

- 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  $-40^{\circ}\text{C}$  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 Vin min.)
TSR 1-2415			1.5 VDC	78 % (at Vin min.)
TSR 1-2418			1.8 VDC	82 % (at Vin min.)
TSR 1-2425			2.5 VDC	87 % (at Vin min.)
TSR 1-2433			3.3 VDC	91 % (at Vin min.)
TSR 1-2450		6.5 - 36 VDC (12 VDC nom.)	5 VDC	94 % (at Vin min.)
TSR 1-2465		9 - 36 VDC (12 VDC nom.)	6.5 VDC	93 % (at Vin min.)
TSR 1-2490		12 - 36 VDC (24 VDC nom.)	9 VDC	95 % (at Vin min.)
TSR 1-24120		15 - 36 VDC (24 VDC nom.)	12 VDC	95 % (at Vin min.)
TSR 1-24150		18 - 36 VDC (24 VDC nom.)	15 VDC	96 % (at Vin min.)

Note - For input voltage higher than 32 VDC an external input capacitor 22  $\mu\text{F}$  / 50 V is required.

### Input Specifications

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

### Output Specifications

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

### EMC Specifications

EMI (Emissions)	- Conducted Emissions	<b>EN 55032 class A</b> (with external filter)
	- Radiated Emissions	<b>EN 55032 class A</b> (with external filter)
	External filter proposal:	<a href="http://www.tracopower.com/overview/tsr1">www.tracopower.com/overview/tsr1</a>

### General Specifications

Relative Humidity		<b>95% max.</b> (non condensing)
Temperature Ranges	- Operating Temperature	<b>-40°C to +85°C</b>
	- Storage Temperature	<b>-55°C to +125°C</b>
Power Derating	- High Temperature	<b>2.4 %/K above 60°C</b>
		See application note: <a href="http://www.tracopower.com/overview/tsr1">www.tracopower.com/overview/tsr1</a>
Over Temperature	- Protection Mode	<b>150°C typ.</b> (Automatic recovery)
Protection Switch Off	- Measurement Point	<b>Internal IC temperature</b>
Cooling System		<b>Natural convection</b> (20 LFM)

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

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 <a href="http://www.tracopower.com/info/cleaning.pdf">www.tracopower.com/info/cleaning.pdf</a>
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	<a href="http://www.tracopower.com/info/reach-declaration.pdf">www.tracopower.com/info/reach-declaration.pdf</a> REACH SVHC list compliant REACH Annex XVII compliant
- RoHS Declaration	<a href="http://www.tracopower.com/info/rohs-declaration.pdf">www.tracopower.com/info/rohs-declaration.pdf</a> Exemptions: 7a, 7c-I (RoHS exemptions refer to the component concentration only, not to the overall concentration in the product (O5A rule))
- SCIP Reference Number	9d15ed19-93d9-4ef5-b2ab-a4e3f77f58e2

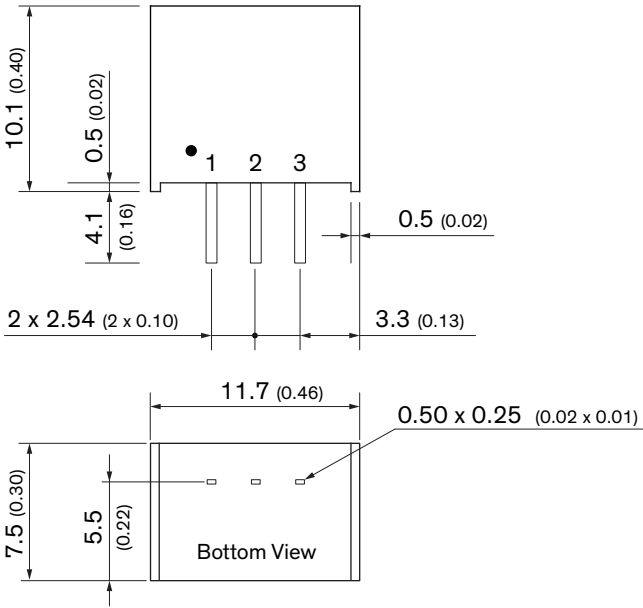
## Supporting Documents

Overview Link (for additional Documents)

[www.tracopower.com/overview/tsr1](http://www.tracopower.com/overview/tsr1)

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

**Outline Dimensions**



Dimensions in mm (inch)  
 Tolerances:  $\pm 0.5$  ( $\pm 0.02$ )  
 Pin pitch tolerances:  $\pm 0.25$  ( $\pm 0.01$ )  
 Pins:  $\pm 0.05$  ( $\pm 0.002$ )

Pinout	
Pin	Function
1	+Vin
2	GND
3	+Vout

# Mouser Electronics

Authorized Distributor

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[TSR 1-2415](#) [TSR 1-2465](#) [TSR 1-2433](#) [TSR 1-24120](#) [TSR 1-2450](#) [TSR 1-2490](#) [TSR 1-24150](#) [TSR 1-2412](#) [TSR 1-2418](#) [TSR 1-2425](#)