TRACO POWER®

TON 15 Series — Application Note

DC/DC Converter 18 to 36Vdc or 36 to 75 Vdc input, 3.3 to 15 Vdc Single Outputs, 15W

E188913

Complete TON 15 datasheet can be downloaded at:
http://www.tracopower.com/products/ton15.pdf

Features

- Lead free directive compatible
- Low profile: 27.94 x 23.88 x 8.5mm
  (1.10 x 0.94 x 0.335 inch)
- Industry standard pin-out TEN 15 series compatible
- 2：1 wide input voltage of 18-36, 36-75VDC
- 15 Watts output power
- Input to output isolation: 2250Vdc, min for 60 seconds
- Over-current protection, auto-recovery
- Output over voltage protection
- Under voltage lookout
- Remote on/off control
- Adjustable output voltage
- ISO 9001 certified manufacturing facilities
- UL60950-1 Recognized E188913
- EN 55022 class B / FCC class B conducted noise
- Approved for basic insulation

Applications

- Distributed power architectures
- Communication equipment
- Computer equipment
- Test equipment

Option

- Surface mount

General Description

TON 15 single output DC/DC converters provide up to 15 watts of output power in an industry standard package and footprint. These units are specifically designed to meet the power needs of low profile. All models feature a wide input range, comprehensively protected against over-current, over-voltage and input under-voltage protection conditions, and adjustable output voltage. The TON 15 converters are especially suited to Network, Data processing, Wireless and Enterprise equipment and microprocessor, intermediate bus voltage power application.

Table of contents

ABSOLUTE MAXIMUM RATINGS					
Parameter	Device	Min	Typ	Max	Unit
Input Surge Voltage (100mS max)	TON 15–24xx TON 15–48xx	-0.3 -0.3		50 100	Vdc Vdc
Input Voltage Variation (complies with EST300 132 part 4.4)	All			5	V/ms
Operating Ambient Temperature	All	-40		85	°C
Storage Temperature	All	-55		125	°C
I/O Isolation Voltage	All	2250			Vdc

OUTPUT SPECIFICATIONS					
Parameter	Device	Min	Typ	Max	Unit
Operating Output Range	TON 15–xx10 TON 15–xx11 TON 15–xx12 TON 15–xx13	3.267 4.95 11.88 14.85	3.3 5 12 15	3.333 5.05 12.12 15.15	Vdc Vdc Vdc Vdc
Voltage Adjustability (Note 1)	All	-10		+10	%
Output Regulation Line (LL to HL at Full Load) Load (0% to 100% of Full Load)	 All All			 0.2 0.2	 % %
Output Ripple & Noise (Note 2) (With a 1µF M/C and a 10µF T/C at 20MHz bandwidth)	3,3V & 5V model 12V & 15V model			75 100	mV Pk-Pk
Temperature Coefficient	All	-0.02		+0.02	%/°C
Output Voltage Overshoot	All			3	%
Transient Response Recovery Time (50% to 75% to 50% load change, △Iout / △t = 0.1A/µs)	All		300		µs
Output Current	TON 15–xx10 TON 15–xx11 TON 15–xx12 TON 15–xx13	0 0 0 0		3.5 3.0 1.25 1.0	A A A A
Output Over Voltage Protection (Control voltage clamp)	TON 15–xx10 TON 15–xx11 TON 15–xx12 TON 15–xx13	3.7 5.6 13.5 16.8		5.4 7.0 19.6 20.5	Vdc Vdc Vdc Vdc
Output Over Current Protection	TON 15–xx10 TON 15–xx11 TON 15–xx12 TON 15–xx13	3.85 3.3 1.375 1.1	4.375 3.75 1.56 1.25	4.9 4.2 1.75 1.4	A A A A
Max Capacitive Load	TON 15–xx10 TON 15–xx11 TON 15–xx12 TON 15–xx13			1000 1000 330 220	µF µF µF µF

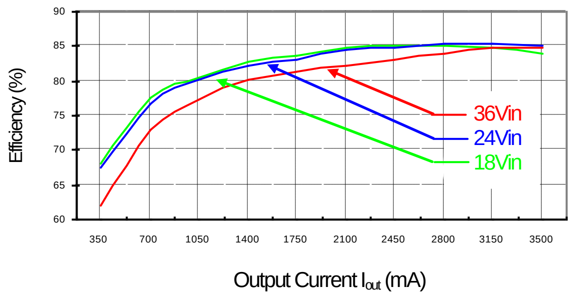
INPUT SPECIFICATIONS					
Parameter	Device	Min	Typ	Max	Unit
Operating Input Voltage	TON 15–24xx	18	24	36	Vdc
	TON 15–48xx	36	48	75	Vdc
Under Voltage Lockout Turn-on Threshold	TON 15–24xx		17		Vdc
	TON 15–48xx		33		Vdc
Under Voltage Lockout Turn-off Threshold	TON 15–24xx		14.5		Vdc
	TON 15–48xx		30.5		Vdc
Input reflected ripple current (Note 2)	All		30		mA_{Pk-Pk}
Start Up Time					
Power Up	All			30	ms
Remote ON/OFF	All			30	ms
(Test at Vin nom and constant resistive load)					
Remote ON/OFF (Note 3)					
Negative Logic DC-DC ON(Short)	All	-0.7		1.2	Vdc
DC-DC OFF(Open)	All	3		15	Vdc
Positive Logic DC-DC ON(Open)	All	3		15	Vdc
DC-DC OFF(Short)	All	-0.7		1.2	Vdc

GENERAL SPECIFICATIONS					
Parameter	Device	Min	Typ	Max	Unit
Efficiency (Note 2)	TON 15–2410		85		%
(Test at Vin,nom and full load)	TON 15–2411		86		%
	TON 15–2412		86		%
	TON 15–2413		87		%
	TON 15–4810		85		%
	TON 15–4811		86		%
	TON 15–4812		87		%
	TON 15–4813		88		%
Isolation resistance	All	10			MΩ
Isolation Capacitance	All		1000		pF
Switching Frequency	3,3V & 5V model		270		KHz
(Test at Vin nom and full load)	12V & 15V model		470		KHz
Transient Response Recovery Time (50% to 75% to 50% load change, △Iout / △t = 0.1A/μs)	All		300		μs
Weight	All		10.5		g
MTBF (Note 4)	All		2.2×10^6		hours

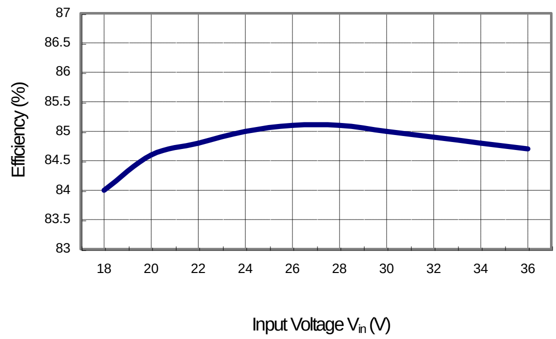
Note 1：Please see the external trim adjustment.
Note 2：Please see the testing configurations part.
Note 3：Please see the remote ON/OFF control part.
Note 4：Please see the MTBF and reliability part.

TON 15-2410 Characteristic Curves

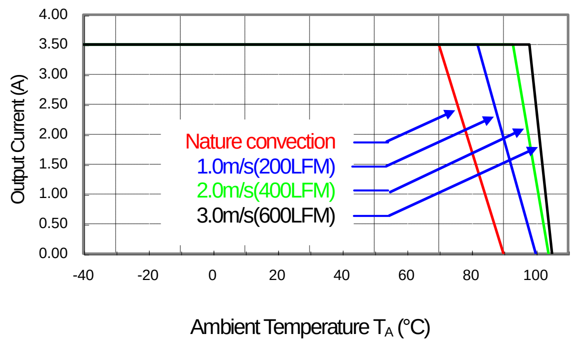
All test conditions are at 25°C.



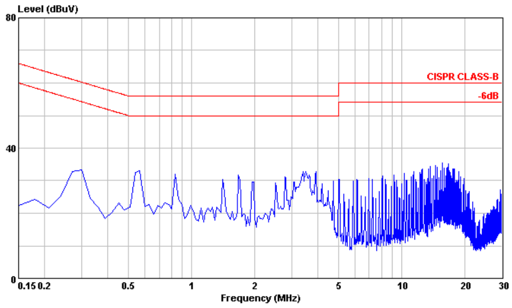
Efficiency η vs. Output Current I_{out}



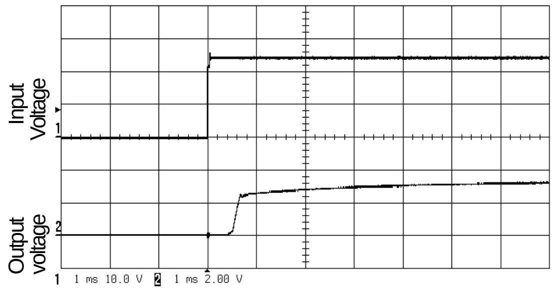
Efficiency η vs. Input Voltage V_{in}



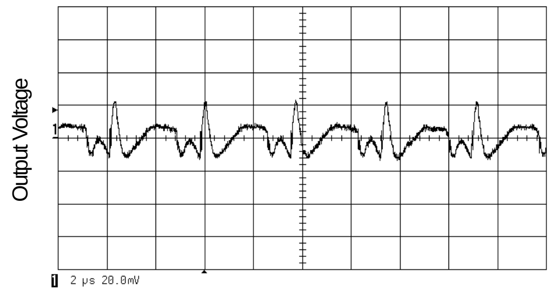
Load Derating vs. Ambient Temperature and Airflow



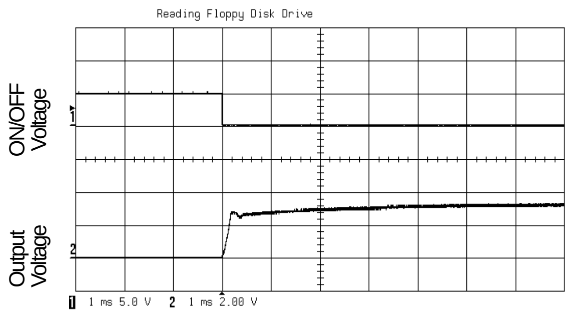
Conducted Emission according to EN55022 Class B



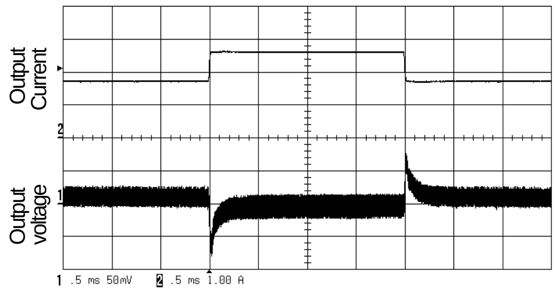
Typical Start-Up and Output Voltage Rise



Typical Ripple and Noise at V_{in} = 24Vdc & I_{out} = 100%



Using Extern ON/OFF Start-Up and Output Voltage Rise

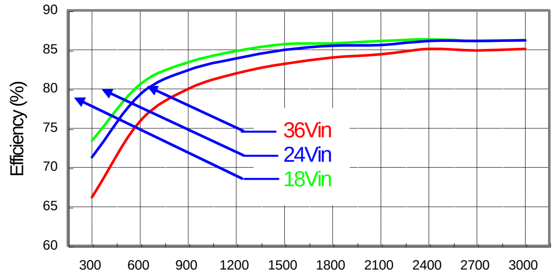


Transient Response

Dynamic Load Change from 75% to 50% to 75% of Full Load

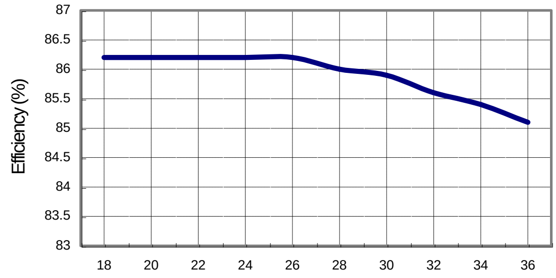
TON 15-2411 Characteristic Curves

All test conditions are at 25°C



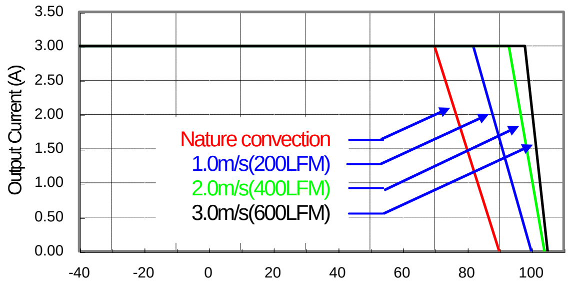
Output Current I_{out} (mA)

Efficiency η vs. Output Current I_{out}



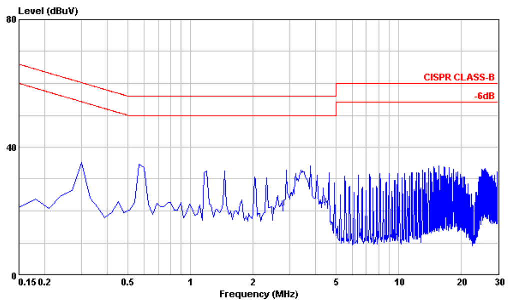
Input Voltage V_{in} (V)

Efficiency η vs. Input Voltage V_{in}

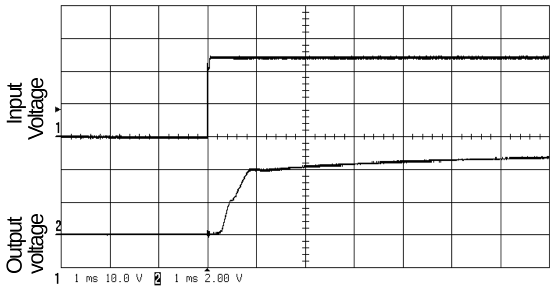


Ambient Temperature T_A (°C)

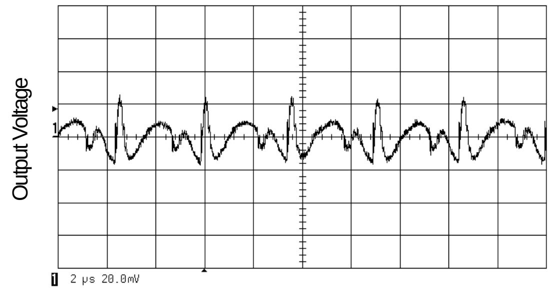
Load Derating vs. Ambient Temperature and Airflow



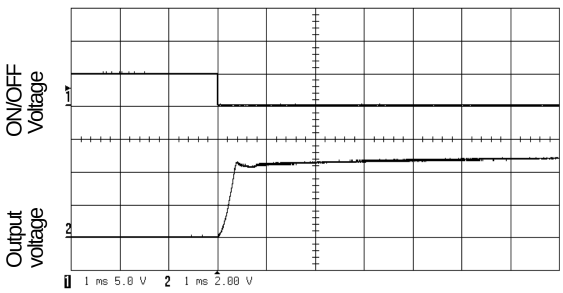
Conducted Emission according to EN55022 Class B



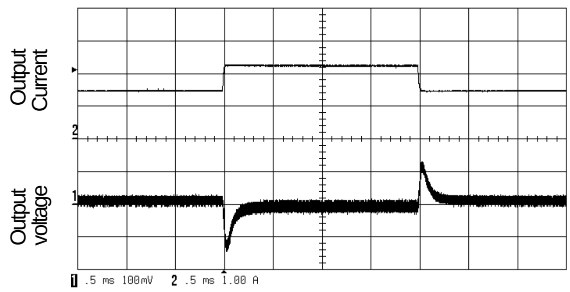
Typical Start-Up and Output Voltage Rise



Typical Ripple and Noise at V_{in} = 24Vdc & I_{out} = 100%



Using Extern ON/OFF Start-Up and Output Voltage Rise

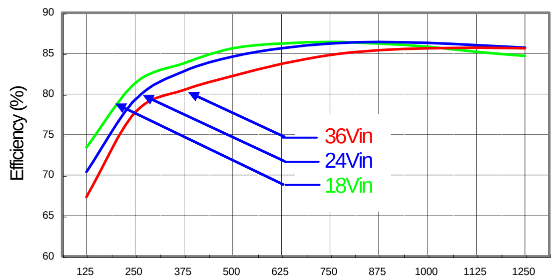


Transient Response

Dynamic Load Change from 75% to 50% to 75% of Full Load

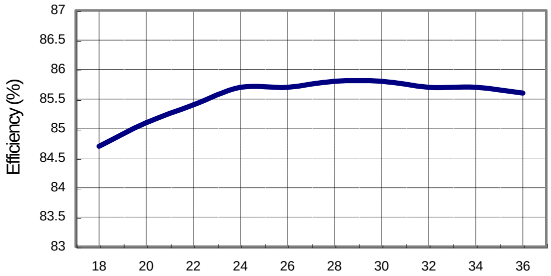
TON 15-2412 Characteristic Curves

All test conditions are at 25°C



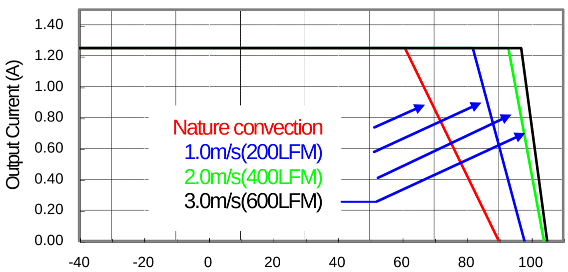
Output Current I_{out} (mA)

Efficiency η vs. Output Current I_{out}



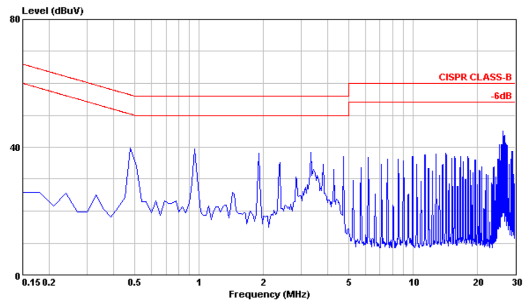
Input Voltage V_{in} (V)

Efficiency η vs. Input Voltage V_{in}

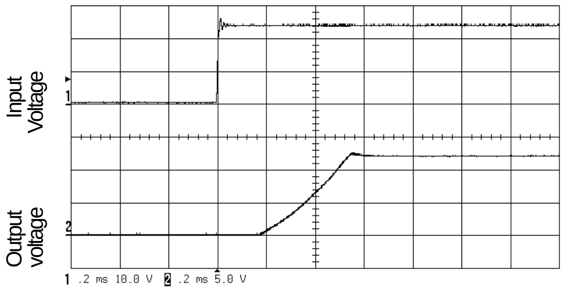


Ambient Temperature T_A (°C)

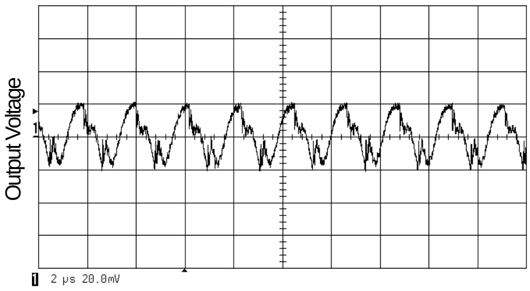
Load Derating vs. Ambient Temperature and Airflow



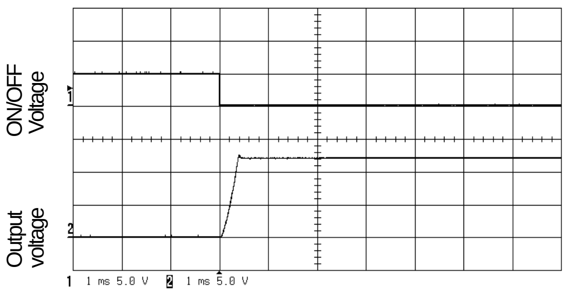
Conducted Emission according to EN55022 Class B



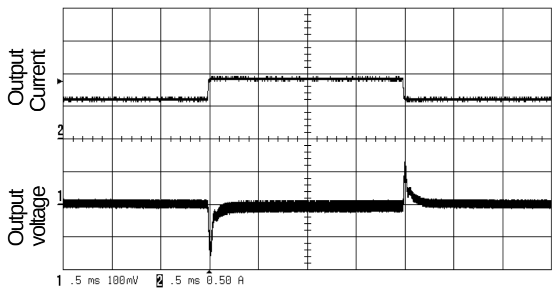
Typical Start-Up and Output Voltage Rise



Typical Ripple and Noise at V_{in} = 24Vdc & I_{out} = 100%



Using Extern ON/OFF Start-Up and Output Voltage Rise

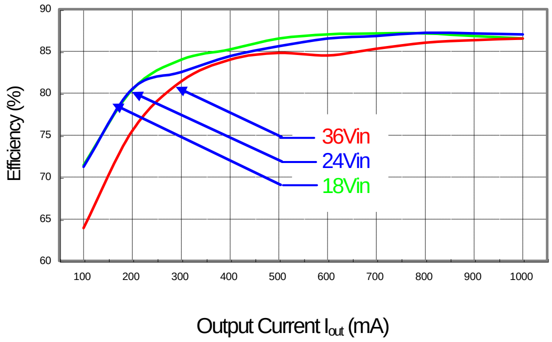


Transient Response

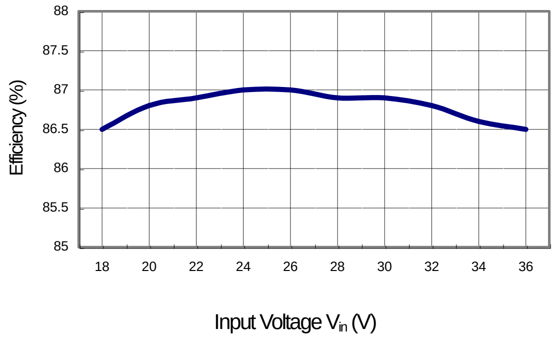
Dynamic Load Change from 75% to 50% to 75% of Full Load

TON 15-2413 Characteristic Curves

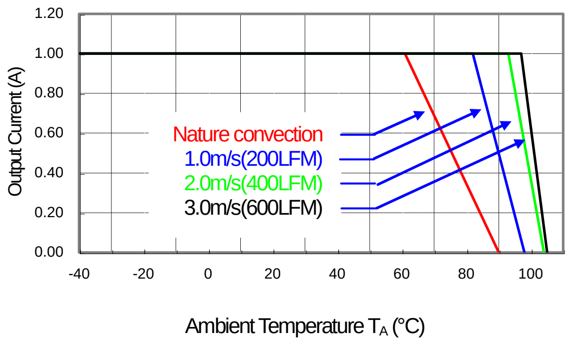
All test conditions are at 25°C.



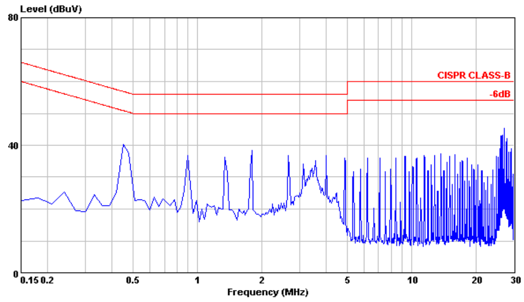
Efficiency η vs. Output Current I_{out}



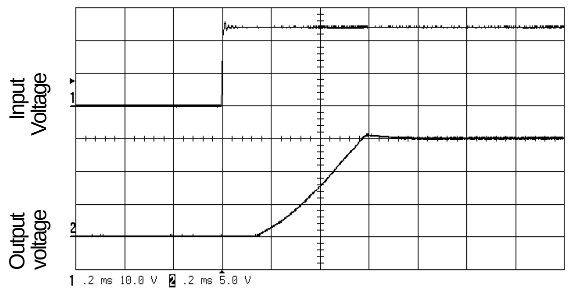
Efficiency η vs. Input Voltage V_{in}



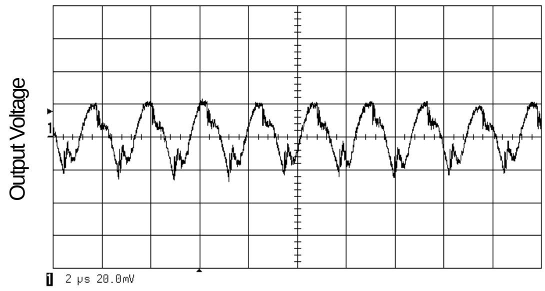
Load Derating vs. Ambient Temperature and Airflow



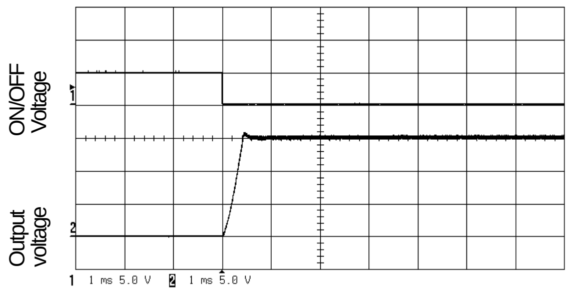
Conducted Emission according to EN55022 Class B



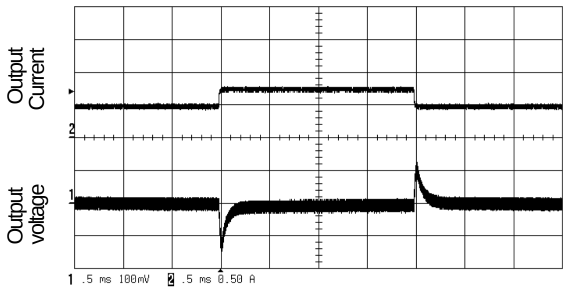
Typical Start-Up and Output Voltage Rise



Typical Ripple and Noise at V_{in} = 24Vdc & I_{out} = 100%



Using Extern ON/OFF Start-Up and Output Voltage Rise

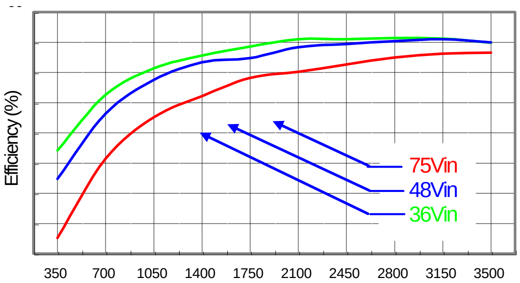


Transient Response

Dynamic Load Change from 75% to 50% to 75% of Full Load

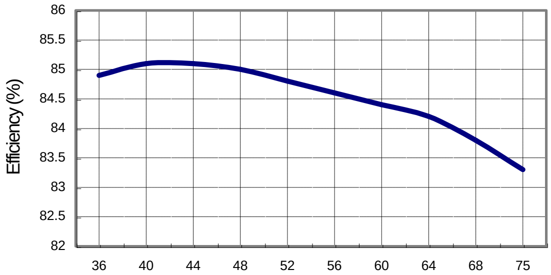
TON 15-4810 Characteristic Curves

All test conditions are at 25°C



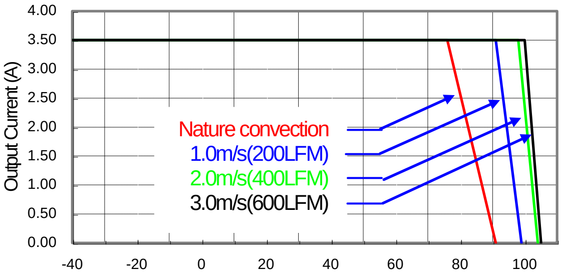
Output Current I_{out} (mA)

Efficiency η vs. Output Current I_{out}



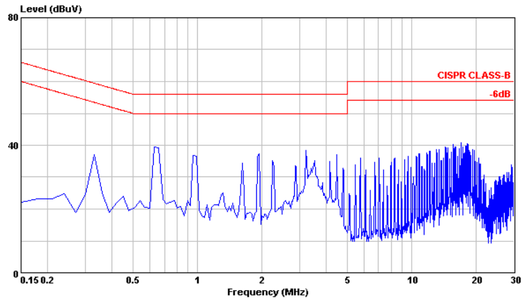
Input Voltage V_{in} (V)

Efficiency η vs. Input Voltage V_{in}

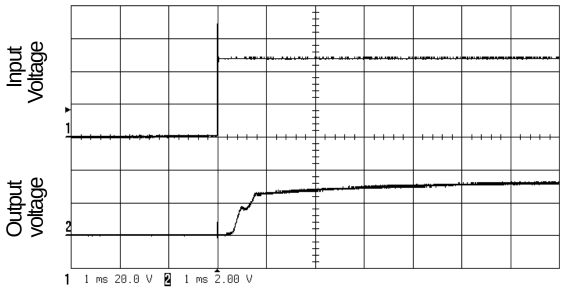


Ambient Temperature T_A (°C)

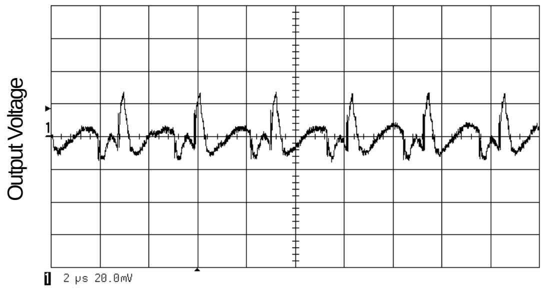
Load Derating vs. Ambient Temperature and Airflow



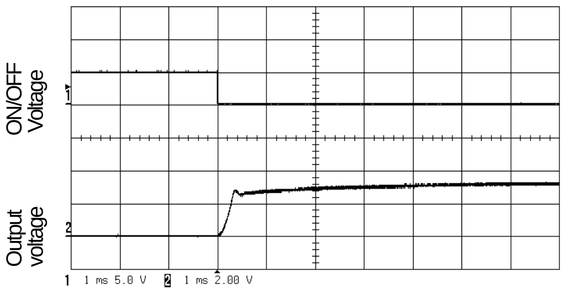
Conducted Emission according to EN55022 Class B



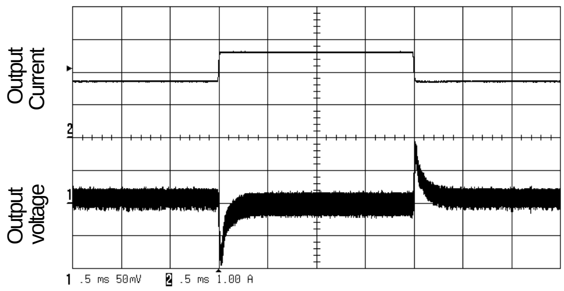
Typical Start-Up and Output Voltage Rise



Typical Ripple and Noise at V_{in} = 48Vdc & I_{out} = 100%



Using Extern ON/OFF Start-Up and Output Voltage Rise

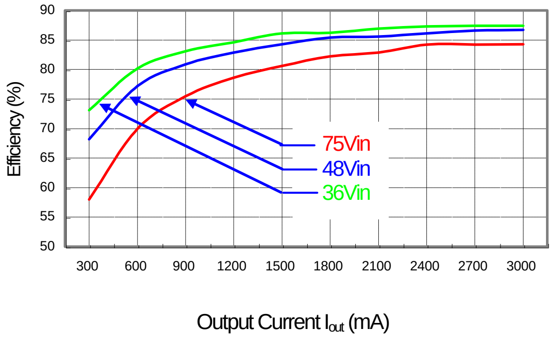


Transient Response

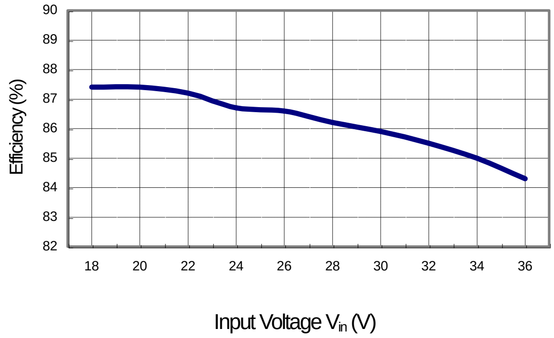
Dynamic Load Change from 75% to 50% to 75% of Full Load

TON 15-4811 Characteristic Curves

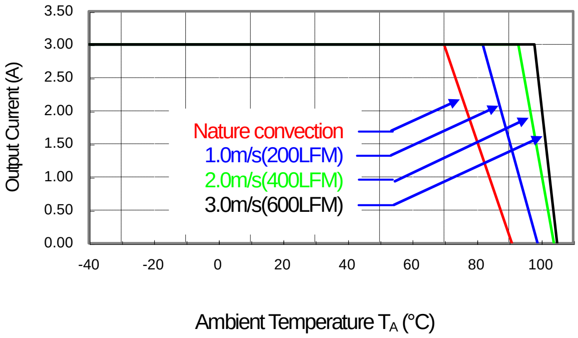
All test conditions are at 25°C.



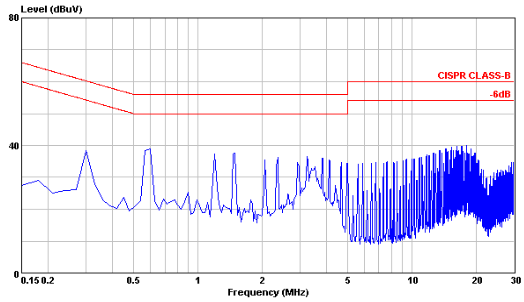
Efficiency η vs. Output Current I_{out}



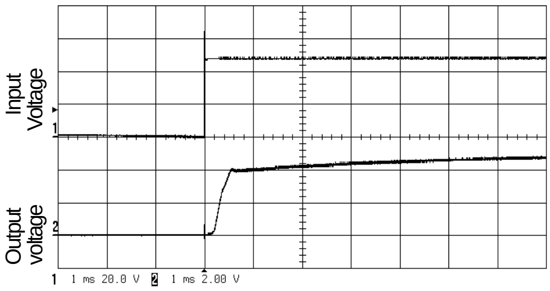
Efficiency η vs. Input Voltage V_{in}



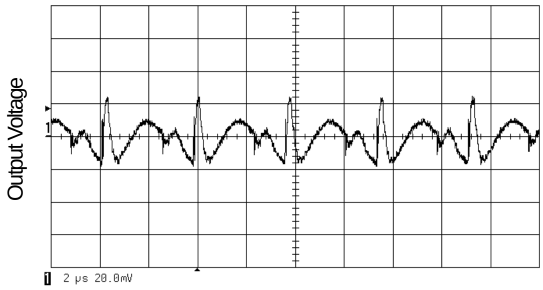
Load Derating vs. Ambient Temperature and Airflow



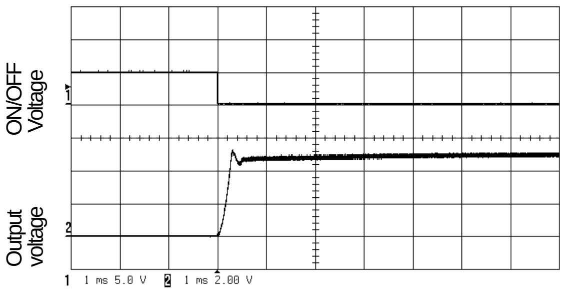
Conducted Emission according to EN55022 Class B



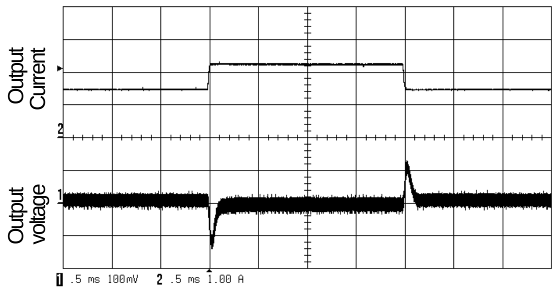
Typical Start-Up and Output Voltage Rise



Typical Ripple and Noise at V_{in} = 48Vdc & I_{out} = 100%



Using Extern ON/OFF Start-Up and Output Voltage Rise

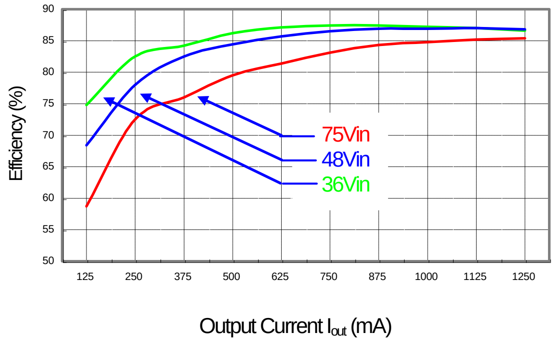


Transient Response

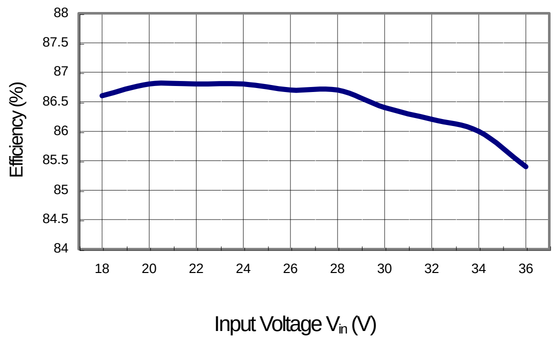
Dynamic Load Change from 75% to 50% to 75% of Full Load

TON 15-4812 Characteristic Curves

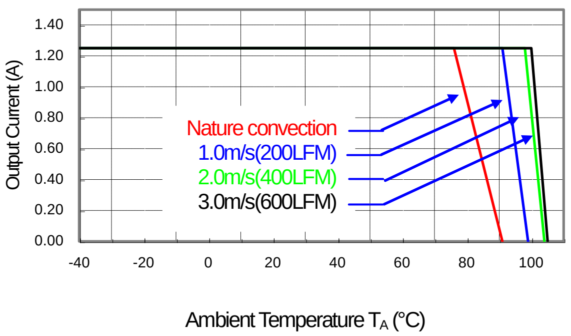
All test conditions are at 25°C



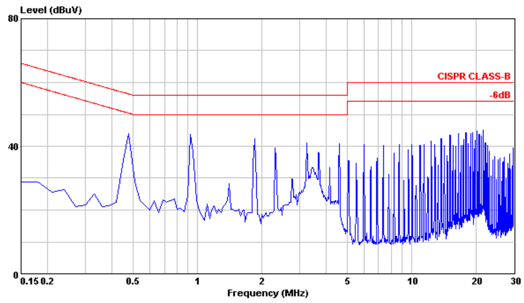
Efficiency η vs. Output Current I_{out}



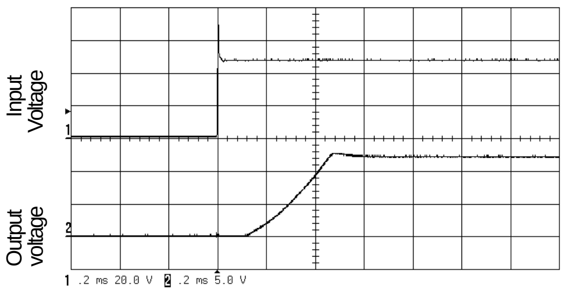
Efficiency η vs. Input Voltage V_{in}



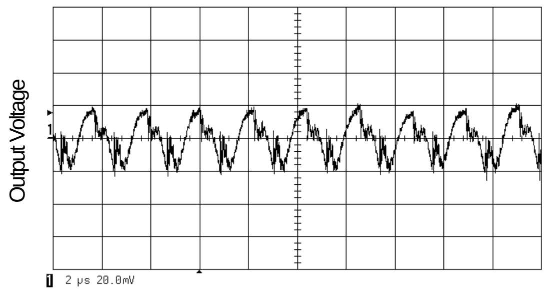
Load Derating vs. Ambient Temperature and Airflow



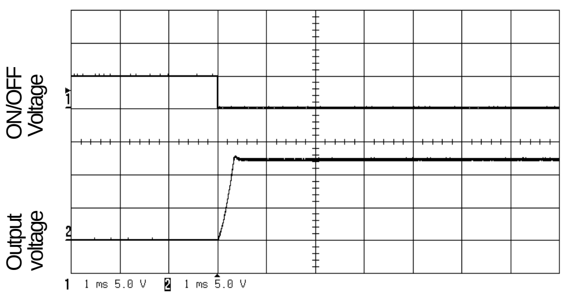
Conducted Emission according to EN55022 Class B



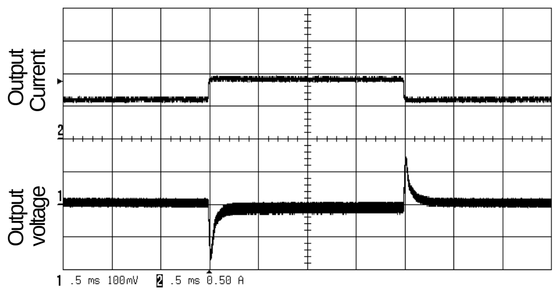
Typical Start-Up and Output Voltage Rise



Typical Ripple and Noise at V_{in} = 48Vdc & I_{out} = 100%



Using Extern ON/OFF Start-Up and Output Voltage Rise

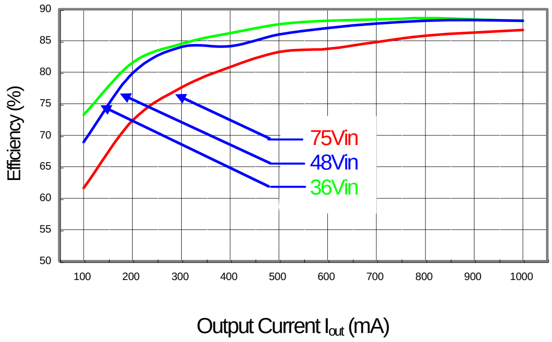


Transient Response

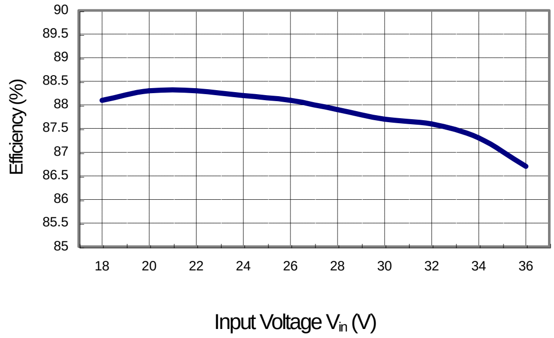
Dynamic Load Change from 75% to 50% to 75% of Full Load

TON 15-4813 Characteristic Curves

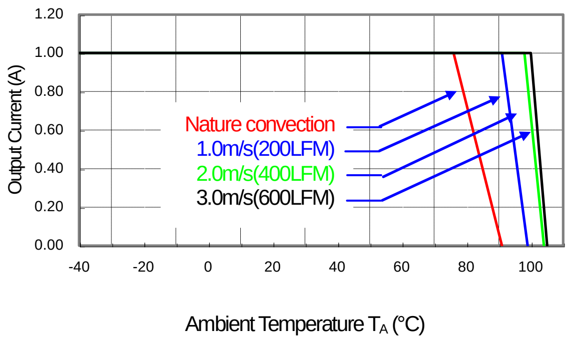
All test conditions are at 25°C



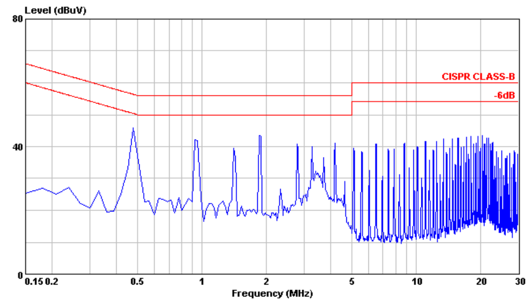
Efficiency η vs. Output Current I_{out}



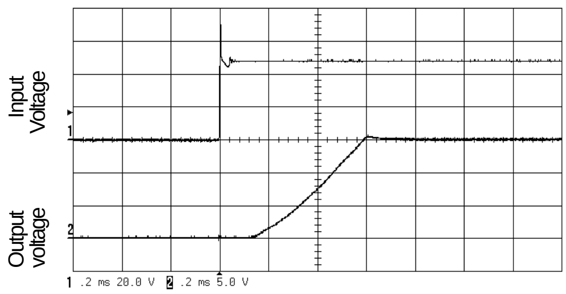
Efficiency η vs. Input Voltage V_{in}



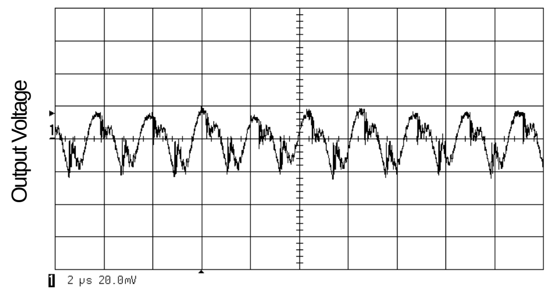
Load Derating vs. Ambient Temperature and Airflow



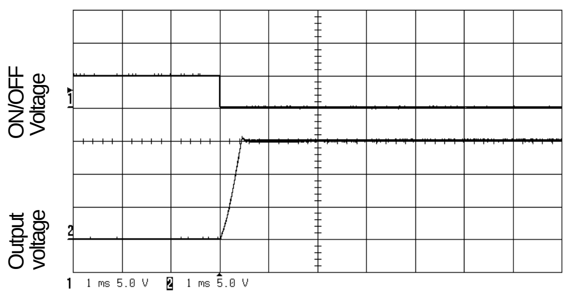
Conducted Emission according to EN55022 Class B



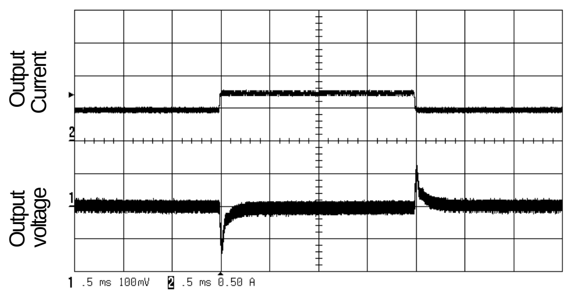
Typical Start-Up and Output Voltage Rise



Typical Ripple and Noise at V_{in} = 48Vdc & I_{out} = 100%



Using Extern ON/OFF Start-Up and Output Voltage Rise

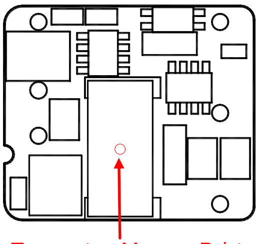


Transient Response

Dynamic Load Change from 75% to 50% to 75% of Full Load

Thermal Consideration

The power module operates in a variety of thermal environments; however, sufficient cooling should be provided to ensure reliable operation of the unit. Heat is removed by conduction, convention, and radiation to the surrounding environment. Proper cooling can be verified by measuring the point as shown at the figure below. The temperature at this position should not exceed 105°C. During operating, adequate cooling must be provided to maintain that the measured temperature at the temperature measure point is below or equal 105°C. Although the maximum temperature of the converter measured at the temperature measure point is 105°C. You can limit this temperature value at a lower value for extremely high reliability.



Output over current protection

The converter has to be protected against output over current. Normally overload trigger point is at approximately 110~140% of rated output current.
Hiccup-mode is a method of operation in a converter which purpose to protect the converter from being damaged during an over-current fault condition. It also enables the converter to restart when the fault is removed. There are other ways of protecting the converter when it is over-loaded, such as the maximum current limiting or current foldback methods.
One of the problems resulting from over current is that excessive heat may be generated in power devices; especially MOSFET and Shottky diodes and the temperature of those devices may exceed their specified limits. A protection mechanism has to be used to prevent those power devices from being damaged.
The operation of hiccup is as follows. When the current sense circuit sees an over-current event, the controller shuts off the converter for a given time and then tries to restart again. If the over-load condition has been removed, the converter will start up and operate normally; otherwise, the controller will see another over-current event and shut off again, repeating the previous cycle. Hiccup operation has none of the drawbacks of the other two protection methods, although its circuit is more complicated because it requires a timing circuit. The excess heat due to overload lasts for only a short duration in the hiccup cycle, hence the junction temperature of the power devices is much lower.
The hiccup operation can be done in various ways. For example, one can start hiccup operation any time an over-current event is detected; or prohibit hiccup during a designated start-up is usually larger than during normal operation and it is easier for an over-current event is detected; or prohibit hiccup during a designated start-up interval (usually a few milliseconds). The reason for the latter operation is that during start-up, the power supply needs to provide extra current to charge up the output capacitor. Thus the current demand during start-up is usually larger than during normal operation and it is easier for an over-current event to occur. If the converter starts hiccup once there is an over-current, it might never start up successfully. Hiccup mode protection will give the best protection for a converter against over current situations, since it will limit the average current to the load at a low level, so reducing power dissipation and case temperature in the power devices.

Short Circuitry Protection

Continuous, hiccup and auto-recovery mode.
The average current during this condition is very low and due to that the device will be safe in this condition.

EMC considerations

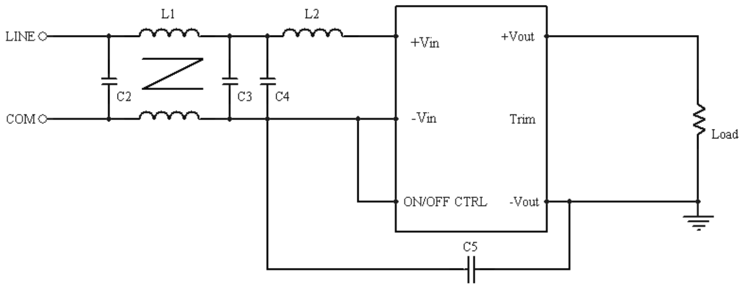


Figure 1: Recommended circuit to comply with EN55022 Conducted

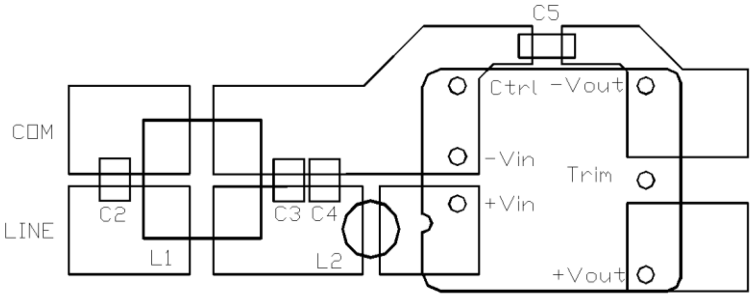


Figure 2: Recommended Layout with Input Filter

To comply with the conducted noise according to EN55022 CLASS B following components are required:

- C2,C3,C4: 2.2µF/100V MLCC
- C5: 470pF/3KV MLCC
- L1: Pulse Engineering type P0354 , 1.17mH
- L2: Inductor 10µH Φ0.35mm

External trim adjustment

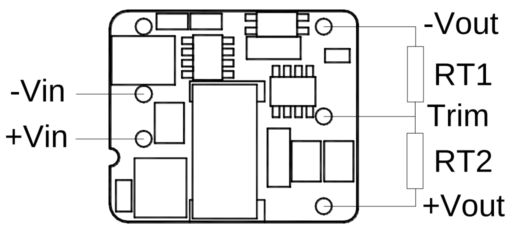
Output voltage set point adjustment allows the user to increase or decrease the output voltage set point of a module by ±10% in maximum. This is accomplished by connecting an external resistor between the TRIM pin and either the $+V_{out}$ or $-V_{out}$ pins. With an external resistor between the TRIM and $+V_{out}$ pin, the output voltage set point decreases. With an external resistor between the TRIM and $-V_{out}$ pin, the output voltage set point increases.

- **Trim up equation**

$$RT1 = \left[\frac{G \times L}{(Vo,up - L - K)} - H\right]\Omega$$

- **Trim down equation**

$$RT2 = \left[\frac{(Vo,down - L) \times G}{(Vo - Vo,down)} - H\right]\Omega$$



- **Trim constants**

Module	G	H	K	L
TON 15-xx13	10000	5110	12.5	2.5
TON 15-xx12	10000	5110	9.5	2.5
TON 15-xx11	5110	2050	2.5	2.5
TON 15-xx10	5110	2050	0.8	2.5

- **RT1 & RT2 List (Unit: KΩ)**

RT1 for trim up

% of V_{out}	+1%	+2%	+3%	+4%	+5%	+6%	+7%	+8%	+9%	+10%
TON 15-xx13	161.557	78.223	50.446	36.557	28.223	22.668	18.700	15.723	13.409	11.557
TON 15-xx12	203.223	99.057	64.334	46.973	36.557	29.612	24.652	20.932	18.038	15.723
TON 15-xx11	253.450	125.700	83.117	61.825	49.050	40.533	34.450	29.888	26.339	23.500
TON 15-xx10	385.071	191.511	126.990	94.730	75.374	62.470	53.253	46.340	40.963	36.662

RT2 for trim down

% of V_{out}	–1%	–2%	–3%	–4%	–5%	–6%	–7%	–8%	–9%	–10%
TON 15-xx13	818.223	401.557	262.668	193.223	151.557	123.779	103.938	89.057	77.483	68.223
TON 15-xx12	776.557	380.723	248.779	182.807	143.223	116.834	97.985	83.848	72.853	64.057
TON 15-xx11	248.340	120.590	78.007	56.715	43.940	35.423	29.340	24.778	21.229	18.390
TON 15-xx10	116.719	54.779	34.133	23.810	17.616	13.486	10.537	8.325	6.604	5.228

Remote ON/OFF Control

Two remote ON/OFF controls are available for TON 15

Positive logic remote ON/OFF turns the modules on during a logic-high voltage on the remote ON/OFF pin, and off during logic low.
Negative logic remote ON/OFF turns the module off during logic high and on during logic low or when the remote ON/OFF pin is shorted to the -INPUT pin.

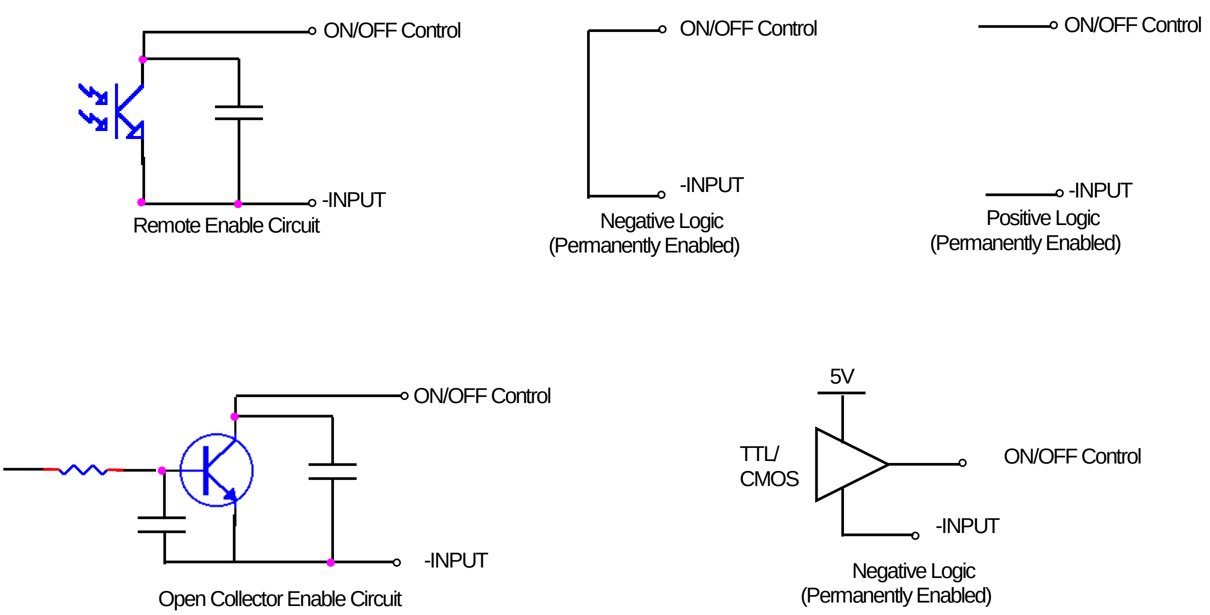
The TON 15 series used a positive remote ON/OFF logic as standard. For the negative remote ON/OFF logic control add the suffix: "–N"

To turn the power module on and off, the user must supply a switch to control the voltage between the ON/OFF terminal ($V_{ON/OFF}$) and the -Vin. The switch may be an open collector or equivalent (see figures below). A logic low is $V_{ON/OFF}$ = –0.7V to 1.2V. The maximum $I_{ON/OFF}$ during a logic low is 1mA. The switch should maintain a logic-low voltage while sinking current is 1mA.

During logic high, the maximum $V_{ON/OFF}$ generated by the power module is 15V. The maximum allowable leakage current of the switch at $V_{on/off}$ = 15V is 50µA

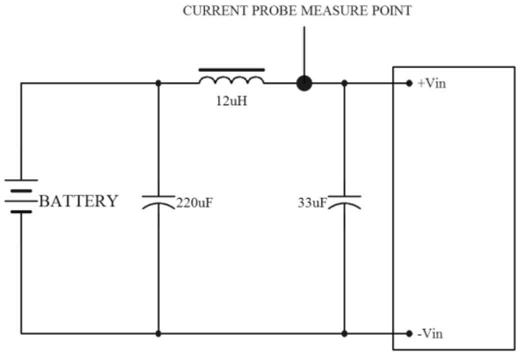
The module has internal capacitance to reduce noise at the ON/OFF pin. Additional capacitance is not generally needed and may degrade the start-up characteristics of the module.

Figure as below details five possible circuits for driving the remote ON/OFF pin.

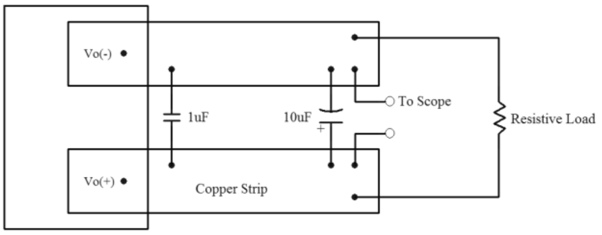


Testing Configurations

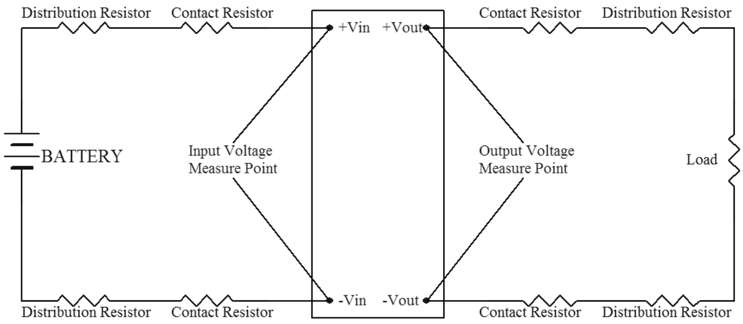
Input reflected-ripple current measurement test up



Peak-to-peak output ripple & noise measurement test up



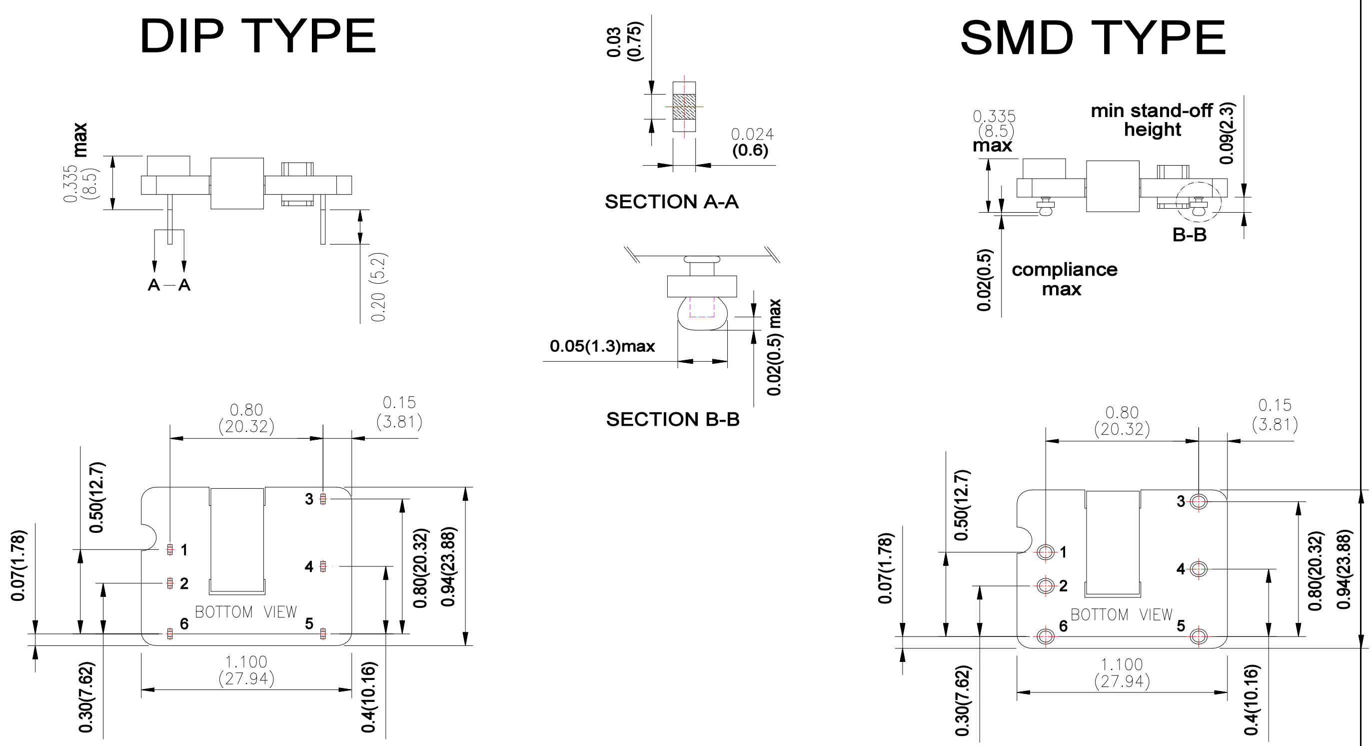
Output voltage and efficiency measurement test up



Note: All measurements are taken at the module terminals.

$$\text{Efficiency}\ \eta = \left(\frac{Vout \times Iout}{Vin \times Iin}\right) \times 100\%$$

Mechanical Data



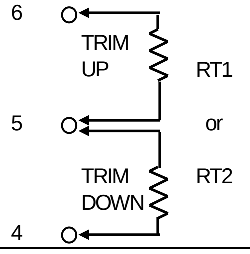
1. All dimensions in inches (mm)
2. Tolerance: x.xx ±0.02 (x.x ±0.5)
   x.xxx ±0.010 (x.xx ±0.25)
3. Pin pitch tolerance ±0.014 (±0.35)

PIN CONNECTION

PIN	TON 15 SERIES
1	+ Vin (Vcc)
2	- Vin (GND)
3	+ Vout
4	Trim
5	- Vout
6	Remote On/Off

EXTERNAL OUTPUT TRIMMING

Output can be externally trimmed by using the method shown below.

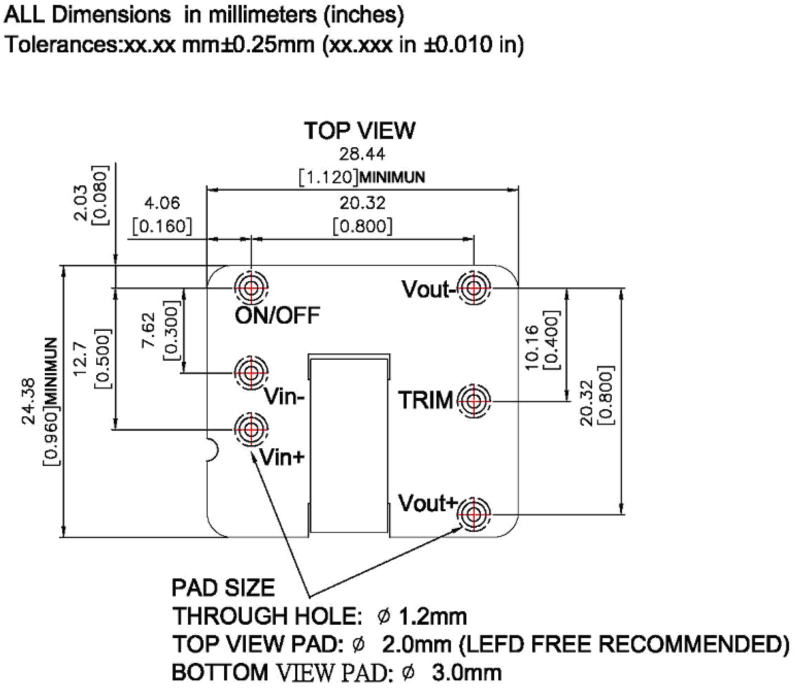


PRODUCT STANDARD TABLE

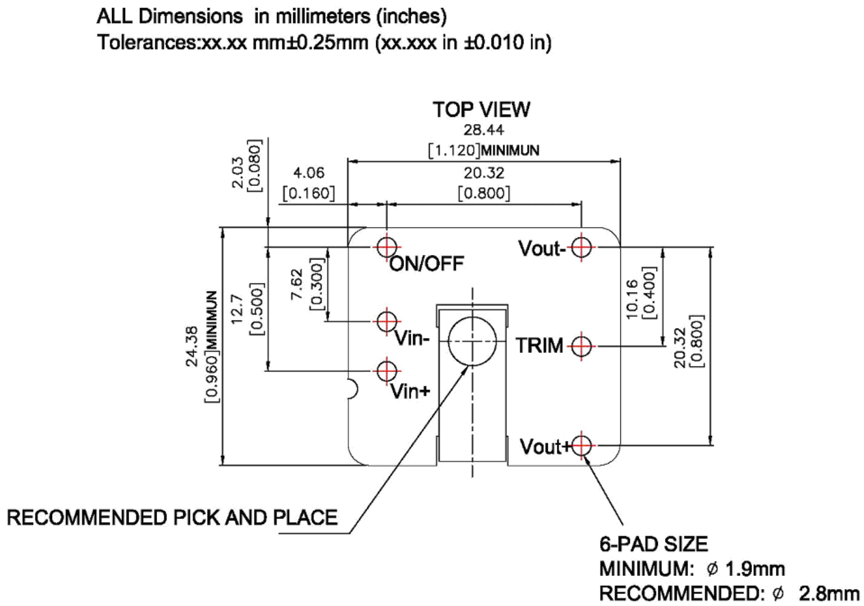
Option	Suffix
TON Series with positive remote ON/OFF	-
TON Series with negative remote ON/OFF	-N

Recommended Pad Layout

Recommended pad layout for DIP type



Recommended pad layout for SMD type

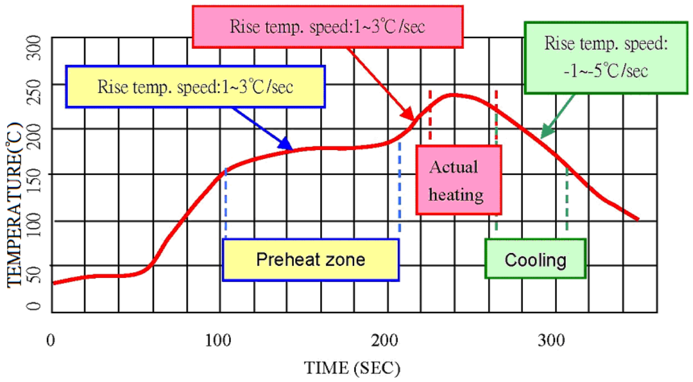


Soldering and Reflow Considerations

Lead free wave solder profile for DIP type

Zone	Reference Parameter
Preheat zone:	Rise temperature speed: 3°C/sec max. Preheat temperature: 100 ~ 130°C
Actual heating:	Peak temperature: 250 ~ 260°C Peak time (T1+T2 time): 4 ~ 6 sec

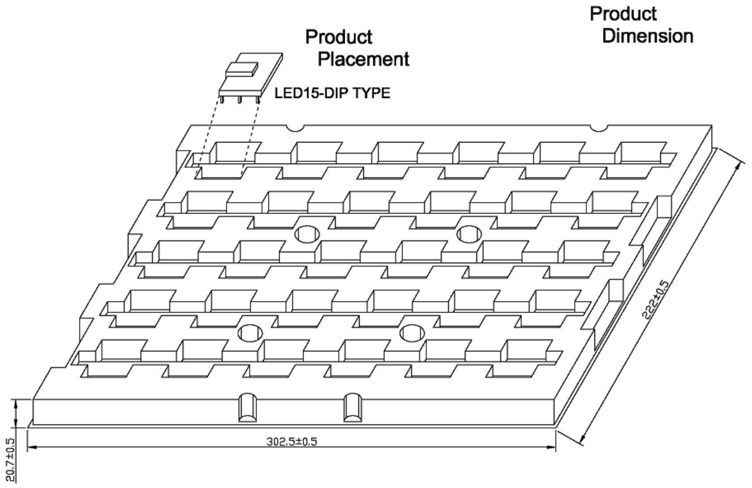
Lead free reflow profile for SMD type



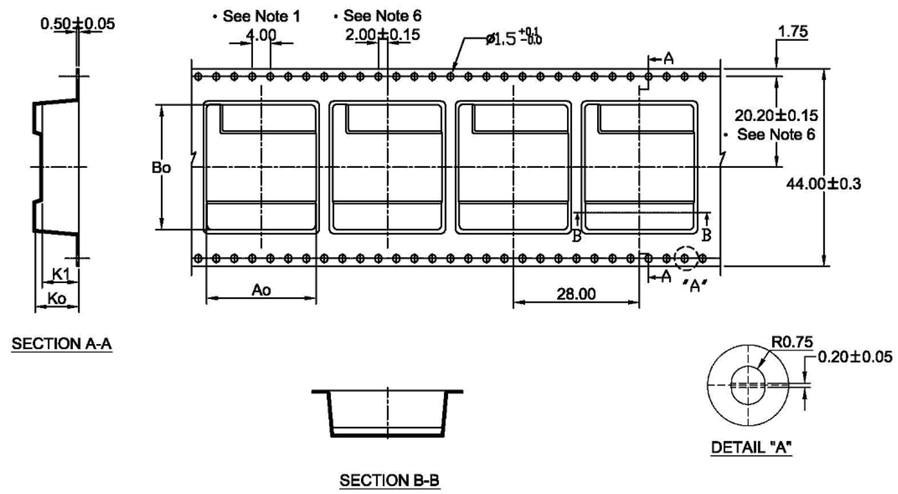
Zone	Reference Parameter.
Preheat zone:	Rise temperature speed: 1 ~ 3°C/sec Preheat time: 60 ~ 90sec Preheat temperature: 155 ~ 185°C
Actual heating:	Rise temperature speed: 1 ~ 3°C/sec Melting time: 20 ~ 40 sec Melting temperature: 220°C Peak temperature: 230 ~ 240°C Peak time: 10 ~ 20sec
Cooling:	Rise temp. speed: -1 ~ -5°C/sec

Packaging Information

Packaging information for DIP type



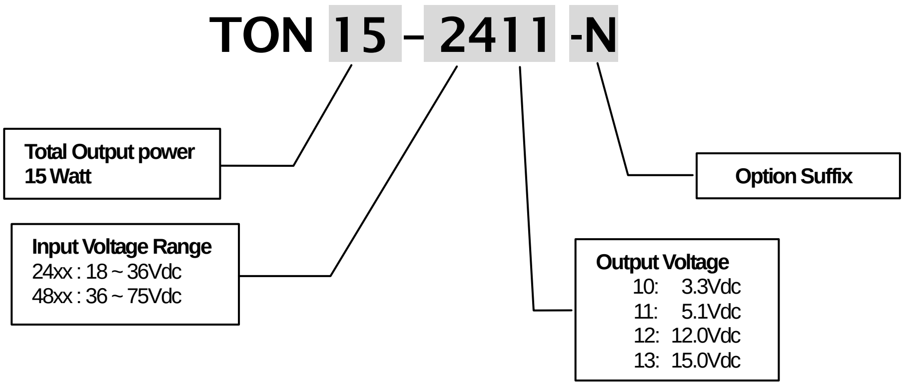
Packaging information for SMD type



Notes:
1. 10 sprocket hole pitch cumulative tolerance ± 0.2
2. Camber not to exceed 1mm in 100mm.
3. Material: Black Advantek Polystyrene.
4. Ao and Bo measured on a plane 0.3mm above the bottom of the pocket.
5. Ko measured from a plane on the inside bottom of the pocket to the top surface of the carrier tape.
6. Pocket position relative to sprocket hole measured as true position of pocket, not pocket hole.

Ao=24.30mm
Bo=27.80mm
Ko= 9.70mm
K1= 8.20mm

Part Number Structure



Safety and Installation Instruction

Isolation consideration:

The TON 15 series features 2250 Volt DC isolation from input to output. The input to output resistance is greater than 10megohms. Nevertheless, if the system using the power module needs to receive safety agency approval, certain rules must be followed in the design of the system using the model. In particular, all of the creepage and clearance requirements of the end-use safety requirement must be observed. These documents include IEC 60950-1, UL60950-1, EN60950-1 and CSA-C22.2 No 60950-1-07, although specific applications may have other or additional requirements.

Fusing Consideration:

Caution: This power module is not internally fused. An input line fuse must always be used.
This encapsulated power module can be used in a wide variety of applications, ranging from simple stand-alone operation to an integrated part of sophisticated power architecture. To maximum flexibility, internal fusing is not included; however, to achieve maximum safety and system protection, always use an input line fuse. The safety agencies require a normal-blow fuse with maximum rating of 5 A. Based on the information provided in this data sheet on Inrush energy and maximum dc input current; the same type of fuse with lower rating can be used. Refer to the fuse manufacturer's data for further information.

MTBF and Reliability

The MTBF of TON 15 series of DC/DC converters has been calculated using

Bellcore TR-NWT-000332 Case I: 50% stress, Operating Temperature at 40°C (Ground fixed and controlled environment)
The resulting figure for MTBF is 1'315'000 hours.