Product Specification

TXS Series: 75…120 A DC-DC Converters
36 to 75 V DC Input, 1.2, 1.5, 1.8, 2.0 and 2.5 V Output, 90 W to 250 W

Features

- High density design in an industry standard ¾ brick size (2.4” x 3.45” x 0.5”)
- Highly efficient topology with synchronous rectifiers (η up to 92 %)
- Unique mechanical and thermal design
- Very high reliability achieved through generous design safety margins
- Tightly regulated output voltage, very low output ripple, excellent dynamic performance
- Monotonic start up
- Provides basic insulation. I/O electric strength test voltage 1500 V DC
- Output voltage trim range ± 10 %
- Remote sense, Primary remote ON/OFF
- Overload, over temperature protection
- Approvals cULus, TÜV, CE for LVD

Applications

- Latest generation of broadband telecom and datacom equipment
- High end computers
- Fibre optic network equipment
- Gate array and RAM bank applications

Options / Accessories

- Negative ON/OFF logic
- Long pins
- Wide trim range -30 %, +10 %
- Horizontal heat sink
- Vertical heat sink

Description

The TXS is a series of 75 to 120 A, open frame, highly efficient, board mountable DC-DC converters with a unique patented thermal and mechanical design. These low voltage – high amperage converters supply the next generation of microprocessors, gate arrays and integrated circuits with reliable power. The TXS series features input under voltage lockout, overload and over temperature protection and fulfills all requirements for a perfect fit into Distributed Power Architectures (DPAs).

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Model	Input voltage range [V]	Output voltage [V]	Output rated current, [A]	Rated power [W]	Required airflow [LFM] [1/2]
TXS75ZY	36-75	1.2	75	90	110
TXS75ZA		1.5		112	160
TXS75ZB		1.8		135	210
TXS80ZC		2.0	80	160	250
TXS80ZD		2.5		200	300
TXS100ZY		1.2	100	120	250
TXS100ZA		1.5		150	290
TXS100ZB		1.8		180	350
TXS100ZC		2.0		200	380
TXS100ZD		2.5		250	500
TXS120ZY		1.2	120	144	400 [3]
TXS120ZA		1.5		180	450 [3]
TXS120ZB		1.8		216	500 [3]

[1] LFM = Linear Feet per Minute (200 LFM ≈ 1 m/s)

[2] Conditions: $T_A = 60$ °C, $T_{\text{Base plate}} = 100$ °C, $U_{\text{i nom}}$ ±25 %, linear airflow, stand alone module.
→ See pages 23 to 25 and calculation tool on TXS product CD ROM.

[3] Preliminary data

Options / Accessories

Options / Accessories		Suffix	Remarks
Negative Logic Unit enabled when control signal is low		N	see Control Specifications table 3
Long Pin, Lengths: 0.24" (6.1 mm)		P2	Standard pin length: 0.18" (4.6 mm)
Wide Trim Range: 70 to 110 % $U_{\text{o nom}}$		R	Standard trim range: 90 to 110 % $U_{\text{o nom}}$ (see pages 13/14)
Horizontal Heat sink (Includes thermal pad)	0.24" (6.1 mm)	1H	To extend operating thermal range Fins on horizontal heat sinks run from the input pins toward the output pins. Fins on vertical heat sinks 90 ° to this.
	0.45" (11.4 mm)	2H	
	0.95" (24.1 mm)	3H	
Vertical Heat sink (Includes thermal pad)	0.24" (6.1 mm	1V	
	0.45" (11.4 mm)	2V	
	0.95" (24.1 mm)	3V	

Absolute Maximum Ratings

Stress in excess of the absolute maximum ratings may cause performance degradation, adversely affect long term reliability or cause permanent damage to the converter.

Parameter	Conditions/Description	Min	Max	Units
Maximum Input voltage (U_i)	Continuous	36	75	V DC
	Transient, 100 ms		100	V DC
Operating Base Plate Temperature (T_{BP})	Full load	-40	100	°C
Storage Temperature (T_S)	Non operational	-55	115	°C
I/O Electric Strength Test Voltage	One minute max.		1500	V DC
ON/OFF Control Voltage (U_{SD})	TTL compatible, referenced to V_i (-)	-1.0	5.5	V DC
Maximum Output Voltage (U_o)	Adjusted by trim and/or sense		120	% $U_{\text{o nom}}$

Safety Specification and Approvals

Approvals

Parameter	Conditions/Description	Value
UL/TÜV Approvals	EN 60950:2000, UL 60950 CSA 22.2 No. 60950-00	UL file N° E132494

Safety

Parameter	Conditions/Description	Value
Isolation	I/Case, I/O	Basic [1]
	O/Case	Functional [1]
Electric Strength Test Voltage [2]	I/Case, I/O	1500 V DC
	O/Case	500 V DC
Insulation Resistance	T_A = 25 °C	typ. 50 MΩ
I/O Capacitance	T_A = 25 °C	typ. 1.6 nF

[1] EN 60950:2000/UL 60950 [2] 100 % factory test, one second

Fusing Considerations:
This power module is not internally fused. To meet safety requirements, an input line fuse should always be used! Select a fuse according the specified input current in Table 1. The fuse rating should be selected in the range [1.3·$I_{i\ max}$..10 A]. The UL file calls for a fuse rated F, 125 V DC, 10 A max. Refer to the fuse manufacturer’s data for further information.

Electrical Specification

Unless otherwise stated the specification applies over the entire input voltage, output load and temperature ranges. Sense lines are connected directly to the power pins. Trim pin is left open.

Table 1: Input Specification

Parameter		Conditions/Description	Min	Nom	Max	Units
Input Voltage	U_i		36	48	75	A
Max. Input Current	$I_{i\ max}$	$U_{i\ min}$, $I_{o\ max}$, T_{BP} = 100 °C				
TXS75ZY					2.9	A
TXS75ZA					3.55	
TXS75ZB					4.2	
TXS80ZC					5.0	
TXS80ZD					6.2	
TXS100ZY					3.9	A
TXS100ZA					4.85	
TXS100ZB					5.7	
TXS100ZC					6.4	
TXS100ZD					7.8	
TXS120ZY [1]					4.8	A
TXS120ZA [1]					6.0	
TXS120ZB [1]					6.9	
Inrush Current: All Types (See figures 23/24)	I_{inrush}	$U_{i\ nom}$, $I_{o\ max}$		0		A
Reflected Input Ripple Current (See figure 21)	$I_{i\ R}$	$U_{i\ nom}$, $I_{o\ max}$		10		mAp-p
Stand-by Power	$P_{i\ off}$	Shut down active		0.3	0.5	W
External Input Capacitance for stable Operation [µF/P_o] (See page 22)	C_i		100			µF / 125 W

[1] **Preliminary data**

Table 2: Output Specification

Parameter		Conditions/Description	Min	Nom	Max	Units
Set Point	U_o	$U_{\text{i nom}}$, 50% $I_{\text{o max}}$, T_A = 25 °C				V DC
TXSxxxZY			1.194	1.2	1.206	
TXSxxxZA			1.492	1.5	1.508	
TXSxxxZB			1.791	1.8	1.809	
TXSxxxZC			1.990	2.0	2.010	
TXSxxxZD			2.487	2.5	2.513	
Output Voltage Accuracy					± 0.5	% U_o
Static Line Regulation (see figure 9)		$U_{\text{i min}}$ to $U_{\text{i max}}$, $I_{\text{o max}}$, T_A = 25 °C		± 0.05	± 0.1	% U_o
Static Load Regulation (see figure 10)		$U_{\text{i nom}}$, 0 to 100 % $I_{\text{o max}}$, T_A = 25 °C		± 0.05	± 0.1	% U_o
Output Voltage Deviation over Temperature Range		$U_{\text{i nom}}$, $I_{\text{o max}}$			± 0.3	% U_o
U_o Overall Tolerance					± 1	% U_o
Output Voltage Ripple and Noise (see figures 17/19) RMS	U_r	$U_{\text{i min}}$ to $U_{\text{i max}}$, $I_{\text{o min}}$ to $I_{\text{o max}}$ T_A = 25 °C 20 MHz Bandwidth		7	16	mV
Peak to Peak				30	70	mV
Output Voltage Trim Range [1/3]	U_{TR}	$U_{\text{i min}}$ to $U_{\text{i max}}$, $I_{\text{o min}}$ to $I_{\text{o max}}$	± 10			% $U_{\text{o nom}}$
Output Current [2/3]	I_o	$U_{\text{i min}}$ to $U_{\text{i max}}$				A DC
TXS75xx			0		75	
TXS80xx			0		80	
TXS100xx			0		100	
TXS120xx			0		120	
Output Current Limit Threshold	I_{lim}	Hiccup, self recovery [4]	110		130	% $I_{\text{o nom}}$
Efficiency	η	$U_{\text{i nom}}$, $I_{\text{o max}}$				%
TXS75ZY				88.0		
TXS100ZY				87.5		
TXS75ZA				89.0		
TXS100ZA				88.5		
TXS75ZB				90.0		
TXS100ZB				89.5		
TXS80ZC				91.0		
TXS100ZC				90.5		
TXS80ZD				91.0		
TXS100ZD				90.5		
(see figures 1-4)						
Switching Frequency	F_s			190		kHz
Input and Output Ripple Frequency	$4 \cdot F_s$			760		kHz
Dynamic Load Regulation (see figures 11/12) Peak Deviation		ΔI_o = 25 A, dI_o/dt = 2 A/µs T_A = 25 °C		± 10		% $U_{\text{o nom}}$
Settling Time				100		µs
Start Up Time (over U_i or ON/OFF) (see figures 14-16)		$U_{\text{i nom}}$, $I_{\text{o max}}$		11	15	ms
Admissible Load Capacitance (see figures 15/16)	C_o	$U_{\text{i nom}}$, $I_{\text{o max}}$	0		100	mF

[1] Wide trim range optional [2] No minimum load required

[3] **Reduced output power** of models ZB (1.8 V) and ZD (2.5 V) at minimum input voltage, highest base plate temperature and increased U_o (via Trim or Sense). Explanation and limits see page 16.

[4] Timing diagram hiccup mode: see figure 37.

Table 3: Control Specification

Parameter	Conditions/Description	Min	Nom	Max	Units
Shut Down Control [1] (ON/OFF, Pin 3)	$U_{\text{i nom}}$ Referenced to V_{i} (-) (pin 1)				V
Unit disabled if shut down low		-1		1.5	
Unit operating if active high or open		1.5		5.5	
Inverse Shut Down [1/3] (ON/OFF, Pin 3)	$U_{\text{i nom}}$ referenced to V_{i} (-) (pin 1)				V
Unit operating if shut down low		-1		1.5	
Unit disabled if active high or open		1.5		5.5	
Shut Down Sink Current (I_{SD})	Standard shut down, $U_{\text{SD}} = 0$		0.02		mA
	Inverted shut down, $U_{\text{SD}} = 0$		0.12		mA
Trim Input [2] (Trim, Pin 7)	Referenced to sense (-) (pin 8)	0		U_{o}	V
Trim Input Impedance			20		kΩ

[1] Shut down control signal = TTL compatible, see page 14
[2] Control function and block diagram for U_{o} adjustment over a trim voltage U_{TR} or a trim resistor R_{TR} see pages 13/14.
[3] Inverse shut down = option N.

Table 4: Protection Specification

Parameter	Conditions/Description	Min	Nom	Max	Units
Input Under Voltage Lockout	Turn on		34	36	V
	Turn off	31	32		
Overload Protection	Hiccup (self recovery)	110		130	% $I_{\text{o max}}$
Output OVP	Continuous limitation, no switch off				% $U_{\text{o set}}$ [1]
Models ZA, ZB, ZY			125		
Models ZC, ZD			115		
Over Temperature Shut Down	Automatic recovery (Thermistor)		120		°C
Over Temperature Hysteresis	Measurement point on PCB		5		K

[1] $U_{\text{o set}}$: Output voltage adjusted over trim or sense.

EMC and Reliability Specification

Table 5: EMC

Parameter	Conditions/Description	Value	Performance
Electrostatic Discharge	IEC/EN 61000-4-2, level 4 $U_{\text{i nom}}$, $I_{\text{o max}}$		criterion A [1]
Air		15 kV	
Contact		15 kV	
Electromagnetic Field	IEC/EN 61000-4-3, level 2	3 V/m	criterion A [1]
Fast Transients/Burst	IEC/EN 61000-4-4, level 4 $U_{\text{i max}}$, $I_{\text{o max}}$		criterion A [1]
To Input		8 kV/2.5 kHz	
To Output		2 kV/5 kHz	
Electromagnetic Emission	CISPR 22/EN 55022, conducted [2]	B	pass [3]

[1] See page 22
[2] Radiated emissions depend heavily on the implementation.
[3] With external filter, see pages 20/21

Table 6: Reliability

Parameter	Conditions/Description	Value
Calculated MTBF [1] Acc. MIL-HDBK 217F Notice 2 (See pages 12/25)	Ground benign, full load T_{BP} = 80 °C T_{BP} = 90 °C T_{BP} = 100 °C	44.6 years / 390 kh 31.7 years / 277 kh 21.8 years / 191 kh
Burn In	Full load	24 h
Manufacturing Facilities		ISO 9001 certified

[1] Further information on MTBF: See reliability report on TXS product CD ROM

Environmental and Mechanical Specification

Parameter	Conditions/Description	Min	Nom	Max	Units
Damp Heat	IEC/EN 60068-2-3, 93 %, 40 °C	56			Days
Shock [1]	IEC 60068-2-27 6 ms, 3 shocks in each direction, Unit operating			100	g_n
Sinusoidal Vibration [1]	IEC 60068-2-6, 10…60/60…2000 Hz Unit operating			0.7 10	mm g_n
Random Vibration [1]	IEC/EN 60068-2-64, 20…500 Hz, Unit operating			0.07	g_n^2/Hz
Bump	IEC/EN 60068-2-29, 6 ms, 1000 shocks in each direction, Unit operating			40	g_n
Water Cleaning	Standard cleaning and drying process [2]				

[1] Unit secured with the four case mounting screws on the PCB during the tests. The test BPC had a size of 176x137x3.3 mm

[2] Cleaning with Vigon A200. For parameters and alternative cleaning procedures consult factory. Inadequate cleaning and drying procedures can adversely affect the reliability of the module.

Application Notes

Application notes and full measurement reports are included on the TXS Product CD ROM, which is available on request. Ask your local representative.

Title	Thematic
Reliability Report TXS Series	Reliability prediction background. Calculation for TXS-series
Reliability and Derating of DC-DC Bricks with Optimised Mechanical Construction	Comparison of different design concepts and its effects on brick temperature and reliability
Thermal Performance of TXS	Thermal basics, design rules for system integration
TXS Layout Considerations	How to implement a 100 A module on a PCB
Second Source Solutions for TXS	Second source issues. Comparison to two paralleled 60A bricks
TXS EMI and EMC Report	EMC basics, EMC performance of TXS series
Next generation of TXS modules	Preliminary data: Product optimisation, Outlook
TXS Stability Prediction	Interactive tool to predict dynamic step response
TXS Thermal Dimensioning (Calculator)	Interactive tool to find the required airflow, the maximum allowed output current, the base plate temperature and the resulting MTBF
TXS Design verification Reports	Measurement data over temperature for different TXS types
TXS Design Maturity Test	Accelerated ageing tests measurement report
Extended Design Integrity Test	Stress tests measurement report
Thermal measurement results	Database (thermal pictures)
TXS Product Presentation	Power point document

Characteristic Curves

The following figures show typical characteristics for the TXS bricks at T_A = 25 °C / 400 LFM.

Efficiency:

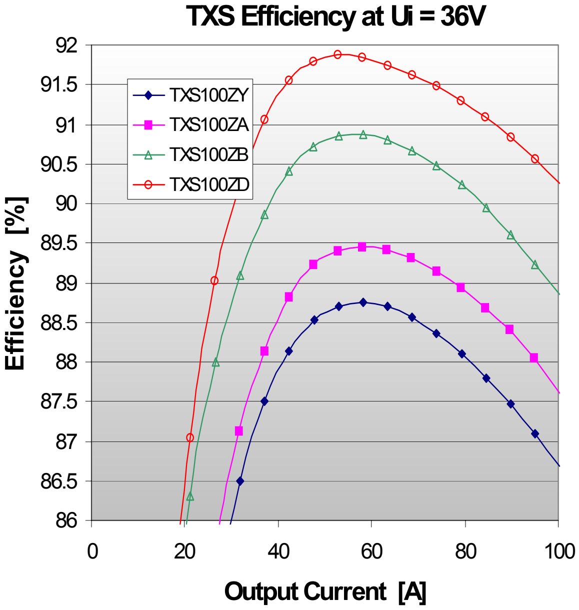


Figure 1

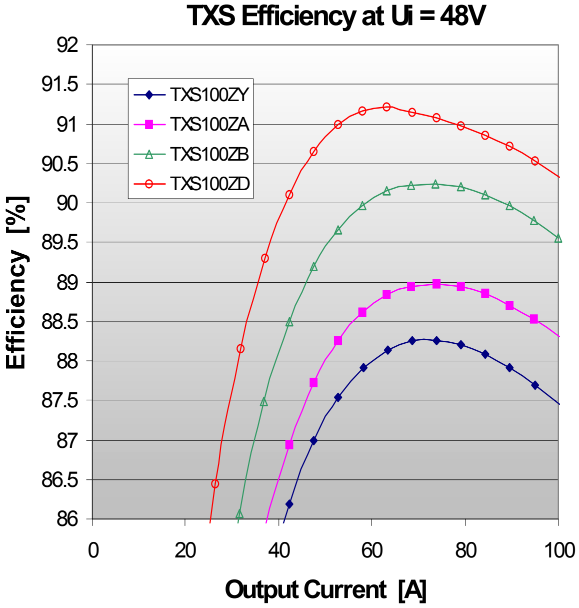


Figure 2

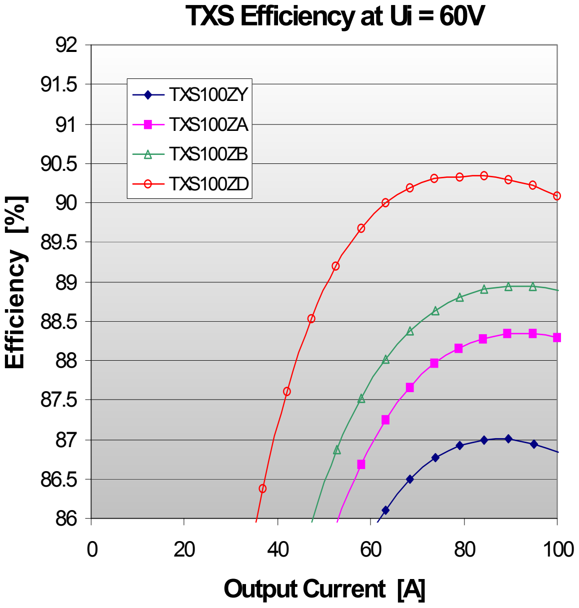


Figure 3

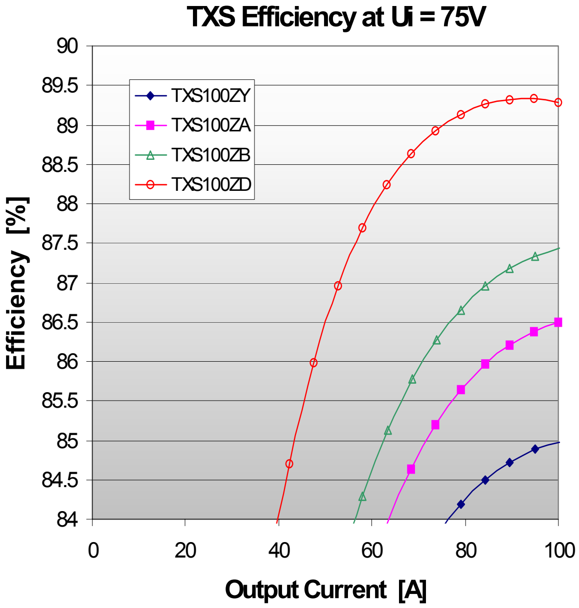


Figure 4

Power loss figures:

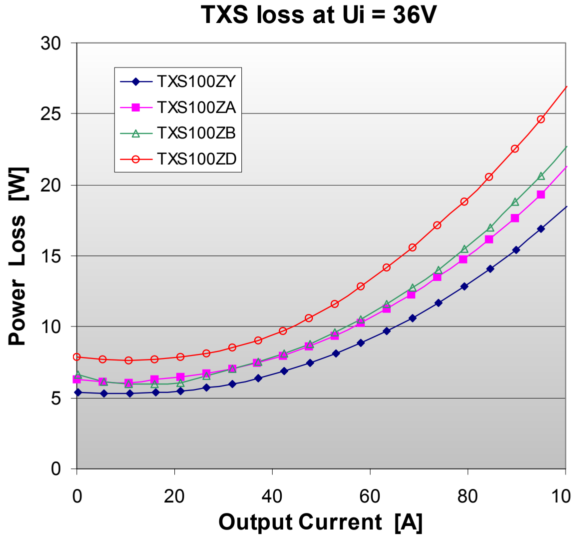


Figure 5

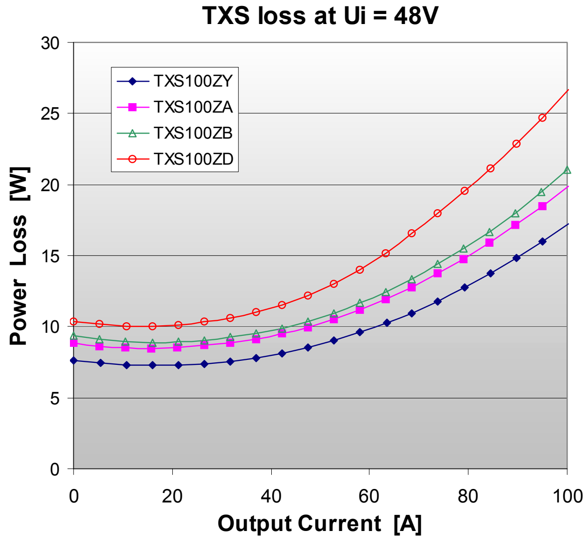


Figure 6

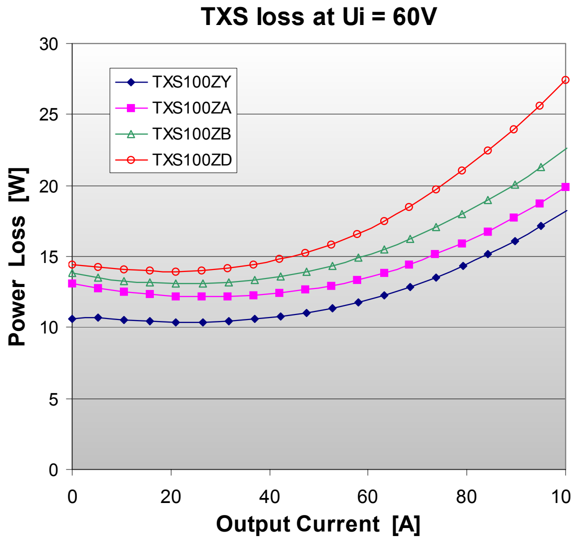


Figure 7

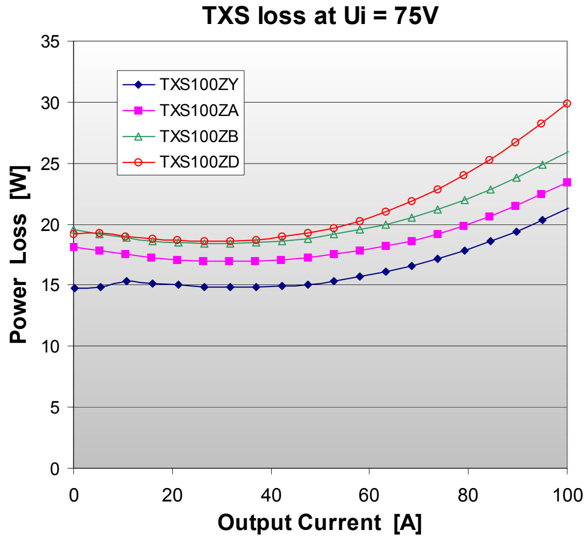


Figure 8

Output power: $P_o = U_o \cdot I_o$
Input power: $P_i = U_i \cdot I_i$
Efficiency: $\eta = P_o / P_i$
Dissipation: $P_{Loss} = P_i - P_o = P_o \cdot (1 / \eta - 1)$

Efficiency and power loss of high output current converters are difficult to measure. See figure 36

Figures 1-8 are typical curves, measured at ambient temperature. At elevated base plate temperatures the dissipation of the converters is increased because of the positive temperature coefficient of copper and MOS FETs. The loss at a specific base plate temperature can be estimated using table 7 on page 15.

The report "Next generation TXS modules" shows preliminary data of power loss and efficiency. Depending on the type, the no load and at full load loss can be reduced by up to 7W.

Line and Load Regulation:

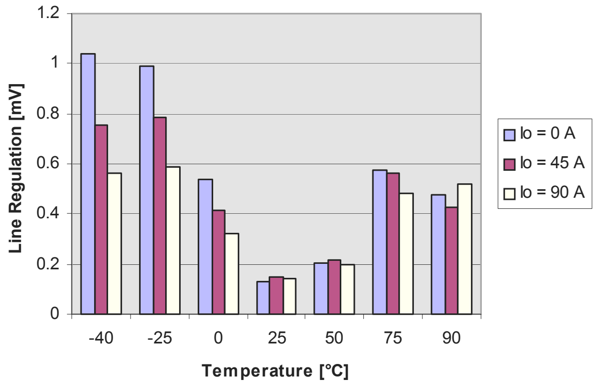


Figure 9: Line Regulation TXS100ZD
U_i = 37…75 V, T_A = -40…+90 °C
T_{BP} = 100°C

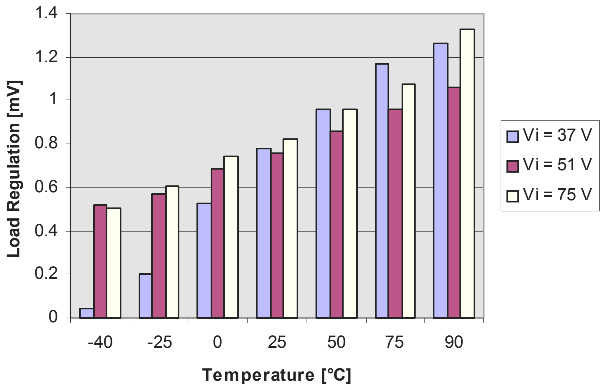
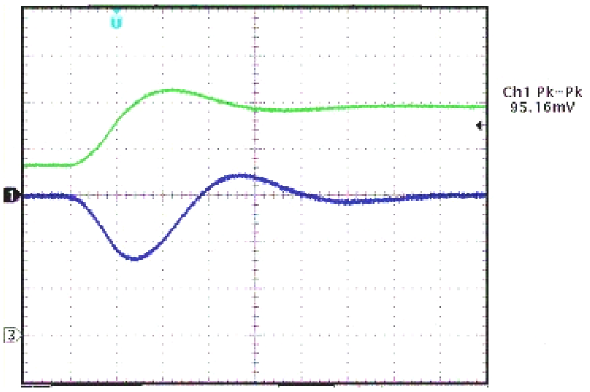


Figure 10: Load Regulation TXS100ZD
I_o = 0…90 A, T_A = -40…+90 °C
T_{BP} = 100°C

For correct measurement results, the sense pins should be connected directly to the power pins.

Dynamic Response:

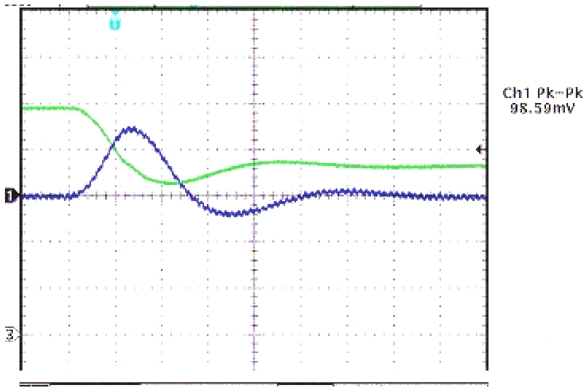
Positive Load Step: dI_o = 25 A



Ch1: V(U_o), 50 mV/div. Ch3: I_o, 20 A/div.
time 40 µs/div.

Figure 11: TXS100ZD Load Step 75 A to 100 A
@ T_A = 25 °C, U_i = $U_{i\,nom}$

Negative Load Step: dI_o = 25 A

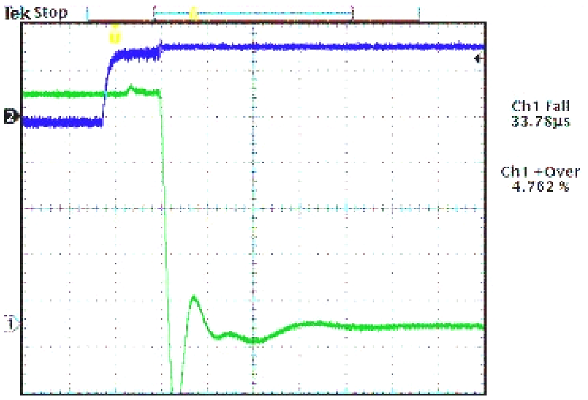


Ch1: V(U_o), 50 mV/div. Ch3: I_o, 20 A/div.
time 40 µs/div.

Figure 12: TXS100ZD Load Step 100 A to 75 A
@ T_A = 25 °C, U_i = $U_{i\,nom}$

The apparent overshoot in the output voltage load step recovery is due to an overshoot in the current drawn by the electronic load. The dynamic performance of the converter at different dI_o/dt and different capacitive loads can be estimated with an interactive tool on the TXS CD ROM.

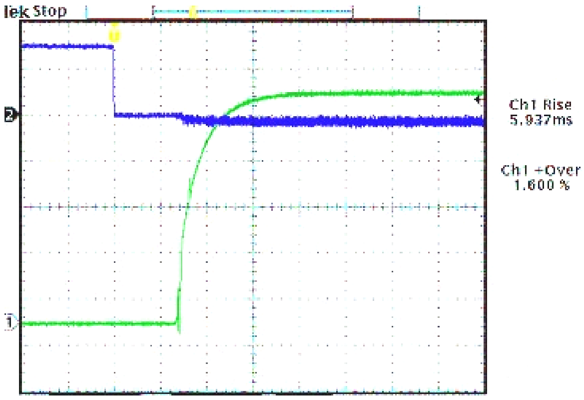
Remote Turn off



Ch1: V(U_o), 0.5 V/div. Ch2: V(U_{SD}), 2 V/div.
time: 200 µs/div.

Figure 13: TXS100ZD remote turn off
@100 A, T_A = 25 °C, U_i = $U_{i\ nom}$

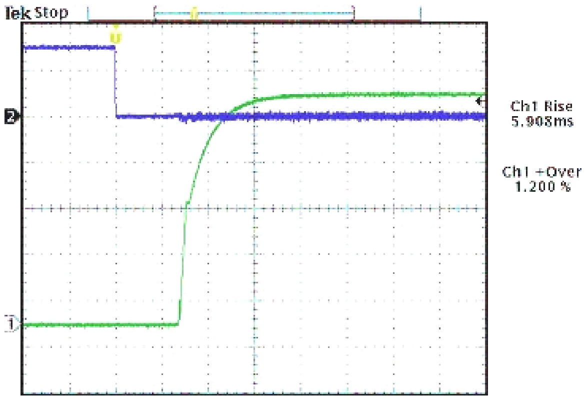
Remote Turn on



Ch1: V(U_o), 0.5 V/div. Ch2: V(U_{SD}), 2 V/div.
time: 4 ms/div.

Figure 14: TXS100ZD remote turn on
@100 A, T_A = 25 °C, U_i = $U_{i\ nom}$

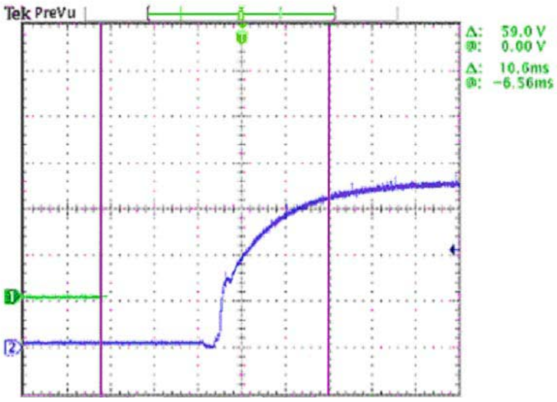
Remote Turn on with C_o = 34 mF



Ch1: V(U_o), 0.5 V/div. Ch2: V(U_{SD}), 2 V/div.
time: 4 ms/div.

Figure 15: TXS100ZD remote turn-on:
@100 A resistive and 34 mF [1]
capacitive load, @ T_A = 25 °C
U_i = $U_{i\ nom}$, td = 11 ms

Switching on U_i with C_o = 34 mF



Ch1: V(U_i), 10V/div. Ch2: V(U_o), 0.5V/div.
time: 2 ms/div.

Figure 16: TXS 100ZB U_i switch-on: 0 to 75V
@100 A resistive and 34 mF [1]
capacitive load, @T_A = 25 °C
td = 12 ms

The turn on and off curves are typical, but they look almost identical at all input voltages [36...75 V], temperatures [-40...+100 °C] and for all models [1.2...2.5 V]. The same curves apply whether the module is switched using the remote signal or the input voltage.

Figures 15 and 16 show that TXS modules are capable of monotonic start up into loads with very high or very low impedance without stability problems.

[1] The ESR of the 34 x 1 mF Tantalum capacitors is < 0.3 mΩ in total.

Output Ripple

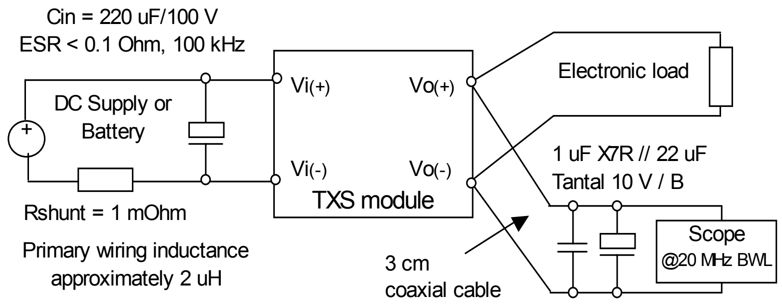


Figure 18: Output Ripple Test Set Up

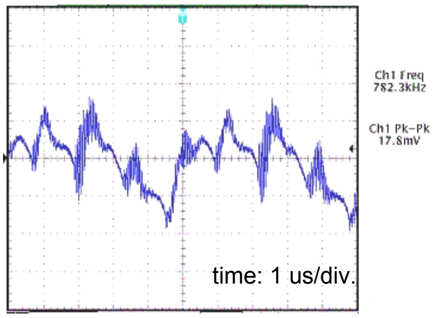


Figure 17: Output Ripple TXS100ZD @ I_o = 100 A, $U_{i\ nom}$, T_A = 25 °C

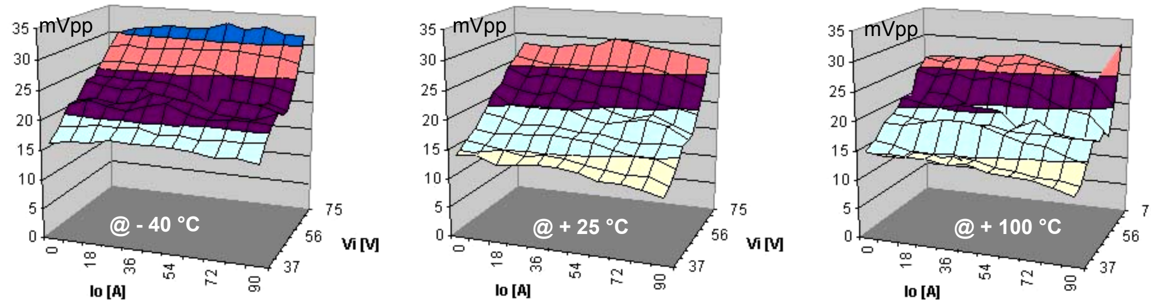


Figure 19: Output Ripple of TXS100ZD over Line, Load [0..90A] and Temperature

Reflected Input Ripple

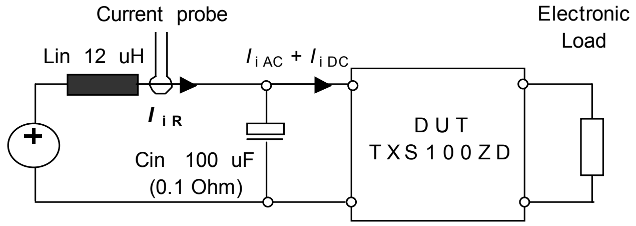


Figure 20: Input Current Reflected Ripple Test Set Up

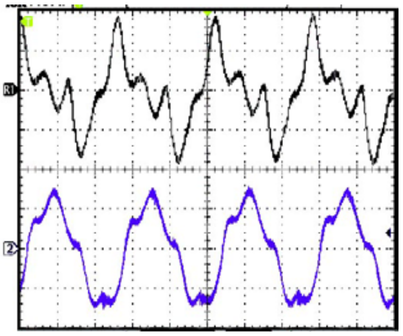


Figure 22:

AC-part of the converter input current $I_{i\ AC}$. measured on a TXS100ZD at T_A = 25 °C, U_i = 75 V. Upper curve: full load; lower curve: no load. 0.2 A/div. time = 2 µs/div.

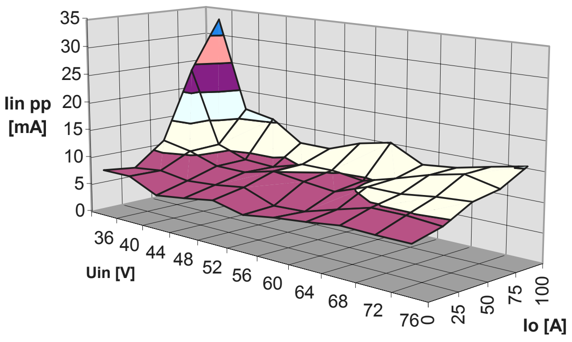
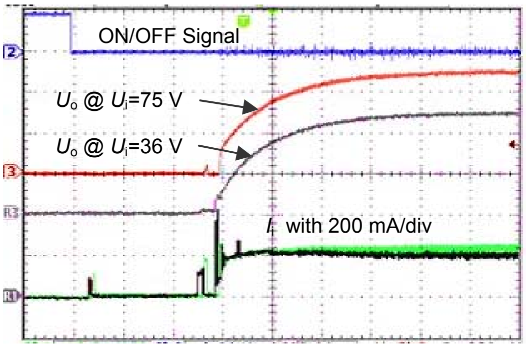


Figure 21:

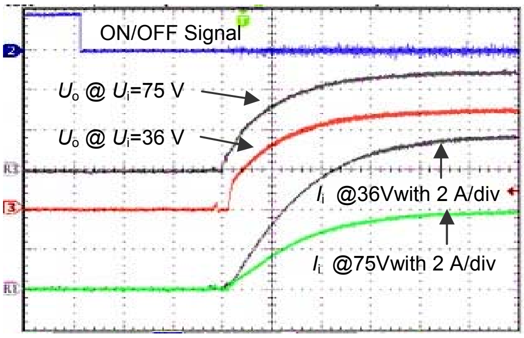
Reflected input current I_{iR} pp:
Measured on a TXS100ZD at full load and ambient temperature.

Inrush Current



Ch 1: I_{in} @ 75 V, 0.2 A/div., Ch R1: I_{in} @ 36 V, 0.2 A/div.
Ch 2: ON/OFF signal, Ch 3: U_o @ U_i= 75 V, 1 V/div.
Ch R3: U_o @ U_i = 36 V, 1 V/div. time: 2 ms/div.

Figure 23: **No Load Inrush Current**
TXS100ZD-NP2, Inhibit Switch On
U_i = 36 V and 75 V



Ch 1: I_{in} @ 75 V, 2 A/div., Ch R1: I_{in} @ 36 V, 2 A/div.
Ch 2: ON/OFF signal, Ch 3: U_o @ U_i = 75 V, 1 V/div.
Ch R3: U_o @ U_i =36 V, 1 V/div. time: 2 ms/div.

Figure 24: **Full Load Inrush Current**
TXS100ZD-NP2, inhibit switch on
U_i = 36 V and 75 V

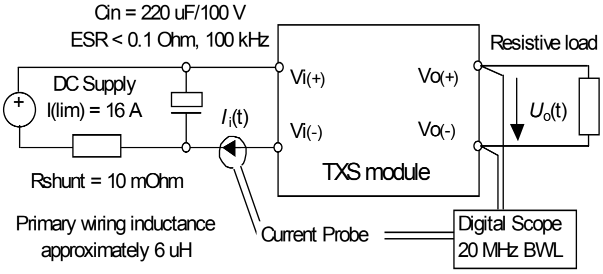


Figure 25: Inrush Current Measurement Set Up

MTBF Figures

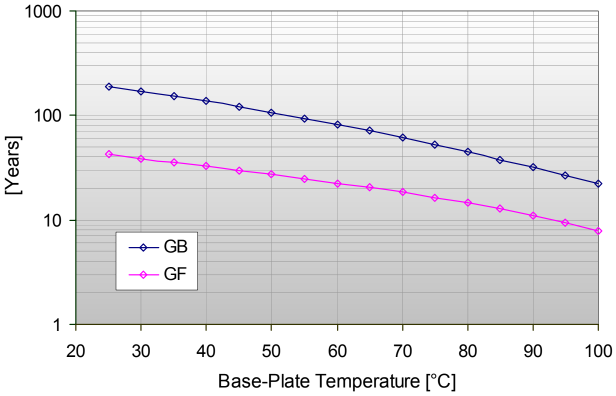


Figure 26: Calculated MTBF Values for Ground Benign and Ground Fixed at Different Base Plate Temperatures

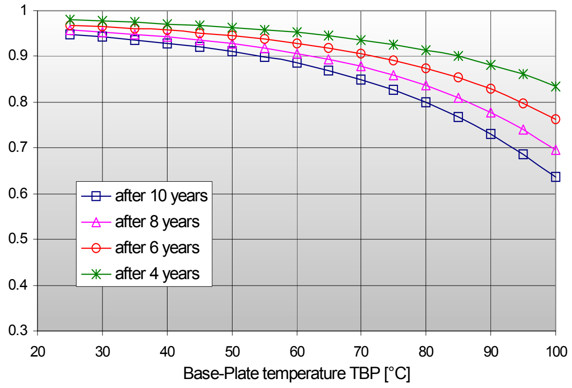


Figure 27: Probability of Survival at Ground Benign (T_{BP})

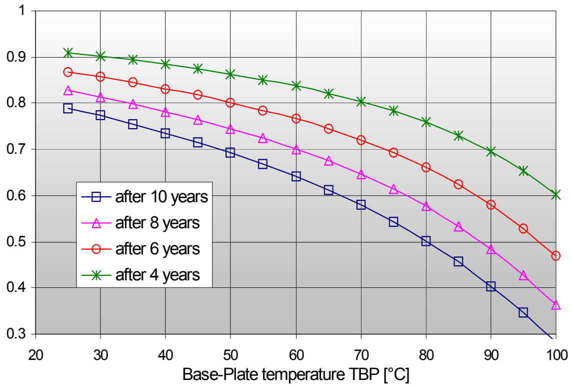


Figure 28: Probability of Survival at Ground Fixed (T_{BP})

Output Voltage Trimming

The Trim feature allows the user to adjust the output voltage in the range 90 …110 % $U_{o\,nom}$.

The output voltage can either be adjusted using an external resistor or with an external voltage source. The adjust resistor should be connected close to the unit. The voltage source should be connected to sense (-).

Adjustment of U_o with an external resistor

The trimming resistor needed to reach $U_{o\,Set}$ can be calculated using equations 1 and 2:

Increasing the output voltage:

To increase the output voltage a resistor should be connected between pins 4 and 7 as indicated in the figure below.

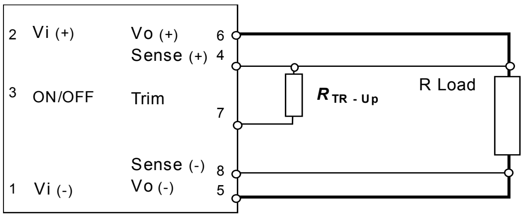


Figure 29: Trim up

$$R_{TR\text{ - up}}\,[k] = 2.4k \cdot U_o/(U_o - U_{o\,nom}) - 17.6k \qquad 1)$$

Decreasing the output voltage:

To decrease the output voltage a resistor should be connected between pins 7 and 8 as indicated in the figure below.

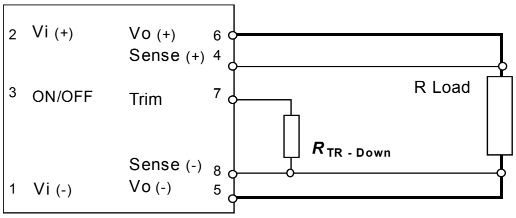


Figure 30: Trim down

$$R_{TR\text{ - down}}\,[k] = 2.4k \cdot U_o/(U_{o\,nom} - U_o) - 17.6k \qquad 2)$$

Example: R_{TR} to trim up U_o to 106% is needed

$R_{TR\text{-up}}$ [k] = 2.4k · $U_o/(U_o - U_{o\,nom})$ – 17.6k
$R_{TR\text{-up}}$ [k] = 2.4k · 1.06/(1.06 – 1) – 17.6k
$R_{TR\text{-up}}$ [k] = 24.8k

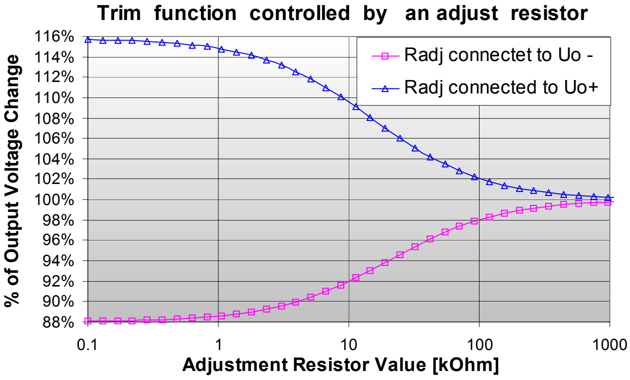


Figure 31: Trim with an external adjust resistor

Adjustment of U_o with an external voltage

The required adjust voltage can be determined using equation 3.

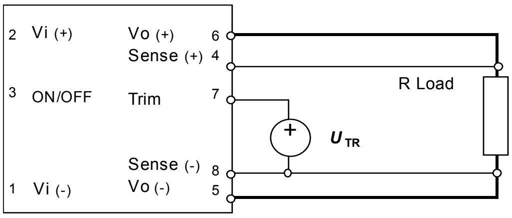


Figure 32: Trim up and down with an external voltage source referenced to sense (-)

$$U_{TR}\,[V] = (U_o - 0.88 \cdot U_{o\,nom})/0.24 \qquad 3)$$

By connecting pin 7 to Vo (+), the output voltage is set to 112 %. By connecting pin 7 to Vo (-), the output voltage is set to 88 %.

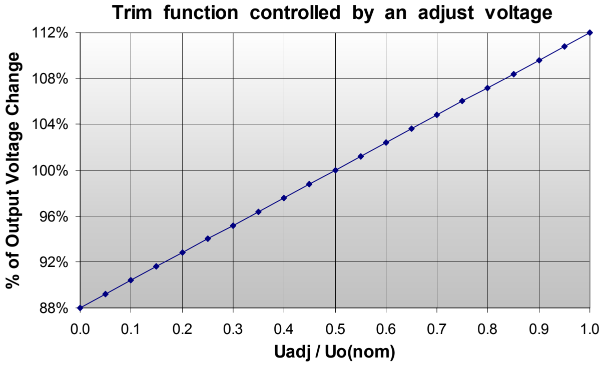


Figure 33: Trim with an external adjust voltage

Example: U_{TR} to trim U_o of the TXS100ZB to 90 %

TXS100ZB $U_{o\,nom}$ = 1.8 V
U_o = 0.9 · 1.8 V = 1.62 V
U_{TR} = (1.62 – 1.584) / 0.24 = 0.15V

Limits:
The combined U_o set by trim and sense should not exceed 120 % $U_{o\ nom}$. The minimum U_o set by trim should not be set below 88 % $U_{o\ nom}$. For increased trim range use the option wide trim (option R).

Note:
When the output voltage is trimmed upwards, the output power P_o from the converter should not exceed its maximum rating P_o. (The voltage directly at the output pins multiplied by the output current).

Wide Trim Range

The wide trim range option (option R) will allow an extended adjustment range of 70…110 % $U_{o\ nom}$, Option R covers two neighbouring output voltages. If trimmed down, the converters perform identically to the standard types, if trimmed up, the converters have slightly increased loss compared to the standard types.

The adjustment functions differently for the wide trim range as for the standard trim:

Adjustment of Vo with an external voltage

$$U_{TR}\ [V] = (U_o - 0.7 \cdot U_{o\ nom})/0.42$$

Adjustment of Vo with an external resistor

Uo increasing: (R_{TR} connected to V_o (+))

$$R_{TR\ -\ up}\ [k] = 2.4k \cdot U_o/(U_o - U_{o\ nom}) - 14k$$

Uo Decreasing: (R_{TR} connected to V_o (-))

$$R_{TR\ -\ down}\ [k] = 6k \cdot U_o/(U_{o\ nom} - U_o) - 14k$$

When the trim pin is left open, the converter regulates to $U_{o\ nom}$. The input impedance of the trim pin is equal to the standard trim 20 kΩ. When trimming with an external voltage source $U_{o\ Set}$ is $U_{o\ nom}$ at $U_{TR} = U_{o\ nom}/1.4$.

Shut Down Feature

The shut down (ON/OFF control, pin 3) is available with positive logic or with negative logic as an option. Shut down is referenced to V_i (-).

Positive logic:
Unit off, when pin 3 pulled to V_i (-) or U_{SD} <1.5 V
Unit working, when pin 3 open or U_{SD} >1.5 V

Negative logic: (Option -N)
Unit off, when pin 3 open or U_{SD} >1.5 V
Unit on, when pin3 pulled down to V_i (-) or U_{SD} <1.5 V

The shut down function is TTL compatible. U_{SD} should be kept below 5.5 V. Alternatively an open collector switch or equivalent can be used. The remote control pin is pulled up internally, so that no external voltage source is required. A bipolar transistor, a FET or an opto coupler output can be used as a switch.
The user should take care that the shut down control signal is referenced directly to Vi(-) close to the converter pins.

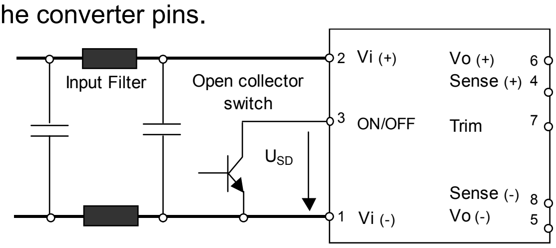


Figure 34: Shut down

Shut down is active after a delay of approximately 300 µs and has a soft restart after typically 6-10 ms. (see figures 13/16).
The turn on over the shut down function does not create any inrush current and has a monotonic form without overshoot. (see figures 22/23).

If the shut down control pin is not used, it can be left open. With option N the shut down pin must be hard wired to the Vi(-) pin.

Remote Sense

Remote sense compensates for distribution losses by regulating the voltage at the remote sense connections.

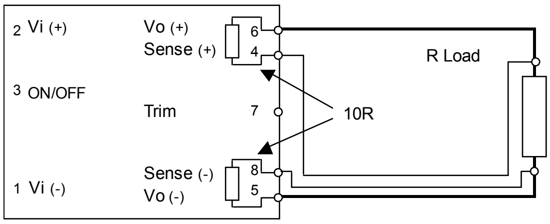


Figure 35: Remote Sense

The sense pins are internally connected to the power pins over 10 Ω resistor, to prevent an uncontrolled output voltage in case of interrupted sense wires.

To minimize noise pick up, appropriate layout techniques should be used. The sense wires should not be wired in loops, but close together. If possible sense should be placed on top of a layer with the negative return Vo (-). More layout information can be found on the TXS CD ROM.

The following points should be observed, when sense wires are used:

- The output voltage of the TXS modules should not be increased above +20 % of $U_{o\ nom.}$ This limit includes any increase due to remote sense and an output voltage set-point adjustment over the trim function.
- The output power of the TXS module is defined as the output voltages at the power pins multiplied by the load current. When the output voltage is increased to compensate voltage drops, the output power from the converter is increased as well. The power should not exceed its maximum rating.
- If not used, the remote sense pins have to be connected as short as possible to Vo (+) and Vo (-) respectively. If not connected, the output voltage shows an increased line and load regulation.
- The sense wires are loaded with a small signal current. Do not place resistors or filters into the sense wires.
- The PCB layout of the power tracks to the load should result in a low wiring inductance. Otherwise the dynamic performance even with sense wires is degraded.
- Do not use filter capacitors between sense and power pins. They could possibly influence the stability of the module.

Power loss and Efficiency

The measurement of loss and efficiency at very high output current converters is quite difficult. To avoid measurement errors, a Kelvin connection directly at the module terminals should be used. sense should be wired directly to the power pins.

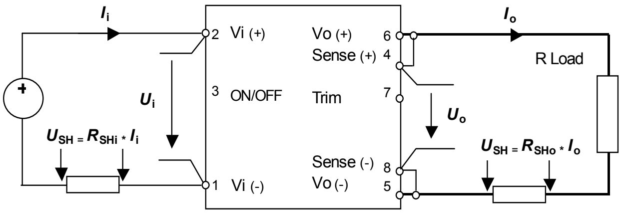


Figure 36: Efficiency Measurement Set Up

Open sense wires result in measurement errors. A low drop precision shunt, rated for 100A should be used to measure the output current.

To remember: At 100 A, a 1 mΩ resistor in trace or over a bad contact in the measurement set up can produce as much as 100 mV of voltage drop or a measuring error of 100 mV · 100 A = 10 W !

The loss and efficiency measurements in the graphs were done in a test system at room temperature. To calculate the approximate dissipation at elevated base plate temperatures, the correction factors of the following table can be used:

I_o / T_{BP}	110	100	90	80	70	60	46
100A	1.18	1.12	1.08	1.05	1.03	1.02	1
80A	1.11	1.09	1.07	1.05	1.03	1.01	1
60A	1.07	1.06	1.04	1.03	1.02	1.01	1

Table 7: Correction factor k for different output currents at elevated base plate temperatures T_{BP}.

Dissipation at T_A: $\mathbf{P_{Loss} = P_i - P_o = P_o \cdot (1/\eta - 1)}$
Dissipation at T_{BP}: $\mathbf{P_{Loss(TBP)} = P_{Loss(Graph)} \cdot k}$

The dissipation at elevated base plate temperatures is needed to determine the cooling requirements (→page 23: Thermal considerations).

Output Over Voltage Protection

The units have a built in over voltage protection, which prevent an uncontrolled increase of the output voltage in case of catastrophic failures of the converter. The over voltage protection consist of a second control loop, which is independent of the main regulating circuit.
The protection is set to 125 % $U_{o\ set}$ (Models ZY, ZA, ZB, ZC) and 115 % $U_{o\ set}$ (Model ZD).

The over voltage protection is not switching, but regulating, so that the converter can't be accidentally turned of by noise or EMI. Output voltage adjustment over sense or trim can't trigger the over voltage protection, because the protection level is tracking with $U_{o\ set}$.

Operation in Parallel

Paralleling of two converters is not possible.

Operation in Series

TXS units can be connected in series. Consult the factory for additional information if a serial connection of modules is planned.

Output Over Current Protection

When the converter output is overloaded or shorted, the module will go into hiccup mode. In the hiccup mode, the brick is switched off completely and restarted after a period of approximately 550 ms. If the overload- or short circuit is still present then, the converter will hiccup until the overload is removed.

In order to be capable of starting large capacitive loads, the converter provides a minimum on time of approximately 30 ms.

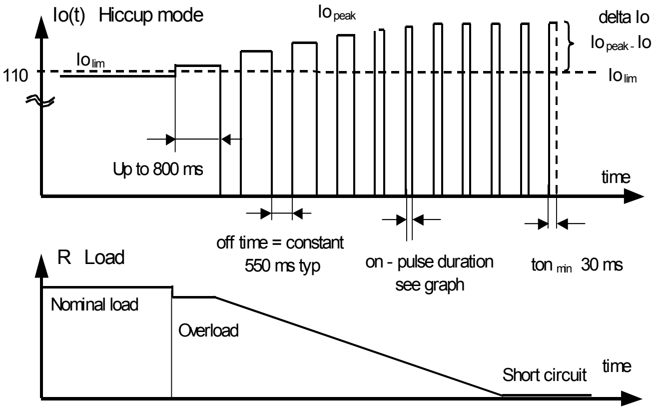


Figure 37: Hiccup Timing at Overload

With increasing overload, the peak output current is slightly increased (delta I_o typically up to 13 A). At the same time the on pulse duration is reduced, so that the total energy in an overload condition is limited.

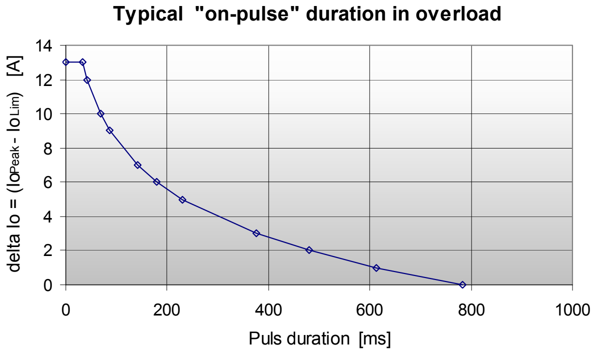


Figure 38: Characteristic of over current protection

The off period allows hot tracks and loads to cool down. The heating energy at the location of the short circuit and in the PCB is proportional to I_{rms}^2. The following graph shows, that $I_{rms}^2 = I_{o\ pulse}^2 \cdot$ ton/T is reduced at high overload, which reduces the danger of overheating and further damage to the system.

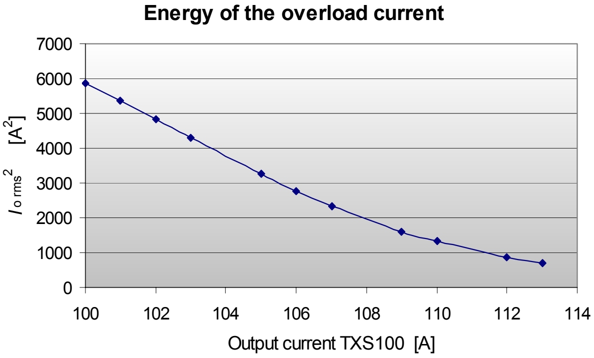


Figure 39: Function of $I_{o\ rms}^2$, proportional to the thermal energy at the overload location

Low Input Voltage

Input under voltage lookout

The unit is equipped with an input under voltage lockout circuit, which ensures a defined start up sequence.

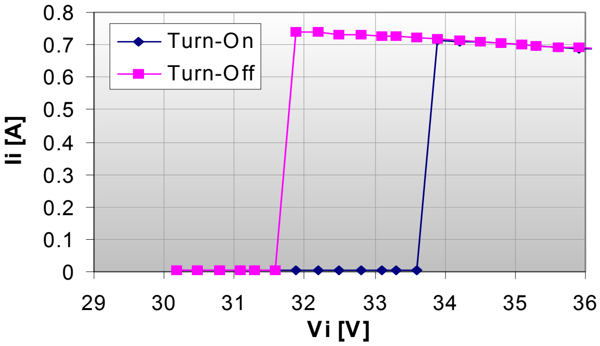


Figure 40: TXS under voltage on / off hysteresis at light load

Reduced output power of models ZB, ZD

The models ZB (1.8 V) and ZD (2.5 V) have a reduced output power at minimum input voltage when operated at highest base plate temperature and increased $U_{o\ Set}$ (over Trim or Sense). The reduction is due to a duty cycle limitation of the controller.
The rated output power of these two types [180 W resp. 250 W] is available under the following conditions:

$U_{i\ min}$ >37 V: for T_{BP} = 100 °C and $U_o = U_{o\ nom}$
$U_{i\ min}$ >40 V: for T_{BP} = 100 °C and U_o = 112 % $U_{o\ nom}$

At low input voltage, the ZB and ZD models will switch off and soft restart periodically. The operation is very similar to an under voltage lockout or over current protection.

Over Temperature Protection

These units feature a non latching over temperature protection circuit to prevent thermal damage in case of failures of the cooling system.

A second function of the over temperature protection, is to prevent long term operation at elevated temperatures due to poor thermal system design. Long time thermal overload reduces the reliability of the converters.

A PTC measures the surface temperature of the PCB near the main transformers. The temperature protection switches the converter off completely at approximately 120 °C. After cooling down by 5 to 10 Kelvin, the converter is restarted.

Thermal time constant

TXS modules have a large thermal time constant of approximately 7 K/Min. A large time constant increases the converter ruggedness. It allows short term operation at overload without triggering the temperature protection. In case of changing loads, the converter operates at a lower average temperature which improves the expected lifetime. Finally a large time constant gives additional operating time after a break down of the cooling system.

Hot Spots

TXS modules have large component and material safety margins. The temperature protection is not set close to destructive limits. Laboratory tests with disabled protection at an on board temperature of 170 °C (24 h, full load) showed no performance or material degradation after cooling down.

Survival under such extreme operating conditions is only possible, when a converter has a uniform temperature distribution without any hot spots. Hot spots are peak temperatures considerably above the neighbouring components. Hot spots can be seen quite often in converters without base plate and are the result of a poor thermal design.

Converters with hot spots need a large derating or they will suffer a large reduction to the expected life time.

Opto Couplers

On TXS modules, thermally sensitive components such as the opto-couplers are placed on a much cooler, separate hybrid circuit. opto-couplers see a highly accelerated aging at operating temperatures above 100 °C. Additionally they are safety critical components, because they are bridging the safety barrier between primary and secondary. Safety agencies don't allow operation of the opto-couplers over the rated temperature, which is in almost every case 100 °C.

Competition single board converters might be specified for 120 °C or even 130 °C PCB operating temperatures, but can't be operated at this point because of the on board opto-couplers. Safety agencies will insist on a temperature reduction of up to 30 K.

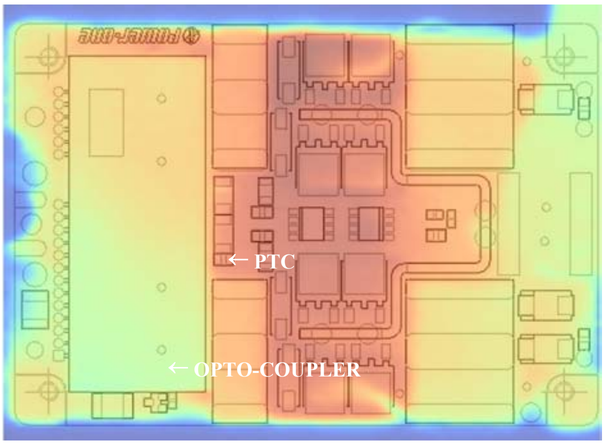
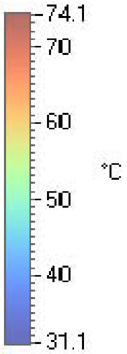


Figure 41: TXS100-ZY at 300 LFM, U_i = 48 V, I_o = 100 A, T_A = 27.9 °C, T_{BP} = 59.7 °C, T_{PCBmax} = 74.1 °C, dT = 14.4 K



The thermal picture of a TXS-module, underlayed with layout data shows clearly that hot spots are successfully avoided. The temperature distribution in the middle section with the synchronous rectifiers is flat. The temperature rise above the base plate is only 14.4 K.

The red area is the only warm section on a TXS. All other power components are located on the bottom of the board where they are in direct thermal contact with the base plate. A thermally conductive potting material keeps the temperature rise above the base plate to below 2 K.

Detailed information on the mechanical concept of the converter, the thermal system design rules and measurement results are available on the TXS product CD ROM (available reports see page 6).

Safety Considerations

TXS modules have been designed for building into system applications in pollution degree 2 environments [1].

The converters provide **basic insulation**[1] from input to output and from input to the metallic base plate. The insulation supports 1500 V DC electric strength test voltage and has an insulation resistance >50 MΩ.

The converters provide **functional insulation**[1] between output and base plate. The insulation supports 500 V DC electric strength test voltage.

The base plate is normally floating. For safety reasons the base plate may only be connected to the secondary or safety ground.

If the system using the converter requires safety agency approval, certain rules should be followed in the design of the system. In particular, all creepage and clearance distance requirements of the appropriate standard should be observed. This document refers to UL 60950, EN 60950:2000 and CSA 60950-00 only. Specific applications may have additional requirements.

- The converter has no internal fuse. An external fuse should be provided to protect the system. For UL purpose the fuse needs to be UL-listed. A fuse rating not greater than 10 A is recommended. The user can select a lower rating fuse based upon the inrush transient of the input filter and the maximum input current of the converter (see page 2). Both input tracks and the chassis ground track (if applicable) should be capable of conducting a current of 1.5 times the value of the fuse without failure. The fuse should be placed in the non-grounded input line.
- The maximum specified input voltage is 100 V DC for 100 ms. Exceeding of this voltage limit may destroy the input stage of the converter but it will not damage the insulation [2].
- If an input supply other than SELV is used, the components on the primary of the converter may need to be considered as hazardous. The report: “TXS layout considerations” on the TXS CD ROM provides recommendations for the PCB layout beneath the converter.

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[1] According to UL 60950, EN 60950:2000, CSA 60950-00

[2] The creepage and clearance distance and the insulation thickness were dimensioned for 200 V DC. The converters have been approved for basic insulation. It is in the responsibility of the customer to use the converter in applications, where supplementary insulation is required.

Definitions

The following section should help to classify the supplying circuit of the converter. For the precise identification of the voltage types in a system, the relevant safety standard should be used.

Primary circuit = Circuit connected to the AC mains which makes it hazardous per definition.

Secondary circuit = Circuit which is isolated from a primary circuit. A battery without connection to a primary circuit is considered to be a secondary circuit.

SELV, ELV and TNV are secondary circuits.

SELV:	Safety Extra Low Voltage
ELV:	Extra Low Voltage
TNV:	Telecommunication Network Voltage

SELV = User accessible secondary circuit with *U* <60 V DC and no transients. An SELV circuit remains safe even after single faults.

ELV = Basic insulated circuit with the same limits as a SELV circuit but without protection to 60 V in case of a single fault.

TNV = Double or reinforced insulated secondary circuit, isolated from earth and connected to a telecommunication network or a circuit meeting the TNV specifications.

Table 8: Normal condition:

With Transients [1]	Without Transients	
TNV-1	**ELV**	**SELV**
<60 V DC or 42.4 V AC peak		
TNV-3	**TNV-2**	
<120 V DC or 70.7 V AC peak [2]		

Table 9: Maximum voltage after a single fault:

With Transients [1]	Without Transients	
TNV-1 <120 V continuous [3]	**ELV** Possibly hazardous	**SELV** <60 V, 120 V for 0.2 s max
TNV-3	**TNV-2**	
<120 V continuous [3]		

[1] Up to 1.5 kV transients possible.

[2] For DC voltages with overlaid AC voltages the limit: $U_{AC}/70.7\ V + U_{DC}/120\ V < 1$ applies.
Exception: According deviation 2 in UL60950, the limit 80 V DC instead of 120 V DC applies in a DC-power system for **TNV2**.

[3] In the event of a single fault, the voltage can rise to 1500 V for 1 ms, then fall down to 400 V within 14 ms and stay at 400 V DC over 185 ms. Limiting curve, see figure in IEC 60950:2000.

User accessible output

If a circuit connected to the converter output is operator accessible, the output should be SELV.

The following table shows some possible installation configurations. However it is the sole responsibility of the installer/system designer to assure the compliance with the relevant and applicable safety regulations.
The output is considered SELV, according to EN 60950:2000, UL 60950, CSA 60950-00, if one of the following requirements is met in the system design:

Power Bus Voltage (Input of TXS module) note A/B	**Output circuit**	
	Earthed SELV	Unearthed SELV
Earthed/Unearthed **SELV**	note 1	
Earthed/Unearthed **ELV**	note 2/6	note 3
Unearthed **TNV-1**	note 4, 5	
Unearthed **TNV-2**	note 5	
Unearthed **TNV-3**	note 4, 5	
Earthed hazardous secondary	note 2	not allowed
Unearthed hazardous secondary		note 7

Table 10: Installation configurations to achieve an SELV output with TXS modules.

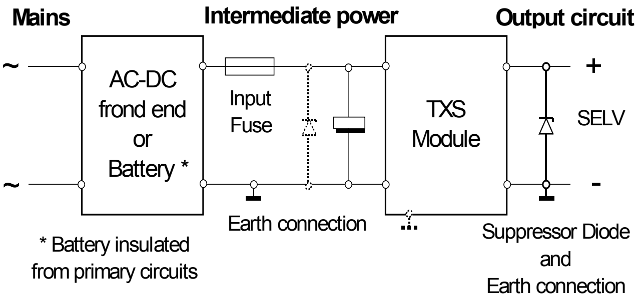


Figure 42: Supply system with TXS. All possible additional elements are shown. See notes 1 to 7 if they are required or not.

Notes

A: An input fuse should be provided in the un-earthed input path (fuses see pages 3/18).

B: The power bus voltage should be limited or regulated to maximum 75 V DC in order of not to damage the TXS modules.

1: No additional requirements

2: All of the following points should be fulfilled:
- A protective device limiting U_o to 60 V DC max. should be connected between the output lines of the TXS. (Clamp, Suppressor Diode, …)
- The output should be earthed.
- The earth connections and the protective device should be adequately dimensioned to allow the fuse to reliably interrupt.
- The power system consisting of the TXS modules and the primary supply (see figure 42) should successfully pass the SELV reliability tests.

3: All of the following points should be fulfilled:
- The power bus and the output circuit needs to be floating:
- To achieve an ELV power bus voltage, the front end needs at least basic insulation.
- The supply of the front end, which feeds the power bus should have a nominal voltage below 150 V AC or 200 V DC. A transient protection to 1500 V peak is required.
- A protection diode is required on the input of the module.

4: To achieve a TNV power bus voltage, the power bus should be isolated from any other hazardous voltage including the AC mains by reinforced insulation. In addition, it needs to be reliably isolated from earth.

5 An impulse or high voltage test is required. TXS modules were already tested for this requirement. If hand held equipment is directly connected to the output circuit, the test should be repeated together with this equipment (see safety standard).

6: The conditions for an ELV power bus need to be fulfilled. To achieve an ELV power bus voltage, the front end needs at least basic insulation.

7: This configuration is only possible if the manufacturing at Power-One follows a special inspection program. Consult factory if required. It is much easier, if the unearthed hazardous voltage can be characterized as TNV-2 circuit. (→ note 5 applies).

ELV or TNV outputs

If the output of a TXS needs only to be an ELV or TNV circuit, less stringent requirements apply.
The power module has an ELV output if the input is ELV or hazardous with a nominal voltage below 200 V DC. The power module has a TNV output if the input is TNV. No additional requirements apply.
For other combinations, consult the safety standards.

EMC Specification

The TXS generates EMI noise at the switching frequency and all it's harmonics.
There are two types of EMI: conducted and radiated emissions. Conducted emissions are currents generated by the converter, propagating mainly over the input and output wires. Radiated emission consists on electrical and magnetic fields.

Conducted Noise

Conducted or low frequency noise is measured between the input lines and protective earth between 150 kHz and 30 MHz with a measurement receiver. Radiated high frequency noise is measured as a field between 30 MHz and 1 GHz with an antenna or with an absorber clamp on the input/output wires

Measurement set up

A TXS100ZB was selected as a representative unit for all the EMI measurements. Other models use similar layouts, have the same mechanical construction and have similar internal voltages.
The unit was operated at full load with approximately 200 LFM airflow. Additional input filters were placed as close as possible to the pins. The output of the converter was wired over 15 inch (38 cm) cables to a resistive load.
The conducted noise was measured with a 50 Ω LISN (Line Impedance Stabilization Network according to EN 55022 and CISPR 22 and an EMC measurement receiver (PMM 8000).

No external filter

The TXS generates predominantly common mode noise.

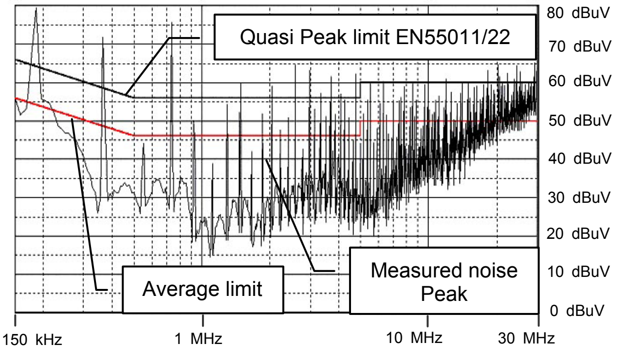


Figure 43: TXS100ZB-N at $U_{i\ nom}$ and full load without an input filter and unearthed output. Peak measurement Vi (-) line.

Only peak measurements were made. If the peak values are below the average and the quasi peak limits, level B is fulfilled in all cases.

One stage input filter

Only a small external filter with few components is required, to reduce the conducted noise below the limits of EN 55022 Class B.

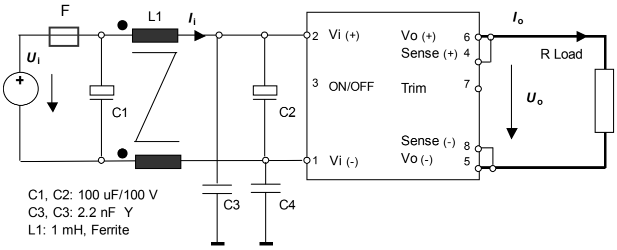


Figure 44: TXS with a one stage input filter.

C1, C2 = 100 uF/100 V (Rubycon YXA), C3, C4 = 2.2 n/250 V (Wima MP3-Y). L1 = 1 mH; Ferrite μ_i = 10'000, 16 turns (B64290L658 T38 Epcos)

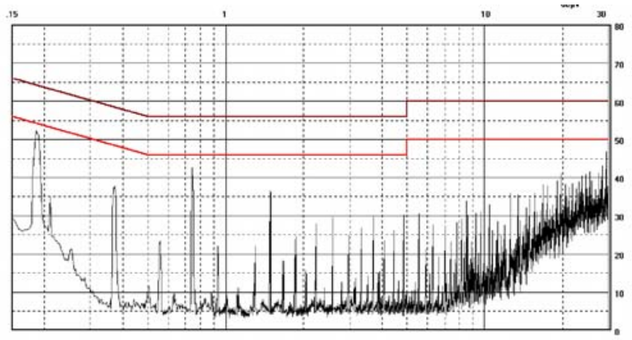


Figure 45: TXS100ZB-N with one stage input filter according to Figure 44.
Peak measurement in the V_i (-) line.

Two stage input filter

The following circuit combines two common mode filter stages.

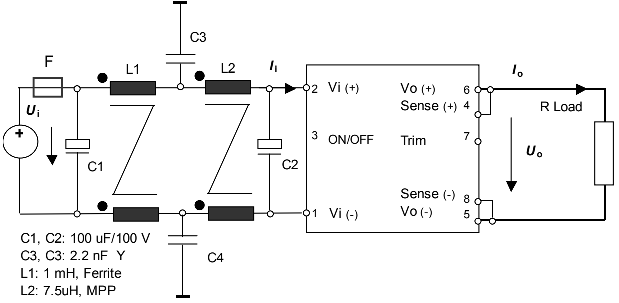


Figure 46: TXS100ZB-N with a two stage input filter:

C1, C2 = 100 uF/100 V (Rubycon YXA), C3, C4 = 2.2 n/250 V (Wima MP3-Y). L1 = 1 mH; Ferrite μ_i =10'000, 16 turns (B64290L658 T38 Epcos), L2 = 7.5 uH, 125 u MPP Powder core (Magnetics 55050-A2)

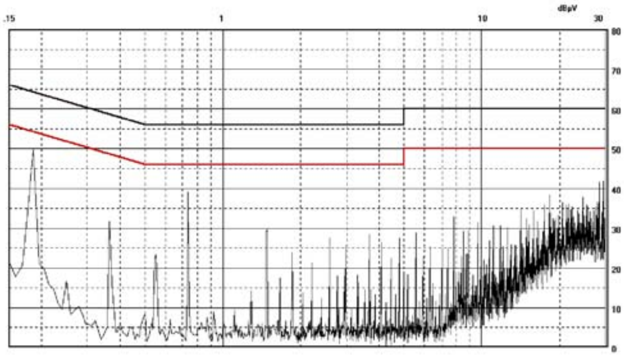


Figure 47: TXS100ZB-N with a two stage input filter according to Figure 32.
Peak measurement in the V_i (-) line.

A two stage input filter can be used, if a better high frequency damping is required.

Grounded output or grounded case

For safety reasons or to reduce possible EMI coupling to the secondary, the output circuit may need to be connected to protective earth. Grounding the output or the case has a negative influence on the EMI performance. To overcome this problem, a two stage input filter is proposed (see figures 50/51).

Alternatively, if the ground connection is needed for safety reasons only, an inductor in the ground line can be used (Figures 48/49). This solution allows a safe connection and minimises high frequency emission.

According UL 60950, the ground inductor should be capable to conduct 1.5 times the value of the input fuse without failure. The overall impedance of the connection should be below 0.1 Ω.

One stage input filter and ground Inductor

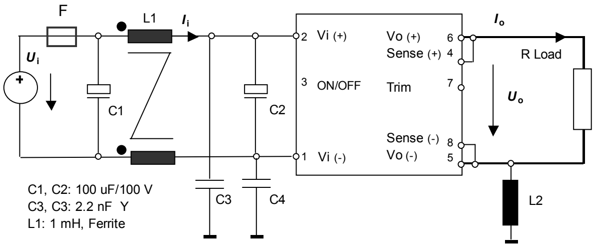


Figure 48: TXS100ZB-N with a one stage input filter according figure 44 and an inductor in the ground line to the output.
L2 = 9.6 mH, μ_I = 50’000, (VAC W620)

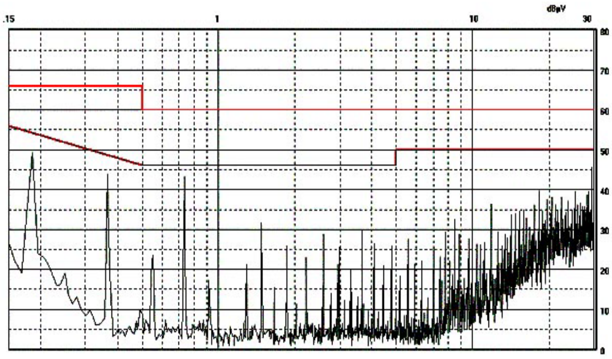


Figure 49: TXS100ZB-N with a one stage input filter and an earthed output over an inductor in the ground line according to Figure 48
Peak measurement in the V_i (-) line.

Two stage input filter and grounded output

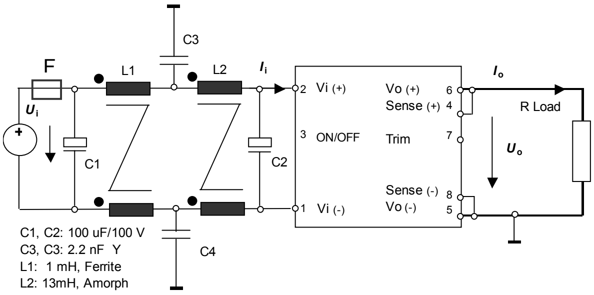


Figure 50: TXS100ZB-N with a two stage input filter and ground output.

C1, C2 = 100 uF/100 V (Rubycon YXA), C3, C4 = 2.2 nF/250 V (Wima MP3-Y). L1 = 1 mH; Ferrite μ_I = 10’000, 16 turns (B64290L658 T38 Epcos), L2 = 13 mH, 15 turns, amorphous core (Magnetec M128-01)

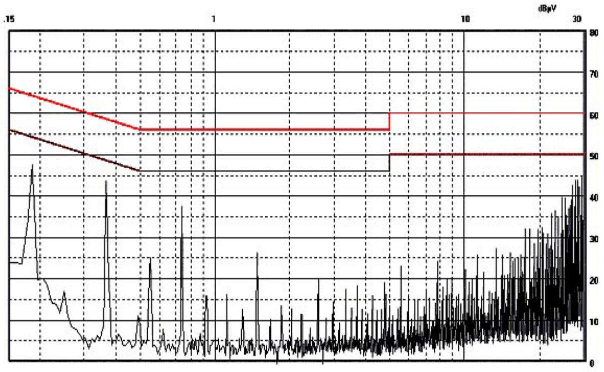


Figure 51: TXS100ZB-N with a two stage input filter and an earthed output. Peak measurement in the V_i (-) line

Radiated Noise

The radiated noise from the converter is extremely difficult to predict since it depends largely upon the motherboard layout and the switching characteristic of the loads.

The report: “TXS layout considerations” on the TXS product CD ROM provides recommendations for reducing the radiated noise through shielding and optimal layout.

Input Impedance

All switching power supplies exhibit negative input impedance. A power source with inductive output impedance and/or the wiring inductance from the supply to the converter can affect the stability of the modules.

A good general stability rule is, that the magnitude of the source impedance should be lower than the magnitude of the input impedance of the module at all frequencies up to the switching frequency. The minimum input impedance of a module is calculated as 20 log($U_{i\,min}$ / $I_{i\,max}$).

Example: At $U_{i\ min} = 36$ V and $I_{i\ max} = 7.8$ A (see Table 1 on page 3), a TXS100ZD needs an AC-impedance $|Z_{line}| < 13.2$ dBΩ at full load.

A possibility to reduce the input impedance is to connect a low ESR input filter capacitor between the input lines (at least 100 uF per 125 W output power is recommended). With such a blocking capacitor, a performance within the specifications can be achieved with almost all supply conditions.

To consider:
- The stabilising input capacitor and the capacitors of the input filters generate an inrush current.
- The blocking capacitor should be able to handle the input ripple current of the module, which is much larger than the reflected input ripple (see measurement set up: figures 20/22).
- The capacitors may resonate with the inductance of the input filter and the wiring. If this happens, the resonance will require damping.

On Board Input and Output Filters

TXS converters use a topology that achieves input- and output ripple frequencies four times higher than the switching frequency. This results in excellent ripple and noise values and low external filter requirements.

The on board output filter is a parallel connection of very low impedance Tantalum capacitors connected in parallel with an overall capacitance of 3.3 mF. Total ESR < 4.5 mΩ (@100 kHz/25 °C).

The high efficient on-board input filter consists of several ceramic capacitors, a damping network and a filter inductor. Two EMC capacitors (Cy1+Cy2) in a series connection with 2.2 nF each, are connected between primary and secondary.

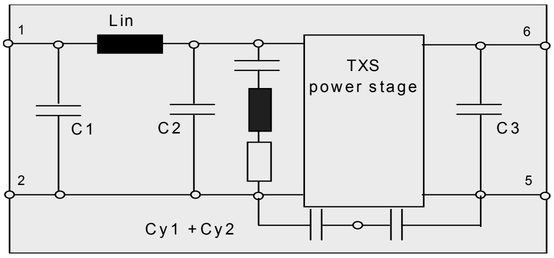


Figure 52: On board input and output filters.
C1 = 1 uF, C2 = 6 · (1 uF), C3 = 3 mF
Cy = 1.1 nF, Lin = 0.9 uH for TXS models ZC and ZD, 1.1 uH for models ZY, ZA and ZB

Electromagnetic Susceptibility

The converter does not react to EMI pulses. However the Y capacitors and the interwinding capacitance of the multilayer board can couple some common mode noise to the secondary.
Earthing or decoupling the output with large Y capacitors needs a two stage EMC filter or a ground line inductor to meet the EMC conducted noise level B (see EMC specifications).

- The EMI measurements have been done with a one stage input filter according to Figure 44.
- ESD pulses were directly discharged into the TXS pins.
- Burst pulses were applied in front of the input filter.

Performance criterion **A** denotes normal operation, no deviation from specification. Performance criterion **B** denotes temporary deviation from specification.

Thermal Considerations

TXS converters achieve one of the highest current and power densities on the market. This would be useless, if in practise the available current should be reduced a lot because of cooling problems.
But TXS converters achieve also the highest full load efficiency on the market and use a unique thermal design which makes them to real high density, high current converters.

Maximum Base Plate Temperature

To ensure reliable long term operation, and to comply with safety agency requirements, the base plate temperature (T_{BP}) should always be kept below 100 °C. The maximum base plate temperature is defined by two conditions:

- Maximum multilayer temperature ≤ 120 °C. (UL 130 °C print material is used: Power-One designs use normally 10 K safety margin).
- Maximum opto-coupler temperature ≤ 100 °C. (Device limits, otherwise accelerated aging)

If the base plate temperature stays below 100 °C, both of the above limits are kept under all operating and cooling conditions.

The maximum base plate temperature is limited by the temperature protection, but should be verified after system integration. T_{BP} can be measured on the temperature measuring point on the base plate. See mechanical drawing for location.

Thermal Resistance

To operate the converters below the maximum base plate temperature, sufficient cooling should be provided. The modules can be cooled by conduction, convection and radiation to the surrounding environment.

The path for the heat transport can be described with a ***thermal resistance***. A low thermal resistance allows a lot of heat or loss to flow from a hot component x to the surrounding y.

$$Rth_{xy} = (T_x - T_y) / P_{Loss} \quad [\mathrm{K/W}]$$

The thermal resistance between x and y is defined as temperature difference between the two parts, divided through the amount of loss flowing from the hot to the cool part (see report “Thermal performace of TXS” on the TXS product CD ROM for further information).

TXS provide two main ways for heat transport: Heat can be transported to the motherboard and to ambient.

Base Plate to Motherboard $Rth_{BP\text{-}PCB}$

TXS converters provide an efficient way to transport heat to the motherboard over the pins and the case. Since the efficiency of this method varies from design to design, it can’t be predicted. (See report: “TXS layout considerations”)

Base Plate to Ambient $Rth_{BP\text{-}A}$

TXS modules are designed for forced convection cooling. To estimate the thermal resistance at different airflows the following graph can be used:

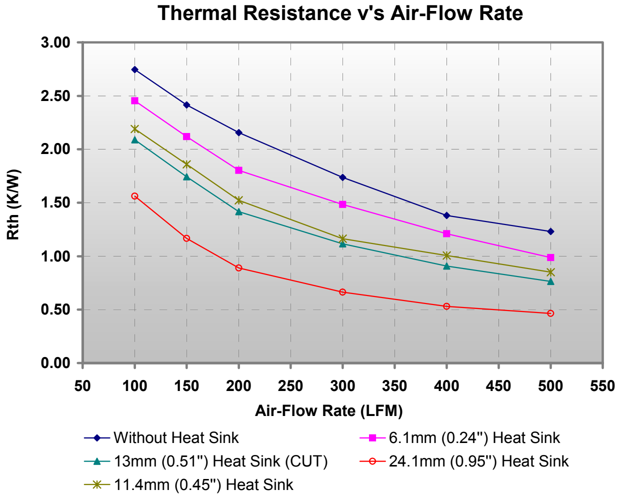


Figure 53: Thermal resistances at laminar airflow

TXS modules are designed to work without additional heat sink. But it is possible to attach an external heat sink to the base plate.
Heat sinks can efficiently help to increase the thermal safety margin or to increase the available power if the available airflow in a system is not sufficient.

Calculation of the Required Airflow

The thermal resistance $Rth_{BP\text{-}A}$ allows determining the required airflow or heat sink, for a given ambient temperature and operating condition.

1 The operating conditions define the loss of the converter: Loss figures for different output voltages, input voltage ranges, and output currents can be found on page 8. They should be corrected with the factors of Table 7 for the targeted base plate temperature.

2 The required thermal resistance for a given environment (T_{BP}, T_A) and loss can be calculated using the formula from above: $Rth_{BP\text{-}A} = (T_{BP} - T_A) / P_{Loss}$. To remember: The base plate temperature should not be

selected above 100 °C. It can be convenient to use a base plate temperature below 100 °C in order to optimise the expected lifetime.

3 The value of Rth_{BP-A} allows to determine the required airflow or heat sink using Figure 53.

Derating

A "Derating" is the reduction of the available output power at high ambient temperature. A derating keeps the maximum temperatures of the unit below safety critical limits.

To decide how much the converter can be loaded, some system parameters need to be known:

- Maximum ambient temperature and minimum airflow at the converter
- Height / space restrictions for an additional heat sink
- Layout situation (maximum current density, neighboring heat sources, shadowing effects, cooling to the board...)
- Supply voltage and maximum output current (average and peak)
- Least favorable input voltage
- Reliability target

TXS derating curves were defined for converters without heat sinks operating at constant base plate temperatures of 100 °C !

Derating Curves

The derating curves allow a first rough estimation if a design work. More detailed curves and explanations can be found in the report "thermal performance of TXS units" on the product CD ROM. A second report "Next generation TXS modules" shows preliminary data of optimised TXS modules.

The derating data in the figures 54 and 55 shows two bars for each airflow value. The first bar can be used for 48 V battery types, where the input voltage stays within 36 V to 60 V. The second bar should be used for 60 V battery types, where the continuous input voltage can be as high as 75 V.

At 75 V, TXS converters have increased loss compared to the 36 V to 60 V input range. Thus the maximum allowed ambient temperature for the full input range is reduced.

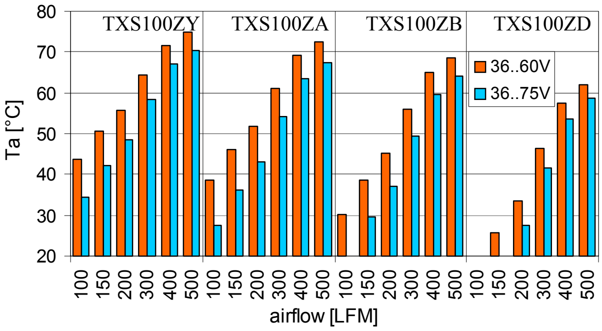


Figure 54: Maximum ambient temperature for different TXS models at different airflows at 100 A output current and T_{BP}=100 °C.

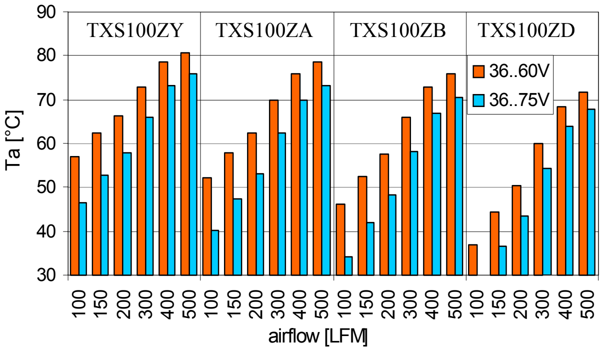


Figure 55: Maximum ambient temperature for different TXS models at different airflows at 80 A output current and T_{BP} = 100 °C

How to calculate the derating in situations where a converter should operate at a lower base plate temperature or when additional heat sinks can be used?

1 The thermal resistance for a given airflow and heat sink can be found in figure 53

2 The basic formula of the thermal resistance $Rth_{BP-A} = (T_{BP} - T_A) / P_{Loss}$ allows to determine the loss at this cooling condition: $P_{Loss} = (T_{BP} - T_A) / Rth_{BP-A}$

3 Normalise the loss figure to the operating ambient temperature using the correction factor of table 7. $P_{loss\ 25°C} = P_{loss\ TBP} / K$

4 With the loss value at 25°C it is possible to determine the maximum output current of the converter using the loss figures on page 8.

The converter itself does not set the derating as for example the output current limit. It is the responsibility of the end user to decide how much current/power can be drawn in his design or how much airflow is required, in order to ensure reliable operation in the field.

Calculator

Instead of using the graphs, the required airflow or the allowed output current can be calculated with a automated, easy to use tool on the TXS Product CD ROM. The tool uses interpolation between values and also gives a prediction of the expected life time for the chosen operating condition. 120A units are not jet included.

Important Reminder

> Calculations and graphs only give a rough guide to the required cooling. The specific card and rack design can vary a lot, which makes it almost impossible to predict the exact temperatures of a Brick.

> It is good practice to verify the thermal performance in worst case operating conditions with all obstructions in place at highest ambient temperature before the card design is finished.

Reliability

The reliability of TXS converters was verified using the MIL-HDBK and the Physics of failure approach.

Reliability Prediction

Reliability prediction is a calculation method, based on the analysis of component failure rates of a product or a system, with the target to predict the rate at which the product will fail. It also pinpoints areas for potential reliability improvements.

> A reliability prediction gives not an exact value for an individual module, but a statistical estimate for an equipment population in the field.

The basis of the analysis is a general reliability prediction model, which describes how the components react to electrical, thermal and mechanical stress.

There are several calculation models available:

- MIL-HDBK 217-F Notice 2
- Belcore TR-332
- PRISM
- CNET RDF

Alternatively to this standardised calculation methods, some companies use models based on experience, returns and field data. This makes it very difficult to compare reliability data from different manufacturers. Especially if models from the MIL-HDBK are used for components with good reliability data only, and "in house" models for all the others.

MIL HDBK 217F Notice 2

There is an ongoing discussion about the best suited method for reliability prediction.

The MIL-HDBK is the most elaborate, well documented and most widely used tool for predicting the component reliability. MIL models are better suited to describing the component loading in high density converters, than other models. Belcore models for example were developed for predicting the reliability of standard telecom equipment, working at much lower operating temperatures.

The problem with the MIL HDBK is, that the models are often based on old data, neglecting component improvements achieved in the market. This leads to pessimistic results. Bad prediction results, related design restrictions and resulting higher product costs were the main reasons why the US government recently cancelled the use of the MIL-HDBK 217 in army specifications.

For power supplies however there is no real alternative for predicting reliability in sight. Because it is easy to use and has models for all components included, the MIL-HDBK-217 is still the best method to get a quantitative measure of the reliability.

Physics of failure (PoF)

Because of the limitations of reliability prediction, PoF is used as a second tool for a qualitative measure of the reliability.

The Physics of failure approach defines a set of specific screening and stress tests to detect possible failure mechanism, to analyse the stress response of the modules and verify their safety margins.

The TXS CD ROM contains the results from a "Design Maturity" and a "Design Integrity" test as a part of the PoF analysis.

Background information about reliability prediction and detection methods, the assumptions for the calculation with the MIL HDBK and detailed results can be found in the "reliability report for TXS DC-DC Converters" on the TXS product CD ROM.

Layout Considerations

The layout for a TXS module has to be done carefully to minimise EMI effects and to avoid current crowding on the motherboard.

The application note "TXS layout considerations" on the TXS product CD ROM gives some general rules how to achieve a good layout. It explains how to work with 100A currents, how EMI is avoided, how signal wires should be routed and how the module should be positioned. It gives safety advice and describes the advantages of Bus Bars.

Screw fixing

To relieve the solder connections from mechanical stress, it is recommended that the modules be screwed to the motherboard. This is especially important, if an external heatsink is used.

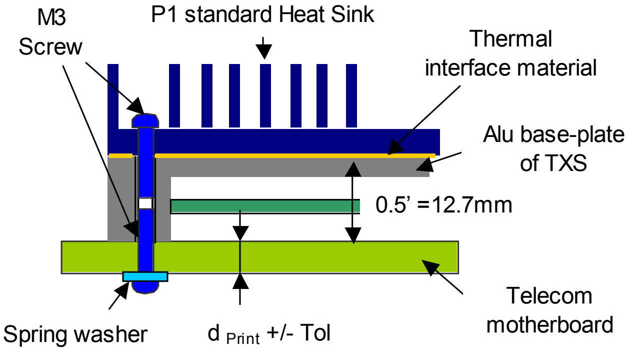


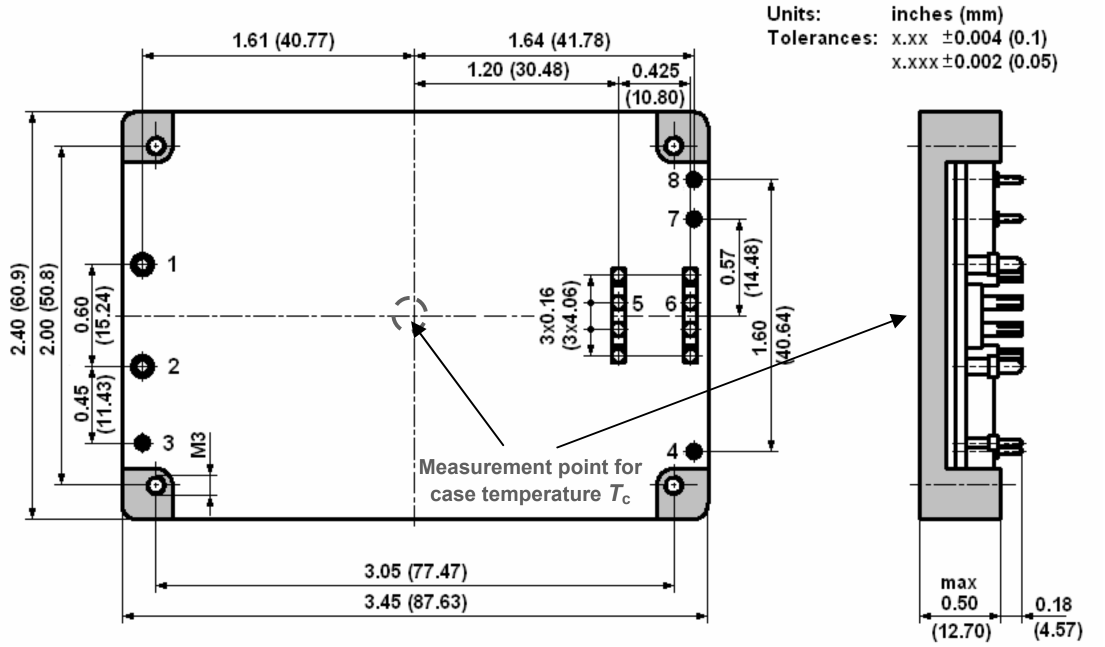
Figure 56: Screw fixing of the TXS converter

Care should be taken when selecting the screw lengths to mount the TXS on the motherboard and the heatsink on the TXS. The available thread length in the TXS case and the tolerances of the screws and the board should be considered.

The minimum insertion depth of the screw in the material should be 4.5 mm. It is recommend to use spring washers to compensate for changes in the motherboard thickness due to ageing and temperature variations.

Mechanical Drawings

Print mountable industry standard ¾ brick (2.4 x 3.45 x 0.5 inch^3)
Converter weight: 150 g; Aluminium case (base plate) with metal mounting posts.



Pin	Function	∅ inch (mm)
1	V_i-	0.08 ± 0.002 (2.03 ± 0.05)
2	V_i+	
3	ON/OFF	0.04 ± 0.002 (1.02 ± 0.05)
4	Sense+	
5	V_o-	4x 0.085 ± 0.002 (4x 2.16 ± 0.05)
6	V_o+	
7	Trim	0.04 ± 0.002 (1.02 ± 0.05)
8	Sense -	

Thermal Impedance (Base plate to ambient)	
100 LFM	2.75 K/W
200 LFM	2.16 K/W
300 LFM	1.74 K/W
400 LFM	1.38 K/W

Note: Thermal impedance data is dependent on many environmental factors. The exact thermal performance should be validated for each specific application. The figure is for a stand-alone module. The thermal impedance was measured with laminar airflow at 500 m over sea level.

Ordering Information

Available types, options and accessories: see tables on page 2. The sequence of options in the part number should be set according to their position in the option table, eg: - NP2R1H

TXS [output current] Z [Code Output voltage] — [Code Option(s)]

Example: TXS100ZB-NP2R1H
TXS with 1.8 V/100 A output, inverted logic shut down, long pins, wide trim and a 0.24” horizontal heat sink.

Notes

1. Power-One products are not authorized for use as critical components in life support systems, equipment used in hazardous environments, or nuclear control systems without the express written consent of the President of Power-One, Inc.
2. Specifications are subject to change without notice.