

SM74503 800mA Low-Dropout Linear Regulator

Check for Samples: [SM74503](#)

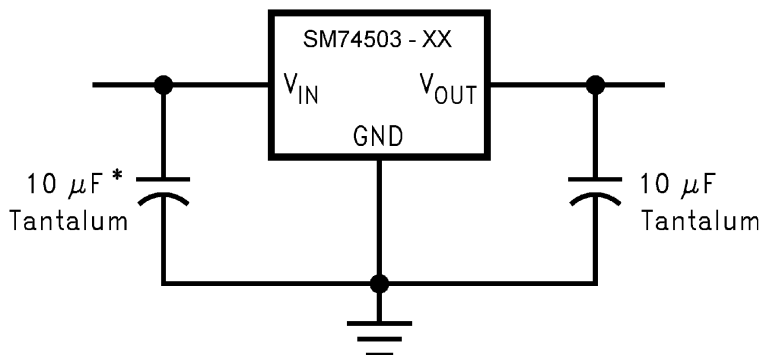
FEATURES

- Renewable Energy Grade
- Available in 3.3V and 5V Versions
- Space Saving SOT-223 Package
- Current Limiting and Thermal Protection
- Output Current 800mA
- Line Regulation 0.2% (Max)
- Load Regulation 0.4% (Max)
- Temperature Range -40°C to 125°C

APPLICATIONS

- Photovoltaic Electronics
- Post Regulator for Switching DC/DC Converter
- High Efficiency Linear Regulators
- Battery Charger
- Battery Powered Instrumentation

Typical Application



* Required if the regulator is located far from the power supply filter.

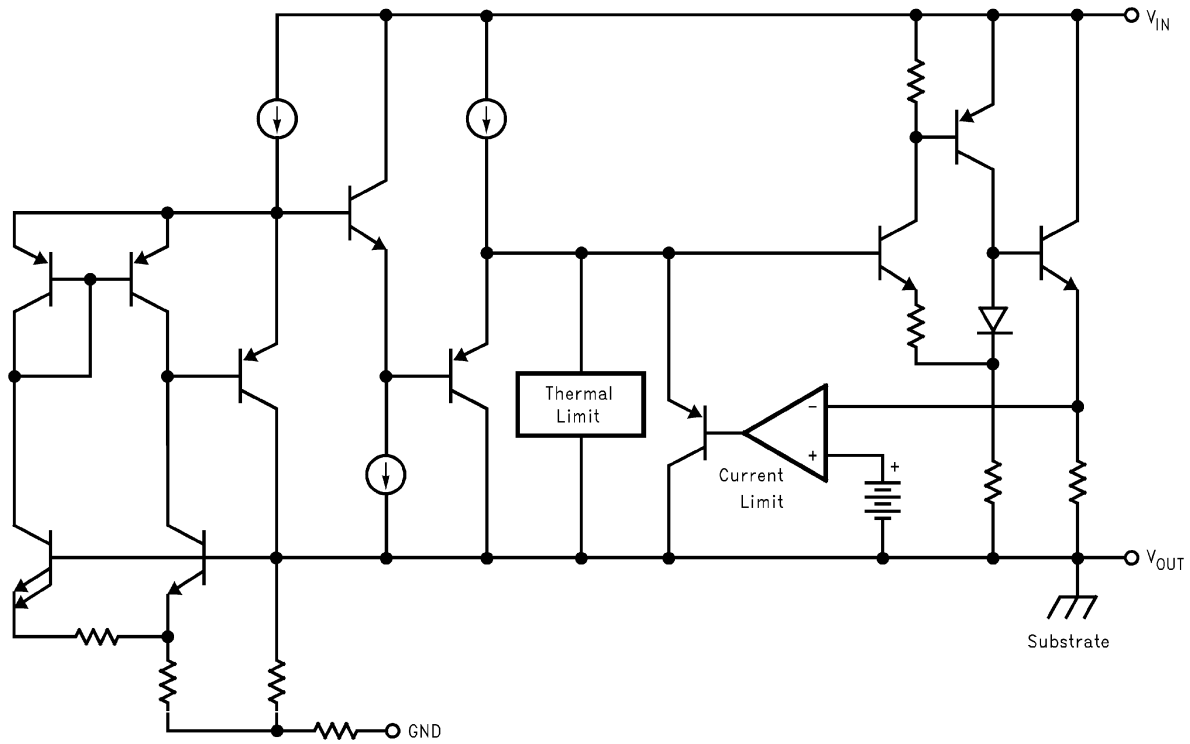
Figure 1. Fixed Output Regulator



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Block Diagram



Connection Diagram

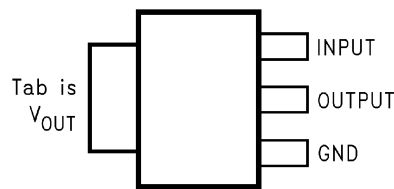


Figure 2. SOT-223 Top View

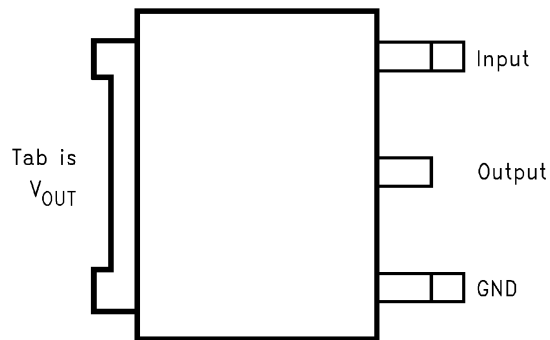


Figure 3. PFM Top View



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

Absolute Maximum Ratings⁽¹⁾⁽²⁾

| | |
|---|--------------------|
| Maximum Input Voltage (V_{IN} to GND) | 20V |
| Power Dissipation ⁽³⁾ | Internally Limited |
| Junction Temperature (T_J) ⁽³⁾ | 150°C |
| Storage Temperature Range | -65°C to 150°C |
| Lead Temperature | |
| SOT-223 Package | 260°C, 4 sec |
| ESD Tolerance ⁽⁴⁾ | 2000V |

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance. For specifications and the test conditions, see the Electrical Characteristics.
- (2) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.
- (3) The maximum power dissipation is a function of $T_{J(max)}$, θ_{JA} , and T_A . The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(max)} - T_A) / \theta_{JA}$. All numbers apply for packages soldered directly into a PC board.
- (4) For testing purposes, ESD was applied using human body model, 1.5k Ω in series with 100pF.

Operating Ratings⁽¹⁾

| | |
|---|----------------|
| Input Voltage (V_{IN} to GND) | 15V |
| Junction Temperature Range (T_J) ⁽²⁾ | |
| SM74503 | -40°C to 125°C |

- (1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance. For specifications and the test conditions, see the Electrical Characteristics.
- (2) The maximum power dissipation is a function of $T_{J(max)}$, θ_{JA} , and T_A . The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(max)} - T_A) / \theta_{JA}$. All numbers apply for packages soldered directly into a PC board.

SM74503 Electrical Characteristics

Typicals and limits appearing in normal type apply for $T_J = 25^\circ\text{C}$. Limits appearing in **Boldface** type apply over the entire junction temperature range for operation, -40°C to 125°C .

| Symbol | Parameter | Conditions | Min ⁽¹⁾ | Typ ⁽²⁾ | Max ⁽¹⁾ | Units |
|------------------|--------------------------------|---|--------------------|--------------------|--------------------|-------|
| V_{OUT} | Output Voltage | SM74503-3.3 $I_{OUT} = 10\text{mA}$, $V_{IN} = 5\text{V}$, $T_J = 25^\circ\text{C}$ $0 \leq I_{OUT} \leq 800\text{mA}$, $4.75\text{V} \leq V_{IN} \leq 10\text{V}$ | 3.267 | 3.300 | 3.333 | V |
| | | | 3.168 | 3.300 | 3.432 | V |
| | | SM74503-5.0 $I_{OUT} = 10\text{mA}$, $V_{IN} = 7\text{V}$, $T_J = 25^\circ\text{C}$ $0 \leq I_{OUT} \leq 800\text{mA}$, $6.5\text{V} \leq V_{IN} \leq 12\text{V}$ | 4.950 | 5.000 | 5.050 | V |
| | | | 4.800 | 5.000 | 5.200 | V |
| ΔV_{OUT} | Line Regulation ⁽³⁾ | SM74503-3.3 $I_{OUT} = 0\text{mA}$, $4.75\text{V} \leq V_{IN} \leq 15\text{V}$ | | 1 | 10 | mV |
| | | SM74503-5.0 $I_{OUT} = 0\text{mA}$, $6.5\text{V} \leq V_{IN} \leq 15\text{V}$ | | 1 | 15 | mV |
| ΔV_{OUT} | Load Regulation ⁽³⁾ | SM74503-3.3 $V_{IN} = 4.75\text{V}$, $0 \leq I_{OUT} \leq 800\text{mA}$ | | 1 | 15 | mV |
| | | SM74503-5.0 $V_{IN} = 6.5\text{V}$, $0 \leq I_{OUT} \leq 800\text{mA}$ | | 1 | 20 | mV |

- (1) All limits are guaranteed by testing or statistical analysis.
- (2) Typical Values represent the most likely parametric norm.
- (3) Load and line regulation are measured at constant junction room temperature.

SM74503 Electrical Characteristics (continued)

Typicals and limits appearing in normal type apply for $T_J = 25^\circ\text{C}$. Limits appearing in **Boldface** type apply over the entire junction temperature range for operation, -40°C to 125°C .

| Symbol | Parameter | Conditions | Min (1) | Typ (2) | Max (1) | Units |
|------------------|---|--|------------|------------|-------------|---------------------------|
| $V_{IN}-V_{OUT}$ | Dropout Voltage ⁽⁴⁾ | $I_{OUT} = 100\text{mA}$ | | 1.10 | 1.30 | V |
| | | $I_{OUT} = 500\text{mA}$ | | 1.15 | 1.35 | V |
| | | $I_{OUT} = 800\text{mA}$ | | 1.20 | 1.40 | V |
| I_{LIMIT} | Current Limit | $V_{IN}-V_{OUT} = 5\text{V}$, $T_J = 25^\circ\text{C}$ | 800 | 1200 | 1500 | mA |
| | Quiescent Current | SM74503-3.3 $V_{IN} \leq 15\text{V}$ | | 5 | 15 | mA |
| | | SM74503-5.0 $V_{IN} \leq 15\text{V}$ | | 5 | 15 | mA |
| | Thermal Regulation | $T_A = 25^\circ\text{C}$, 30ms Pulse | | 0.01 | 0.1 | %/W |
| | Ripple Regulation | $f_{RIPPLE} = 1\text{ 20Hz}$, $V_{IN}-V_{OUT} = 3\text{V}$ $V_{RIPPLE} = 1V_{PP}$ | 60 | 75 | | dB |
| | Temperature Stability | | | 0.5 | | % |
| | Long Term Stability | $T_A = 125^\circ\text{C}$, 1000Hrs | | 0.3 | | % |
| | RMS Output Noise | (% of V_{OUT}), $10\text{Hz} \leq f \leq 10\text{kHz}$ | | 0.003 | | % |
| | Thermal Resistance Junction-to-Case | 4-Lead SOT-223 | | 15.0 | | $^\circ\text{C}/\text{W}$ |
| | | 3-Lead PFM | | 10 | | $^\circ\text{C}/\text{W}$ |
| | Thermal Resistance Junction-to-Ambient No air flow) | 4-Lead SOT-223 (No heat sink) | | 136 | | $^\circ\text{C}/\text{W}$ |
| | | 3-Lead PFM (No heat sink) ⁽⁵⁾ | | 92 | | $^\circ\text{C}/\text{W}$ |

(4) The dropout voltage is the input/output differential at which the circuit ceases to regulate against further reduction in input voltage. It is measured when the output voltage has dropped 100mV from the nominal value obtained at $V_{IN} = V_{OUT} + 1.5\text{V}$.

(5) Minimum pad size of 0.038in^2

Typical Performance Characteristics

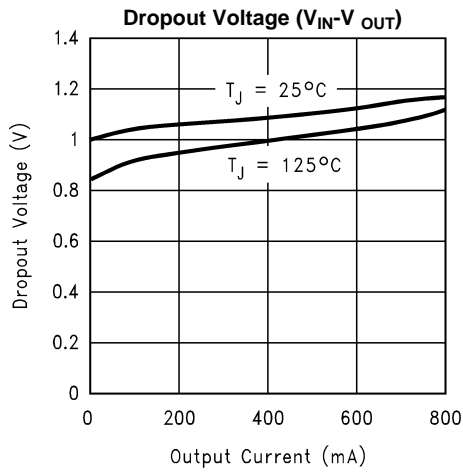


Figure 4.

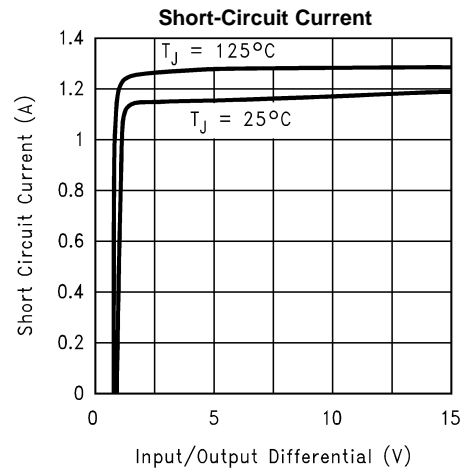


Figure 5.

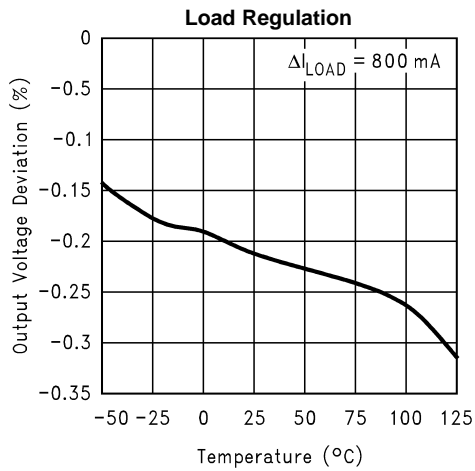


Figure 6.

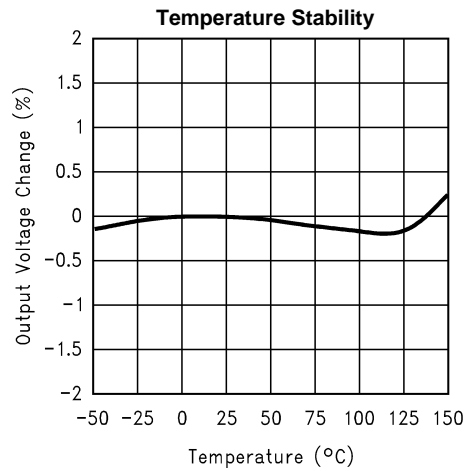


Figure 7.

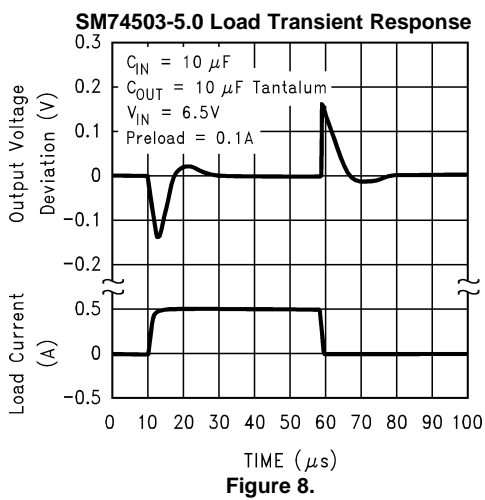


Figure 8.

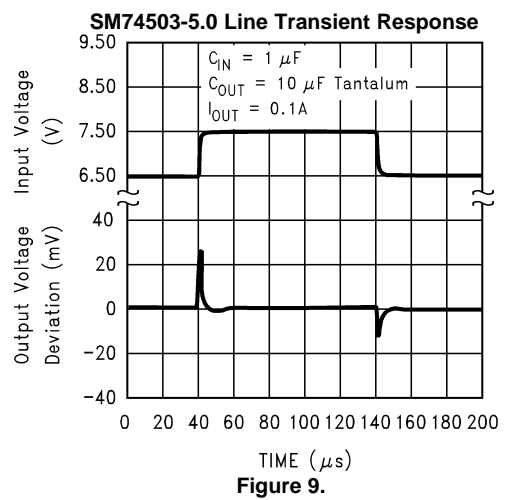


Figure 9.

APPLICATION NOTE

EXTERNAL CAPACITORS/STABILITY

Input Bypass Capacitor

An input capacitor is recommended. A 10 μ F tantalum on the input is a suitable input bypassing for almost all applications.

Output Capacitor

The output capacitor is critical in maintaining regulator stability, and must meet the required conditions for both minimum amount of capacitance and ESR (Equivalent Series Resistance). The minimum output capacitance required by the SM74503 is 10 μ F, if a tantalum capacitor is used. Any increase of the output capacitance will merely improve the loop stability and transient response. The ESR of the output capacitor should range between 0.3 Ω - 22 Ω .

LOAD REGULATION

The SM74503 regulates the voltage that appears between its output and ground pins. In some cases, line resistances can introduce errors to the voltage across the load. To obtain the best load regulation, a few precautions are needed.

Figure 10, shows a typical application using a fixed output regulator. The R_{t1} and R_{t2} are the line resistances. It is obvious that the V_{LOAD} is less than the V_{OUT} by the sum of the voltage drops along the line resistances. In this case, the load regulation seen at the R_{LOAD} would be degraded from the data sheet specification. To improve this, the load should be tied directly to the output terminal on the positive side and directly tied to the ground terminal on the negative side.

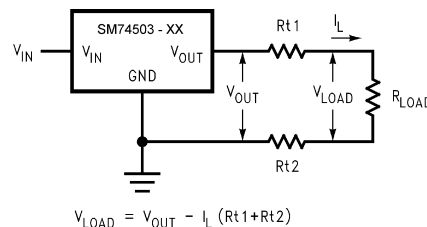


Figure 10. Typical Application using Fixed Output Regulator

PROTECTION DIODES

Under normal operation, the SM74503 regulators do not need any protection diode. When a output capacitor is connected to a regulator and the input is shorted to ground, the output capacitor will discharge into the output of the regulator. The discharge current depends on the value of the capacitor, the output voltage of the regulator, and rate of decrease of V_{IN} . In the SM74503 regulators, the internal diode between the output and input pins can withstand microsecond surge currents of 10A to 20A. With an extremely large output capacitor ($\geq 1000 \mu$ F), and with input instantaneously shorted to ground, the regulator could be damaged.

In this case, an external diode is recommended between the output and input pins to protect the regulator, as shown in Figure 11.

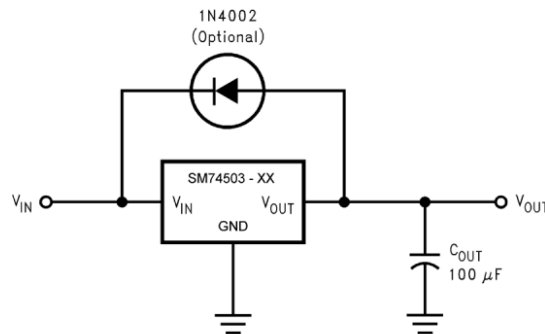
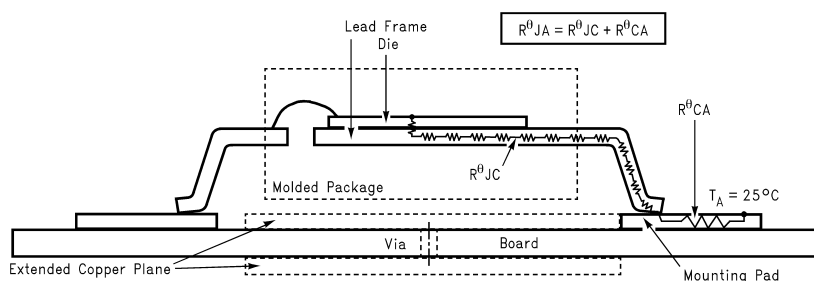


Figure 11. Regulator with Protection Diode

HEATSINK REQUIREMENTS

When an integrated circuit operates with an appreciable current, its junction temperature is elevated. It is important to quantify its thermal limits in order to achieve acceptable performance and reliability. This limit is determined by summing the individual parts consisting of a series of temperature rises from the semiconductor junction to the operating environment. A one-dimensional steady-state model of conduction heat transfer is demonstrated in Figure 12. The heat generated at the device junction flows through the die to the die attach pad, through the lead frame to the surrounding case material, to the printed circuit board, and eventually to the ambient environment. Below is a list of variables that may affect the thermal resistance and in turn the need for a heatsink.

| $R_{\theta JC}$ (Component Variables) | $R_{\theta CA}$ (Application Variables) |
|---------------------------------------|---|
| Leadframe Size & Material | Mounting Pad Size, Material, & Location |
| No. of Conduction Pins | Placement of Mounting Pad |
| Die Size | PCB Size & Material |
| Die Attach Material | Traces Length & Width |
| Molding Compound Size and Material | Adjacent Heat Sources |
| | Volume of Air |
| | Ambient Temperature |
| | Shape of Mounting Pad |



Note that the case temperature is measured at the point where the leads contact with the mounting pad surface.

Figure 12. Cross-sectional view of Integrated Circuit Mounted on a printed circuit board

The SM74503 regulators have internal thermal shutdown to protect the device from over-heating. Under all possible operating conditions, the junction temperature of the SM74503 must be within the range of -40°C to 125°C . A heatsink may be required depending on the maximum power dissipation and maximum ambient temperature of the application. To determine if a heatsink is needed, the power dissipated by the regulator, P_D , must be calculated:

$$I_{IN} = I_L + I_G$$

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

Figure 13 shows the voltages and currents which are present in the circuit.

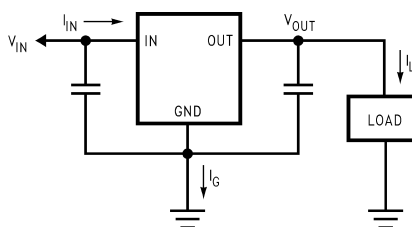


Figure 13. Power Dissipation Diagram

The next parameter which must be calculated is the maximum allowable temperature rise, $T_R(\text{max})$:

$$T_R(\text{max}) = T_J(\text{max}) - T_A(\text{max})$$

where $T_J(\text{max})$ is the maximum allowable junction temperature (125°C), and $T_A(\text{max})$ is the maximum ambient temperature which will be encountered in the application.

Using the calculated values for $T_R(\text{max})$ and P_D , the maximum allowable value for the junction-to-ambient thermal resistance (θ_{JA}) can be calculated:

$$\theta_{JA} = T_R(\text{max})/P_D$$

If the maximum allowable value for θ_{JA} is found to be $\geq 136^\circ\text{C}/\text{W}$ for SOT-223 package or $\geq 92^\circ\text{C}/\text{W}$ for PFM package, no heatsink is needed since the package alone will dissipate enough heat to satisfy these requirements. If the calculated value for θ_{JA} falls below these limits, a heatsink is required.

As a design aid, Table 1 shows the value of the θ_{JA} of SOT-223 and PFM for different heatsink area. The copper patterns that we used to measure these θ_{JA} s are shown at the end of the Application Notes Section. Figure 14 and Figure 15 reflects the same test results as what are in the Table 1

Figure 16 and Figure 17 shows the maximum allowable power dissipation vs. ambient temperature for the SOT-223 and PFM device. Figure 18 and Figure 19 shows the maximum allowable power dissipation vs. copper area (in^2) for the SOT-223 and PFM devices. Please see AN1028 for power enhancement techniques to be used with SOT-223 and PFM packages.

Table 1. θ_{JA} Different Heatsink Area

| Layout | Copper Area | | Thermal Resistance | |
|--------|---|-------------------------------|---------------------------------|-----------------------------|
| | Top Side (in^2) ⁽¹⁾ | Bottom Side (in^2) | (θ_{JA} , °C/W) SOT-223 | (θ_{JA} , °C/W) PFM |
| 1 | 0.0123 | 0 | 136 | 103 |
| 2 | 0.066 | 0 | 123 | 87 |
| 3 | 0.3 | 0 | 84 | 60 |
| 4 | 0.53 | 0 | 75 | 54 |
| 5 | 0.76 | 0 | 69 | 52 |
| 6 | 1 | 0 | 66 | 47 |
| 7 | 0 | 0.2 | 115 | 84 |
| 8 | 0 | 0.4 | 98 | 70 |
| 9 | 0 | 0.6 | 89 | 63 |
| 10 | 0 | 0.8 | 82 | 57 |
| 11 | 0 | 1 | 79 | 57 |
| 12 | 0.066 | 0.066 | 125 | 89 |
| 13 | 0.175 | 0.175 | 93 | 72 |
| 14 | 0.284 | 0.284 | 83 | 61 |
| 15 | 0.392 | 0.392 | 75 | 55 |
| 16 | 0.5 | 0.5 | 70 | 53 |

(1) Tab of device attached to topside copper

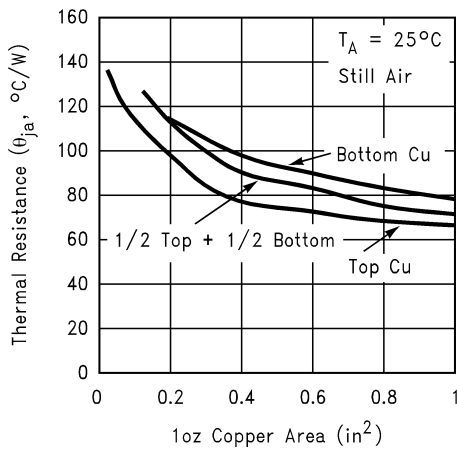


Figure 14. θ_{JA} vs. 1oz Copper Area for SOT-223

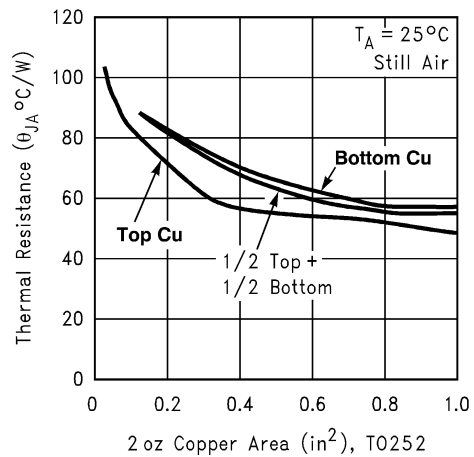


Figure 15. θ_{JA} vs. 2oz Copper Area for PFM

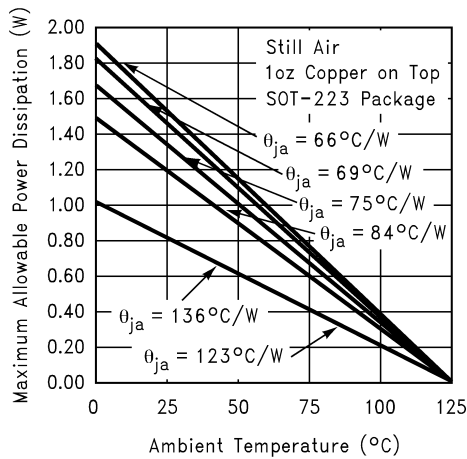


Figure 16. Maximum Allowable Power Dissipation vs. Ambient Temperature for SOT-223

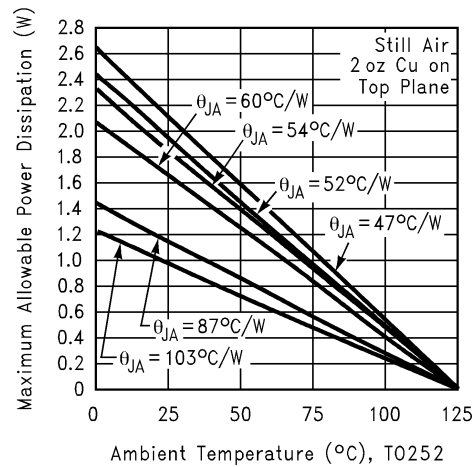


Figure 17. Maximum Allowable Power Dissipation vs. Ambient Temperature for PFM

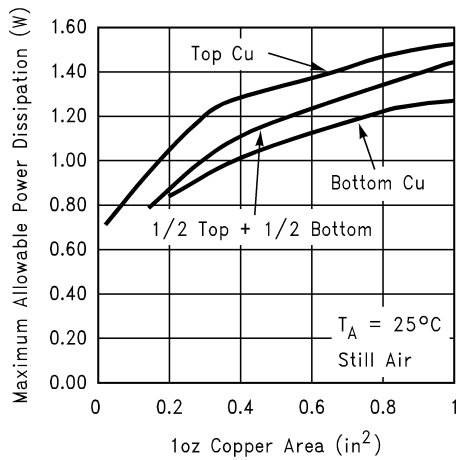


Figure 18. Maximum Allowable Power Dissipation vs. 1oz Copper Area for SOT-223

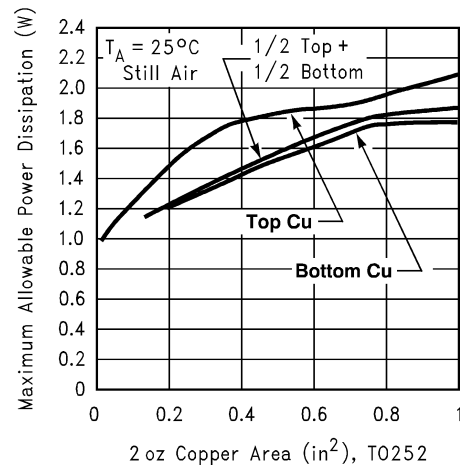


Figure 19. Maximum Allowable Power Dissipation vs. 2oz Copper Area for PFM

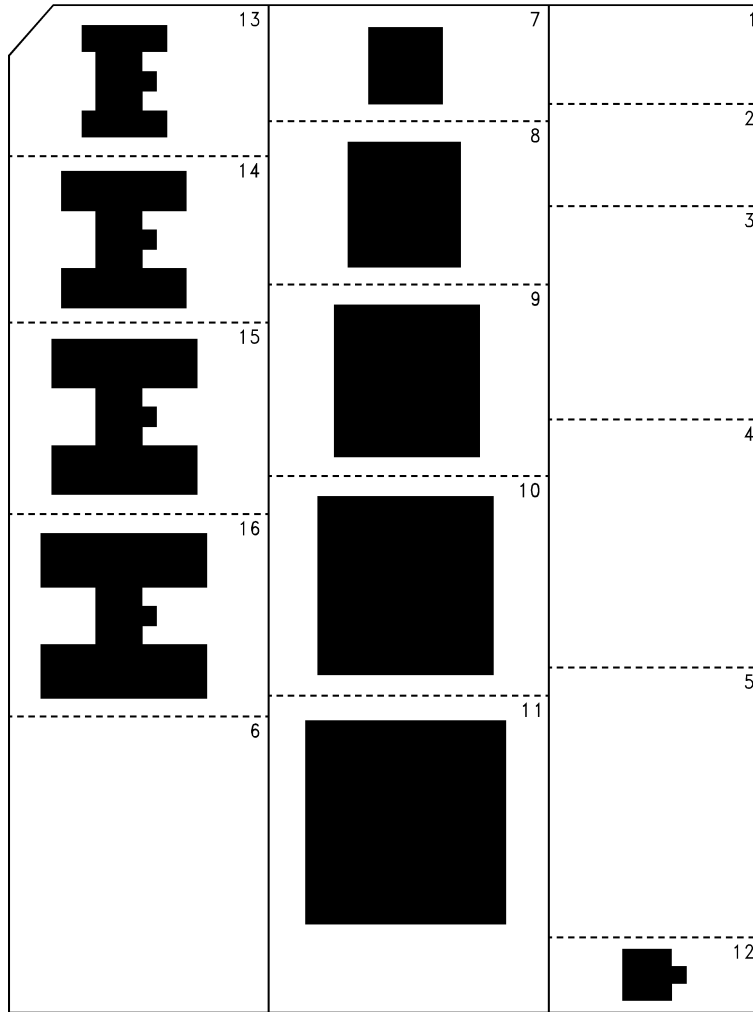


Figure 20. Top View of the Thermal Test Pattern in Actual Scale

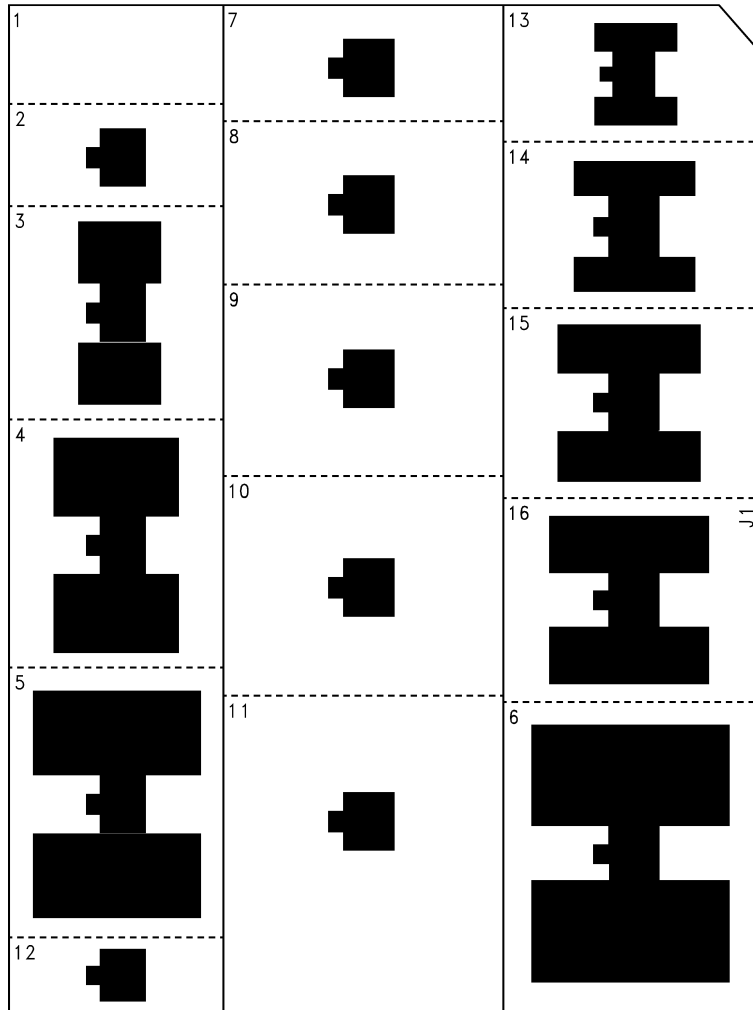


Figure 21. Bottom View of the Thermal Test Pattern in Actual Scale

Typical Application Circuits

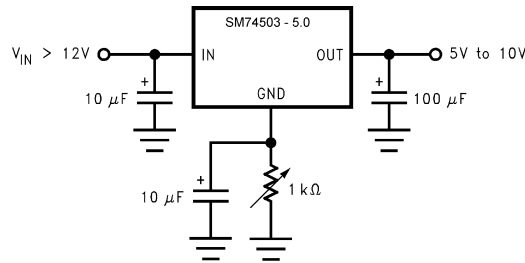


Figure 22. Adjusting Output of Fixed Regulators

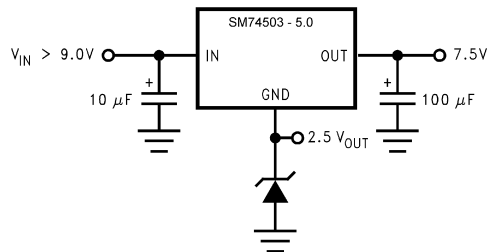
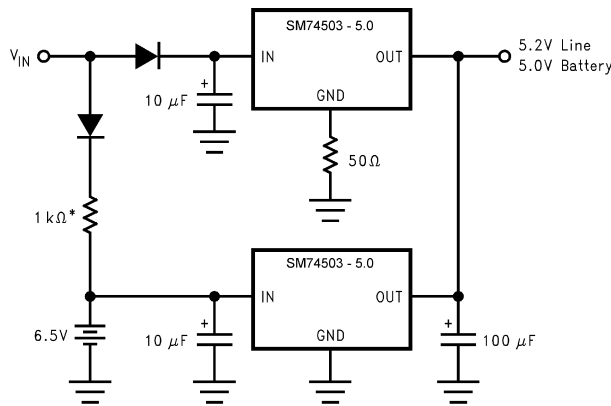


Figure 23. Regulator with Reference



* Select for charge rate.

Figure 24. Battery Backed-Up Regulated Supply

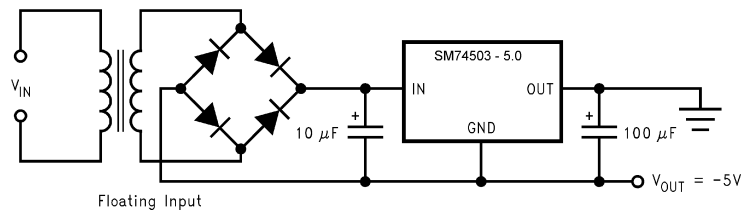


Figure 25. Low Dropout Negative Supply

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