*EVM User's Guide: UCC33421EVM-092*

# *Evaluation Module for Automotive and Industrial Applications*

## Description

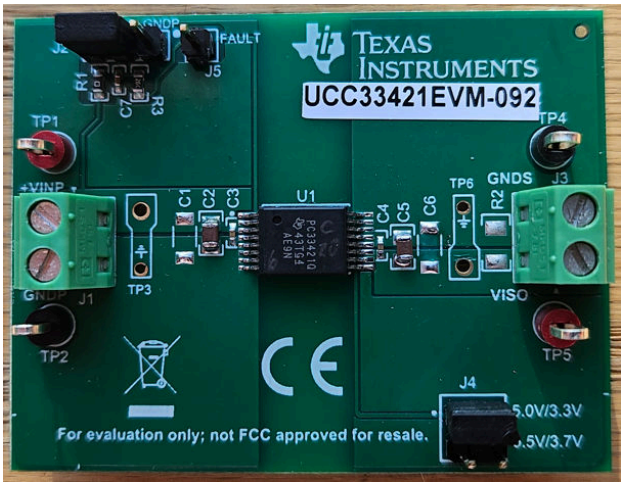
The UCC33421EVM-092 is intended to allow designers to evaluate the performance characteristics and capabilities of the UCC33421-Q1 quickly and easily for use in automotive and industrial bias applications. The EVM allows users to test functions of the UCC33421-Q1 such as: Enable/Fault (EN/FLT) of the device as well as configure the isolated output voltage for VISO=5.0V or VISO=5.5V using the SEL pin and apply variable loads to the outputs. The EVM allows the user to measure efficiency across the input voltage range and vary output loads according to system requirements.

## Features

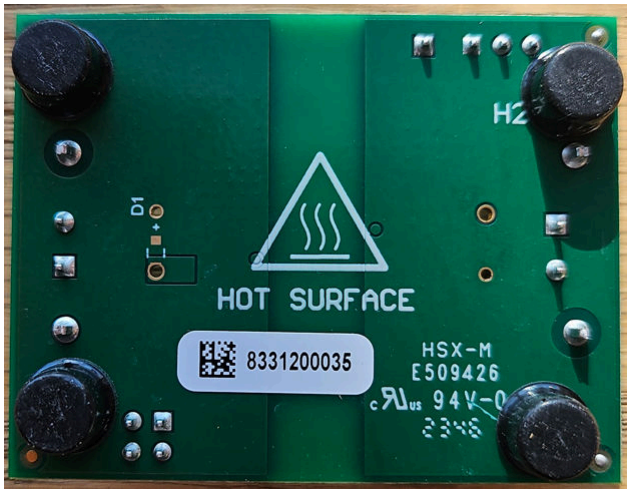
- UCC33421-Q1 1.5W DC/DC isolated converter module with isolated bias supply voltages
- Transformer, power and control stage fully integrated in a 5.85mmx7.50mmx2.65mm DHA-16 package
- AEC-Q100, 5-kVrms isolation, protection features and low electromagnetic emissions
- EVM demonstrates an isolated bias supply used in automotive and industrial applications

## Applications

- Battery-Management Systems (BMS)
- HEV/EV OBC and DC/DC converters
- Traction inverters
- Factory automation PLC modules
- EV charging infrastructure
- Isolated bias power for digital isolators
- Isolated bias for isolated voltage and current sensors
- Isolated bias power for RS-485, RS-422 and CAN
- Isolated bias power for MCU power




**UCC33421EVM-092 (Top View)**




**UCC33421EVM-092 (Bottom View)**

# 1 Evaluation Module Overview

## 1.1 Introduction

This user's guide provides a description as well as directions for use of the UCC33421EVM-092 to evaluate the UCC33421-Q1 high frequency integrated transformer DC-DC converter, low-emissions, 5kV$_{RMS}$ reinforced isolation module from Texas Instruments. UCC33421-Q1 comes in a minimum footprint DHA-16 package which provides high power density, 1.5W nominal power. The UCC33421-Q1 delivers class-leading efficiency in power conversion from the primary to the secondary side while removing the need for external transformers or power modules commonly used in existing designs. This integration allows for minimal printed circuit board (PCB) area as well as decreased height profile

## 1.2 Kit Contents

**Table 1-1. UCC33421EVM-092 Kit Contents**

| Designator | Description | Quantity |
|---|---|---|
| PCB1 | UCC33421EVM-092 Circuit Board | 1 |

## 1.3 Device Information

### *1.3.1 U1 Component Selection*

The UCC33421-Q1 is the default IC used in the UCC33421EVM-092 but any of the alternate versions listed in Table 1-1 can be used for evaluation. Each of the component versions listed in Table 1-1 are pin-to-pin and BOM-to-BOM compatible

**Table 1-2. UCC334x1-Q1 Devices**

| General Part Number | Orderable Part Number | Input Voltage/Output Voltage/Isolation |
|---|---|---|
| UCC33421-Q1 | UCC33421QDHARQ1 | 4.5V-5.5V/5.0V/5kV$_{RMS}$ |
| UCC33421 | UCC33421DHAR | 4.5V-5.5V/5.0V/5kV$_{RMS}$ |
| UCC33411-Q1 | UCC33411QDHARQ1 | 4.5V-5.5V/3.3V/5kV$_{RMS}$ |
| UCC33411 | UCC33411DHAR | 4.5V-5.5V/3.3V/5kV$_{RMS}$ |

If IC replacement is required, TI recommends to always use best practice soldering techniques which can include taking appropriate ESD precautions and having qualified personnel, skilled at surface mount soldering and board level rework.

### *1.3.2 UCC33421-Q1 Pin Definition*

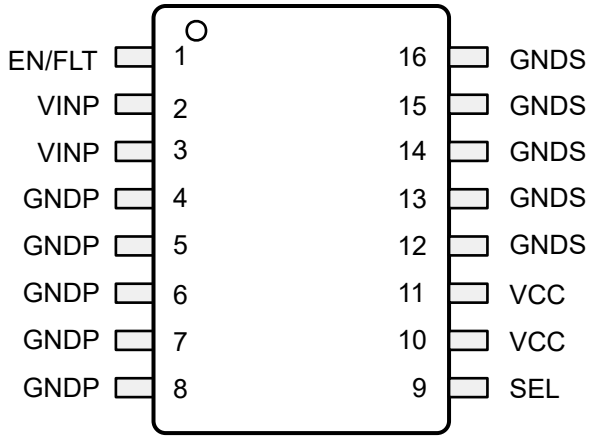



**Figure 1-1. UCC33421-Q1 Package Top View**

**Table 1-3. UCC33421-Q1 Pin Description**

| PIN | | TYPE (1) | DESCRIPTION |
|---|---|---|---|
| NAME | NO. | | |
| EN/FLT | 1 | I/O | Multi-functional enable input pin and output fault pin. Connect to microcontroller through an 18kΩ or greater pull-up resistor. **Enable input pin:** Forcing EN low disables the device. Pull high to enable normal device functionality. **Fault output pin:** This pin is pulled low for 200µs to alert that power converter is shutdown due to a fault condition. |
| VINP | 2, 3 | P | Primary input supply voltage. Connect parallel 15nF ($C_{IN1}$) 0402, and 10µF ($C_{IN2}$) ceramic bypass capacitors close to VINP to GNDP pins. |
| GNDP | 4, 5, 6, 7, 8 | G | Power ground return connection for VINP. |
| SEL | 9 | I | VCC selection pin. VCC setpoint is 5V when SEL is connected to VCC and 5.5V when SEL is shorted to GNDS. |
| VCC | 10, 11 | P | Isolated supply output voltage pin. Connect parallel 15nF ($C_{OUT1}$) 0402, and 22µF ($C_{OUT2}$) ceramic bypass capacitors close to VCC and GNDS pins. |
| GNDS | 12, 13, 14, 15, 16 | G | Power ground return connection for VCC. |

(1) P=Power, G=Ground, I=Input, O=Output

## 1.4 Specification

**Table 1-4. EVM Electrical Characteristics for UCC33421-Q1**

VINP=5V, VCC=5V, $T_A$=25°C (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| **INPUT CHARACTERISTICS** | | | | | | |
| VINP | Input voltage range | $P_{VCC}$=1.5W | 4.5 | 5 | 5.5 | V |
| $I_{IN\_FL}$ | Input current at full load | VINP=4.5V-5.5V, VCC=5.0V, $I_{out}$=300 mA | 489 | 508 | 529 | mA |
| $I_{IN\_NL}$ | Input current at no load | VINP =5.0V, VCC=5.0V, $I_{out}$=0 mA | | 7 | 15 | mA |
| **OUTPUT CHARACTERISTICS** | | | | | | |
| VCC | DC full load set-point | VINP=4.5V-5.5V, VCC=5.0V, $I_{out}$=300 mA | 4.85 | 5 | 5.15 | V |
| $I_{out}$ | VCC load current range | VINP=4.5V-5.5V | 0 | | 300 | mA |
| $VCC_{\%LD}$ | Load regulation | VINP=5.0V, VCC=5.0V, $I_{out}$ =0-300mA | | 0.5 | | % |
| $VCC_{(AC)}$ | pk-to-pk AC ripple | 20MHz bandwidth, VINP=5.0V, VCC=5.0V, $I_{out}$=300mA, Ta=25ºC, $C_{OUT}$=22uF | | 50 | 75 | mV |
| $P_{MAX}$ | Recommended maximum output power | VINP=5.0V, $I_{out}$=300mA, Ta=25ºC | | 1.5 | | W |
| **SYSTEM CHARACTERISTICS** | | | | | | |
| η | Full load efficiency | VINP=5.0V, VCC=5.0V, $I_{out}$=300mA, Ta=25ºC, $C_{OUT}$=22uF | | 59 | | % |
| $f_{SW}$ | Switching frequency | | | 64.5 | | MHz |

**Table 1-5. EVM Electrical Characteristics for UCC33411-Q1**

VINP=5V, VCC=3.3V, $T_A$=25°C (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| **INPUT CHARACTERISTICS** | | | | | | |
| VINP | Input voltage range | $P_{VCC}$=1W | 4.5 | 5 | 5.5 | V |
| $I_{IN\_FL}$ | Input current at full load | VINP=4.5V-5.5V, VCC=3.3V, $I_{out}$=300 mA | 375 | 395 | 412 | mA |
| $I_{IN\_NL}$ | Input current at no load | VINP =5.0V, VCC=3.3V, $I_{out}$=0 mA | | 7 | 15 | mA |
| **OUTPUT CHARACTERISTICS** | | | | | | |
| VCC | DC full load set-point | VINP=4.5V-5.5V, VCC=3.3V, $I_{out}$=300 mA | 3.2 | 3.3 | 3.4 | V |
| $I_{out}$ | VCC load current range | VINP=4.5V-5.5V | 0 | | 300 | mA |
| $VCC_{\%LD}$ | Load regulation | VINP=5.0V, VCC=3.3V, $I_{out}$ =0-300mA | | 0.5 | | % |

**Table 1-5. EVM Electrical Characteristics for UCC33411-Q1 (continued)**

VINP=5V, VCC=3.3V, $T_A$=25°C (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $VCC_{(AC)}$ | pk-to-pk AC ripple | 20MHz bandwidth, VINP=5.0V, VCC=3.3V, $I_{out}$=300mA, Ta=25ºC, $C_{OUT}$=22uF | | 50 | 75 | mV |
| $P_{MAX}$ | Recommended maximum output power | VINP=5.0V, $I_{out}$=300mA, Ta=25ºC | | 1 | | W |
| **SYSTEM CHARACTERISTICS** | | | | | | |
| η | Full load efficiency | VINP=5.0V, VCC=3.3V, $I_{out}$=300mA, Ta=25ºC, $C_{OUT}$=22uF | | 52 | | % |
| $f_{SW}$ | Switching frequency | | | 64.5 | | MHz |

# 2 Hardware

## 2.1 EVM Setup and Operation

### 2.1.1 Recommended Test Equipment

1. $V_{EN}$: DC power supply1: 5.0V, 10mA
2. VINP: DC power supply2: 5.0V, 1A
3. $I_{out}$: Electronic load or fixed resistor: 5V, 500mA
4. (2) DVMs measuring DC voltage <10V
5. (2) DVMs measuring DC current <1.0A on $I_{VINP}$ and $I_{out}$
6. Oscilloscope: 4 channel, 500MHz or better, voltage probes, current probes
7. Minimum wire gauge 20 AWG to 22 AWG or heavier
8. Thermal camera or thermocouple to measure U1 case temperature

### 2.1.2 External Connections for Easy Evaluation

The UCC33421EVM-092 EVM utilizes screw terminals for easily connecting to VINP and VCC. EN connections are made through pin connectors. Connecting the appropriate ammeters and voltmeters, as shown in Figure 4-1, allows accurate EVM efficiency measurements.

**Connecting Test Equipment:**

1. Connect the VINP DC power supply capable of 4.5V<VINP<5.5V, 1A at J1:1-2 (VINP-GNDP). With the power supply disable, adjust the power supply to 5.0V, and set the current limit to 4A.
2. Connect a power supply capable of 5V, 100mA or a function generator at J2:2-1 to serve as the pull up bias for EN/FLT. With the supply disabled, set to 3.3V/5.0V. As an option, the user can use the input power supply as a bias supply connecting a jumper to short +VINP and EN pins at J2:1-2 (top left corner).
3. Connect a variable load between J3:1 (VCC) and J3:2 (GNDS). If using an electronic load, then set to constant current (CC), 300mA. Leave the load disabled until the EVM is powered.
4. Some electronic loads are not able to regulate or stabilize CC when setting in the low mA range. Monitor the input current and load currents by inserting ammeters as shown in Figure 2-1. A current probe can be used with the oscilloscope to verify the stability of the DC current being regulated by an electronic load.

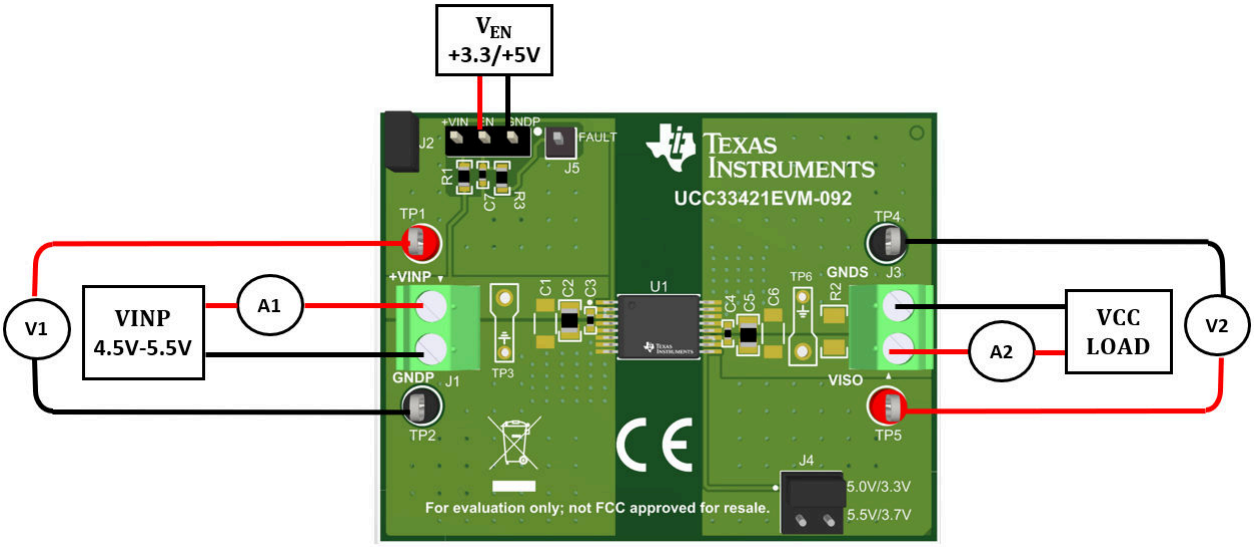



**Figure 2-1. Typical Efficiency Measurement Setup**

### 2.1.3 Powering the EVM

**WARNING**

- Hot surface. Contact can cause burns. U1 package surface can reach temperatures of 100°C above ambient. Do not touch.
- Do not test this EVM unless trained in the proper safety, handling and testing of power electronics.

#### 2.1.3.1 Power on for Start-up

1. Verify VINP and $V_{EN}$ power supplies are off/disabled and no voltage is applied to the DUT.
2. Verify the load on VCC is disabled.
3. Turn on the VINP DC power supply. Verify 5V is present at TP1-to-TP2.
4. Turn on the $V_{EN}$ bias power supply. EVM is now enabled with VCC in regulation under no load condition.
5. Verify 5V present on VCC-GNDS.
6. Enable the 300mA load on VCC.
7. The UCC33421-Q1 is now regulating VCC and processing approximately 1.5W of isolated output power.
8. Vary VINP between 4.5V<VINP<5.5V, vary $I_{out}$ between 0mA<$I_{out}$<300 mA.
9. Insert oscilloscope probes into TP3 and TP6 for measuring VINP and VCC startup, steady state and AC ripple voltage.

#### 2.1.3.2 Power off for Shutdown

1. Turn off $V_{EN}$ power supply.
2. Disable $I_{out}$ load.
3. Turn off VINP power supply.

### 2.1.4 EVM Test Points

Table 2-1 describes the various EVM test points, allowing easy access for connecting oscilloscope probes, DVM test leads and wire connections to lab test equipment as outlined in Section 2.1.1. Maintain separation between the primary side, GNDP, and secondary side, GNDS. Primary-side test points are not to be referenced to GNDS through improper test equipment insertion. Likewise, secondary-side test points are not to be referenced to GNDP through improper test equipment insertion.

**Table 2-1. Input, Output, Test Point (I/O/TP) Description**

| PIN | I/O/TP | COLOR | DESCRIPTION | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| J1 | I | Green | VINP, primary input voltage. | | 4.5 | 5.0 | 5.5 | V |
| J2:1-2 | I | Black | EN, on | | | 0 | | V |
| J2:2-3 | I | Black | EN, off | | 0 | $V_{EN}$ | 5.5 | V |
| J4:1-2 | O | Black | Selector 5.0V/3.3V output voltage. | | 0 | | 5.7 | V |
| J4:3-4 | O | Black | Selector 5.5V/3.7V output voltage. | | 0 | | 5.7 | V |
| J3 | O | Green | VCC, secondary output voltage. | | 0 | | 5.7 | V |
| TP1 | TP | Red | VINP, primary input voltage test point. | | 4.5 | 5 | 5.5 | V |
| TP2 | TP | Black | GNDP, primary ground test point. | | | 0 | | V |
| TP3 | TP | PCB | VINP-to-GNDP, scope probe point. | | 4.5 | 5 | 5.5 | V |
| TP4 | TP | Black | GNDS, secondary ground test point. | | | 0 | | V |
| TP5 | TP | Red | VCC, secondary output voltage test point. | | 4.85 | 5 | 5.15 | V |
| TP6 | TP | PCB | VCC-to-GNDS, scope probe point. | SEL 5.0V | 4.85 | 5 | 5.15 | V |
| | | | | SEL 5.5V | 5.34 | 5.5 | 5.67 | V |

### 2.1.5 Oscilloscope Probes: Probing the EVM

#### Using TP3 and TP6 Oscilloscope Probe PCB Test Points

The UCC33421-Q1 is a high frequency DC-DC module that requires careful measurement for accurately capturing transient events and measuring high frequency, AC ripple voltage. Remove the *witch hat* probe tip cover and ground lead from the scope probe. If scope probe ground springs are not available, then wrap a piece of 22 AWG bare wire around the scope probe ground ring or use a fitted ground spring and insert the probe tip and ground into the EVM as shown in Figure 2-2.

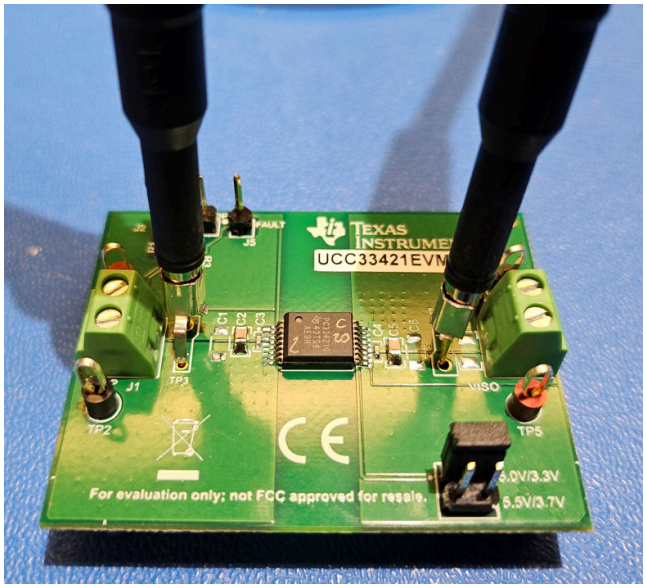



**Figure 2-2. PCB Scope Probe Test Points**

The EVM input (VINP, GNDP) and output nomenclature (VCC, GNDS) corresponds to what is commonly used when referring to isolated amplifiers that need to be biased from primary and secondary sides.

# 3 Implementation Results

## 3.1 Schematic

Figure 3-1 shows the EVM electrical schematic. C1, C6, R2 and D1 are intentionally unpopulated as indicated by a red X placed directly over the component. The user can use C1 and C8 placeholders to add input or output capacitance that the user requires for the systems.

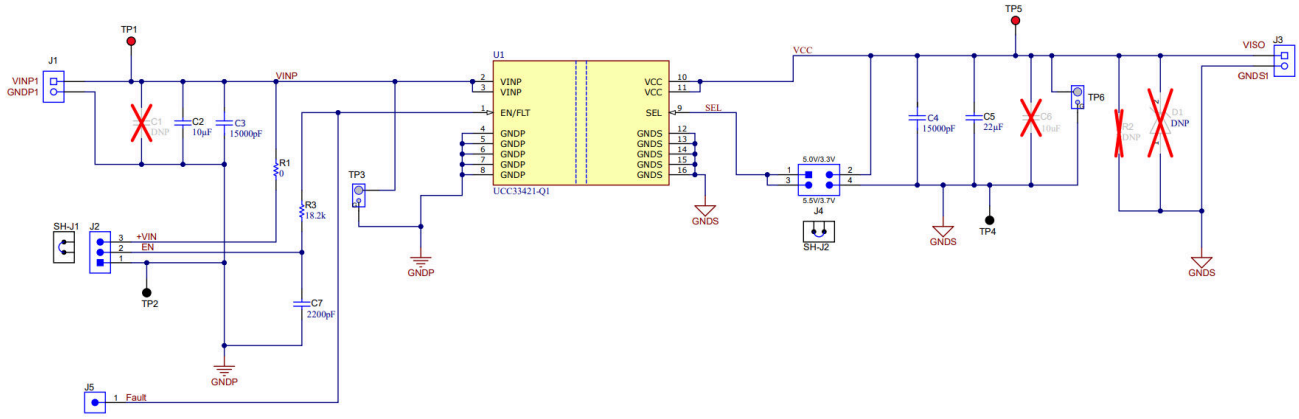



**Figure 3-1. Schematic**

## 3.2 Performance Data

UCC33421-Q1: VINP=5.0V, VCC=5.0V, $T_A$=25°C (unless otherwise noted).

UCC33411-Q1: VINP=5.0V, VCC=3.3V, $T_A$=25°C (unless otherwise noted).

### *3.2.1 Efficiency Data*

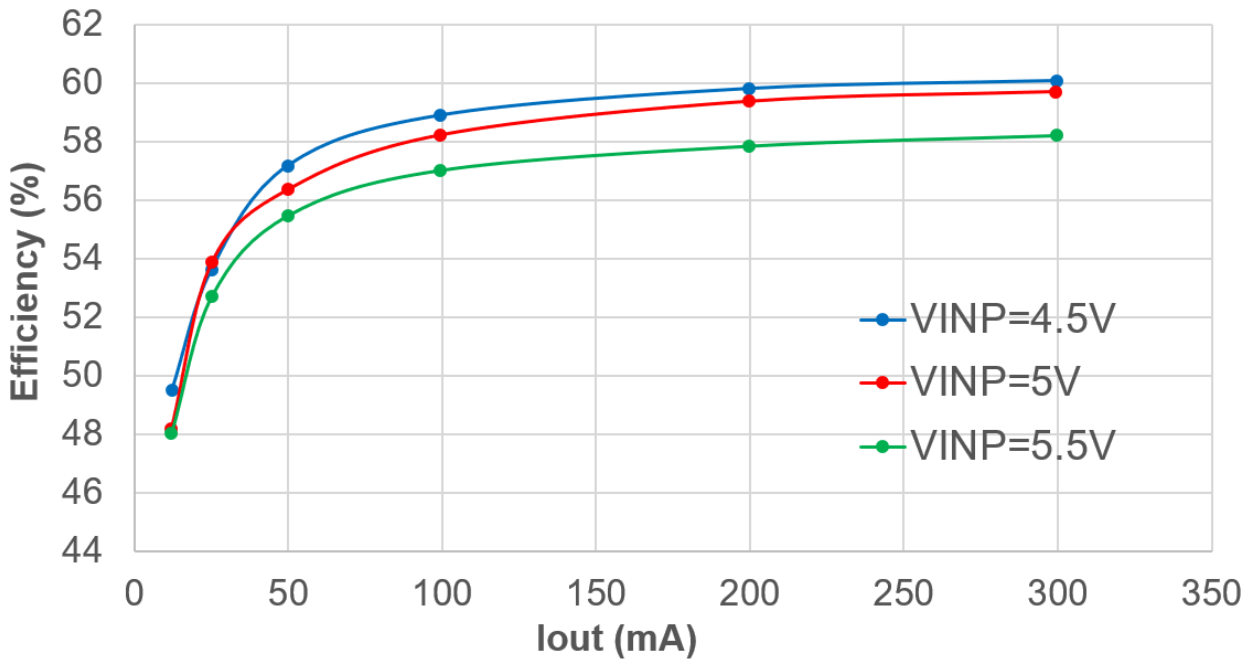



**Figure 3-2. UCC33421-Q1 Efficiency VCC=5.0V**

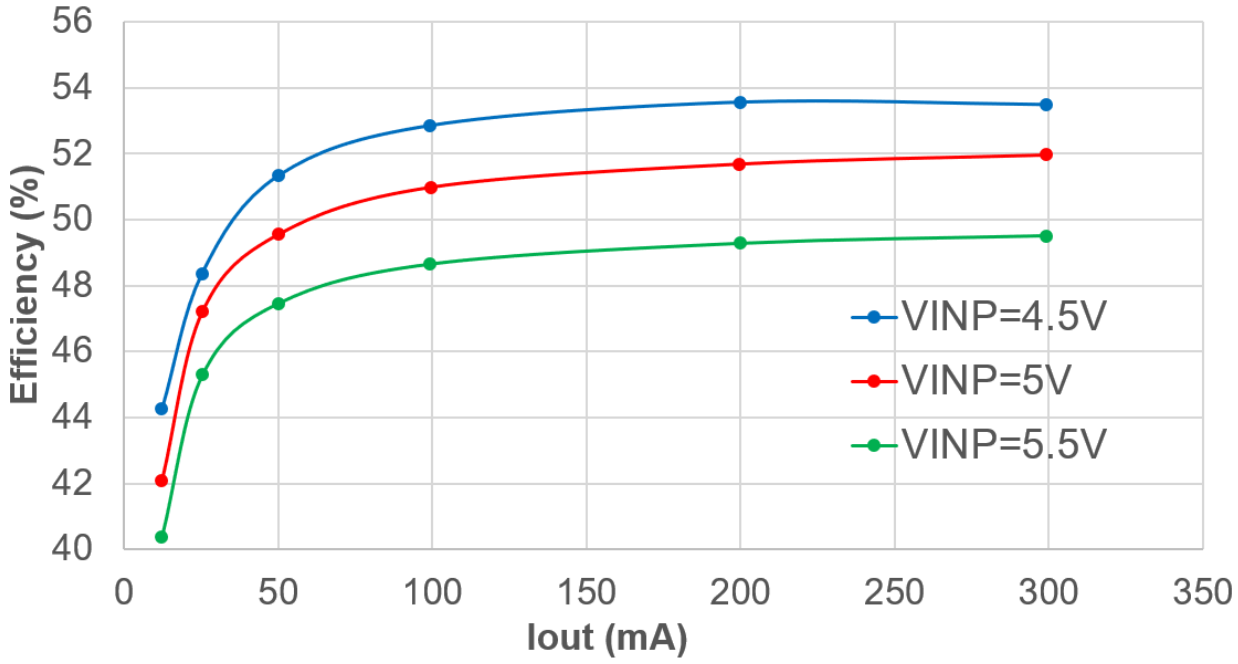



**Figure 3-3. UCC33411-Q1 Efficiency VCC=3.3V**

### *3.2.2 Regulation Data*

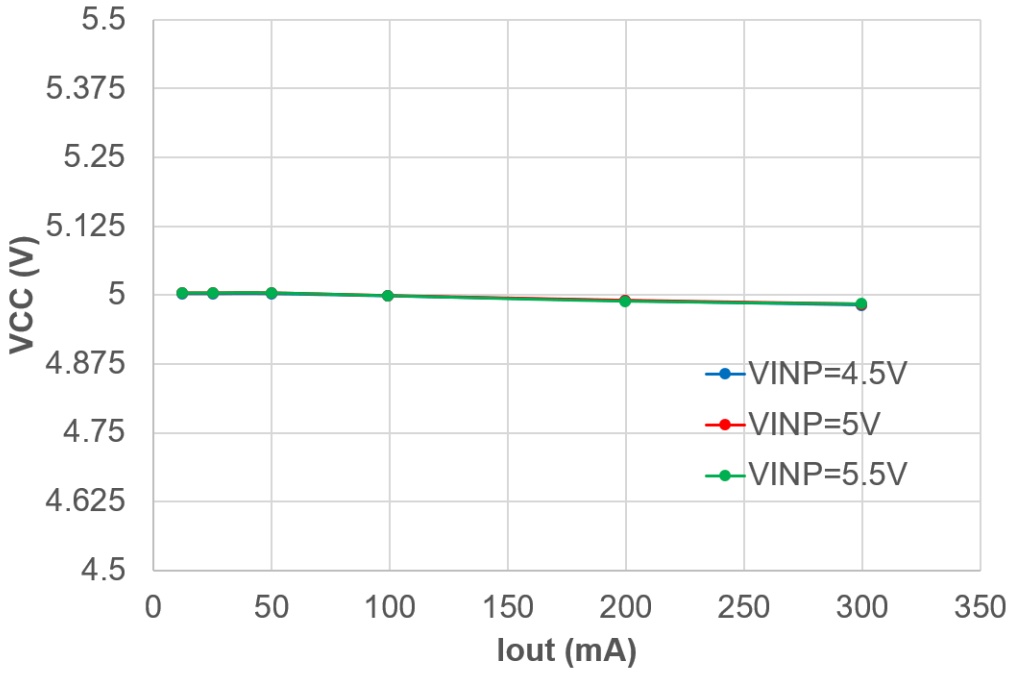



**Figure 3-4. UCC33421-Q1 Regulation vs Load Current VCC=5.0V**

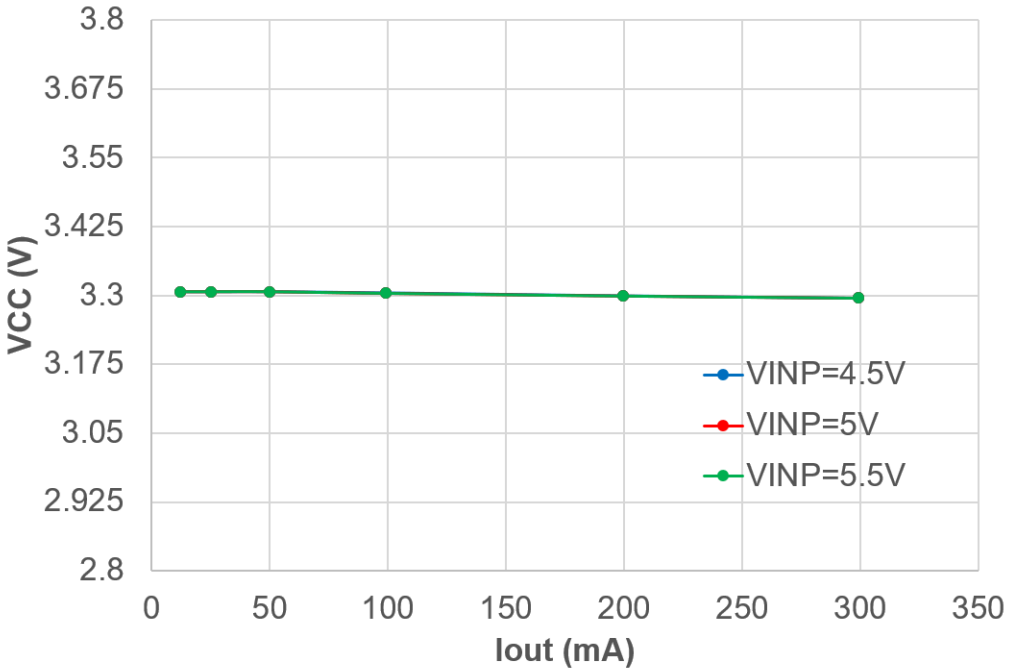



**Figure 3-5. UCC33411-Q1 Regulation vs Load Current VCC=3.3V**

### 3.2.3 Startup Waveforms

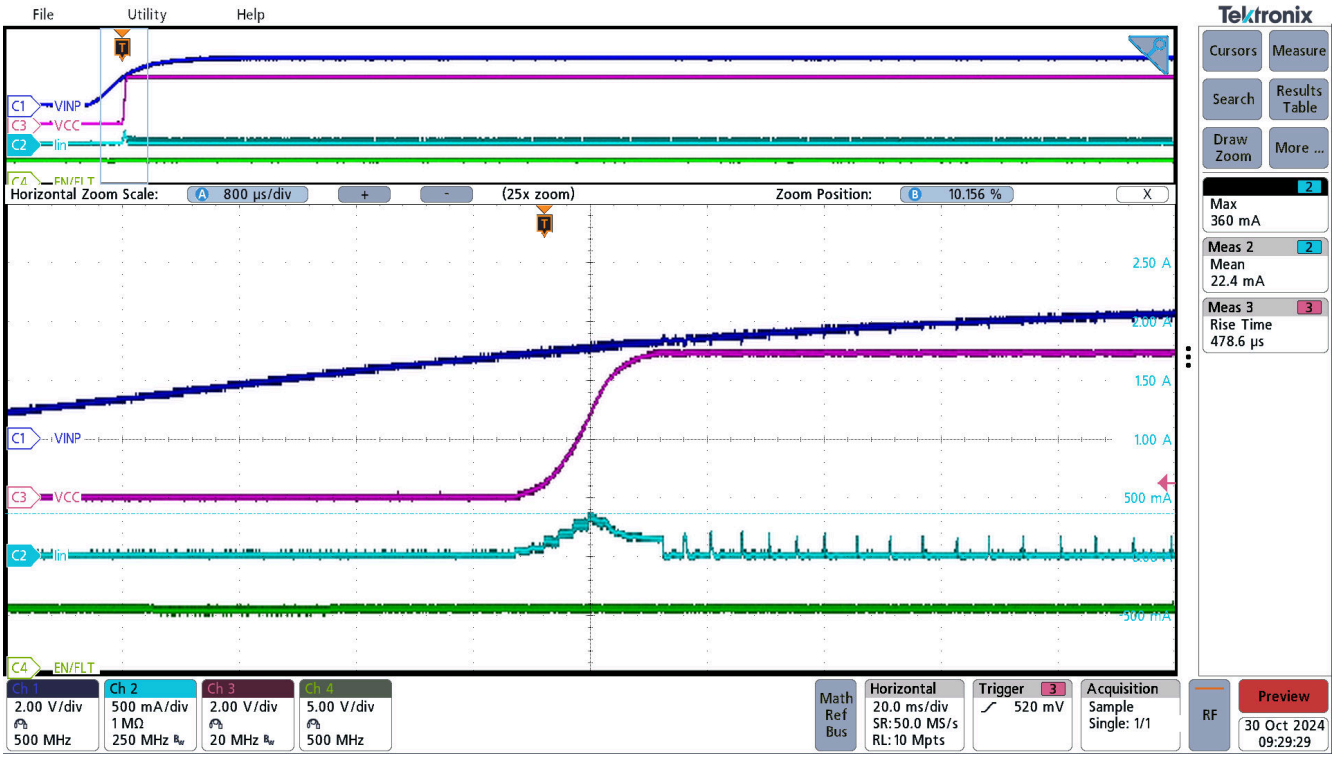



**Figure 3-6. UCC33421-Q1 Start-up, sequence EN=5.0V → VINP=5.0V, VCC=5.0V, $I_{out}$=0mA**

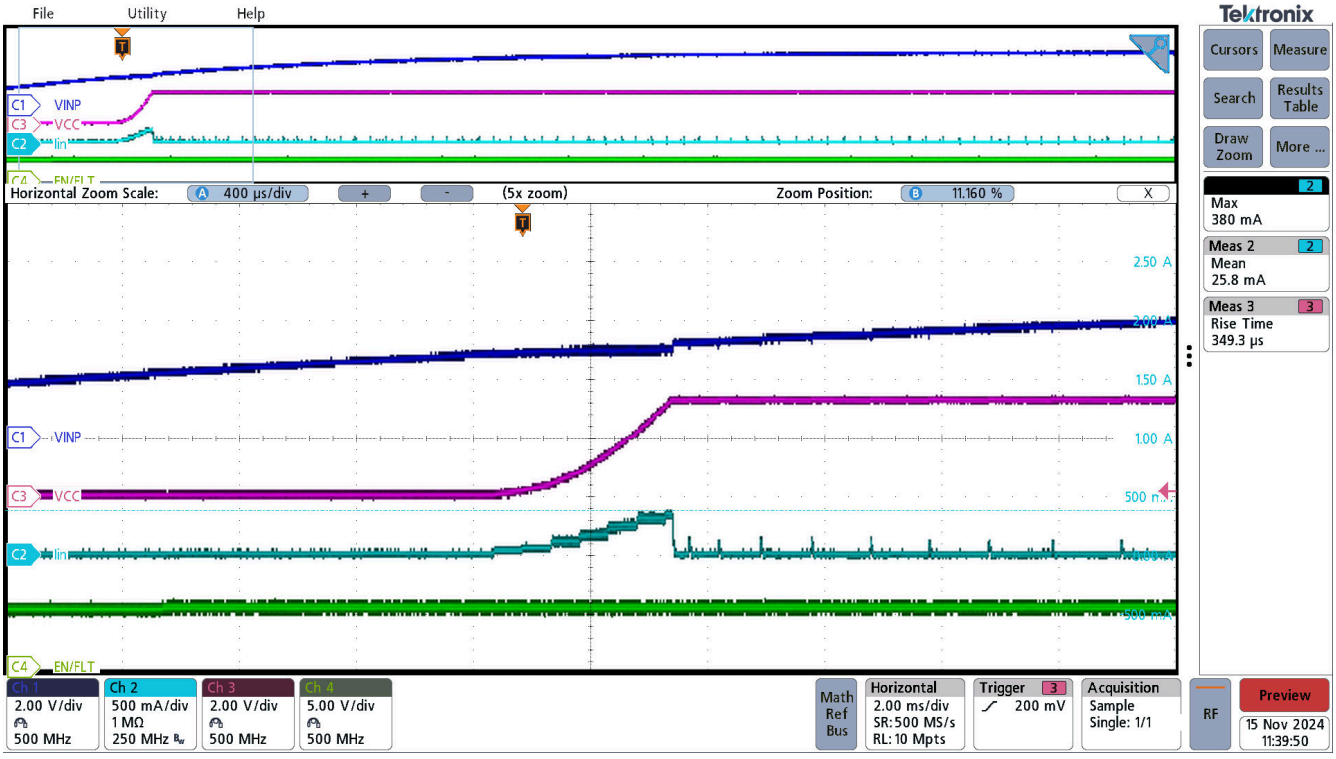



**Figure 3-7. UCC33411-Q1 Start-up, sequence EN=5.0V → VINP=5.0V, VCC=3.3V, $I_{out}$=0mA**

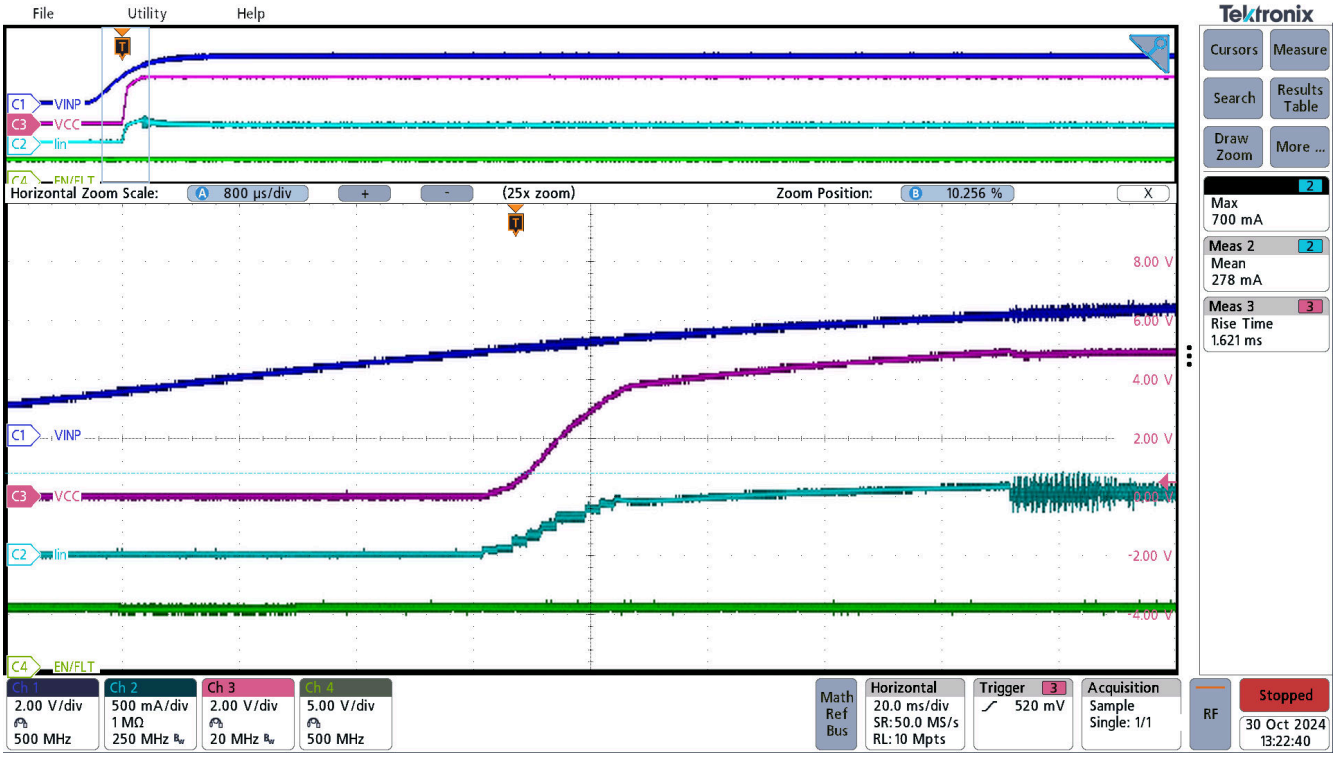



**Figure 3-8. UCC33421-Q1 Start-up, sequence EN=5.0V → VINP=5.0V, VCC=5.0V, Rload=18Ω**

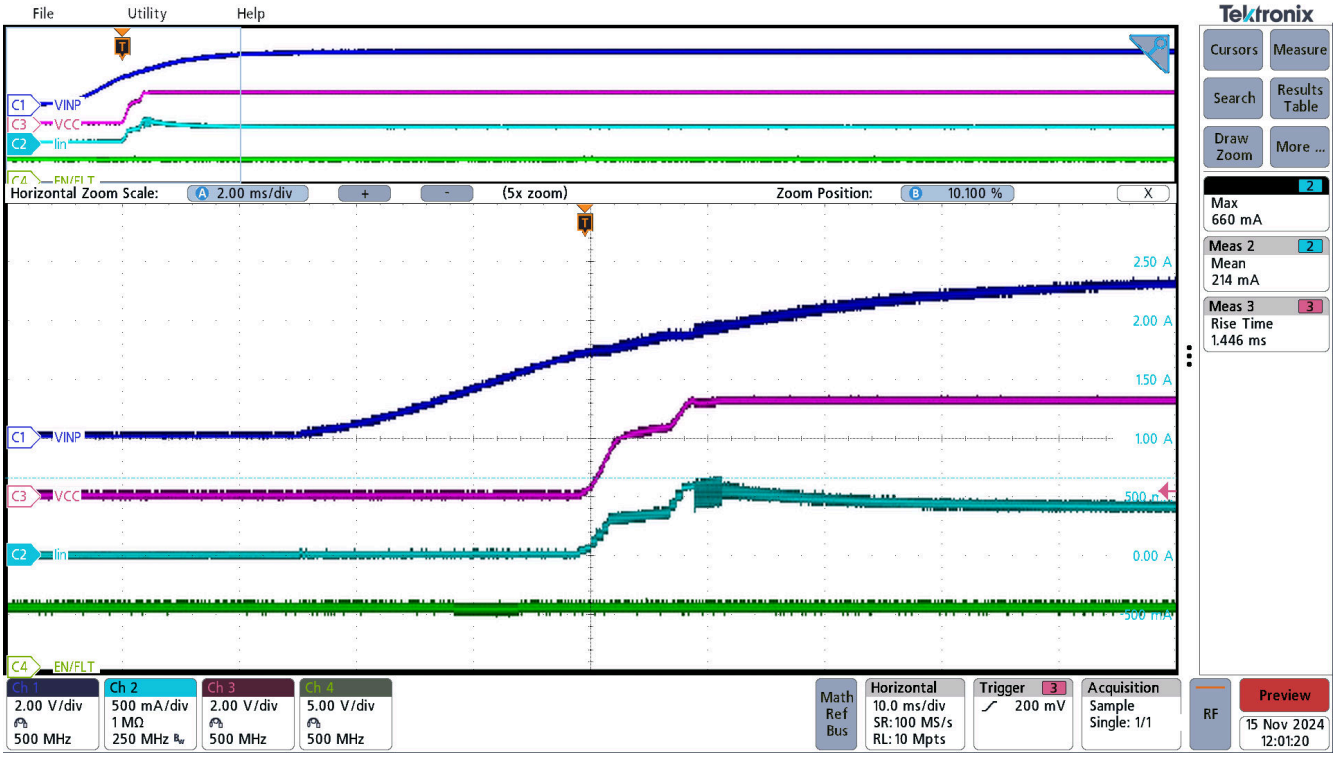



**Figure 3-9. UCC33411-Q1 Start-up, sequence EN=5.0V → VINP=5.0V, VCC=3.3V, Rload=10Ω**

### 3.2.4 Inrush Current

Inrush current measurements made with VINP applied first, then toggling EN pin second. The input capacitors are pre-biased to VINP and make negligible contribution to the measured inrush current.

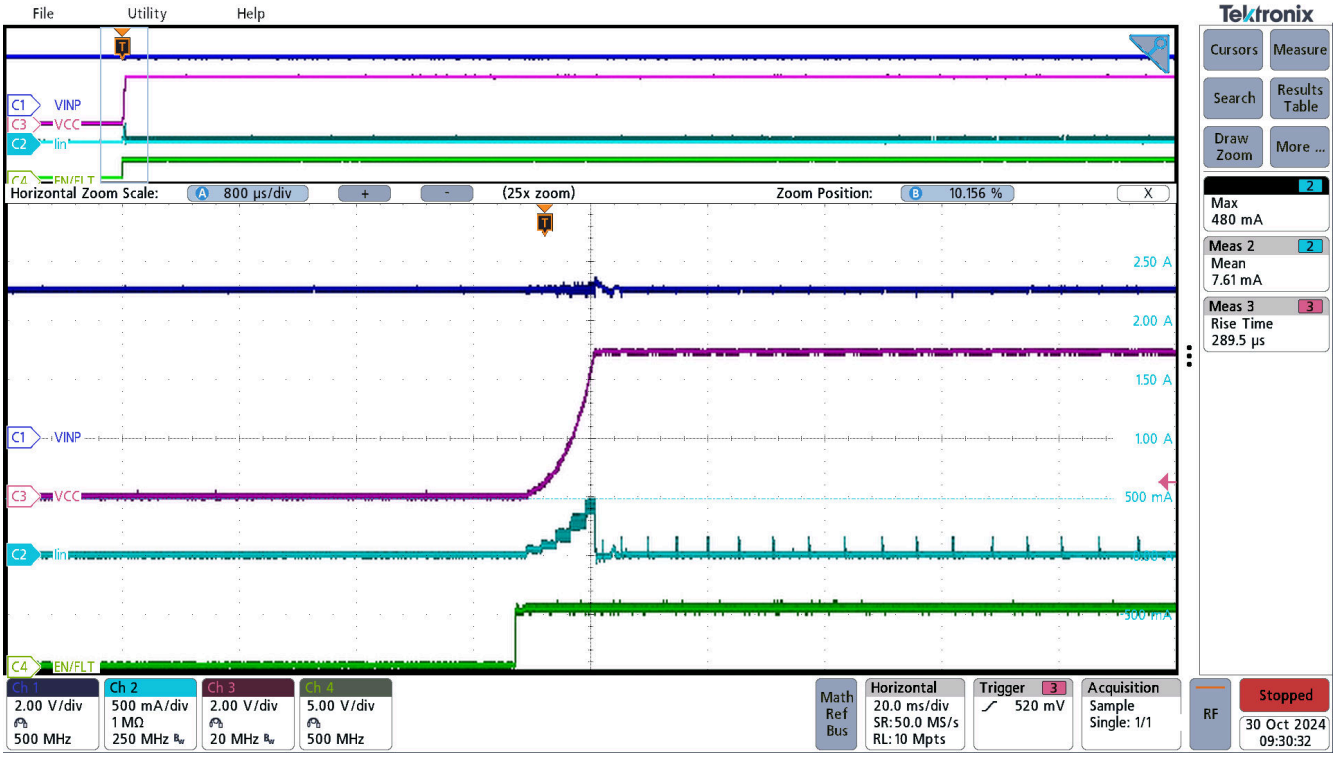



**Figure 3-10. UCC33421-Q1 Inrush current , sequence VINP=5.0V → EN=5.0V, VCC=5.0V, $I_{out}$=0mA**

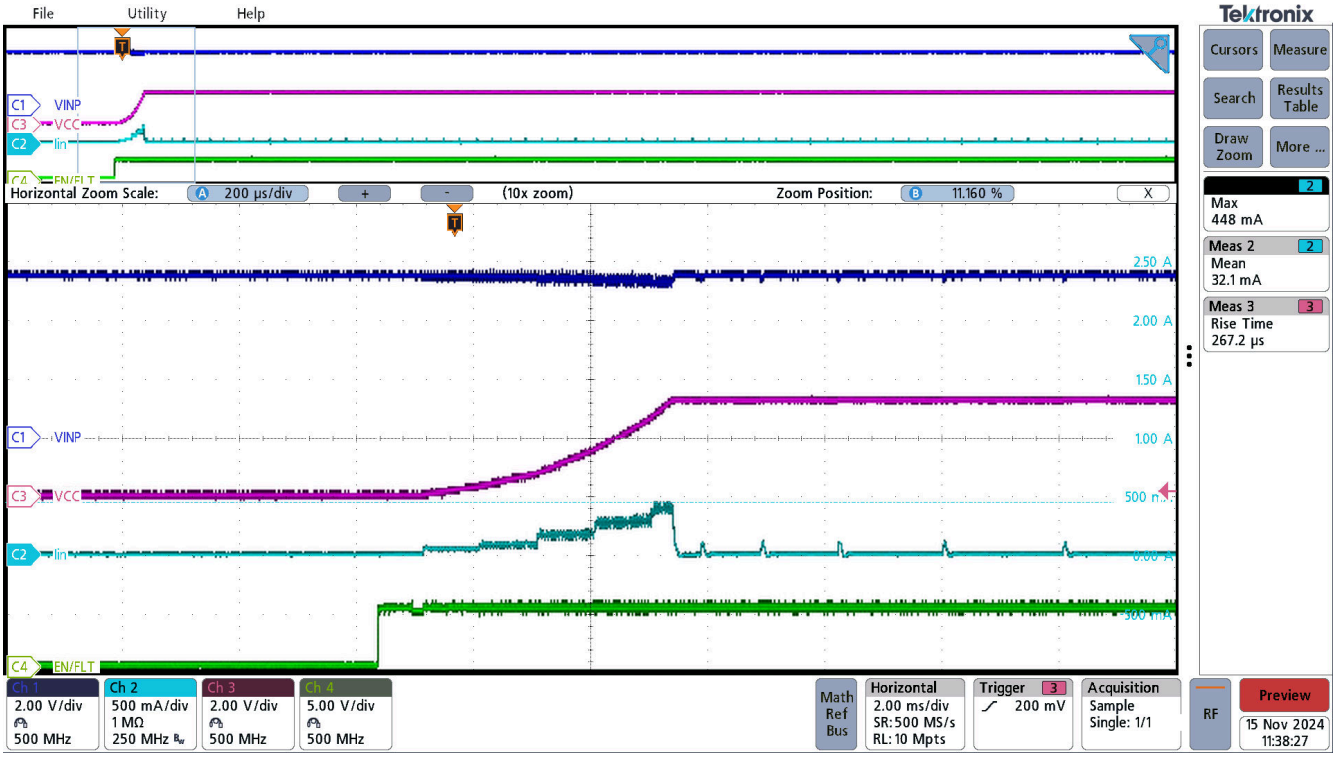



**Figure 3-11. UCC33411-Q1 Inrush current , sequence VINP=5.0V → EN=5.0V, VCC=3.3V, $I_{out}$=0mA**

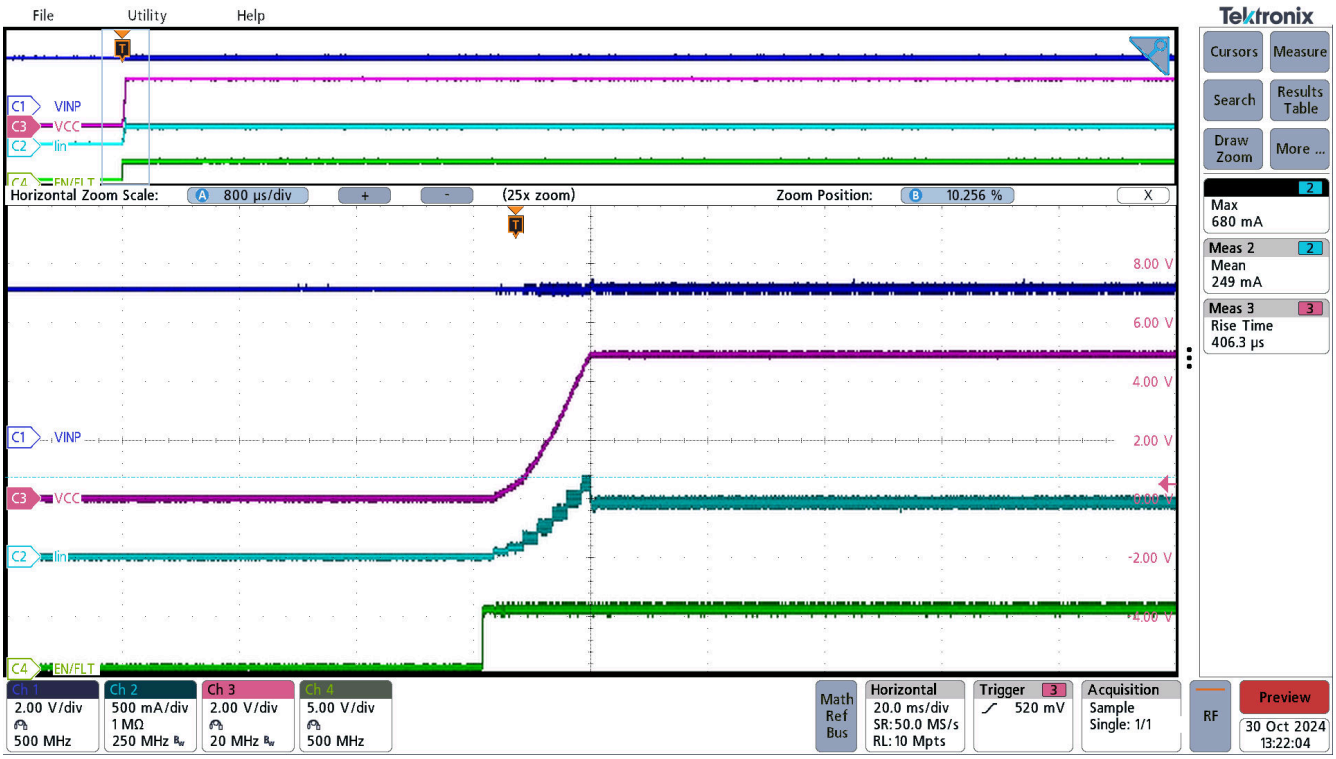



**Figure 3-12. UCC33421-Q1 Inrush current, sequence VINP=5.0V → EN=5.0V, VCC=5.0V, Rload=18Ω**

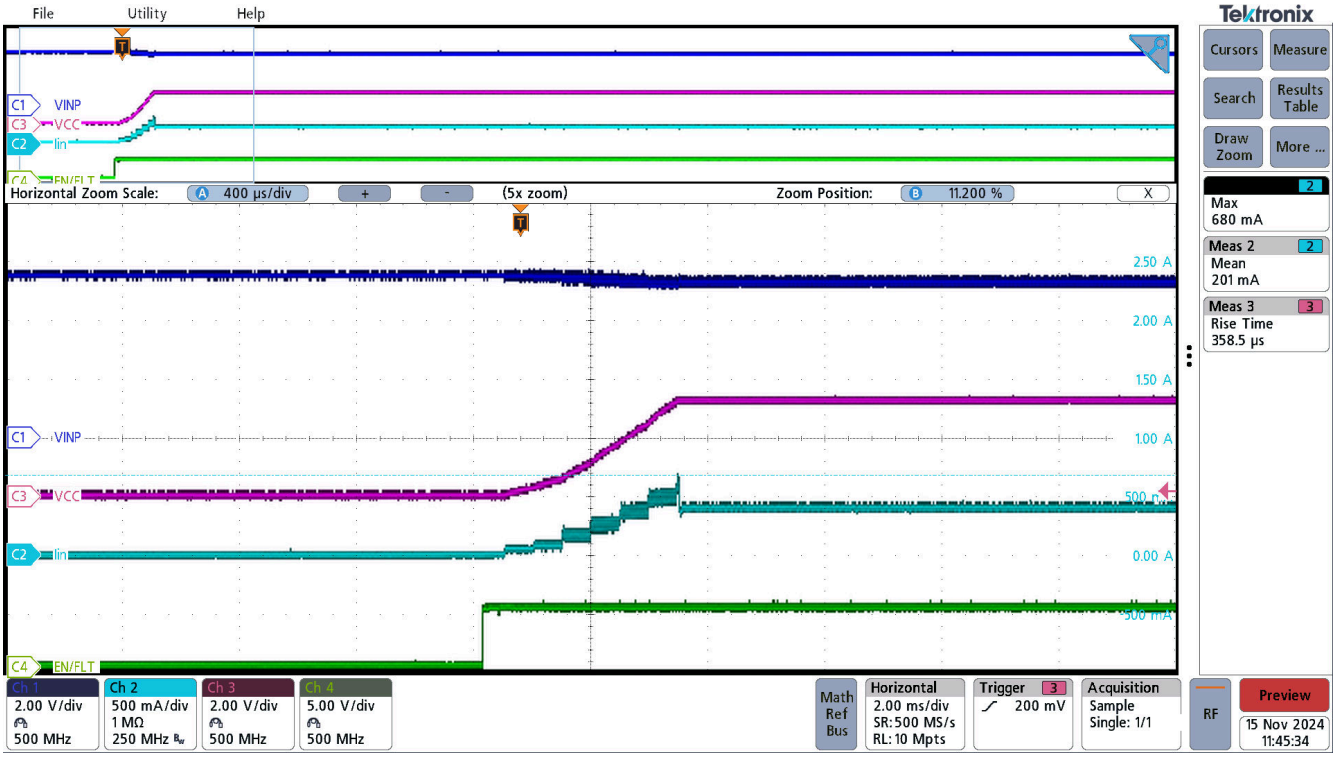



**Figure 3-13. UCC33411-Q1 Inrush current, sequence VINP=5.0V → EN=5.0V, VCC=3.3V, Rload=10Ω**

### 3.2.5 AC Ripple Voltage

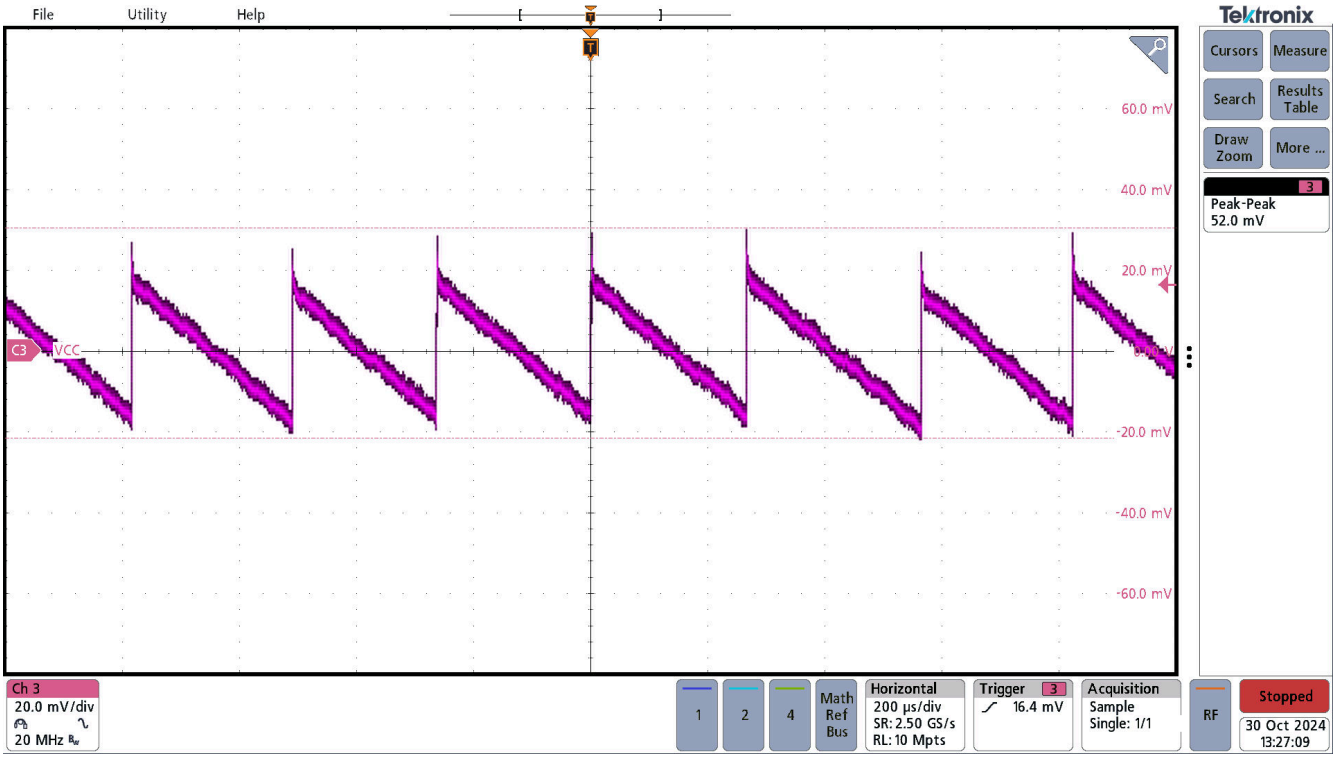



**Figure 3-14. UCC33421-Q1 VCC AC Ripple, VINP=5.0V, VCC=5.0V, $I_{out}$=0mA**

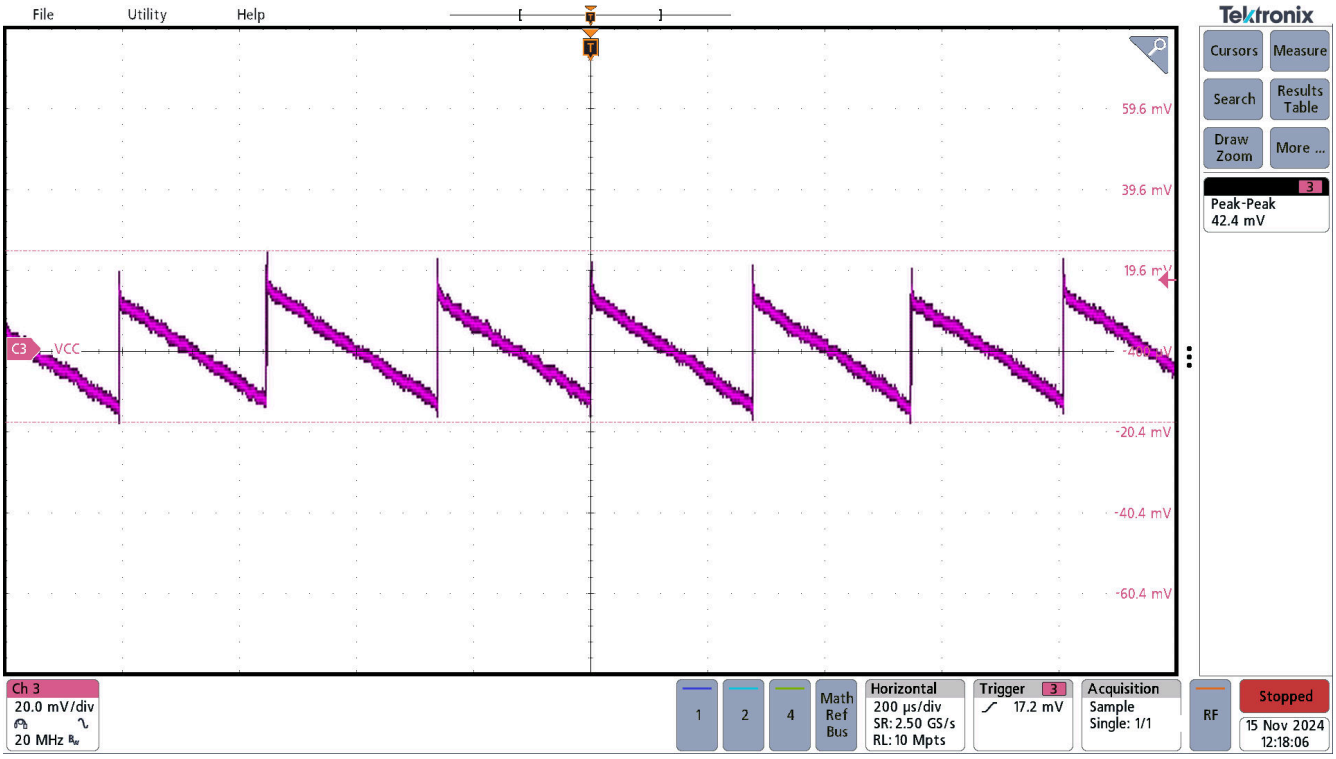



**Figure 3-15. UCC33411-Q1 VCC AC Ripple, VINP=5.0V, VCC=3.3V, $I_{out}$=0mA**

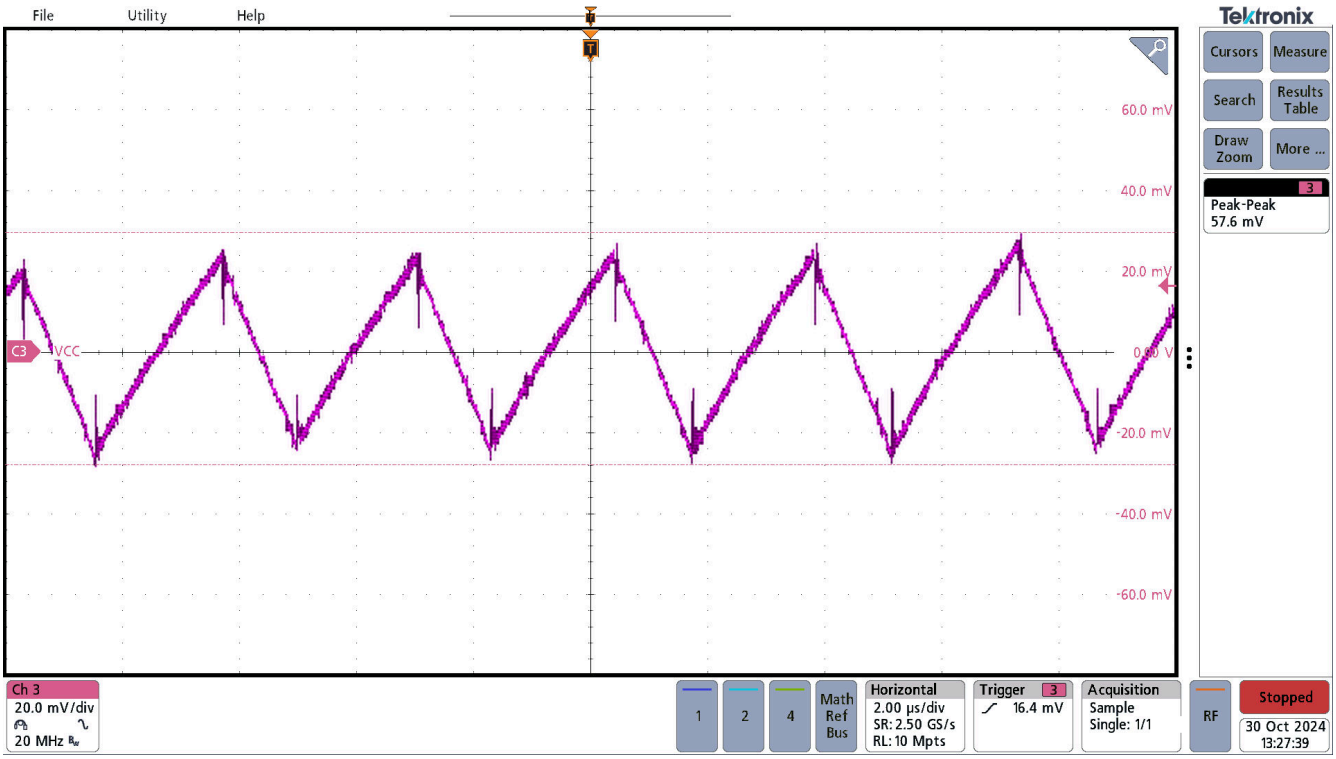



**Figure 3-16. UCC33421-Q1 VCC AC Ripple, VINP=5.0V, VCC=5.0V, $I_{out}$=300mA**

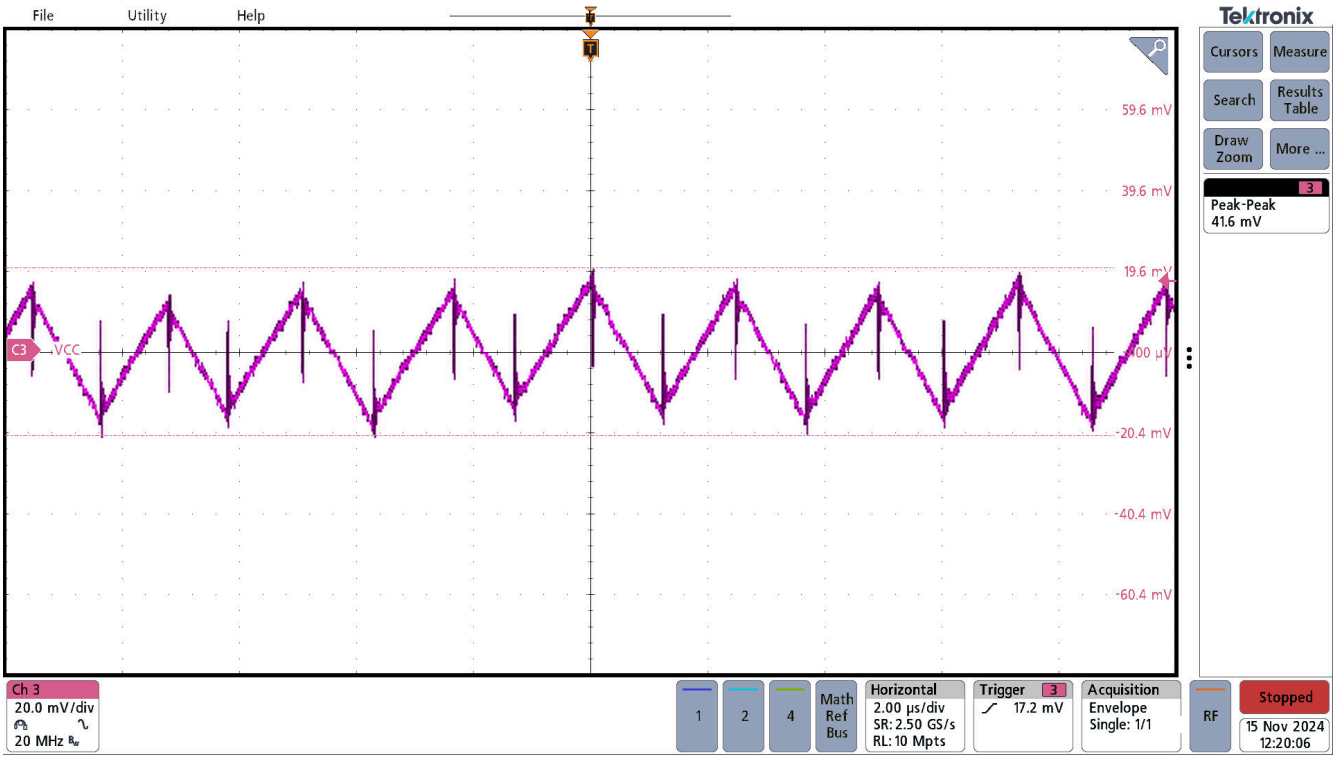



**Figure 3-17. UCC33411-Q1 VCC AC Ripple, VINP=5.0V, VCC=3.3V, $I_{out}$=300mA**

### 3.2.6 Load Transient

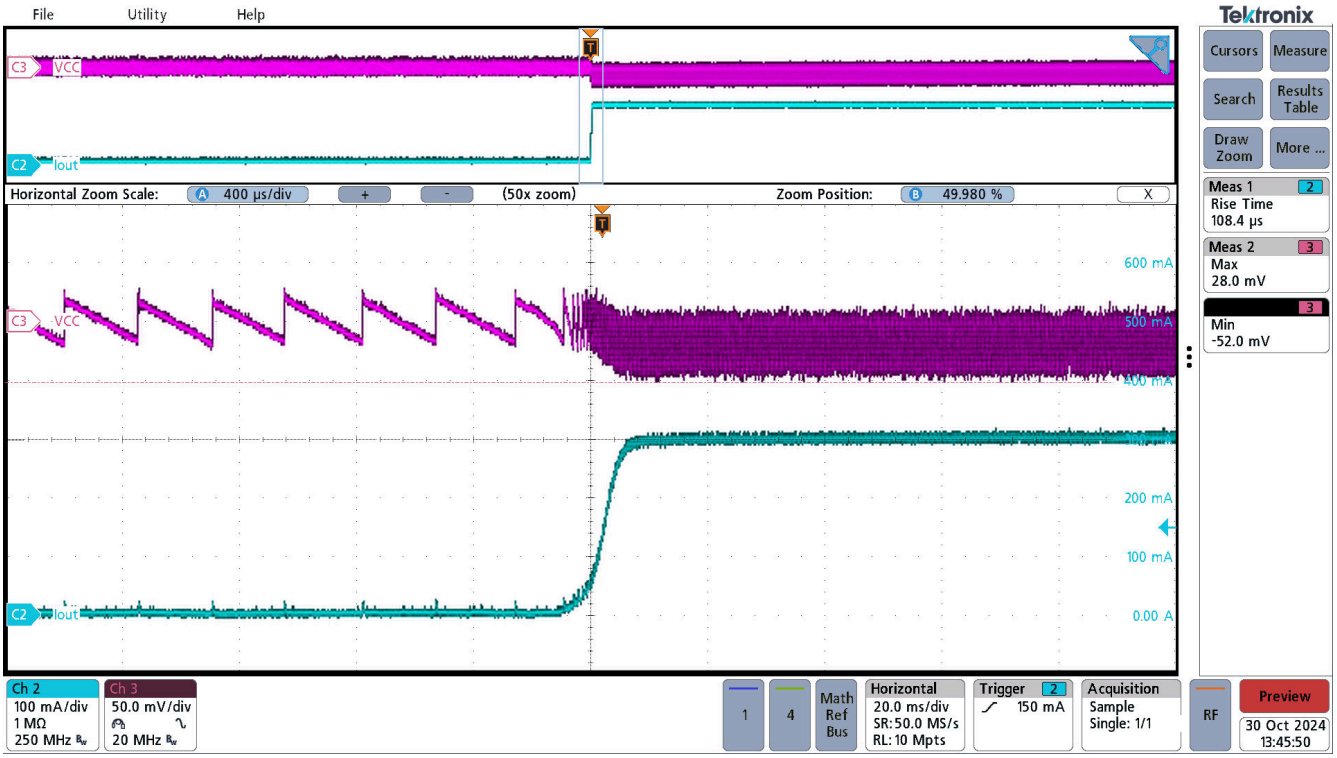



**Figure 3-18. UCC33421-Q1 Load transient, VINP=5.0V, VCC=5.0V, No load ($I_{out}$=0mA) to Full load ($I_{out}$=300mA)**

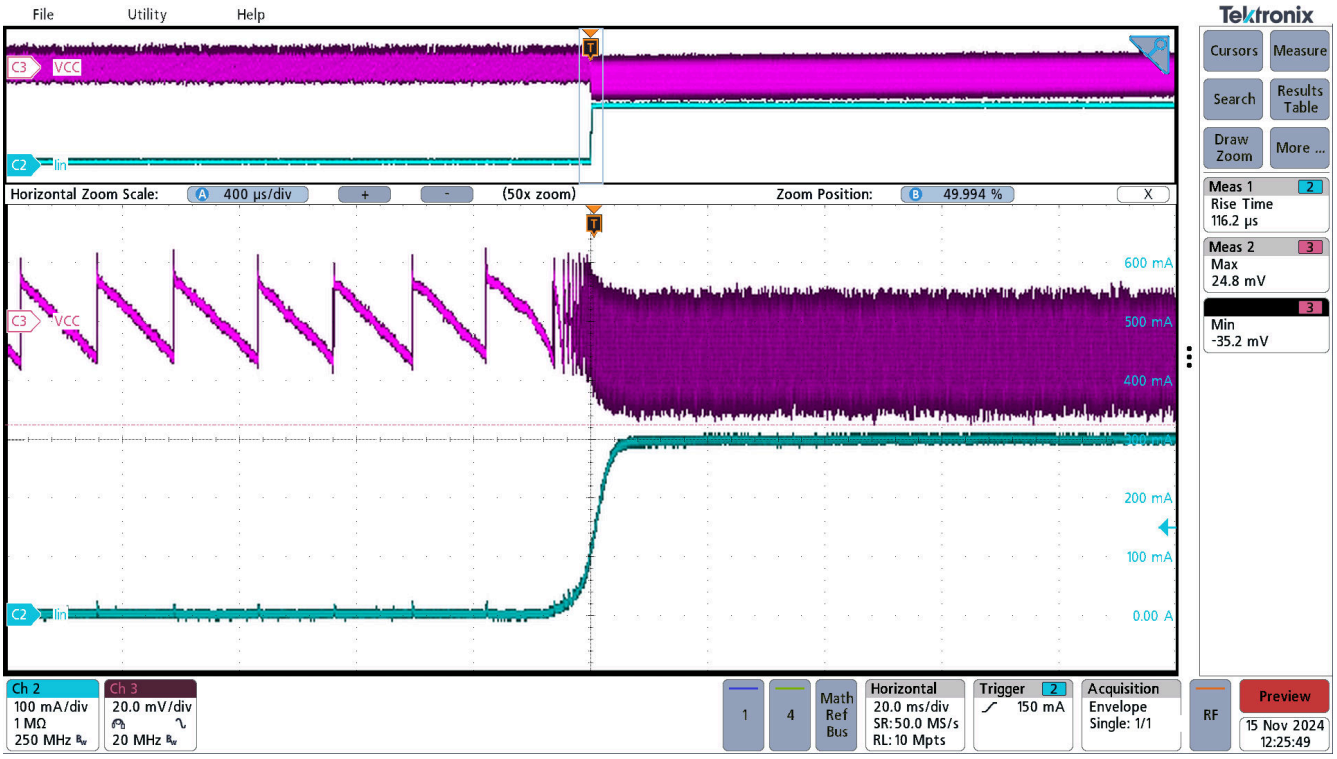



**Figure 3-19. UCC33411-Q1 Load transient, VINP=5.0V, VCC=3.3V, No load ($I_{out}$=0mA) to Full load ($I_{out}$=300mA)**

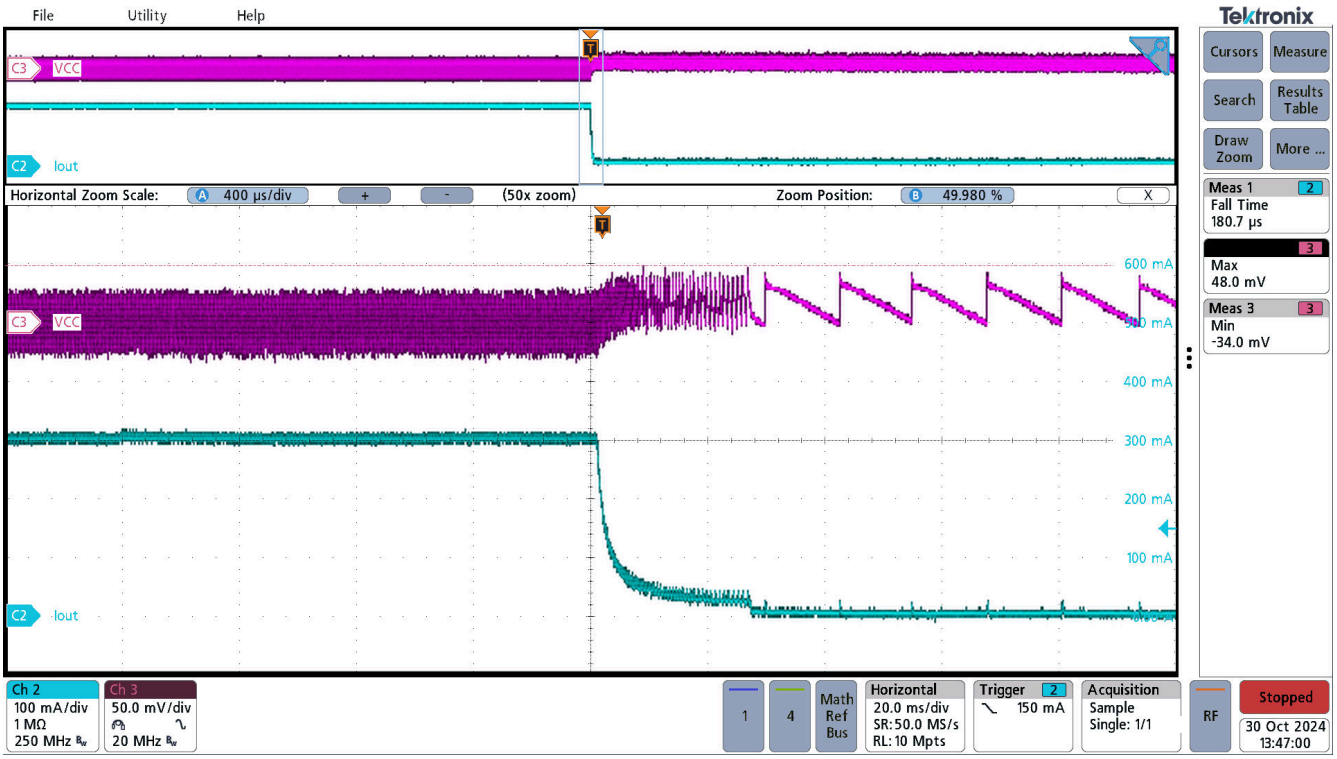



**Figure 3-20. UCC33421-Q1 Load transient, VINP=5.0V, VCC=5.0V, Full load ($I_{out}$=300mA) to No load ($I_{out}$=0mA)**

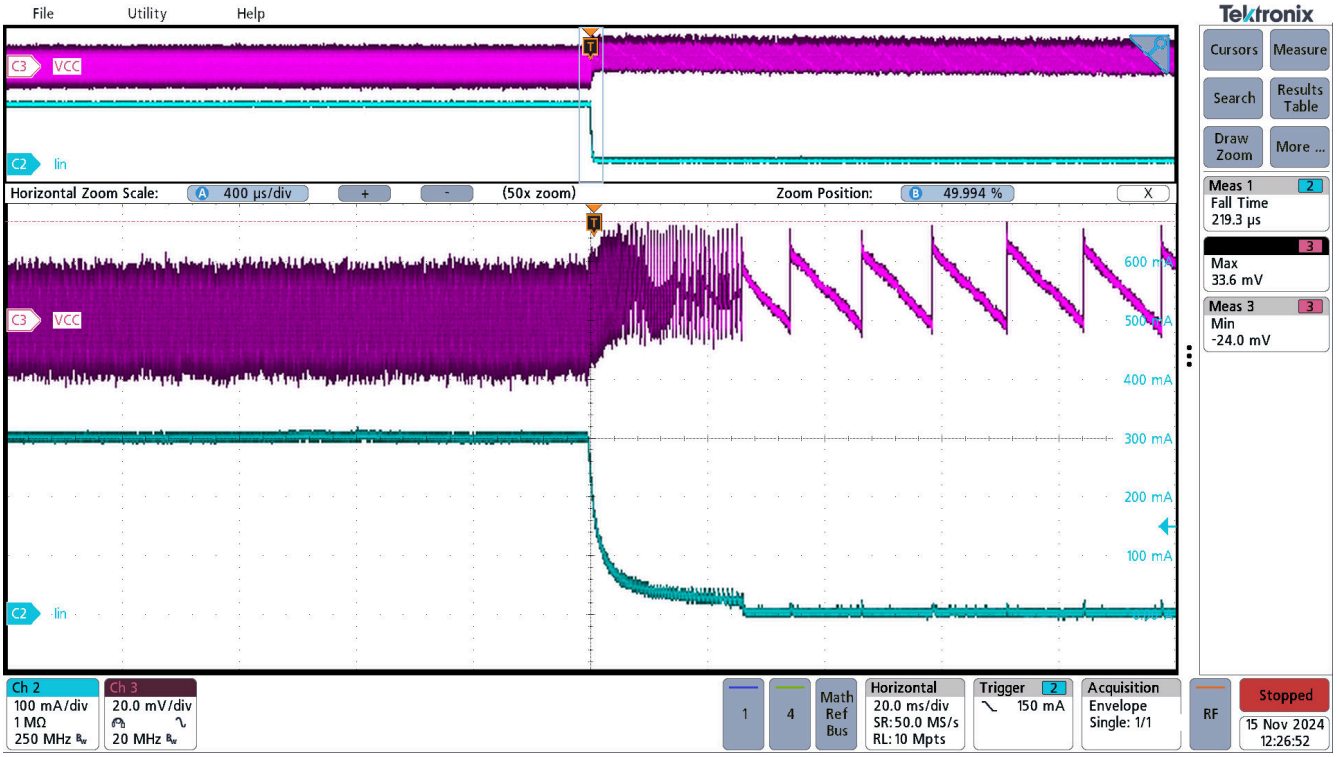



**Figure 3-21. UCC33411-Q1 Load transient, VINP=5.0V, VCC=3.3V, Full load ($I_{out}$=300mA) to No load ($I_{out}$=0mA)**

### 3.2.7 VCC Short-Circuit

Short circuit is applied with an electronic load. FLT pin is pulled down during 200µs and the device tries to restart after 160ms as shown in the waveform below. Device restarts successfully after short circuit is released.

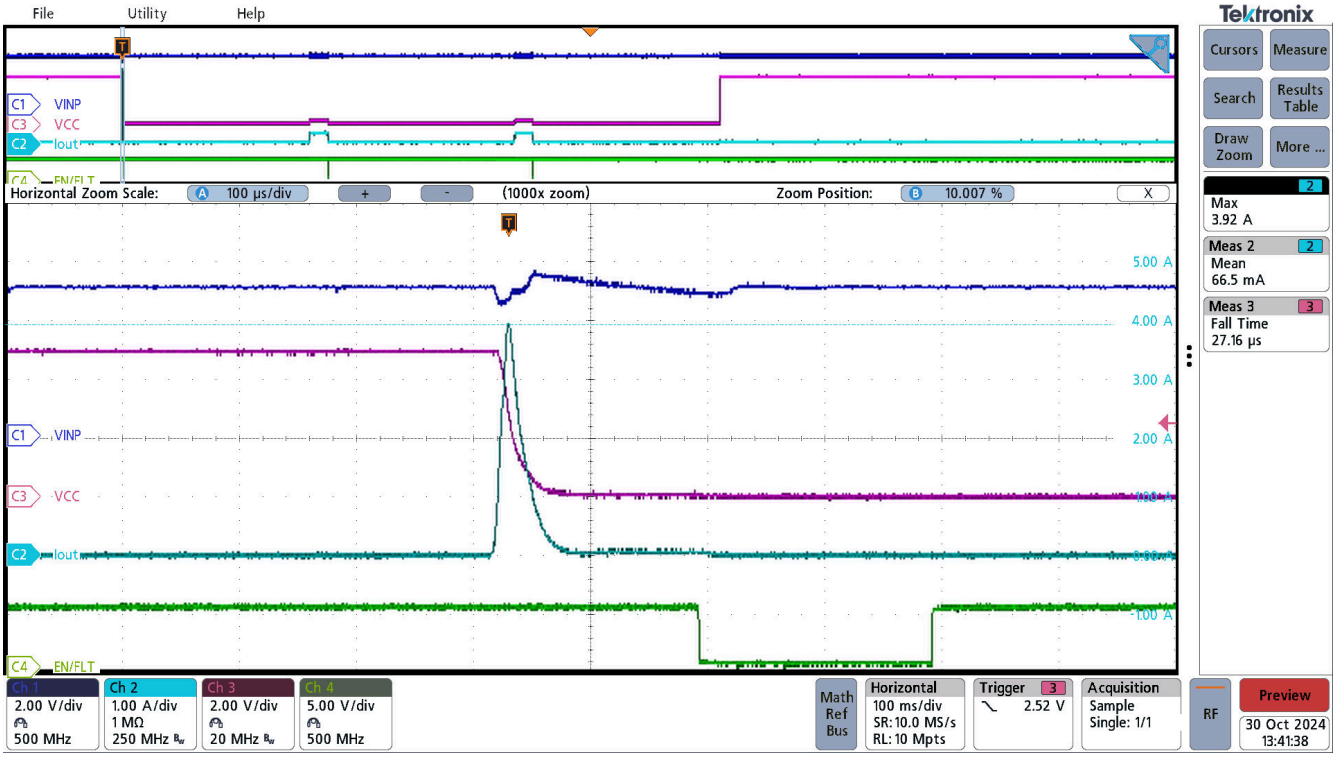



**Figure 3-22. UCC33421-Q1 Short circuit, VINP=5.0V, VCC=5.0V**

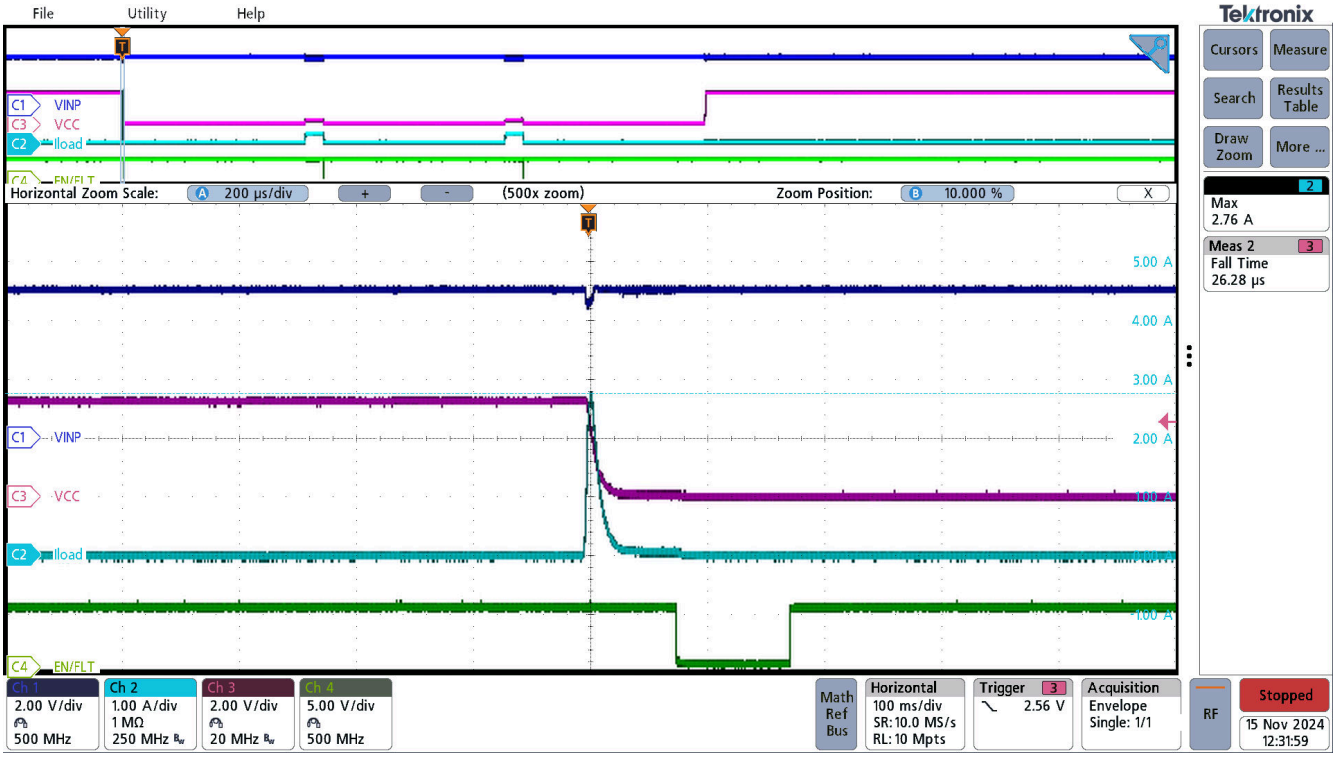



**Figure 3-23. UCC33411-Q1 Short circuit, VINP=5.0V, VCC=3.3V**

### 3.2.8 Thermal Performance

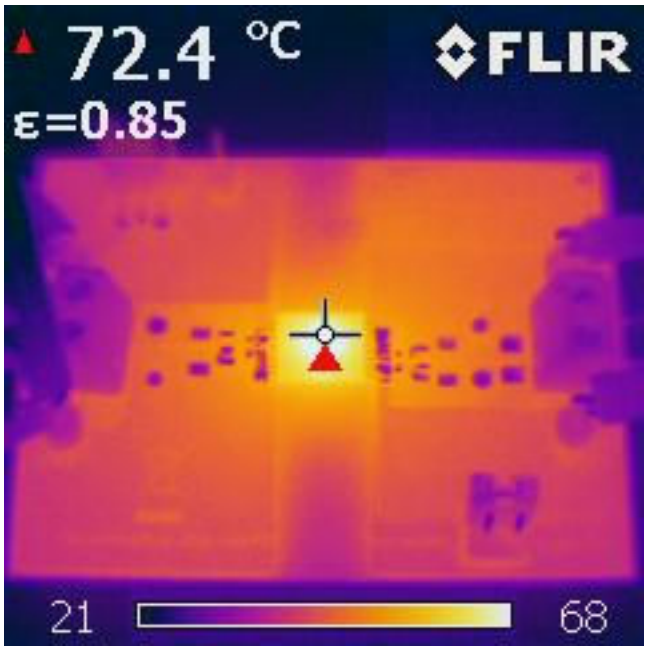



**Figure 3-24. UCC33421-Q1 VINP=5.0V, VCC=5.0V, $I_{out}$=300mA, Pout=1.5W, TA=25°C**

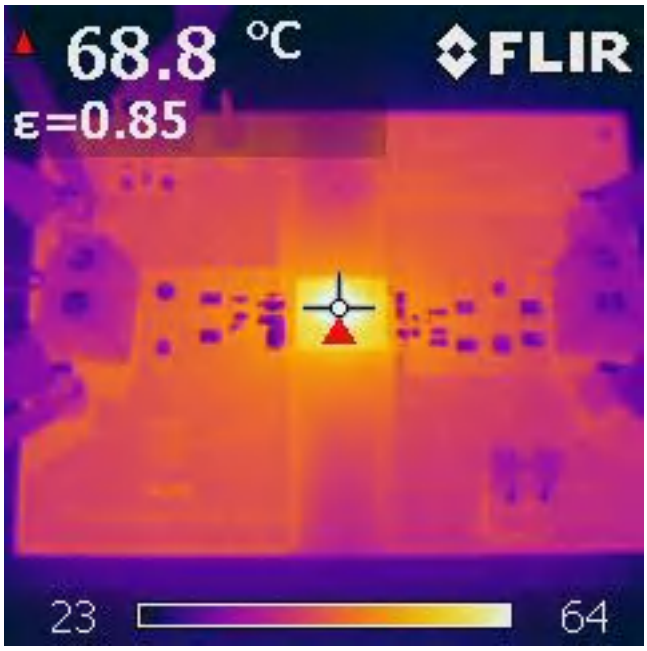



**Figure 3-25. UCC33411-Q1 VINP=5.0V, VCC=3.3V, $I_{out}$=300mA, Pout=1W, TA=25°C**

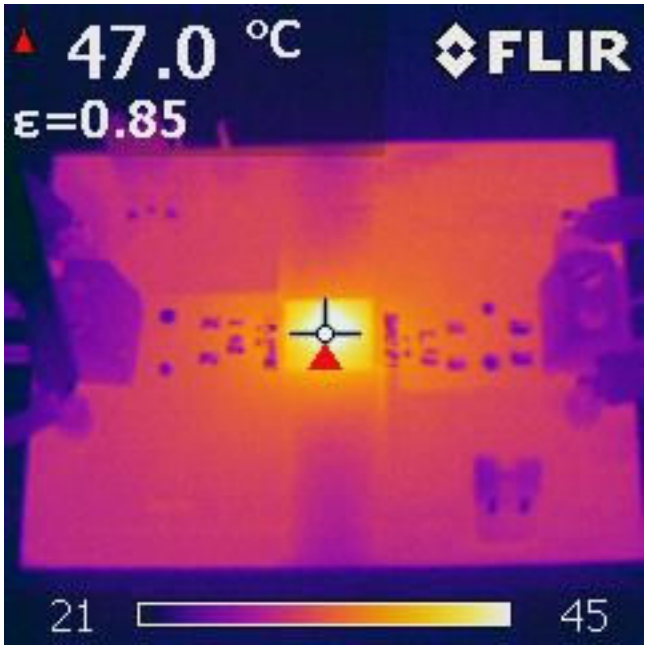



**Figure 3-26. UCC33421-Q1 VINP=5.0V, VCC=5.0V, $I_{out}$=150 mA, Pout=0.75W, TA=25°C**

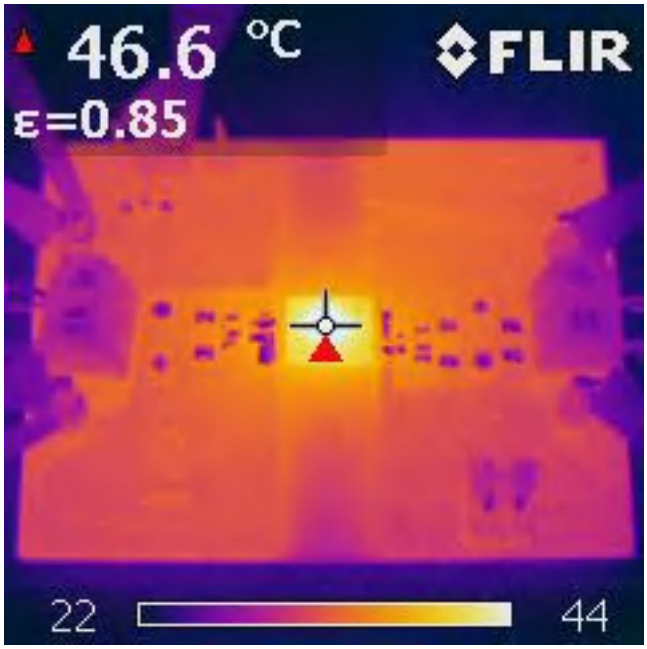



**Figure 3-27. UCC33411-Q1 VINP=5.0V, VCC=3.3V, $I_{out}$=150 mA, Pout=0.5W, TA=25°C**

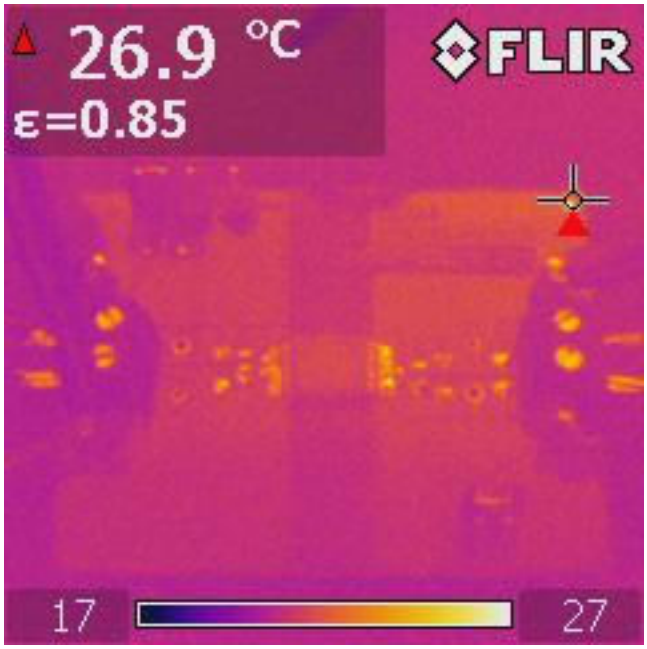



**Figure 3-28. UCC33421-Q1 VINP=5.0V, VCC=5.0V, $I_{out}$=0mA, Pout=0W, TA=25°C**

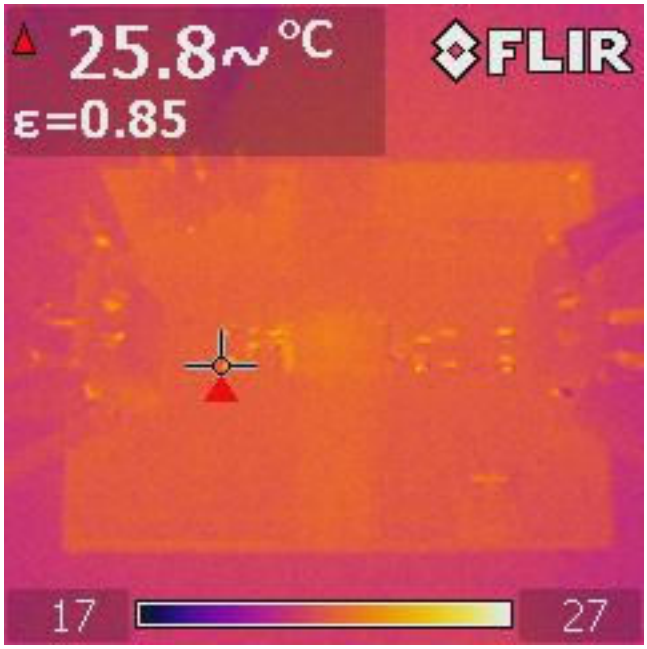



**Figure 3-29. UCC33411-Q1 VINP=5.0V, VCC=3.3V, $I_{out}$=0mA, Pout=0W, TA=25°C**

**Note**

The calibration of the thermal camera set the emissivity used on the thermal performance pictures.

# 4 Hardware Design Files

## 4.1 Assembly and Printed Circuit Board (PCB)

The UCC33421EVM-092 is designed using a four-layer, FR4, PCB, fabricated with 1-ounce copper on all four layers. The EVM, PCB demonstrates the important use of ground planes and tented stitching vias for shielding and providing low impedance connection between GND layers. For higher density PCBs such as automotive traction inverters, the PCB can include several additional signal layers but similar design methodology should be applied as best as possible.

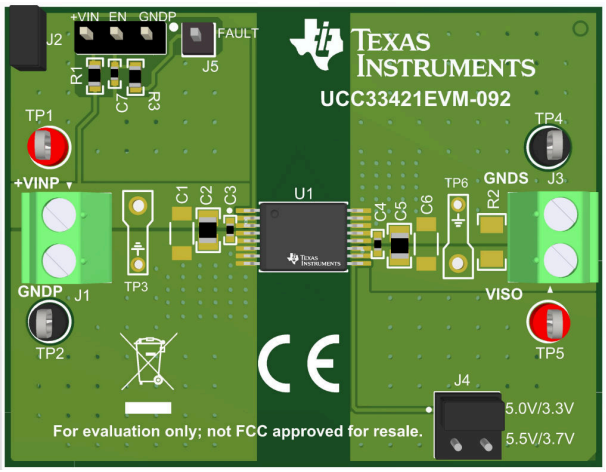



**Figure 4-1. Fully Assembled 3D Top View**

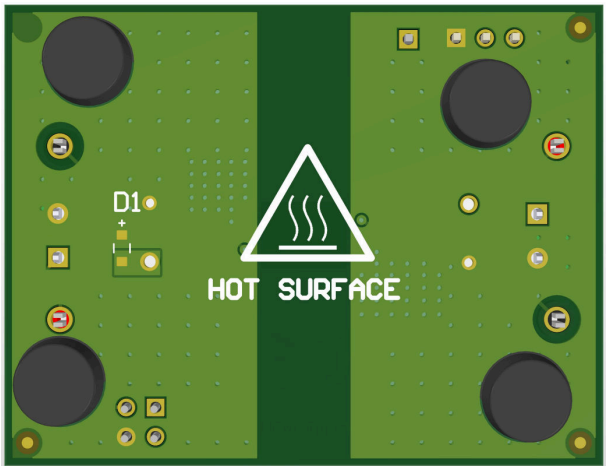



**Figure 4-2. Fully Assembled 3D Bottom View**

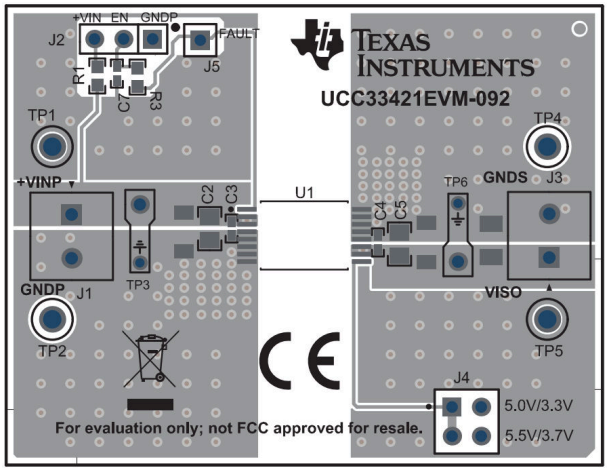



**Figure 4-3. PCB Top Layer, Assembly**

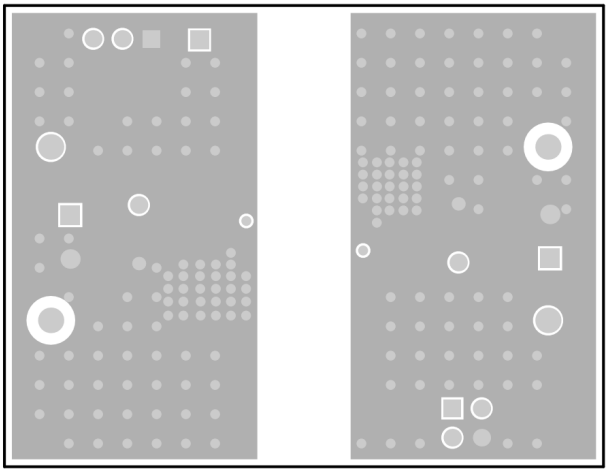


**Figure 4-4. Ground Layer 2**

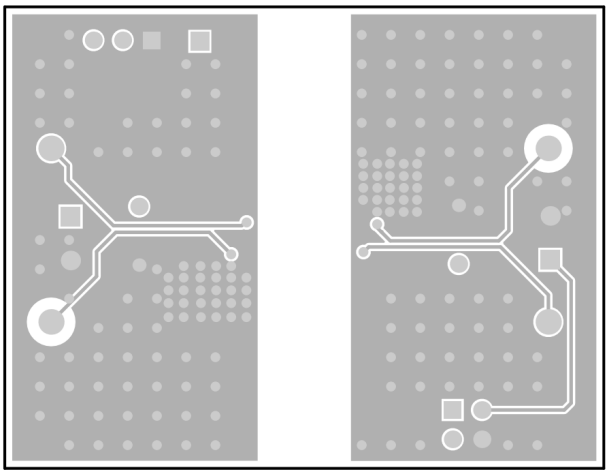


Figure 4-5. Ground Layer 3

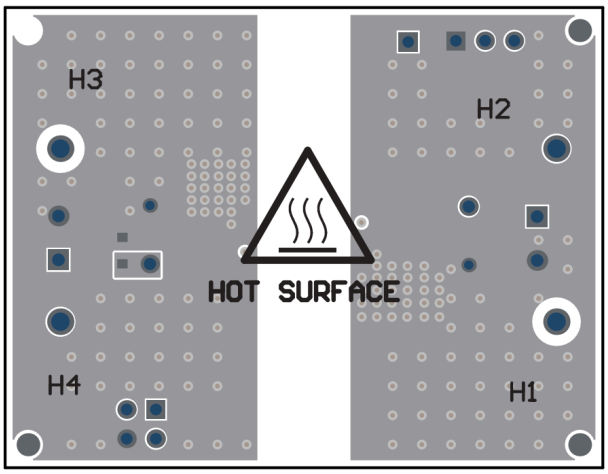



Figure 4-6. PCB Bottom Layer, Assembly (Mirrored View)

## 4.2 Bill of Materials (BOM)

**Table 4-1. Bill of Materials**

| Designator | Qty | Description | Part Number | Manufacturer |
|---|---|---|---|---|
| PCB1 | 1 | Printed Circuit Board | HVP092E1 | Any |
| C2 | 1 | CAP, CERM, 10µF, 10V,+/- 10%, X7R, AEC-Q200 Grade 1, 0805 | GCJ21BR71A106KE01L | MuRata |
| C3, C4 | 2 | 0.015uF ±10% 50V, Ceramic Capacitor X7R, 0402 (1005 Metric) | GCM155R71H153KA55D | MuRata |
| C5 | 1 | CAP, CERM, 22µF, 10V, +/- 20%, X7R, 0805 | GRM21BZ71A226ME15L | MuRata |
| C7 | 1 | CAP, CERM, 2200pF, 50V, +/- 10%, X7R, AEC-Q200 Grade 1, 0402 | GCM155R71H222KA37D | MuRata |
| H1, H2, H3, H4 | 4 | Bumpers | SJ61A6 | 3M |
| J1, J3 | 2 | Conn Term Block, 2POS, 3.81mm, TH | 1727010 | Phoenix Contact |
| J2 | 1 | Header, 100mil, 3x1, Tin, TH | PEC03SAAN | Sullins Connector |
| J4 | 1 | Header, 100mil, 2x2, Tin, TH | PEC02DAAN | Sullins Connector |
| J5 | 1 | Header, 1x1, Tin, TH | PEC01SAAN | Sullins Connector |
| R1 | 1 | RES, 0Ω, 5%, 0.1 W, AEC-Q200 Grade 0, 0603 | CRCW06030000Z0EA | Vishay-Dale |
| R3 | 1 | RES, 18.2kΩ, 1%, 0.1W, AEC-Q200 Grade 0, 0603 | CRCW060318K2FKEA | Vishay-Dale |
| SH-J1, SH-J2 | 2 | Shunt, 100mil, Flash Gold, Black | SPC02SYAN | Sullins Connector |
| TP1, TP5 | 2 | Test Point, Multipurpose, Red, TH | 5010 | Keystone |
| TP2, TP4 | 2 | Test Point, Multipurpose, Black, TH | 5011 | Keystone |
| U1 | 1 | 1.5W, High-Density, >3 kVRMS Isolated DC-DC Converter | PUCC33421-Q1 | Texas Instruments |
| U1-alt | 0 | 1.5W, High-Density, >3 kVRMS Isolated DC-DC Converter | PUCC33421RAQR | Texas Instruments |
| U1-alt | 0 | 1.5W, High-Density, >3 kVRMS Isolated DC-DC Converter | PUCC33411QRAQRQ1 | Texas Instruments |
| U1-alt | 0 | 1.5W, High-Density, >3 kVRMS Isolated DC-DC Converter | PUCC33411RAQR | Texas Instruments |
| C1, C6 | 0 | CAP, CERM, 10µF, 10V, +/- 10%, X7R, AEC-Q200 Grade 1, 1206 | GCM31CR71A106KA64L | MuRata |

**Table 4-1. Bill of Materials (continued)**

| Designator | Qty | Description | Part Number | Manufacturer |
|---|---|---|---|---|
| R2 | 0 | RES, 200Ω, 5%, 0.25W, AEC-Q200 Grade 0, 1206 | CRCW1206200RJNEA | Vishay-Dale |
| D1 | 0 | Zener Diode 5.94V 960mW ±2.61% | PLZ6V2A-G3/H | Vishay |

# 5 Additional Information

## 5.1 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 A (November 2024) to Revision B (December 2024) | Page |
|---|---|
| • Added UCC33411-Q1 and UCC33411 devices | 2 |
| • Added EVM Electrical Characteristics Table for UCC33411-Q1 | 3 |
| • Added Performance Data for UCC33411-Q1 | 8 |

| Changes from Revision * (May 2024) to Revision A (November 2024) | Page |
|---|---|
| • Updated schematics | 8 |
| • Added *Efficiency Data* section | 8 |
| • Added *Regulation Data* section | 9 |
| • Added *Inrush Current* section | 13 |
| • Updated *AC Ripple Voltage* section | 15 |
| • Updated *Load Transient* section | 17 |
| • Updated *VCC Short-Circuit* section | 19 |
| • Added *Thermal Performance* section | 20 |

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