

**FEATURES**

- ▶ Industrial Standard 2 X 1" Package
- ▶ Wide 2:1 Input Voltage Range
- ▶ Fully Regulated Output Voltage
- ▶ I/O Isolation 4200VAC with Reinforced Insulation, rated for 300Vrms Working Voltage
- ▶ Low Leakage Current < 5µA
- ▶ Operating Ambient Temp. Range -40°C to +80°C
- ▶ No Min. Load Requirement
- ▶ Overload/Voltage and Short Circuit Protection
- ▶ Designed-in EMI Emission meets EN 55011 Class A & FCC Level A
- ▶ Medical EMC Standard meets 4<sup>th</sup> Edition of EMI EN 55011 and EMS EN 60601-1-2
- ▶ Medical Safety meets 2xMOPP per 3<sup>rd</sup> Edition of IEC/EN 60601-1 & ANSI/AAMI ES60601-1 with CE Marking


**PRODUCT OVERVIEW**

The MINMAX MKW20M series is a new range of high performance 20W medical approved dc-dc converter within encapsulated 2"x1" package which specifically design for medical applications. There are 21 models available for input voltage of 12, 24, 48VDC with wide 2:1 input range and tight output voltage. The I/O isolation is specified for 4200VAC with reinforced insulation, which rated for 300Vrms working voltage. Further features include overload, short circuit protection, no min. load requirement, EMI conduction meets EN 55011 Class A, low leakage current 5µA max. and operating ambient temp. range by -40°C to 80°C by high efficiency up to 90%. MKW20M series conform to 4<sup>th</sup> edition medical EMC standard, medical safety approval meets 2xMOPP (Means Of Patient Protection) per 3<sup>rd</sup> edition of IEC/EN 60601-1 & ANSI/AAMI ES60601-1.

The MKW20M series offer a economical solution for demanding application in medical instrument requesting a certified supplementary and reinforced insulation system to comply with latest medical safety approval for 2xMOPP requirement.

**Model Selection Guide**

| Model Number  | Input Voltage (Range)<br>VDC | Output Voltage<br>VDC | Output Current |            | Input Current |            | Reflected Ripple Current<br>mA(typ.) | Over Voltage Protection<br>VDC | Max. capacitive Load<br>µF | Efficiency (typ.) |    |      |     |      |    |    |      |    |      |    |    |     |    |     |    |    |     |    |     |    |     |      |     |      |    |
|---------------|------------------------------|-----------------------|----------------|------------|---------------|------------|--------------------------------------|--------------------------------|----------------------------|-------------------|----|------|-----|------|----|----|------|----|------|----|----|-----|----|-----|----|----|-----|----|-----|----|-----|------|-----|------|----|
|               |                              |                       | Max.           | @Max. Load | @No Load      | @Max. Load |                                      |                                |                            | %                 |    |      |     |      |    |    |      |    |      |    |    |     |    |     |    |    |     |    |     |    |     |      |     |      |    |
|               |                              |                       | mA             | mA(typ.)   | mA (typ.)     |            |                                      |                                |                            |                   |    |      |     |      |    |    |      |    |      |    |    |     |    |     |    |    |     |    |     |    |     |      |     |      |    |
| MKW20-12S05M  | 12<br>(9 ~ 18)               | 5                     | 4000           | 1938       | 20            | 100        | 6.2                                  | 6800                           | 86                         | 86                |    |      |     |      |    |    |      |    |      |    |    |     |    |     |    |    |     |    |     |    |     |      |     |      |    |
| MKW20-12S051M |                              | 5.1                   | 4000           | 1977       |               |            |                                      |                                |                            |                   | 15 | 50   | 6.2 | 6800 | 88 |    |      |    |      |    |    |     |    |     |    |    |     |    |     |    |     |      |     |      |    |
| MKW20-12S12M  |                              | 12                    | 1670           | 1876       |               |            |                                      |                                |                            |                   |    |      |     |      |    | 15 | 1160 | 15 | 1160 | 89 |    |     |    |     |    |    |     |    |     |    |     |      |     |      |    |
| MKW20-12S15M  |                              | 15                    | 1333           | 1893       |               |            |                                      |                                |                            |                   |    |      |     |      |    |    |      |    |      |    | 18 | 750 | 18 | 750 | 89 |    |     |    |     |    |     |      |     |      |    |
| MKW20-12S24M  |                              | 24                    | 840            | 1888       |               |            |                                      |                                |                            |                   |    |      |     |      |    |    |      |    |      |    |    |     |    |     |    | 27 | 295 | 27 | 295 | 89 |     |      |     |      |    |
| MKW20-12D12M  |                              | ±12                   | ±840           | 1888       |               |            |                                      |                                |                            |                   |    |      |     |      |    |    |      |    |      |    |    |     |    |     |    |    |     |    |     |    | ±15 | 590# | ±15 | 590# | 89 |
| MKW20-12D15M  |                              | ±15                   | ±670           | 1882       |               |            |                                      |                                |                            |                   |    |      |     |      |    |    |      |    |      |    |    |     |    |     |    |    |     |    |     |    |     |      |     |      |    |
| MKW20-24S05M  | 24<br>(18 ~ 36)              | 5                     | 4000           | 947        | 15            | 50         | 6.2                                  | 6800                           | 88                         | 88                |    |      |     |      |    |    |      |    |      |    |    |     |    |     |    |    |     |    |     |    |     |      |     |      |    |
| MKW20-24S051M |                              | 5.1                   | 4000           | 966        |               |            |                                      |                                |                            |                   | 15 | 1160 | 6.2 | 6800 | 88 |    |      |    |      |    |    |     |    |     |    |    |     |    |     |    |     |      |     |      |    |
| MKW20-24S12M  |                              | 12                    | 1670           | 938        |               |            |                                      |                                |                            |                   |    |      |     |      |    | 15 | 1160 | 15 | 1160 | 89 |    |     |    |     |    |    |     |    |     |    |     |      |     |      |    |
| MKW20-24S15M  |                              | 15                    | 1333           | 936        |               |            |                                      |                                |                            |                   |    |      |     |      |    |    |      |    |      |    | 18 | 750 | 18 | 750 | 89 |    |     |    |     |    |     |      |     |      |    |
| MKW20-24S24M  |                              | 24                    | 840            | 933        |               |            |                                      |                                |                            |                   |    |      |     |      |    |    |      |    |      |    |    |     |    |     |    | 27 | 295 | 27 | 295 | 90 |     |      |     |      |    |
| MKW20-24D12M  |                              | ±12                   | ±840           | 933        |               |            |                                      |                                |                            |                   |    |      |     |      |    |    |      |    |      |    |    |     |    |     |    |    |     |    |     |    | ±15 | 590# | ±15 | 590# | 90 |
| MKW20-24D15M  |                              | ±15                   | ±670           | 931        |               |            |                                      |                                |                            |                   |    |      |     |      |    |    |      |    |      |    |    |     |    |     |    |    |     |    |     |    |     |      |     |      |    |
| MKW20-48S05M  | 48<br>(36 ~ 75)              | 5                     | 4000           | 473        | 10            | 30         | 6.2                                  | 6800                           | 88                         | 88                |    |      |     |      |    |    |      |    |      |    |    |     |    |     |    |    |     |    |     |    |     |      |     |      |    |
| MKW20-48S051M |                              | 5.1                   | 4000           | 483        |               |            |                                      |                                |                            |                   | 15 | 1160 | 6.2 | 6800 | 88 |    |      |    |      |    |    |     |    |     |    |    |     |    |     |    |     |      |     |      |    |
| MKW20-48S12M  |                              | 12                    | 1670           | 469        |               |            |                                      |                                |                            |                   |    |      |     |      |    | 15 | 1160 | 15 | 1160 | 89 |    |     |    |     |    |    |     |    |     |    |     |      |     |      |    |
| MKW20-48S15M  |                              | 15                    | 1333           | 463        |               |            |                                      |                                |                            |                   |    |      |     |      |    |    |      |    |      |    | 18 | 750 | 18 | 750 | 90 |    |     |    |     |    |     |      |     |      |    |
| MKW20-48S24M  |                              | 24                    | 840            | 472        |               |            |                                      |                                |                            |                   |    |      |     |      |    |    |      |    |      |    |    |     |    |     |    | 27 | 295 | 27 | 295 | 89 |     |      |     |      |    |
| MKW20-48D12M  |                              | ±12                   | ±840           | 472        |               |            |                                      |                                |                            |                   |    |      |     |      |    |    |      |    |      |    |    |     |    |     |    |    |     |    |     |    | ±15 | 590# | ±15 | 590# | 89 |
| MKW20-48D15M  |                              | ±15                   | ±670           | 465        |               |            |                                      |                                |                            |                   |    |      |     |      |    |    |      |    |      |    |    |     |    |     |    |    |     |    |     |    |     |      |     |      |    |

# For each output

| Input Specifications              |   |                  |      |      |      |  |
|-----------------------------------|---|------------------|------|------|------|--|
| Parameter                         | Conditions/Model                        | Min.             | Typ. | Max. | Unit |  |
| Input Surge Voltage (100 ms 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                        | ---              | 7.5  | ---  |      |  |
|                                   | 24V Input Models                        | ---              | 15   | ---  |      |  |
|                                   | 48V Input Models                        | ---              | 33   | ---  |      |  |
| Start Up Time (Power On)          | Nominal Vin and Constant Resistive Load | ---              | ---  | 30   | ms   |  |
| Input Filter                      | All Models                              | Internal Pi Type |      |      |      |  |

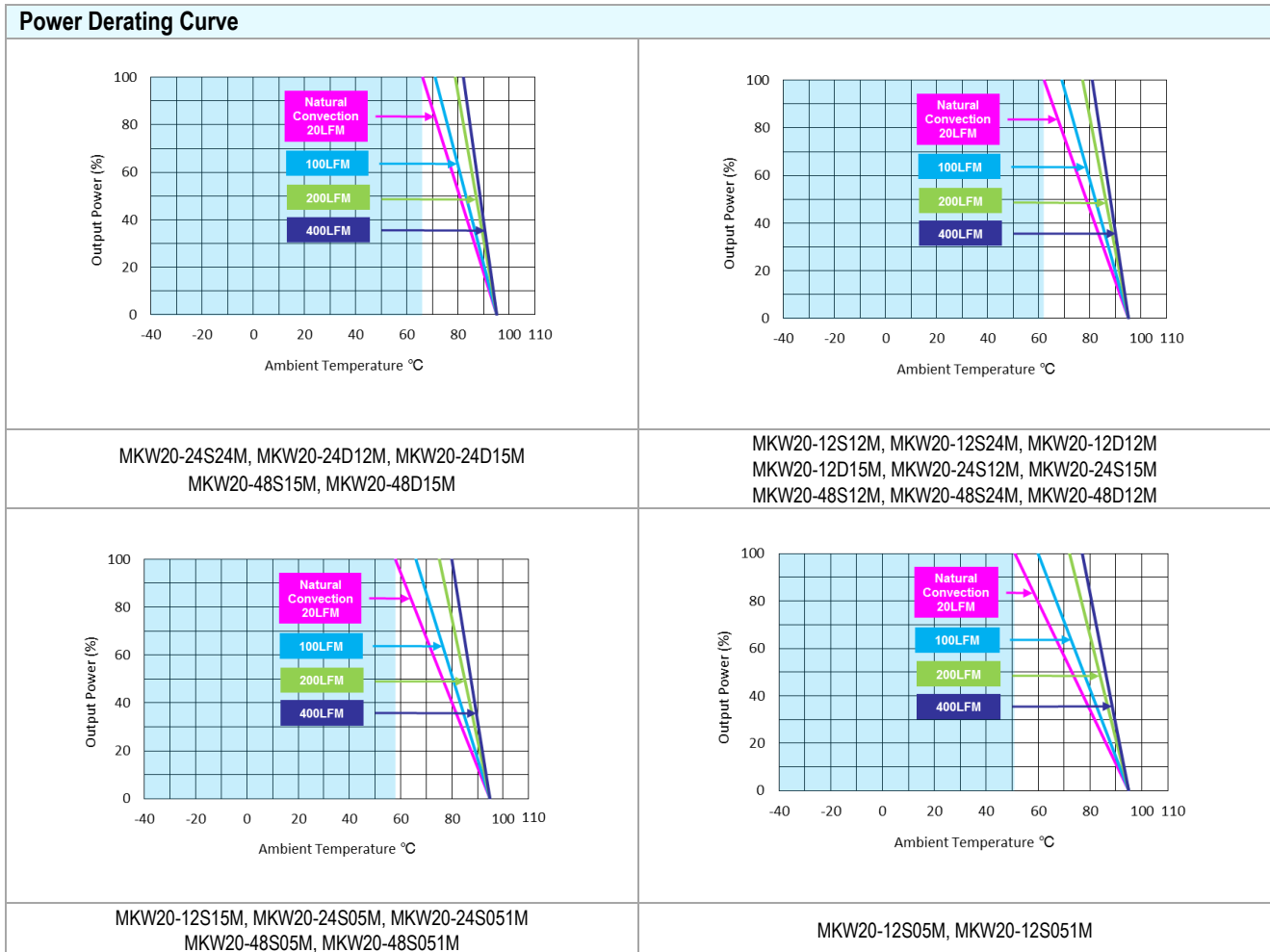
| Output Specifications           |   |                      |                              |       |        |     |                   |
|---------------------------------|---|----------------------|------------------------------|-------|--------|-----|-------------------|
| Parameter                       | Conditions/Model                            | Min.                 | Typ.                         | Max.  | Unit   |     |                   |
| Output Voltage Setting Accuracy |   | ---                  | ---                          | ±1.0  | %Vnom. |     |                   |
| Output Voltage Balance          | Dual Output, Balanced Loads                 | ---                  | ---                          | ±2.0  | %      |     |                   |
| Line Regulation                 | Vin=Min. to Max. @Full Load                 | ---                  | ---                          | ±0.5  | %      |     |                   |
| Load Regulation                 | Io=0% to 100%                               | Single Output        | ---                          | ---   | ±0.5   | %   |                   |
|                                 |   | Dual Output          | ---                          | ---   | ±1.0   | %   |                   |
| Minimum Load                    | No minimum Load Requirement                 |                      |                              |       |        |     |                   |
| Ripple & Noise                  | 0-20 MHz Bandwidth                          | 5V & 5.1Vo           | Measured with a MLCC : 4.7µF | ---   | 50     | --- | mV <sub>P-P</sub> |
|                                 |   | 12V,15V, ±12V, ±15Vo |                              | ---   | 100    | --- | mV <sub>P-P</sub> |
|                                 |   | 24Vo                 |                              | ---   | 150    | --- | mV <sub>P-P</sub> |
| Transient Recovery Time         | 25% Load Step Change <sub>(2)</sub>         | ---                  | ---                          | 300   | µsec   |     |                   |
| Transient Response Deviation    |   | ---                  | ±3                           | ±5    | %      |     |                   |
| Temperature Coefficient         |   | ---                  | ---                          | ±0.02 | %/°C   |     |                   |
| Over Load Protection            | Hiccup                                      | ---                  | 150                          | ---   | %      |     |                   |
| Short Circuit Protection        | Hiccup Mode 0.7 Hz typ., Automatic Recovery |                      |                              |       |        |     |                   |

| Isolation, Safety Standards |   |      |      |      |        |  |
|-----------------------------|---|------|------|------|--------|--|
| Parameter                   | Conditions  | Min. | Typ. | Max. | Unit   |  |
| I/O Isolation Voltage       | 60 Seconds<br>Reinforced insulation, rated for 300Vrms working voltage                                      | 4200 | ---  | ---  | VACrms |  |
| Leakage Current             | 240VAC, 60Hz  | ---  | ---  | 5    | µA     |  |
| I/O Isolation Resistance    | 500 VDC   | 10   | ---  | ---  | GΩ     |  |
| I/O Isolation Capacitance   | 100KHz, 1V  | ---  | ---  | 80   | pF     |  |
| Safety Standards            | ANSI/AAMI ES60601-1, CAN/CSA-C22.2 No. 60601-1<br>IEC/EN 60601-1 3 <sup>rd</sup> Edition 2xMOPP             |      |      |      |        |  |
| Safety Approvals            | ANSI/AAMI ES60601-1 2xMOPP recognition (UL certificate), IEC/EN 60601-1 3 <sup>rd</sup> Edition (CB-report) |      |      |      |        |  |

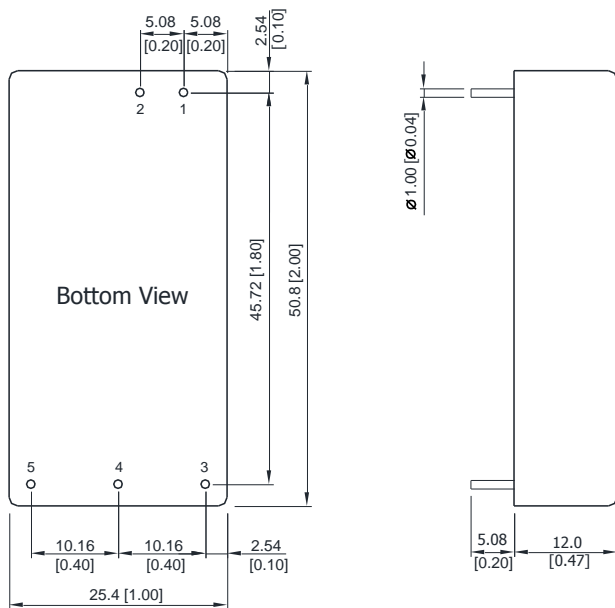
| General Specifications |                                   |           |      |      |       |  |
|------------------------|-----------------------------------|-----------|------|------|-------|--|
| Parameter              | Conditions                        | Min.      | Typ. | Max. | Unit  |  |
| Switching Frequency    |                                   | ---       | 285  | ---  | kHz   |  |
| MTBF(calculated)       | MIL-HDBK-217F@25°C, Ground Benign | 1,087,344 | ---  | ---  | Hours |  |

| Environmental Specifications   |  |      |      |          |
|--|--|------|------|----------|
| Parameter  | Conditions/Model   | Min. | Max. | Unit     |
| Operating Ambient Temperature Range<br>Natural Convection (6)<br>Nominal Vin, Load 100% Inom.<br>(for Power Derating see relative Derating Curves) | MKW20-24S24M, MKW20-24D12M, MKW20-24D15M<br>MKW20-48S15M, MKW20-48D15M   | -40  | 66   | °C       |
|  | MKW20-12S12M, MKW20-12S24M, MKW20-12D12M<br>MKW20-12D15M, MKW20-24S12M, MKW20-24S15M<br>MKW20-48S12M, MKW20-48S24M, MKW20-48D12M |      | 62   |          |
|  | MKW20-12S15M, MKW20-24S05M, MKW20-24S051M<br>MKW20-48S05M, MKW20-48S051M   |      | 58   |          |
|  | MKW20-12S05M, MKW20-12S051M  |      | 51   |          |
| Thermal Impedance  | Natural Convection   | 13.0 | ---  | °C/W     |
| Case Temperature   |  | ---  | +95  | °C       |
| Storage Temperature Range  |  | -50  | +125 | °C       |
| Humidity (non condensing)  |  | ---  | 95   | % rel. H |
| Altitude   |  | ---  | 4000 | M        |
| Cooling  | Natural Convection   |      |      |          |
| Lead Temperature (1.5mm from case for 10Sec.)  |  | ---  | 260  | °C       |

| EMC Specifications |                              |  |             |
|--------------------|------------------------------|--|-------------|
| Parameter          | Standards & Level            |  | Performance |
| EMI                | Conduction & Radiation       | EN 55011, FCC part 15                  | Class A     |
| EMS                | EN 60601-1-2 4 <sup>th</sup> |  |             |
|                    | ESD                          | EN 61000-4-2 Air ± 15kV, Contact ± 8kV | A           |
|                    | Radiated immunity            | EN 61000-4-3 10V/m                     | A           |
|                    | Fast transient (5)           | EN 61000-4-4 ±2kV                      | A           |
|                    | Surge (5)                    | EN 61000-4-5 ±1kV                      | A           |
|                    | Conducted immunity           | EN 61000-4-6 10Vrms                    | A           |
|                    | PFMF                         | EN 61000-4-8 30A/M                     | A           |


**Notes**

- 1 Specifications typical at  $T_a = +25^\circ\text{C}$ , 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 We recommend to protect the converter by a slow blow fuse in the input supply line.
- 4 Other input and output voltage may be available, please contact factory.
- 5 To meet EN 61000-4-4 & EN 61000-4-5 an external capacitor across the input pins is required. Suggested capacitor : 330 $\mu\text{F}$ /100V.
- 6 That "natural convection" is about 20LFM but is not equal to still air (0 LFM).
- 7 Specifications are subject to change without notice.

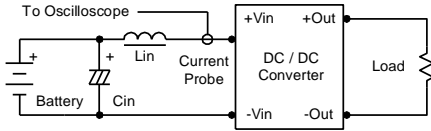
| <b>Package Specifications</b>   |   |             |               |             |   |      |      |   |      |      |   |       |       |   |        |        |   |       |       |
|---|---|-------------|---------------|-------------|---|------|------|---|------|------|---|-------|-------|---|--------|--------|---|-------|-------|
| <div style="border: 1px solid #ccc; padding: 5px;"> <p><b>Mechanical Dimensions</b></p>  <p style="text-align: center;">Bottom View</p> </div> | <div style="border: 1px solid #ccc; padding: 5px;"> <p><b>Pin Connections</b></p> <table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 15%;">Pin</th> <th style="width: 35%;">Single Output</th> <th style="width: 50%;">Dual Output</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>+Vin</td> <td>+Vin</td> </tr> <tr> <td>2</td> <td>-Vin</td> <td>-Vin</td> </tr> <tr> <td>3</td> <td>+Vout</td> <td>+Vout</td> </tr> <tr> <td>4</td> <td>No Pin</td> <td>Common</td> </tr> <tr> <td>5</td> <td>-Vout</td> <td>-Vout</td> </tr> </tbody> </table> <p style="margin-top: 10px;">                     ▶ All dimensions in mm (inches)<br/>                     ▶ Tolerance: X.X±0.5 (X.XX±0.02)<br/>                                       X.XX±0.25 ( X.XXX±0.01)<br/>                     ▶ Pin diameter <math>\varnothing 1.0 \pm 0.05</math> (0.04±0.002)                 </p> </div> | Pin         | Single Output | Dual Output | 1 | +Vin | +Vin | 2 | -Vin | -Vin | 3 | +Vout | +Vout | 4 | No Pin | Common | 5 | -Vout | -Vout |
| Pin   | Single Output   | Dual Output |               |             |   |      |      |   |      |      |   |       |       |   |        |        |   |       |       |
| 1   | +Vin  | +Vin        |               |             |   |      |      |   |      |      |   |       |       |   |        |        |   |       |       |
| 2   | -Vin  | -Vin        |               |             |   |      |      |   |      |      |   |       |       |   |        |        |   |       |       |
| 3   | +Vout   | +Vout       |               |             |   |      |      |   |      |      |   |       |       |   |        |        |   |       |       |
| 4   | No Pin  | Common      |               |             |   |      |      |   |      |      |   |       |       |   |        |        |   |       |       |
| 5   | -Vout   | -Vout       |               |             |   |      |      |   |      |      |   |       |       |   |        |        |   |       |       |

| <b>Physical Characteristics</b> |   |
|---------------------------------|---|
| Case Size                       | : 50.8x25.4x12.0mm (2.0x1.0x0.47 inches)                        |
| Case Material                   | : Non-Conductive Black Plastic (flammability to UL 94V-0 rated) |
| Pin Material                    | : Tinned Copper   |
| Weight                          | : 30g   |

## Test Setup

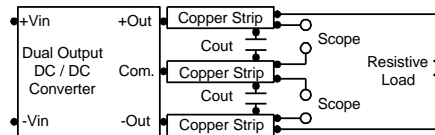
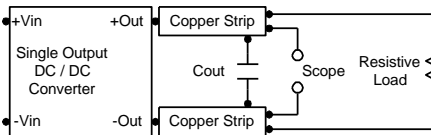
### Input Reflected-Ripple Current Test Setup

Input reflected-ripple current is measured with an inductor  $L_{in}$  ( $4.7\mu H$ ) and  $C_{in}$  ( $220\mu F$ ,  $ESR < 1.0\Omega$  at 100 KHz) to simulate source impedance. Capacitor  $C_{in}$  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  $C_{out}$   $4.7\mu F$  ceramic 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

### Overload Protection

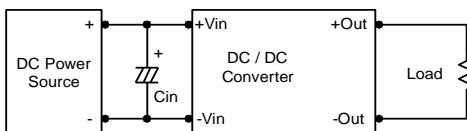
To provide hiccup mode protection in a fault (output overload) condition, the unit is equipped with internal current limiting circuitry and can endure overload for an unlimited duration.

### 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.

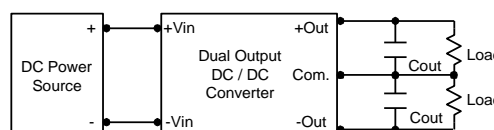
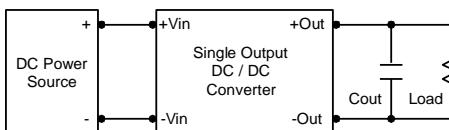
### Input Source Impedance

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 on the input to insure startup. By using a good quality low Equivalent Series Resistance ( $ESR < 1.0\Omega$  at 100 kHz) capacitor of a  $10\mu F$  for the 12V input devices and a  $4.7\mu F$  for the 24V input devices and a  $2.2\mu F$  for the 48V devices, capacitor mounted close to the power module helps ensure stability of the unit.



### 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  $4.7\mu F$  capacitors at the output.



### Maximum Capacitive Load

The MKW20M series has limitation of maximum connected capacitance on the output. The power module may operate in current limiting mode during start-up, affecting the ramp-up and the startup time. Connect capacitors at the point of load for best performance. 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  $95^{\circ}C$ . The derating curves are determined from measurements obtained in a test setup.

