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POWER FOR A BETTER FUTURE

# MINMAX® RAILWAY CERTIFIED POWER SOLUTION GUIDE | 2021

# RAILWAY CERTIFIED POWER SOLUTIONS ENGINEERED BY MINMAX

The MINMAX Railway Certified DC–DC Converter family with powers ranging from 3 to 150 W are designed to meet stringent requirements and harsh environmental testing and are specifically designed to be the primary insulation barriers for railway DC power architectures. These railway certified DC–DC converters are available for DC battery bus voltages of 24, 36, 48, 72, 96, and 110 VDC, and for tight regulation for output voltages of 5, 12, 15, 24, 54, ±12, and ±15 VDC. In accordance with EN 50155:2017 certification requirements, these railway certified DC–DC converters conform to the railway DC input-voltage range and transient/variation requirements; the voltage isolation/withstand test vibration and shock/bump test requirements in EN 61373; the cooling, dry, and damp heat test requirements in IEC/EN 60068-2-1, 2, and 30; and the EMC railway standards in EN 50121-3-2.

An advanced circuit topology provides a very high efficiency up to 93%, which allows a base plate temperature up to 105 ° C and very high I/O isolation up to 3000 VAC with reinforced insulation. Further features include overload, overvoltage, and short-circuit protection; remote ON/OFF; output trim; and output sense. For fire protection testing, these converters meet the EN 45545-2 standard to ensure system safety.

## THE INTRODUCTION OF RAILWAY CERTIFICATION EN 50155:2017



## MINMAX RAILWAY CERTIFIED POWER SOLUTIONS

# FUNDAMENTAL INTRODUCTION

- Trains and high-speed rail have become more technically advanced and passenger-friendly with many additional infotainment systems and critical safety equipment. These types of electrical systems and functions, such as monitoring sensors around the train; air conditioning; lighting; and door-opening, communication, and entertainment systems, will inherently include CPUs, DSPs, analog circuitry, and highly sensitive sensors, which all must be powered from the railway storage battery system within the train.

- Modern trains and high-speed rail achieve reductions in weight and space by using a vehicle battery voltage upto 72 V or 110 VDC, but most electronic equipment/systems require input voltages of 5, 12, 15, 24, and 54 VDC. Basically, there are many railway certified DC–DC converters between the electronic equipment/systems and train's storage battery to transform the basic 72 V or 110 VDC into 5, 12, 15, 24, and 54 VDC.

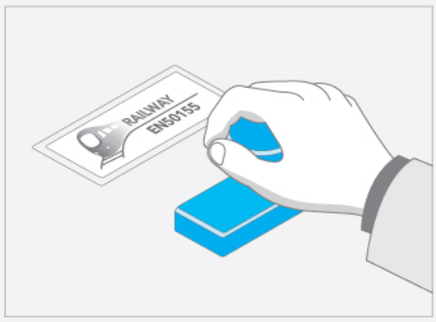
- Moreover, the train's storage battery is typically located within the drive train locomotive at the front or rear of the vehicle. Therefore, the DC voltage is supplied over long distances by a power cable to the electronic equipment/system. These long power-cable lengths can pick up electromagnetic disturbances, induced transient voltage spikes (caused by nearby lightning strikes), and power-line fluctuations.
  The train's storage battery is also used to drive starter motors, pumps, compressors, drivers, relay coils, and other switch gears. These and other high-power loads are connected to the alternator, generator, and transformers. The end result of this environment is an unstable, highly fluctuating, noisy power source. It can also cause the risk of dangerous energy shocks due to excess energy hazards such as electric shocks, transient voltage spikes, mechanical damage, shorts developing between PCB tracks, air gaps, arcing, and ground loops, which cause ignition and fire situations. Each of these situations will extremely impact/interfere with the train's electronic equipment/system, resulting in a failure.
  Thus, we conclude that high-performance, high-isolation (with reinforced insulation), high-robustness, reliable, rugged, durable, uninterruptible railway certified DC–DC converters between the electronic equipment/system and the train's storage battery are necessary for long-term stable operation of the train's equipment and systems.

- Therefore, MINMAX railway certified DC–DC converters between the train's storage battery and electronic equipment/system, which are integrated into train/rolling stock applications must comply with the international railway certification "**EN 50155:2017(IEC 60571): Railway Application Electronic Equipment Used on Rolling Stock.**" This certification covers specification requirements including the input voltage specification test, I/O voltage isolation test, insulation test, Electromagnetic Capability (EMC) test, mechanical requirement test, and harsh environmental test including the operating temperature test and the humidity, cooling, dry heat and damp heat tests that trains/rolling stock electronic equipment must meet.

- The right product is essential, but it is not everything. In addition to our product offerings, we provide a comprehensive range of services, including analysis and qualification in the development stage, demand planning and special logistics in the production phase, and end-user support in the aftermarket.
  **MINMAX aim to serve you with sincerity to ensure that your customers return time and again.**

# INPUT VOLTAGE SPECIFICATION TEST FOR EN 50155:2017 RAILWAY CERTIFICATION

- In the case of railway certified DC-DC converters, the input port must interface with the train's storage battery power source. The standard specifies that the input-voltage range of the converters must be operated in the same range as the train's storage battery voltage during normal operation.
  A surge voltage test is specified to cover extreme variations, in addition to the minimum insulation requirements for safety.




- Nominal DC input voltages (VN) of 24, 36, 48, 72, 96, and 110 VDC are usually provided by the train's storage battery power sources used as the primary insulation barrier in the railway DC power architecture.
- MINMAX railway certified DC-DC converters powered directly from batteries with no voltage stabilizing device must function properly with input voltages that range from 0.7VN to 1.25VN during normal operation. Further, these converters also withstand input voltage drops of 0.6VN for 100 ms and overvoltage surges of 1.4VN for 1s that may occur during startup.

The table below summarizes, with some exceptions, the MINMAX railway certified DC-DC converters that cover all the specified input ranges, brown-outs, transients, and voltage spikes for the permanent operation of a train's electronic equipment system.

| Phenomenon | EN 50155 : 2017 Reference Clause / Standard | |
|---|---|---|
| | Standard Test Level | MINMAX Test Level |
| Supply Variations | EN 50155 12.2.2 / EN 50155 5.1.1.1 | |
| | Test Voltage / Time: 0.7 VN / 10min.<br>Test Voltage / Time: VN / 10min.<br>Test Voltage / Time: 1.25 VN / 10min.<br>Test Voltage / Time: 0.6 VN / 0.1sec.<br>Test Voltage / Time: 1.4 VN / 0.1sec.<br>Test Voltage / Time: 1.4 VN / 1sec<br>Test Number: repeated 10 times | Test Voltage / Time: 0.7 VN / 10min.<br>Test Voltage / Time: VN / 10min.<br>Test Voltage / Time: 1.25 VN / 10min.<br>Test Voltage / Time: 0.6 VN / 1min.<br>Test Voltage / Time: 1.4 VN / 1sec.<br>Test Voltage / Time: 1.4 VN / 1min.<br>Test Number: repeated 10 times |
| Supply Interruptions | EN 50155 12.2.2 / EN 50155 5.1.1.2 | |
| | Class S1: 100%VN / 0mS<br>Class S2: 100%VN / 10mS<br>Test Number: repeated 10 times | Class S1: 100%VN / 0mS<br>Class S2: 100%VN / 10mS*<br>Test Number: repeated 10 times |
| Supply Change Over | EN 50155 12.2.2 / EN 50155 5.1.1.3 | |
| | Class C1: Dip 40%VN / 100mS<br>Class C2: Interruptions 100%VN / 30mS<br>Test Number: repeated 10 times | Class C1: Dip 40%VN / 100mS & 10min.<br>Class C2: Interruptions 100%VN / 30mS*<br>Test Number: repeated 10 times |
| Supply Over Voltages | EN 50155 12.2.6 | |
| | Voltage Level / Duration: 1.4 VN / 0.1sec<br>Voltage Level / Duration: 1.4 VN / 1sec.<br>Test Number: repeated 10 times | Voltage Level / Duration: 1.4 VN / 10min.<br>Voltage Level / Duration: 1.4 VN / 60min.<br>Test Number: repeated 10 times |

*Note: Peripheral Components Needed, Please Contact MINMAX for More Information.

# VOLTAGE ISOLATION/WITHSTAND TEST FOR EN 50155:2017 RAILWAY CERTIFICATION

- Railway certified DC-DC converters have significantly played a crucial role in the certification of on-train electrical equipment.

- A 3000-VAC isolation/withstand voltage test with reinforced insulation of the MINMAX railway certified DC-DC converters will verify the design creepage, air clearances, and insulation level of the power module demands.

  The above criteria comply with the limited leakage current under normal/single-fault conditions and protect sensitive circuit loads from noise, electromagnetic disturbances, power bus fluctuations, surges, electrical shocks, transient voltage spikes, insulation breakdown of the power architecture, mechanical damage, shorts developing between PCB tracks, air gaps, arcing, and ground loops, which cause ignition and fire situations.

| Phenomenon | EN 50155 : 2017 Reference Clause | |
|---|---|---|
| | Standard Test Level | MINMAX Test Level |
| Isolation / Withstand Voltage Test | EN 50155 12.2.9 | |
| | Test Voltage / Time: 2100VAC / 60sec. | Test Voltage / Time: 3000VAC / 60sec. |

# ELECTROMAGNETIC CAPABILITY (EMC) TEST FOR EN 50155:2017 RAILWAY CERTIFICATION

- Electromagnetic compatibility (EMC) is another main category of the **EN 50155** certification.

  MINMAX railway certified DC-DC converters are approved at the European **EN 50121-3-2** standard "Railways Applications Electromagnetic Compatibility Part 3-2 Rolling Stock Apparatus," which states that the power module should not emit conducted and radiated electromagnetic interference (EMI) in excess of the defined levels and should be protected from outside negative effects due to conduction, radiation, surges, ESD, and EFT interference.

# ELECTROMAGNETIC CAPABILITY (EMC) TEST FOR EN 50155:2017 RAILWAY CERTIFICATION

| EMC | Phenomenon | EN 50155 : 2017 Reference Clause / Standard | |
|---|---|---|---|
| | | Standard Test Level | MINMAX Test Level |
| EMI | Conducted Emission | EN 50155 12.2.8.2 / EN 50121-3-2, EN 55011 sub-clause 7 | |
| | | Frequency / level: 0.15~0.5MHz / 99 dBuV<br>Frequency / level: 0.5~5MHz / 93 dBuV<br>Frequency / level: 5~30MHz / 93 dBuV | Frequency / level: 0.15~0.5MHz / 66 dBuV*<br>Frequency / level: 0.5~5MHz / 60 dBuV*<br>Frequency / level: 5~30MHz / 60 dBuV* |
| | Radiated Emission | EN 50155 12.2.8.2 / EN 50121-3-2, EN 55011 sub-clause 7 | |
| | | Frequency / level: 30~230MHz / 40 dB(uV/m)<br>Frequency / level: 230~1000MHz / 47 dB(uV/m) | Frequency / level: 30~230MHz / 40 dB(uV/m)*<br>Frequency / level: 230~1000MHz / 47 dB(uV/m)* |
| EMS | ESD Immunity Test | EN 50155 12.2.7.2 / EN 50121-3-2, IEC 61000-4-2 | |
| | | Air Discharge: ±8KVDC<br>Contact Discharge: ±6KVDC<br>Indirect Discharge HCP & VCP: ±6KVDC | Air Discharge: ±8KVDC<br>Contact Discharge: ±6KVDC<br>Indirect Discharge HCP & VCP: ±2/4/6KVDC |
| | Radio-Frequency, Electromagnetic Field Immunity Test | EN 50155 12.2.8.1 / EN 50121-3-2, IEC 61000-4-3 | |
| | | Frequency / Field: 80~1000MHz/20 V/m<br>Frequency / Field: 1400~2000MHz/10 V/m<br>Frequency / Field: 2000~2700MHz/5 V/m<br>Frequency / Field: 5100~6000MHz/3 V/m | Frequency / Field: 27~80MHz/20 V/m<br>Frequency / Field: 80~1000MHz/20 V/m<br>Frequency / Field: 1400~2000MHz/20 V/m<br>Frequency / Field: 2000~2700MHz/10 V/m<br>Frequency / Field: 2700~5000MHz/10 V/m<br>Frequency / Field: 5100~6000MHz/10 V/m |
| | Electrical Fast Transient/Burst Immunity Test | EN 50155 12.2.7.3 / EN 50121-3-2, IEC 61000-4-4 | |
| | | Line, Neutral, Line+Neutral: ±2KVDC | Line, Neutral, Line+Neutral: ±2KVDC* |
| | Surge Immunity Test | EN 50155 12.2.7.1 / EN 50121-3-2, IEC 61000-4-5 | |
| | | Line to Line: ±1KVDC | Line to Line: ±2KVDC* |
| | Radio-Frequency, Conducted Disturbances Immunity Test | EN 50155 12.2.8.1 / EN 50121-3-2, IEC 61000-4-6 | |
| | | Frequency : 0.15 to 80MHz<br>Field: 10 Vrms | Frequency : 0.15 to 80MHz<br>Field: 10 Vrms |
| | Power Frequency Magnetic Field Immunity Test | IEC 61000-4-8 | |
| | | No Needed | Frequency: 50Hz<br>Field: 30/100/1000 A/m |
| | Damp Oscillatory Magnetic Field Immunity Test | IEC 61000-4-10 | |
| | | No Needed | Frequency: 0.1 & 1 MHz<br>Field: 30 A/m |

*Note:Peripheral Components Needed, Please Refer to the Datasheet or Contact MINMAX for More Information.

# ENVIRONMENTAL REQUIREMENT TEST FOR EN 50155:2017 RAILWAY CERTIFICATION

- Operating Temperature Range Requirement

The operating temperatures are divided into four classes according to the severity of the environment, as summarized in the table below. When designing railway certified DC-DC converters, it is necessary to consider the over-temperature during startup, as indicated in the third column.

**Table 1 - Operating Temperature Rating**

| Class | Equipment Operating Temperature Range (°C) |
|---|---|
| OT1 | -25°C to +55°C |
| OT2 | -40°C to +55°C |
| OT3 | -25°C to +70°C |
| OT4 | -40°C to +70°C |
| OT5 | -25°C to +85°C |
| OT6 | -40°C to +85°C |

The OT5 and OT6 types cannot serve as the general specifications of temperature requirements for vehicles (but can be used in the semiconductor drive unit (SDU), engine control unit).

The OT1 and OT2 types are suitable for passenger compartments and driver's cab. The long-term temperature must be maintained at 25°C, while the temperature at the passenger compartments and driver's cab can affect the service life of the material. The OT3 and OT4 types are ideal for the equipment in the cabinets with a long-term reference temperature of 45°C. This ambient temperature can also affect the service life of the material.

- The indoor temperature rise should be considered during design phase to ensure that the temperature of the components will not exceed the specified rated temperature. For example, if the air temperature around the PCB rises by about 15°C (this temperature rise depends mainly on the power consumption of the PCB itself and the adjacent PCB, or the natural airflow, enforced airflow, etc.). While designing the PBA, we should consider placing one PBA horizontally or vertically; or allow the sub-racks of the PBA to be stacked together. The suppliers should consider the requirements imposed by specific onboard installations.

In some exceptional cases (such as partitions, effects of sunlight, the shutdown of the auxiliary cooling system), the additional operational checks on the switch-on equipment should be processed under a short-term thermal condition based on the status of ST1 or ST2 as shown in Table 2.

# ENVIRONMENTAL REQUIREMENT TEST FOR EN 50155:2017 RAILWAY CERTIFICATION

**Table 2 - Switch-On Status of the Extended Operating Temperature Rating**

| Class | Switch-On Extended Operating Temperature (Duration: 10 min) |
|---|---|
| ST0 | No Switch-On Extended Operating Temperature |
| ST1 | OTx + 15°C |
| ST2 | OTx + 15°C |

**Operating Temperature and Humidity Test**

| Phenomenon | EN 50155 : 2017 Reference Clause / MINMAX Test Level |
|---|---|
| Low Temperature Start-up Test | EN 50155 13.4.4 / EN 60068-2-1 |
| | Test Curve Follow by EN 50155 : 2017 with:<br>• Operating Temperature Class : OT4<br>• Continuous Operation Checks Period: 8 HRs |
| Dry Heat Test | EN 50155 13.4.5 / EN 60068-2-2 |
| | Test Curve Follow by EN 50155 : 2017 with:<br>• Operating Temperature Class: OT4<br>• Switch-On Extended Operating Temperature Range Class: ST2<br>• Thermal Test Cycle: C<br>• Continuous Operational Checks Period: 8 HRs |
| Low Temperature Storage Test | EN 50155 13.4.6 / EN 60068-2-2 |
| | Test Curve Follow by EN 50155 : 2017 with:<br>• Temperature / Dwell Time: 16HRs in Storage |
| Cyclic Damp Heat Test | EN 50155 13.4.7 / EN 60068-2-30 |
| | Test Curve Follow by EN 50155 : 2017 with:<br>• Test Temperature ($T_{TEST}$) under Equip. Switched ON: +70°C<br>• Continuous Operation Checks Period under Equip. Switched ON: 24HRs<br>• Test Temperature ($T_{TEST}$) of Recovery Period under Equip. Switched OFF: +70°C |

# MECHANICAL REQUIREMENTS TEST FOR EN 50155:2017 RAILWAY CERTIFICATION

**Vibration and Increased Vibration Test**

- The EN 50155 certification specifies that railway certified DC-DC converters mounted on boards and boxes fixed to the railway/railroad vehicle frame must be able to withstand and satisfy the stringent EN 61373 vibration and shock test. Therefore, the manufacturing processes must be rigorously controlled to ensure consistent performance.

  The entire process requires dedication and commitment to serve the special needs of rolling-stock on board electronics.

  MINMAX railway certified DC-DC converters have been specially designed for high shock and vibration tolerances are able to withstand, without deterioration or malfunction, such conditions in compliance with EN 61373 standards.

| Phenomenon | EN 50155 : 2017 Reference Clause / Standard | |
|---|---|---|
| | Standard Test Level | MINMAX Test Level |
| Functional Random Vibration Test | EN 50155 12.2.11 / EN 61373 (EN 60068-2-6) | |
| | Category 1, Class B, Body Mounted<br>Frequency Range: 5Hz~150Hz<br>Grms Value: 0.102 Grms (1.0/s²) for Each Axis<br>Dwell Time: 10min/axis in Storage | Category 3, Axle Mounted<br>Frequency Range: 5Hz~150Hz<br>Grms Value: 5.102 Grms (50m/s²) for Each Axis<br>Dwell Time: 10min/axis in Operation |
| Increased Random Vibration Test | EN 50155 12.2.11 / EN 61373 (EN 60068-2-6) | |
| | Category 1, Class B, Body Mounted<br>Frequency Range: 5Hz~150Hz<br>Grms Value: 0.806 Grms (7.9m/s²) for Each Axis<br>Dwell Time: 5 HRs/axis in Storage | Category 2, Bogie Mounted<br>Frequency Range: 5Hz~150Hz<br>Grms Value: 5.102 Grms (50m/s²) for Each Axis<br>Dwell Time: 5 HRs/axis in Operation |
| Shock Test | EN 50155 12.2.11 / EN 61373 (EN 60068-2-27) | |
| | Category 1, Class A&B, Body Mounted<br>Wave Form: Half-Sine<br>Acceleration Peak: 5.102 Grms (50m/s²) for Each Axis<br>Dwell Time: 30mS in Storage<br>Shock/Bump Times: 3 Times for Each Direction | Category 3, Axle Mounted<br>Wave Form: Half-Sine<br>Acceleration Peak: 5.102 Grms (50m/s²) for Each Axis<br>Dwell Time: 30mS in Operation<br>Acceleration Peak: 10 Grms (100m/s²) for Each Axis<br>Dwell Time: 11mS in Operation<br>Acceleration Peak: 100 Grms (1000m/s²) for Each Axis<br>Dwell Time: 6mS in Operation<br>Shock Times: 3 Times for Each Direction |
| Bump Test | No Reference / No Reference (EN 60068-2-29) | |
| | No Needed | Wave Form: Half-Sine<br>Acceleration Peak: 5.102 Grms (50m/s²) for Each Axis<br>Dwell Time: 30mS in Operation<br>Acceleration Peak: 10 Grms (100m/s²) for Each Axis<br>Dwell Time: 11mS in Operation<br>Bump Times: 2000Bumps for Each Direction |

# FIRE PROTECTION TEST OF THE EN 45545-2 STANDARD

- The railway/railroad transportation industry generally requires power module materials to meet the relevant requirements of the EN 45545-2 fire protection test standard. The EN 45545-2 guidelines specify that different materials under test shall be classified, and their "fire safety index parameter and test conditions" are defined according to different categories of R1–R26.

**Test Content :**

1. Functional descriptions of fire-safe samples
2. Fire safety requirements for homogeneous materials
3. Component materials of the internal structure

**The following index parameters are used to evaluate the fire protection capabilities :**

Heat release rate, Combustibility, Smoke toxicity, Smoke opacity

- The fire protection grades (HL Levels) of the different materials under test will be evaluated on the basis of the final test data of the "fire safety index parameter".
- The fire protection grades of the materials required for railway/railroad vehicles will be classified according to the vehicle's operating environment and different vehicle categories and by referencing the table below (Table 1 - Hazard Level Classification).

**Table 1-Hazard Level Classification**

| Operation category | Design category | | | |
|---|---|---|---|---|
| | N : Standard vehicles | A : Vehicles forming part of an automatic train having no emergency trained staff on board | D : Double decked vehicles | S : Sleeping and couchette vehicles |
| 1 | HL1 | HL1 | HL1 | HL2 |
| 2 | HL2 | HL2 | HL2 | HL2 |
| 3 | HL2 | HL2 | HL2 | HL3 |
| 4 | HL3 | HL3 | HL3 | HL3 |

# FIRE PROTECTION TEST OF THE EN 45545-2 STANDARD

**Operation Category 1**

Vehicles for operation on infrastructure where railway vehicles may be stopped with minimum delay, and where a safe area can always be reached immediately.

**Operation Category 2**

Vehicles for operation on underground sections, tunnels and/or elevated structures, with side evacuation available and where there are stations or rescue stations that offer a place of safety to passengers, reachable within a short running time.

**Operation Category 3**

Vehicles for operation on underground sections, tunnels and/or elevated structure, with side evacuation available and where there are stations or rescue stations that offer a place of safety to passengers, reachable within a long running time.

**Operation Category 4**

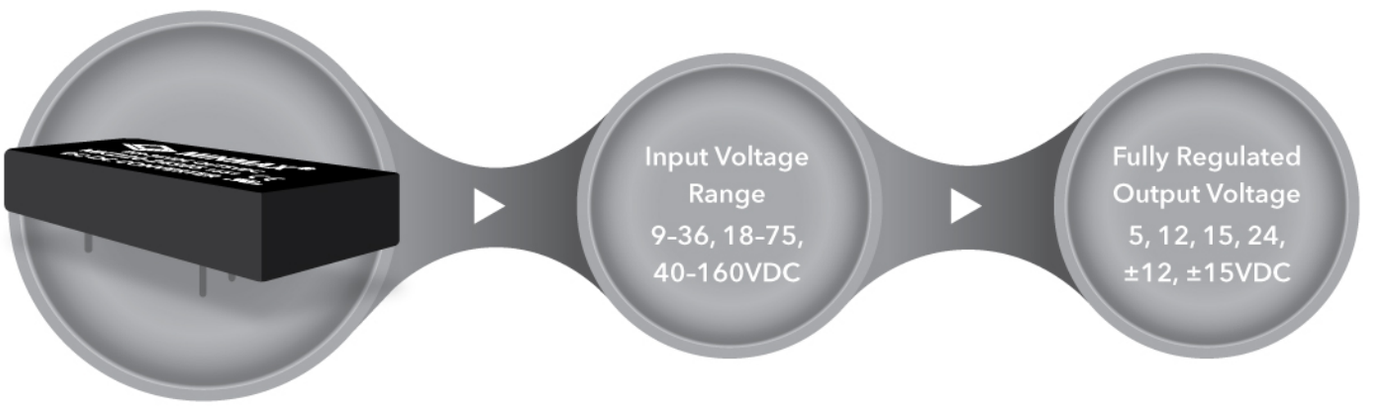
Vehicles for operation on underground sections, tunnels and/or elevated structure, without side evacuation available and where there are stations or rescue stations that offer a place of safety to passengers, reachable within a short running time.

- The fire protection grades (HL Levels) of all plastic housings, printed circuit boards (PCBs), and potting compounds of all MINMAX's railway certified power modules will be evaluated on the basis of the final test results of the "fire safety index parameter" to ensure safety during railway/railroad vehicle operation.

# HIGHLIGHTED PERFORMANCE OF RAILWAY CERTIFIED PRODUCTS

## Ultra-wide Input Voltage Range

- Using wide 4:1 input voltage range for railway DC bus with 24V, 36V, 48V, 72V, 96V, 110VDC easily (MKZI20 series as example).

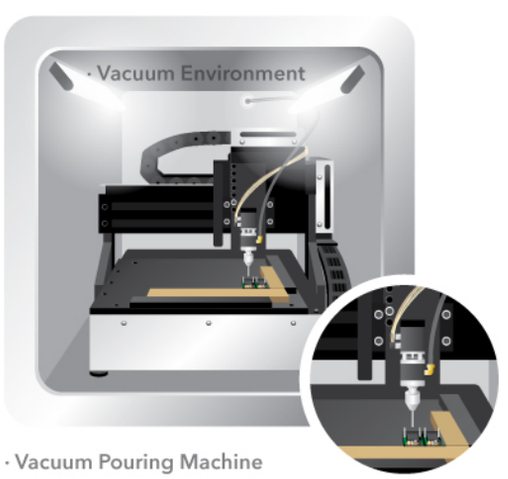



* Example : MKZI20-110S12
* Please refer to the "Input Voltage Specification Test for EN 50155 Railway Certification" on Page 03 for more information.

## Fully Vacuum Encapsulated & Fire Protection Test to Save Your System

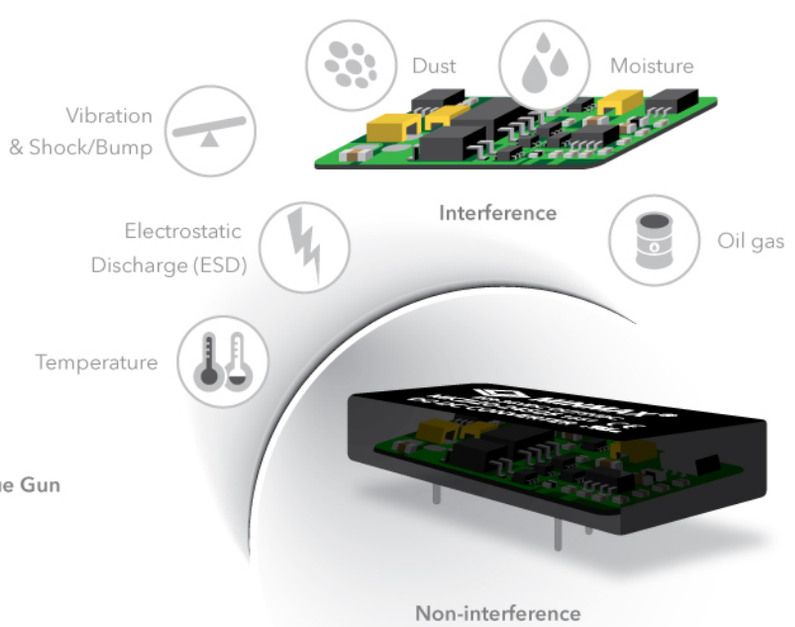
- **MINMAX railway certified DC-DC converters** are fully vacuum encapsulated and use the glue of UL 94V-0 grade.

**MTBF>1Million HRs**




· Vacuum Pouring Machine

· Glue Gun




* Example : MKZI20-110S12
* Please refer to the "Environmental & Mechanical Requirement Test for EN 50155 Railway Certification" on Page 06-08 for more information.

# Fully Encapsulated & Fire Protection Test to Save Your System

**Fire Protection Test**

- The following index parameters are used to evaluate fire protection capabilities:

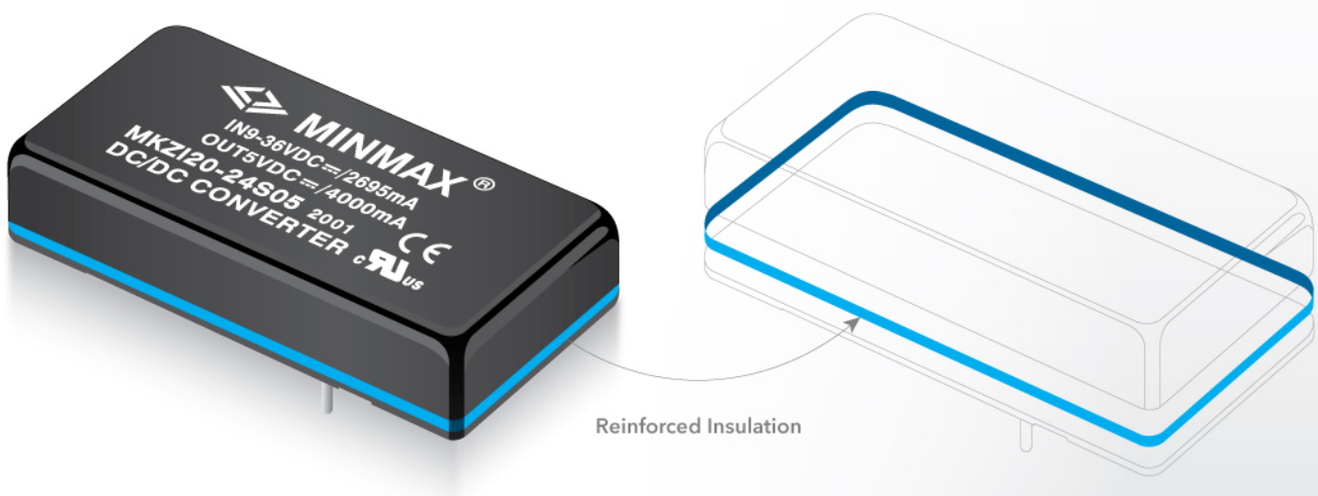

- Fire protection grades (HL Level) of all plastic housings, printed circuit boards (PCB), and potting compounds of all MINMAX's railway certified power modules will be evaluated based on the final test results of the "fire safety index parameter" to ensure safety during railway/railroad vehicle operation.

* Please refer to the "Fire Protection Test of the EN 45545-2 Standard" on Page 09 for more information.

# Primary Reinforced Insulation Barrier with Patent Insulated Frame for Strength Railway Power Architecture

- The MINMAX railway certified DC-DC power modules have been verified by UL organization that transient rating test for Reinforced Insulation Barrier of PRIMARY CIRCUIT is based on : (1) 160VDC input voltage, not only 110VDC input voltage (2) Highest 3000VAC Isolation (3) Working Voltage of 1000Vrms.

- The MINMAX railway certified DC-DC power modules applied for the power distribution system that is either an AC MAINS SUPPLY or a DC MAINS SUPPLY both available.

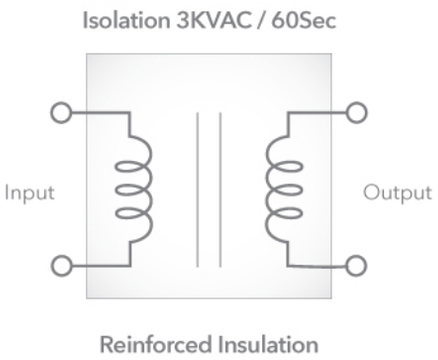



* Example : MKZI20-110S12

# Reinforced Insulation & 3KVAC Isolation for System Safety

- The 3KVAC I/O isolation with reinforced insulation and vacuum encapsulated creates a solid electrical barrier which to protect sensitive circuit load from noise, electromagnetic disturbances, power bus fluctuation, surge, electric shock, transient voltage spike, insulation breakdown of power architecture, mechanical damage and short developing between PCB tracks, air gaps, arcing and ground loop. Thus provide safety on long-term operation of railway/railroad equipment.

* Please refer to the "Voltage Isolation/Withstand Test for EN 50155 Railway Certification" on Page 04 for more information.




# Wider Operating Ambient Temperature Range

- Wide operating temp. range by latest thermal management technology and fully vacuum encapsulated.

**Wider Operating Temp. Range**

-40 to +88.5°C without air-forced fan or heatsink cooling

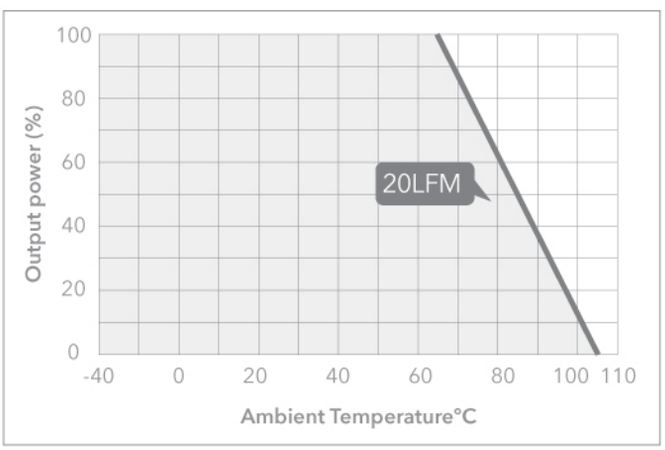
**Storage Temp. Range**

-50 to +125°C

**Operating Humidity**

95% rel. H

* Please refer to the "Environmental Requirement Test for EN 50155 Railway Certification" on Page 06 & 07 for more information.



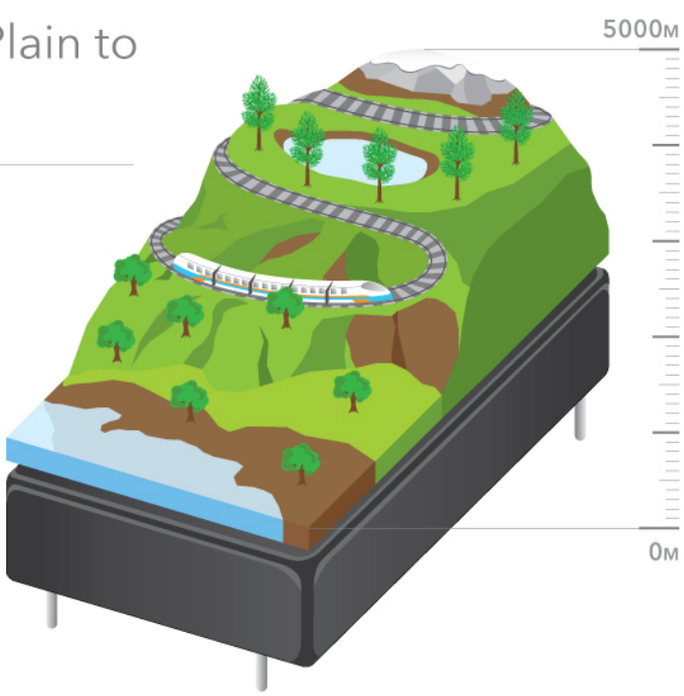

* Example : MKZI20-110S12

# Altitude by 5000 Meters for Plain to Plateau Operation

- Certified by UL standards of safety to withstand an altitude of 5000m.

Avoids short circuit development between PCB tracks, air gaps and arcing, to solve the high-altitude operation-limit issues of your train.

* Example : MKZI20-110S12



# MINMAX Reliability Test

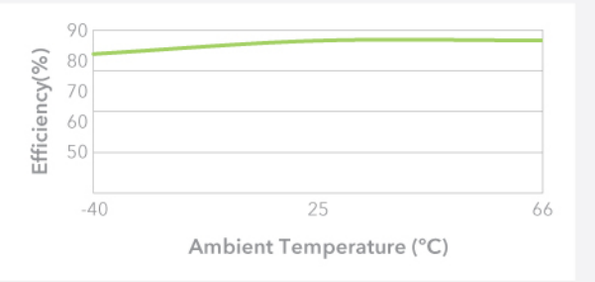
- Besides EN 50155 standard, our railway DC-DC converters are tested by conscientious and reliable to provide high quality and safe products.

| Testing Characteristics | Testing Condition | |
|---|---|---|
| **Developing Product Reliability Test** | | |
| Burn-in | Input Line<br>Output Load<br>Temperature<br>Duration | Nom. Line<br>Full Load<br>Room Temperature<br>1032 HRs |
| Highly Accelerated Life Test(HALT) | Thermal Step Stress Test<br>Rapid Thermal Stress Test<br>Vibration Step Stress Test<br>Combined Environmental Stress Test | |
| Temperature Cycling Test(TCT) | Temperature Change<br>Steady State Duration<br>Ramp Rate<br>Number of Cycles | -40°C ~ +125°C<br>30min<br>20°C/min<br>200+ |
| Temperature & Humidity Storage Cycling Test<br>(Non-Operation) | Temperature Change<br>Ramp Rate<br>Relative Humidity<br>Steady State Duration<br>Number of Cycles | Low to High Temperature<br>1-3°C/min<br>+95% RH.<br>1 HR<br>5 Cycles |
| Power and Temperature Cycling Test(PTCT)<br>(In Operation) | Input Line Change<br>Output Load Change<br>Temperature Change<br>Relative Humidity<br>Duration for ON/OFF<br>Number of Cycles | Low/Nom./High Line<br>No or Min./Full Load<br>Low to High Temperature<br>+95% RH.<br>3 Sec<br>300 Cycles |
| Temperature, Humidity and Bias Test(THB)<br>(In Operation) | Input Line<br>Output Load<br>Temperature<br>Relative Humidity<br>Operating Duration | High Line<br>No or Min. Load<br>+85°C<br>+85% RH.<br>1000 HRs |
| Low Temperature Test<br>(In Operation) | Input Line<br>Output Load<br>Temperature<br>Duration | Nom. Line<br>Full Load<br>Low Temperature<br>Achieve Thermal Equilibrium |
| High Temperature Test<br>(In Operation) | Input Line<br>Output Load<br>Temperature<br>Duration | Nom. Line<br>Full Load<br>High Temperature<br>Achieve Thermal Equilibrium |
| Vibration Test<br>(Non-Operation) | Waveform | Random |
| | P.S.D Level | 10 Hz · $1.04\times10^{-3}$ $g^2/Hz$<br>30 to 200Hz · $20.8\times10^{-3}$ $g^2/Hz$<br>500 Hz · $2.08\times10^{-3}$ $g^2/Hz$ |
| | Duration | 30 minutes |
| | Directions | X, Y and Z |
| Shock Test<br>(Operation) | Waveform<br>Acceleration<br>Duration<br>Number of Shocks | Half-sine<br>30 g<br>11 ms<br>3 shocks for each ±axis |
| ESD Test | Contact Discharge<br>Air Discharge | ±4KV<br>±2/4/8KV |
| Soldering Heat Test | MIL-STD-202F Method 210E | |
| RoHS | RoHS Directive 2011/65/EU | |
| **Additional Test** | | |
| Drop Test | Drop Height | 66 cm |
| | Drop Sequence | 1 corner, 3 edges and 6 faces |

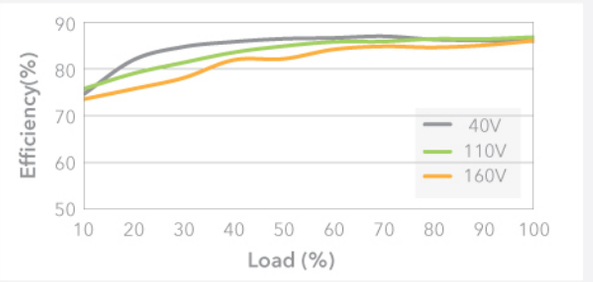
# ECO-technology

## Green Design for Higher Full Range Efficiency

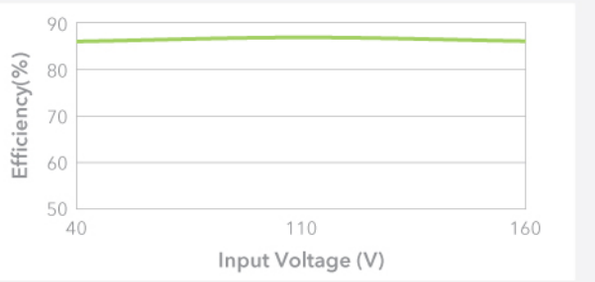
- High efficiency for whole output load, input line & ambient temp. range by latest green design technology helps to energy saving, thermal management, minimize the temp. rise and size miniaturization.




* Example : MKZI20-110S12 @ Nom. Line & 100% Load




* Example : MKZI20-110S12



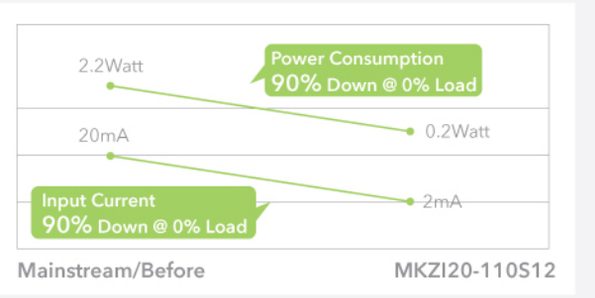

* Example : MKZI20-110S12 @ 100% Load

## Green Design for Energy Saving, Minimize Temperature Rise

- Ultra low no-load power consumption by latest green design technology helps to improve and minimize the temp. rise (avoid thermal problem), energy saving and prolong the battery life.

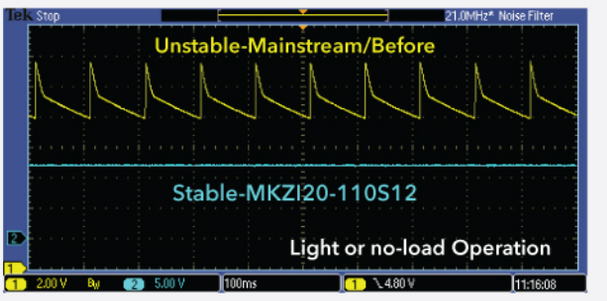
**Very Low No Load Input Current 2mA @ 110Vin**

**Very Low No Load Power Consumption 0.2Watt @ 110Vin**




## Green Design for No Min. Load / Dummy Load Requirement

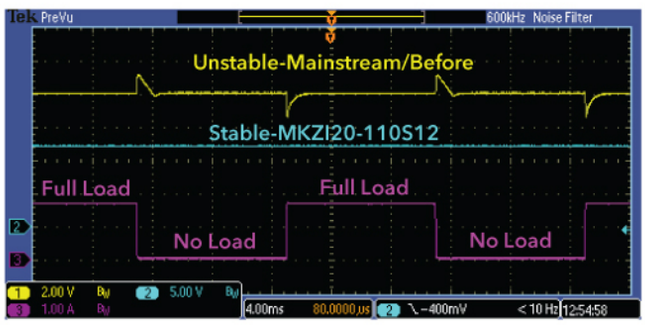
- With high stability feedback loop design, the MINMAX railway certified DC-DC converters will not oscillate in no-load or light-load condition.



# Power Your System Precisely

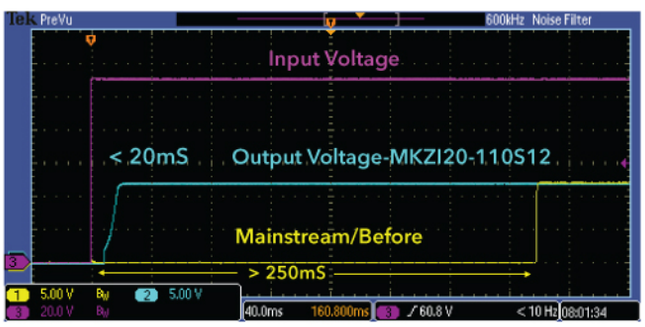
**Setting Accuracy ±1% Vom • Line Regulation ±0.2% • Load Regulation ±0.5% • High Transient Response • Low Temperature Coefficient**

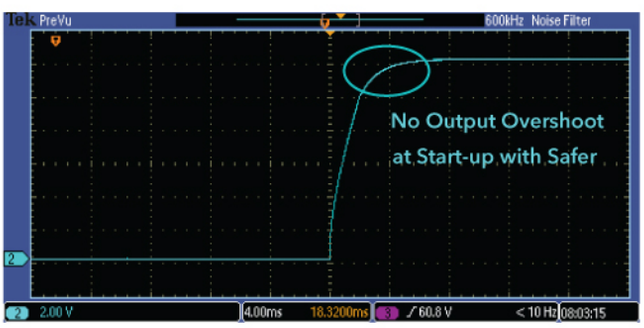
- The output voltage will still keep with excellent accuracy, even though the input voltage, output current and ambient temp. of the system are unstable .
- The output voltage of mainstream products may undershoot and overshoot obviously during the load changes. MINMAX railway certified DC-DC converters still keep with rated output voltage preciously.



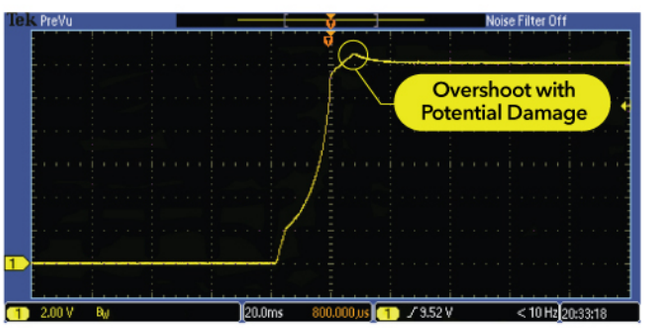

# Faster Start-up Time without Overshoot

- The start-up time of MKZI20 decreases from 250mS to 20mS which helps to avoid any system timing failure caused by long start-up time.
- Faster start-up time without overshoot ensures the safety of your system.



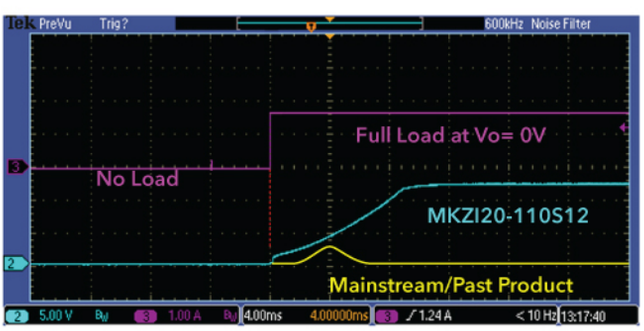

* Example : MKZI20-110S12




* Example : Mainstream/Before

# Superior Load Driving Capability

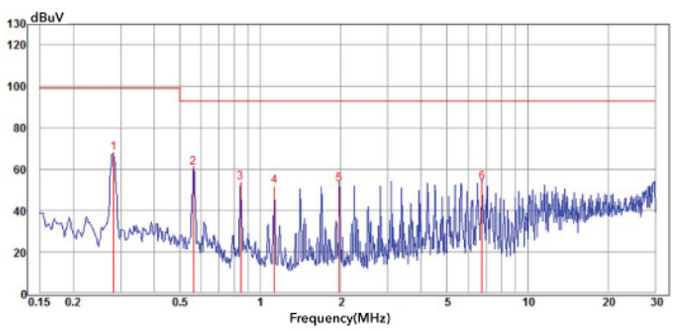
- MINMAX railway certified DC-DC converters have superior load driving capability which can drive your system during very low voltage and even zero voltage output without start-up failure.

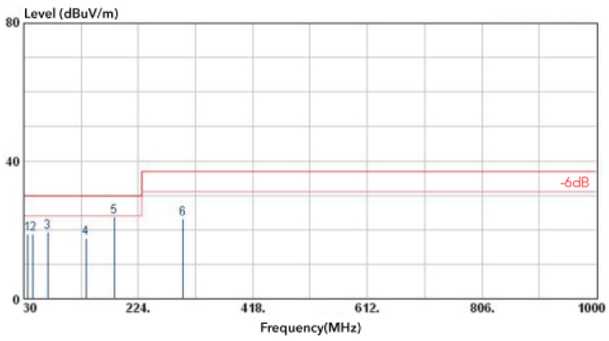


# Excellent EMC Performance

**Excellent EMI performance by upgraded noise filtering technology helps to improve overall system EMI performance on conduction and radiation emission.**

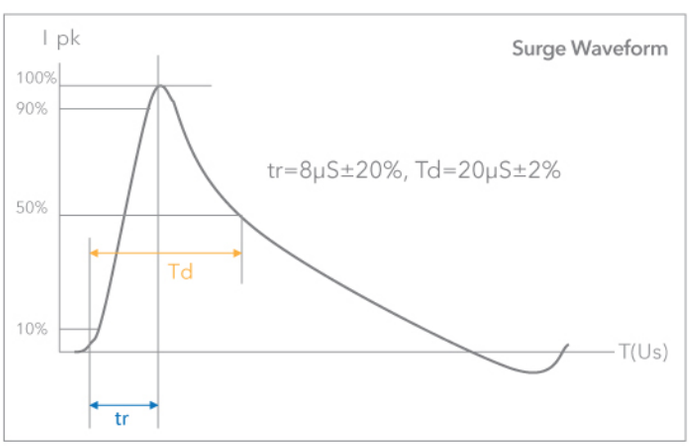
- No external component needed for conducted emission meets EN 55011 Class A.
- Only few peripheral components needed for radiated emission meets EN 55011 Class B.

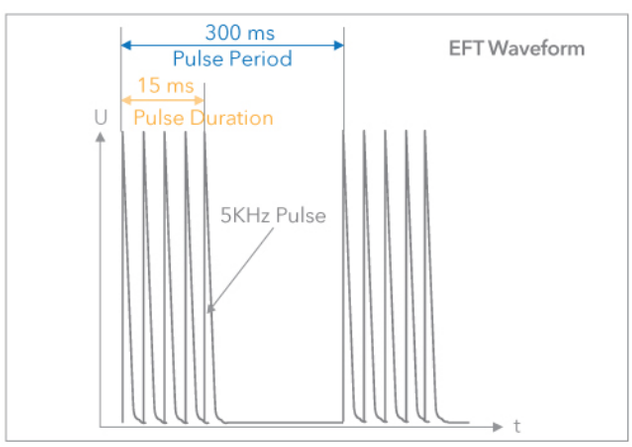



**Excellent EMS performance by upgraded noise immunity technology helps to improve overall system EMS performance on ESD, Surge, EFT, RS, CS and PFMF.**

- Only one E-cap. needed for ±2KV surge immunity by IEC 61000-4-5 with criteria A
- Only one E-cap. needed for ±2KV EFT immunity by IEC 61000-4-4 with criteria A.



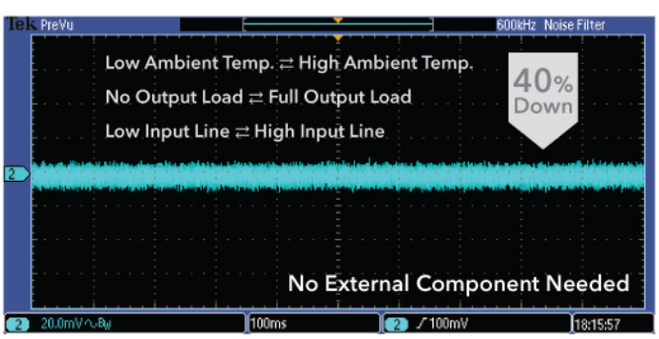




* Example : MKZI20

* Please refer to the "Electromagnetic Capability (EMC) Test for EN 50155 Railway Certification" on Page 04-05 for more information.

# Lower Ripple & Noise

- Small Ripple & Noise for whole output load, input line & ambient temp. range by upgraded noise filtering technology helps to reduce the peripheral components needed and noise interference.



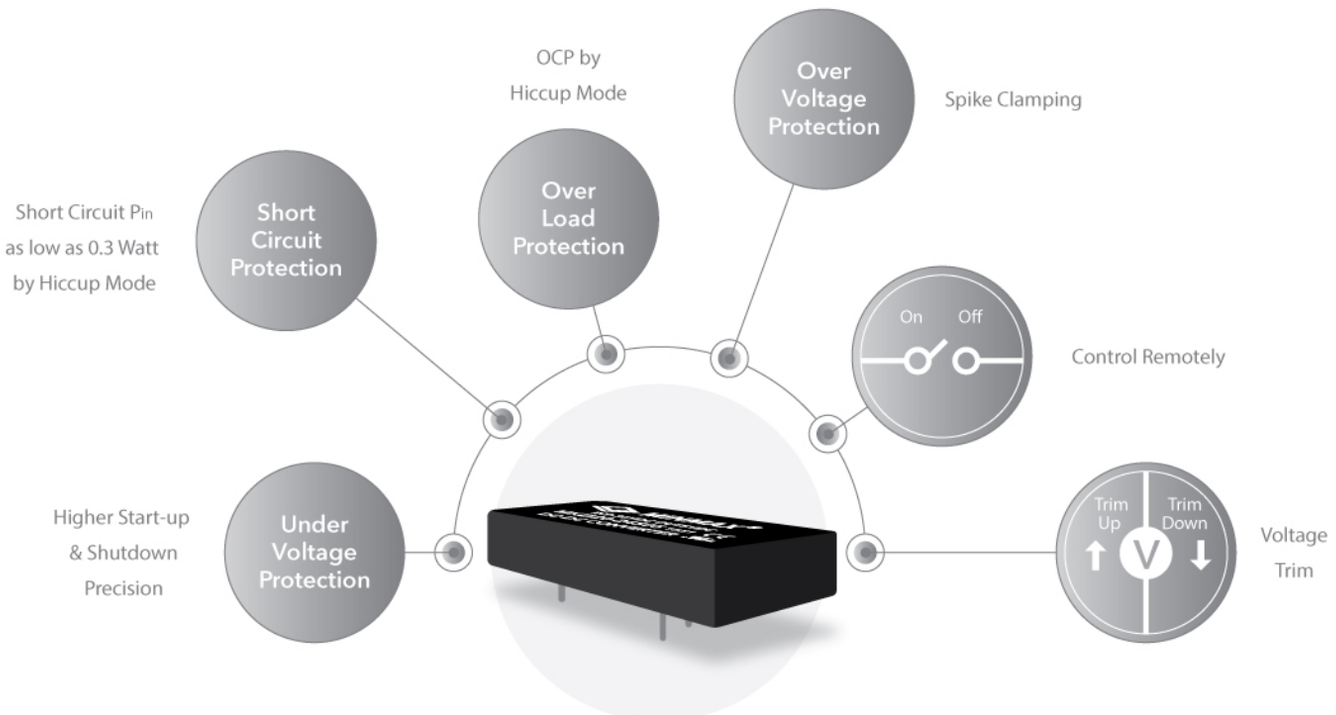

* Example : MKZI20

## Protection Functions on Abnormal Operation

- MINMAX railway certified DC-DC converters are the instantaneous protection for UVP, OCP, OVP & SCP which help to ensure long-term safety of system operation.

## Remote Control & Voltage Trim

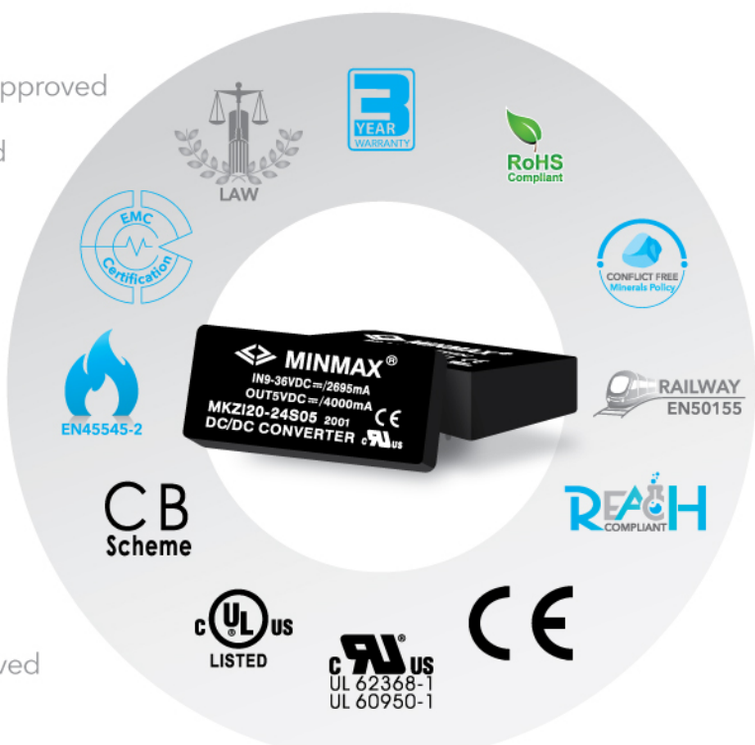
- MINMAX railway certified DC-DC converters can be switched on/off remotely via the remote control function and trim up/down on output voltage via the trim function to increase your design flexibility and freedom.



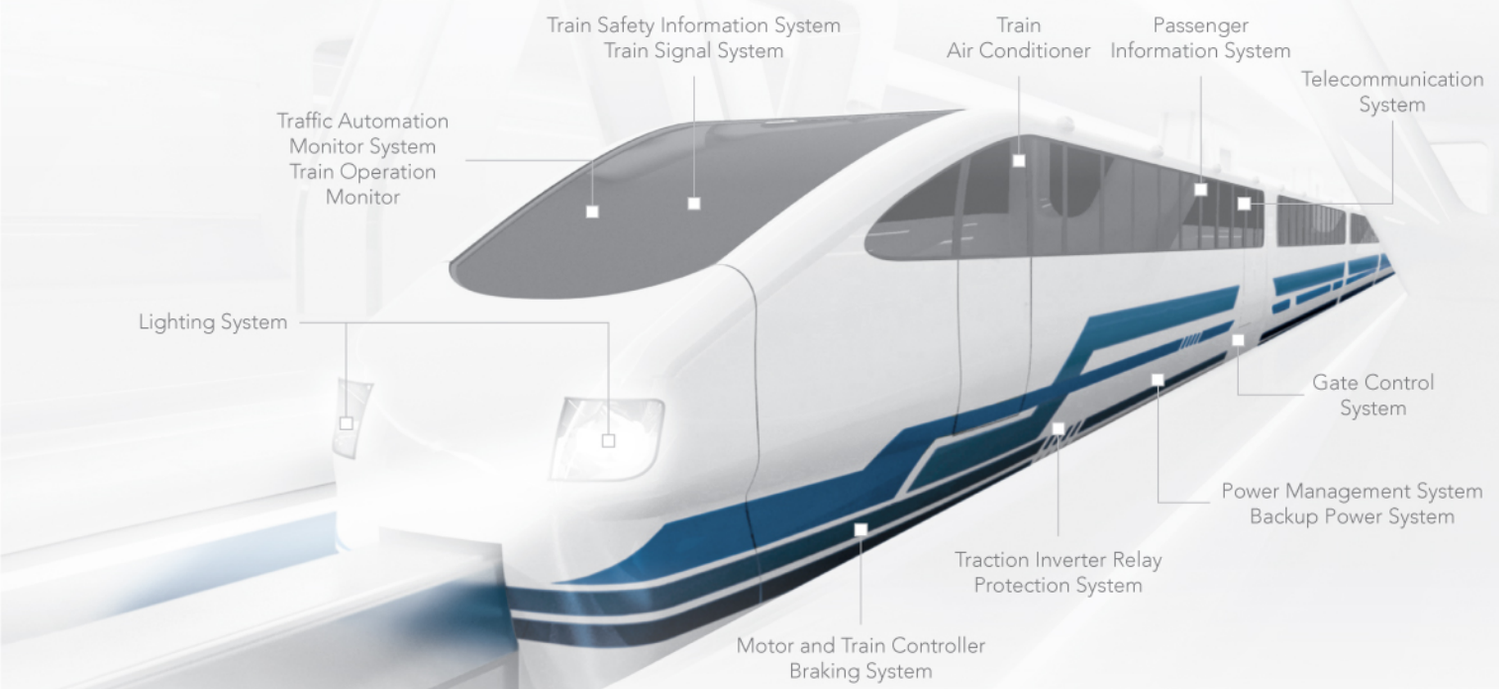

## Certifications

- Railway Certified EN 50155 (IEC 60571) Approved
- Fire Protection Test EN 45545-2 Approved
- Vibration and Shock Test EN 61373 Approved
- Cooling, Dry & Damp Heat Test IEC/EC 60068-2-1, 2, 30 Approved
- Railway EMC Standard EN 50121-3-2 Approved
- CE Marking
- UL/cUL/IEC/EN 62368-1(60950-1) Approved

*Depends on series



# Successful Application




# Railway Certified Products Overview

| Series | Output Power | Input Voltage Range (VDC) | Output Voltage (VDC) | Isolation (VAC) | Efficiency | Operating Ambient Temp. Range[1] | No Min. Load | OCP/SCP | OVP | OTP | Remote ON/OFF Control | Output Voltage Trim | Output Sense | EN50155 (IEC60571) | UL/cUL/IEC/EN 62368-1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3W • DIP Package | | | | | | | | | | | | | | | |
| MIZI03 | 3W | 9-36<br>18-75<br>40-160 | 5, 12,15,<br>±12, ±15 | 3000VAC<br>Reinforced | 85% | -40~+92°C<br>Ambient | • | • | | | | | | • | • |
| 10-40W • 2"×1" Package | | | | | | | | | | | | | | | |
| MKZI10 | 10W | 9-36<br>18-75<br>40-160 | 5, 12,<br>15, 24,<br>±12, ±15 | 3000VAC<br>Reinforced | 89% | -40~+95°C<br>Ambient | • | • | • | | • | • | | • | • |
| MKZI20 | 20W | 9-36<br>18-75<br>40-160 | 5, 12,<br>15, 24,<br>±12, ±15 | 3000VAC<br>Reinforced | 88% | -40~+88.5°C<br>Ambient | • | • | • | | • | • | | • | • |
| NEW MKZI40 | 40W | 36-160 | 5, 12, 15,<br>24, 54,<br>±12, ±15 | 3000VAC<br>Reinforced | 90% | -40~+77.5°C<br>Ambient | • | • | • | • | • | • | | • | • |
| 50-150W • Quarter Brick | | | | | | | | | | | | | | | |
| MTQZ50 | 50W | 43-101<br>66-160 | 5, 12,<br>15, 24 | 3000VAC<br>Reinforced | 92% | -40~+85°C<br>Ambient | • | • | • | • | • | • | • | • | • |
| MTQZ75 | 75W | 43-101<br>66-160 | 5, 12,<br>15, 24 | 3000VAC<br>Reinforced | 92% | -40~+80°C<br>Ambient | • | • | • | • | • | • | • | • | • |
| NEW MRZI100 | 100W | 36-160[2] | 5, 12, 15,<br>24, 54 | 2000VAC<br>Reinforced | 91.5% | -40~+105°C<br>Base plate | • | • | • | • | • | • | • | • | • |
| NEW MRZI150 | 150W | 36-160[2] | 5, 12, 15,<br>24, 54 | 2000VAC<br>Reinforced | 90% | -40~+105°C<br>Base plate | • | • | • | • | • | • | • | • | • |

[1] Please refer to derating curve information from datasheet
[2] Please refer to star-up voltage information from datasheet

## 3W | MIZI03 Series
DIP Package

RAILWAY EN50155 | c UL us UL 62368-1 UL 60950-1 | CB Scheme | CE | 3 YEAR WARRANTY


### Model Selection Table

| Model Number | Input Voltage (VDC) | Output Voltage (VDC) | Output Current (mA)max | Efficiency |
|---|---|---|---|---|
| MIZI03-24S05 | 24 (9 - 36) | 5 | 600 | 80% |
| MIZI03-24S12 | | 12 | 250 | 84% |
| MIZI03-24S15 | | 15 | 200 | 85% |
| MIZI03-24D12 | | ±12 | ±125 | 83% |
| MIZI03-24D15 | | ±15 | ±100 | 84% |
| MIZI03-48S05 | 48 (18 - 75) | 5 | 600 | 80% |
| MIZI03-48S12 | | 12 | 250 | 83% |
| MIZI03-48S15 | | 15 | 200 | 84% |
| MIZI03-48D12 | | ±12 | ±125 | 83% |
| MIZI03-48D15 | | ±15 | ±100 | 83% |
| MIZI03-110S05 | 110 (40 - 160) | 5 | 600 | 80% |
| MIZI03-110S12 | | 12 | 250 | 84% |
| MIZI03-110S15 | | 15 | 200 | 84% |
| MIZI03-110D12 | | ±12 | ±125 | 83% |
| MIZI03-110D15 | | ±15 | ±100 | 85% |

## 10W | MKZI10 Series
2"×1" Package

RAILWAY EN50155 | c UL us UL 62368-1 UL 60950-1 | CB Scheme | CE | 3 YEAR WARRANTY


### Model Selection Table

| Model Number | Input Voltage (VDC) | Output Voltage (VDC) | Output Current (mA)max | Efficiency |
|---|---|---|---|---|
| MKZI10-24S05 | 24 (9 - 36) | 5 | 2000 | 84% |
| MKZI10-24S12 | | 12 | 835 | 86% |
| MKZI10-24S15 | | 15 | 670 | 87% |
| MKZI10-24S24 | | 24 | 417 | 88% |
| MKZI10-24D12 | | ±12 | ±417 | 86% |
| MKZI10-24D15 | | ±15 | ±335 | 87% |
| MKZI10-48S05 | 48 (18 - 75) | 5 | 2000 | 85% |
| MKZI10-48S12 | | 12 | 835 | 87% |
| MKZI10-48S15 | | 15 | 670 | 87% |
| MKZI10-48S24 | | 24 | 417 | 86% |
| MKZI10-48D12 | | ±12 | ±417 | 89% |
| MKZI10-48D15 | | ±15 | ±335 | 88% |
| MKZI10-110S05 | 110 (40 - 160) | 5 | 2000 | 82% |
| MKZI10-110S12 | | 12 | 835 | 85% |
| MKZI10-110S15 | | 15 | 670 | 85% |
| MKZI10-110S24 | | 24 | 417 | 85% |
| MKZI10-110D12 | | ±12 | ±417 | 86% |
| MKZI10-110D15 | | ±15 | ±335 | 86% |

*There are different features & spec. by each series.
For detailed series datasheet, please refer to www.minmax.com.tw

## 20W | MKZI20 Series
2"×1" Package

RAILWAY EN50155 | c UL us UL 62368-1 UL 60950-1 | CB Scheme | CE | 3 YEAR WARRANTY


### Model Selection Table

| Model Number | Input Voltage (VDC) | Output Voltage (VDC) | Output Current (mA)max | Efficiency |
|---|---|---|---|---|
| MKZI20-24S05 | 24 (9 - 36) | 5 | 4000 | 87% |
| MKZI20-24S12 | | 12 | 1670 | 87% |
| MKZI20-24S15 | | 15 | 1330 | 87% |
| MKZI20-24S24 | | 24 | 833 | 87% |
| MKZI20-24D12 | | ±12 | ±833 | 86% |
| MKZI20-24D15 | | ±15 | ±667 | 86% |
| MKZI20-48S05 | 48 (18 - 75) | 5 | 4000 | 87% |
| MKZI20-48S12 | | 12 | 1670 | 88% |
| MKZI20-48S15 | | 15 | 1330 | 88% |
| MKZI20-48S24 | | 24 | 833 | 88% |
| MKZI20-48D12 | | ±12 | ±833 | 87% |
| MKZI20-48D15 | | ±15 | ±667 | 87% |
| MKZI20-110S05 | 110 (40 - 160) | 5 | 4000 | 84% |
| MKZI20-110S12 | | 12 | 1670 | 86% |
| MKZI20-110S15 | | 15 | 1330 | 86% |
| MKZI20-110S24 | | 24 | 833 | 86% |
| MKZI20-110D12 | | ±12 | ±833 | 86% |
| MKZI20-110D15 | | ±15 | ±667 | 86% |

## 40W | MKZI40 Series NEW
2"×1" Package

RAILWAY EN50155 | c UL us UL 62368-1 | CB Scheme | CE | 3 YEAR WARRANTY


### Model Selection Table

| Model Number | Input Voltage (VDC) | Output Voltage (VDC) | Output Current (mA)max | Efficiency |
|---|---|---|---|---|
| MKZI40-110S05 | 110 (36 - 160) | 5 | 8000 | 88% |
| MKZI40-110S12 | | 12 | 3330 | 89% |
| MKZI40-110S15 | | 15 | 2670 | 89% |
| MKZI40-110S24 | | 24 | 1670 | 89% |
| MKZI40-110S54 | | 54 | 741 | 90% |
| MKZI40-110D12 | | ±12 | ±1670 | 89% |
| MKZI40-110D15 | | ±15 | ±1330 | 89% |

*There are different features & spec. by each series.
For detailed series datasheet, please refer to www.minmax.com.tw

## 50W | MTQZ50 Series
Quarter Brick Package


### Model Selection Table

| Model Number | Input Voltage (VDC) | Output Voltage (VDC) | Output Current (mA)max | Efficiency |
|---|---|---|---|---|
| MTQZ50-72S05 | 72 (43 - 101) | 5 | 10000 | 90% |
| MTQZ50-72S12 | | 12 | 4170 | 92% |
| MTQZ50-72S15 | | 15 | 3330 | 92% |
| MTQZ50-72S24 | | 24 | 2080 | 91% |
| MTQZ50-110S05 | 110 (66 - 160) | 5 | 10000 | 90% |
| MTQZ50-110S12 | | 12 | 4170 | 91% |
| MTQZ50-110S15 | | 15 | 3330 | 92% |
| MTQZ50-110S24 | | 24 | 2080 | 91% |

## 75W | MTQZ75 Series
Quarter Brick Package


### Model Selection Table

| Model Number | Input Voltage (VDC) | Output Voltage (VDC) | Output Current (mA)max | Efficiency |
|---|---|---|---|---|
| MTQZ75-72S05 | 72 (43 - 101) | 5 | 15000 | 89% |
| MTQZ75-72S12 | | 12 | 6250 | 92% |
| MTQZ75-72S15 | | 15 | 5000 | 92% |
| MTQZ75-72S24 | | 24 | 3125 | 91% |
| MTQZ75-110S05 | 110 (66 - 160) | 5 | 15000 | 89% |
| MTQZ75-110S12 | | 12 | 6250 | 91% |
| MTQZ75-110S15 | | 15 | 5000 | 91% |
| MTQZ75-110S24 | | 24 | 3125 | 90% |

*There are different features & spec. by each series.
For detailed series datasheet, please refer to www.minmax.com.tw

## 100W | MRZI100 Series NEW

Quarter Brick Package

RAILWAY EN50155 | cULus UL 62368-1 | CB Scheme | CE | 3 YEAR WARRANTY


### Model Selection Table

| Model Number | Input Voltage (VDC) | Output Voltage (VDC) | Output Current (A)max | Efficiency |
|---|---|---|---|---|
| MRZI100-110S05 | 110 (36 - 160) | 5 | 20 | 91.5% |
| MRZI100-110S12 | | 12 | 8.4 | 91% |
| MRZI100-110S15 | | 15 | 6.7 | 90.5% |
| MRZI100-110S24 | | 24 | 4.2 | 89% |
| MRZI100-110S54 | | 54 | 1.85 | 89% |

## 150W | MRZI150 Series NEW

Quarter Brick Package

RAILWAY EN50155 | cULus UL 62368-1 | CB Scheme | CE | 3 YEAR WARRANTY


### Model Selection Table

| Model Number | Input Voltage (VDC) | Output Voltage (VDC) | Output Current (A)max | Efficiency |
|---|---|---|---|---|
| MRZI150-110S05 | 110 (36 - 160) | 5 | 27 | 90% |
| MRZI150-110S12 | | 12 | 12.5 | 90% |
| MRZI150-110S15 | | 15 | 10 | 89% |
| MRZI150-110S24 | | 24 | 6.25 | 88% |
| MRZI150-110S54 | | 54 | 2.78 | 88.5% |

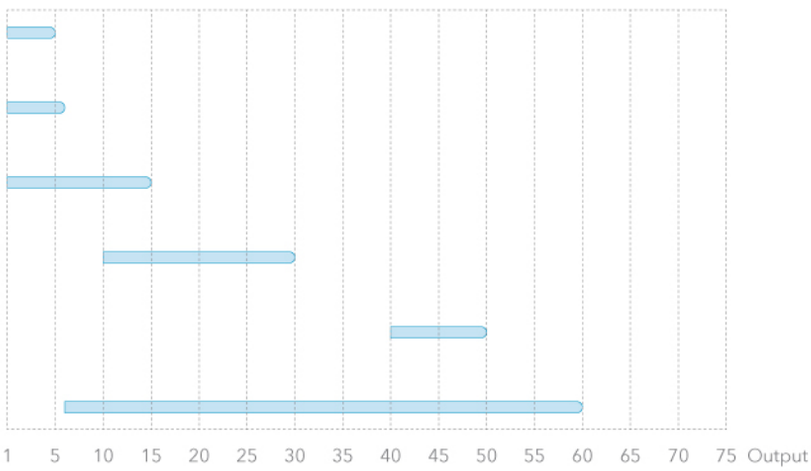
*There are different features & spec. by each series.
For detailed series datasheet, please refer to www.minmax.com.tw

Our general industrial DC-DC converters are used in every corner of modern equipment & systems about everywhere.

We offer different electrical specifications and create competitive advantage performance to meet your critical design.

## · DC-DC CONVERTERS

| | |
|---|---|
| **1-5W** | SIP Package |
| **1-6W** | SMD Package |
| **1-15W** | DIP Package |
| **10-30W** | 1"×1" Package |
| **40-50W** | 2"×1" Package |
| **6-60W** | Chassis & DIN-Rail Mounting |



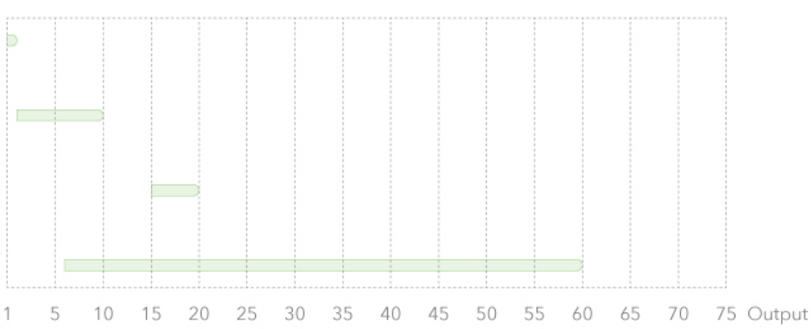

## · AC-DC POWER SUPPLIES

| | |
|---|---|
| **3-60W** | Encapsulated Package |


Ultra-high isolation family equipped with very high common mode transient immunity with 15KV/μs qualifies and I/O isolation 4000 to 5000VAC with reinforced insulation, rated for 1000Vrms working voltage.

## · DC-DC CONVERTERS

| | |
|---|---|
| **1-2W** | SIP Package |
| **2-10W** | DIP Package |
| **15-20W** | 2"×1" Package |
| **6-60W** | Chassis & DIN-Rail Mounting |



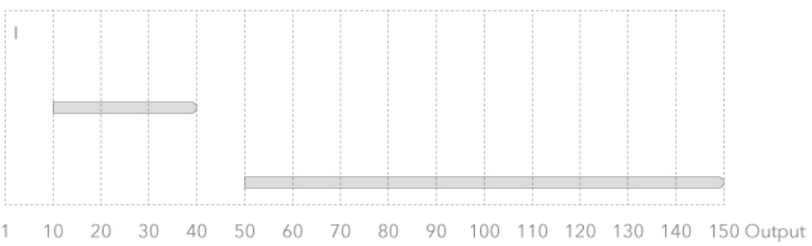
# MINMAX POWER SOLUTIONS

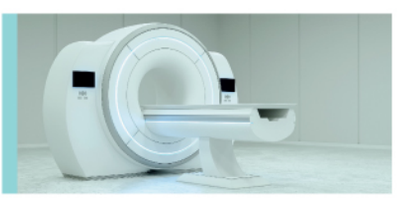
DC-DC CONVERTERS · AC-DC POWER SUPPLIES | 1-150W

Our railway certified DC-DC converters are designed for stringent requirements and harsh environment. The products family are I/O isolation 3000 VAC with reinforced insulation. Furthermore, all railway products comply with EN 50155 certified and fire protection EN 45545-2 approval.

## · DC-DC CONVERTERS

| | |
|---|---|
| **3W** | DIP Package |
| **10-40W** | 2"×1" Package |
| **50-150W** | Quarter Brick |



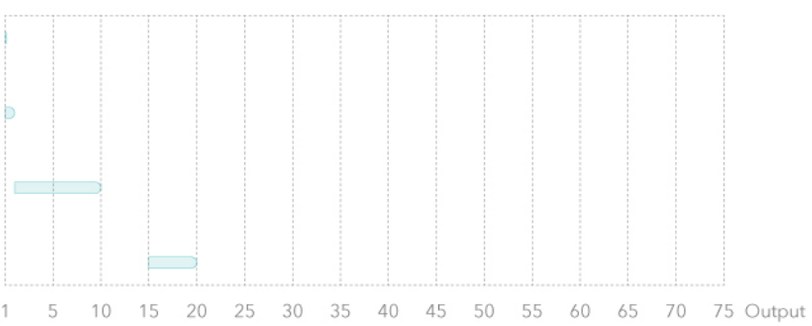



The medical grade DC-DC converters & AC-DC Power Supplies for demanding applications in both medical and healthcare instrumentations.

All medical products are approved to latest medical safety standards: ANSI/AAMI ES 60601-1, IEC/EN 60601-1 3rd edition with 2xMOPP/2xMOOP.

## · DC-DC CONVERTERS

| | |
|---|---|
| **1W** | SIP Package |
| **1-2W** | SMD Package |
| **2-10W** | DIP Package |
| **15-20W** | 2"×1" Package |




## · AC-DC POWER SUPPLIES

| | |
|---|---|
| **24-60W** | Encapsulated Package |