

## RTKA210040DR0000BU

The RTKA210040DR0000BU demonstration board (shown in [Figure 2](#) and [Figure 3](#)) features the RAA210040. Capable of delivering up to 4A of continuous current, the [RAA210040](#) is a compact, synchronous step-down, non-isolated complete power supply that is optimized for space-constrained applications. The RAA210040 is based on a peak current mode PWM control scheme that provides a fast transient response and excellent loop stability. The switching frequency is programmable from 500kHz to 4MHz with either the external resistor or synchronization to an external clock through the SYNC pin.

The RTKA210040DR0000BU demonstration board is a 1×1 inch 4-layer FR4 board with 2oz. copper on all layers. It is optimized to minimize the complete power module solution size. Operating from a single 2.7V to 5.5V input power rail, the RTKA210040DR0000BU demonstration board offers adjustable output voltages down to 0.6V, up to 95% efficiency, and better than 1.5% accuracy over line, load, and temperature. A dedicated enable pin and power-good flag allow for easy system power rails sequencing.

By default, the board is set to a 1.2V output voltage with a 1.2MHz switching frequency.

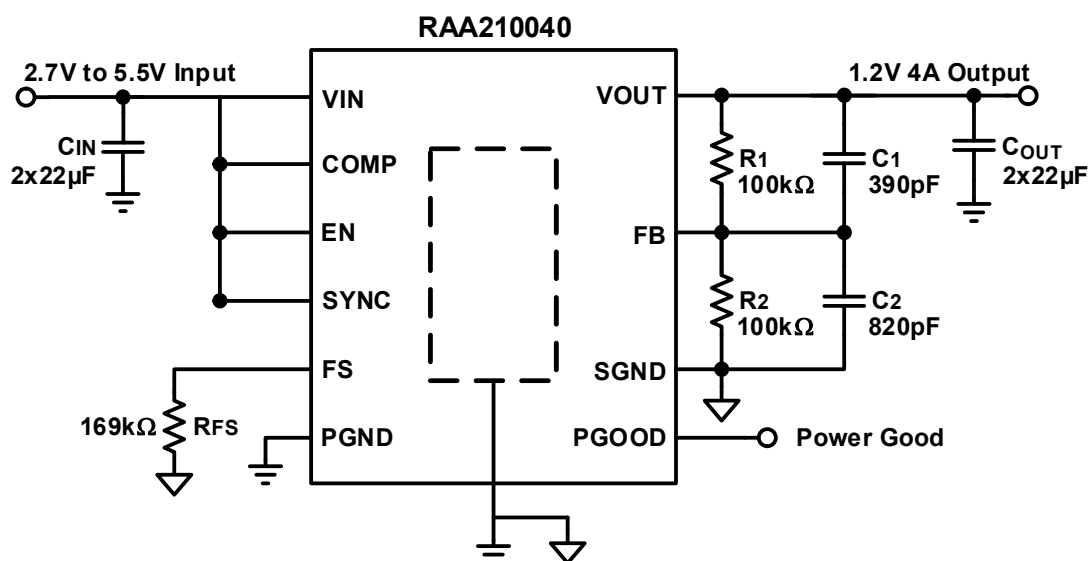
## Features

- Wide input voltage range from 2.7V to 5.5V
- Adjustable output voltage down to 0.6V with  $\pm 1.5\%$  accuracy over line, load, and temperature
- Up to 95% conversion efficiency
- 100% duty cycle
- Internal 1ms soft-start time
- Prebias output start-up
- External frequency synchronization up to 4MHz
- Dedicated enable pin and PGOOD flag
- UVLO, overcurrent, negative overcurrent, overvoltage, and over-temperature protections

## Specifications

The demonstration board is configured and optimized for the following operating conditions:

- $V_{IN} = 2.7V$  to  $5.5V$
- $V_{OUT} = 1.2V$
- $I_{OUT-MAX} = 4A$
- $f_{SW} = 1.2MHz$



### Figure 1. RTKA210040DR0000BU Block Diagram

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# 1. Functional Description

The RTKA210040DR0000BU provides the peripheral circuitry to demonstrate the feature set of the RAA210040. The demonstration board includes several connectors, test points, and jumpers that simplify the validation of the module. The module is enabled and disabled by moving the jumper across the EN pin as shown in [Figure 2](#). Selecting features like external frequency synchronization is performed by removing the pull-up resistor  $R_3$  of the SYNC pin and connecting the signal generator (square pulse waveform clock signal) to TP4 of the SYNC pin. The output voltage (0.6V - 5V) and the switching frequency (500kHz to 4MHz) are programmed by changing the resistors as shown in [Figure 3](#).

## 1.1 Recommended Testing Equipment

- 0V to 5.5V power supply with at least 4A source current capability
- Electronic loads capable of sinking current up to 4A
- Digital Multimeters (DMMs)
- Oscilloscope with higher than 100MHz bandwidth

## 1.2 Quick Test Guide

1. Disable the module by connecting the jumper across 2 and 1 on J3 for the EN pin as shown in [Figure 2](#) and [Figure 7](#).
2. Use the appropriate cables to connect the DC input power supply to banana sockets J1 and J2 and the electronic load to sockets J4 and J5. Ensure that the polarity for the power leads is correct and the input voltage is within the operating range (2.7V - 5.5V) of the module. Use test points TP1 (VIN) and TP2 (PGND) for accurately measuring the input voltage.
3. Turn on the input power supply.
4. To enable the module, you can connect the jumper across 2 and 3 on J3 for the EN pin to enable the module.
5. To enable external frequency synchronization, remove the pull-up resistor  $R_3$  of the SYNC pin and connect the external clock to TP4 (SYNC). To ensure proper operation, Renesas recommends that the external SYNC frequency is within  $\pm 25\%$  of the switching frequency set by  $R_2$  and the FS pin.
6. Probe test points TP6 (VOUT) and TP7 (PGND) to observe the output voltage. The output voltage should read 1.2V.
7. Adjust the input voltage,  $V_{IN}$ , within the specified range and observe the output voltage. The output voltage variation should be within  $\pm 1.5\%$ .
8. Adjust the load current to within the specified range (0 - 4A) and observe the output voltage. The output voltage variation should be within  $\pm 1.5\%$ .
9. To change  $V_{OUT}$ , disconnect the demonstration board from the setup and populate standard 0402 resistors at the  $R_{10}$  and  $R_{11}$  locations on the bottom layer. The Output Voltage Resistor Settings table in the RAA210040 datasheet can be used as a reference for programming different output voltages. See the RAA210040 Design Guide Matrix table in [Table 1](#) for correct input and output capacitors, switching frequency, and output voltage combinations.
10. The switching frequency is modified by populating a standard 0402 resistor at the  $R_2$  location on the bottom layer. See Equation 1 in the RAA210040 datasheet for selecting the correct value of  $R_2$  within the admissible operating range (500kHz - 4MHz).

Table 1. RAA210040 Design Guide Matrix (See Figure 1)

| Case | V <sub>IN</sub><br>(V) | V <sub>OUT</sub><br>(V) | R <sub>1</sub><br>(kΩ) | R <sub>2</sub><br>(kΩ) | C <sub>IN</sub><br>(Ceramic)<br>(μF) | C <sub>OUT</sub><br>(Ceramic)<br>(μF) | Freq<br>(MHz) | R <sub>FS</sub><br>(kΩ) | C <sub>1</sub><br>(pF) | C <sub>2</sub><br>(pF) |
|------|------------------------|-------------------------|------------------------|------------------------|--------------------------------------|---------------------------------------|---------------|-------------------------|------------------------|------------------------|
| 1    | 3.3                    | 0.6                     | 100                    | open                   | 2x22                                 | 1x47                                  | 0.8           | 261                     | 390                    | 820                    |
| 2    | 3.3                    | 0.8                     | 100                    | 301                    | 2x22                                 | 2x22                                  | 0.9           | 232                     | 390                    | 820                    |
| 3    | 3.3                    | 0.9                     | 100                    | 200                    | 2x22                                 | 2x22                                  | 1             | 205                     | 390                    | 820                    |
| 4    | 3.3                    | 1                       | 100                    | 150                    | 2x22                                 | 2x22                                  | 1             | 205                     | 390                    | 820                    |
| 5    | 3.3                    | 1.2                     | 100                    | 100                    | 2x22                                 | 2x22                                  | 1.2           | 169                     | 390                    | 820                    |
| 6    | 3.3                    | 1.5                     | 100                    | 66.5                   | 2x22                                 | 2x22                                  | 1.3           | 154                     | 390                    | 680                    |
| 7    | 3.3                    | 1.8                     | 100                    | 49.9                   | 2x22                                 | 2x22                                  | 1.5           | 133                     | 390                    | 560                    |
| 8    | 3.3                    | 2.5                     | 100                    | 31.6                   | 2x22                                 | 2x22                                  | 1.8           | 107                     | 390                    | 470                    |
| 9    | 5                      | 1                       | 100                    | 150                    | 2x22                                 | 2x22                                  | 1             | 205                     | 390                    | 820                    |
| 10   | 5                      | 1.2                     | 100                    | 100                    | 2x22                                 | 2x22                                  | 1.2           | 169                     | 390                    | 820                    |
| 11   | 5                      | 1.5                     | 100                    | 66.5                   | 2x22                                 | 2x22                                  | 1.3           | 154                     | 390                    | 680                    |
| 12   | 5                      | 1.8                     | 100                    | 49.9                   | 2x22                                 | 2x22                                  | 1.5           | 133                     | 390                    | 560                    |
| 13   | 5                      | 2.5                     | 100                    | 31.6                   | 2x22                                 | 2x22                                  | 1.8           | 107                     | 390                    | 470                    |
| 14   | 5                      | 3.3                     | 100                    | 22.1                   | 2x22                                 | 2x22                                  | 2.4           | 76.8                    | 390                    | 470                    |

### 1.3 Thermal Considerations and Current Derating

To ensure the module can operate safely and deliver the maximum allowable power, the board layout is critical. For the board to operate properly at high ambient temperature environments and carry full load current, carefully design the board layout to maximize thermal performance. To achieve this, use enough trace width, copper weight, and proper connectors.

The RTKA210040DR0000BU demonstration board is capable of operating at 4A full-load current at room temperature without the need for additional cooling systems. However, if the board needs to operate at elevated ambient temperatures, the available output current may need to be derated. See the derated current curves in the RAA210040 datasheet to determine the maximum output current that the module can supply.

## 2. Board Design

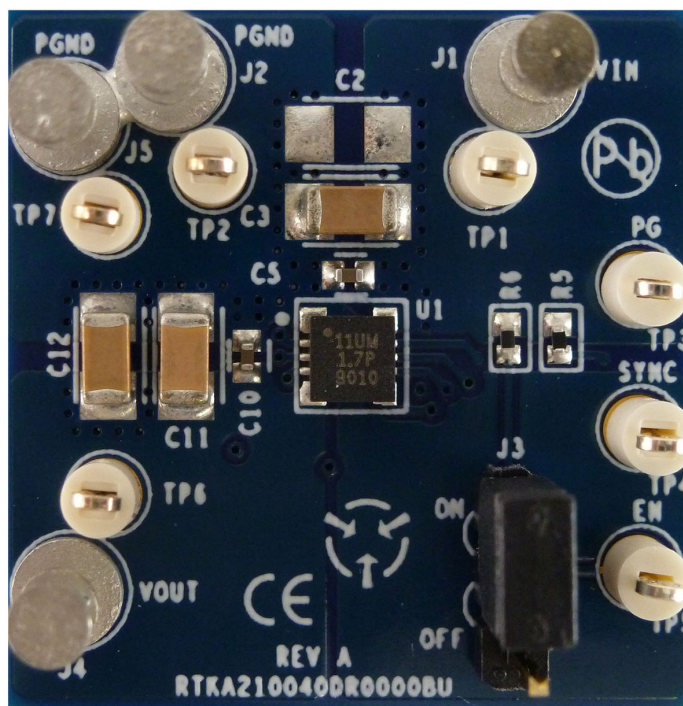


Figure 2. Top of Board

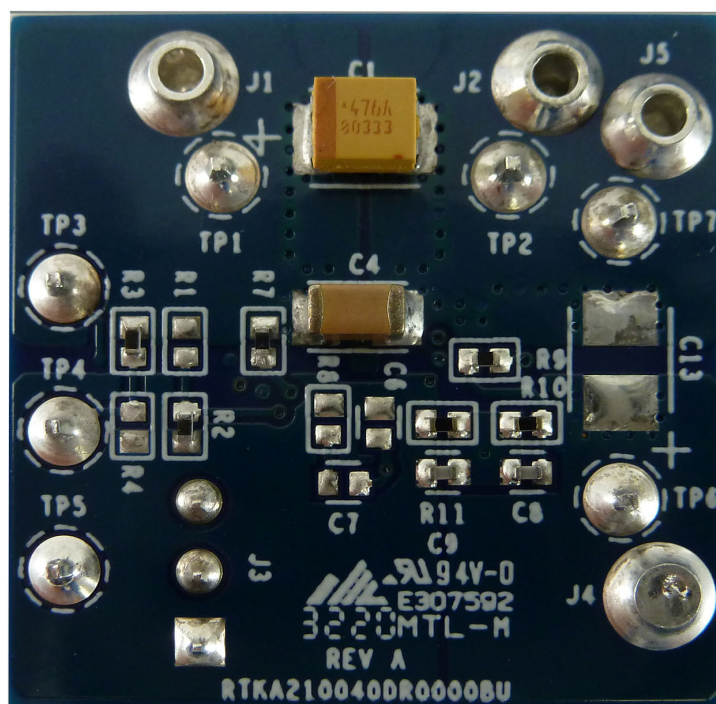


Figure 3. Bottom of Board

## 2.1 Layout Guidelines

The RTKA210040DR0000BU demonstration board is a 1x1 inch four-layer FR-4 board with 2oz. copper on all the layers. The board can be used as a single 4A reference design. See [Figure 8](#) through [Figure 13](#) for board layout information.

The RTKA210040DR0000BU board layout is optimized for compact complete power module solution size, good electrical and thermal performance. For similar performance in designs involving RAA210040, follow these layout design tips.

### 2.1.1 Layout Considerations

- Place the input ceramic capacitors as close as possible to the module input. These ceramic capacitors minimize the high frequency noise by reducing the parasitic inductance of the power loop. Proper placement of these capacitors not only leads to less PHASE node spikes and ringing, but also minimizes the switching noise coupled to the module. Renesas recommends using dielectric X7R or equivalent with a minimum total capacitance of 44 $\mu$ F at the module input. A layout example is shown in [Figure 4](#) and [Figure 5](#).
- Use large copper planes to minimize conduction loss and thermal stress for VIN, VOUT, and PGND. Use multiple vias to connect the power planes in different layers.
- Use a separate SGND plane for components that are connected to SGND. Connect SGND and PGND at a single point on the top layer as shown in [Figure 6](#).
- Use a remote-sensing trace to connect to the point-of-load and achieve tight output voltage regulation. Route the remote-sensing trace underneath the PGND layer and avoid routing it near noisy planes. Place an optional 2 $\Omega$  resistor close to the output voltage resistor divider and FB pin to damp the noise on the trace.

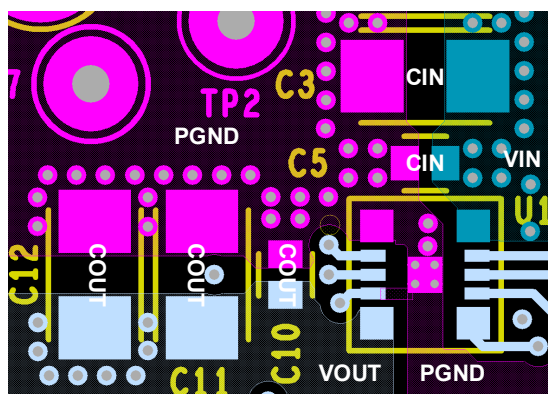


Figure 4. Layout Example - Top Layer

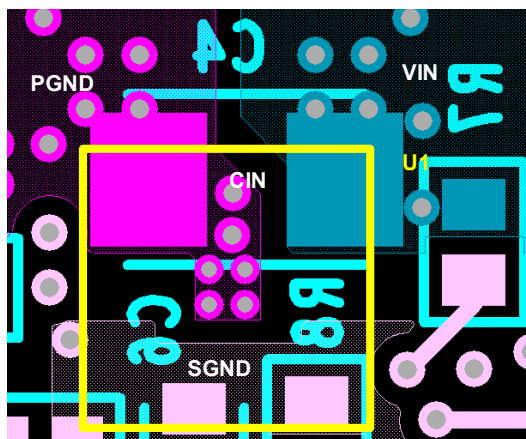


Figure 5. Layout Example - Bottom Layer



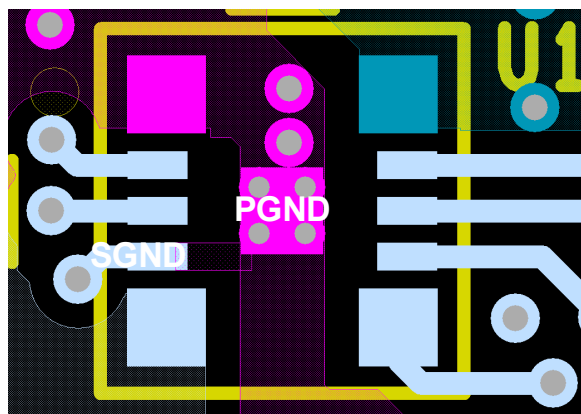


Figure 6. Layout Example - SGND is Connected to PGND at Single Point

## 2.2 Schematic Drawing

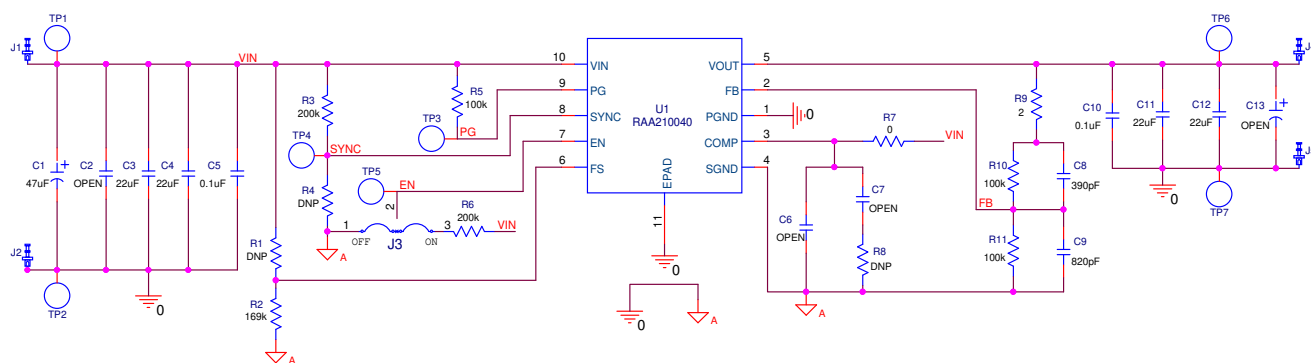


Figure 7. Schematic

## 2.3 Bill of Materials

| Qty | Reference Designators | Value       | Tol.       | Volt | PWR | Package Type | Manufacturer    | Part Number        | Description       |
|-----|-----------------------|-------------|------------|------|-----|--------------|-----------------|--------------------|-------------------|
| 1   | C1                    | 47 $\mu$ F  | $\pm 10\%$ | 10V  |     | 1411         | AVX Corporation | TPSB476K010R0250   | POSCAP            |
| 1   | C2                    | OPEN        | $\pm 10\%$ | 10V  |     | 1206         | Murata          | GRM31CR71A226KE15L | Ceramic Capacitor |
| 2   | C3, C4                | 22 $\mu$ F  | $\pm 10\%$ | 10V  |     | 1206         | Murata          | GRM31CR71A226KE15L | Ceramic Capacitor |
| 2   | C5, C10               | 0.1 $\mu$ F | $\pm 10\%$ | 50V  |     | 0402         | Murata          | GRM155R71H104KE14D | Ceramic Capacitor |
| 2   | C6, C7                | OPEN        | $\pm 10\%$ | 50V  |     | 0402         | Murata          |                    | Ceramic Capacitor |
| 1   | C8                    | 390pF       | $\pm 5\%$  | 50V  |     | 0402         | Murata          | GRM1555C1H391JA01D | Ceramic Capacitor |
| 1   | C9                    | 820pF       | $\pm 5\%$  | 50V  |     | 0402         | Murata          | GRM1555C1H821JA01D | Ceramic Capacitor |

| Qty | Reference Designators   | Value         | Tol.        | Volt | PWR   | Package Type                         | Manufacturer | Part Number        | Description                          |
|-----|-------------------------|---------------|-------------|------|-------|--------------------------------------|--------------|--------------------|--------------------------------------|
| 2   | C11, C12                | 22 $\mu$ F    | $\pm 10\%$  | 6.3V |       | 1206                                 | Murata       | GRM31CR70J226KE19L | Ceramic Capacitor                    |
| 1   | C13                     | OPEN          | $\pm 10\%$  | 6.3V |       | 1206                                 | Murata       | GRM31CR70J226KE19L | Ceramic Capacitor                    |
| 1   | R1                      | DNP           |             |      |       | 0402                                 |              |                    | Thick Film Chip Resistor             |
| 1   | R2                      | 169k $\Omega$ | $\pm 1\%$   |      | 1/16W | 0402                                 | Stackpole    | RMCF0402FT169K     | Thick Film Chip Resistor             |
| 2   | R3, R6                  | 200k $\Omega$ | $\pm 1\%$   |      | 1/16W | 0402                                 | Stackpole    | RMCF0402FT200K     | Thick Film Chip Resistor             |
| 2   | R4, R8                  | DNP           |             |      | 1/16W | 0402                                 |              |                    | Thick Film Chip Resistor             |
| 1   | R5                      | 100k $\Omega$ | $\pm 1\%$   |      | 1/10W | 0402                                 | Panasonic    | ERJ-2RKF1003X      | Miniature PC Test Point              |
| 1   | R7                      | 0 $\Omega$    |             |      | 1/16W | 0402                                 | Stackpole    | RMCF0402ZT0R00     | Thick Film Chip Resistor             |
| 1   | R9                      | 2 $\Omega$    | $\pm 1\%$   |      | 1/16W | 0402                                 | Vishay Dale  | CRCW04022R00FNED   | Thick Film Chip Resistor             |
| 2   | R10, R11                | 100k $\Omega$ | $\pm 0.5\%$ |      | 1/16W | 0402                                 | Vishay Dale  | CRCW0402100KDHPD   | Thick Film Chip Resistor             |
| 4   | J1, J2, J3, J4          |               |             |      |       | Through Hole                         | Keystone     | 1514-2             | Terminal Turret Connector Single End |
| 1   | J3                      |               |             |      |       | Through Hole                         | Metz Connect | PR20203VBNN        | Connector Header                     |
| 5   | TP1, TP2, TP3, TP4, TP5 |               |             |      |       | CONN-MINI TEST POINT                 | Keystone     | 5002               | Miniature PC Test Point              |
| 1   | U1                      |               |             |      |       | 10Ld 3x3 Dual Flat Embedded Laminate | Renesas      | RAA210040          | Power Module                         |



## 2.4 PCB Layout

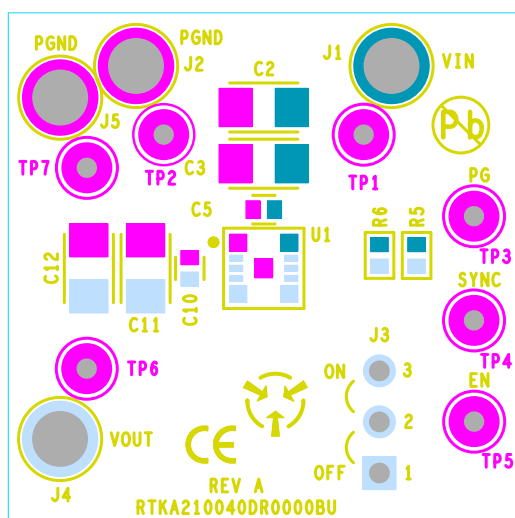


Figure 8. Silkscreen Top

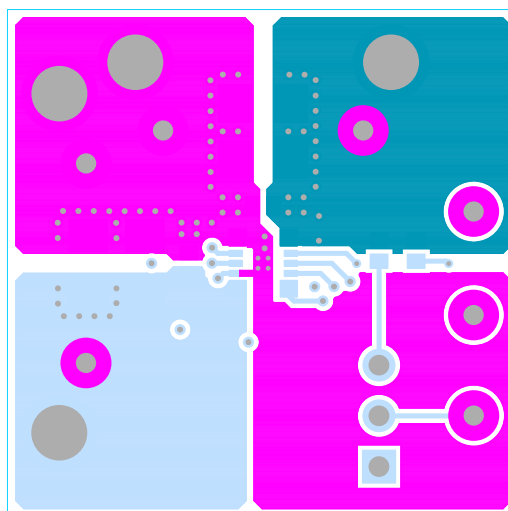


Figure 9. Top Layer

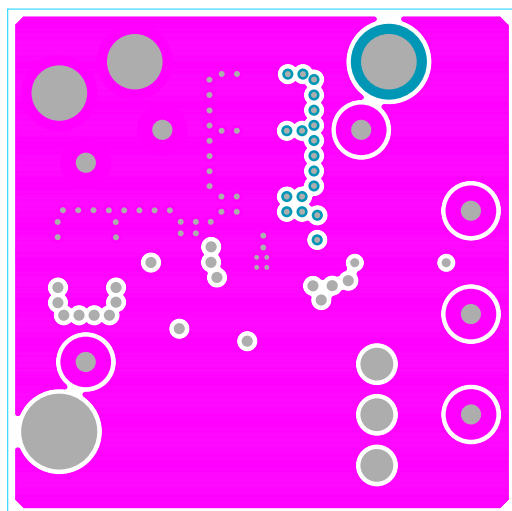


Figure 10. Layer 2

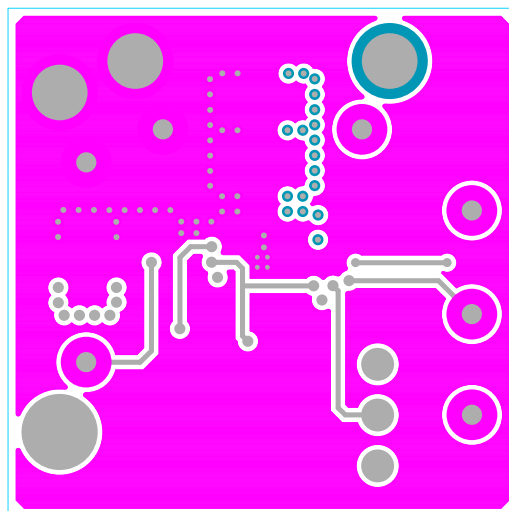


Figure 11. Layer 3

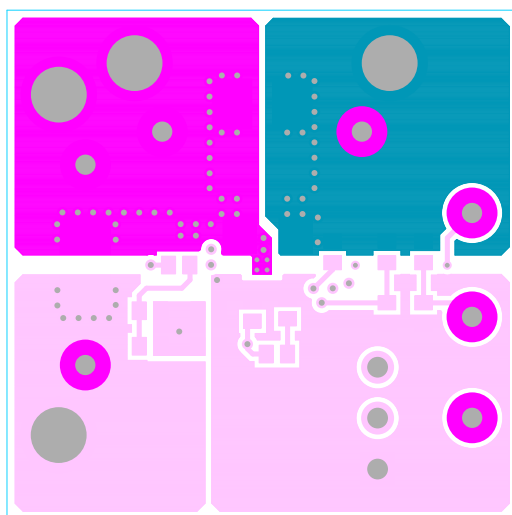


Figure 12. Layer 4

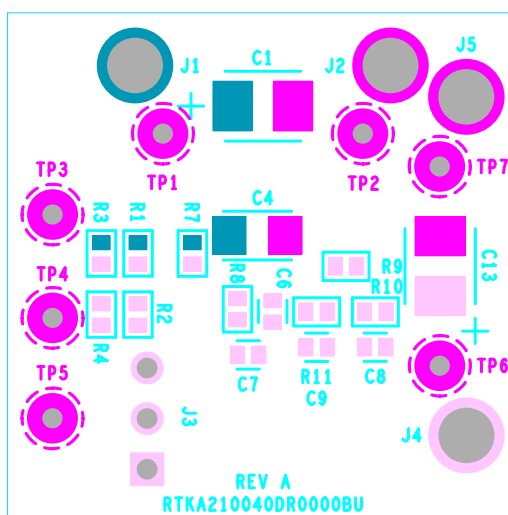


Figure 13. Silkscreen Bottom

### 3. Typical Performance Graphs

The following data was acquired using the RTKA210040DR0000BU demonstration board at +25°C ambient and free air 0LFM. Operating condition:  $V_{OUT} = 1.2V$ ,  $f_{SW} = 1.2MHz$ , unless otherwise noted. See the [Table 1](#) for recommended configurations for different output voltages.

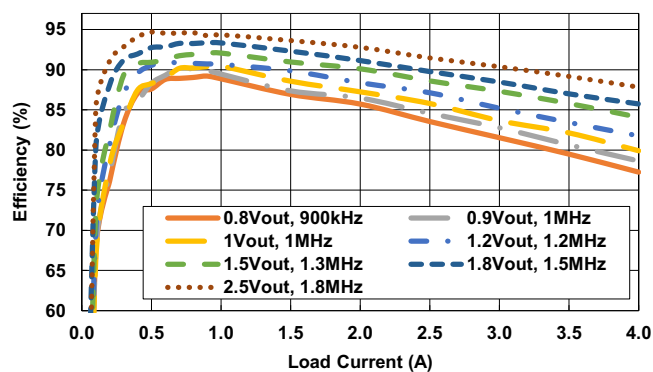


Figure 14. Efficiency vs Load Current at  $V_{IN} = 3.3V$

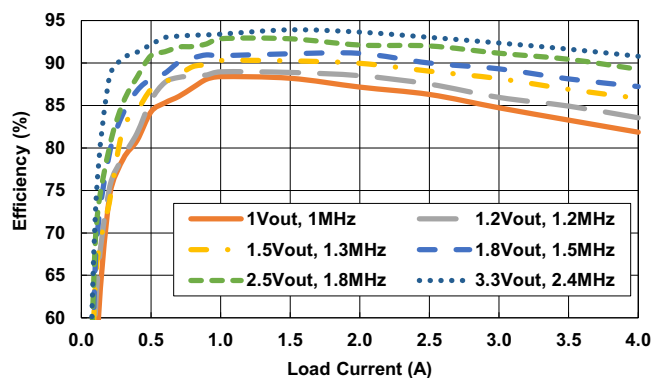


Figure 15. Efficiency vs Load Current at  $V_{IN} = 5V$

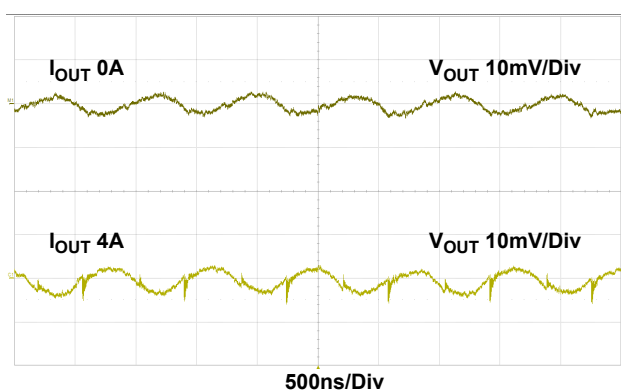


Figure 16. Output Ripple,  $V_{IN} = 3.3V$ ,  $V_{OUT} = 1.2V$ ,  $f_{SW} = 1.2MHz$ ,  $C_{OUT} = 2x22\mu F$  Ceramic

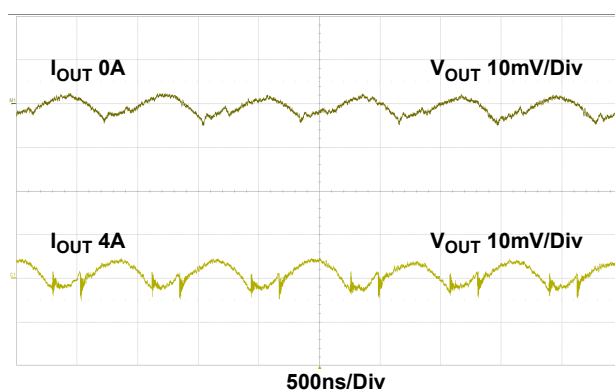


Figure 17. Output Ripple,  $V_{IN} = 5V$ ,  $V_{OUT} = 1.2V$ ,  $f_{SW} = 1.2MHz$ ,  $C_{OUT} = 2x22\mu F$  Ceramic

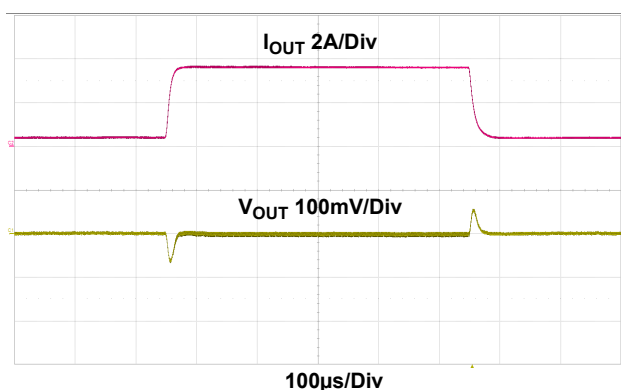


Figure 18. Transient Response,  $V_{IN} = 3.3V$ ,  $V_{OUT} = 1.2V$ ,  $f_{SW} = 1.2MHz$ , 0.4A to 3.6A,  $C_{OUT} = 2x22\mu F$  Ceramic

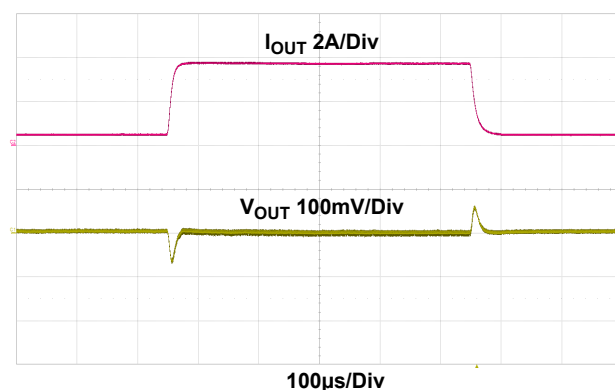


Figure 19. Transient Response,  $V_{IN} = 5V$ ,  $V_{OUT} = 1.2V$ ,  $f_{SW} = 1.2MHz$ , 0.4A to 3.6A,  $C_{OUT} = 2x22\mu F$  Ceramic

Operating condition:  $V_{OUT} = 1.2V$ ,  $f_{SW} = 1.2MHz$ , unless otherwise noted.

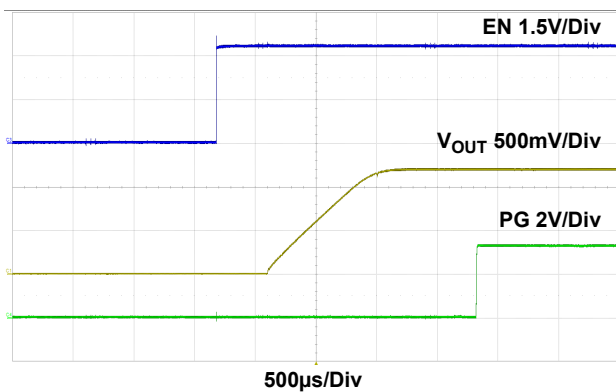


Figure 20. Start-Up Waveform,  $V_{IN} = 3.3V$ ,  $V_{OUT} = 1.2V$ ,  $f_{SW} = 1.2MHz$ ,  $I_{OUT} = 0A$ ,  $C_{OUT} = 2 \times 22\mu F$  Ceramic

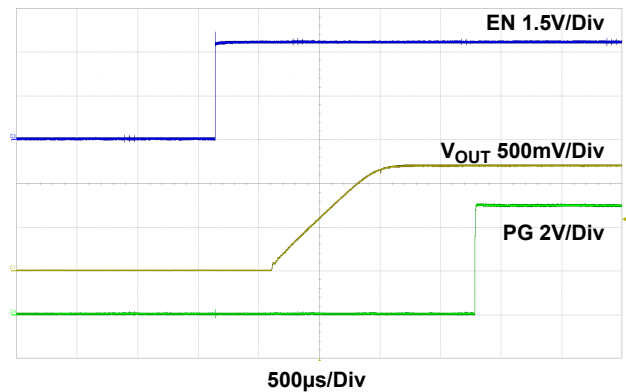


Figure 21. Start-Up Waveform,  $V_{IN} = 5V$ ,  $V_{OUT} = 1.2V$ ,  $f_{SW} = 1.2MHz$ ,  $I_{OUT} = 0A$ ,  $C_{OUT} = 2 \times 22\mu F$  Ceramic

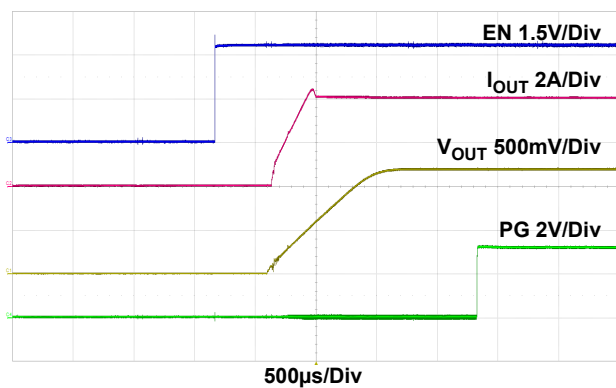


Figure 22. Start-Up Waveform,  $V_{IN} = 3.3V$ ,  $V_{OUT} = 1.2V$ ,  $f_{SW} = 1.2MHz$ ,  $I_{OUT} = 2A$ ,  $C_{OUT} = 2 \times 22\mu F$  Ceramic

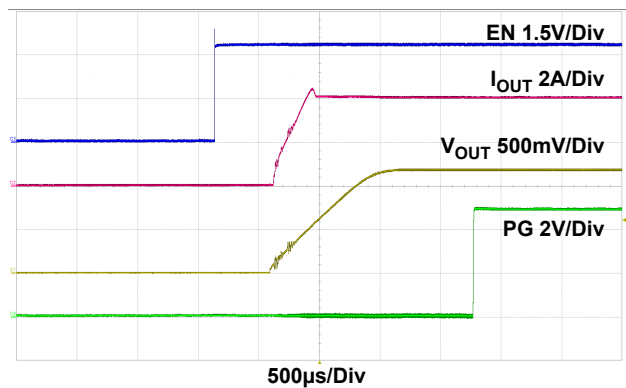


Figure 23. Start-Up Waveform,  $V_{IN} = 5V$ ,  $V_{OUT} = 1.2V$ ,  $f_{SW} = 1.2MHz$ ,  $I_{OUT} = 2A$ ,  $C_{OUT} = 2 \times 22\mu F$  Ceramic

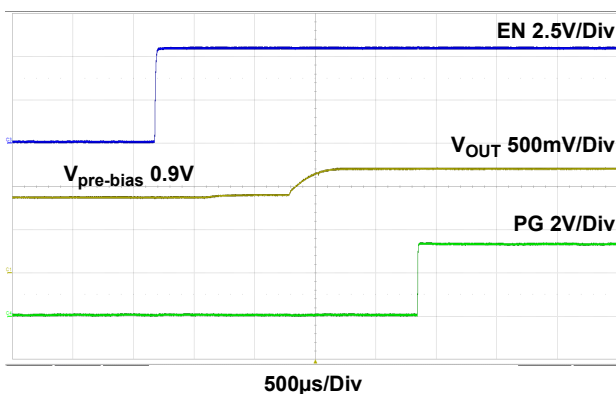


Figure 24. Pre-biased Power-Up Waveform, Pre-biased Voltage = 0.9V,  $V_{IN} = 3.3V$ ,  $V_{OUT} = 1.2V$ ,  $f_{SW} = 1.2MHz$ ,  $I_{OUT} = \text{No Load}$ ,  $C_{OUT} = 2 \times 22\mu F$  Ceramic

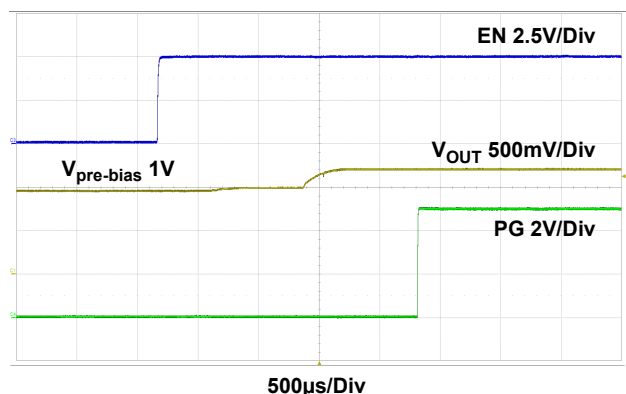
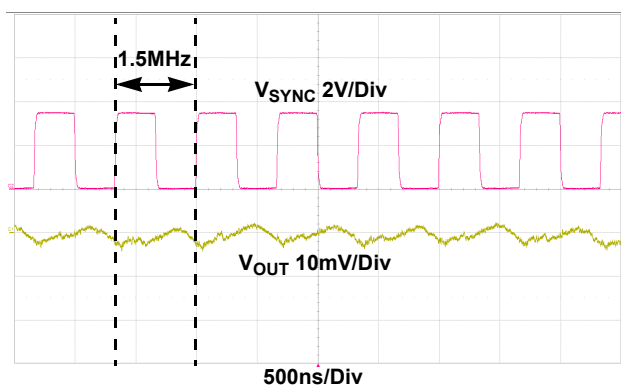
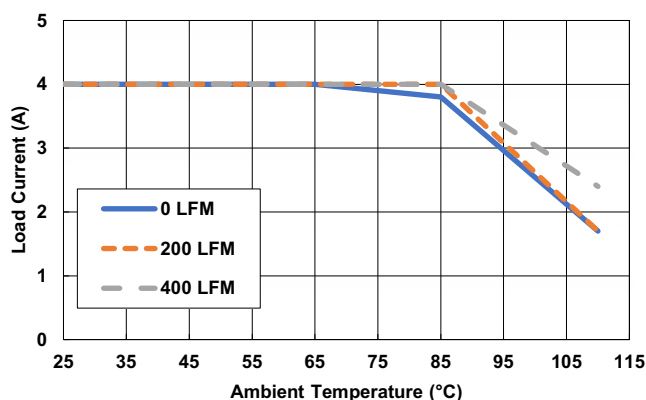


Figure 25. Pre-biased Power-Up Waveform, Pre-biased Voltage = 1V,  $V_{IN} = 5V$ ,  $V_{OUT} = 1.2V$ ,  $f_{SW} = 1.2MHz$ ,  $I_{OUT} = \text{No Load}$ ,  $C_{OUT} = 2 \times 22\mu F$  Ceramic

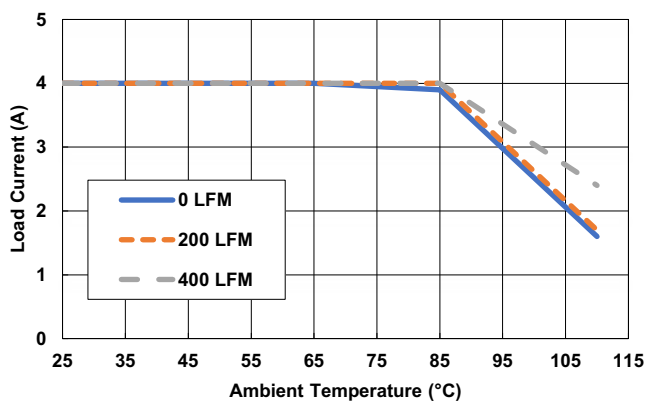
Operating condition:  $V_{OUT} = 1.2V$ ,  $f_{SW} = 1.2MHz$ , unless otherwise noted.



**Figure 26. External Frequency Synchronization Waveform,  $V_{IN} = 3.3V$ ,  $V_{OUT} = 1.2V$ ,  $f_{SYNC} = 1.5MHz$ ,  $I_{OUT} = 0A$ ,  $C_{OUT} = 2x22\mu F$  Ceramic**



**Figure 27. Derating Curve,  $V_{IN} = 3.3V$ ,  $V_{OUT} = 1.2V$ ,  $C_{OUT} = 2x22\mu F$  Ceramic**



**Figure 28. Derating Curve,  $V_{IN} = 5V$ ,  $V_{OUT} = 1.2V$ ,  $C_{OUT} = 2x22\mu F$  Ceramic**

## 4. Ordering Information

| Part Number        | Description                                       |
|--------------------|---------------------------------------------------|
| RTKA210040DR0000BU | RAA210040 5V, 4A power module demonstration board |

## 5. Revision History

| Rev. | Date         | Description                                                                                                   |
|------|--------------|---------------------------------------------------------------------------------------------------------------|
| 1.1  | Apr 14, 2021 | Updated file number to correct numbering: R16UH0009EU0101.<br>Updated Quick Test Guide section Steps 5 and 6. |
| 1.0  | Apr 4, 2021  | Initial release                                                                                               |

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