

**FEATURES**

- ▶ Smallest encapsulated 50W Converter
- ▶ Package Size 2.0"x 1.0"x 0.4"
- ▶ Ultra-Wide 4:1 Input Range
- ▶ Excellent Efficiency up to 92%
- ▶ Output Current Up To 10A
- ▶ I/O-isolation Voltage 1500VDC
- ▶ Under- Voltage Shutdown
- ▶ Over Load and Over Voltage Protection
- ▶ Shielded Metal Case with Isolated Baseplate
- ▶ CSA/UL/IEC/EN 60950-1 (Approval pending)
- ▶ Heatsink (Optional)
- ▶ 3 Years Product Warranty



**PRODUCT OVERVIEW**

The MINMAX MKW150 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 ultra-wide 4:1 input voltage range and precisely regulated output voltages.

A very high efficiency up to 92% which allows an operating temperature range of -40°C to +80°C is achieved by advanced circuit topology. 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) VDC	Output Voltage VDC	Output Current	Input Current		Reflected Ripple Current mA(typ.)	Over Voltage Protection VDC	Max. capacitive Load µF	Efficiency (typ.)
			Max.	@Max. Load	@No Load				@Max. Load
			mA	mA(typ.)	mA(typ.)				%
MKW150-24S033	24 (9 ~ 36)	3.3	10000	1528	80	40	3.9	26000	90
MKW150-24S05		5	10000	2290	60		6.2	17000	91
MKW150-24S12		12	4170	2267	80		15	3000	92
MKW150-24S15		15	3330	2263	80		18	2000	92
MKW150-24S24		24	2080	2286	80		30	750	91
MKW150-48S033	48 (18 ~ 75)	3.3	10000	764	40	30	3.9	26000	90
MKW150-48S05		5	10000	1145	30		6.2	17000	91
MKW150-48S12		12	4170	1134	60		15	3000	92
MKW150-48S15		15	3330	1134	60		18	2000	92
MKW150-48S24		24	2080	1143	50		30	750	91

**Input Specifications**

Parameter	Model	Min.	Typ.	Max.	Unit
Input Surge Voltage (100ms. max)	24V Input Models	-0.7	---	50	VDC
	48V Input Models	-0.7	---	100	
Start-Up Threshold Voltage	24V Input Models	---	---	9	
	48V Input Models	---	---	18	
Under Voltage Lockout	24V Input Models	---	7.5	---	
	48V Input Models	---	16	---	
Input Polarity Protection	None				
Start Up Time	Power Up	---	---	30	ms
	Remote On/Off	Nominal Vin and Constant Resistive Load	---	---	30
Internal Filter Type	All Models	LC Filter (for EN55022, Class A compliance see Page 6)			
Short Circuit Current	--- (Hiccup Mode 0.3 Hz typ.)				

**Output Specifications**

Parameter	Conditions	Min.	Typ.	Max.	Unit
Output Voltage Setting Accuracy	At 50% Load and Nominal Vin	---	---	±1.0	%Vnom.
Line Regulation	Vin=Min. to Max. @Full Load	---	---	±0.5	%
Load Regulation	Min. Load to Full Load	---	---	±0.5	%
Minimum Load	No minimum Load Requirement				
Ripple & Noise (20MHz bandwidth)	3.3V & 5V Models <sup>(3)</sup>	---	100	---	mV <sub>P-P</sub>
	12V, 15V & 24V Models <sup>(3)</sup>	---	150	---	mV <sub>P-P</sub>
Transient Recovery Time	25% Load Step Change <sup>(2)</sup>	---	250	---	µsec
Temperature Coefficient		---	---	±0.02	%/°C
Over Load Protection	Current Limitation at 150% typ. of Iout max., Hiccup				
Short Circuit Protection	Hiccup Automatic Recovery				
Over Voltage Protection	For Shutdown Voltage see Model Selection Guide				

**General Specifications**

Parameter	Conditions	Min.	Typ.	Max.	Unit
I/O Isolation Voltage (rated)	60 Seconds	1500	---	---	VDC
I/O Isolation Resistance	500 VDC	1000	---	---	MΩ
I/O Isolation Capacitance	100KHz, 1V	---	---	2200	pF
Switching Frequency		---	285	---	KHz
MTBF(calculated)	MIL-HDBK-217F@25°C, Ground Benign	233,500	---	---	Hours
Safety Approvals(pending)	UL/cUL 60950-1 recognition(CSA certificate), IEC/EN 60950-1(CB-scheme)				

**Input Fuse**

24V Input Models	48V Input Models
10000mA Slow-Blow Type	5000mA Slow-Blow 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 Voltage Trim**

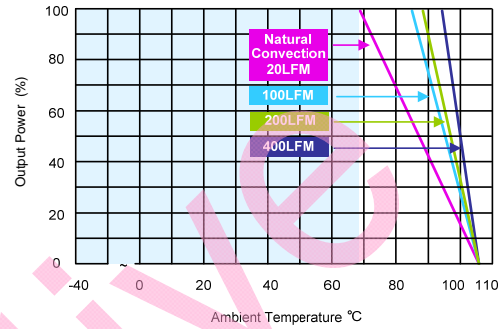
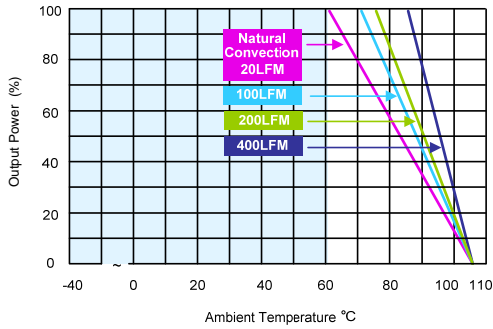
Parameter	Conditions	Min.	Typ.	Max.	Unit
Trim Up / Down Range <sup>(8)</sup>	% of nominal output voltage (24Vo Models)	+20 / -10	---	---	%
	% of nominal output voltage (Other Models)	±10	---	---	%

**Environmental Specifications**

Parameter	Model	Min.	Max.		Unit
			without Heatsink	with Heatsink	
Operating Ambient Temperature Range (Natural Convection, see Derating)	MKW150-24S033, MKW150-48S033	-40	61	69	°C
	MKW150-24S12, MKW150-24S15		53	62	
	MKW150-48S12, MKW150-48S15				
	MKW150-24S05, MKW150-24S24		46	57	
	MKW150-48S05, MKW150-48S24				
Thermal Impedance	Natural Convection without Heatsink	12.1	---	---	°C/W
	Natural Convection with Heatsink	9.8	---	---	°C/W
	100LFM Convection without Heatsink	9.2	---	---	°C/W
	100LFM Convection with Heatsink	5.4	---	---	°C/W
	200LFM Convection without Heatsink	7.8	---	---	°C/W
	200LFM Convection with Heatsink	4.5	---	---	°C/W
	400LFM Convection without Heatsink	5.2	---	---	°C/W
400LFM Convection with Heatsink	3.0	---	---	°C/W	
Case Temperature		---	+105		°C
Thermal Protection	Shutdown Temperature		110°C typ.		
Storage Temperature Range		-50	+125		°C
Humidity (non condensing)		---	95		% rel. H
RFI	Six-Sided Shielded, Metal Case				
Lead Temperature (1.5mm from case for 10Sec.)		---	260		°C

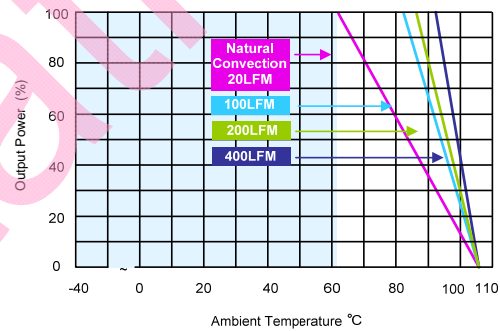
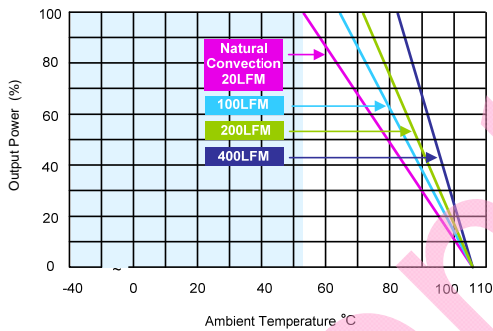
**EMC Specifications**

Parameter	Standards & Level	Performance
EMI	EN55022	Class A (See Page 6)
ESD	EN61000-4-2 air $\pm$ 8KV , Contact $\pm$ 6KV	Perf. Criteria A
Radiated immunity	EN61000-4-3 10V/m	Perf. Criteria A
Fast transient (See Note 7)	EN61000-4-4 $\pm$ 2KV	Perf. Criteria A
Surge (See Note 7)	EN61000-4-5 $\pm$ 1KV	Perf. Criteria A
Conducted immunity	EN61000-4-6 10V/m	Perf. Criteria A

**Power Derating Curve**


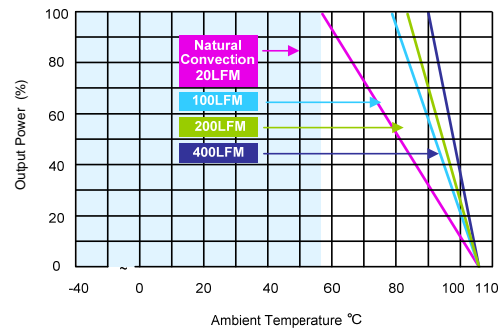
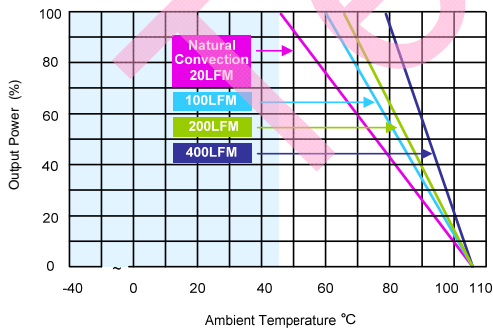
MKWI50-24S033, MKWI50-48S033 Derating Curve without Heatsink

MKWI50-24S033, MKWI50-48S033 Derating Curve with Heatsink



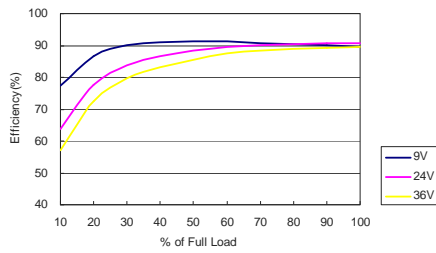
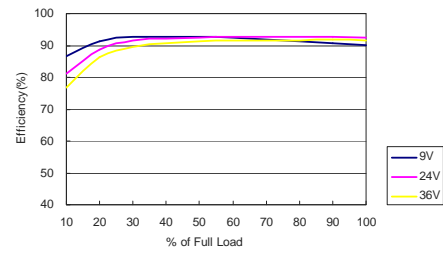
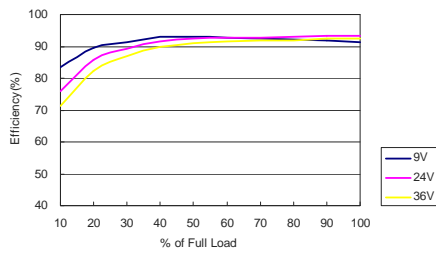
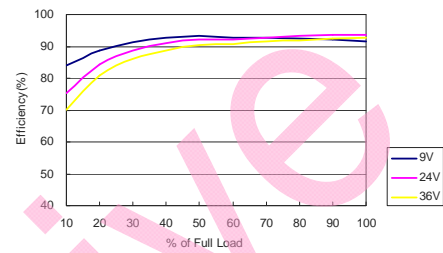
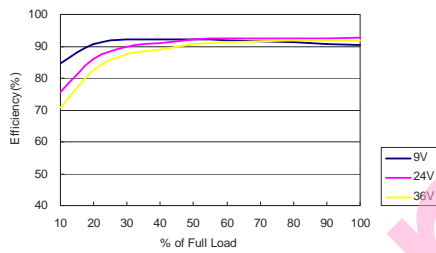
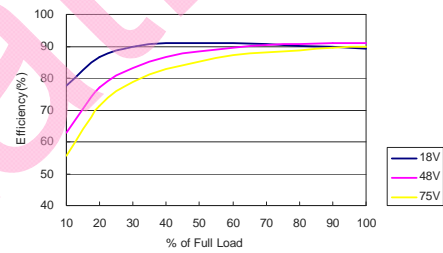
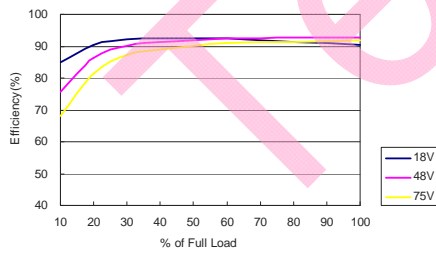
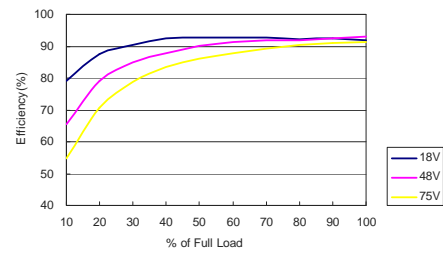
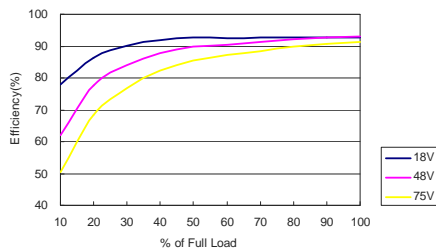
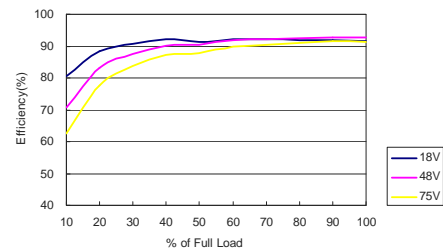
MKWI50-24S12, MKWI50-24S15, MKWI50-48S12, MKWI50-48S15 Derating Curve without Heatsink

MKWI50-24S12, MKWI50-24S15, MKWI50-48S12, MKWI50-48S15 Derating Curve with Heatsink

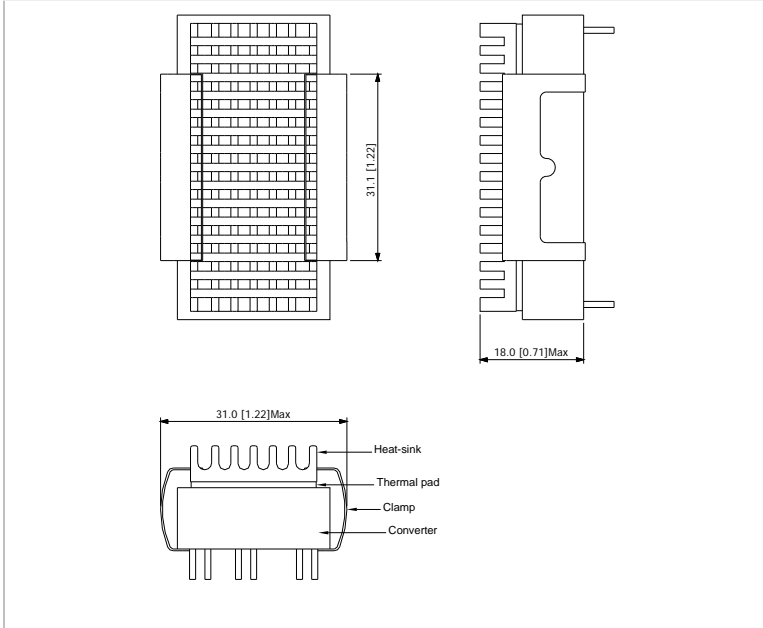


MKWI50-24S05, MKWI50-24S24, MKWI50-48S05, MKWI50-48S24 Derating Curve without Heatsink

MKWI50-24S05, MKWI50-24S24, MKWI50-48S05, MKWI50-48S24 Derating Curve with Heatsink

**Efficiency Curve @25°C**

**MKWI50-24S033 Efficiency vs Load Current**

**MKWI50-24S05 Efficiency vs Load Current**

**MKWI50-24S12 Efficiency vs Load Current**

**MKWI50-24S15 Efficiency vs Load Current**

**MKWI50-24S24 Efficiency vs Load Current**

**MKWI50-48S033 Efficiency vs Load Current**

**MKWI50-48S05 Efficiency vs Load Current**

**MKWI50-48S12 Efficiency vs Load Current**

**MKWI50-48S15 Efficiency vs Load Current**

**MKWI50-48S24 Efficiency vs Load Current**



**Heatsink (Option -HS)**

**Physical Characteristics**

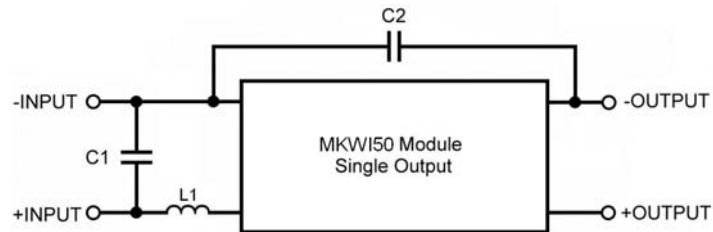
Heatsink Material	: Aluminum
Finish	: Black Anodized Coating
Weight	: 9g

**► The advantages of adding a heatsink are:**

1. To help heat dissipation and increase the stability and reliability of DC/DC converters at high operating temperature atmosphere.
2. To upgrade the operating temperature of DC/DC converters, please refer to Derating Curve.

**EMI-Filter to meet EN 55022, class A; FCC part 15 ,level A**

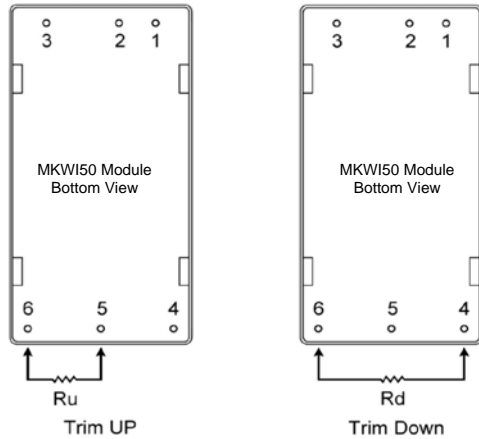
Conducted and radiated emissions EN55022 Class A



Part No.	MKW150-24SXX	MKW150-48SXX
C1	10 $\mu$ F/50V 1210 X7S MLCC	3.3 $\mu$ F/100V 1210 X7S MLCC
C2	1000pF/2KV 1206 MLCC	1000pF/2KV 1206 MLCC
L1	SMTDR54-1R5M-JT8	SMTDR54-6R8M-JT8

**External Output Trimming**

Output can be externally trimmed by using the method shown below



MKWI50-XXS033 Trim Table

Trim down	1	2	3	4	5	6	7	8	9	10	%
Vout=	Vox0.99	Vox0.98	Vox0.97	Vox0.96	Vox0.95	Vox0.94	Vox0.93	Vox0.92	Vox0.91	Vox0.90	Volts
Rd=	63.59	30.28	18.19	11.95	8.13	5.56	3.70	2.31	1.21	0.34	KOhms
Trim up	1	2	3	4	5	6	7	8	9	10	%
Vout=	Vox1.01	Vox1.02	Vox1.03	Vox1.04	Vox1.05	Vox1.06	Vox1.07	Vox1.08	Vox1.09	Vox1.10	Volts
Ru=	70.50	29.28	16.87	10.90	7.38	5.06	3.42	2.20	1.25	0.49	KOhms

MKWI50-XXS05 Trim Table

Trim down	1	2	3	4	5	6	7	8	9	10	%
Vout=	Vox0.99	Vox0.98	Vox0.97	Vox0.96	Vox0.95	Vox0.94	Vox0.93	Vox0.92	Vox0.91	Vox0.90	Volts
Rd=	45.53	20.61	12.31	8.15	5.66	4.00	2.81	1.92	1.23	0.68	KOhms
Trim up	1	2	3	4	5	6	7	8	9	10	%
Vout=	Vox1.01	Vox1.02	Vox1.03	Vox1.04	Vox1.05	Vox1.06	Vox1.07	Vox1.08	Vox1.09	Vox1.10	Volts
Ru=	36.57	16.58	9.92	6.59	4.59	3.25	2.30	1.59	1.03	0.59	KOhms

MKWI50-XXS12 Trim Table

Trim down	1	2	3	4	5	6	7	8	9	10	%
Vout=	Vox0.99	Vox0.98	Vox0.97	Vox0.96	Vox0.95	Vox0.94	Vox0.93	Vox0.92	Vox0.91	Vox0.90	Volts
Rd=	394.50	179.74	106.08	68.86	46.39	31.36	20.60	12.51	6.21	1.17	KOhms
Trim up	1	2	3	4	5	6	7	8	9	10	%
Vout=	Vox1.01	Vox1.02	Vox1.03	Vox1.04	Vox1.05	Vox1.06	Vox1.07	Vox1.08	Vox1.09	Vox1.10	Volts
Ru=	368.92	161.92	94.97	61.86	42.12	29.00	19.66	12.66	7.23	2.89	KOhms

MKWI50-XXS15 Trim Table

Trim down	1	2	3	4	5	6	7	8	9	10	%
Vout=	Vox0.99	Vox0.98	Vox0.97	Vox0.96	Vox0.95	Vox0.94	Vox0.93	Vox0.92	Vox0.91	Vox0.90	Volts
Rd=	572.67	248.63	145.60	94.97	64.87	44.92	30.72	20.10	11.86	5.28	KOhms
Trim up	1	2	3	4	5	6	7	8	9	10	%
Vout=	Vox1.01	Vox1.02	Vox1.03	Vox1.04	Vox1.05	Vox1.06	Vox1.07	Vox1.08	Vox1.09	Vox1.10	Volts
Ru=	392.98	182.12	108.73	71.43	48.85	33.71	22.86	14.69	8.33	3.23	KOhms

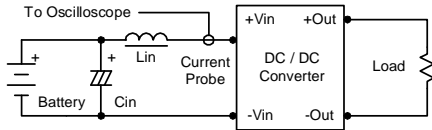
MKWI50-XXS24 Trim Table

Trim down	1	2	3	4	5	6	7	8	9	10	%
Vout=	Vox0.99	Vox0.98	Vox0.97	Vox0.96	Vox0.95	Vox0.94	Vox0.93	Vox0.92	Vox0.91	Vox0.90	Volts
Rd=	318.05	146.05	85.8	55.51	37.415	25.625	16.515	9.81	4.9785	0.9185	KOhms
Trim up	2	4	6	8	10	12	14	16	18	20	%
Vout=	Vox1.02	Vox1.04	Vox1.06	Vox1.08	Vox1.1	Vox1.12	Vox1.14	Vox1.16	Vox1.18	Vox1.20	Volts
Ru=	247.2	109.255	63.38	39.025	27.52	18.39	11.77	7.29	3.308	0.3658	KOhms

## Test Setup

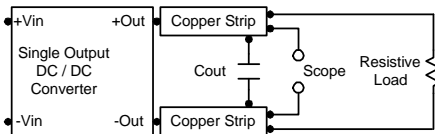
### Input Reflected-Ripple Current Test Setup

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 1 $\mu$ F ceramic capacitor and a 10 $\mu$ F 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 -100 $\mu$ A.

### Overcurrent Protection

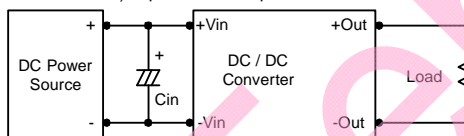
To provide hiccup mode protection in a fault (output overload) condition, the unit is equipped with internal current limiting circuitry and can endure overload for an unlimited duration.

### 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.

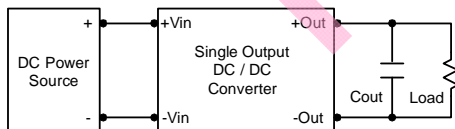
### Input Source Impedance

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 < 1.0  $\Omega$  at 100 KHz) capacitor of a 10 $\mu$ F 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 4.7 $\mu$ F capacitors at the output.



### Maximum Capacitive Load

The MKW150 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 $^{\circ}$ C. The derating curves are determined from measurements obtained in a test setup.

