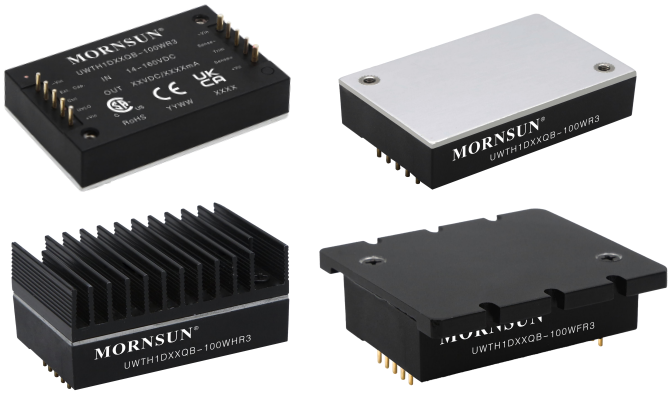
DC/DC Converter
UWTH1D_QB-100W(H/F)R3 Series

MORNSUN®

100W isolated DC-DC converter
Ultra-wide input and regulated single output



CSA62368 EN62368 EN50155 EN45545 BS EN62368 IEC62368-1

CB Report Patent Protection RoHS

FEATURES

- Ultra-wide 12:1 input voltage range: 14 -160VDC
- High efficiency up to 90%
- Reinforced insulation, I/O isolation test voltage 3k VAC
- Operating ambient temperature range -40℃ to +105℃
- Active hold-up control, programmable input under-voltage control
- Input reverse polarity protection, Input under-voltage protection, output over-voltage, over-current, short-circuit protection, over-temperature protection
- Industry standard 1/4-Brick package
- Design to meet AREMA standards
- Design to meet UL62368 standards

The UWTH1D_QB-100W(H/F)R3 series is a high-performance product specifically designed for a variety of railway applications. The output power can reach at 100W. It features wide input voltage of 14-160VDC, which is compatible with nominal input type of 24V, 48V, 72V, 96V and 110V. Meets EN50155 standard for voltage fluctuations. The reinforced high insulation 3000VAC ensures that the system can still be used safely in 5000m high altitude applications. The allowable operating temperature is up to 105° C. It integrates multiple protection functions to ensure the safety and high reliability of the system, with functions of Remote control and compensation, output voltage adjustment, etc., which perfectly matches the requirements of line loss and special voltage in the application. It is widely used in vehicle-mounted switches, train control systems and associated equipment.

Selection Guide

Certification	Part No.①	Input Voltage (VDC)		Output		Full Load Efficiency(%)③ Min./Typ.	Max. Capacitive Load(μF)
		Nominal (Range)	Max.②	Voltage (VDC)	Current (mA) (Max./Min.)		
CSA/EN/ BS EN/IEC	UWTH1D12QB-100W(H/F)R3	110 (14-160)	160	12	8330/0	88/90	7000
	UWTH1D15QB-100W(H/F)R3			15	6670/0		4500
	UWTH1D24QB-100W(H/F)R3			24	4160/0	87/89	1800
	UWTH1D28QB-100W(H/F)R3			28	3570/0		1300
	UWTH1D48QB-100W(H/F)R3			48	2080/0	88/90	1000
	UWTH1D54QB-100W(H/F)R3			54	1850/0		820

Note:
①Use "F/H" suffix for heat sink mounting. We recommend to choose modules with a heat sink for enhanced heat dissipation and applications with extreme temperature requirements;
②Exceeding the maximum input voltage may cause permanent damage;
③Efficiency is tested at nominal voltage and full load at +25℃ ambient;
④When UWTH1D_QB-100W(H/F)R3 series products input voltage is 14V~16.8V, the converter can work 100ms at full load.

Input Specifications

Item	Operating Conditions		Min.	Typ.	Max.	Unit
Input Current (full load)	24V input voltage	24V, 28V output	--	4789	4902	mA
		12V, 15V, 48V, 54V output	--	4735	4845	
	36V input voltage	24V, 28V output	--	3157	3230	
		12V, 15V, 48V, 54V output	--	3121	3193	
	48V input voltage	24V, 28V output	--	2341	2396	
		12V, 15V, 48V, 54V output	--	2315	2369	
	72V input voltage	24V, 28V output	--	1561	1597	
		12V, 15V, 48V, 54V output	--	1543	1578	

	96V input voltage	24V, 28V output	--	1184	1211	
		12V, 15V, 48V, 54V output	--	1171	1197	
Input Current (full load)	110V input voltage	24V, 28V output	--	1033	1057	mA
		12V, 15V, 48V, 54V output	--	1022	1045	
Maximum input current			--	--	8930	
Reflected Ripple Current	Nominal input voltage		--	150	--	
Surge Voltage (1sec. max.)			-0.7	--	200	VDC
Start-up Voltage			--	--	14	
Start-up Current	Nominal 48 input voltage, full load		--	--	5000	mA
Start-up Time	Nominal input voltage, constant resistance load		--	50	100	ms
Input Filter			LC filter			
Hot Plug			Unavailable			
No-load Input Power	Ctrl pin open or pulled high, DC-DC ON (14-160VDC)		--	1.2	2.0	W
Idle Input Power	Ctrl pin pulled low to -Vin, DC-DC OFF (14-160VDC)		--	0.7	1.6	
Ctrl①	Module on		Ctrl pin open or pulled high (3.5-12VDC)			
	Module off		Ctrl pin pulled low to -Vin (0-1.2VDC)			
Input Under-voltage Protection			10	11	--	VDC
UVLO②	Operating temperature range, UVLO pin open, module off		10	--	--	
	Operating temperature range, UVLO pin connect to -Vin, module off		60	--	--	

Note:
①The Ctrl pin voltage is referenced to input -Vin;
②The UVLO pin voltage is referenced to input -Vin, please refer to Fig. 9.

Output Specifications

Item	Operating Conditions	Min.	Typ.	Max.	Unit
Voltage Accuracy	Nominal input voltage, 0%-100% load	--	--	±2	%
Linear Regulation	Input voltage variation from low to high at full load	--	±0.2	±0.5	
Load Regulation	Nominal input voltage, 10%-100% load	--	±0.5	±1	
Transient Recovery Time	25% load step change @25℃	--	--	500	μs
Transient Response Deviation		--	±3	±5	%
Temperature Coefficient	Nominal output voltage, full load	--	--	±0.03	%/℃
Ripple & Noise①	20MHz bandwidth, 10%-100% load	--	150	300	mVp-p
Trim	Input voltage range (14-160V)	90	--	110	%Vo
Sense		--	--	105	
Over-temperature Protection	Max. Case Temperature	--	115	125	℃
Over-voltage Protection		110	--	160	%Vo
Over-current Protection		105	160	260	%Io
Short-circuit Protection		Hiccup, continuous, self-recovery			

Note:
①The "Tip and barrel method" is used for ripple and noise test, for details please refer to Fig.3.

General Specifications

Item	Operating Conditions		Min.	Typ.	Max.	Unit
Isolation	Electric Strength Test for 1 minute with a leakage current of 5mA max	Input-output	3000	--	--	VAC
		Input-case	2500	--	--	
		Output-case	2100	--	--	
Insulation Resistance	Input-output resistance at 500VDC		1000	--	--	MΩ
Isolation Capacitance	Input-output capacitance at 100KHz/0.1V		--	1100	--	pF
Operating Temperature			-40	--	105	℃
Storage Temperature			-55	--	125	
Pin Soldering Resistance Temperature	Soldering spot is 1.5mm away from case for 10 seconds		--	--	300	
Storage Humidity	Non-condensing		5	--	95	%RH
Switching Frequency	PWM mode		--	175	--	KHz
MTBF	IEC 61709 @25℃		1000	--	--	k hours

Cooling Test		EN60068-2-1
Dry Heat		EN60068-2-2
Damp Heat		EN60068-2-30
Shock and Vibration Test		IEC/EN61373 Class B
Pollution Level		PD 3
Fire & Smoke Compliance		EN45545-2, HL3
Salt Mist Test		EN60068-2-11, Ka
Cyclic Damp Heat Test		EN60068-2, Db variant 2
Altitude①		5000m
Low Temperature Start-up and Storage Test		EN60068-1, Ad and Ab

Note: ①When the altitude is above 2000m, the product surface max. temperature must be below 105℃.

Mechanical Specifications

Case Material	Aluminum alloy case; Black plastic bottom, flame-retardant and heat-resistant (UL94 V-0)	
Dimension	Without heat sink	57.90 x 36.80x 12.70mm
	With H heat sink	57.90 x 36.80x 25.40mm
	With F heat sink	62.00 x 56.00 x 14.50mm
Weight	Without heat sink	79.5g (Typ.)
	With H heat sink	109.5g (Typ.)
	With F heat sink	99.5g (Typ.)
Cooling Method	Conduction cooling or forced air cooling Free air convection cooling with additional heat sink	

Electromagnetic Compatibility (EMC) (EN50121-3-2)

Emissions	CE	EN50121-3-2	EN55016-2-1 150kHz-500kHz 99dBuV (see Fig. 6 for recommended circuit) 500kHz-30MHz 93dBuV (see Fig. 6 for recommended circuit)	
		EN55032	EN55032-11 150kHz-500kHz 79dBuV (see Fig. 6 for recommended circuit) 500kHz-30MHz 73dBuV (see Fig. 6 for recommended circuit)	
	RE	CISPR16-2-3	30MHz-230MHz 40dBuV/m at 10m (see Fig. 6 for recommended circuit) 230MHz-1GHz 47dBuV/m at 10m (see Fig. 6 for recommended circuit) 1GHz-6GHz 47dBuV/m at 10m (see Fig. 6 for recommended circuit)	
Immunity	ESD	EN61000-4-2	Contact ±6kV/Air ±8kV	perf. Criteria A
	RS	EN61000-4-3	80 – 800MHz 20V/m 800 – 1000MHz 20V/m 1400 – 2000MHz 10V/m 2000 – 2700MHz 5V/m 5100 – 6000MHz 3V/m	perf. Criteria A
	EFT	EN61000-4-4	±2kV 5/50ns 5kHz (see Fig. 6 for recommended circuit)	perf. Criteria A
	Surge	EN61000-4-5	line to line ±1kV (42Ω, 0.5μF) line to ground ±2kV(42Ω, 0.5μF) (see Fig. 6 for recommended circuit) line to line ±1kV (2Ω, 18μF) line to ground ±2kV(12Ω, 9μF) (see Fig. 6 for recommended circuit)	perf. Criteria A
	CS	EN61000-4-6	0.15MHz-80MHz 10V r.m.s	perf. Criteria A

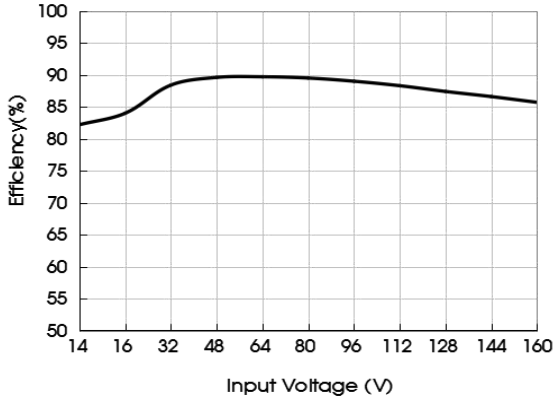
Electromagnetic Compatibility (EMC) (AREMA)

Emissions	CE	CISPR16-2-1	150kHz-500kHz 79dBuV (see Fig. 6 for recommended circuit)	
		CISPR16-1-2	500kHz-30MHz 73dBuV (see Fig. 6 for recommended circuit)	
	RE	CISPR16-2-3	30MHz-230MHz 40dBuV/m at 10m (see Fig. 6 for recommended circuit) 230MHz-1GHz 47dBuV/m at 10m (see Fig. 6 for recommended circuit)	
Immunity	ESD	IEC61000-4-2	Contact ±6kV/Air ±8kV	perf. Criteria A
	RS	IEC61000-4-3	80 – 1000MHz 10V/m 160 – 165MHz 20V/m 450 – 470MHz 20V/m 800 – 960MHz 20V/m 1400 – 2000MHz 20V/m 2100 – 2500MHz 5V/m	perf. Criteria A
	EFT	IEC61000-4-4	±2kV 5/50ns 5kHz (see Fig. 6 for recommended circuit)	perf. Criteria A

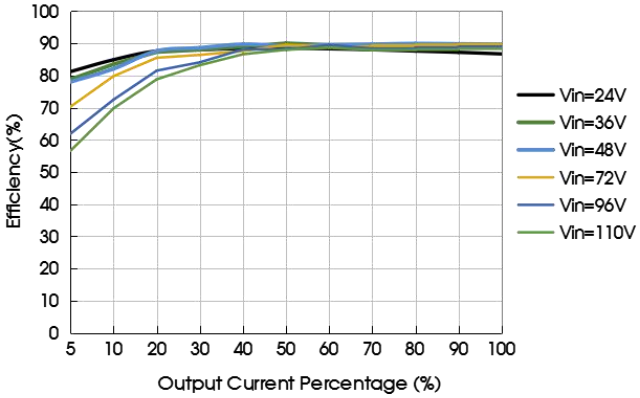
	Surge	IEC61000-4-5	line to line ±2kV (2Ω , 18μF) line to ground ±2kV(2Ω , 18μF) (see Fig. 6 for recommended circuit)		perf. Criteria A
	CS	IEC61000-4-6	0.15MHz-80MHz	10V r.m.s	perf. Criteria A
	MS	IEC61000-4-8	60Hz 100A/m	(see Fig. 6 for recommended circuit)	perf. Criteria A
			60Hz 300A/m	(see Fig. 6 for recommended circuit)	

Typical Performance Curves

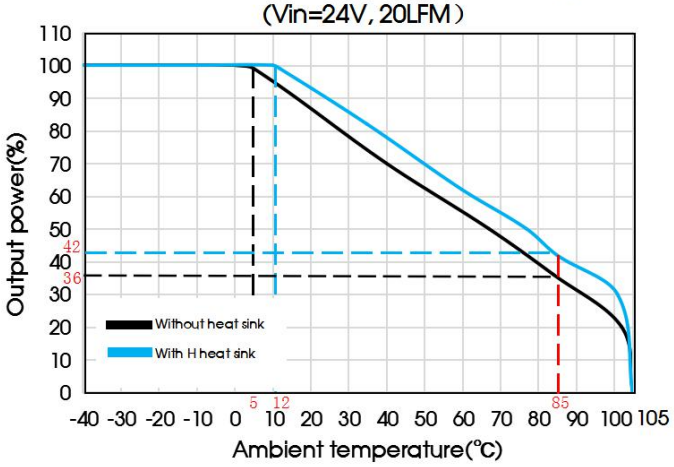
UWTH1D54QB-100WR3 Efficiency Vs Input Voltage (Full Load)



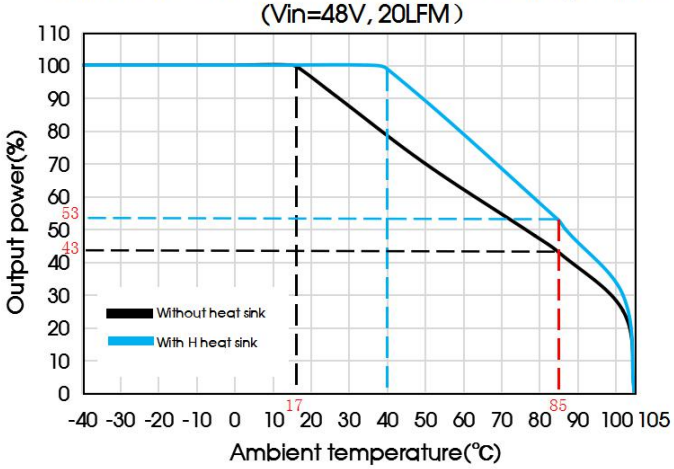
UWTH1D54QB-100WR3 Efficiency Vs Output Load



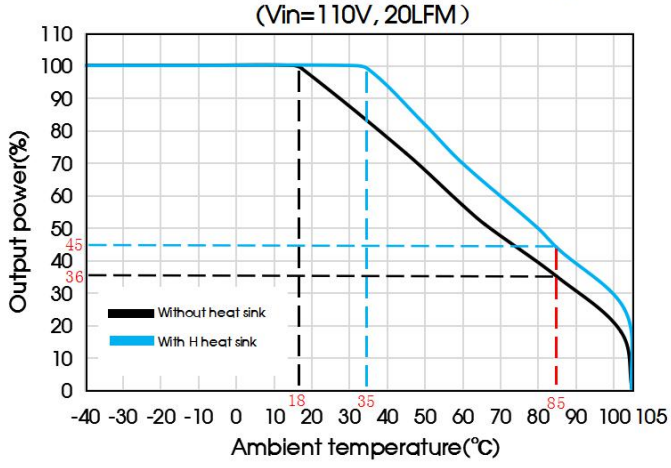
UWTH1D12QB-100WR3 Temperature Derating Curves (Vin=24V, 20LFM)



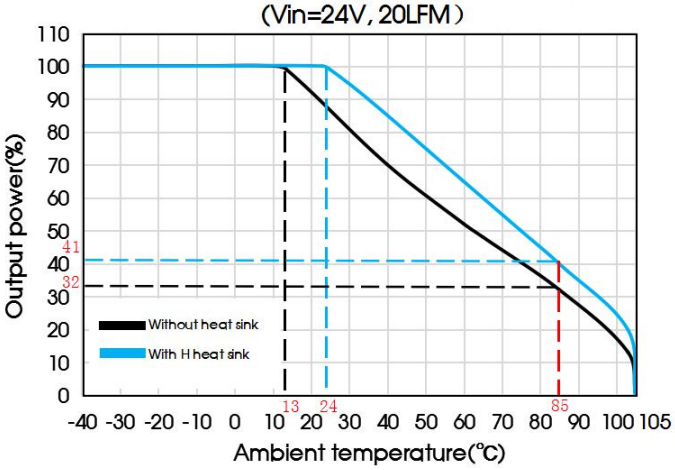
UWTH1D12QB-100WR3 Temperature Derating Curves (Vin=48V, 20LFM)



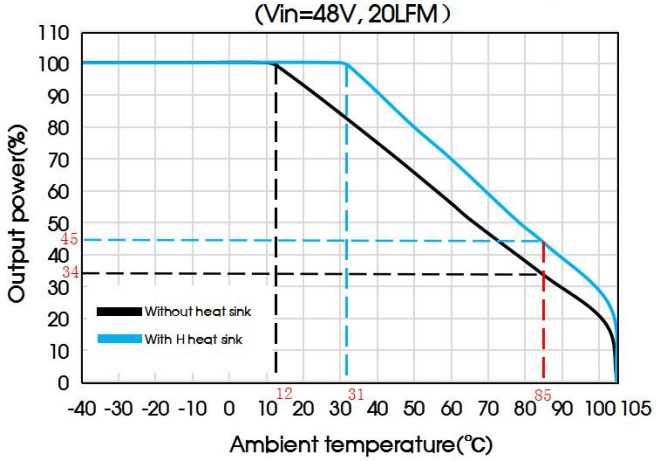
UWTH1D12QB-100WR3 Temperature Derating Curves (Vin=110V, 20LFM)



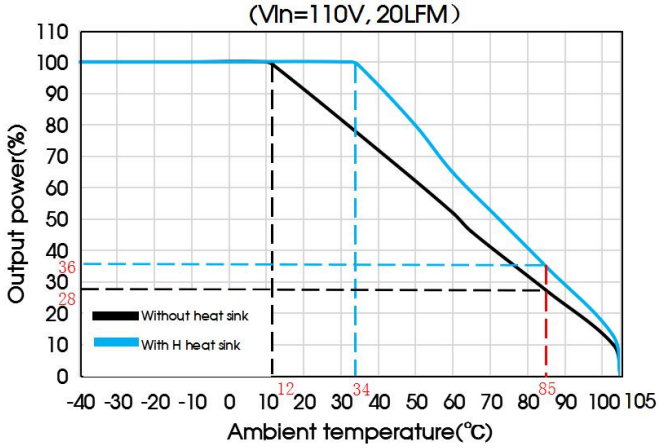
UWTH1D24QB-100WR3 Temperature Derating Curves (Vin=24V, 20LFM)



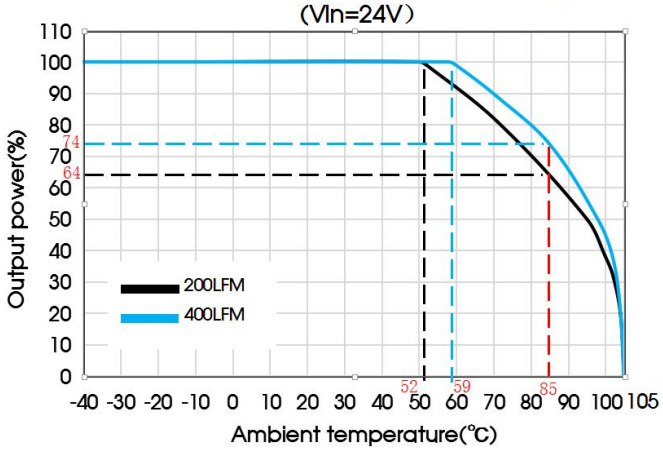
UWTH1D24QB-100WR3 Temperature Derating Curves
(Vin=48V, 20LFM)



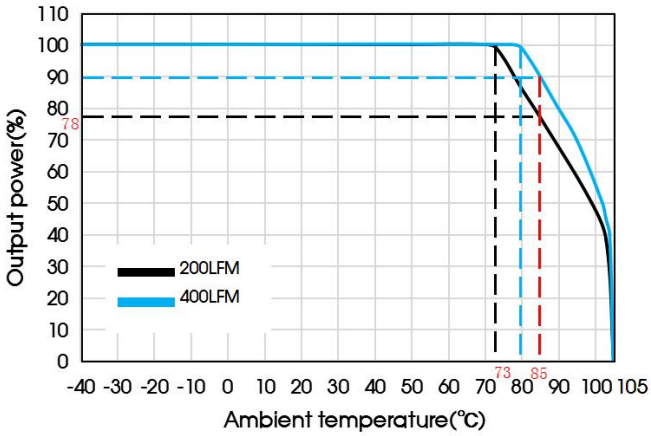
UWTH1D24QB-100WR3 Temperature Derating Curves
(Vin=110V, 20LFM)



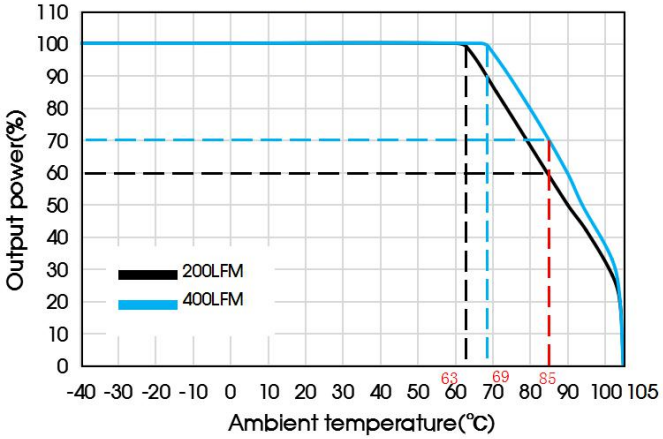
UWTH1D54QB-100WHR3 Temperature Derating Curves
(Vin=24V)



UWTH1D54QB-100WHR3 Temperature Derating Curves
(Vin=48V)



UWTH1D48/54QB-100WHR3 Temperature Derating Curves
(Vin=110V)



Remote Sense Application

1. Remote Sense Connection if not used

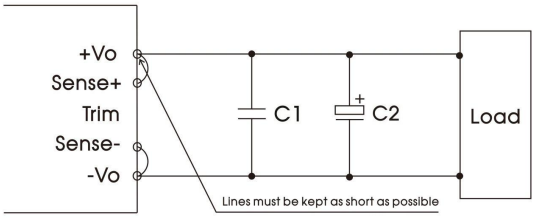


Fig.1

Notes:
(1) If the sense function is not used for remote regulation the user must connect the +Sense to +Vo and -Sense to -Vo.
(2) The connections between Sense lines and their respective power lines must be kept as short as possible, otherwise they may be picking up noise, interference and/or causing unstable operation of the power module.

2. Remote Sense Connection used for Compensation

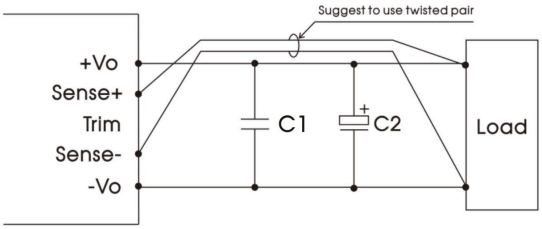


Fig.2

Notes:
(1) Using remote sense with long wires may cause unstable output, please contact technical support if long wires must be used.
(2) PCB-tracks or cables/wires for Remote Sense must be kept as short as possible. Twisted pair or shielded wires are suggested for remote compensation and must be kept as short as possible.
(3) We recommend using adequate cross section for PCB-track layout and/or cables to connect the power supply module to the load in order to keep the voltage drop below 0.3V and to make sure the power supply's output voltage remains within the specified range.
(4) Note that large wire impedance may cause oscillation of the output voltage and/or increased ripple. Consult technical support or factory for further advice of sense operation.

Design Reference

1. Ripple & noise

All the DC-DC converters of this series are tested before delivery using the recommended circuit shown in Fig. 3.

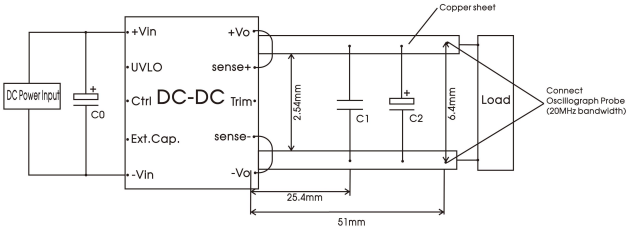


Fig.3

Output voltage \ Capacitors value	C0(μF)	C1(μF)	C2(μF)
12VDC	100μF, voltage ≥200V	1μF, voltage ≥1.2*Vo	330μF, voltage ≥1.2*Vo
15VDC			
24VDC			
28VDC			
48VDC			
54VDC			

2. Typical application

1. Mornsun EMC circuit is recommended, otherwise please ensure that at least a 100μF electrolytic capacitors is connected at the input in order to ensure adequate voltage surge suppression and protection.
2. Output ripple can be further reduced by appropriately increasing the output capacitor values C3 and/or by selecting capacitors with a low ESR (equivalent series resistance). Also make sure that the capacitance is not exceeding the specified max. capacitance load value of the product.
3. The UVLO pin can adjust the point of input under-voltage protection by the external resistance RUVLO. Please refer to Fig.9 for the value of RUVLO, if the pin is left open, the under-voltage protection point is 11V.
4. Ctrl current-mode logic recommended circuit design refer to fig.4.

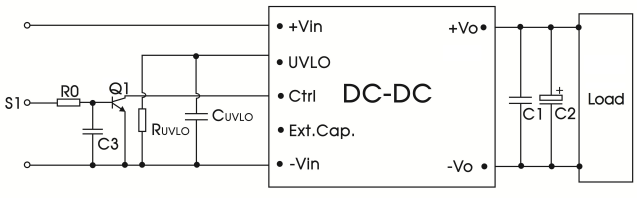


Fig.4

Components	Value	Recommended Component
R0	10KΩ	--
C3	0.1μF	voltage≥25V
Q1	Ic≥10mA	voltage≥30V
Note: S1 pin open, DC-DC ON.		

3. Trim Function for Output Voltage Adjustment (open if unused)

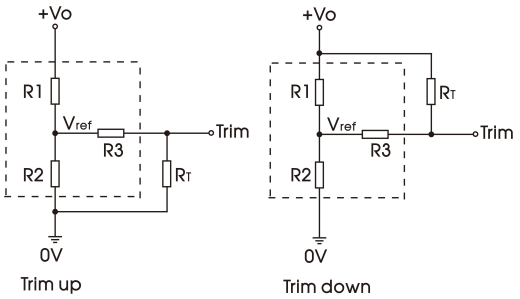


Fig.5
Trim resistor connection (dashed line shows internal resistor network)

Calculation formula of Trim resistance:

$$\text{Trim up}: R_T = \frac{a * R_2}{R_2 - a} - R_3 \qquad a = \frac{2.5 * R_1}{Vo - 2.5}$$

$$\text{Trim down}: R_T = \frac{b * R_1}{R_1 - b} - R_3 \qquad b = \frac{(Vo - 2.5) * R_2}{2.5}$$

Note:
a, b: self-defined parameter, accurate to two decimal places.
R_T(kΩ): Resistance of Trim.
Vo: Output voltage change.
V_{ref}(VDC): Reference voltage.

Vo / Res	12(VDC)	15(VDC)	24(VDC)	28(VDC)	48(VDC)	54(VDC)
R1(KΩ)	11	14.35	24.8	28.8	54	61
R2(KΩ)	2.87	2.87	2.87	2.87	2.94	2.94
R3(KΩ)	20.2	20.2	23.1	23.1	18.2	18.2

Practical Example trim up -10% for 12V output:

$$b = \frac{(10.8 - 2.5) * 2.87}{2.5} = 9.53$$

$$R_T = \frac{9.53 * 11}{11 - 9.53} - 20.2 = 51.113K\Omega$$

R_T according to E24≈51 kΩ

Practical Example trim up +10% for 12V output:

$$a = \frac{2.5 * 11}{13.2 - 2.5} = 2.57$$

$$R_T = \frac{2.57 * 2.87}{2.87 - 2.57} - 20.2 = 4.386K\Omega$$

R_T according to E24≈4.3kΩ

4. EMC compliance circuit

1. The anti-reverse connection circuit is composed of a circuit breaker and a diode D1. The withstand voltage of the diode D1 must be greater than 250V;

2. The EMC filter part is composed of modular circuits. Please refer to Figure 6 for recommended circuits and parameters. Self-built circuits can also be used;

3. Resistor RUVLO is used to adjust the input under-voltage protection point. Refer to Figure 9 for the value.

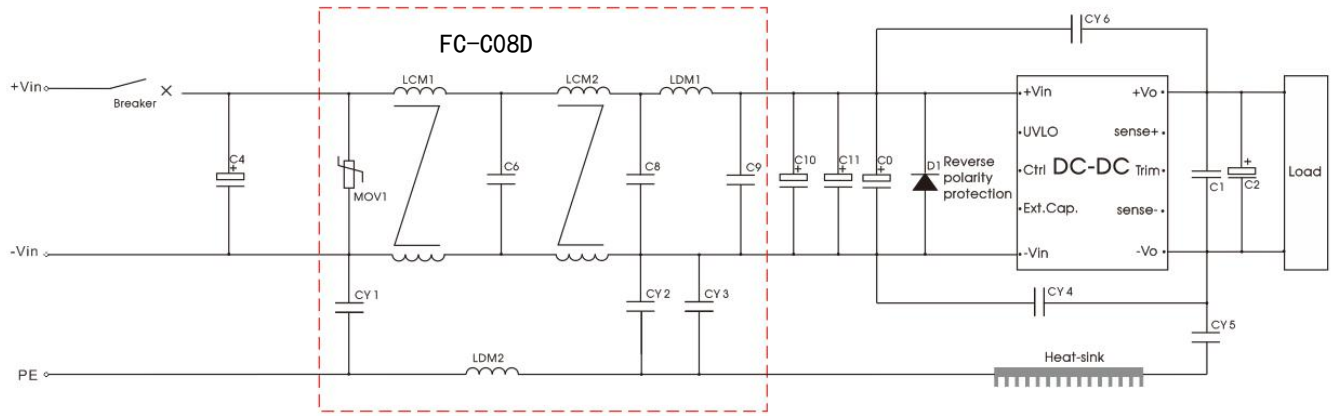


Fig.6

Components Value / Matching Power output voltage	C4	C2	C1	CY4, CY5, CY6	D1
12V	330μF Voltage≥200V	330μF Voltage≥1.2*Vo	1μF Voltage≥1.2*Vo	3300 pF /400VAC Y1 safety capacitor	20A Voltage≥200V
15V					
24V	560μF Voltage≥200V				
28V					
48V					
54V					
Breaker	The Breaker value varies with different power modules and must be selected in accordance with the specified input current of the corresponding power converter, but not exceeding the filter specifications.				
Note: A ferrite core on the power lines and load lines can ensures a better EMI test margin.					

EMC Filter		
Components	Value	Recommended Component
C6	0.1μF	Voltage≥630V
C8	0.22μF	Voltage≥250V
C9	2.2μF	Voltage≥250V
LCM1	≧2mH	FL2D-A2-202
LCM2	≧4mH	Common mode, ≧4mH, 35mΩ, -40 to +125℃
LDM1	0.47μH	Shielding Inductive
LDM2	150μH	Differential mode, 150uH±35%, 30mΩ, -40 to +125℃
CY1, CY2	2200 pF /400VAC	Y1 safety capacitor
CY3	1000 pF /400VAC	Y1 safety capacitor
MOV1	7D221K	Varistor
Note: The emc filter recommended to use MORNSUN P/N: FC-C08D.		

Surge standard	Components	Value	Recommended Component
line to line ±1KV (42Ω, 0.5μF) line to ground ±2kV (42Ω, 0.5μF)	C0	100μF	Voltage≥250V
	C10, C11	--	--
line to line ±1KV (2Ω, 18μF) line to ground ±2kV (12Ω, 9μF)	C0, C10	100μF	Voltage≥250V
	C11	--	--
line to line ±2KV (2Ω, 18μF) line to ground ±2kV (2Ω, 18μF)	C0, C10, C11	100μF	Voltage≥250V

5. Hold-up time setup capacitor

Fig.7 Recommended circuit and PCB layout for hold-up time

The hold-up time capacitor $C_{Ext.\,Cap}$ is used to hold the output when the input power off.

Note:

1. If there is no requirement for the hold-up time, no additional capacitor $C_{Ext.\,Cap}$ is required;
2. For the hold-up time of 10ms and 30ms, please refer to table blow;
3. Vq is Start-up voltage;

4.$C_{Ext.\ Cap}$ withstand voltage is greater than≧100V.

Po (W)		100					
Vin (V)		24	36	48	72	96	110
V_o(V)		13.2	19.5	26.9	40.3	53.4	61.1
$C_{Ext.\ Cap}$ (μF)	△t: 10ms	470	470	470	470	470	470
	△t: 30ms	1410	1410	1410	1410	1410	1410

6. Recommended circuit for multi-module parallel redundant design

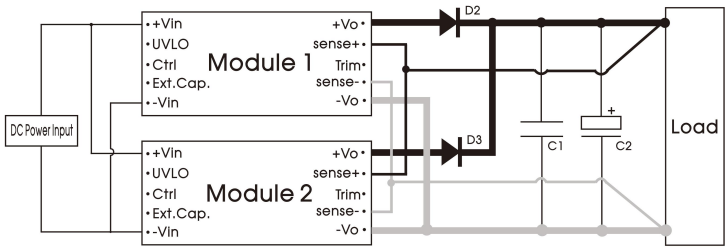


Fig.8

Note:

1. The function of capacitor C1, C2 is filtering. It is used for margin design and cannot be used to increase power;

2. The diodes D2 and D3 are used to protect the power module. In actual use, the user can choose the parameters of the diode or MOSFET according to the output current;

3. Because the output impedance of the two modules is different, the output power of each module cannot be guaranteed to be equal; Pload = P1 + P2 <Pmax (100W).

7. UVLO Function and R_{UVLO} Values

The products with an ultra-wide input voltage range, covering a variety of nominal input voltages. Set the input under-voltage point adjustable function for different input systems, connect a resistor between UVLO pin and -Vin, adjust the under-voltage point of the product by adjusting the resistor value.

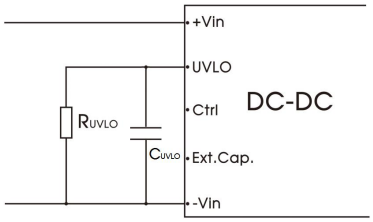


Fig.9

UVLO values for various nominal input voltage and R_{UVLO} table

Nominal input voltage (V)	24	36	48	72	96	110
Starting Voltage (V)	13.2	19.5	26.9	40.3	53.4	61.1
Shutdown Voltage (V)	11.2	16.7	23.3	34.8	46.3	53.1
UVLO setup resistance (KΩ)	open	150	56.1	18.3	5.6	1.5
UVLO setup calculation	100nF/50V/0805					

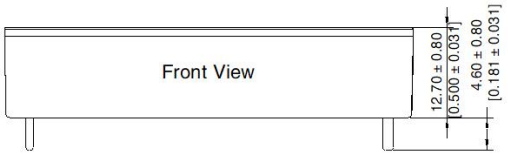
Calculation formula of R_{UVLO} setup resistance :

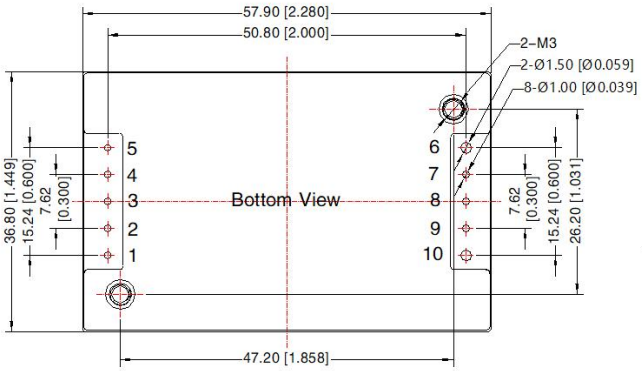
$$R_{UVLO} = \frac{182 * c}{182 - c} - 20 \qquad c = \frac{1272.35}{V_{shutdown} - 6.45}$$

Note:
c: self-defined parameter.
R_{UVLO}(KΩ): UVLO setup resistance.
$V_{shutdown}$: UVLO shutdown voltage.

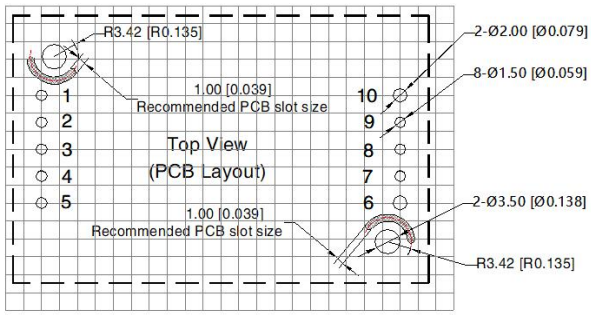
8. For additional information please refer to DC-DC converter application notes on www.mornsun-power.com

Dimensions and Recommended Layout（without heat sink）



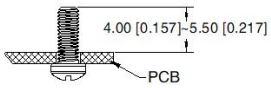


THIRD ANGLE PROJECTION



Note: Grid 2.54*2.54mm

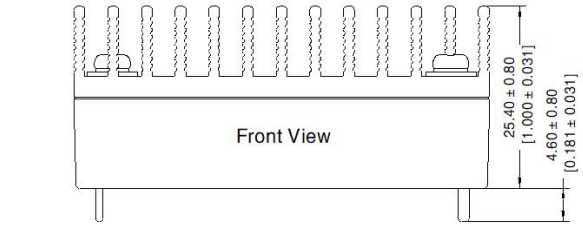
Recommended screw length

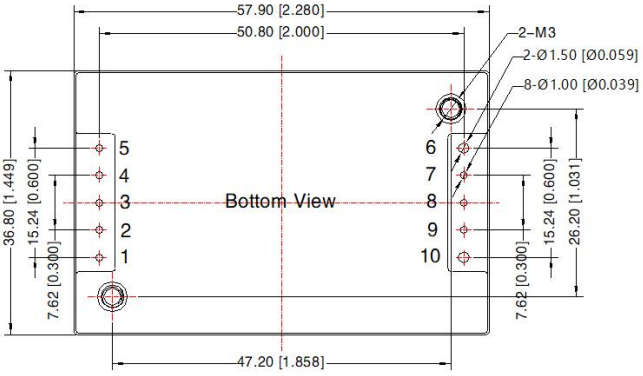


Pin–Out			
Pin	Mark	Pin	Mark
1	+Vin	6	–Vo
2	UVLO	7	Sense–
3	Ctrl	8	Trim
4	Ext. Cap.	9	Sense+
5	–Vin	10	+Vo

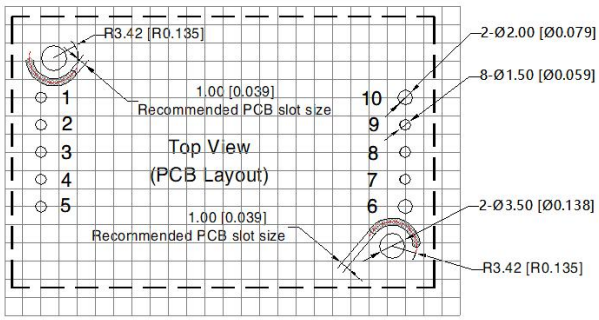
Note:
Unit: mm[inch]
Pin1, 2, 3, 4, 5, 7, 8, 9's diameter: 1.00 [0.039]
Pin6, 10's diameter: 1.50 [0.059]
Pin diameter tolerances: ± 0.10 [± 0.004]
General tolerances: ± 0.50 [± 0.020]
Mounting hole screwing torque: Max 0.4 N ▪ m

Dimensions and Recommended Layout（with H heat sink）



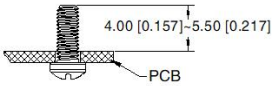


THIRD ANGLE PROJECTION



Note: Grid 2.54*2.54mm

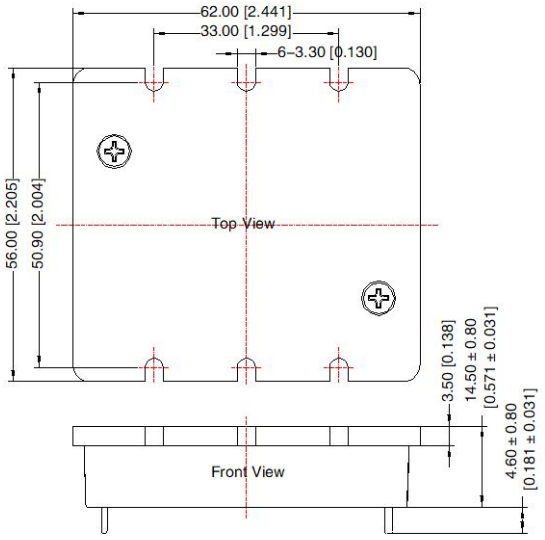
Recommended screw length

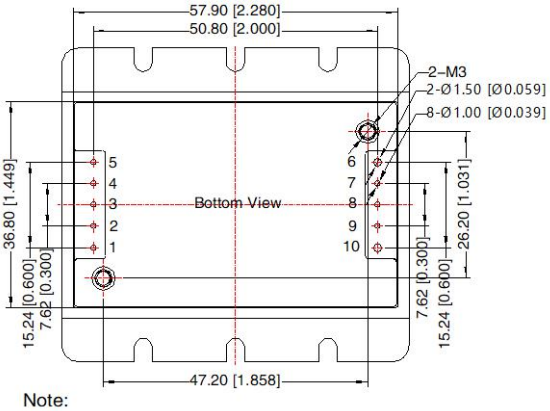


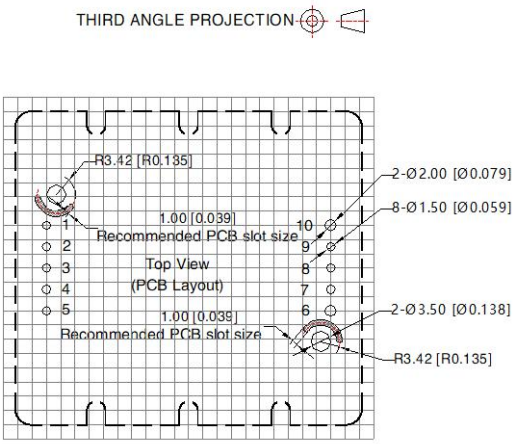
Note:
Unit: mm[inch]
Pin1, 2, 3, 4, 5, 7, 8, 9's diameter: 1.00 [0.039]
Pin6, 10's diameter: 1.50 [0.059]
Pin diameter tolerances: ± 0.10 [± 0.004]
General tolerances: ± 0.50 [± 0.020]
Mounting hole screwing torque: Max 0.4 N · m

Pin–Out			
Pin	Mark	Pin	Mark
1	+Vin	6	–Vo
2	UVLO	7	Sense–
3	Ctrl	8	Trim
4	Ext. Cap.	9	Sense+
5	–Vin	10	+Vo

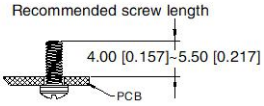
Dimensions and Recommended Layout（with F heat sink）







Note: Grid 2.54*2.54mm



Pin-Out			
Pin	Mark	Pin	Mark
1	+Vin	6	-Vo
2	UVLO	7	Sense-
3	Ctrl	8	Trim
4	Ext. Cap.	9	Sense+
5	-Vin	10	+Vo

Note:
Unit: mm[inch]
Pin1, 2, 3, 4, 5, 7, 8, 9's diameter: 1.00 [0.039]
Pin6, 10's diameter: 1.50 [0.059]
Pin diameter tolerances: ± 0.10 [± 0.004]
General tolerances: ± 0.50 [± 0.020]
Mounting hole screwing torque: Max 0.4 N ▪ m

Note:
1. For additional information on Product Packaging please refer to www.mornsun-power.com. Packaging bag number: 58010113(UWTH1DxxQB-100WR3); 58220017(UWTH1DxxQB-100WHR3); 58200069(UWTH1DxxQB-100WFR3);
2. The maximum capacitive load offered were tested at input voltage range and full load;
3. Unless otherwise specified, data in this datasheet should be tested under the conditions of Ta=25℃, humidity<75%RH with nominal input voltage and rated load;
4. All index testing methods in this datasheet are based on our company corporate standards;
5. Product customization is available, please contact below email directly for specific needs;
6. Products are related to laws and regulations: see "Features" and "EMC";
7. Our products shall be classified according to ISO14001 and related environmental laws and regulations, and shall be handled by qualified units.

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