RTKA211403DE0000BU

The RAA211403 is an integrated 3.3V, 300mA buck regulator with an ultra low quiescent current (I_Q) of 4µA. It supports a wide input voltage range from 7V to 40V. The RAA211403 is offered in a TSOT23-5 (2.9mm×1.63mm) package. The RTKA211403DE0000BU evaluation board provides a quick and comprehensive platform for evaluating the performance features of the RAA211403 buck regulator.

The RTKA211403DE0000BU evaluation board operates from a supply voltage of 7V to 40V_{DC} with the capability of delivering a continuous load up to 300mA at 3.3V output voltage.

Specifications

This board is configured and optimized for the following operating conditions:

- Input voltage range: 7V to 40V
- Output voltage: 3.3V
- Up to 300mA output current capability
- Inductor current limit of 750mA (typical) peak
- Operating temperature range: -40°C to +125°C

Features

- 7V to 40V input supply range
- Up to 300mA output current
- I_Q = 4µA at 40V, at no load conditions, switching
- I_Q = 2.5µA at 40V at no load and no switching conditions
- Minimum on-time of 75ns
- Fixed 3.3V V_{OUT}
- Variable frequency operation, frequency programmed by external inductor (4.7µH to 15µH)
- Pre-bias start-up / Monotonic / smooth start-up
- Total of four external components
- Protections: Overcurrent (OC) Limit, input Undervoltage Lockout (UVLO), Over-Temperature Protection (OTP), output Overvoltage Protection (OVP)
- Accurate EN threshold

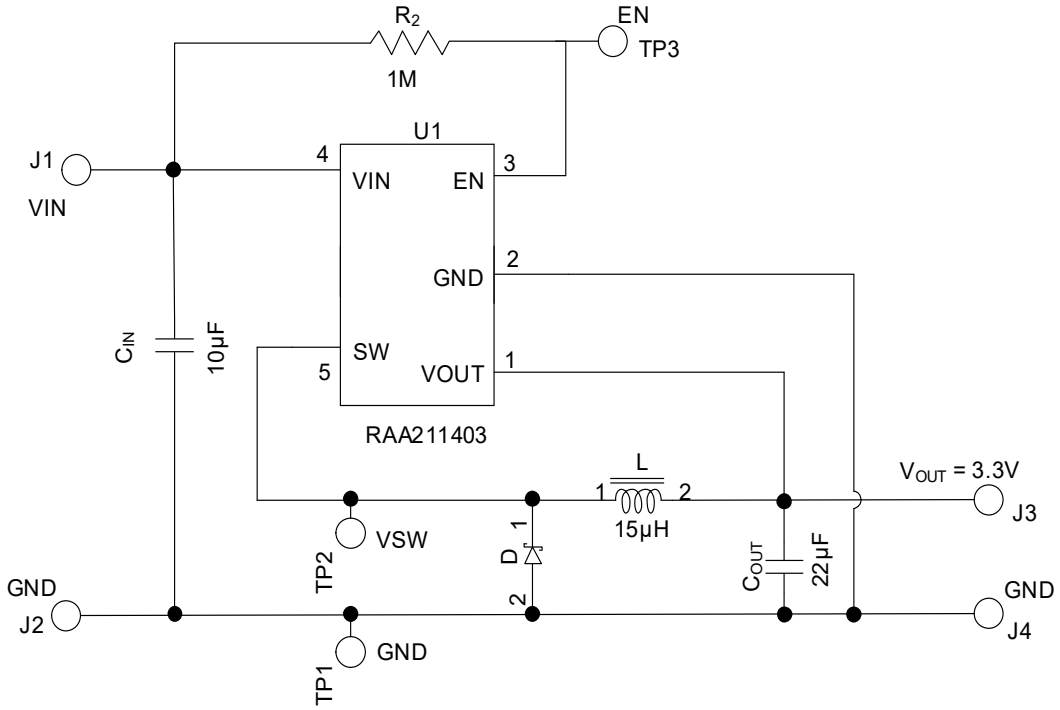

Figure 1. RTKA211403DE0000BU Block Diagram

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1. Functional Description

The RTKA211403DE0000BU evaluation board provides a comprehensive and versatile platform for you to asses functionality and prototype an application with the integrated 3.3V, 300mA buck regulator RAA211403. The board has options for evaluating most features of the RAA211403 and includes test points that facilitate probing.

1.1 Operational Characteristics

The RTKA211403DE0000BU evaluation board evaluates the RAA211403 with VIN from 7V to 40V and a continuous load of 300mA. Renesas recommends operating the board within the specifications for the proper functioning of the evaluation board.

You can connect EN to VIN through a resistor, or you can connect EN to external logic voltage for enable and disable.

1.2 Connectors, Test Points, Selection Switches, and Jumper Descriptions

The RTKA211403DE0000BU evaluation board includes I/O connectors, test points, selection switches, and jumpers to provide a comprehensive and versatile platform for evaluating the RAA211403 (see Table 1).

Table 1. Connectors, Test Points, and Jumper Descriptions

Reference Designator	Description
J1	Input voltage positive connection
J2	Input voltage return connection
J3	Output voltage positive connection
J4	Output voltage return connection
TP1	GND test point
TP2	VSW
TP3	ENABLE test point

1.3 Recommended Equipment

- A power supply that can deliver 40V or higher with at least 350mA source current capability.
- Electronic load capable of sinking at least 350mA current.
- 4-channel oscilloscope with voltage and current probes.

1.4 Quick Start Guide

Complete the following steps to configure and power up the board properly.

1. Set the power supply voltage to 24V and turn off the power supply. Connect the positive output of the power supply to J1 (VIN) and the negative output to J2 (GND).
2. Connect an electronic load to J3 (VOUT) for the positive connection and J4 (GND) for the negative connection.
3. Place scope probes to VOUT (J3), VSW (TP2), and/or other test points of interest.
4. Set the load current to 0.1A and turn on the power supply. The output voltage should be in regulation with nominal 3.3V output.
5. Slowly increase the load up to 300mA. The output voltage should remain in regulation with nominal 3.3V output.
6. Slowly sweep VIN from 7V to 40V. The output voltage should remain in regulation with nominal 3.3V output.
7. Decrease the input voltage to 0V to shut down the regulator.

1.5 Enable

EN is connected to VIN through R_2. EN can be driven by an external source or by removing R_2. Do not leave this pin floating.

1.6 Soft-Start

RAA211403 is naturally current limited and automatically provides a smoothly rising V_{OUT} voltage at power up. Because the total output of the device is limited, a startup with a heavy load generates a longer V_{OUT} ramp; a startup with no load generates a faster ramp.

The approximate soft-start time[1] based on the RTKA211403DE00BU with 24V input at no load is 135µs and 235µs at full load.

1.7 Switching Frequency

The regulator is a variable frequency converter, and the switching frequency varies proportionally to the load. The maximum switching frequency is dependent on inductance and input voltage.

Figure 2 and Figure 3 show the bench data for the evaluation board. Use Equation 1 to approximate the switching frequency.

(EQ. 1)

$$\text{SwitchingFrequency} = \frac{2\text{xIload}}{\text{LxIpeakxIpeakx}\left(\frac{1}{V_{IN}-V_{OUT}}+\frac{1}{V_{OUT}}\right)\times\text{Efficiency}}$$

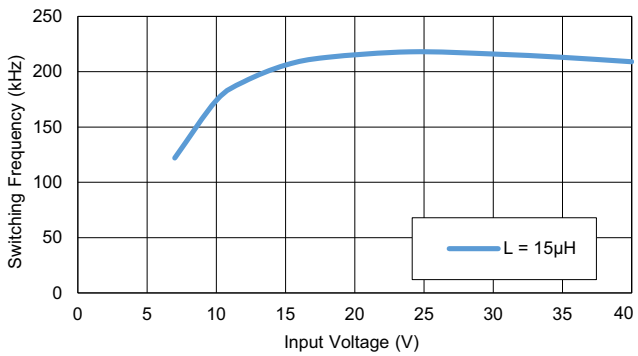

Figure 2. Switching Frequency (Full Load, 300mA) vs. Input Voltage

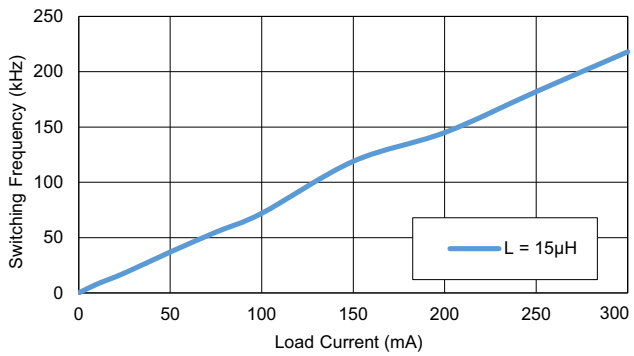

Figure 3. Switching Frequency (V_{IN}: 24V) vs. Load Current

1. Test conditions: V_{IN} = 24V, C_{OUT} = 22µF (PN:GRM187R61A226ME15D), C_{IN} = 10µF (PN:GRM21BR61H106KE43L), L = 15µH (PN:74438335150), Power supply: Chroma-632012P-100-50, Load: Resistive Load equivalent to full load at nominal V_{OUT}. Measured from 0 and 100% of nominal V_{OUT}.

2. Board Design

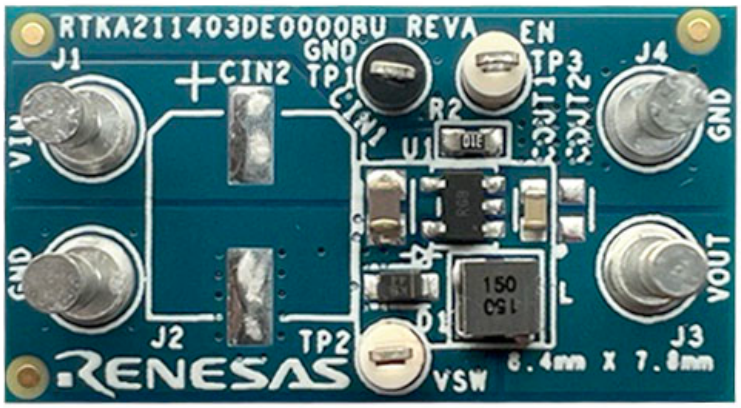

Figure 4. RTKA211403DE0000BU Evaluation Board (Top)

2.1 Layout Guidelines

The printed circuit board (PCB) layout is critical for the proper operation of RAA211403. The following guidelines are recommended to achieve optimal performance.

- Use a multilayer PCB structure to achieve optimized performance. The evaluation board RTKA211403DE0000BU uses a 2-layer PCB with 1oz copper and the bottom layer as ground.
- Place the input capacitor as close as possible to the IC. The input capacitor is the most important component for any step-down converter and should be the first component to be placed in the layout.
- The copper area of the SW NODE should not be more than needed. Place the inductor close to the regulator.
- Place an output capacitor close to the inductor.
- Place and route the power component to keep the power loop area as minimum and short as possible.
- Keep all the power components on the same side of the PCB.
- Include thermal vias as necessary to improve heat dissipation.

2.2 Schematic Diagram

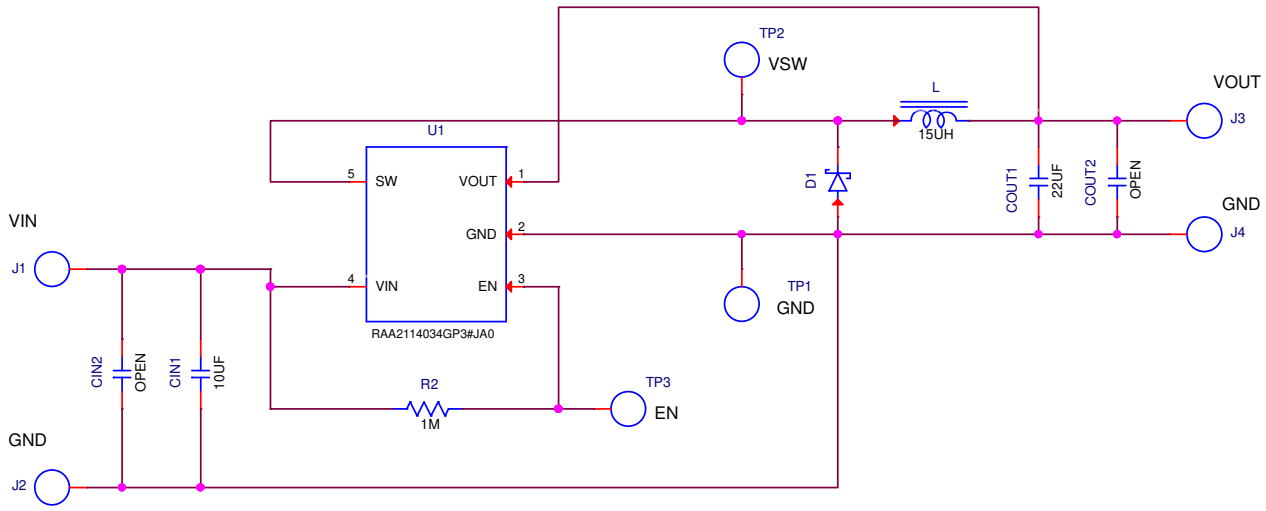

Figure 5. RTKA211403DE0000BU Schematic

2.3 Bill of Materials

Qty	Reference Designator	Description	Manufacturer	Manufacturer Part Number
1	L	COIL-PWR Inductor, SMD, 3mm, 15µH, 20%, 1.71A, 720mΩ DCR, WW, ROHS	Wurth	74438335150
1	CIN1	Multilayer Cap, SMD, 0805, 10µF, 10%, 50V	Murata	GRM21BR61H106KE43L
0	CIN2	CAP ALUM POLY 56UF 20% 63V SMD	DNP	DNP
1	R2	Thick Film Chip Resistor, SMD, 0603, 1M, 1%, 1/10W	Generic	Various
1	D1	1A 60V Low Vf Schottky Barrier Rectifier, SOD323F	Panjit	MBR1060HEWS_R1_00001
1	U1	3.3V, 300mA DC-DC Buck Regulator with low quiescent current, SOT23-5	Renesas	RAA2114034GP3#JA0
1	COUT1	Multilayer Cap, SMD, 0603, 22µF, 20%, 10V	Generic	Various
0	COUT2	Multilayer Cap, SMD, 0603, 22µF, 20%, 10V	DNP	DNP
4	J1, J2, J3, J4	Brass Test Point Turret, 0.150 Pad, 0.100 Thole, PCB Depth <0.078 in	Keystone	1502-1
1	GND	Miniature Black Test Point, 0.100 Pad, 0.040 Thole	Keystone	5001
2	VSW, EN	Miniature White Test Point, 0.100 Pad, 0.040 Thole	Keystone	5002

2.4 Board Layout

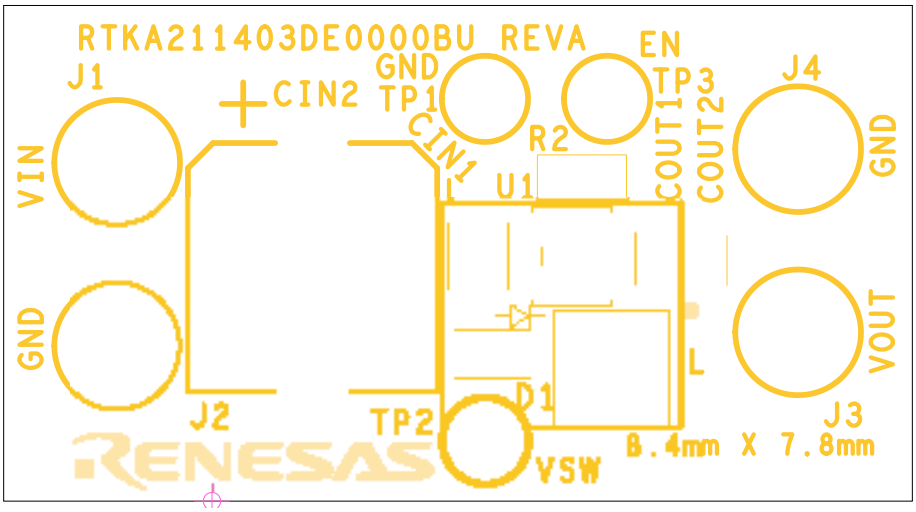

Figure 6. Silkscreen Top

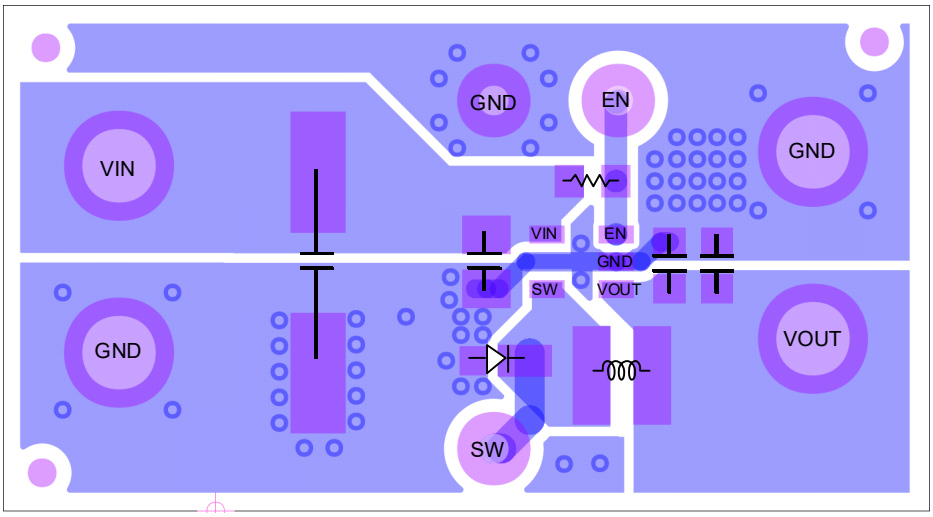

Figure 7. Top Layer

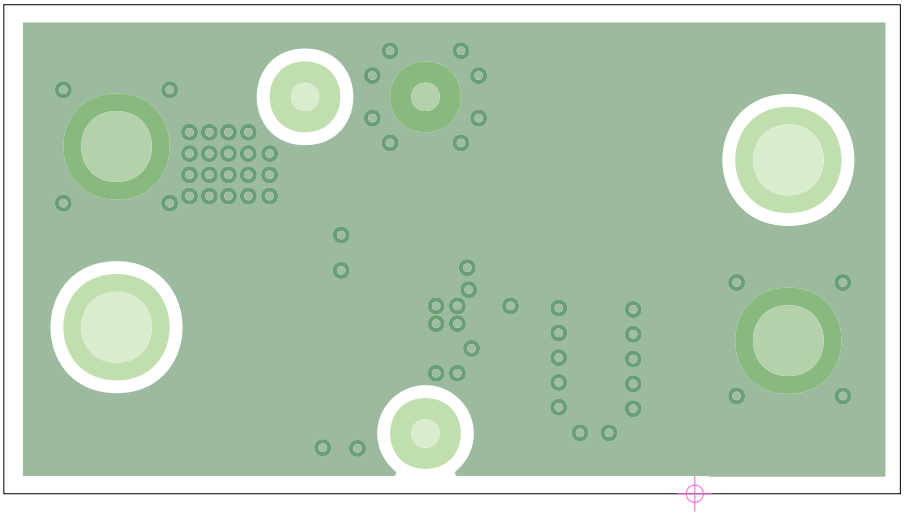

Figure 8. Bottom Layer

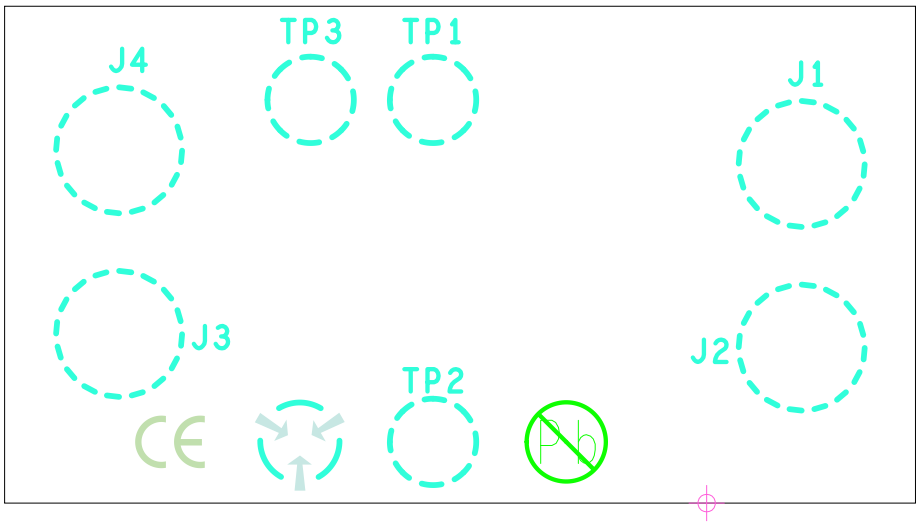

Figure 9. Silkscreen Bottom

3. Typical Performance Graphs

VIN = 24V, V_{OUT} = 3.3V, L = 15µH, I_{OUT} = 300mA, C_{OUT} = 22µF, Ren = 1MΩ, T_A = +25°C, internal compensation, internal soft-start unless otherwise stated.

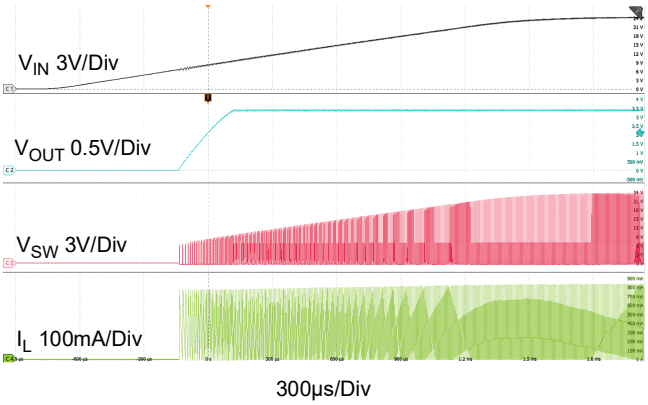

Figure 10. Startup through VIN

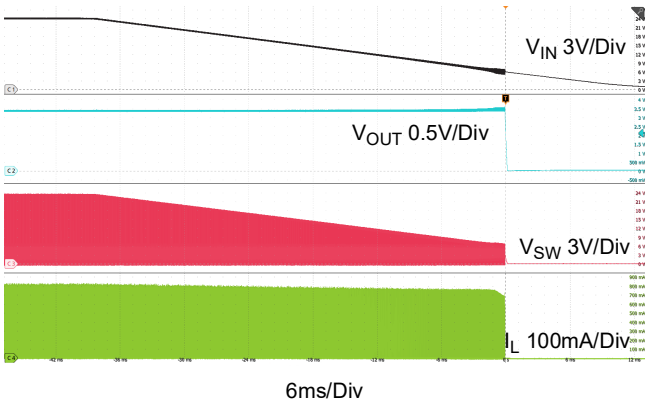

Figure 11. Shutdown through VIN

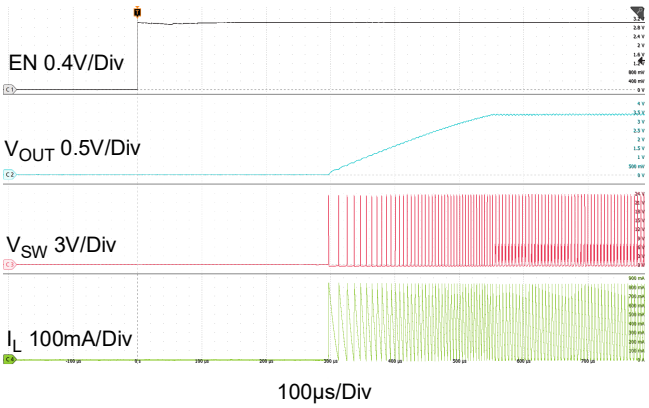

Figure 12. Startup through EN

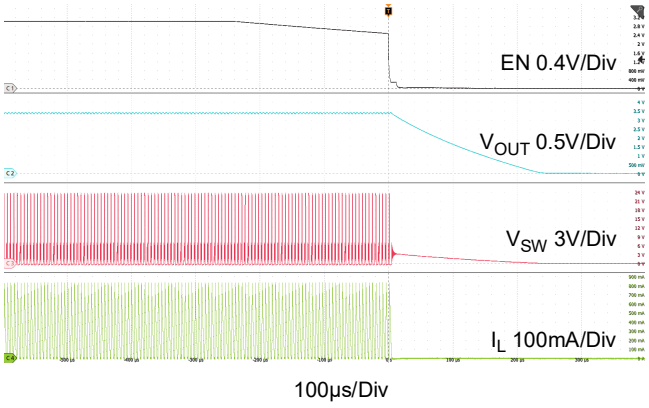

Figure 13. Shutdown through EN

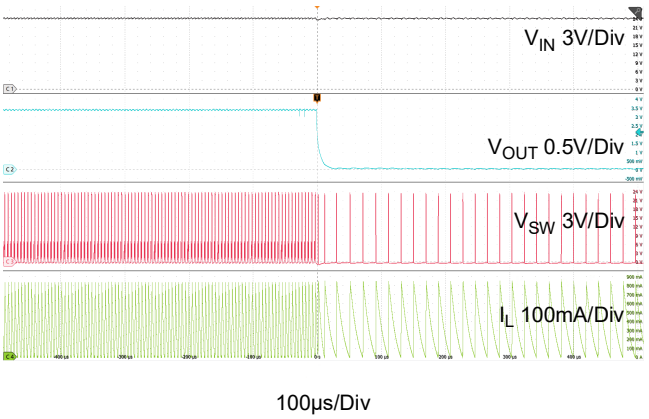

Figure 14. Short-Circuit

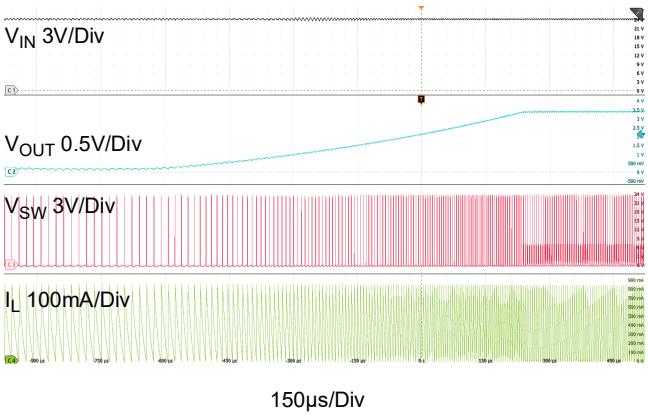

Figure 15. Recovery from Short-Circuit

VIN = 24V, V_{OUT} = 3.3V, L = 15µH, I_{OUT} = 300mA, C_{OUT} = 22µF, Ren = 1MΩ, T_A = +25°C, internal compensation, internal soft-start unless otherwise stated. (Cont.)

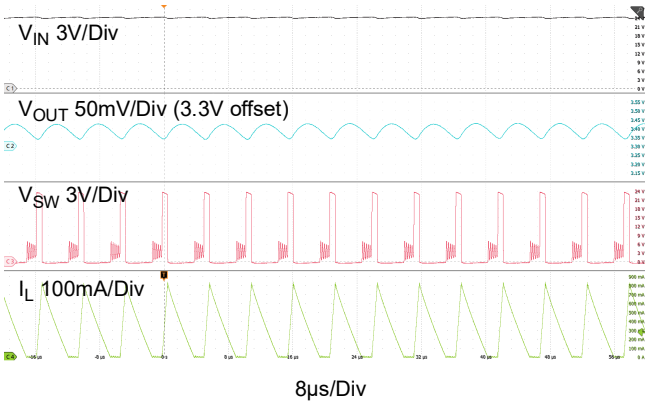

Figure 16. Typical Operation (Full Load)

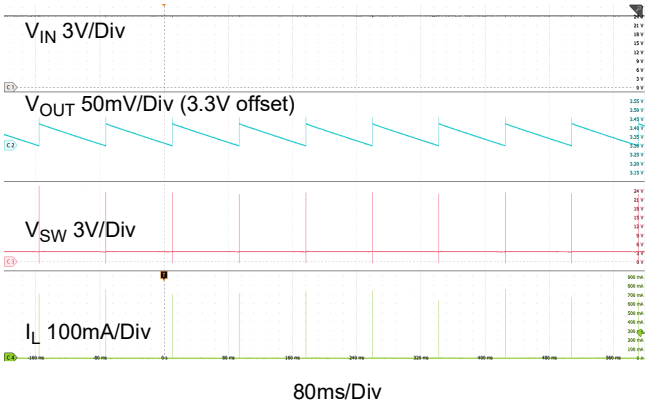

Figure 17. Typical Operation (No Load)

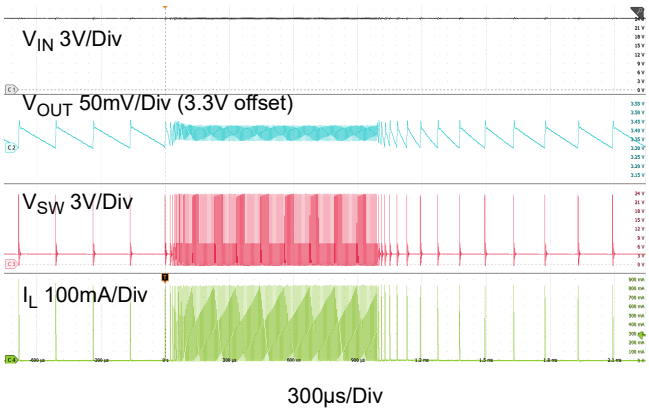

Figure 18. Load Transient (10mA to 300mA)

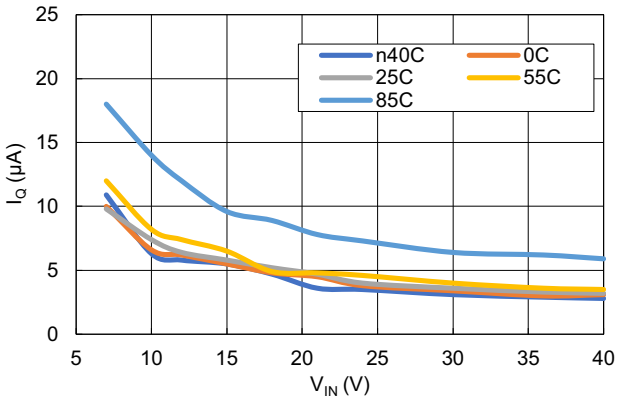

Figure 19. I_Q vs V_{IN}(In Regulation: No Load)

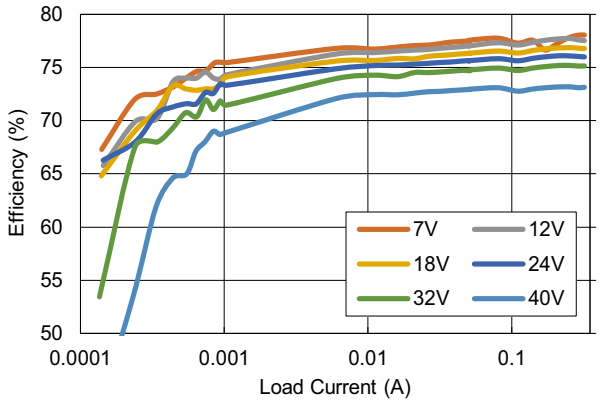

Figure 20. Efficiency

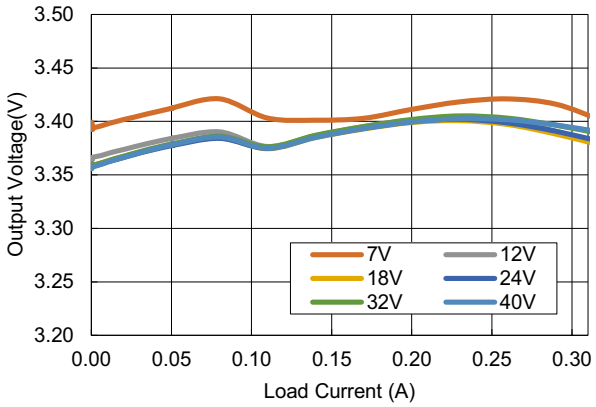

Figure 21. Load Regulation

4. Ordering Information

Part Number	Description
RTKA211403DE0000BU	RAA211403 TSOT23-5 evaluation board

5. Revision History

Revision	Date	Description
1.02	Dec 1, 2023	Updated Equation 1. Updated Figure 8 and 9. Updated the Bill of Materials, COUT1 and COUT2.
1.01	May 8, 2023	Updated page 1 information. Reordered sections. Updated Schematic, Layout, and BOM information. Updated Typical performance graphs.
1.00	Oct 7, 2022	Initial release

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