	Diode Rectifier Bridge Single 600V 8A 4-Pin Case GBU Tube	GBU806
D8	1	Diode Small Signal Schottky 100V 0.5A 2-Pin SOD-123T/R	BAS100AS_R1_00001
D9	1	Diode 1000V 1A Surface Mount SOD-123FL	SL1M
D10	1	Diode, Fast Rectifier, 800V, 1A, SMA	US1K-13F
D11, D12	2	Diode, Superfast Rectifier, 600V, 1A, 3.5x1.6mm	CSFMT108-HF
D13	1	Diode, Zener, 15V, 200mW, SOD-323	MMSZ5245BS-7F
F1	1	Fuse Subminiature Slow Blow Acting 3.15A 350V Radial 8.35X 4X 7.8mm Thermoplastic Box	0697W3150-01

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Description	Part Number
H1, H2, H3, H4	4	Standoff, Hex, 0.5"L #4-40 Nylon	NY PMS 440 0025 PH
H5, H6, H7, H8	4	Standoff, Hex, 0.5"L #4-40 Nylon	1902C
J1, J2	2	Terminal Block, 5.08mm, 2x1, Brass, TH	ED120/2DS
L1	1	'Power Choke Unshielded Wirewound 150uH 10% 10KHz Ferrite 2A 180mΩ DCR RDL Tray	7447480151
L2	1	Inductor 240uH 10% 100kHz 0.223Ω 9.8A 26.16x26.16x19.05mm TH	750317130
L3	1	Coupled inductor, 1mH, 2A, 0.045Ω, TH	744821201
L4	1	Coupled Inductor 15mH	DC-SQ1515-02010-03L
Neutral, PGND1, PGND2, SGND	4	Test Point, Multipurpose, Black, TH	Neutral, PGND, SGND
Q2	1	MOSFET, N-CH, 150V, 87A, PG-TDSON-8	BSC093N15NS5ATMA1
Q3	1	MOSFET, N-CH, 100V, 0.17A, SOT-23	BSS123
Q4	1	Optoisolator Transistor Output 5000Vrms 1 Channel 6-SO	TLP383(GR-TPL,E)
R1, R3, R6, R8, R11, R14, R17, R18, R20	9	RES, 3.32M, 1%, 0.25W, AEC-Q200 Grade 0, 1206	CRCW12063M32FKEA
R2	1	RES, 0, 5%, 0.125W, AEC-Q200 Grade 0, 0805	ERJ-6GEY0R00V
R4	1	RES SMD 127Ω 0.5% 1/10W 0603	RT0603DRD07127RL
R5, R49	2	RES, 0, 5%, 0.125W, AEC-Q200 Grade 0, 0805	RC0603JR-070RL
R9, R12, R15, R27	4	RES, 324k, 1%, 0.25W, AEC-Q200 Grade 0, 1206	ERJ-8ENF3243V
R10	1	RES, 24.9k, 1%, 0.125W, AEC-Q200 Grade 0, 0805	CRCW080524K9FKEA
R13	1	1.01kΩ ±0.1% 0.1W, 1/10W Chip Resistor 0603 (1608 Metric) Moisture Resistant Thin Film	RN73R1JTTD1011B25
R16	1	RES, 3.00k, 0.1%, 0.1W, 0603	RG1608P-302B-T5
R19, R35	2	RES, 1.00M, 1%, 0.125W, 0603	MCT06030C1004FP500
R22	1	RES, 47, 5%, 0.1W, AEC-Q200 Grade 0, 0603	CRCW060347R0JNEA
R23	1	RES, 180k, 0.1%, 0.125W, 0805	RT0805BRD07180KL
R24	1	RES, 20.0k, 0.1%, 0.1W, 0603	RT0603BRD0720KL
R25	1	RES, 180k, 0.1%, 0.1W, 0603	RT0603BRD07180KL
R26	1	RES, 220k, 0.1%, 0.1W, 0603	RG1608P-224B-T5
R29	1	RES, 10.0, 0.5%, 1W, AEC-Q200 Grade 0, 1206	HRG3216Q-10R0D-T1
R30	1	RES, 0, 5%, 0.063W, AEC-Q200 Grade 0, 0402	CRCW04020000Z0ED
R31	1	RES, 511, 1%, 0.063W, AEC-Q200 Grade 0, 0402	CRCW0402511RFKED
R32, R63	2	RES, 511, 1%, 0.25W, AEC-Q200 Grade 0, 1206	CRCW1206511RFKEA
R33	1	RES, 10.0, 0.05%, 0.1W, 0805	RNCF0805AKT10R0
R34	1	RES, 100k, 1%, 0.1W, 0402	ERJ-2RKF1003X
R36	1	0Ωs Jumper 0.125W, 1/8W Chip Resistor 0805 (2012 Metric) Automotive AEC-Q200 Thick Film	RMCF0805ZT0R00
R37	1	RES, 15.0k, 0.05%, 0.1W, AEC-Q200 Grade 0, 0603	ERA-3ARW153V
R38	1	RES, 2.74k, 0.1%, 0.1W, 0603	RT0603BRD072K74L
R39, R53	2	RES, 249k, 0.1%, 0.1W, 0603	RT0603BRD07249KL
R40	1	RES, 7.68k, 0.5%, 0.1W, 0603	RT0603DRE077K68L
R41, R60, R61, R72, R73	5	RES, 0, 0%, 0.25W, AEC-Q200 Grade 0, 0603	RCS06030000Z0EA
R42	1	RES, 1.00k, 0.01%, 0.063W, 0603	RNCF0603TKY1K00
R43	1	RES, 28.7k, 0.5%, 0.1W, 0603	RT0603DRE0728K7L
R44	1	RES, 75.0k, 0.5%, 0.1W, 0603	RT0603DRE0775KL
R45	1	RES, 49.9k, 0.5%, 0.1W, 0603	RT0603DRE0749K9L
R46	1	RES, 5.23k, 0.1%, 0.1W, 0603	RT0603BRD075K23L

Table 4-1. Bill of Materials (continued)

Designator	Quantity	Description	Part Number
R47	1	RES, 35.2k, 0.1%, 0.1W, 0603	RT0603BRD0735K2L
R48	1	RES, 44.2k, 0.5%, 0.1W, 0603	RT0603DRE0744K2L
R54	1	RES, 49.9k, 0.1%, 0.1W, 0603	RT0603BRD0749K9L
R55	1	RES, 95.3k, 0.1%, 0.1W, 0603	RT0603BRD0795K3L
R59	1	RES, 2.0k, 5%, 0.25W, AEC-Q200 Grade 0, 1206	CRCW12062K00JNEA
R64	1	RES, 28.7k, 0.1%, 0.1W, 0603	RT0603BRD0728K7L
R65	1	RES, 24.3k, 0.1%, 0.1W, 0603	RT0603BRD0724K3L
R66	1	RES, 5.05, 0.5%, 0.1W, 0603	RT0603DRE075R05L
R68	1	NTC Thermistor 150k 0603 (1608 Metric)	NT06155F4050B1F
R71	1	RES, 64.9k, 0.5%, 0.1W, 0603	RT0603DRE0764K9L
RV1	1	VARISTOR 490V 1.2KA DISC 7MM	V300LA2P
T1	1	Transformer	ATQ28T-351K-W5
T2, T3, VD_SR	3	Test Point, Miniature, SMT	5019
U1	1	650V GaN FET With Integrated Driver and Current Sense Emulation	LMG3622REQ
U2	1	6-Pin Single-Phase Transition-Mode PFC Controller, DBV0006A (SOT-23-6)	UCC28056ADBVR
U3	1	Active-low voltage monitor with low quiescent current and 2.5% threshold accuracy 5-SOT-23 -40 to 85	LM8364BALMF20/NOPB
U4	1	FAST TURN-OFF INTELLIGENT RECTIF	MP6908AGJ-P
U5	1	Self-Biased High Frequency QR Flyback Converter With 750V Integrated GaN HEMT	UCG28828-1REZR
U6	1	Shunt Voltage Reference IC Adjustable 2.5V 36VV $\pm 1\%$ 15mA SOT-23-3	ATL431LIAIDBZR
ZD1, ZD2	2	Diode, Zener, 5.1V, 400mW, SOD-323F	D3Z5V1BF-7

5 Additional Informations

Trademarks

All trademarks are the property of their respective owners.

6 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision * (July 2026) to Revision A (August 2026)	Page
• Updated axis labels on Figure 3-4 through Figure 3-6	11

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.
 - 1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software
 - 1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.
2. *Limited Warranty and Related Remedies/Disclaimers:*
 - 2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
 - 2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.
 - 2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI's recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI's recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI's instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGRADATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 Regulatory Notices:

3.1 United States

3.1.1 Notice applicable to EVMs not FCC-Approved:

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

3.2 Canada

3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. Operation is subject to the following two conditions:

(1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

3.3 Japan

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/sds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html>

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】 開発キットの中には技術基準適合証明を受けていないものがあります。技術適合証明を受けていないもののご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。 日本テキサス・インスツルメンツ株式会社
東京都新宿区西新宿 6 丁目 2 4 番 1 号
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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/sds/ti_ja/general/eStore/notice_02.page

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-for-power-line-communication.html>

3.4 European Union

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive):*

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 EVM Use Restrictions and Warnings:

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 Safety-Related Warnings and Restrictions:

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4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

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