DC/DC Converter

- Wide 2:1 input voltage range
- High efficiency up to 91%
- No minimum load required
- Over temperature protection
- Under voltage lock-out circuit
- Remote On/Off
- 3-year product warranty

The TEN 60 series is a family of high performance 60W DC/DC converter modules with wide 2:1 input voltage ranges in a low profile case with industry-standard 2" x 2" footprint. High efficiency allows for an operating temperature range of –40°C to 75°C. Built-in filters for both input and output minimizes the need for external filtering. Further standard features include remote On/Off, output voltage trimming, over voltage protection, under voltage lockout and short circuit protection. Typical applications for these products are battery operated equipment and distributed power architectures in communication and industrial electronics.

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>TEN 60-2410</td>
<td>18 - 36 VDC</td>
<td>3.3 VDC (2.97 - 3.63 VDC)</td>
<td>14'000 mA</td>
<td>89 %</td>
</tr>
<tr>
<td>TEN 60-2411</td>
<td>(24 VDC nom.)</td>
<td>5 VDC (4.5 - 5.5 VDC)</td>
<td>12'000 mA</td>
<td>90 %</td>
</tr>
<tr>
<td>TEN 60-2412</td>
<td></td>
<td>12 VDC (10.8 - 13.2 VDC)</td>
<td>5'000 mA</td>
<td>90 %</td>
</tr>
<tr>
<td>TEN 60-2413</td>
<td></td>
<td>15 VDC (13.5 - 16.5 VDC)</td>
<td>4'000 mA</td>
<td>90 %</td>
</tr>
<tr>
<td>TEN 60-2415</td>
<td></td>
<td>24 VDC (21.6 - 26.4 VDC)</td>
<td>2'500 mA</td>
<td>90 %</td>
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<tr>
<td>TEN 60-4810</td>
<td>36 - 75 VDC</td>
<td>3.3 VDC (2.97 - 3.63 VDC)</td>
<td>14'000 mA</td>
<td>89 %</td>
</tr>
<tr>
<td>TEN 60-4811</td>
<td>(48 VDC nom.)</td>
<td>5 VDC (4.5 - 5.5 VDC)</td>
<td>12'000 mA</td>
<td>91 %</td>
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<tr>
<td>TEN 60-4812</td>
<td></td>
<td>12 VDC (10.8 - 13.2 VDC)</td>
<td>5'000 mA</td>
<td>90 %</td>
</tr>
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<td>2'500 mA</td>
<td>90 %</td>
</tr>
</tbody>
</table>

Options

### Input Specifications

**Input Current**
- **At no load**
  - 24 Vin models: 100 mA typ. (3.3 Vout model)
  - 130 mA typ. (5 Vout model)
  - 50 mA typ. (12 Vout model)
  - 50 mA typ. (15 Vout model)
  - 50 mA typ. (24 Vout model)
- **At full load**
  - 24 Vin models: 2'260 mA typ. (3.3 Vout model)
  - 2'940 mA typ. (5 Vout model)
  - 2'900 mA typ. (12 Vout model)
  - 2'900 mA typ. (15 Vout model)
  - 2'940 mA typ. (24 Vout model)
- **48 Vin models**
  - 80 mA typ. (3.3 Vout model)
  - 90 mA typ. (5 Vout model)
  - 30 mA typ. (12 Vout model)
  - 30 mA typ. (15 Vout model)
  - 30 mA typ. (24 Vout model)

**Surge Voltage**
- 24 Vin models: 50 VDC max. (100 ms max.)
- 48 Vin models: 100 VDC max. (100 ms max.)

**Under Voltage Lockout**
- 24 Vin models: 14.5 VDC min. / 15.5 VDC typ. / 17.5 VDC max.
- 48 Vin models: 31 VDC min. / 32 VDC typ. / 35.5 VDC max.

**Recommended Input Fuse**
- 24 Vin models: 6'300 mA (slow blow)
- 48 Vin models: 3'150 mA (slow blow)

(The need of an external fuse has to be assessed in the final application)

**Input Filter**
- Internal Pi-Type

### Output Specifications

**Output Voltage Adjustment**
- Input Variation (Vmin - Vmax)
  - ±10% to +20% (all Vout models)
- Load Variation (0 - 100%)
  - ±10% (other output models)
  - (By external trim resistor)

**Voltage Set Accuracy**
- ±1% max.

**Regulation**
- Input Variation (Vmin - Vmax)
  - 0.2% max.
- Load Variation (0 - 100%)
  - 0.5% max.

**Ripple and Noise**
(20 MHz Bandwidth)
- 3.3 Vout models: 75 mVp-p typ.
- 5 Vout models: 75 mVp-p typ.
- 12 Vout models: 100 mVp-p typ.
- 15 Vout models: 100 mVp-p typ.
- 24 Vout models: 200 mVp-p typ.

**Capacitive Load**
- 3.3 Vout models: 36'000 µF max.
- 5 Vout models: 20'400 µF max.
- 12 Vout models: 3'550 µF max.
- 15 Vout models: 2'300 µF max.
- 24 Vout models: 885 µF max.

**Minimum Load**
- Not required

**Temperature Coefficient**
- ±0.02 %/°K max.

**Start-up Time**
- 20 ms max.

**Short Circuit Protection**
- Continuous, Automatic recovery

**Output Current Limitation**
- 150% typ. of Iout max.

All specifications valid at nominal voltage, resistive full load and +25°C after warm-up time, unless otherwise stated.
### Overvoltage Protection
- Overvoltage Protection: 112 - 164% of Vout nom. (depending on model)
- 3.7 - 5.4 VDC (3.3 VDC model)
- 5.6 - 7 VDC (5 VDC model)
- 13.8 - 17.5 VDC (12 VDC model)
- 16.8 - 20.5 VDC (15 VDC model)
- 30 - 33 VDC (24 VDC model)

### Transient Response
- Response Deviation: 8% max. (25% Load Step)
- Response Time: 250 µs typ. (25% Load Step)

### Safety Specifications
#### Safety Standards
- IT / Multimedia Equipment
  - EN 60950-1
  - EN 62368-1
  - IEC 60950-1
  - IEC 62368-1
  - UL 60950-1
  - UL 62368-1
- Certification Documents: [www.tracopower.com/overview/ten60](http://www.tracopower.com/overview/ten60)

#### Pollution Degree
- PD 2

#### Over Voltage Category
- Not mains connected

### EMC Specifications
#### EMI Emissions
- Conducted Emissions
  - EN 55032 class A (with external filter)
  - EN 55032 class B (with external filter)
- Radiated Emissions
  - EN 55032 class A (with external filter)
  - EN 55032 class B (with external filter)
- External filter proposal: [www.tracopower.com/overview/ten60](http://www.tracopower.com/overview/ten60)

#### EMS Immunity
- Electrostatic Discharge
  - Air: EN 61000-4-2, ±8 kV, perf. criteria A
  - Contact: EN 61000-4-2, ±6 kV, perf. criteria A
- RF Electromagnetic Field
  - EFT (Burst) / Surge
    - EN 61000-4-4, ±2 kV, perf. criteria A
    - EN 61000-4-5, ±1 kV, perf. criteria A
- Conducted RF Disturbances
  - Contact: EN 61000-4-6, 10 Vrms, perf. criteria A
  - Continuous: EN 61000-4-8, 100 A/m, perf. criteria A
  - Ext. input component: KY 220 µF / 100 V
- Pulse RF Field
  - Contact: 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 +75°C
- Case Temperature: +110°C max.
- Storage Temperature: -55°C to +125°C

#### Power DerATING
- High Temperature: Depending on model
  - See application note: [www.tracopower.com/overview/ten60](http://www.tracopower.com/overview/ten60)

#### Over Temperature Protection Switch Off
- Protection Mode: 120°C typ. (Automatic recovery at 100°C typ.)
- Measurement Point: Case

#### Cooling System
- Natural convection (20 LFM)

#### Sense Function
- 10% max. of Vout nom.
  - (If sense function is not used, sense pins should be connected to output pins)

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

[www.tracopower.com](http://www.tracopower.com)  
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Remote Control
- Voltage Controlled Remote
  - Off Idle Input Current
  - Remote Pin Input Current
    On: 3.0 to 12 VDC or open circuit
    Off: 0 to 1.2 VDC or short circuit

Refers to 'Remote' and '-Vin' Pin
4 mA typ.
-0.5 to 1.0 mA

Altitude During Operation
2'000 m max.

Switching Frequency
270 - 330 kHz (PWM)
300 kHz typ. (PWM)

Insulation System
Functional Insulation

Isolation Test Voltage
- Input to Output, 60 s
  1'600 VDC
- Input to Case, 60 s
  1'600 VDC
- Output to Case, 60 s
  1'600 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
  410'000 h (MIL-HDBK-217F, ground benign)

Washing Process
According to Cleaning Guideline
www.tracopower.com/info/cleaning.pdf

Environment
- Vibration
  MIL-STD-810F
  7.7 g, 3 axis, random waveform, 60 min
- Mechanical Shock
  MIL-STD-810F
  50 g, 3 axis, terminal peak sawtooth, 11 ms
- Thermal Shock
  MIL-STD-810F
  -55°C to +125°C, 72 cycles, 30 min each

Housing Material
Copper, Nickel plated

Base Material
Non-conductive FR4 (UL 94 V-0 rated)

Potting Material
Epoxy (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 2"

Soldering Profile
Lead-Free Wave Soldering
265°C / 10 s max.

Weight
60 g

Thermal Impedance
- Case to Ambient
  10.5 K/W typ.
  8.4 K/W typ. (with Heat Sink)

Environmental Compliance
- REACH Declaration
  www.tracopower.com/info/reach-declaration.pdf
  REACH SVHC list compliant
  REACH Annex XVII compliant
- RoHS Declaration
  www.tracopower.com/info/rohs-declaration.pdf
  Exemptions: 7a, 7c-l
  (RoHS exemptions refer to the component concentration only, not to the overall concentration in the product (O5A rule))
- SOIP Reference Number
  527286fc-5b1c-4797-b181-26e69d91a288

Supporting Documents
Overview Link (for additional Documents)
www.tracopower.com/overview/ten60

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

TEN 60 Series, 60 Watt

Bottom view

Dimensions in mm (inch)
Pin diameter: 1.0 ±0.1 (0.04 ±0.004)
Tolerances: x.x ±0.5 (x.xx ±0.02)
  x.xx ±0.25 (x.xxx ±0.01)

Pinout

<table>
<thead>
<tr>
<th>Pin</th>
<th>Single</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>+Vin (Vcc)</td>
</tr>
<tr>
<td>2</td>
<td>−Vin (GND)</td>
</tr>
<tr>
<td>3</td>
<td>Remote On/Off</td>
</tr>
<tr>
<td>4</td>
<td>−Sense</td>
</tr>
<tr>
<td>5</td>
<td>+Sense</td>
</tr>
<tr>
<td>6</td>
<td>+Vout</td>
</tr>
<tr>
<td>7</td>
<td>−Vout</td>
</tr>
<tr>
<td>8</td>
<td>Trim</td>
</tr>
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