

**FEATURES**

- ▶ Smallest Encapsulated 40W Converter
- ▶ Ultra-compact 2" X 1" Package
- ▶ Ultra-wide 4:1 Input Voltage Range
- ▶ Fully Regulated Output Voltage
- ▶ Excellent Efficiency up to 91%
- ▶ I/O Isolation 1500 VDC
- ▶ Operating Ambient Temp. Range -40°C to +80°C
- ▶ 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


**PRODUCT OVERVIEW**

The MINMAX MKW140 series is the latest generation of high performance DC-DC converter modules setting a new standard concerning power density. The product offers fully 40W 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.

Advanced circuit topology provides a very high efficiency up to 91% which allows an operating temperature range of -40°C to +80°C. Further features include remote On/Off, trimmable output voltage, under-voltage lockout 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. Load %
			Max. mA	Min. mA	@Max. Load mA(typ.)	@No Load mA(typ.)				
MKW140-24S033	24 (9 ~ 36)	3.3	8000	0	1240	90	30	3.9	21000	89
MKW140-24S05		5	8000	0	1850	90		6.2	13600	90
MKW140-24S12		12	3330	0	1870	95		15	2400	89
MKW140-24S15		15	2670	0	1870	105		18	1500	89
MKW140-24S24		24	1670	0	1835	115		30	600	91
MKW140-24D12		±12	±1670	±145	1890	65		±15	1200#	88
MKW140-24D15		±15	±1330	±110	1890	65		±18	750#	88
MKW140-48S033		48 (18 ~ 75)	3.3	8000	0	620		55	20	3.9
MKW140-48S05	5		8000	0	930	55	6.2	13600		90
MKW140-48S12	12		3330	0	930	60	15	2400		90
MKW140-48S15	15		2670	0	930	65	18	1500		90
MKW140-48S24	24		1670	0	918	75	30	600		91
MKW140-48D12	±12		±1670	±145	950	45	±15	1200#		88
MKW140-48D15	±15		±1330	±110	950	45	±18	750#		88

# For each output

**Input Specifications**

Parameter	Conditions / 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	---	8.3	---	
	48V Input Models	---	16.5	---	
Start Up Time (Power On)	Nominal Vin and Constant Resistive Load	---	---	30	ms
Input Filter	All Models	Internal LC Type			

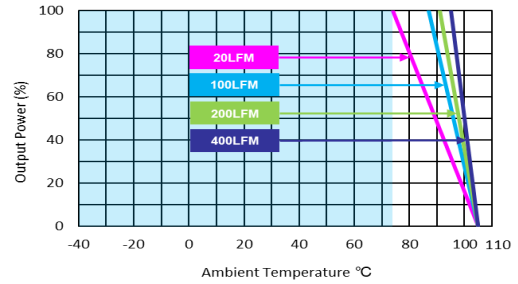
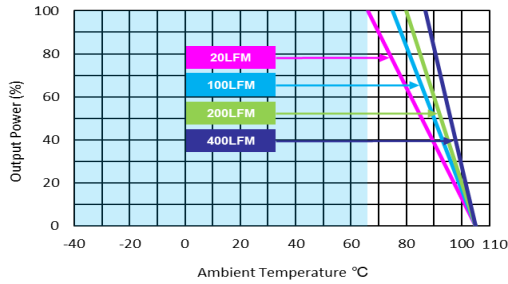
Remote On/Off Control						
Parameter	Conditions	Min.	Typ.	Max.	Unit	
Converter On	3.5V ~ 12V or Open Circuit					
Converter Off	0V ~ 1.2V or Short Circuit					
Control Input Current (on)	Vctrl = 5.0V	---	0.5	---	mA	
Control Input Current (off)	Vctrl = 0V	---	-0.5	---	mA	
Control Common	Referenced to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

Output Specifications						
Parameter	Conditions / Model	Min.	Typ.	Max.	Unit	
Output Voltage Setting Accuracy	---					
Output Voltage Balance	Dual Output, Balanced Loads	---	---	±2.0	%	
Line Regulation	Vin=Min. to Max. @Full Load	---	---	±0.5	%	
Load Regulation	Min. Load to Full Load	Single Output	---	---	±0.5	%
		Dual Output	---	---	±1.0	%
Load Cross Regulation (Dual Output)	Asymmetrical Load 25%/100% Full Load	---	---	±5.0	%	
Minimum Load	No Minimum Load Requirement for Single Output Models, for dual Output Models see Table					
Ripple & Noise	0-20 MHz Bandwidth	3.3V & 5V Models	---	---	100	mV <sub>p-p</sub>
		12V, 15V & 24V Models	---	---	150	mV <sub>p-p</sub>
		Dual Output Models	---	---	150	mV <sub>p-p</sub>
Transient Recovery Time	25% Load Step Change		---	250	---	µsec
Transient Response Deviation			---	±3	±5	%
Temperature Coefficient			---	---	±0.02	%/°C
Trim Up / Down Range (See Page 8)	% of Nominal Output Voltage	24Vo Models	---	---	+20 / -10	%
		Other Models	---	---	±10	
Over Load Protection	Current Limitation at 150% typ. of Iout max., Hiccup					
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 Seconds	1800	---	---	VDC	
I/O Isolation Resistance	500 VDC	1000	---	---	MΩ	
I/O Isolation Capacitance	100kHz, 1V	---	---	1500	pF	
Switching Frequency	24Vo Models	---	285	---	kHz	
	Other Models	---	320	---	kHz	
MTBF(calculated)	MIL-HDBK-217F@25°C, Ground Benign	328,000			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)					

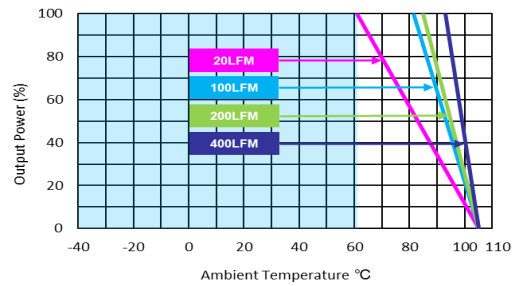
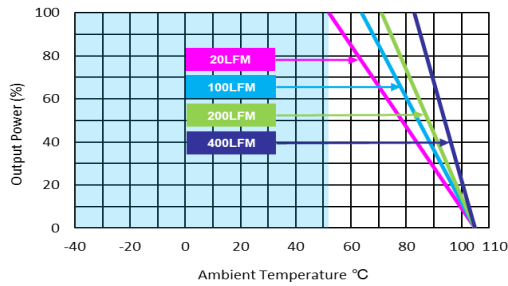
EMC Specifications				
Parameter	Standards & Level			Performance
EMI	Conduction	EN55032, FCC part 15	With external components	Class A
	Radiation			
EMS	EN55024			
	ESD	EN61000-4-2 air $\pm$ 8kV , Contact $\pm$ 6kV		A
	Radiated immunity	EN61000-4-3 10V/m		A
	Fast transient (7)	EN61000-4-4 $\pm$ 2kV		A
	Surge (7)	EN61000-4-5 $\pm$ 1kV		A
	Conducted immunity	EN61000-4-6 10Vrms		A
	PFMF	EN61000-4-8 3A/m		A

Environmental Specifications					
Parameter	Conditions / Model	Min.	Max.		Unit
			without Heatsink	with Heatsink	
Operating Ambient Temperature Range Nominal Vin, Load 100% Inom. (for Power Derating see relative Derating Curves)	MKWI40-XXS033	-40	66	73	°C
	MKWI40-24S05, MKWI40-48S05		51	61	
	MKWI40-48S12, MKWI40-48S15				
	MKWI40-24S12, MKWI40-24S15		45	57	
	MKWI40-24S24, MKWI40-48S24		57	66	
	MKWI40-24D12, MKWI40-24D15 MKWI40-48D12, MKWI40-48D15		40	52	
Thermal Impedance	20LFM Convection without Heatsink	12.0	---	---	°C/W
	20LFM Convection with Heatsink	10.0	---	---	°C/W
	100LFM Convection without Heatsink	9.0	---	---	°C/W
	100LFM Convection with Heatsink	5.4	---	---	°C/W
	200LFM Convection without Heatsink	8.0	---	---	°C/W
	200LFM Convection with Heatsink	4.5	---	---	°C/W
	400LFM Convection without Heatsink	6.0	---	---	°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

**Power Derating Curve**


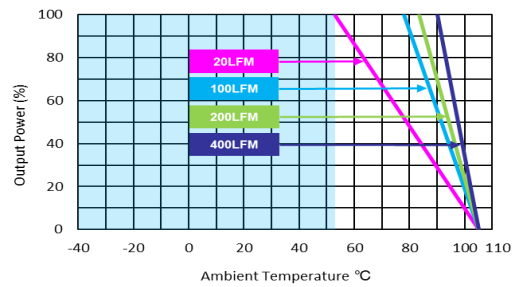
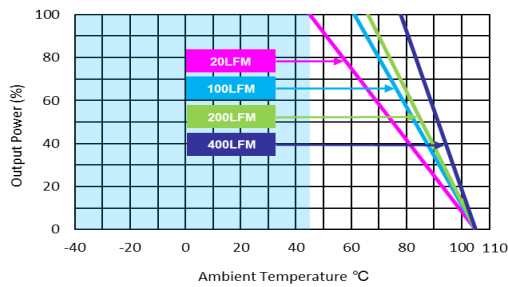
MKWI40-24S033, MKWI40-48S033 Derating Curve without Heatsink

MKWI40-24S033, MKWI40-48S033 Derating Curve with Heatsink



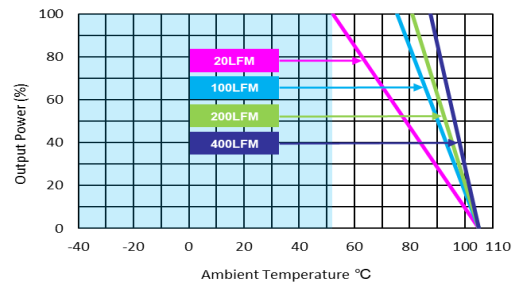
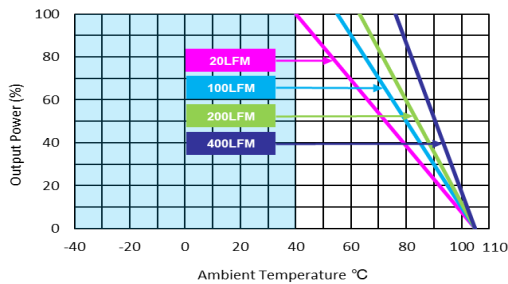
MKWI40-24S05, MKWI40-48S05, MKWI40-48S12, MKWI40-48S15 Derating Curve without Heatsink

MKWI40-24S05, MKWI40-48S05, MKWI40-48S12, MKWI40-48S15 Derating Curve with Heatsink



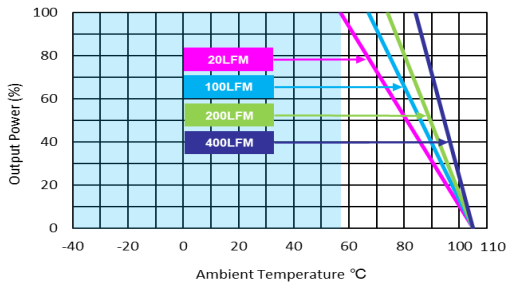
MKWI40-24S12, MKWI40-24S15 Derating Curve without Heatsink

MKWI40-24S12, MKWI40-24S15 Derating Curve with Heatsink

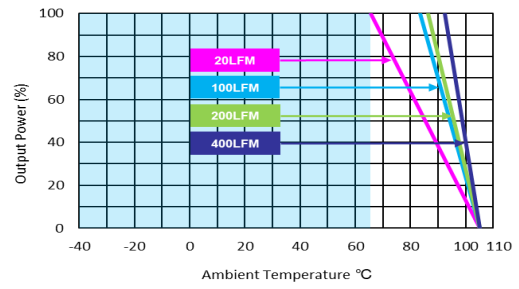


MKWI40-24D12, MKWI40-24D15, MKWI40-48D12, MKWI40-48D15 Derating Curve without Heatsink

MKWI40-24D12, MKWI40-24D15, MKWI40-48D12, MKWI40-48D15 Derating Curve with Heatsink

**Power Derating Curve**


MKWI40-24S24,MKWI40-48S24 Derating Curve without Heatsink



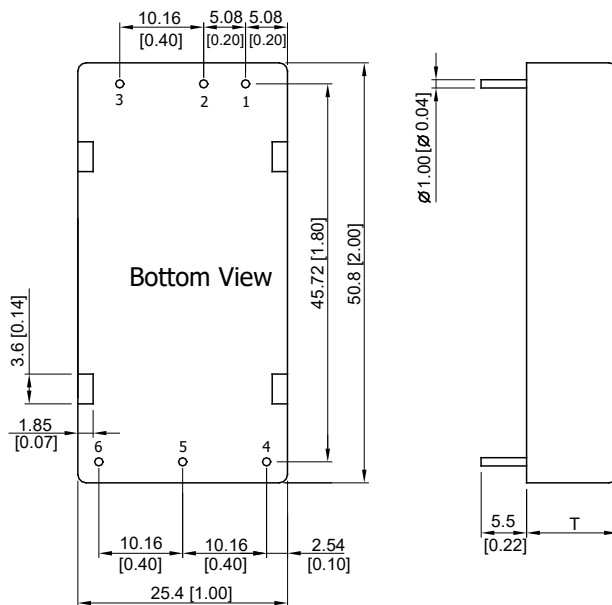
MKWI40-24S24,MKWI40-48S24 Derating Curve with Heatsink

**Notes**

- 1 Specifications typical at Ta=+25°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 Ripple & Noise measurement with a 1μF M/C and a 10μF T/C.
- 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 factory.
- 6 Part Number for heat sink only: MK-HS2 for 24Vo & MK-HS1 for others type.
- 7 To meet EN61000-4-4 & EN61000-4-5 an external capacitor across the input pins is required. Suggested capacitor : 330μF/100V.
- 8 Do not exceed maximum power specification when adjusting output voltage.
- 9 Specifications are subject to change without notice.

**Package Specifications**

## Mechanical Dimensions



## Pin Connections

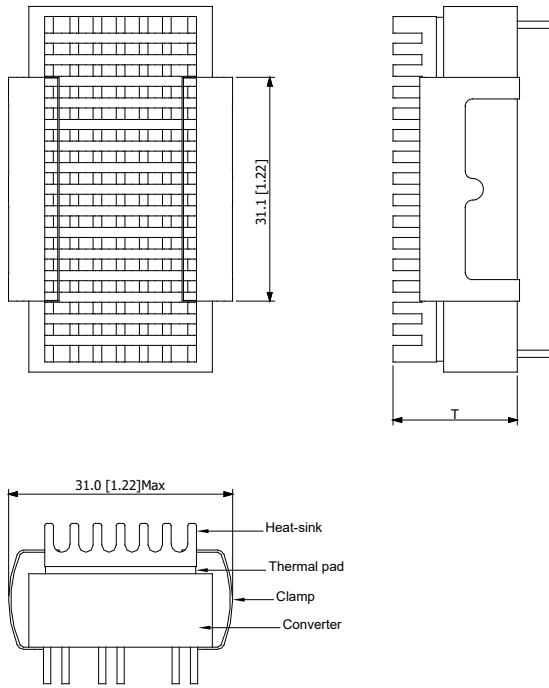
Pin	Single Output	Dual Output
1	+Vin	+Vin
2	-Vin	-Vin
3	Remote On/Off	Remote On/Off
4	+Vout	+Vout
5	-Vout	Common
6	Trim	-Vout

T: 11.0mm(0.43 inch) for 24V Output Models  
 T: 10.2mm(0.40 inch) for Other Output Models

- ▶ All dimensions in mm (inches)
- ▶ Tolerance: X.X±0.25 (X.XX±0.01)  
 X.XX±0.13 (X.XXX±0.005)
- ▶ Pin diameter  $\varnothing$  1.0 ±0.05 (0.04±0.002)

**Physical Characteristics**

Case Size (24V Output)	: 50.8x25.4x11.0mm (2.0x1.0x0.43 inches)
Case Size (Other Output)	: 50.8x25.4x10.2mm (2.0x1.0x0.40 inches)
Case Material	: Aluminium Alloy, Black Anodized Coating
Base Material	: FR4 PCB (flammability to UL 94V-0 rated)
Pin Material	: Copper Alloy with Gold Plate Over Nickel Subplate
Weight	: 30g

**Heatsink (Option -HS)**

**Physical Characteristics**

Heatsink Material : Aluminum

Finish : Black Anodized Coating

Weight : 9g

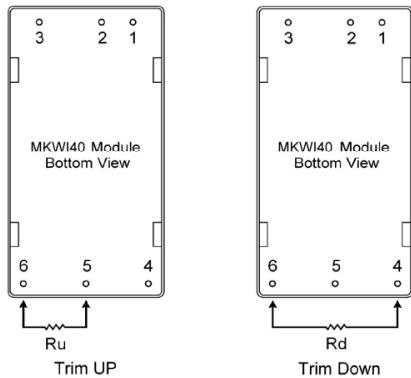
T: 18.0mm(0.71 inch) for 24V Output Models  
 T: 17.2mm(0.68 inch) for Other Output Models

► 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



MKWI40-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=	72.61	32.55	19.20	12.52	8.51	5.84	3.94	2.51	1.39	0.50	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=	60.84	27.40	16.25	10.68	7.34	5.11	3.51	2.32	1.39	0.65	KOhms

MKWI40-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=	138.88	62.41	36.92	24.18	16.53	11.44	7.79	5.06	2.94	1.24	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=	106.87	47.76	28.06	18.21	12.30	8.36	5.55	3.44	1.79	0.48	KOhms

MKWI40-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=	413.55	184.55	108.22	70.05	47.15	31.88	20.98	12.80	6.44	1.35	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=	351.00	157.50	93.00	60.75	41.40	28.50	19.29	12.37	7.00	2.70	KOhms

MKWI40-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=	530.73	238.61	141.24	92.56	63.35	43.87	29.96	19.53	11.41	4.92	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=	422.77	189.89	112.26	73.44	50.15	34.63	23.54	15.22	8.75	3.58	KOhms

MKWI40-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=	333.39	148.80	87.26	56.50	38.04	25.73	16.94	10.35	5.22	1.12	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	Vox1.2	Volts
Ru=	243.70	108.50	63.43	40.90	27.38	18.37	11.93	7.10	3.34	0.34	KOhms

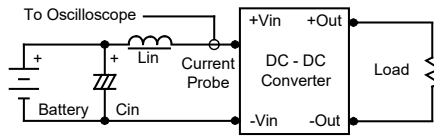


Order Code Table		
Standard	With heatsink	Without Remote On/Off
MKWI40-24S033	MKWI40-24S033-HS	MKWI40-24S033-N
MKWI40-24S05	MKWI40-24S05-HS	MKWI40-24S05-N
MKWI40-24S12	MKWI40-24S12-HS	MKWI40-24S12-N
MKWI40-24S15	MKWI40-24S15-HS	MKWI40-24S15-N
MKWI40-24S24	MKWI40-24S24-HS	MKWI40-24S24-N
MKWI40-24D12	MKWI40-24D12-HS	MKWI40-24D12-N
MKWI40-24D15	MKWI40-24D15-HS	MKWI40-24D15-N
MKWI40-48S033	MKWI40-48S033-HS	MKWI40-48S033-N
MKWI40-48S05	MKWI40-48S05-HS	MKWI40-48S05-N
MKWI40-48S12	MKWI40-48S12-HS	MKWI40-48S12-N
MKWI40-48S15	MKWI40-48S15-HS	MKWI40-48S15-N
MKWI40-48S24	MKWI40-48S24-HS	MKWI40-48S24-N
MKWI40-48D12	MKWI40-48D12-HS	MKWI40-48D12-N
MKWI40-48D15	MKWI40-48D15-HS	MKWI40-48D15-N

## Test Setup

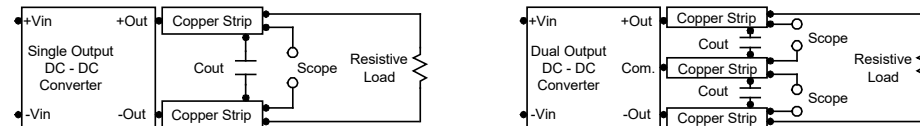
### Input Reflected-Ripple Current Test Setup

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 4.7V to 12V. The maximum sink current at the on/off terminal (Pin 3) during a logic low is  $-100\mu A$ . The maximum allowable leakage current of a switch connected to the on/off terminal (Pin 3) at logic high (2.5V to 100V) is  $5\mu A$ .

### Overcurrent Protection

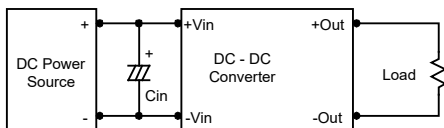
To provide hiccup mode protection in a fault (output overload) condition, the unit is equipped with internal current limiting circuitry and can endure overload for an unlimited duration.

### 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 <math>1.0\Omega</math> 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 MKWI40 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.

