

- 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°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°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		4.75 - 36 VDC (9 VDC nom.)	5 VDC	94 % (at Vin min.)
TSR 1-2465		6.5 - 36 VDC (12 VDC nom.)	6.5 VDC	93 % (at Vin min.)
TSR 1-2490		9 - 36 VDC (12 VDC nom.)	9 VDC	95 % (at Vin min.)
TSR 1-24120		12 - 36 VDC (24 VDC nom.)	12 VDC	95 % (at Vin min.)
TSR 1-24150		15 - 36 VDC (24 VDC nom.)	15 VDC	96 % (at Vin min.)

Note - For input voltage higher than 32 VDC an external input capacitor 22  $\mu$ 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) 6.5 Vout models: <b>1'250 mA</b> (slow blow)
	- 24 Vin input	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

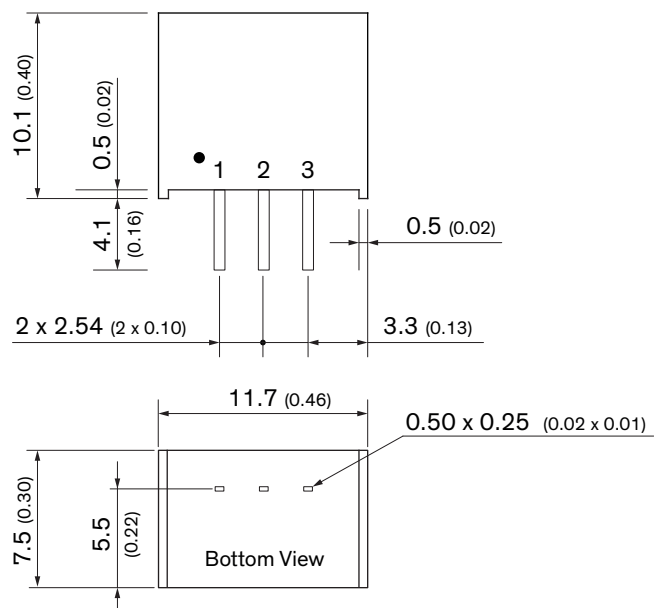
## Supporting Documents

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



### Pinout

Pin	Function
1	+Vin
2	GND
3	+Vout

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