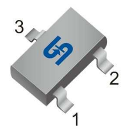
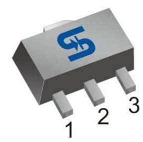
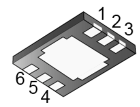
# TS5204

150mA Low Noise LDO Voltage Regulator

| SOT-23 | Pin Definition: | SOT-89 | Pin Definition: | DFN 2x2 | Pin Definition: |
|---|---|---|---|---|---|
|  | 1. Output<br>2. Input<br>3. Ground |  | 1. Output<br>2. Ground<br>3. Input |  | 1. Out<br>2. N/C<br>3. Ground<br>4. N/C<br>5. N/C<br>6. Input |

## General Description

The TS5204 series is an efficient linear voltage regulator with ultra low noise output, very low dropout voltage (typically 20mV at light loads and 500mV at 150mA at 5V version), and very low power consumption (600uA at 100mA), providing high output current even when the application requires very low dropout voltage. The TS5204 series is included a precision voltage reference, error correction circuit, a current limited output driver, over temperature shutdown and revered battery protection.

## Features

- Ultra Low Noise Output
- Output Current up to 150mA
- Low Dropout Voltage
- Low Power Consumption
- Internal Current Limit
- Thermal Shutdown Protection

## Ordering Information

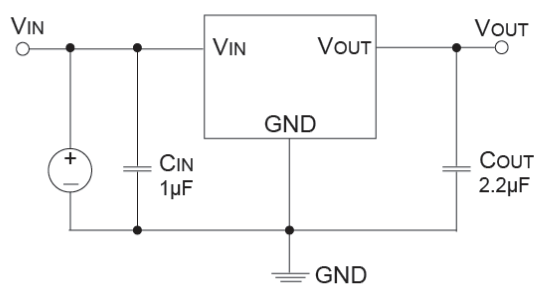
| Part No. | Package | Packing |
|---|---|---|
| TS5204CX**xx** RF | SOT-23 | 3Kpcs / 7" Reel |
| TS5204CY**xx** RF | SOT-89 | 1Kpcs / 7" Reel |
| TS5204CQ**xx** RF | DFN 2x2 | 3Kpcs / 7" Reel |

Note: Where **xx** denotes voltage option, available are **50**=5.0V, **33**=3.3V

## Application

- Cellular Telephones
- Palmtops, Notebook Computers
- Battery Powered Equipment
- Consumer and Personal Electronics
- SMPS Post Regulator and DC to DC Modules
- High-efficiency Linear Power Supplies
- Portable Application

## Typical Application Circuit




## Absolute Maximum Rating (Note 1)

| Parameter | | Symbol | Limit | Unit |
|---|---|---|---|---|
| Input Supply Voltage | | $V_{IN}$ | -20~ +20 | V |
| Recommend Input Supply Voltage | | $V_{IN}$ | +2.5 ~ +16 | V |
| Power Dissipation (Note 2) | | $P_D$ | Internal limited | |
| Thermal Resistance | SOT-23 | $\Theta_{JA}$ | 220 | $^oC/W$ |
| | SOT-89 | | 180 | |
| | DFN 2x2 | | 80 | |
| Operating Junction Temperature Range | | $T_J$ | -40 ~ +125 | $^oC$ |
| Storage Temperature Range | | $T_{STG}$ | -65 ~ +150 | $^oC$ |

**Electrical Specification** ($V_{IN}$=Vo+1V, Io=100uA, $C_{OUT}$=1uF, Vce≥2V, $T_J$ =25°C, unless otherwise specified.)

| Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Output Voltage | $V_{IN}$=Vo + 1V | 0.97\|Vo\| | $V_{OUT}$ | 1.03\|Vo\| | V |
| | $V_{IN}$=Vo + 1V, Io= 120mA | 0.96\|Vo\| | | 1.04\|Vo\| | |
| Output Voltage Temp. Coefficient | (Note 4) | -- | 50 | -- | ppm/ °C |
| Line Regulation | Vo+1V ≤ $V_{IN}$ ≤ 16V | -- | 0.1 | 0.5 | % |
| Load Regulation (Note 5) | 0.1mA ≤ Io ≤ 120mA | -- | 1 | 2 | % |
| Dropout Voltage (Note 6) | Io=100uA | -- | 20 | -- | mV |
| | Io=50mA | -- | 250 | 300 | |
| | Io=120mA | -- | 350 | 400 | |
| | Io=150mA (5V version) | -- | 450 | 500 | |
| Ground Pin Current (Note 7) | Io=100uA | -- | 110 | 150 | uA |
| | Io=50mA | -- | 500 | 1000 | |
| | Io=120mA | -- | 2600 | 3100 | |
| | Io=150mA (5V version) | -- | 3500 | 4200 | |
| Output Current Limit | $V_{OUT}$=0V | -- | 200 | -- | mA |
| Power Supply Rejection Ratio | At f=100Hz, Io=100uA, | -- | 65 | -- | dB |
| Thermal Regulation (Note 8) | | -- | 0.05 | -- | %/W |
| Output Noise | Io=50mA, $C_{OUT}$ =2.2uF, | -- | 260 | -- | nV√Hz |

**Note:**

1. Exceeding the absolute maximum rating may damage the device.
2. The maximum allowable power dissipation at any Ta is Pd(max) = [$T_{J(MAX)}$ - Ta] + $\Theta_{JA}$. Exceeding the maximum allowable power dissipation will result in excessive die temperature, and the regulator will go into thermal shutdown.
3. The device is not guaranteed to function outside its operating rating.
4: Output voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.
5: Regulation is measured at constant junction temperature using low duty cycle pulse testing. Parts are tested for load regulation in the load range from 1mA to 150mA (5V version) and 1mA to 120mA ($V_{OUT}$ <5V version). Changes in output voltage due to heating effects are covered by the thermal regulation specification.
6: 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.
7: Ground pin current is the regulator quiescent current plus pass transistor base current. The total current drawn from the supply is the sum of the load current plus the ground pin current.
8: Thermal regulation is defined as the change in output voltage at a time "t" after a change in power dissipation is applied, excluding load or line regulation effects. Specifications are for a 150mA load pulse at $V_{IN}$ =16V for t=10mS.

## Application Information

TS5204 series is designed to provide 150mA (5V version) of continuous current in a very small package. Maximum power dissipation can be calculated based on the output current and the voltage drop across the part. To determine the maximum power dissipation of the package, use the junction-ambient thermal resistance of the device and the following basic equation:

$$P_{D(MAX)} = [\ T_{J(MAX)} - T_A\ ] / \Theta_{JA}$$

Tj(max) is the maximum junction temperature of the die(125°C), and Ta is the ambient operating temperature. $\Theta_{JA}$ is layout dependent, the actual power dissipation of the regulator circuit can be determined using the equation:

$$P_D = (V_{IN} - V_{OUT}) * I_{OUT} + V_{IN} * I_{GND}$$

Substituting Pd(max) for Pd and solving for the operating conditions that are critical to the application will give the maximum operating conditions for the regulator circuit. For example, when operating the TS5204CX33 at room temperature with a minimum footprint layout, the maximum input voltage for a set output current can be determined as follows:

$$P_{D(MAX)} = (125^oC - 25^oC) / 220^oC/W$$

The junction to ambient thermal resistance for the minimum footprint is 220°C/W, the maximum power dissipation must not be exceeded for proper operation. Using the output voltage of 3.3V and an output current of 120mA, the maximum input voltage can be determined. From the electrical characteristics table, the maximum ground current for 120mA output current is 2.5mA.

$$445mW = (V_{IN} - 3.3V) * 120mA + V_{IN} * 2.5mA$$
$$445mW = V_{IN} * 120mA - 3.3 * 120mA + V_{IN} * 2.5mA$$
$$445mW = V_{IN} * 120mA - 395mW + V_{IN} * 2.5mA$$
$$840mW = V_{IN} * 122.5mA$$
$$V_{IN}\ (max) = 6.85V$$

Therefore, a 3.3V application at 120mA of output current can accept a maximum input voltage of 6.85V in a SOT-23 package.

### Input Capacitor Requirement

An input capacitor of 0.1uF or greater is recommended when the device is more than 10” away from the bulk AC supply capacitance or when the supply is a battery.

### Output Capacitor Requirement

The TS5204 series requires an output capacitor to maintain stability and improve transient response is necessary. 2.2uF minimum is recommended. Larger values improve the regulator’s transient response. The output capacitor value may be increased without limit.

The output capacitor should have an ESR (effective series resistance) less than 5Ω and a resonant frequency above 1MHz. Ultra low ESR capacitors can cause a low amplitude oscillation on the output and/or under damped transient response. Most of tantalum or aluminum electrolytic capacitors are adequate; film types will work. Since many aluminum electrolytic have electrolytes that freeze at about –30°C, solid tantalums are recommended for operation below –25°C. At lower values of output current, less output capacitance is required for output stability. The capacitor can be reduced to 0.47uF for current below 10mA or 0.33uF for currents below 1mA.

### No Load Stability

The TS5204 series will remain stable and in regulation with no load, unlike many other voltage regulators. This is especially important in CMOS RAM keep alive applications.

### Dual Supply Operation

When used in dual supply systems where the regulator load is returned to a negative supply, the output voltage must be diode clamped to ground.

## Electrical Characteristics Curve

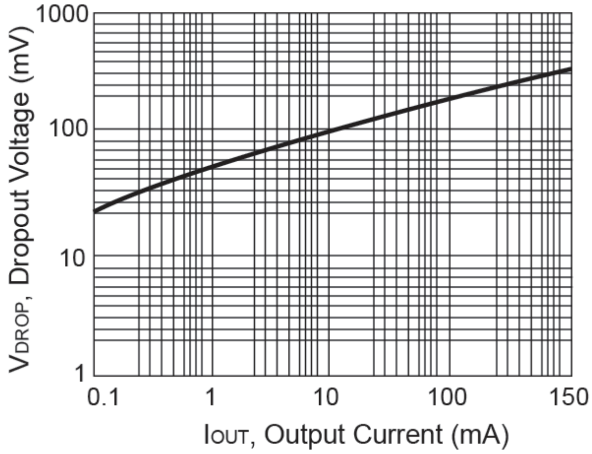



**Figure 1. Dropout Voltage vs. Output Current**

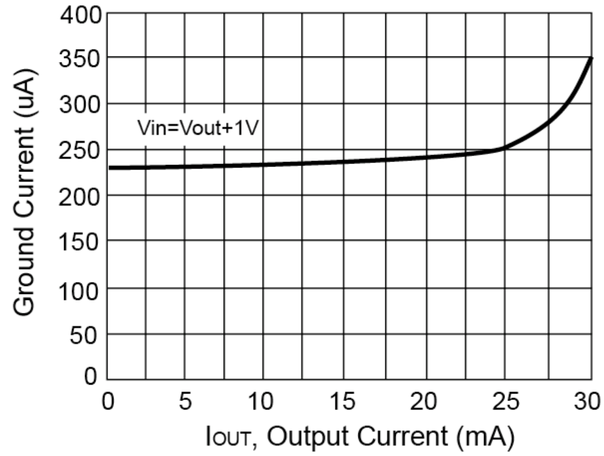



**Figure 2. Ground Current vs. Output Current**

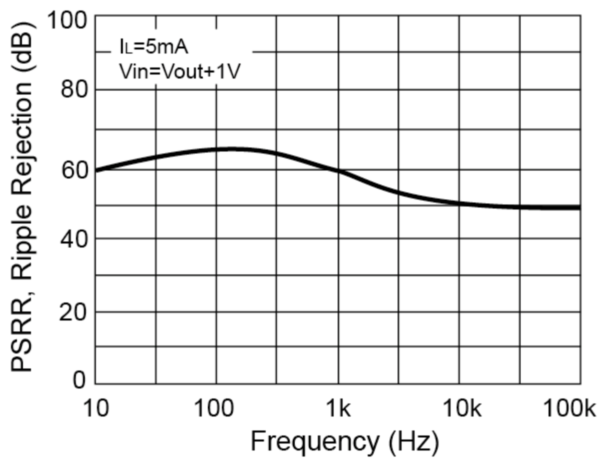



**Figure 3. Dropout Voltage vs. Output Current**

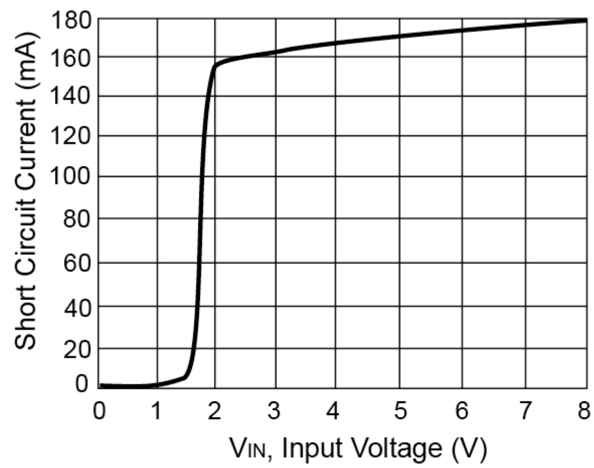
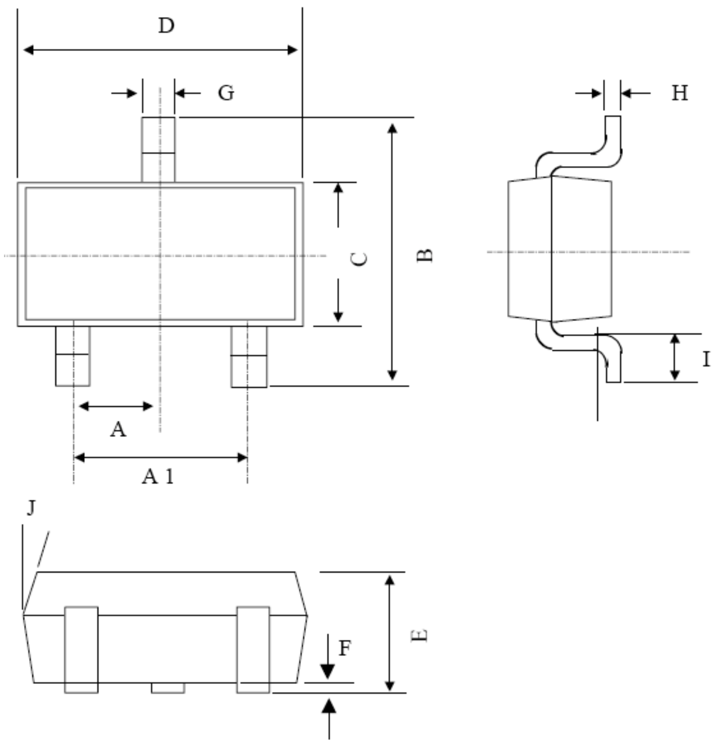


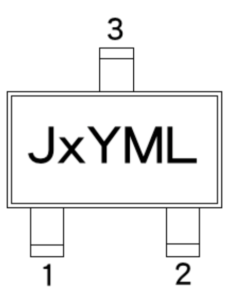

**Figure 4. Short Circuit Current vs. Input Voltage**

## SOT-23 Mechanical Drawing



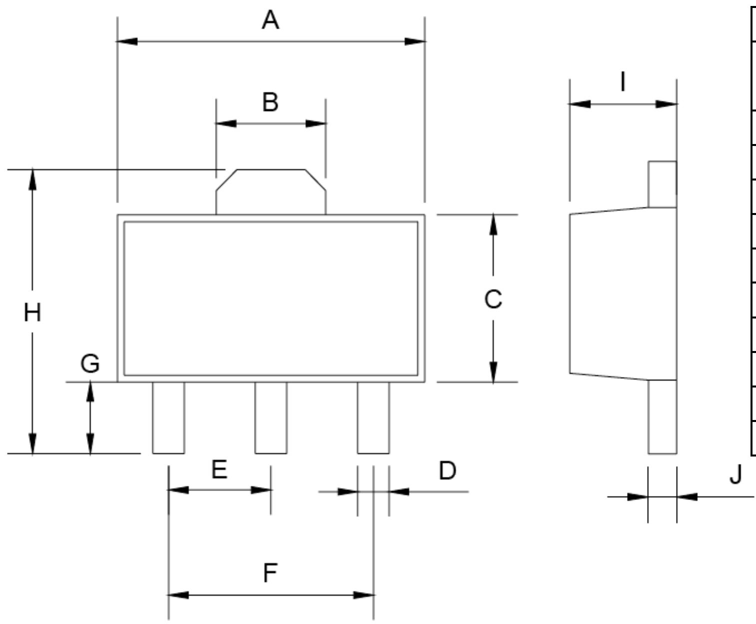

| SOT-23 DIMENSION | | | | |
|---|---|---|---|---|
| DIM | MILLIMETERS | | INCHES | |
| | MIN | MAX | MIN | MAX. |
| A | 0.95 BSC | | 0.037 BSC | |
| A1 | 1.9 BSC | | 0.074 BSC | |
| B | 2.60 | 3.00 | 0.102 | 0.118 |
| C | 1.40 | 1.70 | 0.055 | 0.067 |
| D | 2.80 | 3.10 | 0.110 | 0.122 |
| E | 1.00 | 1.30 | 0.039 | 0.051 |
| F | 0.00 | 0.10 | 0.000 | 0.004 |
| G | 0.35 | 0.50 | 0.014 | 0.020 |
| H | 0.10 | 0.20 | 0.004 | 0.008 |
| I | 0.30 | 0.60 | 0.012 | 0.024 |
| J | 5º | 10º | 5º | 10º |

## Marking Diagram



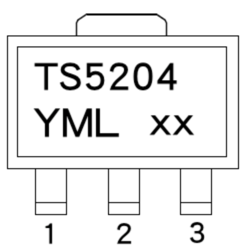

**J** = Device Code
**X** = Voltage Code
(**5** = 5.0V, **S** = 3.3V)
**Y** = Year Code
**M** = Month Code
(**A**=Jan, **B**=Feb, **C**=Mar, **D**=Apl, **E**=May, **F**=Jun, **G**=Jul, **H**=Aug, **I**=Sep, **J**=Oct, **K**=Nov, **L**=Dec)
**L** = Lot Code

## SOT-89 Mechanical Drawing




| SOT-89 DIMENSION | | | | |
|---|---|---|---|---|
| DIM | MILLIMETERS | | INCHES | |
| | MIN | MAX | MIN | MAX |
| A | 4.40 | 4.60 | 0.173 | 0.181 |
| B | 1.40 | 1.75 | 0.055 | 0.069 |
| C | 2.40 | 2.60 | 0.094 | 0.102 |
| D | 0.36 | 0.48 | 0.014 | 0.018 |
| E | 1.40 | 1.60 | 0.054 | 0.063 |
| F | 2.90 | 3.10 | 0.114 | 0.122 |
| G | 0.89 | 1.20 | 0.035 | 0.047 |
| H | -- | 4.25 | -- | 0.167 |
| I | 1.40 | 1.60 | 0.055 | 0.068 |
| J | 0.38 | 0.43 | 0.014 | 0.017 |

### Marking Diagram




**Y** = Year Code
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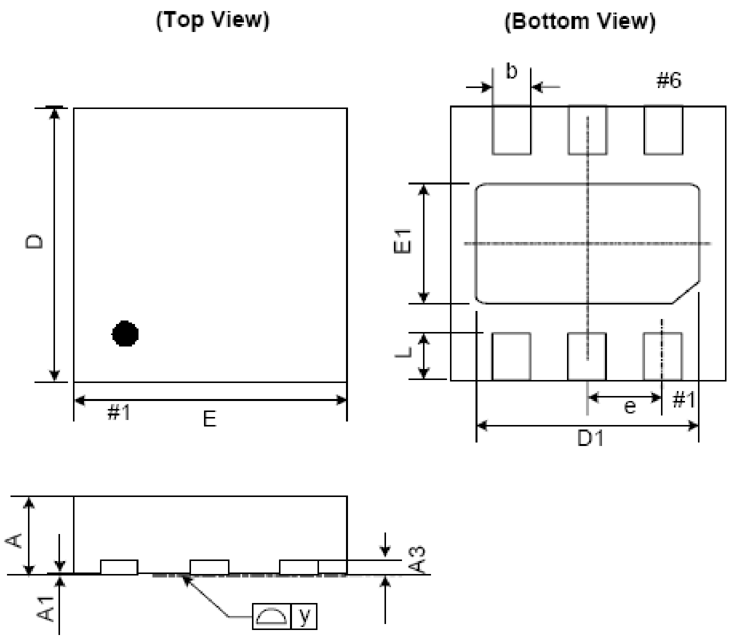
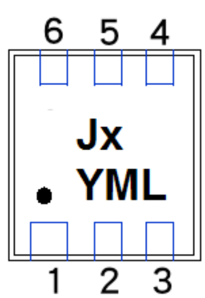
**L** = Lot Code
**XX** = Voltage
(**50** = 5.0V, **33** = 3.3V)

## DFN 2x2 Mechanical Drawing




| DFN 2x2 DIMENSION | | | | |
|---|---|---|---|---|
| DIM | MILLIMETERS | | INCHES | |
| | MIN | MAX | MIN | MAX |
| A | 0.45 | 0.55 | 0.017 | 0.021 |
| A1 | 0.005 (typ) | | 0.0002 (typ) | |
| A3 | 0.152 (typ) | | 0.006(typ) | |
| b | 0.20 | 0.40 | 0.008 | 0.016 |
| D | 1.90 | 2.10 | 0.075 | 0.083 |
| D1 | 1.80 (typ) | | 0.071 (typ) | |
| E | 1.9 | 2.1 | 0.075 | 0.083 |
| E1 | 1.00 (typ) | | 0.039 (typ) | |
| L | 0.25 (typ) | | 0.01 (typ) | |
| e | 0.50 (typ) | | 0.02 (typ) | |
| Y | -- | 0.10 | -- | 0.04 |

## Marking Diagram




**J** = Device Code
**X** = Fixed Output Voltage Code
(**5** =5.0V, **S** =3.3V)
**Y** = Year Code
**M** = Month Code
(**A**=Jan, **B**=Feb, **C**=Mar, **D**=Apl, **E**=May, **F**=Jun, **G**=Jul, **H**=Aug, **I**=Sep, **J**=Oct, **K**=Nov, **L**=Dec)
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