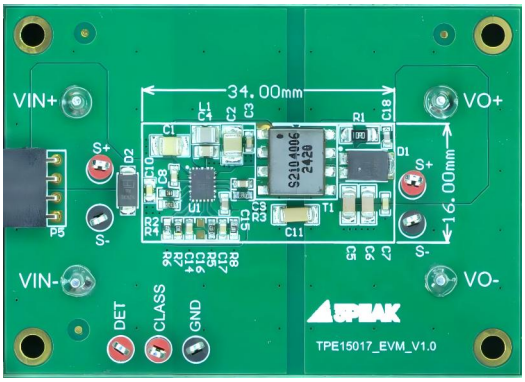
TPE15017 PoE PD Solution with PSR or SSR Active Clamp Flyback Converter



DESCRIPTIONS

The TPE15017 is an integrated IEEE 802.3af compatible PoE Powered Device with integrated PD interface and fly-back power converter. It is targeted for small size 13W isolated PoE applications.

The PD interface has all the functions of IEEE 802.3af, including detection, classification, inrush current, operation current limit, 100V hotswap MOSFET.

TPE15017 fly-back converter is specifically designed for active clamp primary-side regulate (PSR) fly-back topology, which supports small size and high efficiency. TPE15017 can also be set in secondary-side regulate (SSR) active clamped fly-back topology, which can get best regulation through opto-coupler from secondary side.

The TPE15017 can support a front-end solution for PoE-PD application with minimum external components. It is available in QFN-19 (3mmX4mm) package.

The TPE15017 is available in 19-pin 3mmx4mm QFN package.

Key Features

- Compatible with 802.3af Specifications
- 100V 0.5Ω PD Input MOSFET
- Active Clamp Primary-Side Regulated (PSR) Flyback without Aux-winding
- Active Clamp Secondary-Side Regulated (SSR) Flyback through opto-coupler
- 0.37Ω & 0.75Ω Integral Flyback MOSFET
- Programmable up to 650kHz Frequency
- 1.5A Switching Current Limit
- Output Diode Compensation in PSR Mode
- Programmable Soft-Start Time
- Frequency Foldback During Startup and Protection
- Auto Light Load Power Maintain Signature with 10mA Current Sink
- EMI Reduction with Frequency Dithering (Fixed 12.5kHz Double Dithering)
- Hiccup OLP, OVP and OTP Protection
- Operating T_J temperature range from −40°C ~ +125°C
- Available in 3×4 19-pin QFN package

APPLICATIONS

- IEEE 802.3af-Compliant Devices
- Security Camera
- VoIP Phones
- WLAN Access Points
- IoT Devices

Revision History

Revise Date	Version	Reason/Issue
2023-12-12	A0	First Issue
2024-11-22	A1	Update some figures

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1. Performance Specification

A summary of the TPE15017 EVM performance specifications is provided in Table.1. Specifications are given for Vin=48V and Vout=12V, unless otherwise specified. The ambient temperature is 25℃ for all measurements, unless otherwise noted.

Table.1 TPE15017 EVM Performance Specification

PARAMETER	TEST CONDITIONS	MIN	Type	Max	UNITS
INPUT CHARACTERISTICS					
Operating voltage range, Vin		40	48	57	V
OUTPUT CHARACTERISTICS					
Output voltage, Vout	Vin=40V to 57V,Iout=0A to 1A		12		V
Output Current range, Iout	Vin=40V to 57V	0		1	A
SYSTEMS CHARACTERISTICS					
Operating Frequency,fsw			500		kHz
Efficiency	Vin=48V, Iout=1A,fsw=500kHz		85		%

2. EVM Documentation

2.1 Schematic

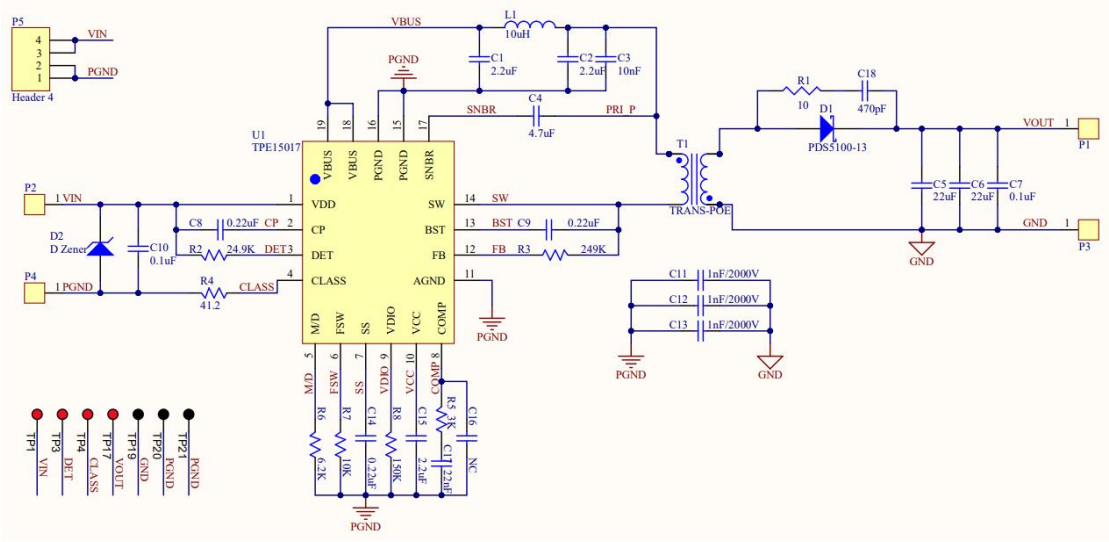


Fig.1 TPE15017 EVM Schematic (Vout=12V)

2.2 Bill of Material

Table.2 TPE15017 EVM Bill of Materials

Designator	Description	Package	MANUFACTURER	Part No.	Value
C1, C2	CAP CREM,2.2uF,100V,X7R	1206	Murata	GRM319R72A225KA01D	2.2uF

C3	CAP CREM,10nF,100V,X7R	0603	Murata	GRM188R72A103KA01D	10nF
C4	CAP CREM,4.7uF,50V,X7R	0805	Murata	GRM21BZ71H475KE15L	4.7uF
C5, C6	CAP CREM,22uF,25V,X7S	1206	Murata	GRM21BR71E226KA01D	22uF
C7, C10	CAP CREM,0.1uF,100V,X7R	0603	Murata	GRM188R71E104KA01D	0.1uF
C8, C9 C14	CAP CREM,0.22uF,25V,X7R	0603	Murata	GRM188R71A224KA01D	0.22uF
C11, C12, C13	CAP CREM,1nF,2000V,X7R	1808	Murata	GR442QR73D102KW01L	1nF
C15	CAP CREM,2.2uF,50V,X7R	0603	Murata	GRM188R71A225KA01D	2.2uF
C16	NC				OPEN
C17	CAP CREM,22nF,25V,X7R	0603	Murata	GRM188R71A223KA01D	22nF
C18	CAP CREM,470pF,100V,X7R	0603	Murata	GRM188R72A471KA01D	470pF
D1	Schottky Diode 3A 100V	PowerDI5-3	Diodes	PDS3100	100V
D2	TVS diode	DIO_SMA	Diodes	SMAJ60A	60V
L1	SMD Inductor	2520	Murata	DFE252012F-100M	10uH
P5	Header,4-Pin	HDR1×4	Wurth		
R1	Res,1%,0.1W,1206	1206	Yageo	RC1206FR-0710RL	10
R2	Res,1%,0.1W,0603	0603	Yageo	RC0603FR-0724K9L	24.9K
R3	Res,1%,0.1W,0603	0603	Yageo	RC0603FR-07249KL	249K
R4	Res,1%,0.1W,0603	0603	Yageo	RC0603FR-0741R2L	41.2
R5	Res,1%,0.1W,0603	0603	Yageo	RC0603FR-073KL	3K
R6	Res,1%,0.1W,0603	0603	Yageo	RC0603FR-076K2L	6.2K
R7	Res,1%,0.1W,0603	0603	Yageo	RC0603FR-0710KL	10K
R8	Res,1%,0.1W,0603	0603	Yageo	RC0603FR-07150KL	150K
T1	Power transformer,NP:NS=2:1	SMD	Sunlord	TWPEP090909B300T	55uH
TP1, TP3, TP4, TP17	Test Point, Multipurpose, Red, TH	SIP	Keystone	5010	
TP19, TP20, TP21	Test Point, Multipurpose, Black, TH	SIP	Keystone	5011	
U1	IC, PoE PD Converter	3mm*4mm QFN-19	3PEAK	TPE15017	

2.3 PCB Layout

Layout is a critical portion of good power supply design. See Figure 2 for a PCB layout example.

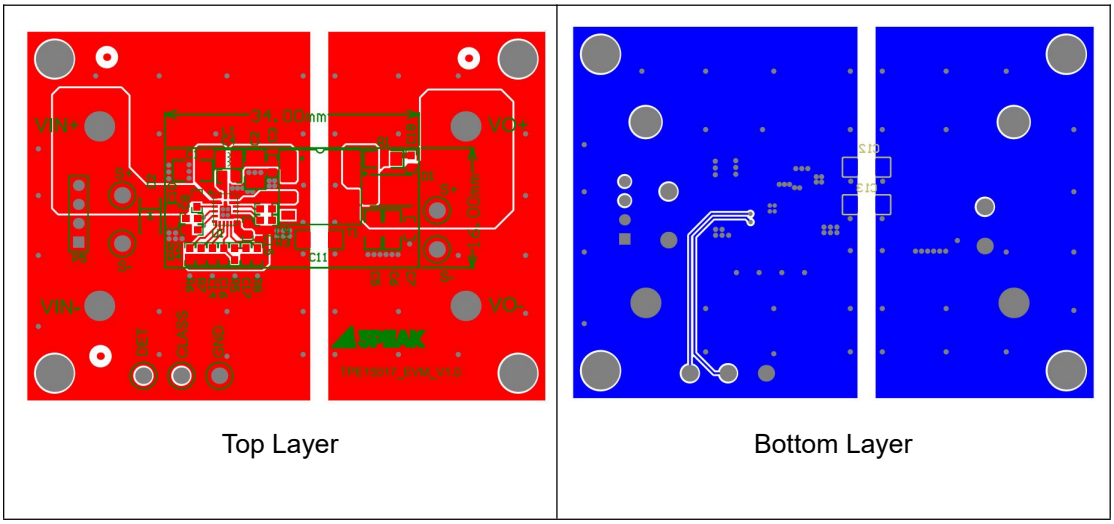
Here's the guidelines below:

It is needed to minimize the input-switching loop area formed by the flyback input cap, transformer, SW and PGND, the output loop area between rectifier diode, output cap and transformer, the active clamp loop area between active clamp cap, transformer, SW and SNBR, and the input hot-swap loop area between PD input cap, VDD, VBUS and VBUS cap.

The VCC capacitor should be placed as close as possible to the VCC PIN to prevent

excessive capacitive coupling.

The feedback trace is sensitive to noise so be short and far away from noise source such as SW.



Top Layer | Bottom Layer

Fig.2 TPE15017 EVM PCB Layout

3. Test Setup and Procedure

3.1 Test Setup

The TPE15017_EVM is provided with input/output connectors and test points as shown in Table.3.

Table.3 TPE15017_EVM Connections

Name	Description
VIN+	Positive input voltage connection
VIN-	Negative input voltage connection
VO+	Positive output voltage connection
VO-	Negative output voltage connection
DET	Test point for DET pin
CLASS	Test point for CLASS pin
GND	Test point for GND pin
S+	Voltage sense pin of VIN+/VO+
S-	Voltage sense pin of VIN-/VO-

Referring to Table.3, the recommended connections to evaluate TPE15017EVM is shown in Fig.3.

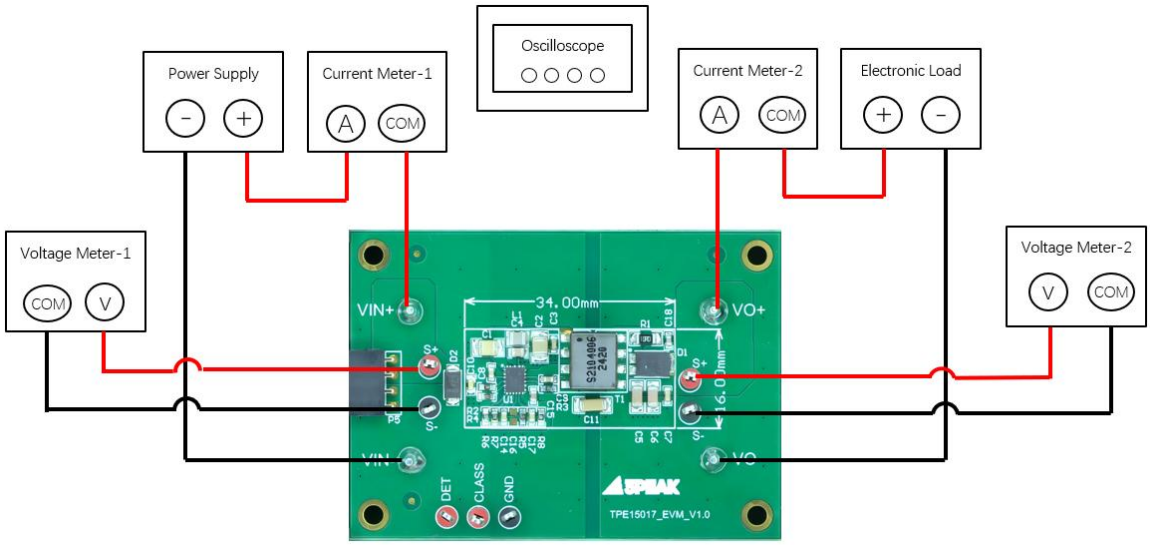


Fig.3 EVM Test Setup

3.2 Test Equipment

Table.4 is the equipment used by 3PEAK, can also use other model of instruments which can support the voltage, current and power level of this EVM test. Multimeters are used as voltage or current meters which measure the voltage and current of input and output.

Table.4 Test Equipment Used by 3PEAK

Instruments	**Model**	**Vender**
DC Source	PSW 160-21.6	GWINSTEK
Electronic Load	63640-150-60	Chroma
Oscilloscope	MSO58	Tektronix
Multimeter	34401A	Keysight

3.3 Test Procedure

- **Method 1**

1. Figure 4 shows the connection method using a DC source supply set-up.
2. Preset the power supply (Vin) between 40V and 57V, then turn off the power supply. After start-up, Vin can operate at down to 37V.
3. Connect the power supply terminals to:
   Positive (+): VIN+
   Negative (-): VIN-
4. Connect the load terminals to:
   Positive (+): VO+
   Negative (-): VO-
5. After making the connections, turn on the power supply.

6. Once VIN+ is turned on, the TPE15017 should be enabled on the evaluation board.

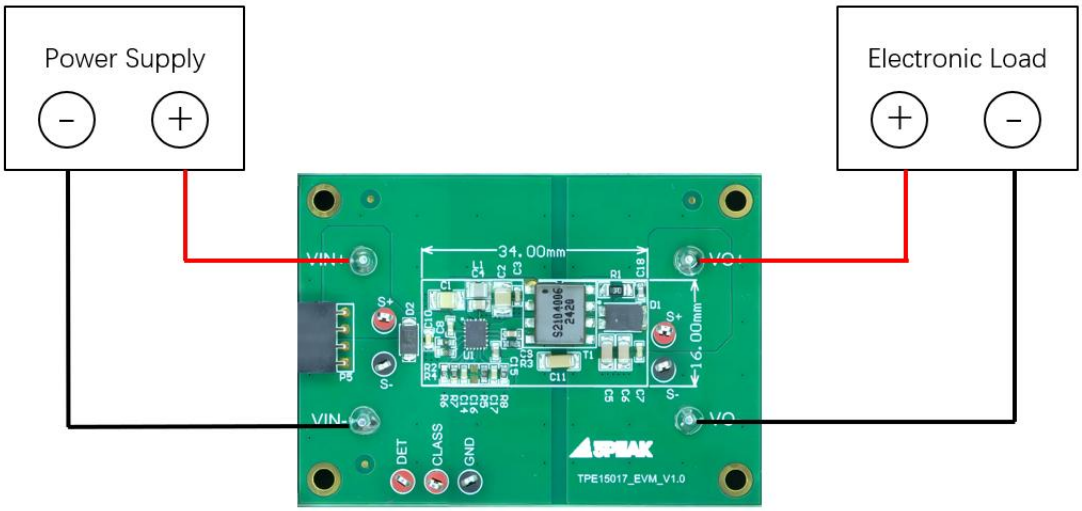


Fig.4 DC Source Supply Set-up

• Method 2

1. Figure 5 shows the connection method using an Ethernet cable supply set-up.
2. Connect the TPE15017_EVM P5 connector to the TPE15017_RJ45_EVM P6 connector.
3. Connect the load terminals to:
   Positive (+): VO+
   Negative (-): VO-
4. Connect the Ethernet cable from the power sourcing equipment (PSE) to the TPE15017_RJ45_EVM P6 connector. The board should automatically start up.

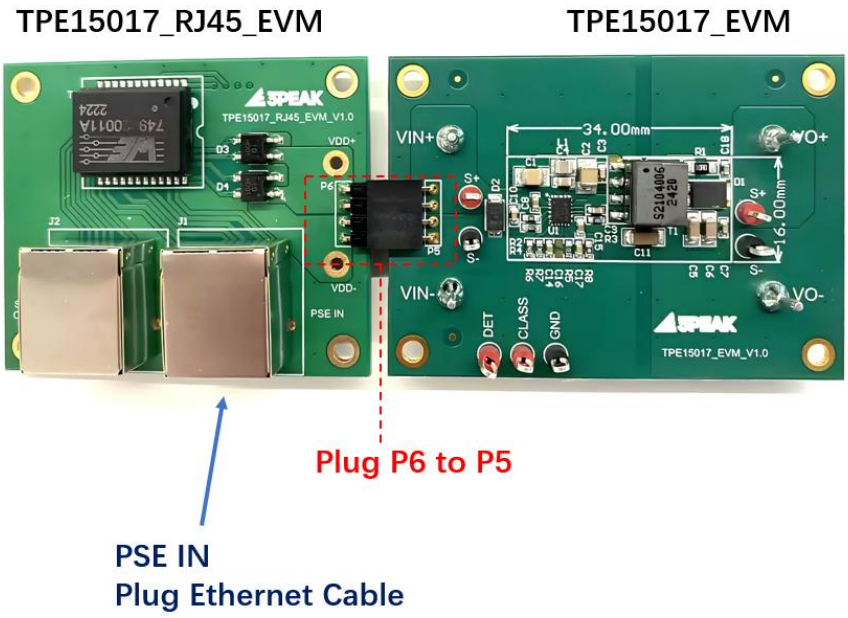


Fig.5 Ethernet Cable Supply Set-up

4. Test Results and Performance Evaluation

4.1 Efficiency

When test efficiency, need measure the input and output voltage at the PCB end or use the voltage sense pins if the EVM have.

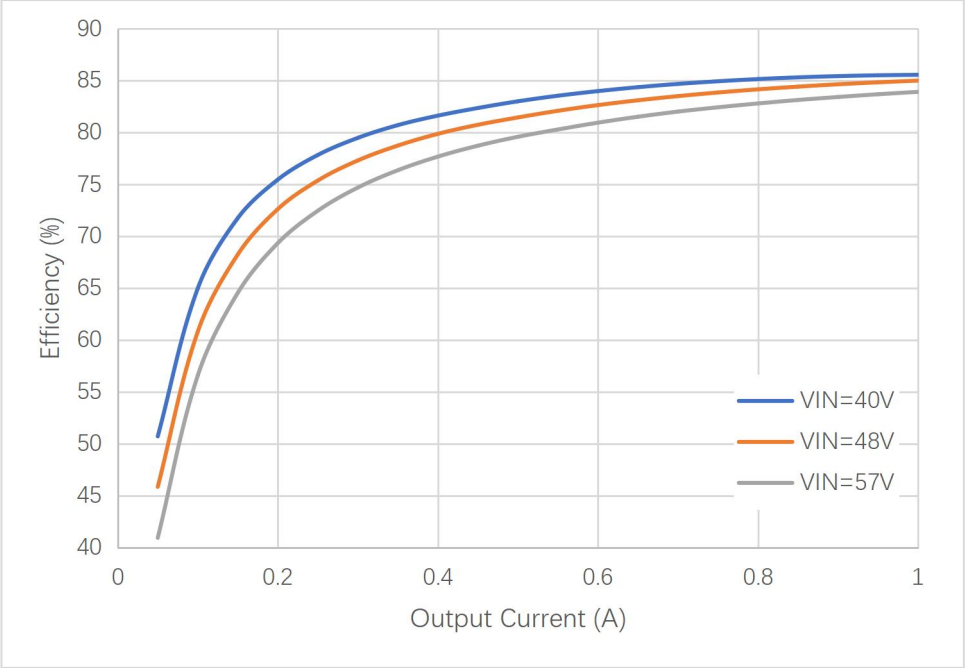


Fig.1 Efficiency Curve（Vout=12V）

4.2 Load Regulation

When test load regulation, the input voltage should be measured at PCB end or sense pins.

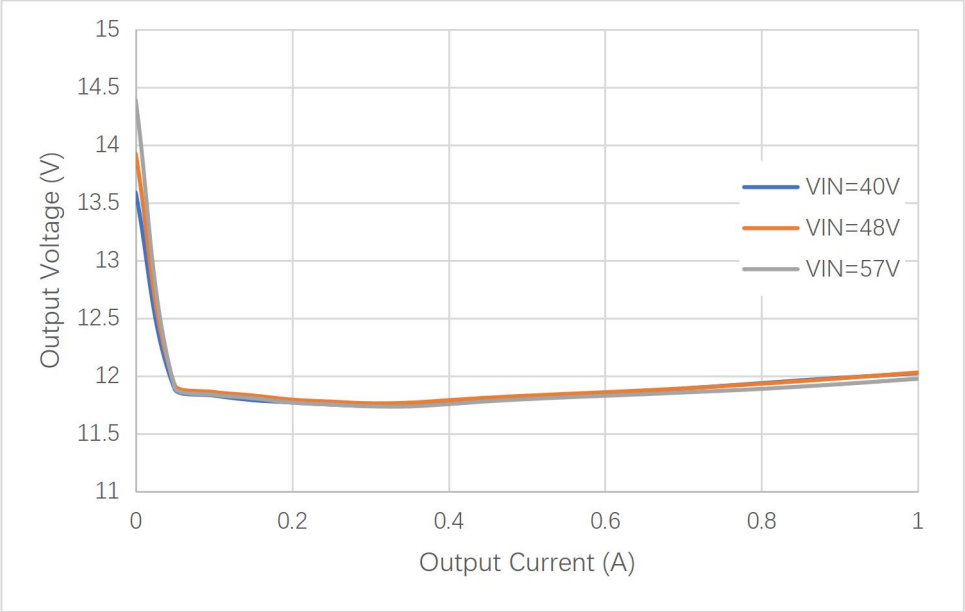


Fig.2 Load Regulation Curve（Vout=12V）

4.3 Line Regulation

When test line regulation, the input and output voltage should be measured at PCB end or sense pins.

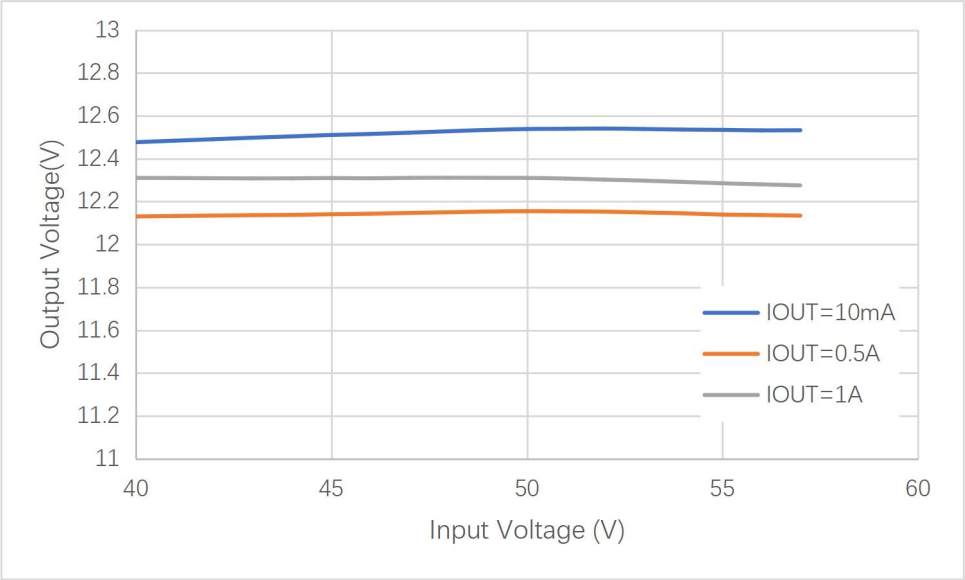


Fig.3 Line Regulation

4.4 Steady State Waveforms

Below shows the SW and inductor current waveforms in steady state with different output current. T_A = 25°C, unless otherwise noted.

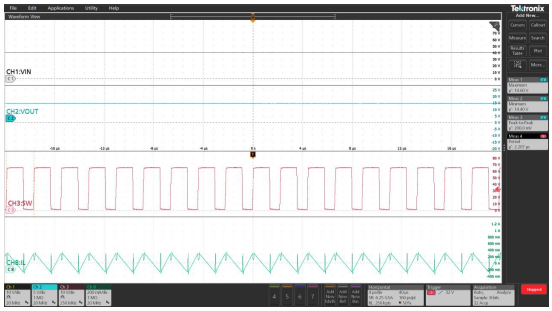


Table.5 VIN=40.0V_IOUT=0.00A_Static Test

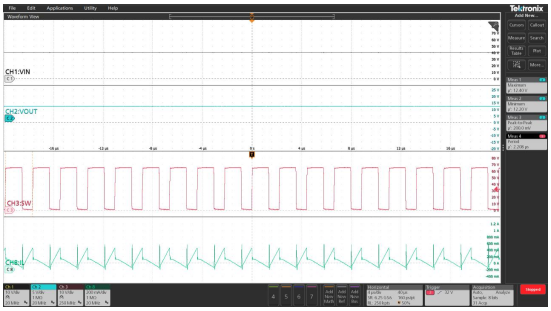


Table.6 VIN=40.0V_IOUT=0.20A_Static Test

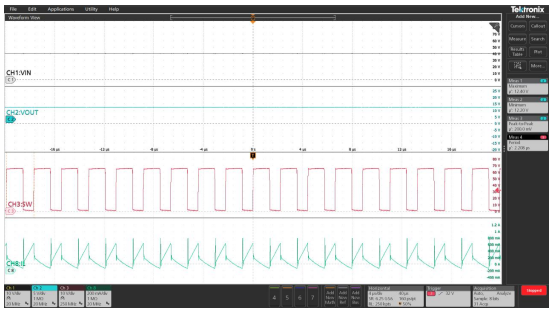


Table.7 VIN=40.0V_IOUT=0.40A_Static Test

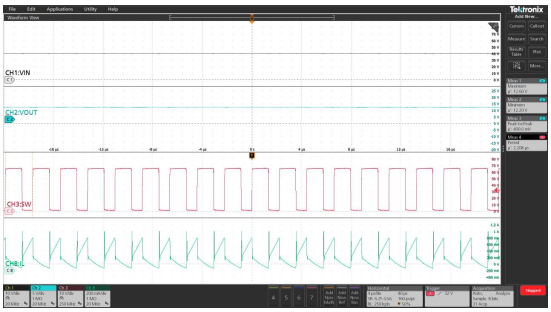


Table.8 VIN=40.0V_IOUT=0.60A_Static Test

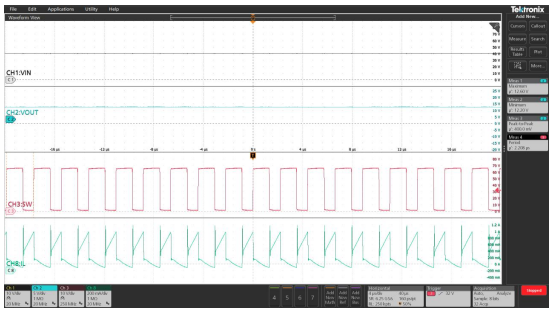


Table.9 VIN=40.0V_IOUT=0.80A_Static Test

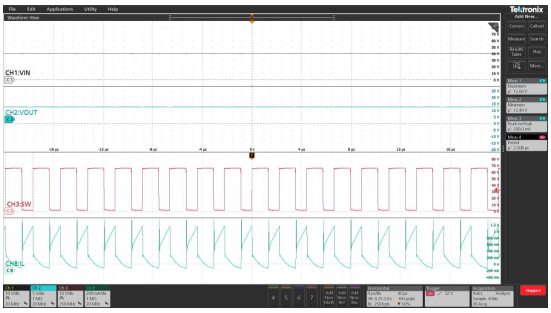


Table.10 VIN=40.0V_IOUT=1.00A_Static Test

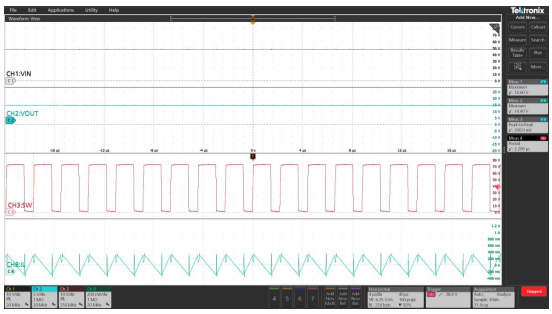


Table.11 VIN=48.0V_IOUT=0.00A_Static Test

Table.12 VIN=48.0V_IOUT=0.20A_Static Test

Table.13 VIN=48.0V_IOUT=0.40A_Static Test

Table.14 VIN=48.0V_IOUT=0.60A_Static Test

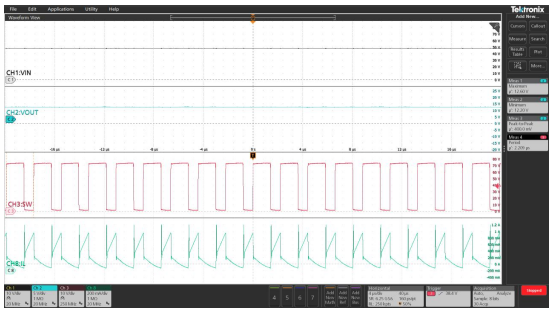


Table.15 VIN=48.0V_IOUT=0.80A_Static Test

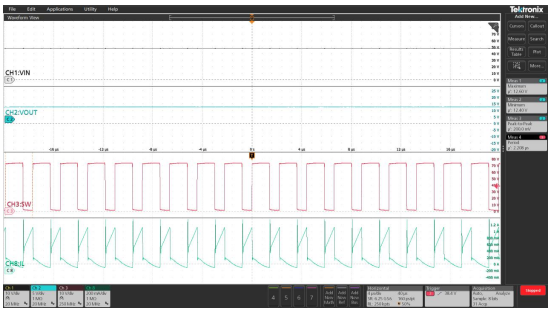


Table.16 VIN=48.0V_IOUT=1.00A_Static Test

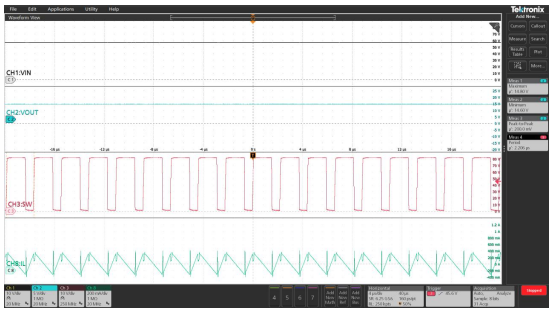


Table.17 VIN=57.0V_IOUT=0.00A_Static Test

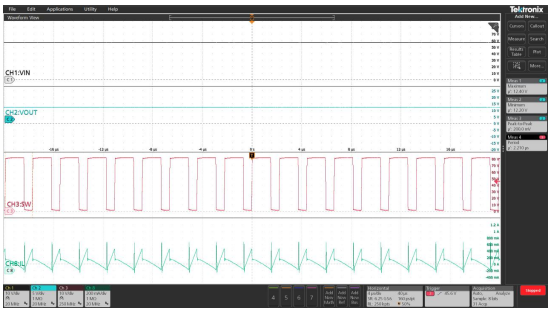


Table.18 VIN=57.0V_IOUT=0.20A_Static Test

Table.19 VIN=57.0V_IOUT=0.40A_Static Test

Table.20 VIN=57.0V_IOUT=0.60A_Static Test

Table.21 VIN=57.0V_IOUT=0.80A_Static Test

Table.22 VIN=57.0V_IOUT=1.00A_Static Test

4.5 Load Transient

Dynamic load with different level is added to output. T_A = 25°C, unless otherwise noted.

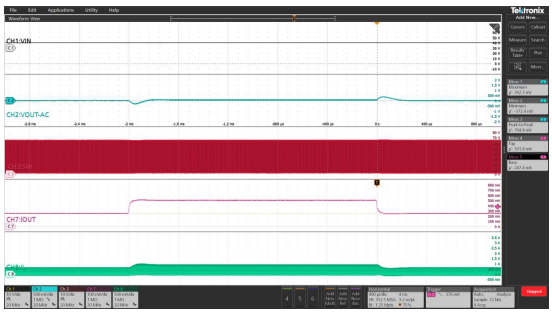


Table.23 VIN=40.0V_IOUT=0.50A-0.25A_Dynamic

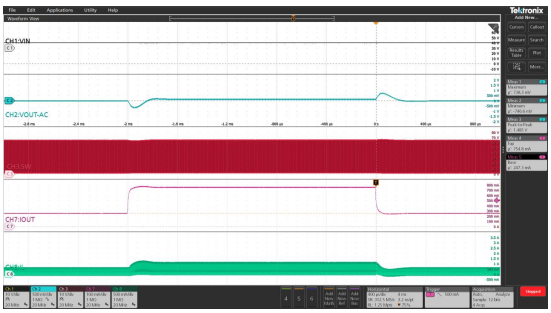


Table.24 VIN=40.0V_IOUT=0.75A-0.25A_Dynamic

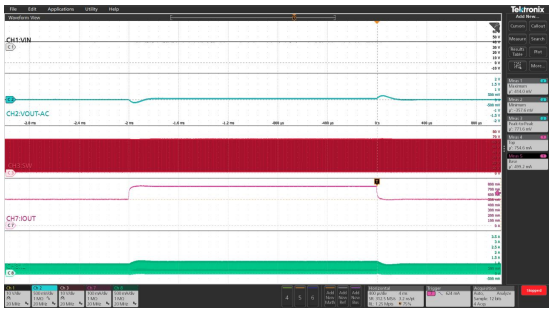


Table.25 VIN=40.0V_IOUT=0.75A-0.50A_Dynamic

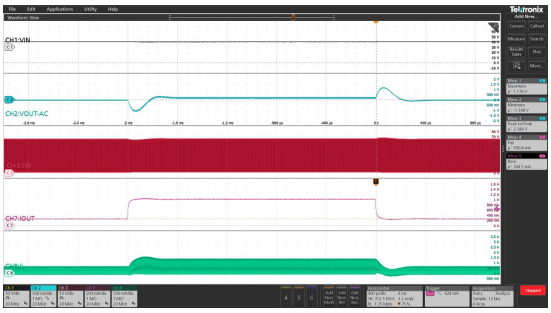


Table.26 VIN=40.0V_IOUT=1.00A-0.25A_Dynamic

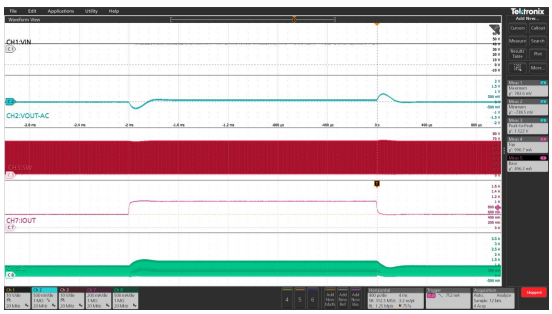


Table.27 VIN=40.0V_IOUT=1.00A-0.50A_Dynamic

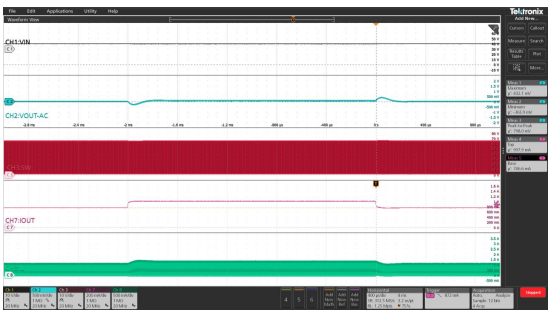


Table.28 VIN=40.0V_IOUT=1.00A-0.75A_Dynamic

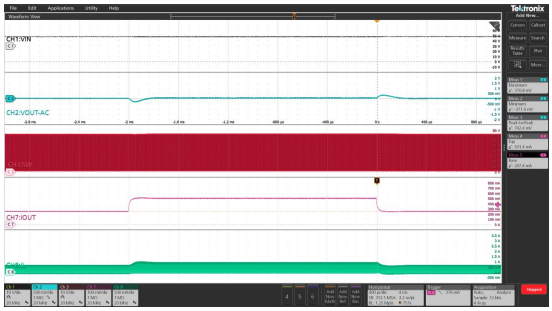


Table.29 VIN=48.0V_IOUT=0.50A-0.25A_Dynamic

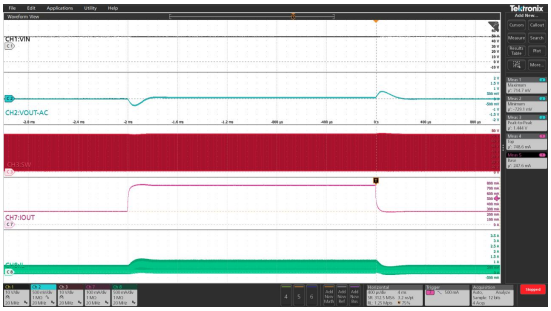


Table.30 VIN=48.0V_IOUT=0.75A-0.25A_Dynamic

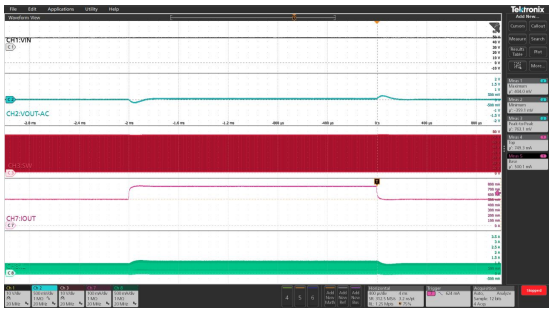


Table.31 VIN=48.0V_IOUT=0.75A-0.50A_Dynamic

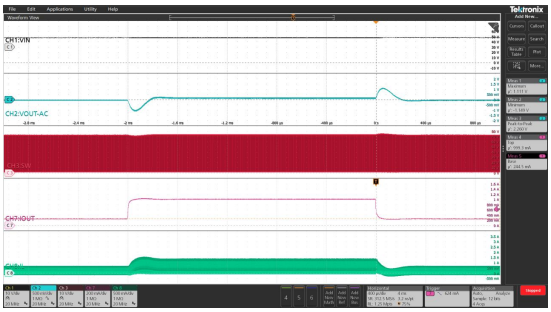
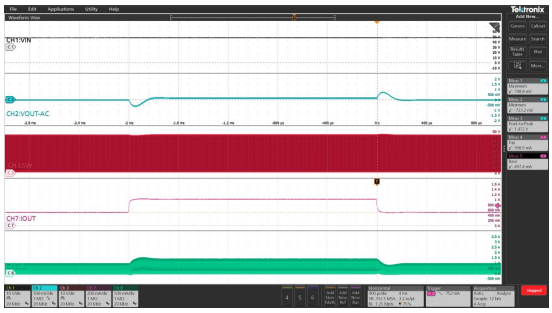


Table.32 VIN=48.0V_IOUT=1.00A-0.25A_Dynamic



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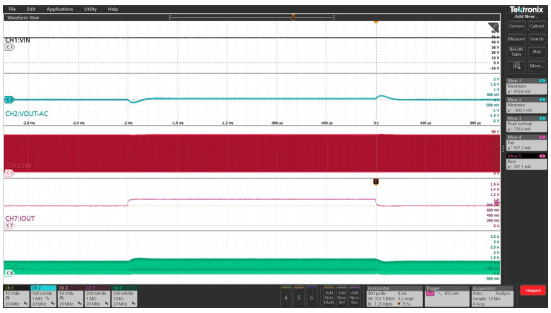

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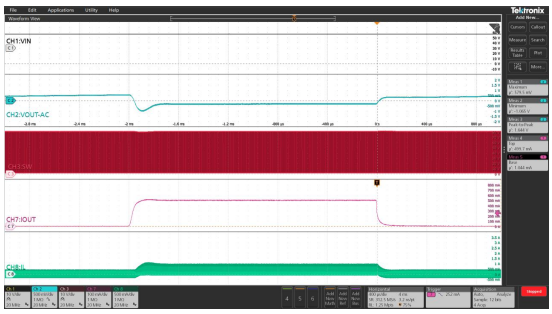


Table.35 VIN=57.0V_IOUT=0.50A-0.00A_Dynamic

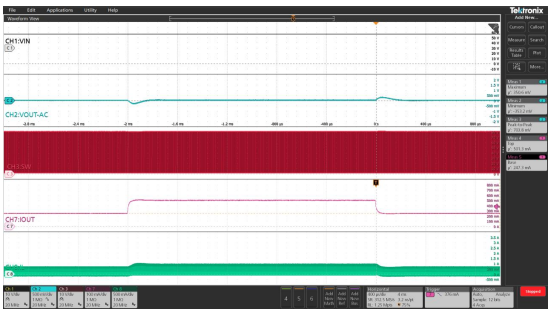


Table.36 VIN=57.0V_IOUT=0.50A-0.25A_Dynamic

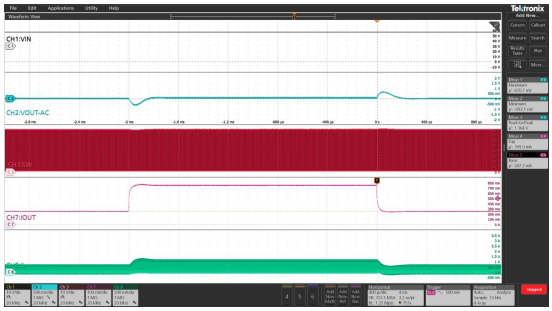


Table.37 VIN=57.0V_IOUT=0.75A-0.25A_Dynamic

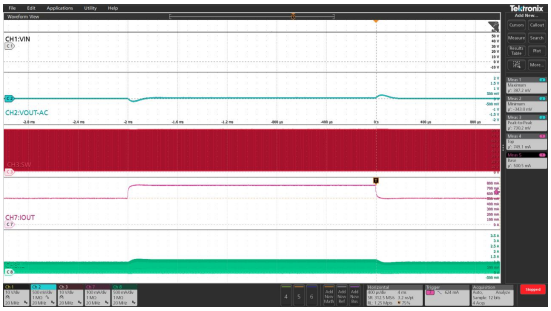


Table.38 VIN=57.0V_IOUT=0.75A-0.50A_Dynamic

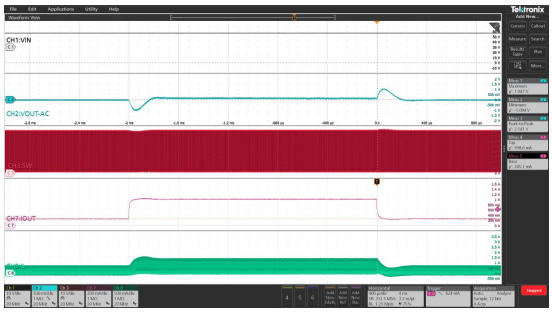


Table.39 VIN=57.0V_IOUT=1.00A-0.25A_Dynamic

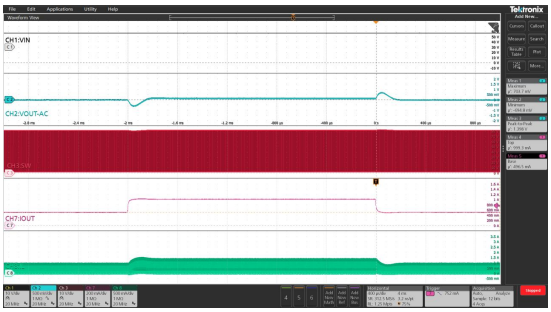


Table.40 VIN=57.0V_IOUT=1.00A-0.50A_Dynamic

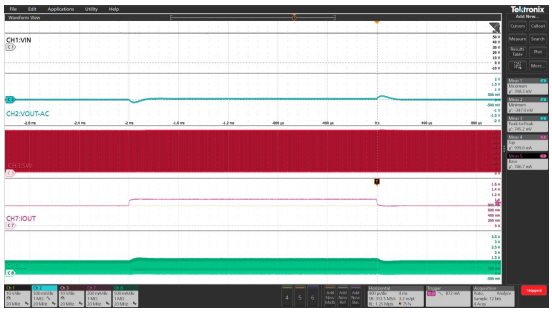


Table.41 VIN=57.0V_IOUT=1.00A-0.75A_Dynamic

4.6 Powering Up

Below show the start-up waveforms for the EVM including input voltage start-up and down. T_A = 25°C, unless otherwise noted.

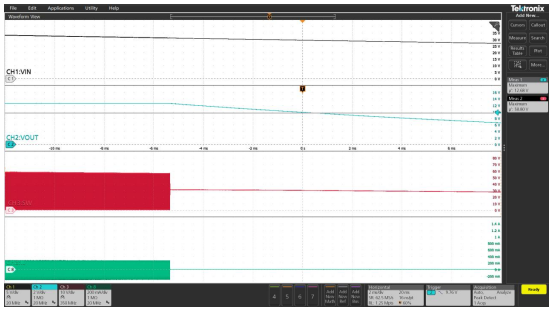


Table.42 VIN=40.0V_IOUT=0.010A_VIN PowerDown

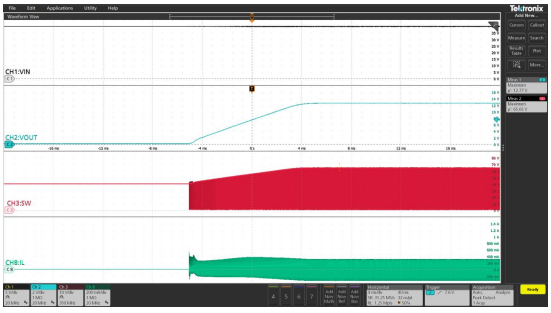


Table.43 VIN=40.0V_IOUT=0.010A_VIN Startup_CC

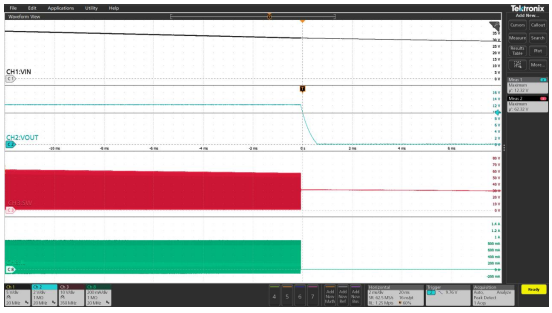


Table.44 VIN=40.0V_IOUT=0.500A_VIN PowerDown

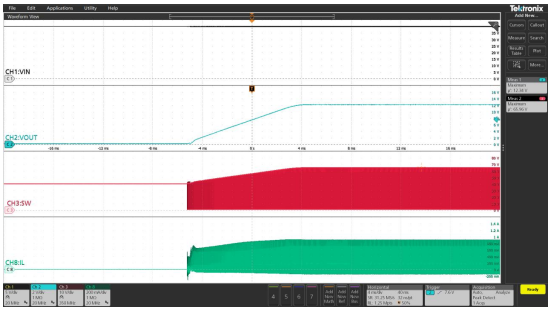


Table.45 VIN=40.0V_IOUT=0.500A_VIN Startup_CC

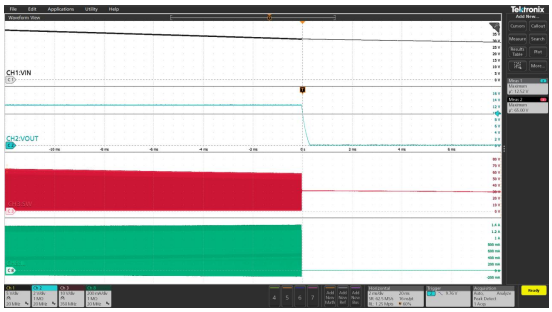


Table.46 VIN=40.0V_IOUT=1.000A_VIN PowerDown

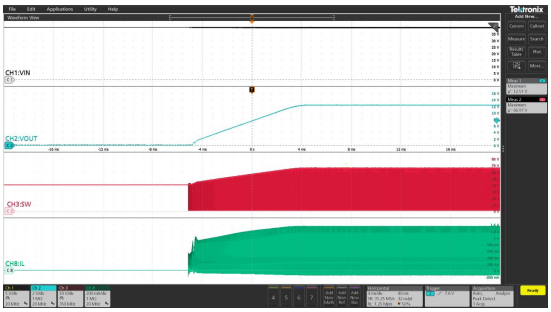


Table.47 VIN=40.0V_IOUT=1.000A_VIN Startup_CC

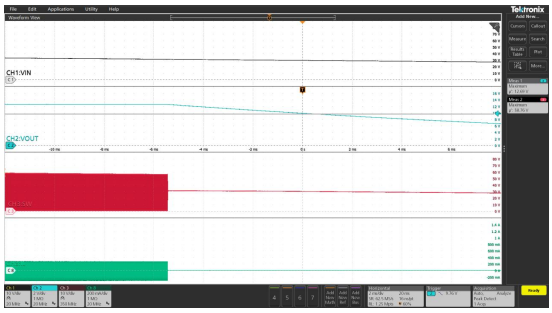


Table.48 VIN=48.0V_IOUT=0.010A_VIN PowerDown

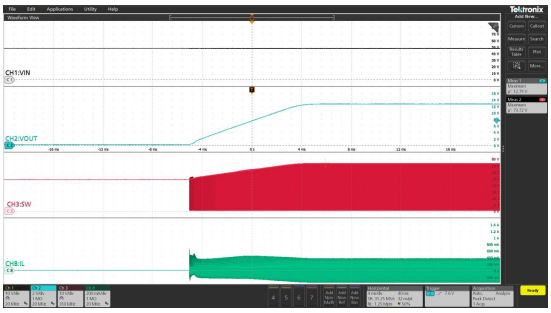


Table.49 VIN=48.0V_IOUT=0.010A_VIN Startup_CC

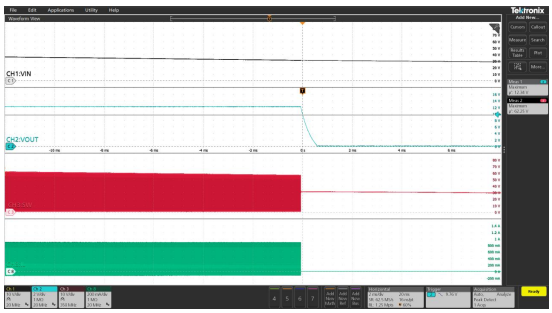


Table.50 VIN=48.0V_IOUT=0.500A_VIN PowerDown

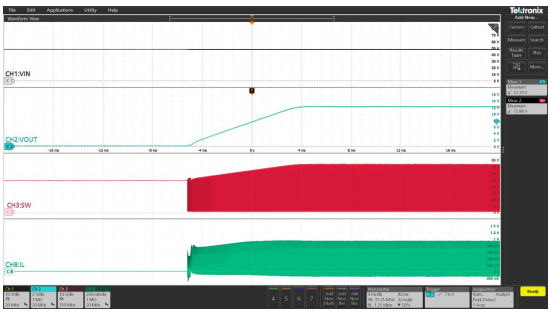


Table.51 VIN=48.0V_IOUT=0.500A_VIN Startup_CC

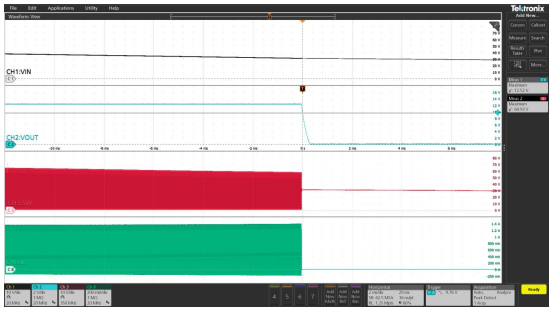


Table.52 VIN=48.0V_IOUT=1.000A_VIN PowerDown

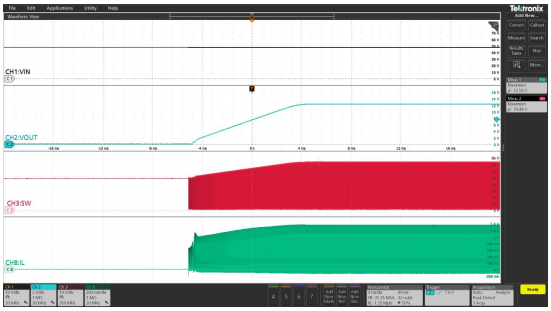


Table.53 VIN=48.0V_IOUT=1.000A_VIN Startup_CC

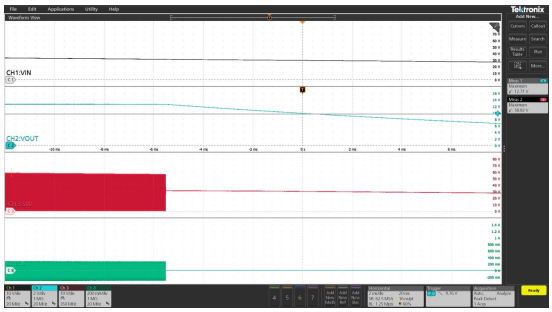


Table.54 VIN=57.0V_IOUT=0.010A_VIN PowerDown

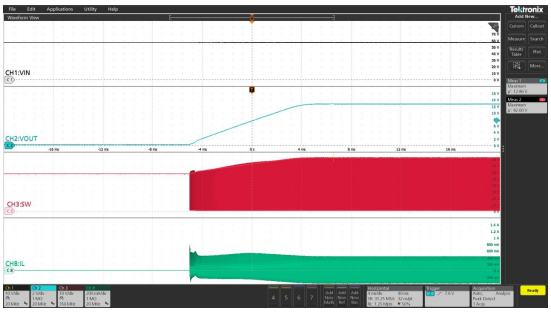
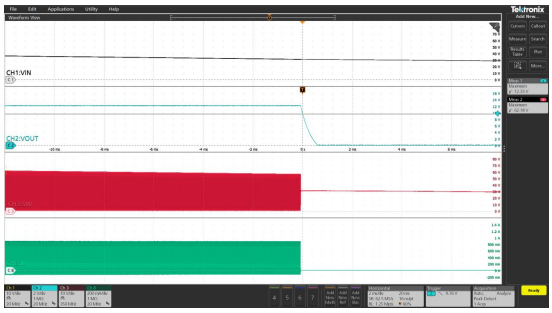
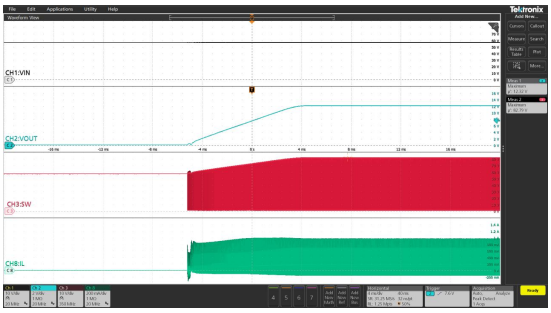


Table.55 VIN=57.0V_IOUT=0.010A_VIN Startup_CC



VIN=12.0V_IOUT=3.000A_VIN

PowerDown



VIN=12.0V_IOUT=3.000A_VIN

Startup_CC

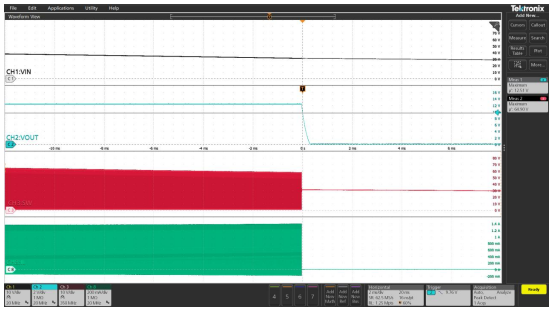


Table.56 VIN=12.0V_IOUT=6.000A_VIN PowerDown

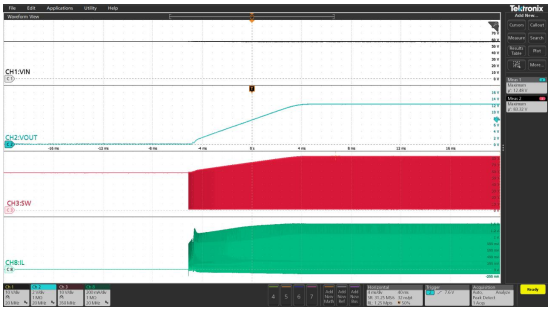


Table.57 VIN=12.0V_IOUT=6.000A_VIN Startup_CC

4.7 SCP

Below shows the SCP entry and recovery waveforms. T_A = 25°C, unless otherwise noted.

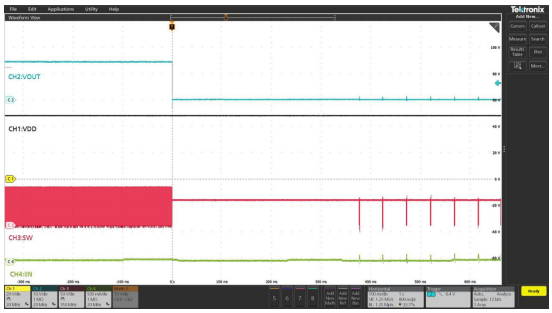


Table.58 VIN=48.0V_IOUT=0.00A to short

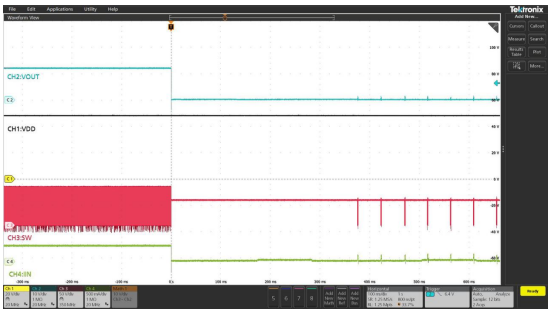


Table.59 VIN=48.0V_IOUT=1.00A to short

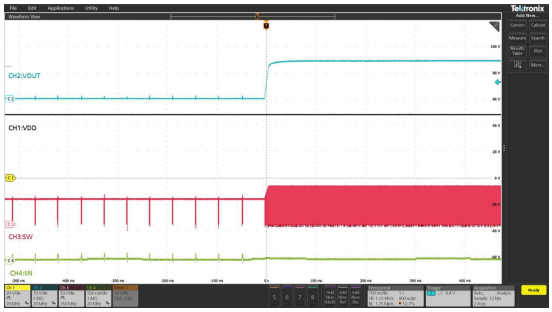


Table.60 VIN=48.0V_IOUT=short to 0.00A

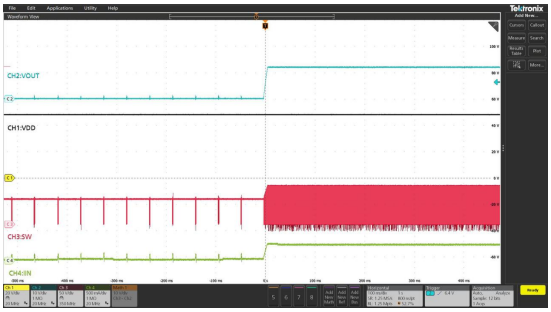


Table.61 VIN=48.0V_IOUT=short to 1.00A

4.8 OCP

Below shows the OCP entry and recovery waveforms. T_A = 25°C, unless otherwise noted.

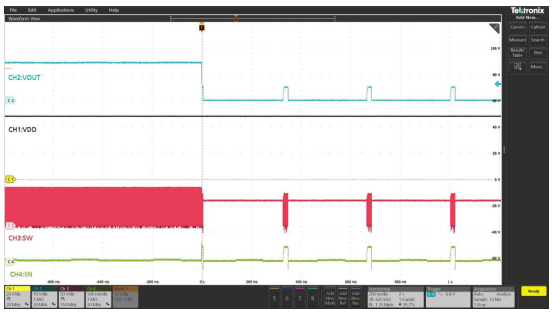


Table.62 VIN=48.0V_IOUT=0.00A to over load

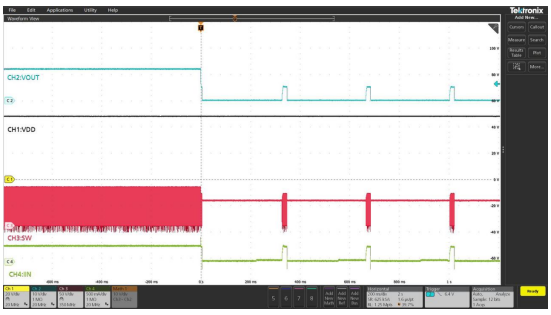


Table.63 VIN=48.0V_IOUT=1.00A to over load

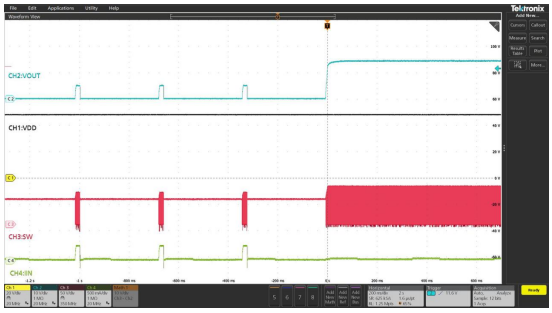


Table.64 VIN=48.0V_IOUT=over load to 0.00A

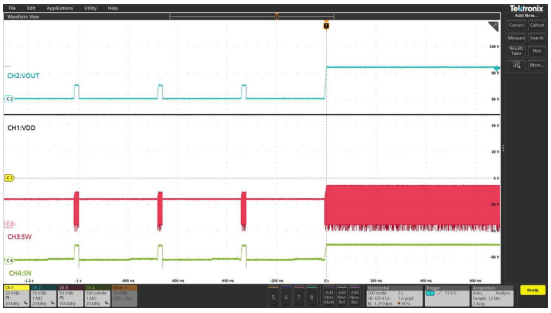


Table.65 VIN=48.0V_IOUT=over load to 1.00A

4.9 OTP

Below shows the OTP entry and recovery waveforms, unless otherwise noted.

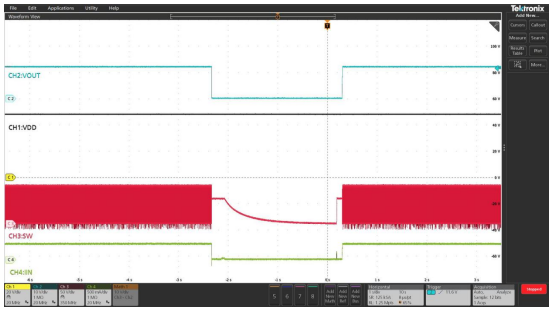


Table.66 VIN=48_IOUT=1A	

4.10 Thermal Test

Below shows the thermal performance of the EVM，T_A = 25°C.

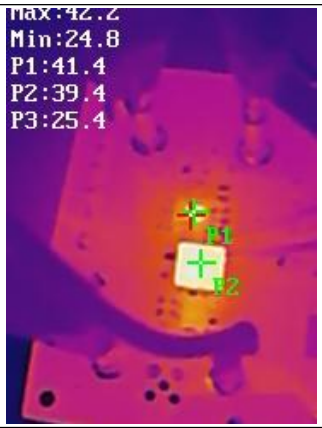
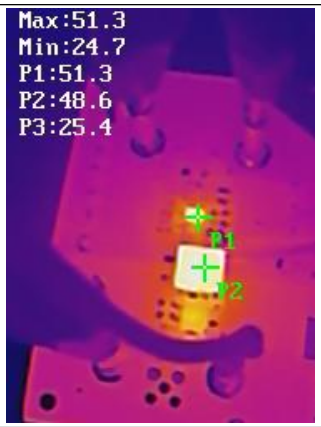
	

Table.67 VIN=48_IOUT=0.5A_P1=TPE15017_P2=transformer	VIN=48_IOUT=1A_P1=TPE15017_P2=transformer

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