# RTKA223021DE0010BU

The RAA223021 evaluation board (RTKA223021DE0010BU) is a high voltage flyback converter that is designed to demonstrate a low-cost high performance isolated AC/DC conversion from a universal input of $85V_{AC}$ to $265V_{AC}$, to a 12V output with the output current up to 1A.

The board has a built-in overcurrent, short-circuit, input brownout and over-temperature protections, and is designed on a double side Printed Circuit Board (PCB) with a full-wave input rectification. It is pre-compliant with the conducted EMI requirements by EN55022/CISPR 22. The RTKA223021DE0010BU uses the RAA223021 SOIC-7 packaged IC.

## Features

- Universal input
- EMI compliance for EN55022/CISPR22
- Standby power less than 50mW
- No audible noise

## Specifications

This board is optimized for the following operating conditions:

- Input voltage: $85V_{AC}$ ~ $265V_{AC}$
- Output voltage: $12V_{DC}$
- Output current: 1A maximum
- Output power: 12W
- Efficiency: >78% at 100% load; 80% at 50% load
- No-load power: 50mW
- Load regulation: ±0.1%
- Operating temperature: -40°C~85°C
- Board dimension: 70mm x 75mm

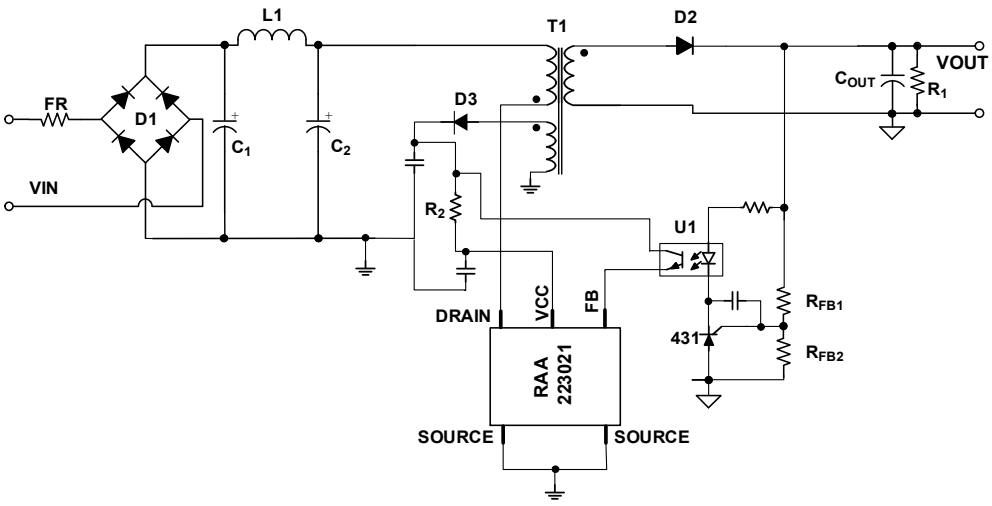


**Figure 1. RTKA223021DE0010BU Block Diagram**


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# Contents

# 1. Functional Description

The RTKA223021DE0010BU is a flyback regulator implemented with constant off control. D1 is a full bridge rectifier on the input end. FR is 1A fuse providing input overcurrent protection. As an option, you can replace the standard fuse with a fusible resistor instead to limit inrush current.

C1, L1, and C2 consist of the input filter that provides the energy buffer after rectification and reduces the conducted EMI noises to the input. RAA223021, T1, and D2 configures the flyback converter. RFB1, RFB2, 431, and U1 provide the output feedback signal to the IC. D3 and R2 provide $V_{CC}$ biasing current after startup, to increase the efficiency. They can be optional for low-cost low power applications.

## 1.1 Recommended Equipment and Operating Range

- AC power supply capable of generating AC voltage from $85V_{AC}$ to $265V_{AC}$ at 60Hz/50Hz, with at least 100mA output current capability.
- Load resistor box with adjustable value of 12Ω and up, or an electronics load that can emulate a resistor load or current load up to 1A.
- Multimeters to measure the output voltage and current.
- Power meter to measure the AC input power.

## 1.2 Quick Test Guide

1. Program the AC power supply with a voltage between $85V_{AC}$ and $265V_{AC}$ at the corresponding frequency of 60Hz or 50Hz.
2. While the AC power supply is off, connect the output cables of the AC power supply to the VIN+ and VIN- terminals of the RTKA223021DE0010BU. An optional power meter can be added in between the AC power supply output and the input of the board.
3. Connect the load to the output terminals VOUT and GND.
4. Connect a voltage meter to VOUT and GND and connect a current meter between the board output and the load.
5. Turn on the AC power supply.

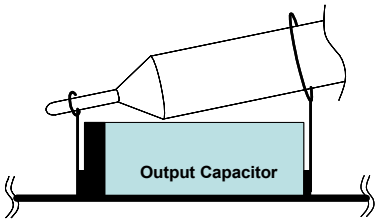



**Figure 2. Proper Probe Setup to Measure Output Ripple**

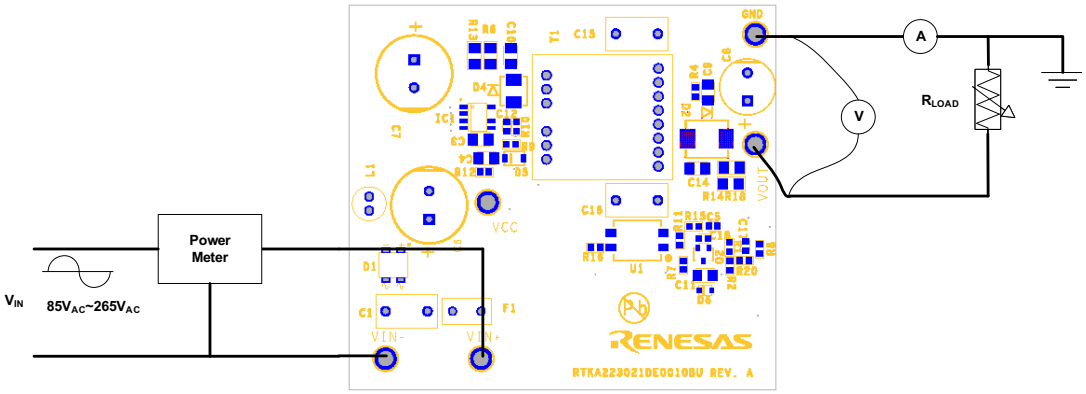



**Figure 3. Proper Test Setup**

# 2. Board Design

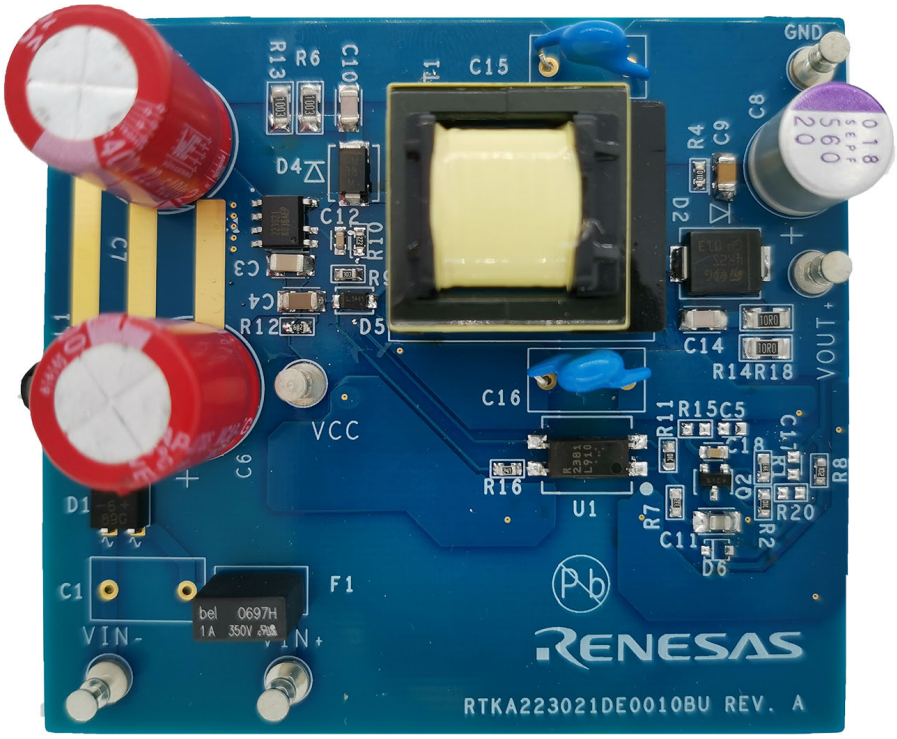



**Figure 4. RTKA223021DE0010BU Board, Top View**

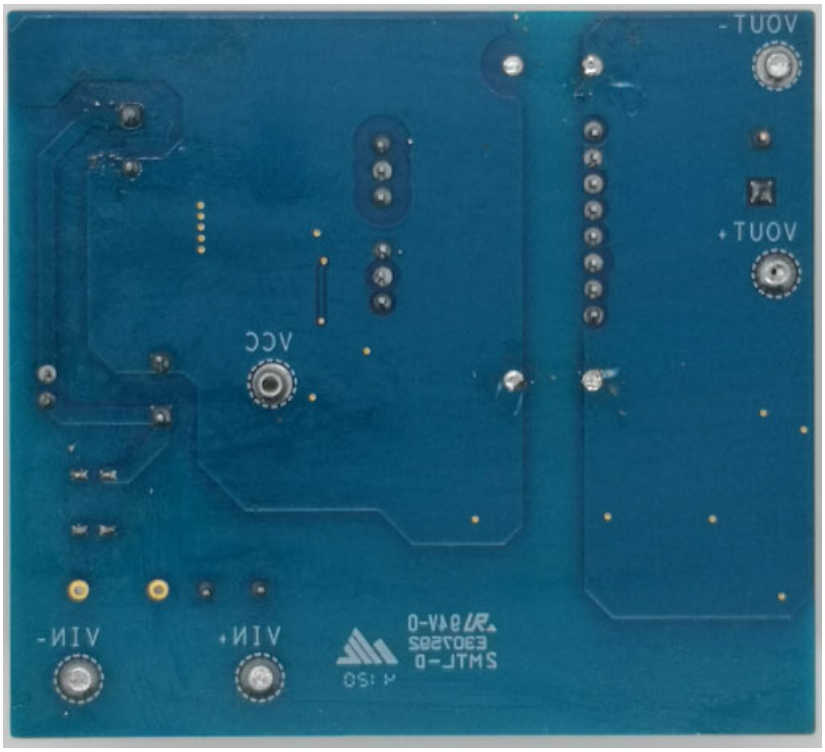



**Figure 5. RTKA223021DE0010BU Board, Bottom View**

## 2.1 PCB Layout Guidelines

Proper layout is important to ensure a stable operation, good thermal behavior, EMI performance, and reliable operation for various operating environments. **Note:** Pay attention to the following layout recommendations.

- Leave proper spacing (minimum 2mm) between the high voltage traces (maximum 400V) and the low voltage traces and between the primary and secondary circuit.
- Keep a small loop from the input filter capacitor to IC and transformer.
- Keep a small loop consisted of a switching transformer, output capacitor, and freewheeling diode.
- Keep a small loop consisted of an input filter capacitor to IC and snubber circuit.
- Keep a sufficient copper area on the IC source pins for better thermal performance.
- Keep the switching node away from the input EMI inductor to avoid noise coupling, especially when an unshielded inductor is used.
- Place the $V_{CC}$ decoupling capacitor and the FB pin decoupling capacitor close to the pins.

## 2.2 Schematic Drawings

### 2.2.1 RTKA223021DE0010BU Circuit

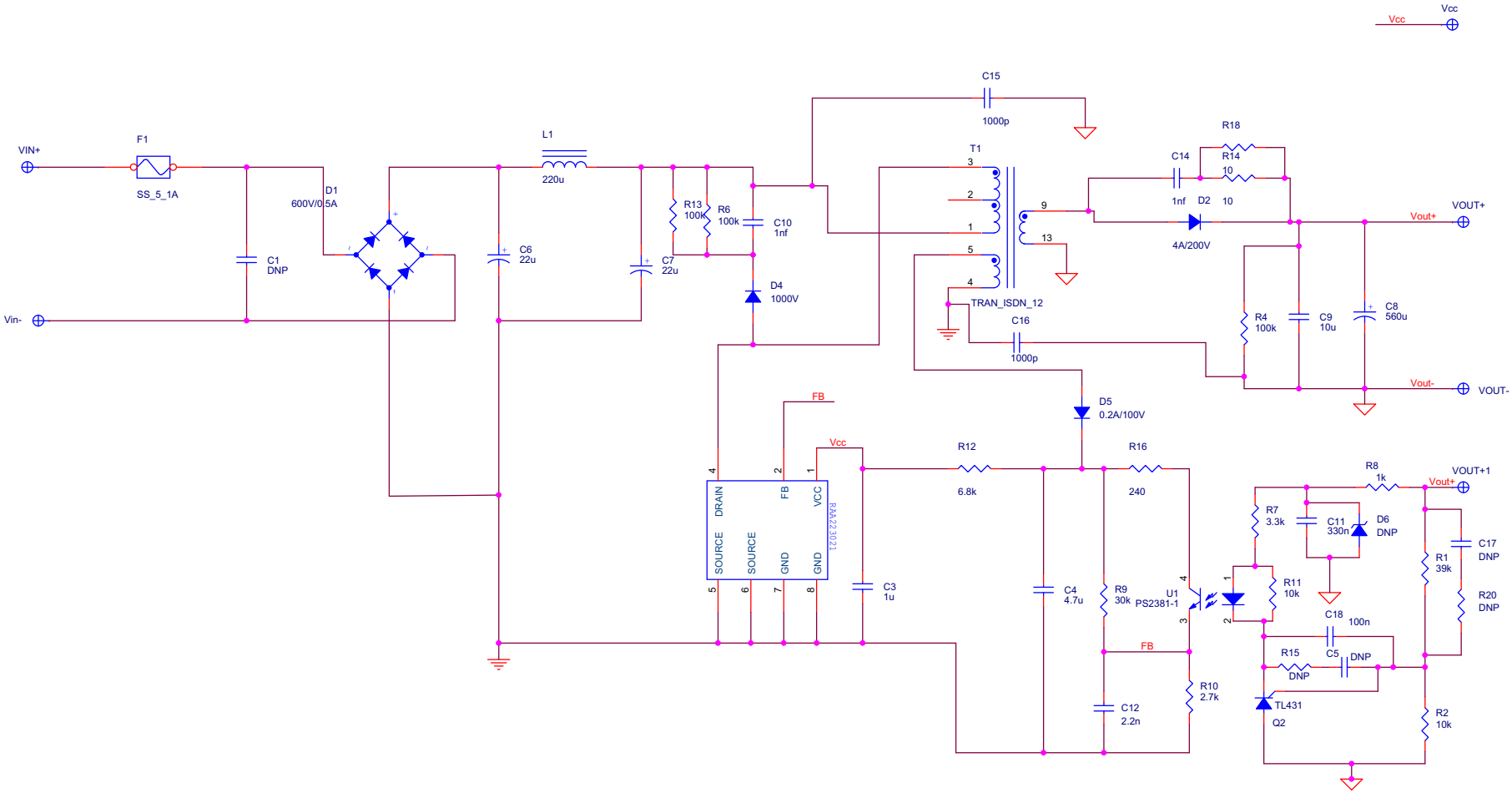



**Figure 6. Schematic**

## 2.2.2 Transformer Information

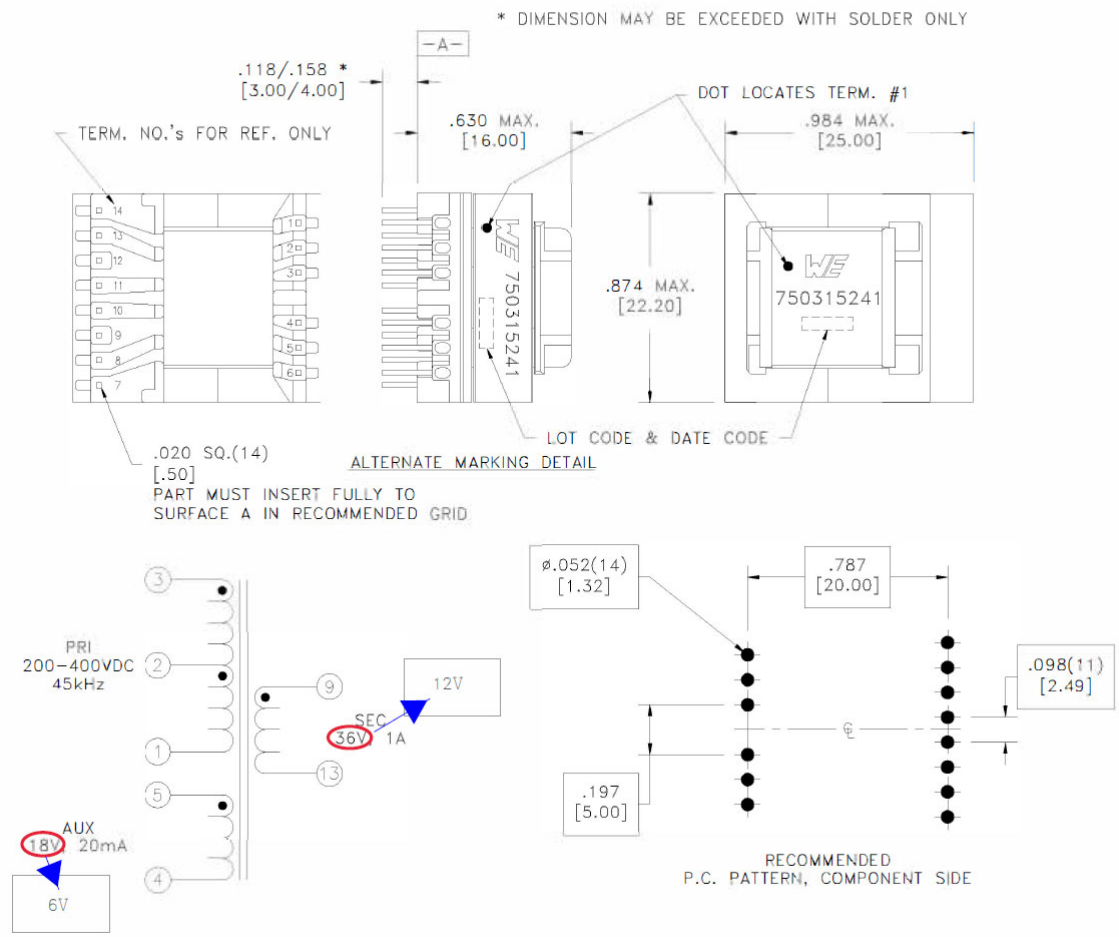



**Figure 7. Transformer Schematic**

Electrical Specifications at 25°C unless otherwise noted

| Parameter | | Test Conditions | Value |
|---|---|---|---|
| D.C. Resistance | 3-1 | at 20°C | 2.10Ω ±10% |
| D.C. Resistance | 5-4 | at 20°C | 0.600Ω ±10% |
| D.C. Resistance | 9-13 | at 20°C | 0.125Ω ±10% |
| Inductance | 3-1 | 10kHz, 100mVAC, Ls | 1.10mH ±1 0% |
| Saturation Current | 3-1 | 20% roll off from initial | 1.3A |
| Leakage Inductance | 3-1 | tie(4 +5, 9 +13), 100kHz, 100mVAC, Ls | 21.0µH typical, 35.0µH maximum |
| Dielectric | 1-13 | tie(3+4), 3750VAC, 1s | 3000VAC, 1min |
| Dielectric | 1-5 | 625VAC, 1s | - |
| Turns Ratio | | (3 - 2):(2 - 1) | 1:1, ±1% |
| Turns Ratio | | (3-1):(5-4) | 8:1, ±1% |
| Turns Ratio | | (3-1):(9-13) | 4:1, ±1% |

## 2.3 Bill of Materials

| Qty | Reference Designator | Description | Manufacturer | Manufacturer Part |
|---|---|---|---|---|
| 1 | C3 | CAP CER 1µF 25V X7R 1206 | TDK | CGJ5L2X7R1E105K160AA |
| 1 | C4 | CAP CER 4.7µF 25V X7R 1206 | TDK | C3216X7R1E475K160AC |
| 2 | C6, C7 | Aluminum Electrolytic Capacitors - Radial Leaded WCAP-AT1H 22µF 400V 20% Radia | WE | 860241378003 |
| 1 | C8 | Aluminum Organic Polymer Capacitors 20V 560µF ESR 12mΩ | Panasonic | 20SEPF560M |
| 1 | C9 | CAP CER 10µF 25V X7R 1206 | TDK | C3216X7R1E106K160AB |
| 2 | C10, C14 | CAP CER 1000PF 630V X7R 1206 | TDK | C3216X7R2J102K115AE |
| 1 | C11 | CAP CER 0.33µF 25V X7R 1206 | TDK | C3216X7R1E334M |
| 1 | C12 | CAP CER 2200PF 50V X7R 0603 | TDK | CGA3E2X7R1H222K080AA |
| 2 | C15, C16 | CAP 7mm X1/Y1 1000pF E 20% | TDK | CD45-E2GA102M-VKA |
| 1 | C18 | SMD/SMT CGA 0603 50V 0.1µF X7R 10% | TDK | CGA3E2X7R1H104K080AA |
| 1 | D1 | Bridge Rectifiers 600V, 0.5A, 35A IFSM | Vishay | MB6M |
| 1 | D2 | Rectifiers Ultrafast Recovery 4A 200V 16ns Planar Pt | ST | STTH4R02S |
| 1 | D4 | Rectifiers 1000Vr 700Vrms 1000V 17pF | MCC | UF1M-TP |
| 1 | D5 | DIODE SCHOTTKY 100V 1A SOD123FL | ON Semiconductor | MBR1H100SFT3G |
| 1 | F1 | Fuses with Leads (Through Hole) 1A 250V SS-5H RADIAL TD FUSE | Eaton | SS_5_1A |
| 1 | IC1 | 700V, 8W AC/DC Buck Regulator | Renesas Electronics | RAA223021 |
| 1 | L1 | Fixed Inductors WE-TI RadXtnd Ld5075 WW220 230H 0.50A 0.96Ω | WE | 7447462221 |
| 1 | Q2 | Linear Voltage Regulators 37V 0.30W 36Vref 100mA 17mV 0.5µA | MCC | TL431K-TP |
| 1 | R1 | RES 39kΩ 1% 1/10W 0603 | Yageo | RT0603FRD0739KL |
| 2 | R2, R11 | RES 10kΩ 1% 1/10W 0603 | Yageo | RC0603FR-0710KL |
| 1 | R4 | RES 100kΩ 1% 1/10W 0603 | Yageo | RC0603FR-07100KL |
| 2 | R6, R13 | RES 100kΩ 1% 1/4W 1206 | Yageo | AT1206BRD07100KL |
| 1 | R7 | RES 3.3kΩ 1% 1/10W 0603 | Yageo | RC0603FR-0733KL |
| 1 | R8 | RES 1kΩ 1% 1/10W 0603 | Yageo | RC0603FR-071KL |
| 1 | R9 | RES 30kΩ 1% 1/10W 0603 | Yageo | RC0603FR-0730KL |
| 1 | R10 | RES 2.7kΩ 1% 1/10W 0603 | Yageo | RC0603FR-132K7L |
| 1 | R12 | RES 6.8kΩ 1% 1/10W 0603 | Yageo | RT0603FRD076K8L |
| 2 | R14, R18 | Thick Film Resistors - SMD 10Ω 1% 200V General Purpose | Yageo | RC1206FR-1010RL |

| Qty | Reference Designator | Description | Manufacturer | Manufacturer Part |
|---|---|---|---|---|
| 1 | R16 | Thick Film Resistors - SMD 240Ω 1% 200V General Purpose | Yageo | RC0603FR-13240RL |
| 1 | T1 | MID-OLTI Offline Flyback Transformers | WE | 750315241 |
| 1 | U1 | Transistor Output Optocouplers BV = 5000Vr.m.s. -40C + 115C | Renesas Electronics | PS2381-1Y-F3-AX |
| 6 | VOUT+1, Vin-, VCC, VOUT-, VOUT+, VIN+ | CONN-DBL TURRET, TH, 0.109LENGTH, BRASS/TIN, ROHS | Keystone Electronics | 1514-2 |

## 2.4 Board Layout

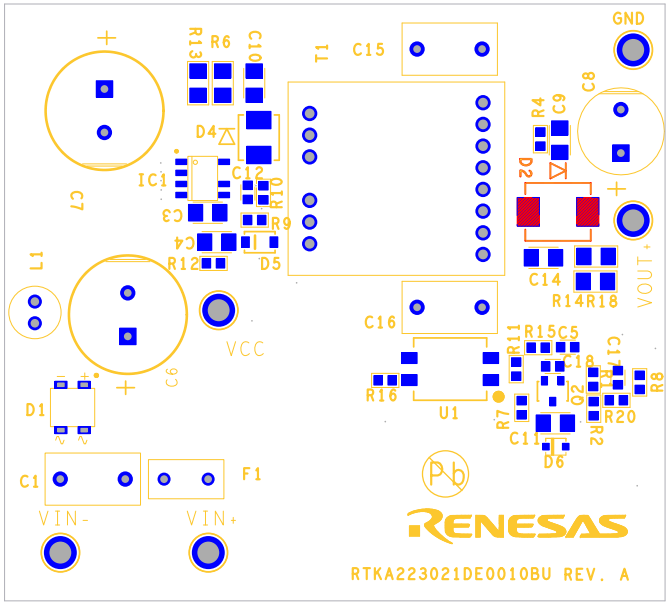



**Figure 8. Top Layer**

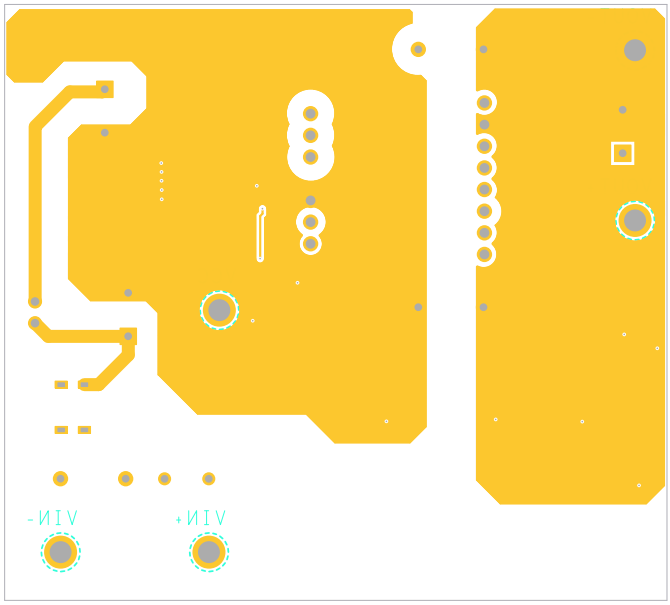



**Figure 9. Bottom Layer**

# 3. Typical Performance Graphs

$V_{IN}$ = 220$V_{AC}$, unless otherwise noted.

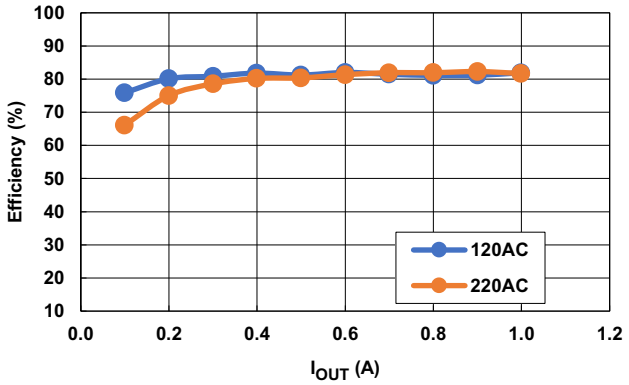



Figure 10. Flyback Efficiency

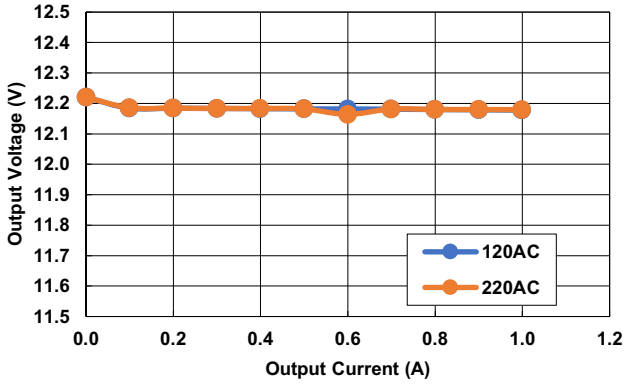



Figure 11. Output Regulation

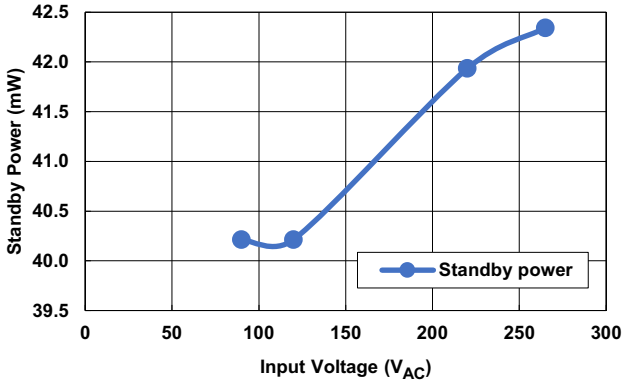



Figure 12. No Load Power Loss

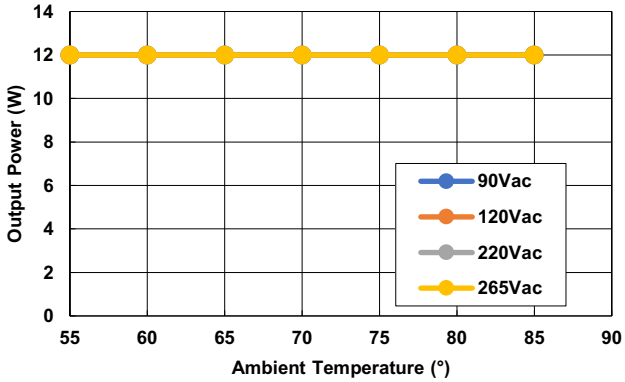



Figure 13. Power Derating

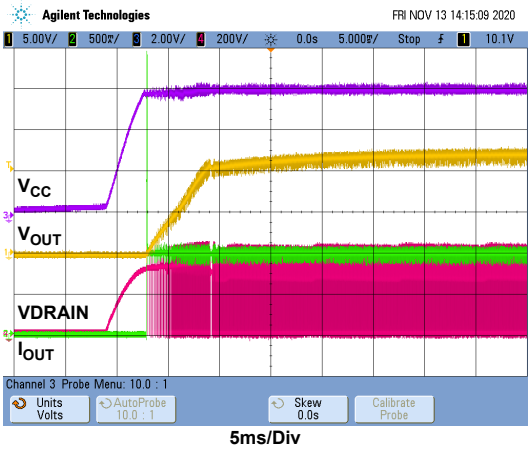



Figure 14. Soft-Start, $I_{OUT}$ = 1A

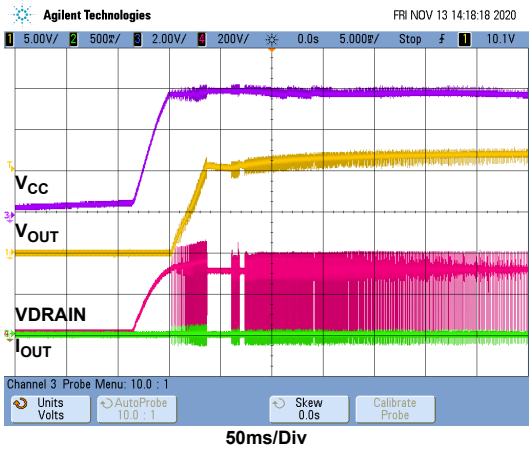
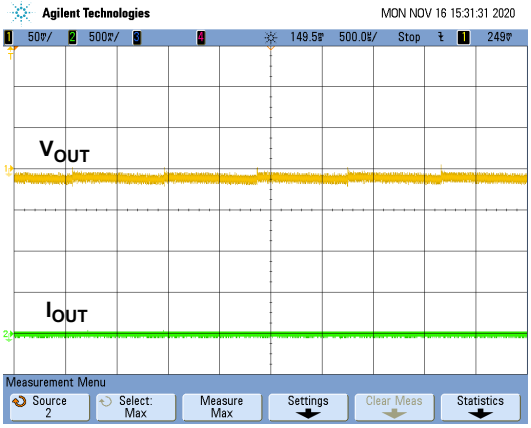


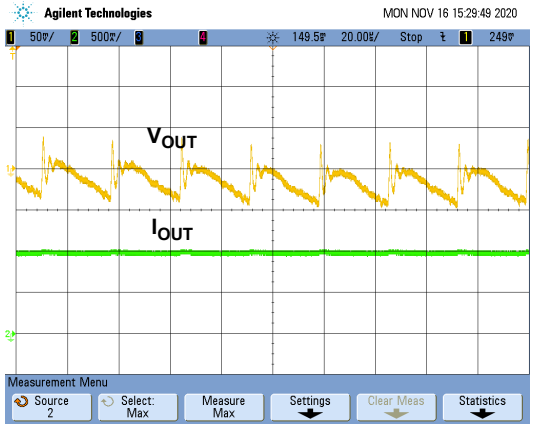

Figure 15. Soft-Start, $I_{OUT}$ = 0A

$V_{IN}$ = 220$V_{AC}$, unless otherwise noted. **(Continued)**



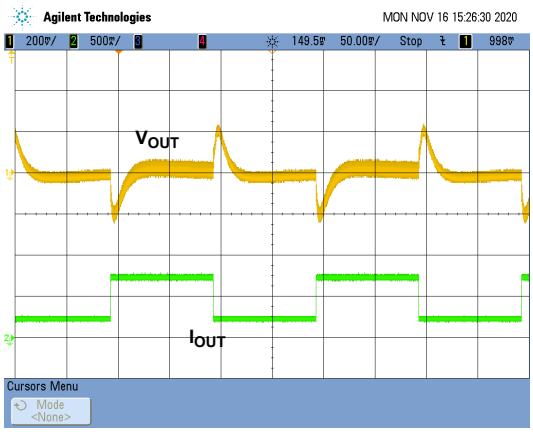

500µs/Div

**Figure 16. Output Ripple at 0A Load**



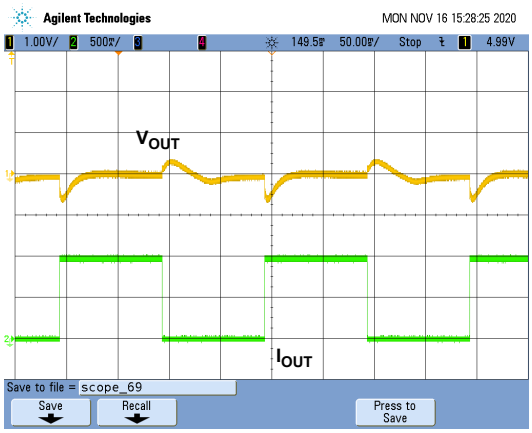

20µs/Div

**Figure 17. Output Ripple at 1A Load**



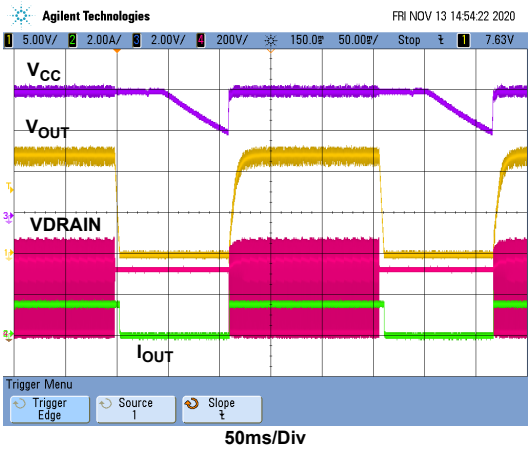

50ms/Div

**Figure 18. Dynamic Load (25% ~ 75%)**



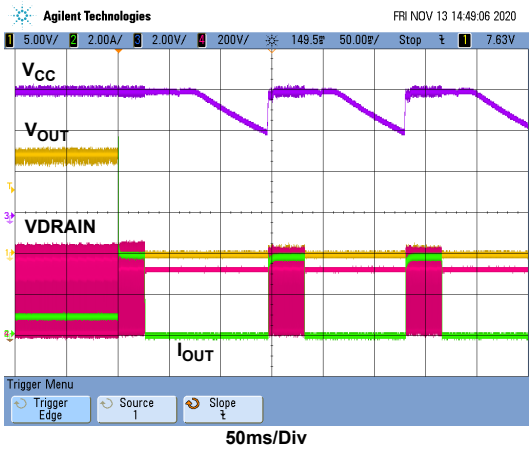

50ms/Div

**Figure 19. Dynamic Load (0% ~ 100%)**




50ms/Div

**Figure 20. OLP**




50ms/Div

**Figure 21. $I_{OUT}$ = 0.667A to Short**

# 4. EMI Test Results

Conducted EMI compliance for EN55022/CISPR22 (12V/600mA output)

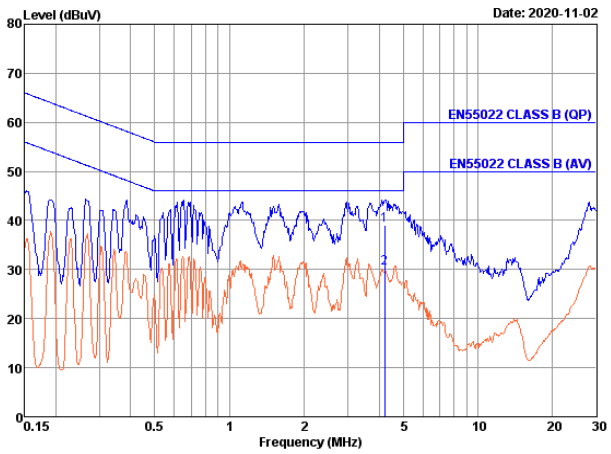



Figure 22. Line, 230$V_{AC}$

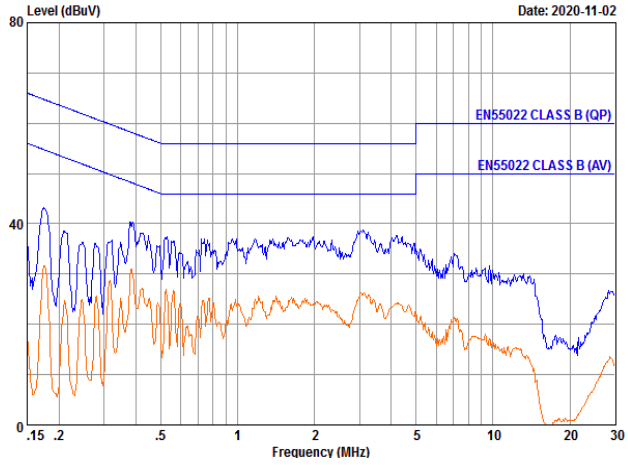



Figure 23. Line, 120$V_{AC}$

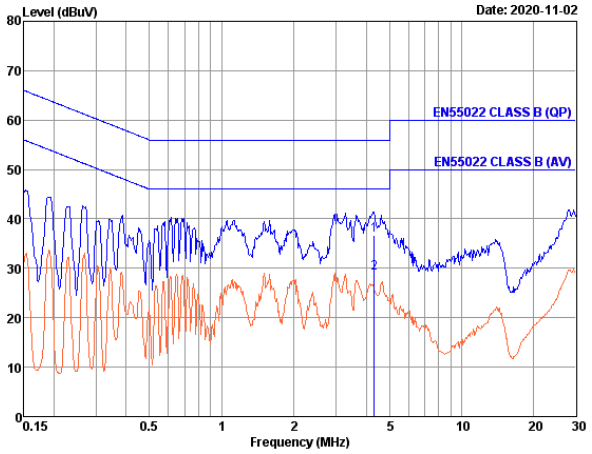



Figure 24. Neutral, 230$V_{AC}$

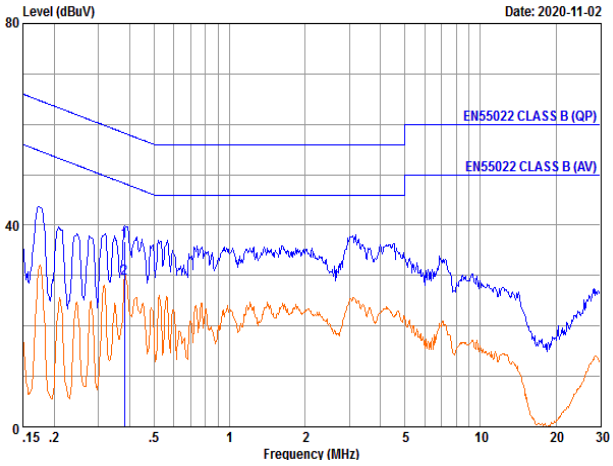



Figure 25. Neutral, 120$V_{AC}$

# 5. Ordering Information

| Part Number | Description |
|---|---|
| RTKA223021DE0010BU | High voltage flyback converter evaluation board |

# 6. Revision History

| Rev. | Date | Description |
|---|---|---|
| 1.1 | Mar 26, 2021 | Applied new template.<br>Updated Figure 1 and made text updates throughout. |
| 1.0 | Dec 11, 2020 | Initial release |

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