

- Up to 96% efficiency – No heat-sink required
- Pin compatible with LMxx linear regulators
- SIP-package fits existing TO-220 footprint
- Built in filter capacitors
- Operation temp. range -40°C to $+85^{\circ}\text{C}$
- Short circuit protection
- Wide input operating range
- Excellent line / load regulation
- Low standby current
- 3-year product warranty



The TSR 1 series step-down switching regulators are drop-in replacement for inefficient 78xx linear regulators. A high efficiency up to 96% allows full load operation up to $+60^{\circ}\text{C}$ ambient temperature without the need of any heat-sink or forced cooling. The TSR 1 switching regulators provide other significant features over linear regulators, i.e. better output accuracy ($\pm 2\%$), lower standby current of 2 mA and no requirement of external capacitors. The high efficiency and low standby power consumption makes these regulators an ideal solution for many battery powered applications.

Models

Order Code	Output Current max.	Input Voltage Range	Output Voltage nom.	Efficiency typ.
TSR 1-2412	1'000 mA	4.6 - 36 VDC (9 VDC nom.)	1.2 VDC	74 % (at V_{in} min.)
TSR 1-2415			1.5 VDC	78 % (at V_{in} min.)
TSR 1-2418			1.8 VDC	82 % (at V_{in} min.)
TSR 1-2425			2.5 VDC	87 % (at V_{in} min.)
TSR 1-2433			3.3 VDC	91 % (at V_{in} min.)
TSR 1-2450		6.5 - 36 VDC (12 VDC nom.)	5 VDC	94 % (at V_{in} min.)
TSR 1-2465		9 - 36 VDC (12 VDC nom.)	6.5 VDC	93 % (at V_{in} min.)
TSR 1-2490		12 - 36 VDC (24 VDC nom.)	9 VDC	95 % (at V_{in} min.)
TSR 1-24120		15 - 36 VDC (24 VDC nom.)	12 VDC	95 % (at V_{in} min.)
TSR 1-24150		18 - 36 VDC (24 VDC nom.)	15 VDC	96 % (at V_{in} min.)

Note - For input voltage higher than 32 VDC an external input capacitor 22 μF / 50 V is required.

Input Specifications

Input Current	- At no load	9 Vin models: 1 mA typ. 12 Vin models: 1 mA typ. 24 Vin models: 1 mA typ.
	- At full load	9 Vin models: 1'000 mA max. 12 Vin models: 1'000 mA max. 24 Vin models: 1'000 mA max. (at Vin min.)
Reflected Ripple Current		150 mAp-p typ.
Recommended Input Fuse	- 9 Vin input	1.2 Vout models: 630 mA (slow blow) 1.5 Vout models: 800 mA (slow blow) 1.8 Vout models: 800 mA (slow blow) 2.5 Vout models: 1'250 mA (slow blow) 3.3 Vout models: 1'250 mA (slow blow)
	- 12 Vin input	5 Vout models: 1'600 mA (slow blow)
	- 24 Vin input	6.5 Vout models: 1'250 mA (slow blow) 9 Vout models: 1'250 mA (slow blow) 12 Vout models: 1'600 mA (slow blow) 15 Vout models: 1'600 mA (slow blow)
		(The need of an external fuse has to be assessed in the final application.)
Input Filter		Internal Capacitor

Output Specifications

Voltage Set Accuracy		±2% max.
Regulation	- Input Variation (Vmin - Vmax)	0.2% max.
	- Load Variation (10 - 100%)	0.6% max. (1.2 & 1.5 Vout models)
		0.4% max. (other models)
Ripple and Noise (20 MHz Bandwidth)		9 Vin models: 50 mVp-p typ. 12 Vin models: 50 mVp-p typ. 24 Vin models: 75 mVp-p typ.
Capacitive Load		470 µF max.
Minimum Load		Not required
Temperature Coefficient		±0.015 %/K max.
Start-up Overshoot Voltage		1% max.
Short Circuit Protection		Continuous, Automatic recovery
Output Current Limitation		250% typ. of Iout max.
Transient Response	- Peak Variation	150 mV typ. / 200 mV max. (50% Load Step)
	- Response Time	250 µs typ. / 350 µs max. (50% Load Step)

Safety Specifications

Over Voltage Category	Not mains connected
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EMC Specifications

EMI (Emissions)	- Conducted Emissions	EN 55032 class A (with external filter)
	- Radiated Emissions	EN 55032 class A (with external filter)
	External filter proposal:	www.tracopower.com/tsr1-emc-filter

General Specifications

Relative Humidity		95% max. (non condensing)
Temperature Ranges	- Operating Temperature	-40°C to +85°C
	- Storage Temperature	-55°C to +125°C
Power Derating	- High Temperature	Depending on model
	See application note:	www.tracopower.com/tsr1-cc

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

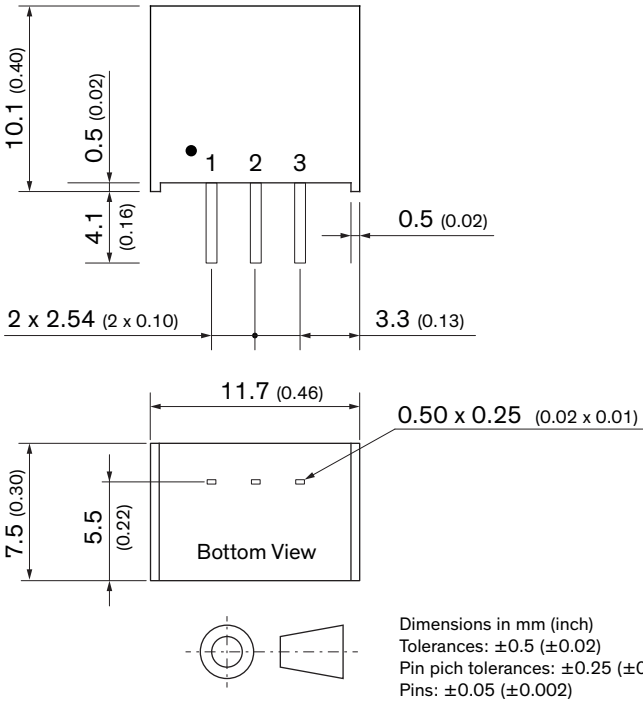
Over Temperature	- Protection Mode	150°C typ. (Automatic recovery)
Protection Switch Off	- Measurement Point	Internal IC temperature
Cooling System		Natural convection (20 LFM)
Regulator Topology		Buck Converter
Switching Frequency		400 - 600 kHz (PWM) 500 kHz typ. (PWM)
Insulation System		Non-isolated
Reliability	- Calculated MTBF	25'710'000 h (MIL-HDBK-217F, ground benign)
Washing Process		According to Cleaning Guideline www.tracopower.com/info/cleaning.pdf
Environment	- Vibration - Thermal Shock	MIL-STD-810F MIL-STD-810F
Housing Material		Non-conductive Plastic (UL 94 V-0 rated)
Potting Material		Silicone (UL 94 V-0 rated)
Pin Material		Copper
Pin Foundation Plating		Nickel (2 - 3 µm)
Pin Surface Plating		Tin (3 - 5 µm), matte
Housing Type		Plastic Case
Mounting Type		PCB Mount
Connection Type		THD (Through-Hole Device)
Footprint Type		SIP3
Soldering Profile		Lead-Free Wave Soldering 265°C / 10 s max.
Weight		1.9 g
Environmental Compliance	- REACH Declaration - RoHS Declaration - SCIP Reference Number	www.tracopower.com/info/reach-declaration.pdf REACH SVHC list compliant REACH Annex XVII compliant www.tracopower.com/info/rohs-declaration.pdf Exemptions: 7(a), 7(c)-I (RoHS exemptions refer to the component concentration only, not to the overall concentration in the product (O5A rule).) 9d15ed19-93d9-4ef5-b2ab-a4e3f77f58e2

Additional Information

Supporting Documents	www.tracopower.com/overview/tsr1
Frequently Asked Questions	www.tracopower.com/glossary-faq
Glossary	www.tracopower.com/info/glossary.pdf

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Outline Dimensions



Pinout	
Pin	Function
1	+Vin
2	GND
3	+Vout