FEATURES

- ▶ **Industrial Standard 2"×1" Package**
- ▶ **Ultra-wide Input Range 36-160VDC**
- ▶ **I/O Isolation 3000VAC with Reinforced Insulation**
- ▶ **Excellent Efficiency up to 90%**
- ▶ **Operating Ambient Temp. Range -40℃ to +77.5℃**
- ▶ **No Min. Load Requirement**
- ▶ **Under-voltage, Overload/Voltage and Short Circuit Protection**
- ▶ **Remote On/Off Control, Output Voltage Trim**
- ▶ **Vibration and Shock/Bump Test EN 61373 Approved**
- ▶ **Cooling, Dry & Damp Heat Test IEC/EN 60068-2-1, 2, 30 Approved**
- ▶ **Railway EMC Standard EN 50121-3-2 Approved**
- ▶ **Railway Certified EN 50155 (IEC60571) Approved**
- ▶ **Fire Protection Test EN 45545-2 Approved**
- ▶ **UL/cUL/IEC/EN 62368-1 Safety Approval & CE Marking**

UL 62368-1 Scheme

PRODUCT OVERVIEW

The MKZI40 series from MINMAX is a next-generation 40W railway-certified isolated DC-DC power converter. It features an ultra-wide input voltage range of 36-160VDC, making it suitable for railway DC systems. The series offers seven models providing precise output voltages of 5/12/15/24/54/±12/±15VDC. With a compact 2"x1" size and full encapsulation packaging, the MKZI40 series is designed to resist external environmental interference, specifically designed for battery-powered railway systems and harsh environmental applications.

Key features of the MKZI40 series include a high I/O isolation withstand voltage of 3000VAC, reinforced insulation system, up to 90% overall efficiency, operating temperature range of -40℃ to +77.5℃, no minimum load requirement, extremely low no-load power consumption, remote on/off control, output voltage trim, and various protection mechanisms (including under-voltage, output over-current, output over-voltage, over-temperature, and output short-circuit protection).

The outstanding circuit topology design allows the MKZI40 series to maintain high stability in overall conversion efficiency, power loss, and heat dissipation even under drastic variations in input voltage, output current, and environmental temperature. Its excellent load driving capability enables it to meet 100% power requirements of the system at startup. Additionally, the MKZI40 series exhibits high ruggedness, durability, and reliability, supporting stable long-term operation at altitudes of up to 4000 meters without any geographical restrictions.

The MKZI40 series complies with railway certification standards, including EN 50155 (IEC 60571), vibration and shock/bump test (EN 61373), cooling/dry/damp heat test (IEC/EN 60068-2-1, 2, 30), railway EMC standard (EN 50121-3-2), fire protection test (EN 45545-2), and safety certifications such as UL/cUL/IEC/EN 62368-1. The series also holds CB and CE certifications. Moreover, the MKZI40 series successfully passes temperature cycle tests from -40°C to +125°C for over 500 cycles and long-term reliability tests to meet the stringent requirements of railway system equipment. The MKZI40 series is an ideal choice for applications emphasizing space constraints, stringent electromagnetic compatibility, and physical environmental stress, and it finds extensive use in railway equipment such as pantographs, high-voltage detection systems, communication systems, collision warning systems, drowsiness detection systems, and autonomous driving systems.

Model Selection Guide

Model Number	Input Voltage (Range)	Output Voltage	Output Power	Output Current	Input Current		Over Voltage Protection	Max. capacitive Load	Efficiency (typ.)
				Max.	@Max. Load	@No Load			@Max. Load
	VDC	VDC	W	mA	mA(typ.)	mA(typ.)	VDC	μF	%
MKZI40-110S05	110 (36 ~ 160)	5	40.00	8000	413	40	6.2	13600	88
MKZI40-110S12		12	39.96	3330	408		15	2400	89
MKZI40-110S15		15	40.05	2670	409		18	1500	89
MKZI40-110S24		24	40.08	1670	409		30	600	89
MKZI40-110S54		54	40.01	741	404		66	130	90
MKZI40-110D12		±12	40.08	±1670	409		±15	1200#	89
MKZI40-110D15		±15	39.90	±1330	408		±18	750#	89

For each output

Input Specifications

Parameter	Model	Min.	Typ.	Max.	Unit
Input Surge Voltage (100ms. max)	All Models	-0.7	---	170	VDC
Start-Up Threshold Voltage		---	---	36	
Under Voltage Shutdown		30	33	35.5	
Start Up Time		---	30	100	mS
Input Filter		Internal Pi 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		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		---	---	±0.2	%
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	5Vo	Measured with a 1μF/100V MLCC	---	75	85	mV P-P
		12Vo,15Vo ±12Vo, ±15Vo		---	125	140	mV P-P
		24Vo		---	150	170	mV P-P
		54Vo		---	250	280	mV P-P
Transient Recovery Time	25% Load Step Change(2)			---	250	---	μsec
Transient Response Deviation				---	±3	±5	%
Temperature Coefficient				---	---	±0.02	%/℃
Trim Up / Down Range (See Page 7)	% of Nominal Output Voltage	Other Models		---	---	±10	%
		54Vo Output		---	---	+5 / -15	%
Over Load Protection	Hiccup			110	150	185	%
Short Circuit Protection	Continuous, Automatic Recovery (Hiccup Mode 0.5Hz typ.)						

General Specifications

Parameter	Conditions	Min.	Typ.	Max.	Unit
I/O Isolation Voltage	Reinforced Insulation, Rated For 60 Seconds	3000	---	---	VAC
Isolation Voltage Input/Output to case	Rated For 60 Seconds	1500	---	---	VAC
I/O Isolation Resistance	500 VDC	1000	---	---	MΩ
I/O Isolation Capacitance	100kHz, 1V	---	1500	---	pF
Switching Frequency		220	265	310	kHz
MTBF(calculated)	MIL-HDBK-217F@25℃ Full Load, Ground Benign	900,000	---	---	Hours
Safety Approval	UL/cUL 62368-1 recognition(UL certificate), IEC/EN 62368-1(CB-report), EN 50155, IEC 60571				

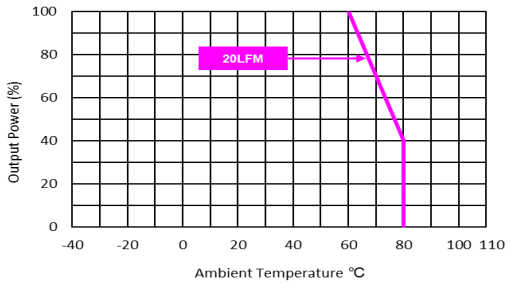
EMC Specifications

Parameter	Standards & Level			Performance
General	Compliance with EN 50121-3-2 Railway Applications			
EMI(5)	Conduction	EN 55032, EN 55011	With external components	Class A
	Radiation			
EMS(5)	EN 55035			
	ESD	Direct discharge	Indirect discharge HCP & VCP	A
		EN 61000-4-2 Air ± 8kV, Contact ± 6kV	Contact ± 6kV	
	Radiated immunity	EN 61000-4-3 20V/m		A
	Fast transient	EN 61000-4-4 ±2kV		A
	Surge	EN 61000-4-5 ±2kV		A
	Conducted immunity	EN 61000-4-6 10Vrms		A
	PFMF	EN61000-4-8 100A/M for Continuous ； 1000A/M for 1 Sec.		A

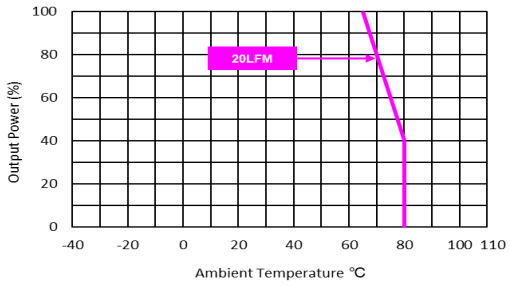
Environmental Specifications

Parameter	Conditions / Model	Min.	Typ.	Max.	Unit
Operating Temperature Range	MKZI40-110S05	-40	---	+60	℃
Nominal Vin, Load 100% Inom. (for Power Derating see relative Derating Curves)	MKZI40-110S12, MKZI40-110S15, MKZI40-110S24 MKZI40-110S54, MKZI40-110D12, MKZI40-110D15			+65	
Thermal Impedance	20LFM Convection	12	---	---	℃/W
Case Temperature		---	---	+105	℃
Over Temperature Protection (Case)		---	+115	---	℃
Storage Temperature Range		-50	---	+125	℃
Humidity (non condensing)		---	---	95	% rel. H
Altitude		---	---	4000	M
Cooling	Compliance to IEC/EN60068-2-1				
Dry Heat	Compliance to IEC/EN60068-2-2				
Damp Heat	Compliance to IEC/EN60068-2-30				
Shock & Vibration Test	Compliance to IEC/EN 61373				
Operating Humidity (non condensing)		---	---	95	% rel. H
RFI	Six-Sided Shielded, Metal Case				
Lead Temperature (1.5mm from case for 10Sec.)		---	---	260	℃

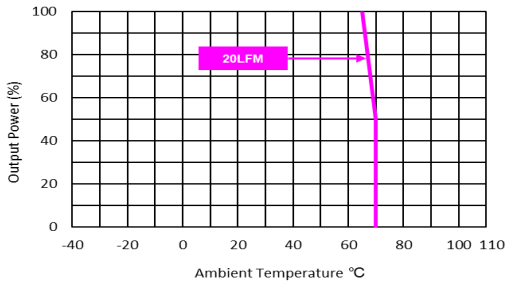
Power Derating Curve



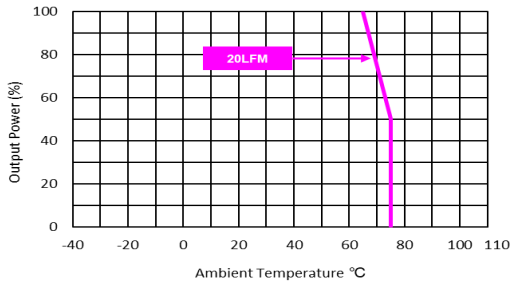
MKZI40-110S05



MKZI40-110S12, MKZI40-110S15, MKZI40-110S24



MKZI40-110S54



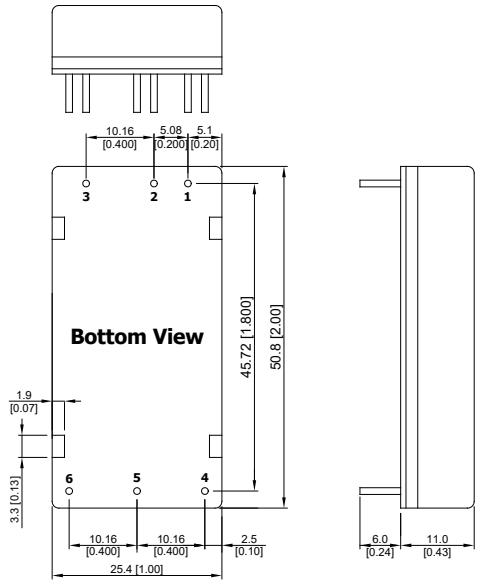
MKZI40-110D12, MKZI40-110D15

Notes

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

Package Specifications

Mechanical Dimensions



Pin Connections

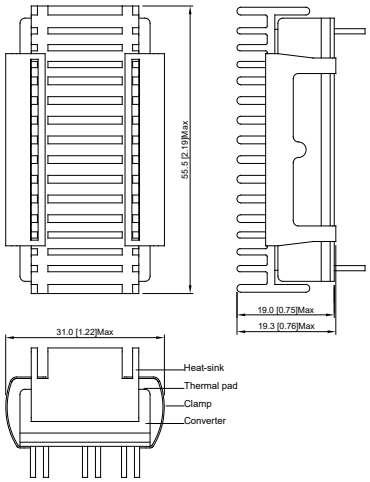
Pin	Single Output	Dual Output	Diameter mm (inches)
1	+Vin	+Vin	Ø 1.0 [0.04]
2	-Vin	-Vin	Ø 1.0 [0.04]
3	Remote On/Off	Remote On/Off	Ø 1.0 [0.04]
4	+Vout	+Vout	Ø 1.0 [0.04]
5	-Vout	Common	Ø 1.0 [0.04]
6	Trim	-Vout	Ø 1.0 [0.04]

- All dimensions in mm (inches)
- Tolerance: X.X±0.75 (X.XX±0.03)
  X.XX±0.25 (X.XXX±0.01)
- Pin diameter tolerance: X.X±0.05 (X.XX±0.002)

Physical Characteristics

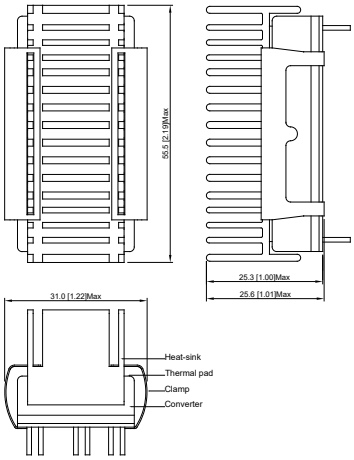
Case Size	:	50.8x25.4x11.0 mm (2.0x1.0x0.43 inches)
Case Material	:	Metal With Non-Conductive Baseplate
Base Material	:	FR4 PCB (flammability to UL 94V-0 rated)
Insulated Frame Material	:	Non-Conductive Black Plastic (flammability to UL 94V-0 rated)
Pin Material	:	Copper Alloy
Potting Material	:	Silicone (UL 94V-0)
Weight	:	51.5g

Heatsink (Option –HS5)



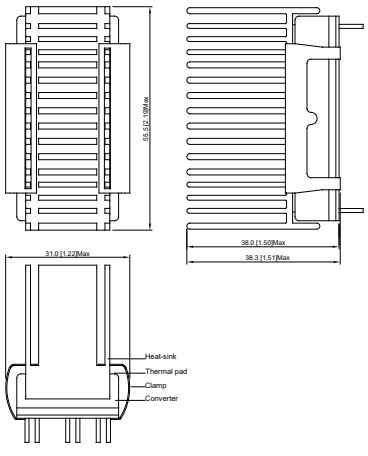
Physical Characteristics		
Heatsink Material	:	Aluminum
Finish	:	Black Anodized Coating
Weight	:	10g

Heatsink (Option –HS6)



Physical Characteristics		
Heatsink Material	:	Aluminum
Finish	:	Black Anodized Coating
Weight	:	16g

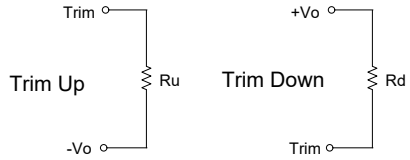
Heatsink (Option –HS7)



Physical Characteristics		
Heatsink Material	:	Aluminum
Finish	:	Black Anodized Coating
Weight	:	28g

External Output Trimming

Output can be externally trimmed by using the method shown below

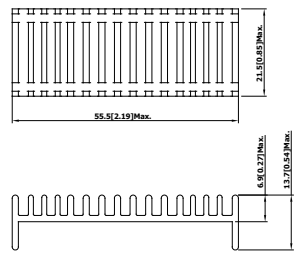
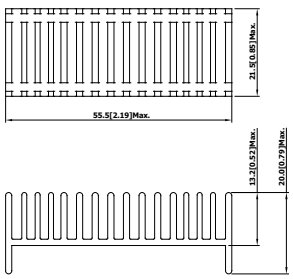
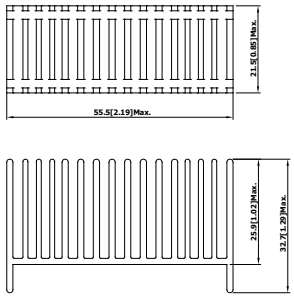


	MKZI40-110S05		MKZI40-110S12		MKZI40-110S15		MKZI40-110S24		MKZI40-110S54	
Trim Range (%)	Trim down (kΩ)	Trim up (kΩ)	Trim down (kΩ)	Trim up (kΩ)	Trim down (kΩ)	Trim up (kΩ)	Trim down (kΩ)	Trim up (kΩ)	Trim down (kΩ)	Trim up (kΩ)
1	156.81	119.77	419.81	344.74	602.92	482.88	598.97	486.83	1946.08	487.21
2	70.69	53.70	187.68	154.37	269.91	215.89	267.93	217.87	907.19	191.10
3	41.99	31.67	110.30	90.92	158.91	126.89	157.59	128.21	560.89	92.40
4	27.64	20.66	71.61	59.19	103.41	82.40	102.42	83.88	387.75	43.05
5	19.03	14.05	48.40	40.15	70.10	55.70	69.31	56.49	283.86	13.44
6	13.29	9.65	32.93	27.46	47.90	37.90	47.25	38.56	214.60	---
7	9.18	6.50	21.87	18.39	32.05	25.18	31.48	25.75	165.13	---
8	6.11	4.14	13.58	11.59	20.15	15.65	19.66	16.14	128.02	---
9	3.72	2.31	7.13	6.31	10.90	8.23	10.46	8.67	99.16	---
10	1.80	0.84	1.98	2. 07	3.50	2.30	3.11	2.69	76.08	---
11	---	---	---	---	---	---	---	---	57.19	---
12	---	---	---	---	---	---	---	---	41.45	---
13	---	---	---	---	---	---	---	---	28.13	---
14	---	---	---	---	---	---	---	---	16.71	---
15	---	---	---	---	---	---	---	---	6.82	---

Order Code Table For Converter and Converter With Heatsink

Standard	With heatsink		
	MKZI40 + HS-K004	MKZI40 + HS-K005	MKZI40 + HS-K006
MKZI40-110S05	MKZI40-110S05-HS5	MKZI40-110S05-HS6	MKZI40-110S05-HS7
MKZI40-110S12	MKZI40-110S12-HS5	MKZI40-110S12-HS6	MKZI40-110S12-HS7
MKZI40-110S15	MKZI40-110S15-HS5	MKZI40-110S15-HS6	MKZI40-110S15-HS7
MKZI40-110S24	MKZI40-110S24-HS5	MKZI40-110S24-HS6	MKZI40-110S24-HS7
MKZI40-110S54	MKZI40-110S54-HS5	MKZI40-110S54-HS6	MKZI40-110S54-HS7
MKZI40-110D12	MKZI40-110D12-HS5	MKZI40-110D12-HS6	MKZI40-110D12-HS7
MKZI40-110D15	MKZI40-110D15-HS5	MKZI40-110D15-HS6	MKZI40-110D15-HS7

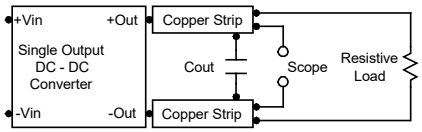
Order Code Table For Heatsink kit (including: Heatsink x1, Clamp x 2, Thermal Pad x1)

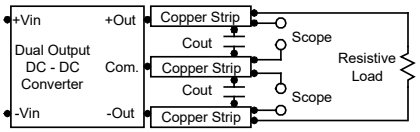
HS-K004	HS-K005	HS-K006
		

Test Setup

Peak-to-Peak Output Noise Measurement Test

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





Technical Notes

Remote On/Off

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

Overload Protection

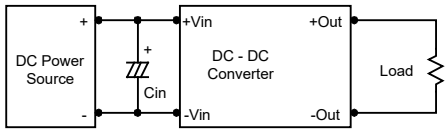
To provide hiccup mode protection in a fault (output overload) condition, the unit is equipped with internal current limiting circuitry and can endure overload for an unlimited duration.

Overvoltage Protection

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

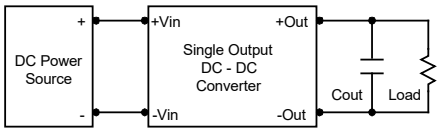
Input Source Impedance

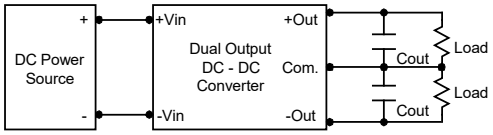
The power module should be connected to a low ac-impedance input source. Highly inductive source impedances can affect the stability of the power module.In applications where power is supplied over long lines and output loading is high, it may be necessary to use a capacitor at the input to ensure startup.
Capacitor mounted close to the power module helps ensure stability of the unit, it is recommended to use a good quality low Equivalent Series Resistance (ESR < 1.0Ω at 100 kHz) capacitor of a 1μF for the 110V input 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 1μF capacitors at the output.





Maximum Capacitive Load

The MKZI40 series has limitation of maximum connected capacitance at the output. The power module may be operated in current limiting mode during start-up, affecting the ramp-up and the startup time. The maximum capacitance can be found in the data sheet.

Thermal Considerations

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