# 500mA Ultra Low Dropout Voltage Regulator

## DESCRIPTION

TS2937 of fixed-voltage monolithic micro-power voltage regulators is designed for a wide range of applications. This device excellent choice of use in battery-power application. Furthermore, the quiescent current increases on slightly at dropout, which prolongs battery life. This series of fixed-voltage regulators features very low ground current (200uA Typ.) and very low drop output voltage (Typ. 60mV at light load and 600mV at 500mA). This includes a tight initial tolerance of 2%, extremely good line regulation of 0.05% typ., and very low output temperature coefficient.

## FEATURES

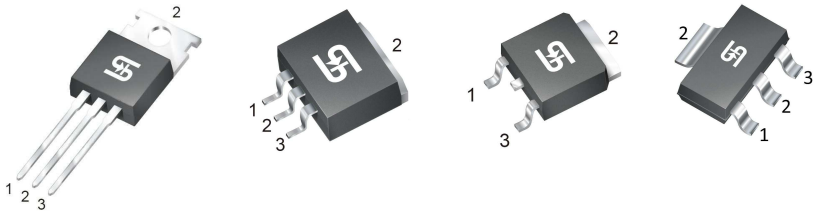
- Dropout voltage typically 0.6V @ Io=500mA
- Output voltage trimmed before assembly
- -18V Reverse peak voltage
- +30V Input over voltage protection
- +60V Transient peak voltage
- Internal current limit
- Thermal shutdown protection

## APPLICATION

- Post Regulator for SMPS
- Industrial Instrumentation

Pb-Free RoHS COMPLIANT HALOGEN FREE

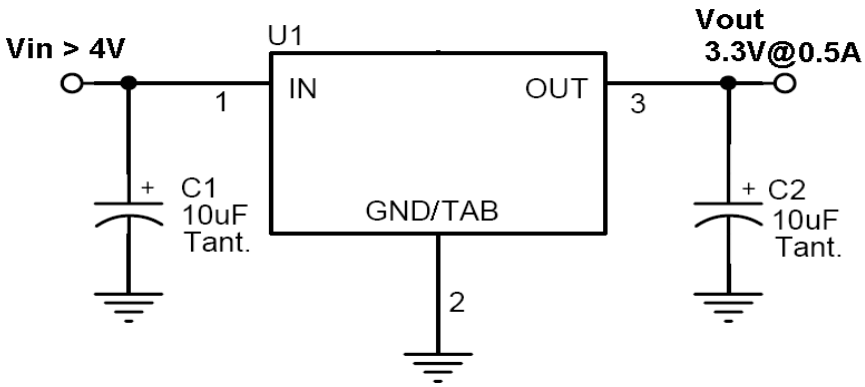
**TO-220** **TO-263 ($D^2PAK$)** **TO-252 (DPAK)** **SOT-223**



**Pin Definition:**
1. Input
2. Ground
3. Output

**Notes:** Moisture sensitivity level: level 3. Per J-STD-020

## TYPICAL APPLICATION CIRCUIT



## ABSOLUTE MAXIMUM RATINGS (Note 1)

| PARAMETER | SYMBOL | LIMIT | UNIT |
|---|---|---|---|
| Input Supply Voltage (Note 2) | $V_{IN}$ | -18 ~ +60 | V |
| Operation Input Supply Voltage | $V_{OPR}$ | 26 | V |
| Power Dissipation (Note 3) | $P_D$ | Internally Limited | W |
| Operating Junction Temperature Range | $T_J$ | -40 ~ +125 | °C |
| Storage Temperature Range | $T_{STG}$ | -65 ~ +150 | °C |

## THERMAL PERFORMANCE

| PARAMETER | SYMBOL | LIMIT | | | | UNIT |
|---|---|---|---|---|---|---|
| | | TO-220 | TO-263 | TO-252 | SOT-223 | |
| Junction to Ambient Thermal Resistance | $R_{\Theta JA}$ | 60 | 80 | 150 | 170 | °C/W |

**Notes:** $R_{\Theta JA}$ is the sum of the junction-to-case and case-to-ambient thermal resistances. The case thermal reference is defined at the solder mounting surface of the drain pins. $R_{\Theta JA}$ is guaranteed by design while $R_{\Theta CA}$ is determined by the user's board design. $R_{\Theta JA}$ shown below for single device operation on FR-4 PCB in still air.

## ELECTRICAL SPECIFICATIONS

($V_{IN}=V_{OUT}+1V$, $I_L=5mA$, $C_O=10uF$, $T_A=25^oC$, unless otherwise noted)

| PARAMETER | CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|
| Output Voltage | | 0.980\|Vo\| | 12 / 10 | 1.020\|Vo\| | V |
| | 5mA ≤ $I_L$ ≤ 500mA, Vo+1V ≤ $V_{IN}$≤ 26V | 0.970\|Vo\| | 5.0 / 3.3 | 1.030\|Vo\| | |
| Input Supply Voltage | | -- | -- | 26 | V |
| Output Voltage Temperature Coefficient | | -- | 50 | 150 | ppm/°C |
| Line Regulation | Vo+1V ≤ $V_{IN}$ ≤ 26V | -- | 0.05 | 0.5 | % |
| Load Regulation | 5mA ≤ $I_L$ ≤ 500mA | -- | 0.2 | 1.0 | % |
| Dropout Voltage (Note 4) | $I_L$=100mA | -- | 100 | 300 | mV |
| | $I_L$=300mA | -- | 400 | 500 | |
| | $I_L$=500mA | -- | 600 | 700 | |
| Quiescent Current (Note 5) | $I_L$=100μA | -- | 200 | -- | μA |
| | $I_L$=300mA | -- | 12 | -- | mA |
| | $I_L$=500mA | -- | 25 | -- | |
| Short Circuit Current (Note 6) | $V_{OUT}$ =0 | -- | -- | 1.3 | A |
| Output Noise, 10Hz to 100KHz, $I_L$=10mA | $C_L$=2.2μF | -- | 500 | -- | μVrms |
| | $C_L$=3.3μF | -- | 350 | -- | |
| | $C_L$=33μF | -- | 120 | -- | |

## ELECTRICAL SPECIFICATIONS

**Note:**

1. Absolute Maximum Rating is limits beyond which damage to the device may occur. For guaranteed specifications and test conditions see the electrical characteristics.
2. Maximum positive supply voltage of 60V must be limited duration (<100ms) and duty cycle (<1%).
3. The maximum allowable power dissipation is a function of the maximum junction temperature, $T_J$, the junction to ambient thermal resistance, $R_{\Theta JA}$, and the ambient temperature, Ta. Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. The effective value of $R_{\Theta JA}$ can be reduced by using a heatsink.
4. Dropout voltage is defined as the input to output differential at which the output voltage drops 2% below its nominal value measured at 1V differential.
5. Ground pin current is the regulator quiescent current. The total current drawn from the source is the sum of the ground pin current and output load current.
6. Output current will decrease with increasing temperature, but it will be not dropped below 500mA at the maximum specified temperature.

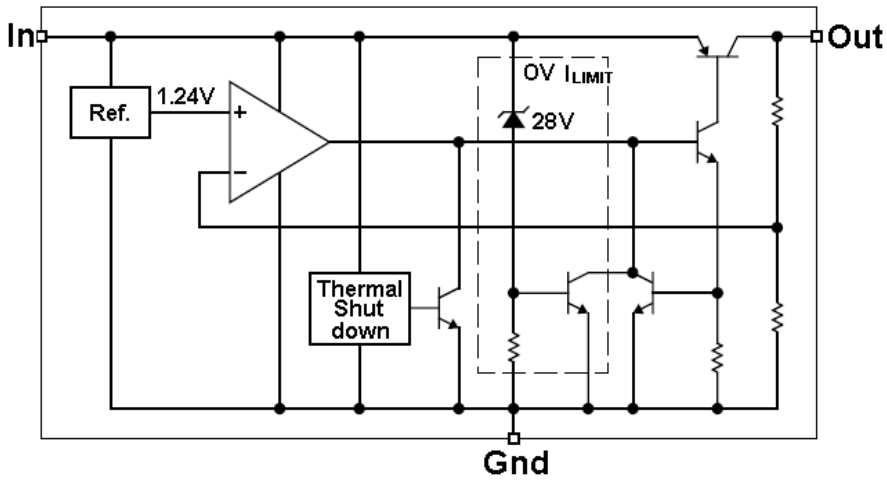
## ORDERING INFORMATION

| VOLTAGE | PART NO. | PACKAGE | PACKING |
|---|---|---|---|
| 5.0V | TS2937CZ50 C0G | TO-220 | 50pcs / Tube |
| 5.0V | TS2937CM50 RNG | TO-263 | 800pcs / 13” Reel |
| 5.0V | TS2937CP50 ROG | TO-252 | 2,500pcs / 13” Reel |
| 5.0V | TS2937CW50 RPG | SOT-223 | 2,500pcs / 13” Reel |
| 3.3V | TS2937CZ33 C0G | TO-220 | 50pcs / Tube |
| 3.3V | TS2937CM33 RNG | TO-263 | 800pcs / 13” Reel |
| 3.3V | TS2937CP33 ROG | TO-252 | 2,500pcs / 13” Reel |
| 3.3V | TS2937CW33 RPG | SOT-223 | 2,500pcs / 13” Reel |

**Note:**

1. Compliant to RoHS Directive 2011/65/EU and in accordance to WEEE 2002/96/EC.
2. Halogen-free according to IEC 61249-2-21 definition.

## BLOCK DIAGRAM




## APPLICATION INFORMATION

The TS2937 series is a high performance with low dropout voltage regulator suitable for moderate to high current and voltage regulator application. Its 600mV(typ.) dropout voltage at full load and over temperature makes it especially valuable in battery power systems and as high efficiency noise filters in post regulator applications. Unlike normal NPN transistor design, where the base to emitter voltage drop and collector to emitter saturation voltage limit the minimum dropout voltage, dropout performance of the PNP output of these devices is limited only by low $V_{CE}$ saturation voltage.

The TS2937 series is fully protected from damage due to fault conditions. Linear current limiting is provided. Output current during overload conditions is constant. Thermal shutdown the device when the die temperature exceeds the maximum safe operating temperature. Transient protection allows device survival even when the input voltage spikes above and below nominal. The output structure of these regulators allows voltages in excess of the desired output voltage to be applied without reverse current flow.

### Output Capacitor

The TS2937 series requires an output capacitor to maintain stability and improve transient response. Proper capacitor selection is important to ensure proper operation. The output capacitor selection is dependent upon the ESR of the output capacitor the maintain stability. When the output capacitor is 10uF or greater, the output capacitor should have an ESR less than 2 ohm. This will improve transient response as well as promoted stability. Ultra low ESR capacitors (<100mohm), such as ceramic chip capacitors may promote instability. These very low ESR levels may cause an oscillation and/or under damped transient response. A low ESR solid tantalum capacitor works extremely well and provides good transient response and stability over temperature. Aluminum electrolytic can also be used, as long as the ESR of the capacitor is <2ohm. The value of the output capacitor can be increased without limit. Higher capacitance values help to improved transient response and ripple rejection and reduce output noise.

### Minimum Load Current

The TS2937 series is specified between finite loads. If the output current is too small leakage currents dominate and the output voltage rises. A 1mA minimum load current is necessary for proper regulation.

### Input Capacitor

An input capacitor of 1uF or greater is recommended when the device is more that 4 inches away from the bulk AC supply capacitance or when the supply is a battery. Small and surface mount ceramic chip capacitors can be used for bypassing. Larger values will help to improve ripple rejection by bypassing the input to the regulator, further improving the integrity of the output voltage.

## APPLICATION INFORMATION (CONTINUED)

### Thermal Characteristics

A heatsink may be required depending on the maximum power dissipation and maximum ambient temperature of the application. Under all possible operating conditions, the junction temperature must be within the range specified under absolute maximum ratings. To determine if the heatsink is required, the power dissipated by the regulator, $P_D$ must be calculated.

The below formula shows the voltages and currents for calculating the $P_D$ in the regulator:

IIN = IL / IG

$P_D = (V_{IN}-V_{OUT}) * I_L + (V_{IN}) * I_G$

Ex. $P_D$ = (3.3V-2.5V) * 0.5A + 3.3V * 11mA

= 400mW + 36mW

= 436mW

Remark: $I_L$ is output load current,

$I_G$ is ground current.

$V_{IN}$ is input voltage

$V_{OUT}$ is output voltage

The next parameter which must be calculated is the maximum allowable temperature rise.

TR(max) is calculated by the using to formula:

TR(max) = TJ(max) – TA(max)

Where: TJ(max) is the maximum allowable junction temperature, which is 125°C for commercial grade parts. $T_A$(max) is the maximum ambient temperature which will be encountered in the application.

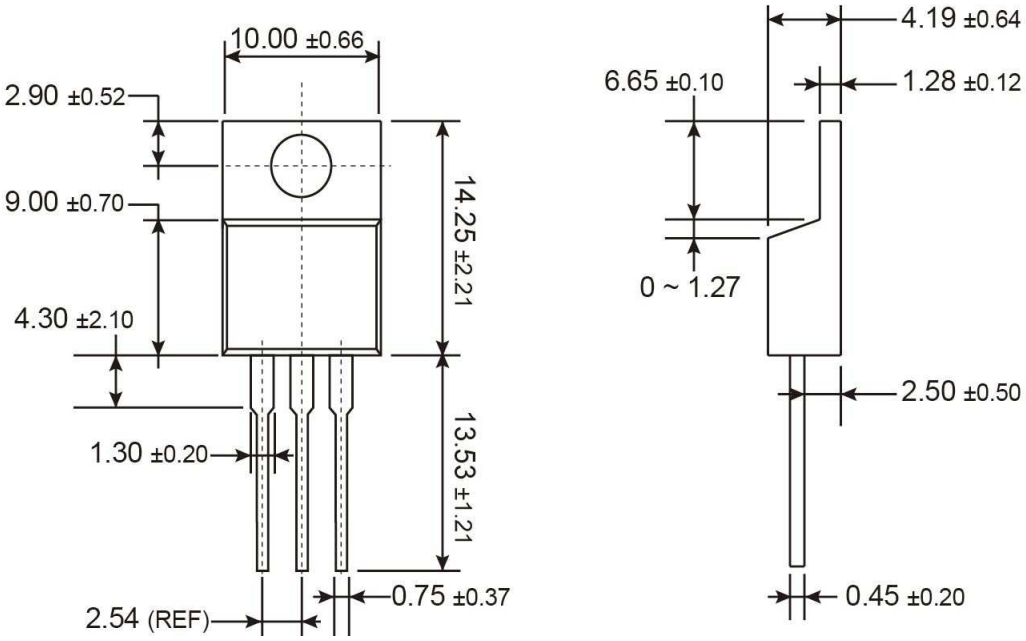
Using the calculated values for TR(max) and PD, the maximum allowable value for the junction to ambient thermal resistance, $\theta_{JA}$, can now be found:

$\theta_{JA}$ = TR(max) / PD

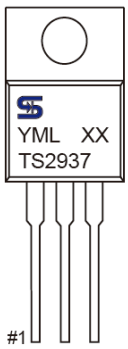
IMPORTANT: if the maximum allowable value for is found to be ≥6 °C /W for the TO-220 package, ≥80°C/W for the TO-263 package, ≥150°C/W for the TO-252 package, or ≥170°C /W for the SOT-223 package, no heatsink is needed since the package alone will dissipate enough heat to satisfy these requirements. If the calculated value for $\theta_{JA}$ falls below these limits, a heatsink is required.

## PACKAGE OUTLINE DIMENSIONS (Unit: Millimeters)

**TO-220**



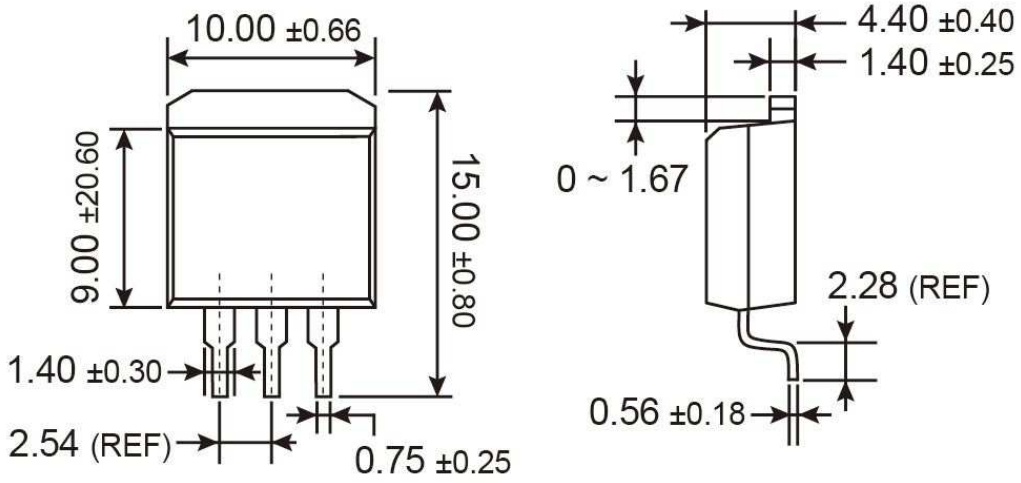

## MARKING DIAGRAM



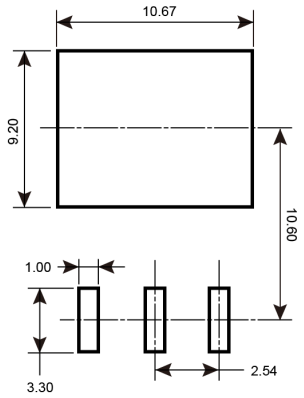

**XX** = Voltage Code ( **50**=5.0V, **33**=3.3V )
**33** =3.3V **50** =5.0V
**Y** = Year Code
**M** = Month Code for Halogen Free Product
**O** =Jan **P** =Feb **Q** =Mar **R** =Apr
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**L** = Lot Code

## PACKAGE OUTLINE DIMENSIONS (Unit: Millimeters)

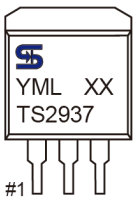
**TO-263**




## SUGGESTED PAD LAYOUT (Unit: Millimeters)




## MARKING DIAGRAM



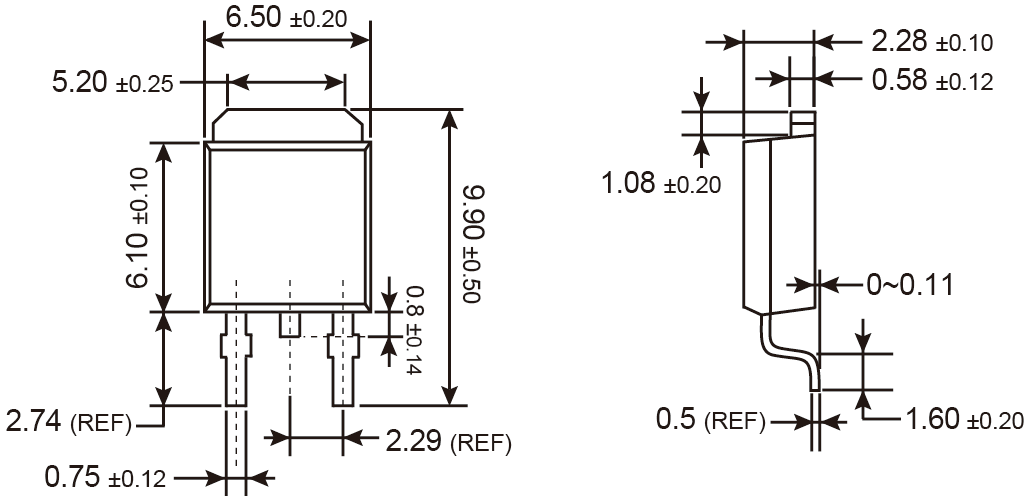

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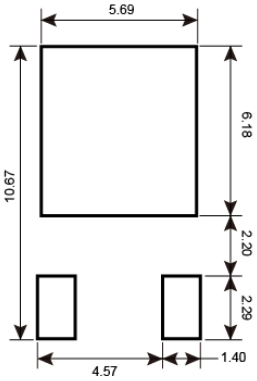
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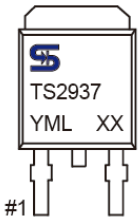
**TO-252**




## SUGGESTED PAD LAYOUT (Unit: Millimeters)




## MARKING DIAGRAM



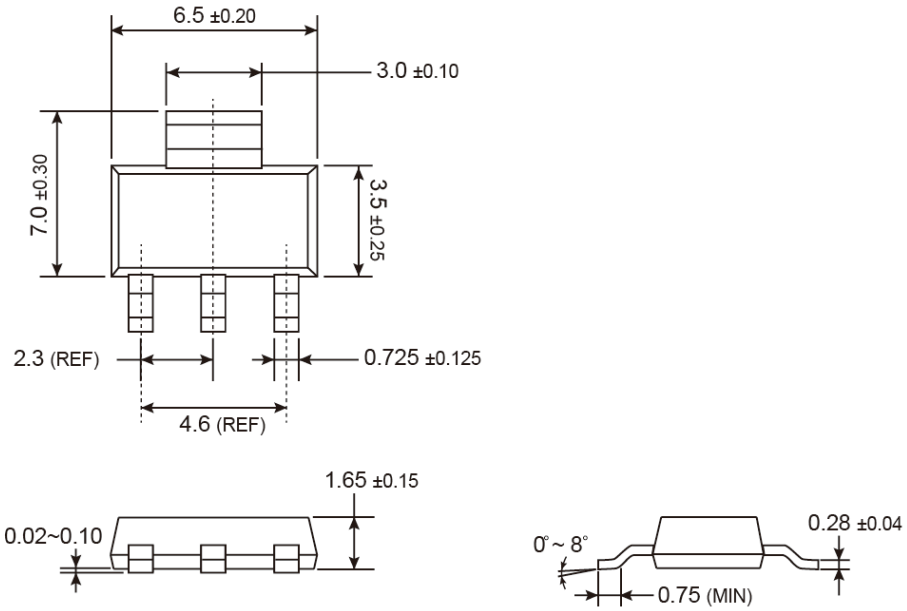

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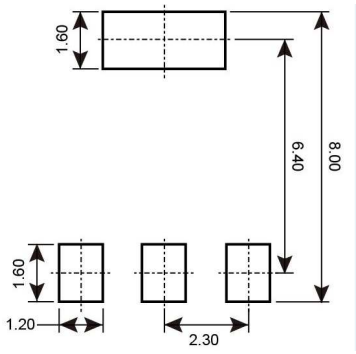
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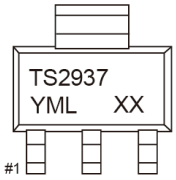
**SOT-223**




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