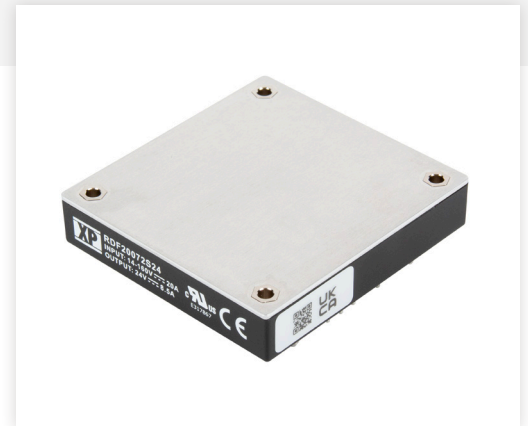


## 200W BASEPLATE COOLED

DC-DC CONVERTER

The RDF200 Series is a range of low profile, baseplate cooled DC-DC brick converters that delivers 200W and offers single output voltages ranging from 12V to 48VDC. The RDF200 series offers an ultra-wide 12:1 input range of 14 to 160VDC, which covers standard industrial voltages and meets all requirements of the EN50155 transportation standard. Baseplate cooling enables effective thermal management which ensures elevated levels of reliability.

With world-wide industrial safety approvals and compliance to transportation standards, high efficiency, high reliability, 3kVAC reinforced isolation, remote On/Off and wide output trimming, the RDF200 series benefits system designers with easy integration into a wide range of applications including; renewable energy, battery systems, autonomous equipment, factory automation and harsh environment railway applications.



### Features

- Single voltage outputs from 12V to 48VDC
- Wide output voltage trim and remote sense
- 12:1 ultra-wide input range 14 to 160VDC
- Industry standard half brick format
- High efficiency, up to 90%
- 3kVAC reinforced input to output isolation
- ITE safety approvals and EN50155 compliance
- Remote On/Off with low 15mA stand-by current
- -40°C to +100°C operating temperature
- Overvoltage, overload, and short circuit protection

### Models & Ratings

| Model Number | Input Voltage        | Output Voltage | Output Current | Input Current                  |           | Ripple & Noise <sup>(1)</sup> | Maximum Capacitive Load | Efficiency <sup>(2)</sup> |
|--------------|----------------------|----------------|----------------|--------------------------------|-----------|-------------------------------|-------------------------|---------------------------|
|              |                      |                |                | No Load                        | Full Load |                               |                         |                           |
| RDF20072S12  | 72VDC<br>(14-160VDC) | 12V            | 16.7A          | 50mA<br>(15mA in inhibit mode) | 3.2A      | 200mV                         | 16700µF                 | 90%                       |
| RDF20072S15  |                      | 15V            | 13.5A          |                                |           | 200mV                         | 13500µF                 | 89%                       |
| RDF20072S24  |                      | 24V            | 8.4A           |                                |           | 240mV                         | 8000µF                  | 88%                       |
| RDF20072S48  |                      | 48V            | 4.2A           |                                |           | 240mV                         | 2200µF                  | 89%                       |

#### Notes:

1. Measured at 20MHz bandwidth and 10µF electrolytic capacitor at 72VDC input and full load.
2. Measured at nominal 72VDC input.
3. Optional M3 x 0.5 threaded baseplate fixing add suffix -T.
4. Recommended input capacitance of 100µF required to reduce input ripple voltage at -40°C operation. See application notes.
5. Add suffix -N for negative logic control.

### Applications



### Dimensions

2.40" x 2.28" x 0.50" (61.0 x 57.9 x 12.7 mm)

## Input

| Characteristic                 | Minimum               | Typical   | Maximum | Units            | Notes & Conditions             |
|--------------------------------|-----------------------|-----------|---------|------------------|--------------------------------|
| Input Voltage Range            | 14                    |           | 160     | VDC              | 24/48/72/110VDC nominal inputs |
| Input Surge                    |                       |           | 180     | VDC              | For 100ms                      |
| Undervoltage Lockout           |                       | On: >13V  |         | VDC              | On                             |
|                                |                       | Off: <11V |         |                  | Off                            |
| Hold Up                        | See application notes |           |         |                  |                                |
| Lockout Hysteresis             |                       | 2         |         | VDC              |                                |
| Idle Current                   |                       | 15        |         | mA               | When output is inhibited       |
| Inrush Current                 |                       |           | 0.1     | A <sup>2</sup> s |                                |
| Input Reflected Ripple Current |                       | 50        |         | mA pk-pk         | Through 12μH inductor          |
| Recommended Input Fuse         | 25A time delay        |           |         |                  |                                |
| Input Filter                   | Pi type               |           |         |                  |                                |

## Output

| Characteristic           | Minimum   | Typical | Maximum | Units    | Notes & Conditions  |
|--------------------------|---|---------|---------|----------|---|
| Output Voltage           | 12  |         | 48      | VDC      | See Models & Ratings  |
| Output Trim              | -20   |         | +15     | %        | See Application Note  |
| Initial Set Accuracy     |   |         | ±1.0    | %        | At full load and 110VDC input   |
| Minimum Load             | No minimum load required  |         |         |          |   |
| Line Regulation          |   |         | ±0.2    | %        | From minimum to maximum input at full load                                      |
| Load Regulation          |   |         | ±0.2    | %        | From 0% to full load  |
| Transient Response       |   |         | ±5.0    | %        | Maximum deviation, recovering to less than 1% in 250μs for 25% step load change |
| Start Up Time            |   | 100     |         | ms       |   |
| Output Voltage Rise Time |   | 100     |         | ms       |   |
| Ripple & Noise           |   |         |         | mV pk-pk | See Models & Ratings  |
| Overload Protection      | 110   | 125     | 140     | %        | With nominal output voltage   |
| Short Circuit Protection | Continuous hiccup mode, with autorecovery   |         |         |          |   |
| Maximum Capacitive Load  | See Models & Ratings table  |         |         |          |   |
| Temperature Coefficient  |   |         | ±0.02   | %/°C     |   |
| Overvoltage Protection   | 115   | 125     | 140     | %        | Of nominal output voltage   |
| Remote On/Off            | Output is on if remote On/Off (pin 4) is open or high (3.5-160VDC), positive logic.<br>Output turns off if remote On/Off (pin 4) is low (0-1.2VDC max.)<br>Positive logic default, for negative logic option add -N suffix to part number |         |         |          |   |

## General

| Characteristic             | Minimum   | Typical      | Maximum | Units            | Notes & Conditions  |
|----------------------------|---|--------------|---------|------------------|---|
| Efficiency                 |   | 90           |         | %                | See Models & Ratings table                                  |
| Isolation: Input to Output | 3000  |              |         | VAC              | 60s, reinforced   |
| Isolation: Input to Case   | 3000  |              |         | VAC              | 60s, basic  |
| Isolation: Output to Case  | 500   |              |         | VAC              | 60s, basic  |
| Isolation Resistance       | 100   |              |         | MΩ               |   |
| Isolation Capacitance      |   | 500          |         | pF               | Input to output   |
| Switching Frequency        | 432   | 480          | 528     | kHz              | Fixed. Sync pin option (please ask for application support) |
| Power Density              |   |              | 73      | Win <sup>3</sup> |   |
| Mean Time Between Failure  |   | 475/551      |         | khrs             | 12/15V MIL-HDBK-217F, +25°C GB                              |
|                            |   | 572/629      |         |                  | 24/48V MIL-HDBK-217F, +25°C GB                              |
| Weight                     |   | 0.23 (105.0) |         | lb (g)           |   |
| Case Material              | Plastic DAP UL94V-0 rated with aluminum baseplate                               |              |         |                  |   |
| Potting Material           | Epoxy UL94V-0   |              |         |                  |   |
| Pin Material               | Copper with nickel and matte tin plate  |              |         |                  |   |
| Solder Profile             | Wave solder 260°C max 10s max 1.5mm from case. With 90W iron 420°C for 15s max. |              |         |                  |   |
| Fire and Smoke             | Meets EN45545-2   |              |         |                  |   |
| Water Washing              | Use de-ionised water, dry thoroughly  |              |         |                  |   |

## Environmental

| Characteristic       | Minimum          | Typical | Maximum | Units | Notes & Conditions                                  |
|----------------------|------------------|---------|---------|-------|---|
| Operating Base Plate | -40              |         | +100    | °C    |   |
| Storage Temperature  | -55              |         | +125    | °C    |   |
| Thermal Protection   |                  | +105    |         | °C    | Measured on baseplate. Non latching. Recover <95°C. |
| Humidity             |                  |         | 95      | %RH   | Non-condensing                                      |
| Cooling              | Baseplate cooled |         |         |       |   |
| Altitude             |                  |         | 5000    | m     | Operating. Storage 12000m                           |

## EMC: Emissions

| Phenomenon | Standard              | Test Level | Notes & Conditions    |
|------------|-----------------------|------------|-----------------------|
| Conducted  | EN550121-3-2, EN55032 | A          | See Application Notes |
| Radiated   | EN50121-3-2           |            | See Application Notes |

## EMC: Immunity

| Phenomenon         | Standard    | Test Level | Criteria | Notes & Conditions   |
|--------------------|-------------|------------|----------|--|
| Railway Equipment  | EN50121-3-2 |            |          | See Application Notes  |
| ESD Immunity       | EN61000-4-2 | ±6kV/±8kV  | A        | Contact Discharge/Air Discharge                                    |
| Radiated Immunity  | EN61000-4-3 | 20V/m      | A        |  |
| EFT/Burst          | EN61000-4-4 | 2kV        | A        | External capacitor required such as Rubycon 4XF Series, 220µF/200V |
| Surge              | EN61000-4-5 | ±4kV/±2kV  | A        | L-E/L-L, External TVS, 1.5 KE 180A Littlefuse                      |
| Conducted immunity | EN61000-4-6 | 10Vrms     | A        |  |

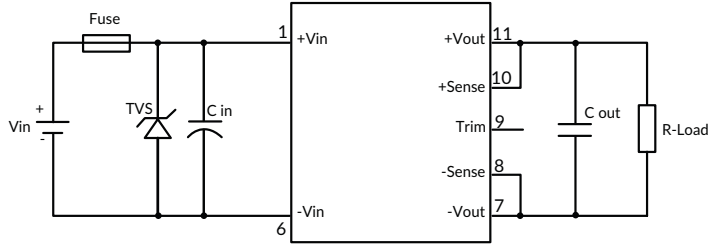
## Safety Approvals

| Safety Agency | Standard                         | Test Level | Notes & Conditions |
|---------------|----------------------------------|------------|--------------------|
| UL            | IEC62368-1                       |            | ITE                |
| EN            | EN50155                          |            | Railway            |
| CE            | Meets all applicable directives  |            |                    |
| UKCA          | Meets all applicable legislation |            |                    |

## Application Notes

### Input Fusing and Safety Considerations

The RDF200 series converters have no internal fuse. In order to achieve maximum safety and system protection, always use an input line fuse. We recommended a 25A time delay fuse. It is recommended that the circuit has a transient voltage suppressor diode (TVS) across the input terminals to protect the unit against surge or spike voltages and input reverse voltage (as shown). A suitable part would be 1.5 KE180 A Littlefuse.



### Output Voltage Adjustment

The Trim input permits the user to adjust the output voltage up by 20% or down by 15%. This is accomplished by connecting an external resistor between the Trim pin and either the +Sense pin or the -Sense pin.

#### To Trim Down

Connecting an external resistor ( $R_d$ ) between the Trim pin and the +Sense pin decreases the output voltage. The following table can be used to determine the required external resistor value to obtain a percentage output voltage change of  $\Delta\%$ .

| Trim Down % | 12V                          | 15V    | 24V    | 48V     |
|-------------|------------------------------|--------|--------|---------|
|             | R <sub>d</sub> (k $\Omega$ ) |        |        |         |
| 1           | 389.67                       | 573.80 | 929.51 | 1715.62 |
| 2           | 186.43                       | 276.35 | 447.25 | 821.86  |
| 3           | 118.69                       | 177.20 | 286.50 | 523.94  |
| 4           | 84.82                        | 127.62 | 206.13 | 374.98  |
| 5           | 64.49                        | 97.88  | 157.90 | 285.60  |
| 6           | 50.94                        | 78.05  | 125.75 | 226.02  |
| 7           | 41.27                        | 63.89  | 102.79 | 183.46  |
| 8           | 34.01                        | 53.26  | 85.56  | 151.54  |
| 9           | 28.36                        | 45.00  | 72.17  | 126.71  |
| 10          | 23.85                        | 38.39  | 61.45  | 106.85  |
| 11          | 20.15                        | 32.98  | 52.68  | 90.60   |
| 12          | 17.07                        | 28.47  | 45.38  | 77.06   |
| 13          | 14.47                        | 24.66  | 39.19  | 65.60   |
| 14          | 12.23                        | 21.39  | 33.89  | 55.78   |
| 15          | 10.30                        | 18.56  | 29.30  | 47.27   |
| 16          | 8.60                         | 16.08  | 25.28  | 39.82   |
| 17          | 7.11                         | 13.89  | 21.74  | 33.25   |
| 18          | 5.78                         | 11.95  | 18.58  | 27.41   |
| 19          | 4.59                         | 10.21  | 15.76  | 22.18   |
| 20          | 3.52                         | 8.64   | 13.23  | 17.48   |

### Output Voltage Sensing

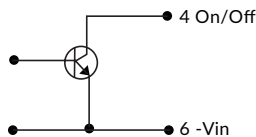
The module will automatically trim the output voltage via the sense pins to the default values either locally or at the load. If not required, the sense pins should be connected locally as indicated in the example circuit.

#### To Trim Up

Connecting an external resistor ( $R_u$ ) between the Trim pin and the -Sense pin increases the output voltage. The following table can be used to determine the required external resistor value to obtain a percentage output voltage change of  $\Delta\%$ .

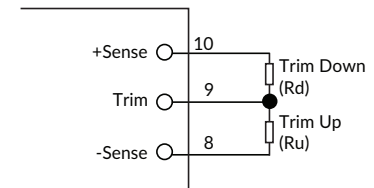
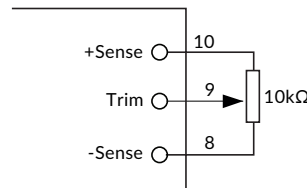
| Trim Up % | 12V                          | 15V    | 24V    | 48V     |
|-----------|------------------------------|--------|--------|---------|
|           | R <sub>u</sub> (k $\Omega$ ) |        |        |         |
| 1         | 263.17                       | 302.45 | 515.62 | 1040.52 |
| 2         | 126.59                       | 145.22 | 247.81 | 498.66  |
| 3         | 81.06                        | 92.82  | 158.54 | 318.04  |
| 4         | 58.29                        | 66.61  | 113.91 | 227.73  |
| 5         | 44.63                        | 50.89  | 87.12  | 173.54  |
| 6         | 35.53                        | 40.41  | 69.27  | 37.42   |
| 7         | 29.02                        | 32.92  | 56.52  | 111.62  |
| 8         | 24.15                        | 27.31  | 46.95  | 92.27   |
| 9         | 20.35                        | 22.94  | 39.51  | 77.21   |
| 10        | 17.32                        | 19.44  | 33.56  | 65.17   |
| 11        | 14.83                        | 16.59  | 28.69  | 55.32   |
| 12        | 12.76                        | 14.20  | 24.64  | 47.11   |
| 13        | 11.01                        | 12.19  | 21.20  | 40.16   |
| 14        | 9.51                         | 10.46  | 18.26  | 34.21   |
| 15        | 8.21                         | 8.96   | 15.71  | 29.05   |

### Remote On/Off Control



Positive logic: "On" if pin 4 is high >3.5V to 160VDC  
 "Off" if pin 4 is low <1.2V to 0VDC

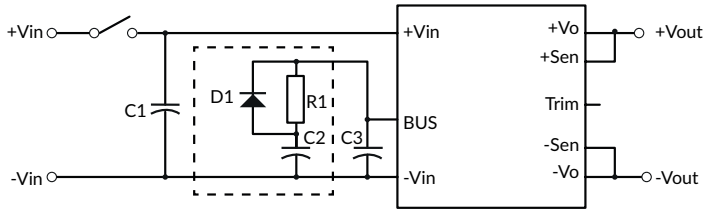
### External Trim



## Application Notes

### Hold Up

To enable hold up functionality the BUS pin can be used as outlined in the following typical circuit where C2 energy is used to maintain the module output.



| C2       | Nominal Input Voltages |        |        |        |        |        |
|----------|------------------------|--------|--------|--------|--------|--------|
|          | 24V                    | 36V    | 48V    | 72V    | 96V    | 110V   |
| For 10ms | 2400µF                 | 2400µF | 2400µF | 2400µF | 820µF  | 560µF  |
| For 30ms | 7200µF                 | 7200µF | 7200µF | 7200µF | 2460µF | 1680µF |

If the hold up function is not required use only C3

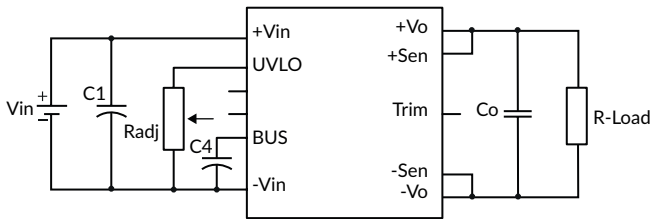
Suggested components:

C1 : 100µF 200V ESR <0.047Ω  
C3 : 240µF (such as Vishay 118AHT)

D1 : 200V 10A  
R1 : 3mΩ 1W

### Adjustable Under Voltage Lockout

The module has default under voltage lockout feature. This can be adjusted by using the following typical circuit:



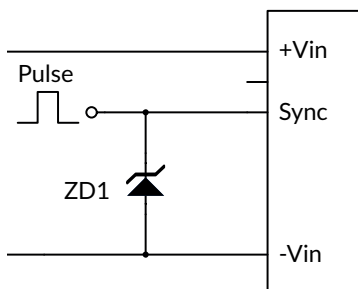
|                                   | Nominal Input Voltages |           |           |           |           |
|-----------------------------------|------------------------|-----------|-----------|-----------|-----------|
|                                   | 24V                    | 36V       | 48V       | 72V       | 110V      |
| Turn Off Threshold (VDC)          | 11.0 ±0.5              | 20.0 ±1.0 | 27.3 ±1.0 | 41.6 ±1.0 | 53.0 ±1.0 |
| Turn On Threshold (VDC)           | 13.0 ±0.5              | 22.0 ±1.0 | 29.6 ±1.0 | 44.6 ±1.0 | 58.0 ±1.0 |
| Radj Resistor (KΩ) (UVLO to -Vin) | Open                   | 62        | 34        | 18        | 10        |

Suggested components:

C1 : 100µF 200V ESR <0.047Ω  
C3 : 240µF (such as Vishay 118AHT)

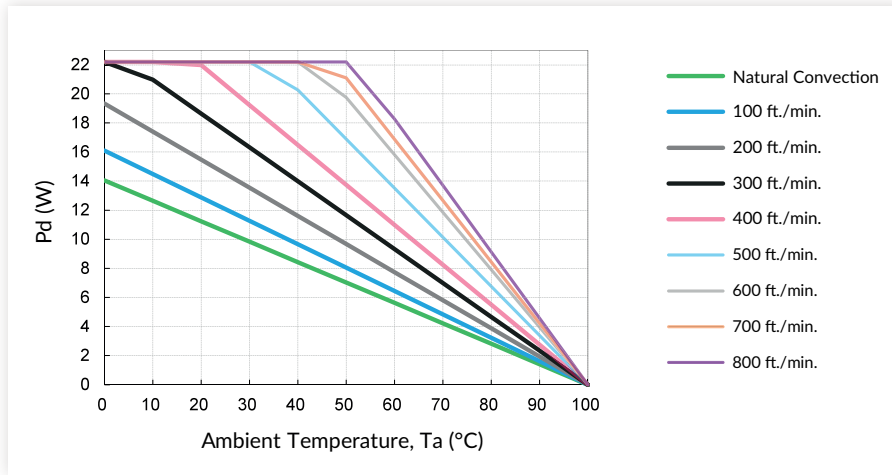
### Synchronized Frequency

An external clock can be used to synchronize the RDF200 by use of a narrow pulse (75ns-120ns, 3.5-5VDC) applied to pin 3 "Sync". The applied signal should be between 530kHz and 630kHz and above the RDF200 switching frequency. Connect applied pulse in parallel with a 5.6V Zener diode as shown.



## Application Notes

### Airflow Derating Graph



| Air Flow Rate                        | Typical Rca |
|--------------------------------------|-------------|
| Natural Convection 20ft/min (0.1m/s) | 7.12°C/W    |
| 100ft/min (0.5m/s)                   | 6.21°C/W    |
| 200ft/min (1.0m/s)                   | 5.17°C/W    |
| 300ft/min (1.5m/s)                   | 4.29°C/W    |
| 400ft/min (2.0m/s)                   | 3.64°C/W    |
| 500ft/min (2.5m/s)                   | 2.96°C/W    |
| 600ft/min (2.5m/s)                   | 2.53°C/W    |
| 700ft/min (2.5m/s)                   | 2.37°C/W    |
| 800ft/min (2.5m/s)                   | 2.19°C/W    |

### Example (Without Heatsink)

To determine the minimum airflow necessary for a RDF20072WS24 operating at an input voltage of 72V, an output current of 6.25A, and a maximum ambient temperature of 20°C:

Determine Power dissipation (Pd):  $Pd = Pi - Po = Po(1-\eta)/\eta$ ,

$$Pd = 24V \times 6.25A \times (1-0.894)/0.894 = 17 \text{ Watts}$$

Where Pi = Input power, Po = Output Power and  $\eta$  = Efficiency

Determine airflow from airflow derating graph using data points for Pd = 17W and Ta = 20°C

Minimum airflow= 400ft./min.

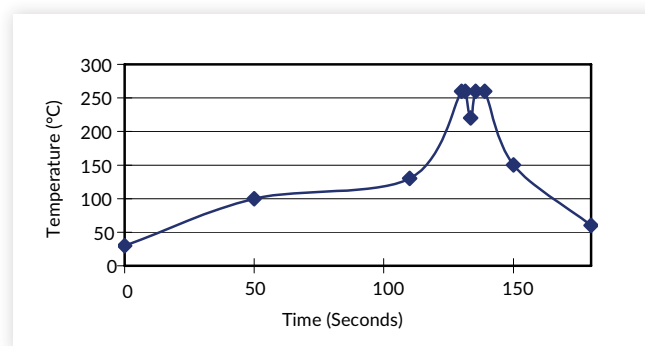
To check that the maximum case temp of 100°C is not exceeded:

Maximum temperature rise is  
 $\Delta T = Pd \times Rca = 17 \times 3.64 = 62.$   
 Maximum case temperature is  
 $Tc = Ta + \Delta T = 82^\circ C < 100^\circ C.$

Where: Rca is the thermal resistance from case to ambient environment. Ta is ambient temperature and Tc is case temperature.

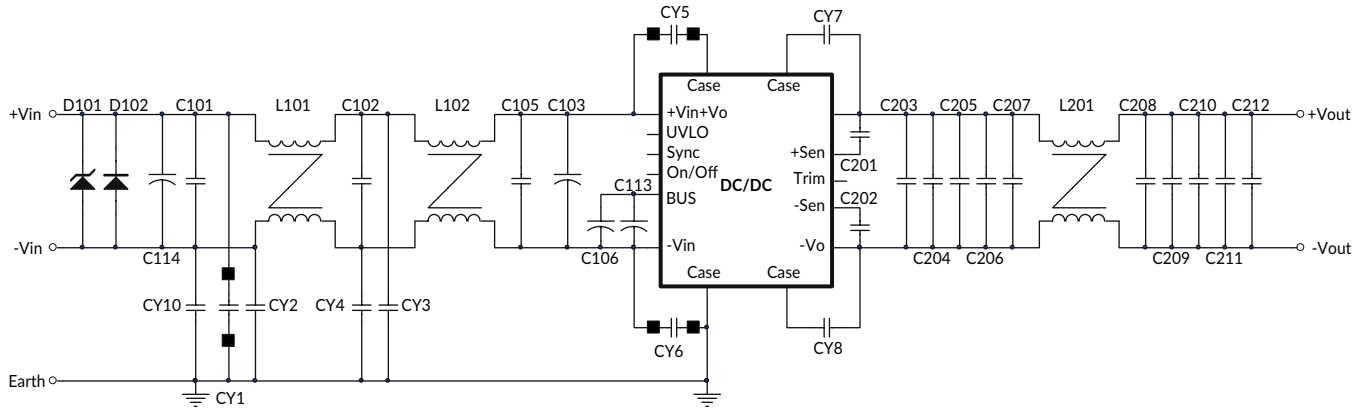
### Solder Profile

With iron 420 ±10°C for maximum 15s.



## Application Notes

### EMC Filter - Emissions and Immunity



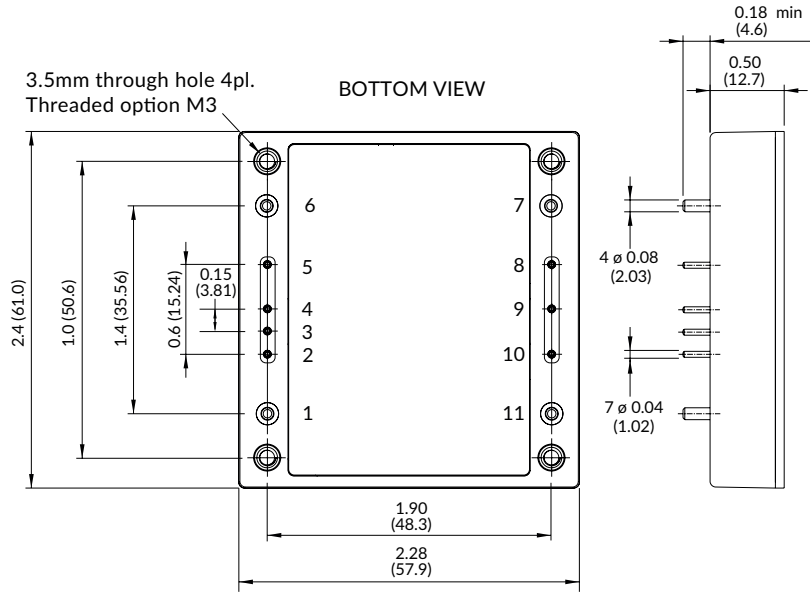
|                  | RDF20072S12   | RDF20072S15                           | RDF20072S24          | RDF20072S48 |
|------------------|---|---------------------------------------|----------------------|-------------|
| C101, C102, C105 | 1 $\mu$ F/250V SMD  |                                       |                      |             |
| C103, C113       | 220 $\mu$ F/200V aluminum cap. KXJ series                         |                                       |                      |             |
| C106             | 68 $\mu$ F/200V aluminum cap. CS series                           |                                       |                      |             |
| C114             | 120 $\mu$ F/220V aluminum cap. KXJ series                         |                                       |                      |             |
| C201, C202       | 0.1 $\mu$ F/100V SMD  | 0.068 $\mu$ F/50V SMD                 | 0.1 $\mu$ F/100V SMD |             |
| C203, 204        | 6.8 $\mu$ F/50V SMD   |                                       | 2.2 $\mu$ F/100V SMD |             |
| C205-C207        | 10 $\mu$ F/50V SMD  |                                       |                      |             |
| C208             | 0.1 $\mu$ F/100V SMD  |                                       |                      |             |
| C209-C210        | 1 $\mu$ F/50V SMD   |                                       |                      |             |
| C211, C212       | 6.8 $\mu$ F/50V SMD   |                                       | 2.2 $\mu$ F/100V SMD |             |
| CY10             | 220pF/Y1  | 100pF/Y1                              |                      |             |
| CY1              |   | 100pF/Y1                              | 220pF/Y1             |             |
| CY2              | 220pF/Y1  | 100pF/Y1                              | 100pF/Y1             |             |
| CY3, CY4         | 2200pF/Y1   |                                       |                      |             |
| CY5, CY6         | 2200pF/Y1   |                                       |                      |             |
| CY7, CY8         | 0.022 $\mu$ F/275Vac 10mm X2                                      |                                       |                      |             |
| L101, L102       | 0.72mH 0.8mm*2/10T R-22/14/8B MA100-C ALWIN                       |                                       |                      |             |
| L201             | 0.12mH 0.7mm*8/2T FCN0179C WELL LIGHT                             | 0.51mH 0.8mm*4/4T FCN0179C WELL LIGHT |                      |             |
| BEAD CORE        | CY5, CY6 BRI 4*1.5*2 CHILISIN (G4058651007), CY1 RDF20075S15 ONLY |                                       |                      |             |

### Notes:

C101, C102, C105: 1812 X7R ceramic.  
 C103, C113: NIPPON CHEMI-CON KXJ series aluminum capacitor or equivalent.  
 C106: Nichicon CS series aluminum capacitor or equivalent.  
 C114: NIPPON CHEMI-CON KXJ series aluminum capacitor or equivalent.  
 C201, C202: 0805 X7R ceramic.  
 C203, C204, C211, C212: 1812 X7R ceramic.  
 C205, C206, C207, C208, C209, C210: 1206 X7R ceramic.  
 CY1, CY2M CY3, CY4, CY5, CY6, CY10: TDK Y1 capacitor or equivalent.

CY7, CY8: CARLI MPX Series X2 capacitor or equivalent.  
 L101, L102: 0.72mH 0.8mm\*2/10T R-22/14/8B MA100-C ALWIN (G91CA125615)  
 L201: 0.12mH 0.7mm\*8/2T, FCN0179C WELL LIGHT (G91C7425515)  
 0.51mH 0.8mm\*4/4T, FCN0179C WELL LIGHT (G91C7421915)  
 D101: SMCJ180A, LITTELFUSE  
 D102: STTH8R03DJF-TR ST

Mechanical Details



| Pin Connections |        |
|-----------------|--------|
| Pin             | Single |
| 1               | +Vin   |
| 2               | UVLO   |
| 3               | Sync   |
| 4               | On/Off |
| 5               | BUS    |
| 6               | -Vin   |
| 7               | -Vout  |
| 8               | -Sense |
| 9               | Trim   |
| 10              | +Sense |
| 11              | +Vout  |

Notes:

1. All dimensions are in inches (mm)
2. Weight: 0.25lbs (114g) approx.
3. Tolerance: x.xx = ±0.02 (x.x = ±0.5)  
x.xxx = ±0.01 (x.xx = ±0.25)
4. Optional M3 x 0.5 threaded baseplate fixing add suffix -T



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