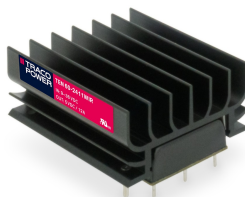


- Compact 2"x1" package (without heatsink)
- Wide 4:1 input voltage range: 9–36, 18–75, 36–160 VDC
- EN 50155 and EN 61373 approval for railway applications
- Qualification for fire behavior according to EN 45545-2
- Operating temperature range –40°C to +85°C
- I/O-isolation 3'000 VDC
- High efficiency up to 92%
- Under voltage lock out circuit
- Adjustable output voltage and Remote On/Off
- 3 year product warranty



The TEN 60WIR is a ruggedized 60 Watt railway approved DC/DC converter series with a wide 4:1 input voltage range and increased resistance against electromagnetic interference, shock/vibration and thermal shock. The standard version comes with a preassembled heatsink which was specifically designed for this 2" x 1" metal package converter. Together with a high efficiency of up to 92% this gives the converter an effective operating temperature range of -40° to +70°C without derating. The approvals according to standards EN 50155 and EN 61373 qualify them for railway and transportation systems. Additional qualification for the fire behavior of components according to EN 45545-2 and the safety approval according IEC/EN 62368-1, UL62368-1 support a potential compliance test of the application. All models offer an I/O-isolation voltage of 3'000 VDC and feature an active under voltage lockout function, remote on/off and adjustable outputs to ensure that these converters fit in any ruggedized application setup.

| Models         |                                |          |                  |          |                  |                 |
|----------------|--------------------------------|----------|------------------|----------|------------------|-----------------|
| Order Code     | Input Voltage Range            | Output 1 |                  | Output 2 |                  | Efficiency typ. |
|                |                                | Vnom     | I <sub>max</sub> | Vnom     | I <sub>max</sub> |                 |
| TEN 60-2411WIR | 9 - 36 VDC<br>(24 VDC nom.)    | 5 VDC    | 12'000 mA        |          |                  | 91 %            |
| TEN 60-2412WIR |                                | 12 VDC   | 5'000 mA         |          |                  | 93 %            |
| TEN 60-2413WIR |                                | 15 VDC   | 4'000 mA         |          |                  | 93 %            |
| TEN 60-2415WIR |                                | 24 VDC   | 2'500 mA         |          |                  | 91 %            |
| TEN 60-2418WIR |                                | 48 VDC   | 1'250 mA         |          |                  | 92 %            |
| TEN 60-2422WIR |                                | +12 VDC  | 2'500 mA         | -12 VDC  | 2'500 mA         | 91 %            |
| TEN 60-2423WIR |                                | +15 VDC  | 2'000 mA         | -15 VDC  | 2'000 mA         | 91 %            |
| TEN 60-2425WIR |                                | +24 VDC  | 1'250 mA         | -24 VDC  | 1'250 mA         | 92 %            |
| TEN 60-4811WIR | 18 - 75 VDC<br>(48 VDC nom.)   | 5 VDC    | 12'000 mA        |          |                  | 92 %            |
| TEN 60-4812WIR |                                | 12 VDC   | 5'000 mA         |          |                  | 93 %            |
| TEN 60-4813WIR |                                | 15 VDC   | 4'000 mA         |          |                  | 94 %            |
| TEN 60-4815WIR |                                | 24 VDC   | 2'500 mA         |          |                  | 92 %            |
| TEN 60-4818WIR |                                | 48 VDC   | 1'250 mA         |          |                  | 92 %            |
| TEN 60-4822WIR |                                | +12 VDC  | 2'500 mA         | -12 VDC  | 2'500 mA         | 92 %            |
| TEN 60-4823WIR |                                | +15 VDC  | 2'000 mA         | -15 VDC  | 2'000 mA         | 92 %            |
| TEN 60-4825WIR |                                | +24 VDC  | 1'250 mA         | -24 VDC  | 1'250 mA         | 92 %            |
| TEN 60-7211WIR | 36 - 160 VDC<br>(110 VDC nom.) | 5 VDC    | 12'000 mA        |          |                  | 91 %            |
| TEN 60-7212WIR |                                | 12 VDC   | 5'000 mA         |          |                  | 92 %            |
| TEN 60-7213WIR |                                | 15 VDC   | 4'000 mA         |          |                  | 92 %            |
| TEN 60-7215WIR |                                | 24 VDC   | 2'500 mA         |          |                  | 91 %            |
| TEN 60-7218WIR |                                | 48 VDC   | 1'250 mA         |          |                  | 91 %            |
| TEN 60-7222WIR |                                | +12 VDC  | 2'500 mA         | -12 VDC  | 2'500 mA         | 91 %            |
| TEN 60-7223WIR |                                | +15 VDC  | 2'000 mA         | -15 VDC  | 2'000 mA         | 91 %            |
| TEN 60-7225WIR |                                | +24 VDC  | 1'250 mA         | -24 VDC  | 1'250 mA         | 91 %            |

## Options

|                                                            |                                                                                                                                                                                                                                                                                                                                                |
|------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>TEN-HS8</b>                                             | - Optional Heat Sink with Height = 0.3 inch: <a href="http://www.tracopower.com/products/ten-hs8.pdf">www.tracopower.com/products/ten-hs8.pdf</a>                                                                                                                                                                                              |
| <b>on demand</b><br>(backorder with MOQ non stocking item) | - Optional Heat Sink with Height = 0.8 inch: <a href="http://www.tracopower.com/products/ten-hs10.pdf">www.tracopower.com/products/ten-hs10.pdf</a><br>- Optional Heat Sink with Height = 0.5 inch: <a href="http://www.tracopower.com/products/ten-hs9.pdf">www.tracopower.com/products/ten-hs9.pdf</a><br>- Optional models without heatsink |

## Input Specifications

|                        |              |                                                                                                                                                                                                                           |
|------------------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Input Current          | - At no load | 24 Vin models: <b>15 mA typ.</b><br>48 Vin models: <b>15 mA typ.</b><br>110 Vin models: <b>15 mA typ.</b>                                                                                                                 |
| Surge Voltage          |              | 24 Vin models: <b>50 VDC max.</b> (1 s max.)<br>48 Vin models: <b>100 VDC max.</b> (1 s max.)<br>110 Vin models: <b>200 VDC max.</b> (1 s max.)                                                                           |
| Under Voltage Lockout  |              | 24 Vin models: <b>7 VDC min. / 8 VDC typ. / 8.8 VDC max.</b><br>48 Vin models: <b>15 VDC min. / 16 VDC typ. / 17.5 VDC max.</b><br>110 Vin models: <b>32 VDC min. / 34 VDC typ. / 35.8 VDC max.</b>                       |
| Recommended Input Fuse |              | 24 Vin models: <b>10'000 mA</b> (fast acting)<br>48 Vin models: <b>6'300 mA</b> (slow blow)<br>110 Vin models: <b>3'150 mA</b> (slow blow)<br>(The need of an external fuse has to be assessed in the final application.) |
| Input Filter           |              | <b>Internal Pi-Type</b>                                                                                                                                                                                                   |

## Output Specifications

|                                        |                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|----------------------------------------|--------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Output Voltage Adjustment              |                                                                                                              | -10% to +20% (15 Vout and 24 Vout models)<br><b>±10%</b> (other models)<br>(By external trim resistor)<br>See application note: <a href="http://www.tracopower.com/overview/ten60wir">www.tracopower.com/overview/ten60wir</a><br>Output power must not exceed rated power!                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Voltage Set Accuracy                   |                                                                                                              | <b>±1% max.</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Regulation                             | - Input Variation (Vmin - Vmax)<br>- Load Variation (0 - 100%)<br>- Cross Regulation (25% / 100% asym. load) | single output models: <b>0.2% max.</b><br>dual output models: <b>0.2% max.</b><br>single output models: <b>0.5% max.</b><br>dual output models: <b>1% max.</b> (Output 1)<br><b>1% max.</b> (Output 2)<br>dual output models: <b>5% max.</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Ripple and Noise<br>(20 MHz Bandwidth) | - single output<br>- dual output<br>- single output<br>- dual output                                         | 5 Vout models: <b>75 mVp-p typ.</b> (w/ 1 $\mu$ F X7R)<br>12 Vout models: <b>100 mVp-p typ.</b> (w/ 1 $\mu$ F X7R)<br>15 Vout models: <b>100 mVp-p typ.</b> (w/ 1 $\mu$ F X7R)<br>24 Vout models: <b>150 mVp-p typ.</b> (w/ 1 $\mu$ F X7R)<br>48 Vout models: <b>300 mVp-p typ.</b> (w/ 1 $\mu$ F X7R)<br>12 / -12 Vout models: <b>100 / 100 mVp-p typ.</b> (w/ 1 $\mu$ F X7R)<br>15 / -15 Vout models: <b>100 / 100 mVp-p typ.</b> (w/ 1 $\mu$ F X7R)<br>24 / -24 Vout models: <b>150 / 150 mVp-p typ.</b> (w/ 1 $\mu$ F X7R)<br>5 Vout models: <b>100 mVp-p max.</b> (w/ 1 $\mu$ F X7R)<br>12 Vout models: <b>125 mVp-p max.</b> (w/ 1 $\mu$ F X7R)<br>15 Vout models: <b>125 mVp-p max.</b> (w/ 1 $\mu$ F X7R)<br>24 Vout models: <b>200 mVp-p max.</b> (w/ 1 $\mu$ F X7R)<br>48 Vout models: <b>350 mVp-p max.</b> (w/ 1 $\mu$ F X7R)<br>12 / -12 Vout models: <b>125 / 125 mVp-p max.</b> (w/ 1 $\mu$ F X7R)<br>15 / -15 Vout models: <b>125 / 125 mVp-p max.</b> (w/ 1 $\mu$ F X7R)<br>24 / -24 Vout models: <b>200 / 200 mVp-p max.</b> (w/ 1 $\mu$ F X7R) |

All specifications valid at nominal voltage, resistive full load and +25°C after warm-up time, unless otherwise stated.

|                           |                 |                       |                                             |
|---------------------------|-----------------|-----------------------|---------------------------------------------|
| Capacitive Load           | - single output | 5 Vout models:        | 17'000 µF max.                              |
|                           |                 | 12 Vout models:       | 3'000 µF max.                               |
|                           |                 | 15 Vout models:       | 1'900 µF max.                               |
|                           |                 | 24 Vout models:       | 730 µF max.                                 |
|                           |                 | 48 Vout models:       | 190 µF max.                                 |
|                           | - dual output   | 12 / -12 Vout models: | 1'500 / 1'500 µF max.                       |
|                           |                 | 15 / -15 Vout models: | 940 / 940 µF max.                           |
|                           |                 | 24 / -24 Vout models: | 370 / 370 µF max.                           |
| Minimum Load              |                 |                       | Not required                                |
| Temperature Coefficient   |                 |                       | ±0.02 %/K max.                              |
| Start-up Time             |                 |                       | 30 ms typ. / 60 ms max.                     |
| Short Circuit Protection  |                 |                       | Continuous, Automatic recovery              |
| Output Current Limitation |                 |                       | 150% typ. of Iout max.                      |
| Overvoltage Protection    |                 |                       | 124 - 133% of Vout nom.<br>(By Zener diode) |
| Transient Response        | - Response Time |                       | 250 µs typ. (25% Load Step)                 |

## Safety Specifications

|                  |                             |                                                                                                |
|------------------|-----------------------------|------------------------------------------------------------------------------------------------|
| Safety Standards | - IT / Multimedia Equipment | EN 62368-1                                                                                     |
|                  |                             | IEC 62368-1                                                                                    |
|                  |                             | UL 62368-1                                                                                     |
|                  | - Railway Applications      | EN 50155                                                                                       |
|                  | - Certification Documents   | <a href="http://www.tracopower.com/overview/ten60wir">www.tracopower.com/overview/ten60wir</a> |
| Pollution Degree |                             | PD 2                                                                                           |

## EMC Specifications

|               |                             |                                                                                                                          |
|---------------|-----------------------------|--------------------------------------------------------------------------------------------------------------------------|
| EMI Emissions | - Conducted Emissions       | EN 50121-3-2 (EMC for Rolling Stock)                                                                                     |
|               |                             | EN 55032 class A (with external filter)                                                                                  |
|               | - Radiated Emissions        | EN 55032 class B (with external filter)                                                                                  |
|               |                             | EN 55032 class A (with external filter)                                                                                  |
|               |                             | EN 55032 class B (with external filter)                                                                                  |
|               |                             | External filter proposal: <a href="http://www.tracopower.com/overview/ten60wir">www.tracopower.com/overview/ten60wir</a> |
| EMS Immunity  | - Electrostatic Discharge   | EN 50155 (Railway Applications)                                                                                          |
|               |                             | EN 50121-3-2 (EMC for Rolling Stock)                                                                                     |
|               |                             | EN 55024 (IT Equipment)                                                                                                  |
|               | - RF Electromagnetic Field  | Air: EN 61000-4-2, ±8 kV, perf. criteria A                                                                               |
|               |                             | Contact: EN 61000-4-2, ±6 kV, perf. criteria A                                                                           |
|               |                             | EN 61000-4-3, 20 V/m, perf. criteria A                                                                                   |
|               | - EFT (Burst) / Surge       | EN 61000-4-4, ±2 kV, perf. criteria A                                                                                    |
|               |                             | EN 61000-4-5, ±2 kV, perf. criteria A                                                                                    |
|               | - Conducted RF Disturbances | Ext. input component: 24 Vin models: 2x KY 220 µF // TVS SMDJ58A                                                         |
|               |                             | 48 Vin models: 2x KY 220 µF // TVS SMDJ120A                                                                              |
|               |                             | 110 Vin models: 2x KXJ 150 µF // TVS SMDJ170A                                                                            |
|               |                             | EN 61000-4-6, 10 Vrms, perf. criteria A                                                                                  |
|               | - PF Magnetic Field         | Continuous: EN 61000-4-8, 100 A/m, perf. criteria A                                                                      |
|               |                             | 1 s: EN 61000-4-8, 1000 A/m, perf. criteria A                                                                            |

## General Specifications

|                       |                         |                           |
|-----------------------|-------------------------|---------------------------|
| Relative Humidity     |                         | 95% max. (non condensing) |
| Temperature Ranges    | - Operating Temperature | -40°C to +85°C            |
|                       | - Case Temperature      | +105°C max.               |
|                       | - Storage Temperature   | -55°C to +125°C           |
| Power Derating        | - High Temperature      | 2.86 %/K above 70°C       |
| Over Temperature      | - Protection Mode       | 115°C typ.                |
| Protection Switch Off |                         |                           |

All specifications valid at nominal voltage, resistive full load and +25°C after warm-up time, unless otherwise stated.

|                           |                                 |                                                                                                                                                                                                                                                                                                               |
|---------------------------|---------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cooling System            |                                 | Natural convection (20 LFM)                                                                                                                                                                                                                                                                                   |
| Remote Control            | - Voltage Controlled Remote     | On: 3.0 to 12 VDC or open circuit<br>Off: 0 to 1.2 VDC or short circuit<br>Refers to 'Remote' and '-Vin' Pin<br>3 mA typ.                                                                                                                                                                                     |
|                           | - Off Idle Input Current        | -0.5 to 0.5 mA                                                                                                                                                                                                                                                                                                |
|                           | - Remote Pin Input Current      |                                                                                                                                                                                                                                                                                                               |
| Altitude During Operation |                                 | 5'000 m max.                                                                                                                                                                                                                                                                                                  |
| Switching Frequency       |                                 | 200 - 275 kHz (PWM)<br>250 kHz typ. (PWM)                                                                                                                                                                                                                                                                     |
| Insulation System         |                                 | Functional Insulation                                                                                                                                                                                                                                                                                         |
| Isolation Test Voltage    | - Input to Output, 60 s         | 3'000 VDC                                                                                                                                                                                                                                                                                                     |
|                           | - Input to Case, 60 s           | 2'250 VDC                                                                                                                                                                                                                                                                                                     |
| Isolation Resistance      | - Input to Output, 500 VDC      | 1'000 MΩ min.                                                                                                                                                                                                                                                                                                 |
| Isolation Capacitance     | - Input to Output, 100 kHz, 1 V | 1'500 pF max.                                                                                                                                                                                                                                                                                                 |
| Reliability               | - Calculated MTBF               | 724'500 h (MIL-HDBK-217F, ground benign)                                                                                                                                                                                                                                                                      |
| Washing Process           |                                 | Allowed (hermetical product)                                                                                                                                                                                                                                                                                  |
|                           | See Cleaning Guideline:         | <a href="http://www.tracopower.com/info/cleaning.pdf">www.tracopower.com/info/cleaning.pdf</a>                                                                                                                                                                                                                |
| Environment               | - Vibration                     | MIL-STD-810F<br>EN 61373                                                                                                                                                                                                                                                                                      |
|                           | - Mechanical Shock              | MIL-STD-810F<br>EN 61373                                                                                                                                                                                                                                                                                      |
|                           | - Thermal Shock                 | MIL-STD-810F<br>EN 50155                                                                                                                                                                                                                                                                                      |
| Housing Material          |                                 | Copper                                                                                                                                                                                                                                                                                                        |
| Base Material             |                                 | Non-conductive FR4 (UL 94 V-0 rated)                                                                                                                                                                                                                                                                          |
| Potting Material          |                                 | Silicone (UL 94 V-0 rated)                                                                                                                                                                                                                                                                                    |
| Pin Material              |                                 | Copper                                                                                                                                                                                                                                                                                                        |
| Pin Foundation Plating    |                                 | Nickel (2 - 3 μm)                                                                                                                                                                                                                                                                                             |
| Pin Surface Plating       |                                 | Tin (3 - 5 μm), matte                                                                                                                                                                                                                                                                                         |
| Housing Type              |                                 | Metal Case                                                                                                                                                                                                                                                                                                    |
| Mounting Type             |                                 | PCB Mount                                                                                                                                                                                                                                                                                                     |
| Connection Type           |                                 | THD (Through-Hole Device)                                                                                                                                                                                                                                                                                     |
| Footprint Type            |                                 | 2" x 1"                                                                                                                                                                                                                                                                                                       |
| Soldering Profile         |                                 | Wave Soldering                                                                                                                                                                                                                                                                                                |
| Weight                    |                                 | 66.9 g                                                                                                                                                                                                                                                                                                        |
| Thermal Impedance         | - Case to Ambient               | 5.9 K/W typ. (standard version)<br>8.3 K/W typ. (with heatsink TEN-HS8)<br>7.0 K/W typ. (with heatsink TEN-HS9)<br>5.7 K/W typ. (with heatsink TEN-HS10)<br>10.8 K/W typ. (without heatsink)                                                                                                                  |
| Environmental Compliance  | - REACH Declaration             | <a href="http://www.tracopower.com/info/reach-declaration.pdf">www.tracopower.com/info/reach-declaration.pdf</a><br>REACH SVHC list compliant<br>REACH Annex XVII compliant                                                                                                                                   |
|                           | - RoHS Declaration              | <a href="http://www.tracopower.com/info/rohs-declaration.pdf">www.tracopower.com/info/rohs-declaration.pdf</a><br>Exemptions: 7a, 7c-I<br>(RoHS exemptions refer to the component concentration only, not to the overall concentration in the product (O5A rule).<br>The SCIP number is provided on request.) |
|                           | - Flammability (EN 45545-2)     | <a href="http://www.tracopower.com/info/en45545-declaration.pdf">www.tracopower.com/info/en45545-declaration.pdf</a>                                                                                                                                                                                          |

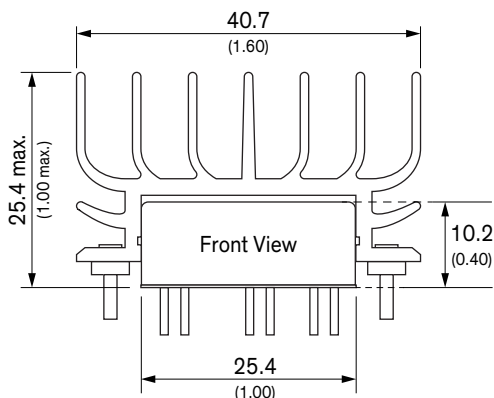
## Supporting Documents

Overview Link (for additional Documents)

[www.tracopower.com/overview/ten60wir](http://www.tracopower.com/overview/ten60wir)

All specifications valid at nominal voltage, resistive full load and +25°C after warm-up time, unless otherwise stated.

### Outline Dimensions



Dimensions in mm (inch)  
 Tolerances: x.x  $\pm 0.5$  ( $\pm 0.02$ )  
 x.xx  $\pm 0.25$  ( $\pm 0.01$ )  
 Pin diameter  $\pm 0.1$  ( $\pm 0.004$ )

| Pinout |               |               |
|--------|---------------|---------------|
| Pin    | Single        | Dual          |
| 1      | +Vin (Vcc)    | +Vin (Vcc)    |
| 2      | -Vin (GND)    | -Vin (GND)    |
| 3      | Remote On/Off | Remote On/Off |
| 4      | +Vout         | +Vout         |
| 5      | -Vout         | Common        |
| 6      | Trim          | -Vout         |
| 7      | NC*           | NC*           |
| 8      | NC*           | NC*           |

NC: Not connected

\*: No pin for converters without heat sink

