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**

DESCRIPTION

The SM74503 is a series of low dropout voltage regulators with a dropout of 1.2V at 800mA of load current. It has the same pin-out as TI's industry standard LM317.

The SM74503 is available in two fixed voltages, 3.3V and 5V.

The SM74503 offers current limiting and thermal shutdown. Its circuit includes a zener trimmed bandgap reference to assure output voltage accuracy to within ±1%.

The SM74503 series is available in SOT-223 and PFM packages. A minimum of 10µF tantalum capacitor is required at the output to improve the transient response and stability.

Typical Application

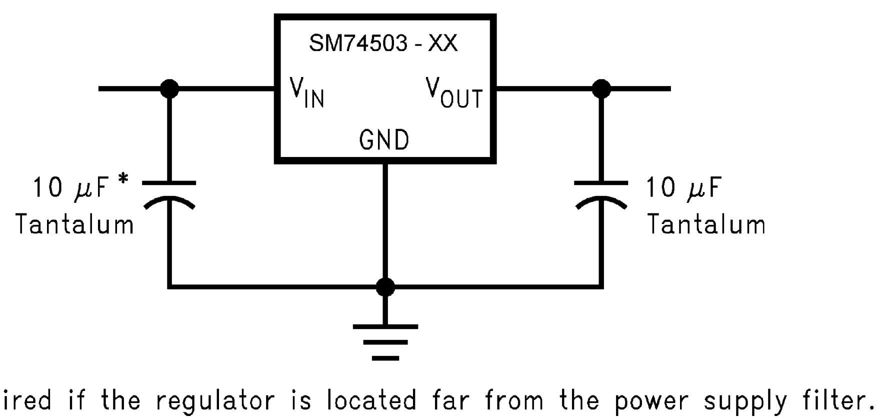
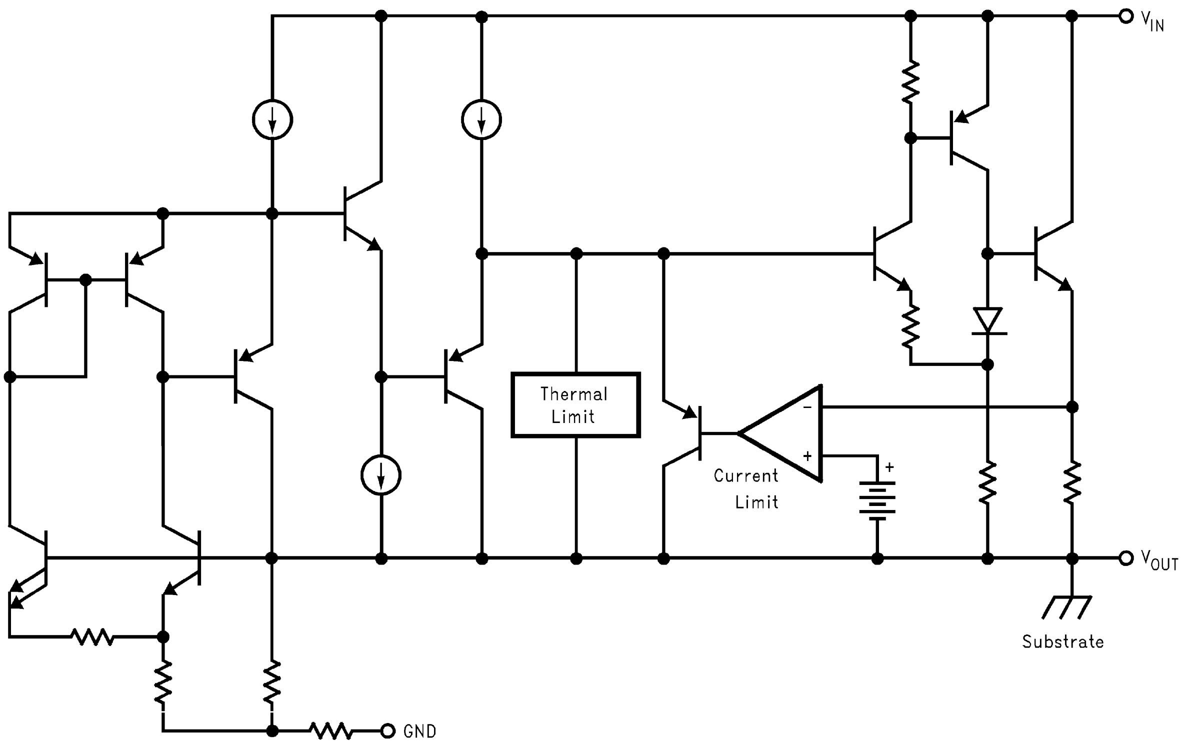


Figure 1. Fixed Output Regulator

Block Diagram



Connection Diagram

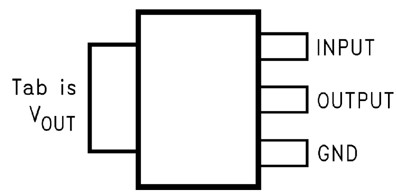


Figure 2. SOT-223
Top View

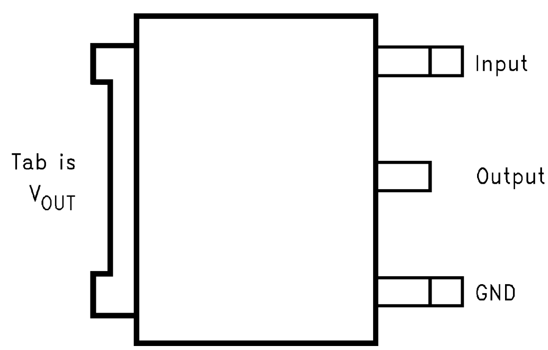


Figure 3. PFM
Top View

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, 1.5kΩ 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°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} = 10mA, V_{IN} = 5V, T_J = 25°C 0 ≤ I_{OUT} ≤ 800mA, 4.75V ≤ V_{IN} ≤ 10V	3.267 **3.168**	3.300 3.300	3.333 **3.432**	V V
		SM74503-5.0 I_{OUT} = 10mA, V_{IN} = 7V, T_J = 25°C 0 ≤ I_{OUT} ≤ 800mA, 6.5V ≤ V_{IN} ≤ 12V	4.950 **4.800**	5.000 5.000	5.050 **5.200**	V V
ΔV_{OUT}	Line Regulation [(3)]	SM74503-3.3 I_{OUT} = 0mA, 4.75V ≤ V_{IN} ≤ 15V		1	**10**	mV
		SM74503-5.0 I_{OUT} = 0mA, 6.5V ≤ V_{IN} ≤ 15V		1	**15**	mV
ΔV_{OUT}	Load Regulation [(3)]	SM74503-3.3 V_{IN} = 4.75V, 0 ≤ I_{OUT} ≤ 800mA		1	**15**	mV
		SM74503-5.0 V_{IN} = 6.5V, 0 ≤ I_{OUT} ≤ 800mA		1	**20**	mV

(1) All limits are specifed 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°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} = 100mA		1.10	**1.30**	V
		I_{OUT} = 500mA		1.15	**1.35**	V
		I_{OUT} = 800mA		1.20	**1.40**	V
I_{LIMIT}	Current Limit	V_{IN}-V_{OUT} = 5V, T_J = 25°C	800	1200	1500	mA
	Quiescent Current	SM74503-3.3 V_{IN} ≤ 15V		5	**15**	mA
		SM74503-5.0 V_{IN} ≤ 15V		5	**15**	mA
	Thermal Regulation	T_A = 25°C, 30ms Pulse		0.01	0.1	%/W
	Ripple Regulation	f_{RIPPLE} =1 20Hz, V_{IN}-V_{OUT} = 3V V_{RIPPLE} = 1V_{PP}	**60**	75		dB
	Temperature Stability			0.5		%
	Long Term Stability	T_A = 125°C, 1000Hrs		0.3		%
	RMS Output Noise	(% of V_{OUT}), 10Hz ≤ f ≤10kHz		0.003		%
	Thermal Resistance Junction-to-Case	4-Lead SOT-223		15.0		°C/W
		3-Lead PFM		10		°C/W
	Thermal Resistance Junction-to-Ambient No air flow)	4-Lead SOT-223 (No heat sink)		136		°C/W
		3-Lead PFM (No heat sink) (5)		92		°C/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} +1.5V.
(5) Minimum pad size of 0.038in^2

Typical Performance Characteristics

Dropout Voltage (V_{IN}-V_{OUT})

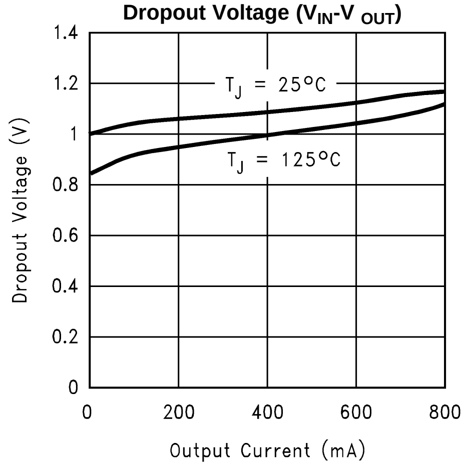


Figure 4.

Short-Circuit Current

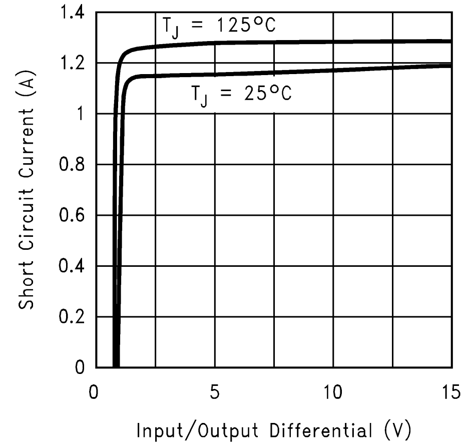


Figure 5.

Load Regulation

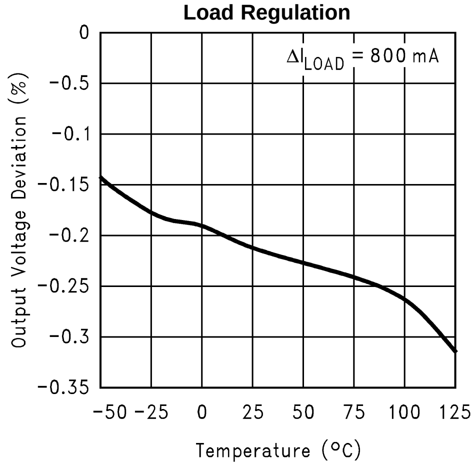


Figure 6.

Temperature Stability

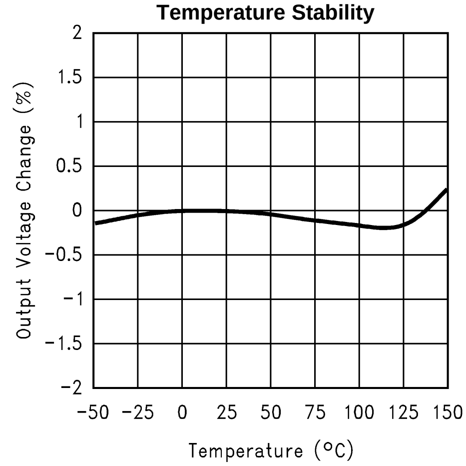


Figure 7.

SM74503-5.0 Load Transient Response

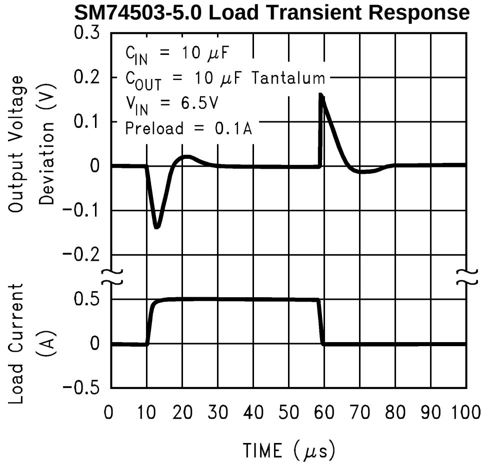


Figure 8.

SM74503-5.0 Line Transient Response

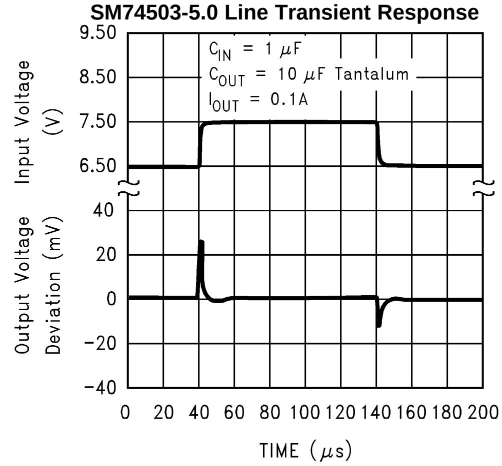


Figure 9.

APPLICATION NOTE

EXTERNAL CAPACITORS/STABILITY

Input Bypass Capacitor

An input capacitor is recommended. A 10µF 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 10µF, 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 0.3Ω - 22Ω.

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 Rt1 and Rt2 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.

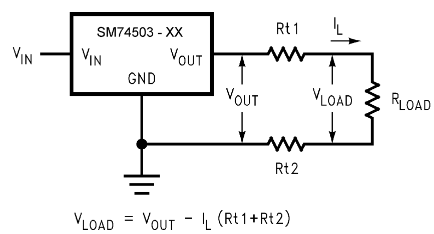


Figure 10. Typical Application using Fixed Output Regulator

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 (≥1000 µF), 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.

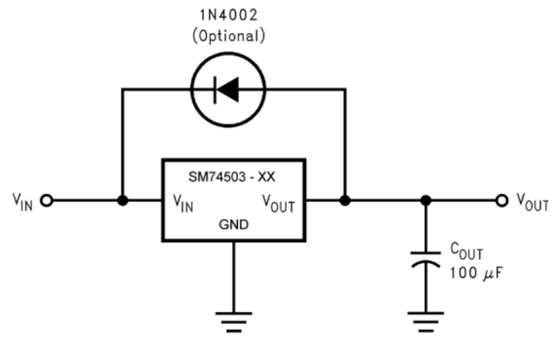
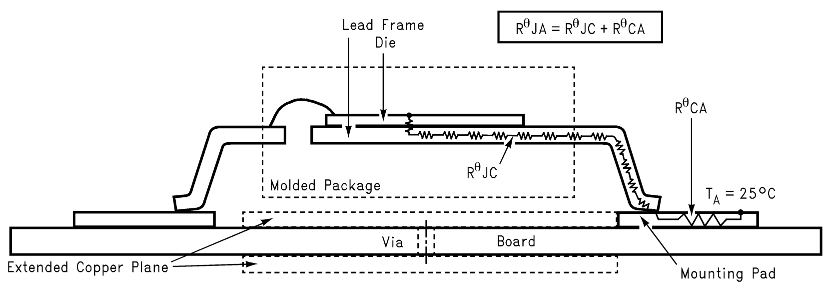


Figure 11. Regulator with Protection Diode

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 Temperatue
	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:

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

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

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

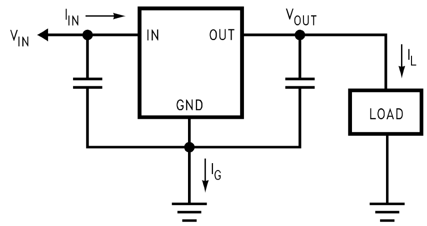


Figure 13. Power Dissipation Diagram

The next parameter which must be calculated is the maximum allowable temperature rise, T_R(max):

$T_R(max) = T_J(max)-T_A(max)$

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

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

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

If the maximum allowable value for θ_{JA} is found to be ≥136°C/W for SOT-223 package or ≥92°C/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

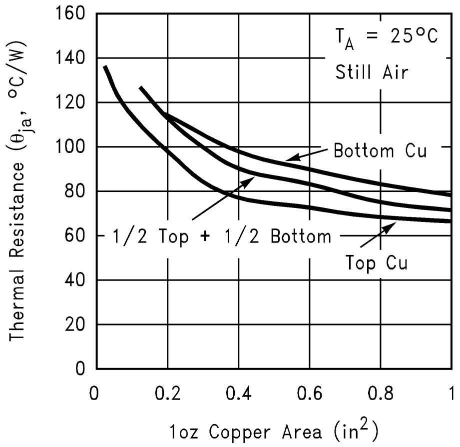


Figure 14. θ_{JA} vs. 1oz Copper Area for SOT-223

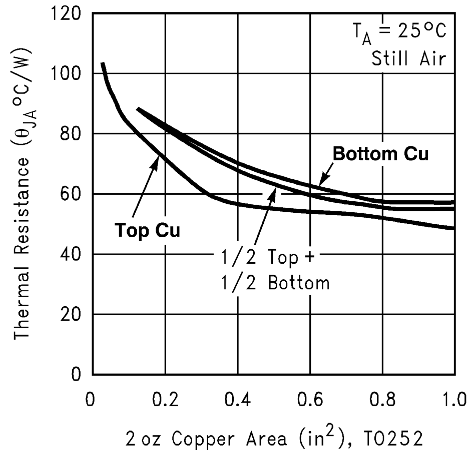


Figure 15. θ_{JA} vs. 2oz Copper Area for PFM

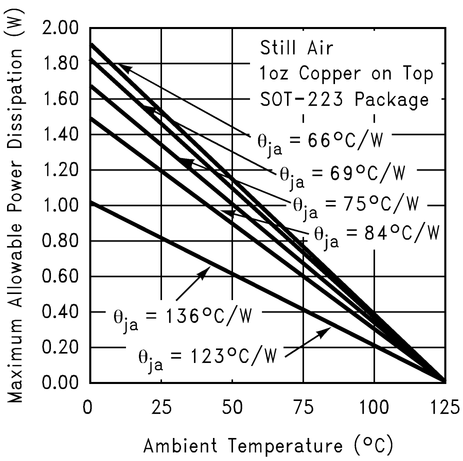


Figure 16. Maximum Allowable Power Dissipation vs. Ambient Temperature for SOT-223

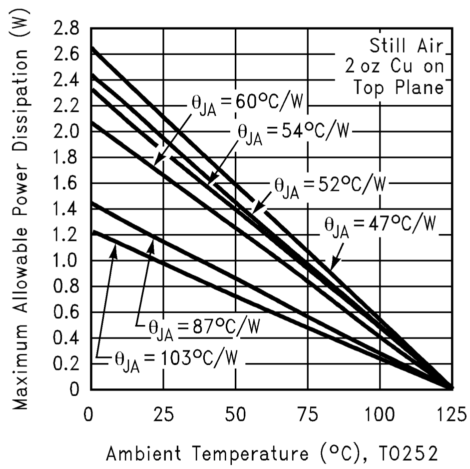


Figure 17. Maximum Allowable Power Dissipation vs. Ambient Temperature for PFM

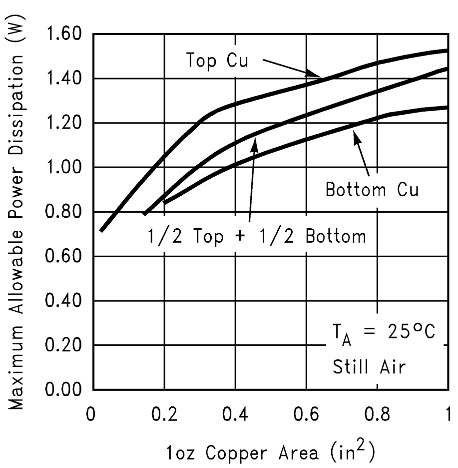


Figure 18. Maximum Allowable Power Dissipation vs. 1oz Copper Area for SOT-223

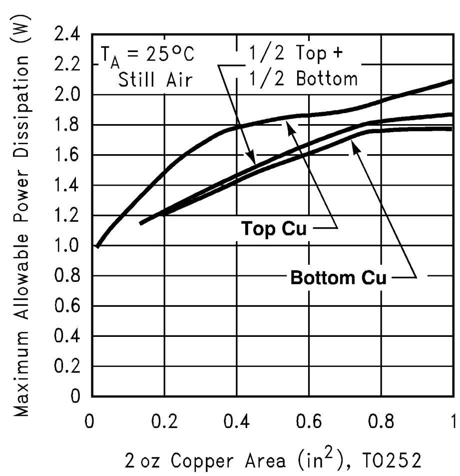


Figure 19. Maximum Allowable Power Dissipation vs. 2oz Copper Area for PFM

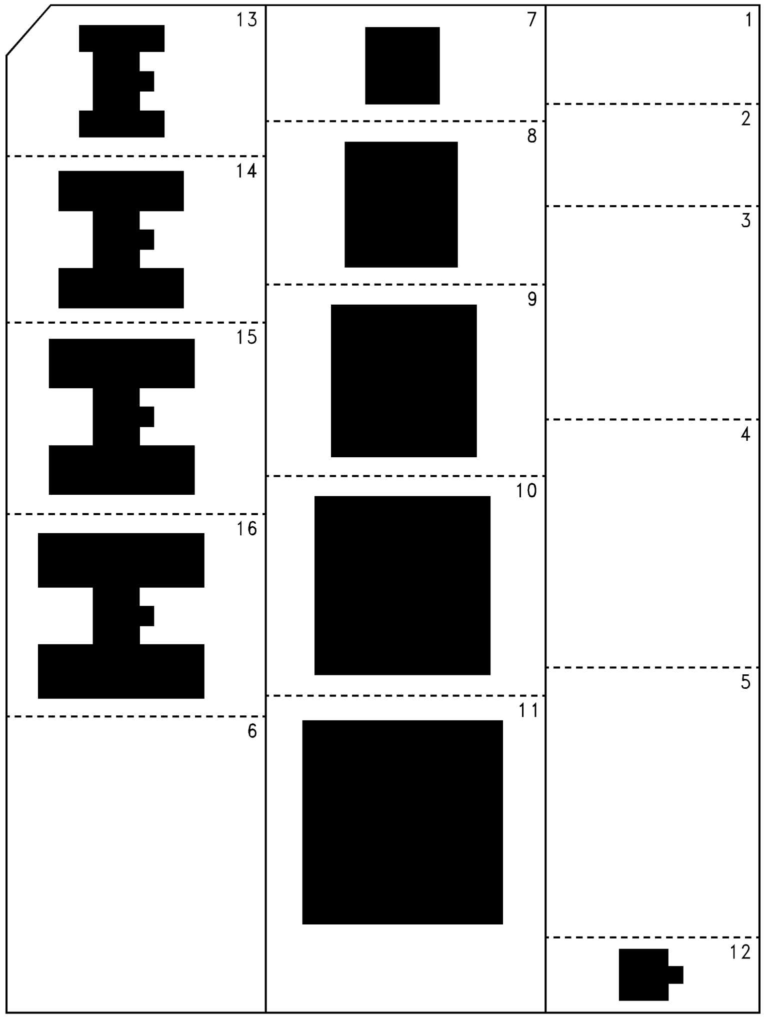


Figure 20. Top View of the Thermal Test Pattern in Actual Scale

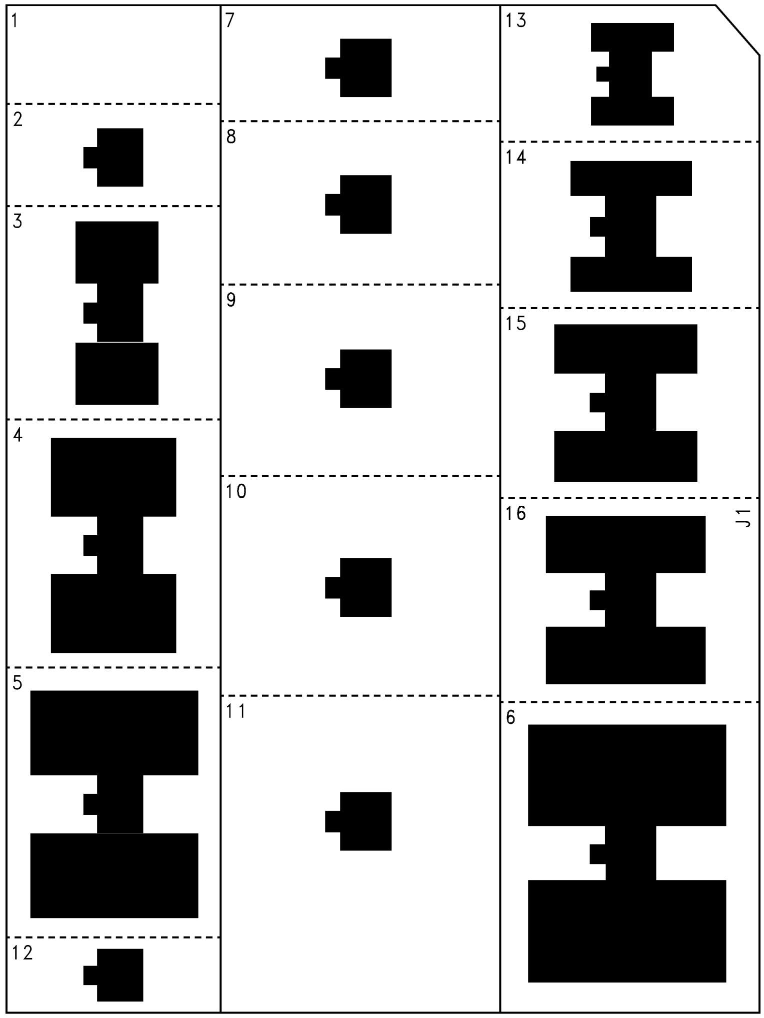


Figure 21. Bottom View of the Thermal Test Pattern in Actual Scale

Typical Application Circuits

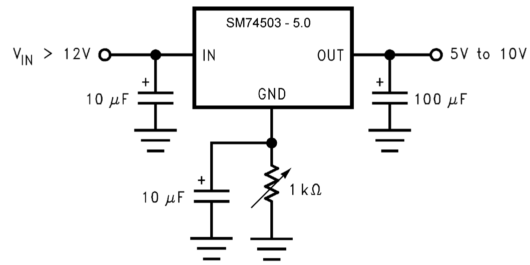


Figure 22. Adjusting Output of Fixed Regulators

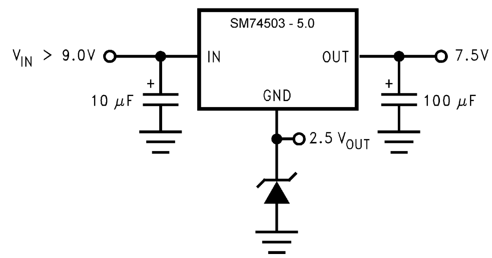


Figure 23. Regulator with Reference

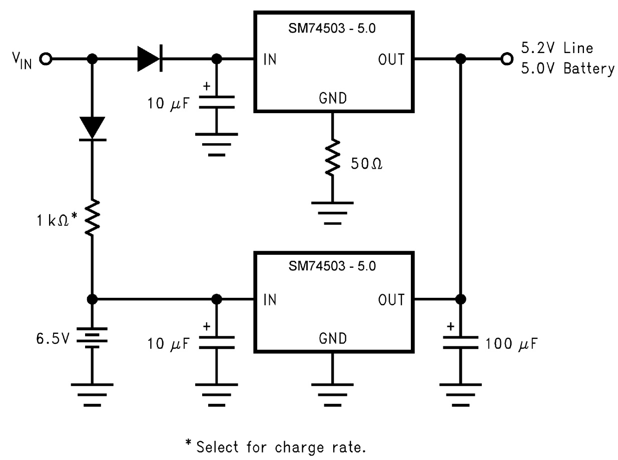


Figure 24. Battery Backed-Up Regulated Supply

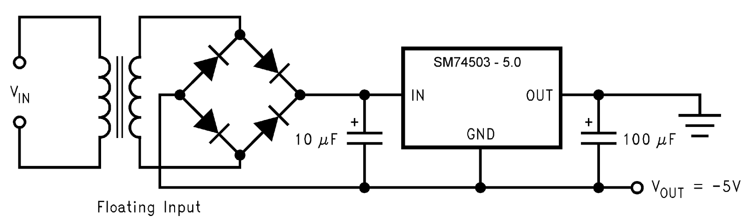


Figure 25. Low Dropout Negative Supply

REVISION HISTORY

Changes from Original (April 2013) to Revision A **Page**