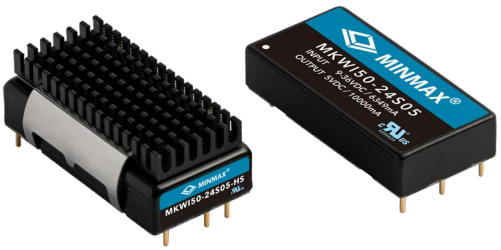
## FEATURES

- ▶ **Smallest Encapsulated 50W Converter**
- ▶ **Ultra-compact 2" X 1" Package**
- ▶ **Wide 2:1 Input Voltage Range**
- ▶ **Fully Regulated Output Voltage**
- ▶ **Excellent Efficiency up to 92%**
- ▶ **I/O Isolation 1500 VDC**
- ▶ **Operating Ambient Temp. Range -40℃ to +80℃**
- ▶ **No Min. Load Requirement**
- ▶ **Overload/Voltage/Temp. and Short Circuit Protection**
- ▶ **Remote On/Off Control, Output Voltage Trim**
- ▶ **Shielded Metal Case with Insulated Baseplate**
- ▶ **UL/cUL/IEC/EN 62368-1(60950-1) Safety Approval & CE Marking**




UL 62368-1 CSA 60950-1 CB Scheme

## PRODUCT OVERVIEW

The MINMAX MKW50 series is the latest generation of high performance DC-DC converter modules setting a new standard concerning power density. The product offers fully 50W in an encapsulated, shielded metal package with dimensions of just 2.0"x1.0"x0.4". All models provide wide 2:1 input voltage range and precisely regulated output voltages.

Advanced circuit topology provides a very high efficiency up to 92% which allows an operating temperature range of -40°C to +80°C. Further features include remote On/Off, trimmable output voltage, under-voltage shutdown as well as overload and over-temperature protection. Typical applications for these converters are battery operated equipment, instrumentation, distributed power architectures in communication and industrial electronics and many other space critical applications.

### Model Selection Guide

| Model Number | Input Voltage (Range) | Output Voltage | Output Current | Input Current | | Reflected Ripple Current | Over Voltage Protection | Max. capacitive Load | Efficiency (typ.) |
|---|---|---|---|---|---|---|---|---|---|
| | | | Max. | @Max. Load | @No Load | | | | @Max. Load |
| | VDC | VDC | mA | mA(typ.) | mA(typ.) | mA(typ.) | VDC | μF | % |
| **MKW50-12S033** | 12 ( 9 ~ 18 ) | 3.3 | 10000 | 3090 | 85 | 50 | 3.9 | 25800 | 89 |
| **MKW50-12S05** | | 5 | 10000 | 4630 | 110 | | 6.2 | 17000 | 90 |
| **MKW50-12S12** | | 12 | 4170 | 4580 | 160 | | 15 | 2900 | 91 |
| **MKW50-12S15** | | 15 | 3330 | 4580 | 160 | | 18 | 1900 | 91 |
| **MKW50-12S24** | | 24 | 2080 | 4570 | 250 | | 30 | 750 | 91 |
| **MKW50-24S033** | 24 ( 18 ~ 36 ) | 3.3 | 10000 | 1550 | 50 | 40 | 3.9 | 25800 | 89 |
| **MKW50-24S05** | | 5 | 10000 | 2260 | 70 | | 6.2 | 17000 | 92 |
| **MKW50-24S12** | | 12 | 4170 | 2260 | 85 | | 15 | 2900 | 92 |
| **MKW50-24S15** | | 15 | 3330 | 2260 | 85 | | 18 | 1900 | 92 |
| **MKW50-24S24** | | 24 | 2080 | 2290 | 110 | | 30 | 750 | 91 |
| **MKW50-48S033** | 48 ( 36 ~ 75 ) | 3.3 | 10000 | 770 | 35 | 30 | 3.9 | 25800 | 89 |
| **MKW50-48S05** | | 5 | 10000 | 1130 | 45 | | 6.2 | 17000 | 92 |
| **MKW50-48S12** | | 12 | 4170 | 1130 | 50 | | 15 | 2900 | 92 |
| **MKW50-48S15** | | 15 | 3330 | 1130 | 50 | | 18 | 1900 | 92 |
| **MKW50-48S24** | | 24 | 2080 | 1150 | 60 | | 30 | 750 | 91 |

## Input Specifications

| Parameter | | Model | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Input Surge Voltage (100ms. max) | | 12V Input Models | -0.7 | --- | 25 | VDC |
| | | 24V Input Models | -0.7 | --- | 50 | |
| | | 48V Input Models | -0.7 | --- | 100 | |
| Start-Up Threshold Voltage | | 12V Input Models | --- | --- | 9 | |
| | | 24V Input Models | --- | --- | 18 | |
| | | 48V Input Models | --- | --- | 36 | |
| Under Voltage Shutdown | | 12V Input Models | --- | 8.3 | --- | |
| | | 24V Input Models | --- | 16.5 | --- | |
| | | 48V Input Models | --- | 33 | --- | |
| Start Up Time | Power Up | Nominal Vin and Constant Resistive Load | --- | --- | 30 | ms |
| | Remote On/Off | | --- | --- | 30 | ms |
| Input Filter | | All Models | Internal LC Type | | | |

## Remote On/Off Control

| Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| Converter On | 3.5V ~ 12V or Open Circuit | | | | |
| Converter Off | 0V ~ 1.2V or Short Circuit | | | | |
| Control Input Current (on) | Vctrl = 5.0V | --- | 0.5 | --- | mA |
| Control Input Current (off) | Vctrl = 0V | --- | -0.5 | --- | mA |
| Control Common | Referenced to Negative Input | | | | |
| Standby Input Current | Nominal Vin | --- | 2.5 | --- | mA |

## Output Specifications

| Parameter | Conditions / Model | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| Output Voltage Setting Accuracy | | | --- | --- | ±1.0 | %Vnom. |
| Line Regulation | Vin=Min. to Max. @ Full Load | | --- | --- | ±0.5 | % |
| Load Regulation | Io=0% to 100% | | --- | --- | ±0.5 | % |
| Minimum Load | No minimum Load Requirement | | | | | |
| Ripple & Noise | 0-20 MHz Bandwidth | 3.3V & 5V Models(3) | --- | --- | 100 | mV P-P |
| | | 12V, 15V & 24V Models(3) | --- | --- | 150 | mV P-P |
| Transient Recovery Time | 25% Load Step Change(2) | | --- | 250 | --- | µsec |
| Transient Response Deviation | | | --- | ±3 | ±5 | % |
| Temperature Coefficient | | | --- | --- | ±0.02 | %/℃ |
| Trim Up / Down Range (See Page 6) | % of Nominal Output Voltage | 24Vo Models | --- | --- | +20 / -10 | % |
| | | Other Models | --- | --- | ±10 | % |
| Over Load Protection | Hiccup | | --- | 150 | --- | % |
| Short Circuit Protection | 24Vo Models | | Continuous, Automatic Recovery (Hiccup Mode 0.3Hz typ.) | | | |
| | Other Models | | Continuous, Automatic Recovery (Hiccup Mode 1.5Hz typ.) | | | |

## General Specifications

| Parameter | Conditions / Model | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| I/O Isolation Voltage | 60 Seconds | 1500 | --- | --- | VDC |
| | 1 Second | 1800 | --- | --- | VDC |
| I/O Isolation Resistance | 500 VDC | 1000 | --- | --- | MΩ |
| I/O Isolation Capacitance | 100kHz, 1V | --- | --- | 2200 | pF |
| Switching Frequency | 24Vo Models | --- | 285 | --- | kHz |
| | Other Models | --- | 320 | --- | kHz |
| MTBF(calculated) | MIL-HDBK-217F@25℃, Ground Benign | 224,700 | | | Hours |
| Safety Approvals | UL/cUL 60950-1 recognition(CSA certificate), IEC/EN 60950-1(CB-report) | | | | |
| | UL/cUL 62368-1 recognition(UL certificate), IEC/EN 62368-1(CB-report) | | | | |

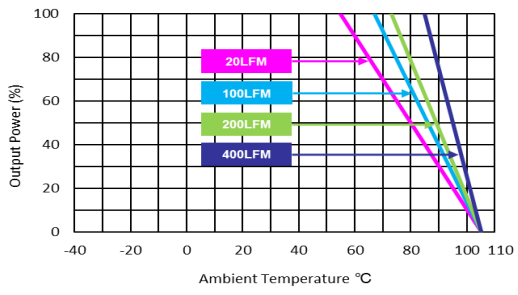
## EMC Specifications

| Parameter | Standards & Level | | | Performance |
|---|---|---|---|---|
| EMI(6) | Conduction | EN 55032 | With external components | Class A |
| | Radiation | | | |
| EMS(6) | EN 55024 | | | |
| | ESD | EN61000-4-2 Air ± 8kV , Contact ± 6kV | | A |
| | Radiated immunity | EN61000-4-3 10V/m | | A |
| | Fast transient | EN61000-4-4 ±2kV | | A |
| | Surge | EN61000-4-5 ±1kV | | A |
| | Conducted immunity | EN61000-4-6 10Vrms | | A |

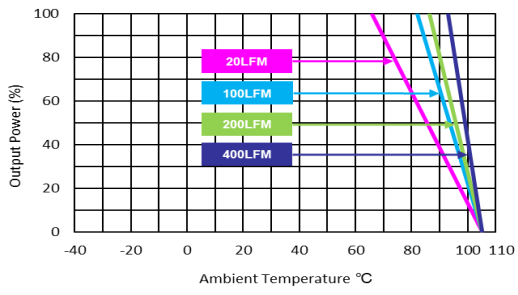
## Environmental Specifications

| Parameter | Conditions / Model | Min. | Max. | | Unit |
|---|---|---|---|---|---|
| | | | without Heatsink | with Heatsink | |
| Operating Ambient Temperature Range<br>Nominal Vin, Load 100% Inom.<br>(for Power Derating see relative Derating Curves) | MKW50-XXS033 | -40 | 56 | 64 | ℃ |
| | MKW50-24S05, MKW50-24S12 | | 53 | 62 | |
| | MKW50-24S15, MKW50-48S05 | | | | |
| | MKW50-48S12, MKW50-48S15 | | | | |
| | MKW50-12S12, MKW50-12S15 | | 46 | 56 | |
| | MKW50-12S24, MKW50-24S24 | | | | |
| | MKW50-48S24 | | | | |
| | MKW50-12S05 | | 38 | 49 | |
| Thermal Impedance | 20LFM Convection without Heatsink | 12.1 | --- | | ℃/W |
| | 20LFM Convection with Heatsink | 9.8 | --- | | ℃/W |
| | 100LFM Convection without Heatsink | 9.2 | --- | | ℃/W |
| | 100LFM Convection with Heatsink | 5.4 | --- | | ℃/W |
| | 200LFM Convection without Heatsink | 7.8 | --- | | ℃/W |
| | 200LFM Convection with Heatsink | 4.5 | --- | | ℃/W |
| | 400LFM Convection without Heatsink | 5.2 | --- | | ℃/W |
| | 400LFM Convection with Heatsink | 3.0 | --- | | ℃/W |
| Case Temperature | | --- | +105 | | ℃ |
| Thermal Protection | Shutdown Temperature | 110℃ typ. | | | |
| Storage Temperature Range | | -50 | +125 | | ℃ |
| Humidity (non condensing) | | --- | 95 | | % rel. H |
| RFI | Six-Sided Shielded, Metal Case | | | | |
| Lead Temperature (1.5mm from case for 10Sec.) | | --- | 260 | | ℃ |

## Power Derating Curve

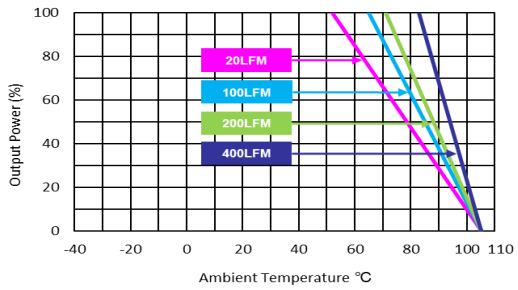



MKW50-12S033, MKW50-24S033, MKW50-48S033
Derating Curve without Heatsink

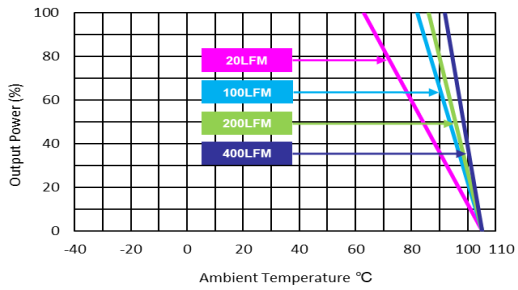



MKW50-12S033, MKW50-24S033, MKW50-48S033
Derating Curve with Heatsink

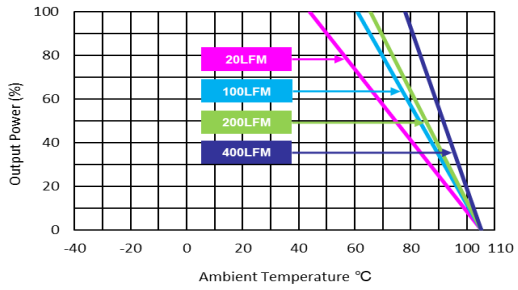
## Power Derating Curve



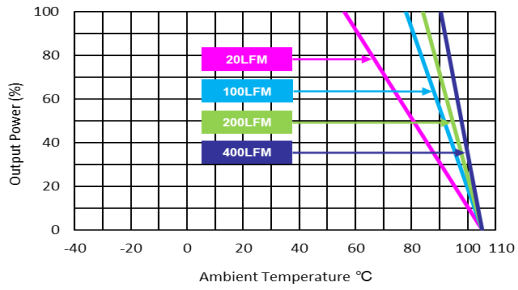

MKW50-24S05, MKW50-24S12, MKW50-24S15, MKW50-48S05, MKW50-48S12, MKW50-48S15 Derating Curve without Heatsink



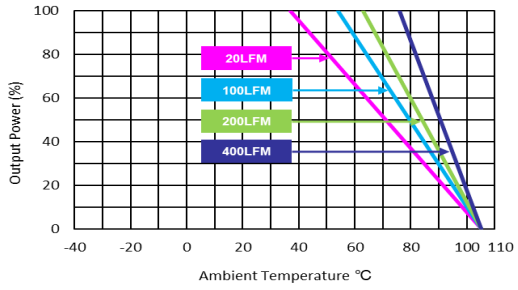

MKW50-24S05, MKW50-24S12, MKW50-24S15, MKW50-48S05, MKW50-48S12, MKW50-48S15 Derating Curve with Heatsink



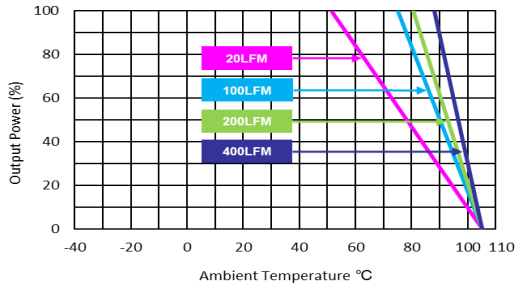

MKW50-12S12, MKW50-12S15, MKW50-12S24, MKW50-24S24, MKW50-48S24 Derating Curve without Heatsink




MKW50-12S12, MKW50-12S15, MKW50-12S24, MKW50-24S24, MKW50-48S24 Derating Curve with Heatsink




MKW50-12S05 Derating Curve without Heatsink



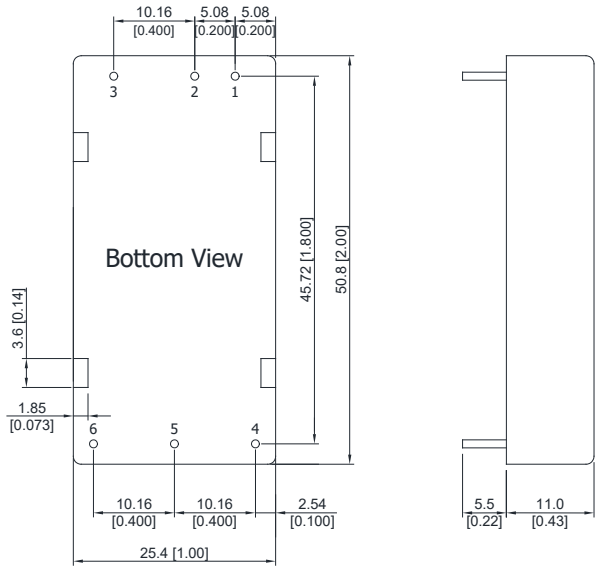

MKW50-12S05 Derating Curve with Heatsink

## Notes

1. Specifications typical at Ta=+25℃, resistive load, nominal input voltage and rated output current unless otherwise noted.
2. Transient recovery time is measured to within 1% error band for a step change in output load of 75% to 100%.
3. Ripple & Noise measurement with a 1μF/50V MLCC and a 10μF/50V Tantalum Capacitor.
4. We recommend to protect the converter by a slow blow fuse in the input supply line.
5. Other input and output voltage may be available, please contact MINMAX.
6. The external components might be required to meet EMI/EMS standard for some of test items. Please contact MINMAX for the solution in detail.
7. Do not exceed maximum power specification when adjusting output voltage.
8. Specifications are subject to change without notice.
9. The repeated high voltage isolation testing of the converter can degrade isolation capability, to a lesser or greater degree depending on materials, construction, environment and reflow solder process. Any material is susceptible to eventual chemical degradation when subject to very high applied voltages thus implying that the number of tests should be strictly limited. We therefore strongly advise against repeated high voltage isolation testing, but if it is absolutely required, that the voltage be reduced by 20% from specified test voltage. Furthermore, the high voltage isolation capability after reflow solder process should be evaluated as it is applied on system.

## Package Specifications

### Mechanical Dimensions




### Pin Connections

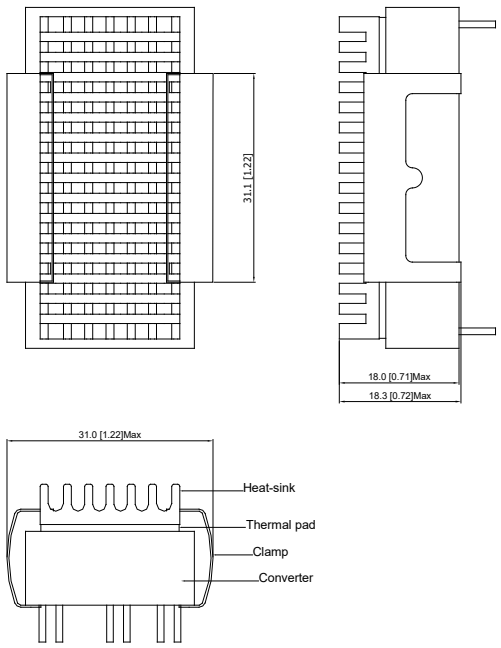
| Pin | Function | Diameter mm (inches) |
|---|---|---|
| 1 | +Vin | Ø 1.0 [0.04] |
| 2 | -Vin | Ø 1.0 [0.04] |
| 3 | Remote On/Off | Ø 1.0 [0.04] |
| 4 | +Vout | Ø 1.0 [0.04] |
| 5 | -Vout | Ø 1.0 [0.04] |
| 6 | Trim | Ø 1.0 [0.04] |

- ▶ All dimensions in mm (inches)
- ▶ Tolerance: X.X±0.25 (X.XX±0.01)
  X.XX±0.13 (X.XXX±0.005)
- ▶ Pin diameter tolerance: X.X±0.05 (X.XX±0.002)

## Physical Characteristics

| | | |
|---|---|---|
| Case Size | : | 50.8x25.4x11.0mm (2.0x1.0x0.43 inches) |
| Case Material | : | Metal With Non-Conductive Baseplate |
| Base Material | : | FR4 PCB (flammability to UL 94V-0 rated) |
| Pin Material | : | Copper Alloy |
| Potting Material | : | Epoxy (UL94-V0) |
| Weight | : | 30g |

## Heatsink (Option –HS)




### Physical Characteristics

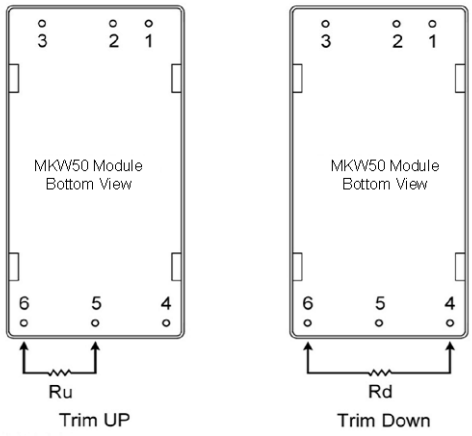
| | | |
|---|---|---|
| Heatsink Material | : | Aluminum |
| Finish | : | Black Anodized Coating |
| Weight | : | 9g |

▶ The advantages of adding a heatsink are:

1. To improve heat dissipation and increase the stability and reliability of the DC-DC converters at high operating temperatures.
2. To increase operating temperature of the DC-DC converter, please refer to Derating Curve.

## External Output Trimming

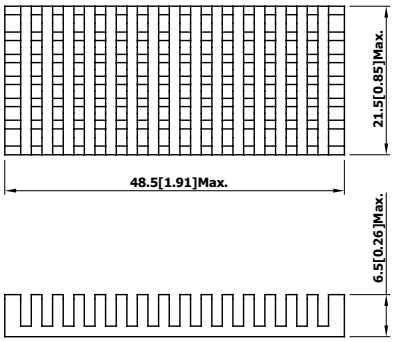
Output can be externally trimmed by using the method shown below




| | MKW50-XXS033 | | MKW50-XXS05 | | MKW50-XXS12 | | MKW50-XXS15 | | MKW50-XXS24 | |
|---|---|---|---|---|---|---|---|---|---|---|
| Trim Range (%) | Trim down (kΩ) | Trim up (kΩ) | Trim down (kΩ) | Trim up (kΩ) | Trim down (kΩ) | Trim up (kΩ) | Trim down (kΩ) | Trim up (kΩ) | Trim down (kΩ) | Trim up (kΩ) |
| 1 | 72.61 | 60.84 | 138.88 | 106.87 | 413.55 | 351.00 | 530.73 | 422.77 | 333.39 | --- |
| 2 | 32.55 | 27.40 | 62.41 | 47.76 | 184.55 | 157.50 | 238.61 | 189.89 | 148.80 | 243.70 |
| 3 | 19.20 | 16.25 | 36.92 | 28.06 | 108.22 | 93.00 | 141.24 | 112.26 | 87.26 | --- |
| 4 | 12.52 | 10.68 | 24.18 | 18.21 | 70.05 | 60.75 | 92.56 | 73.44 | 56.50 | 108.50 |
| 5 | 8.51 | 7.34 | 16.53 | 12.30 | 47.15 | 41.40 | 63.35 | 50.15 | 38.04 | --- |
| 6 | 5.84 | 5.11 | 11.44 | 8.36 | 31.88 | 28.50 | 43.87 | 34.63 | 25.73 | 63.43 |
| 7 | 3.94 | 3.51 | 7.79 | 5.55 | 20.98 | 19.29 | 29.96 | 23.54 | 16.94 | --- |
| 8 | 2.51 | 2.32 | 5.06 | 3.44 | 12.80 | 12.37 | 19.53 | 15.22 | 10.35 | 40.90 |
| 9 | 1.39 | 1.39 | 2.94 | 1.79 | 6.44 | 7.00 | 11.41 | 8.75 | 5.22 | --- |
| 10 | 0.50 | 0.65 | 1.24 | 0.48 | 1.35 | 2.70 | 4.92 | 3.58 | 1.12 | 27.38 |
| 12 | --- | --- | --- | --- | --- | --- | --- | --- | --- | 18.37 |
| 14 | --- | --- | --- | --- | --- | --- | --- | --- | --- | 11.93 |
| 16 | --- | --- | --- | --- | --- | --- | --- | --- | --- | 7.10 |
| 18 | --- | --- | --- | --- | --- | --- | --- | --- | --- | 3.34 |
| 20 | --- | --- | --- | --- | --- | --- | --- | --- | --- | 0.34 |

| Order Code Table | |
|---|---|
| Standard | With heatsink |
| MKW50-12S033 | MKW50-12S033-HS |
| MKW50-12S05 | MKW50-12S05-HS |
| MKW50-12S12 | MKW50-12S12-HS |
| MKW50-12S15 | MKW50-12S15-HS |
| MKW50-12S24 | MKW50-12S24-HS |
| MKW50-24S033 | MKW50-24S033-HS |
| MKW50-24S05 | MKW50-24S05-HS |
| MKW50-24S12 | MKW50-24S12-HS |
| MKW50-24S15 | MKW50-24S15-HS |
| MKW50-24S24 | MKW50-24S24-HS |
| MKW50-48S033 | MKW50-48S033-HS |
| MKW50-48S05 | MKW50-48S05-HS |
| MKW50-48S12 | MKW50-48S12-HS |
| MKW50-48S15 | MKW50-48S15-HS |
| MKW50-48S24 | MKW50-48S24-HS |

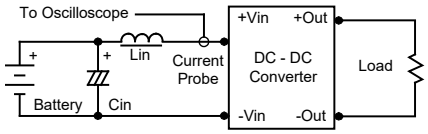
| Order Code For Heatsink kit (including: Heatsink x1, Clamp x 2, Thermal Pad x1) |
|---|
| HS-K002 |



## Test Setup

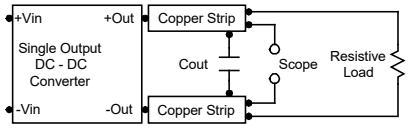
### Input Reflected-Ripple Current Test Setup

Input reflected-ripple current is measured with a inductor Lin (4.7μH) and Cin (220μF, ESR < 1.0Ω at 100 kHz) to simulate source impedance.
Capacitor Cin, offsets possible battery impedance. Current ripple is measured at the input terminals of the module, measurement bandwidth is 0-500 kHz.




### Peak-to-Peak Output Noise Measurement Test

Use a 1μF ceramic capacitor and a 10μF tantalum capacitor. Scope measurement should be made by using a BNC socket, measurement bandwidth is 0-20 MHz.
Position the load between 50 mm and 75 mm from the DC-DC Converter.




## Technical Notes

### Remote On/Off

Positive logic remote on/off turns the module on during a logic high voltage on the remote on/off pin, and off during a logic low. To turn the power module on and off, the user must supply a switch to control the voltage between the on/off terminal and the -Vin terminal. The switch can be an open collector or equivalent.
A logic low is 0V to 1.2V. A logic high is 3.5V to 12V. The maximum sink current at the on/off terminal (Pin 3) during a logic low is -100μA.

### Overload Protection

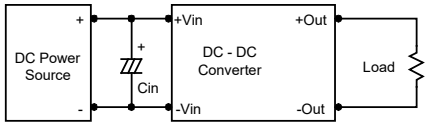
To provide hiccup mode protection in a fault (output overload) condition, the unit is equipped with internal current limiting circuitry and can endure overload for an unlimited duration.

### Overvoltage Protection

The output overvoltage clamp consists of control circuitry, which is independent of the primary regulation loop, that monitors the voltage on the output terminals. The control loop of the clamp has a higher voltage set point than the primary loop. This provides a redundant voltage control that reduces the risk of output overvoltage. The OVP level can be found in the output data.

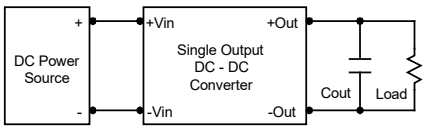
### Input Source Impedance

The power module should be connected to a low ac-impedance input source. Highly inductive source impedances can affect the stability of the power module.
In applications where power is supplied over long lines and output loading is high, it may be necessary to use a capacitor at the input to ensure startup.
Capacitor mounted close to the power module helps ensure stability of the unit, it is recommended to use a good quality low Equivalent Series Resistance (ESR < 1.0Ω at 100 kHz) capacitor of a 33μF for the 12V input devices and a 10μF for the 24V and 48V devices.




### Output Ripple Reduction

A good quality low ESR capacitor placed as close as practicable across the load will give the best ripple and noise performance. To reduce output ripple, it is recommended to use 4.7μF capacitors at the output.




### Maximum Capacitive Load

The MKW50 series has limitation of maximum connected capacitance at the output. The power module may be operated in current limiting mode during start-up, affecting the ramp-up and the startup time. The maximum capacitance can be found in the data sheet.

### Thermal Considerations

Many conditions affect the thermal performance of the power module, such as orientation, airflow over the module and board spacing. To avoid exceeding the maximum temperature rating of the components inside the power module, the case temperature must be kept below 105°C. The derating curves are determined from measurements obtained in a test setup.