SM74501 Ultra-Low Quiescent Current LDO Voltage Regulator

Check for Samples: SM74501

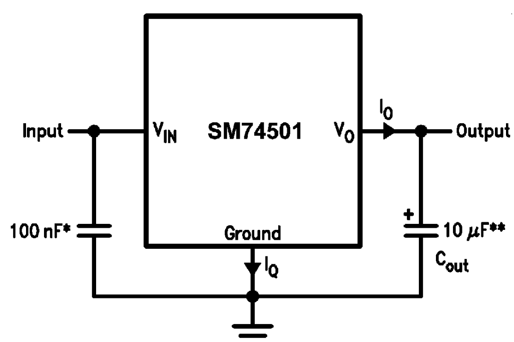
FEATURES

- **Renewable Energy Grade**
- **Ultra Low Quiescent Current (I_Q ≤ 15 µA for I_O = 100 µA)**
- **Fixed 5.0V with 50 mA Output**
- **±2% Initial Output Tolerance**
- **±3% Output Tolerance Over Line, Load, and Temperature**
- **Dropout Voltage Typically 200 mV @ I_O = 50 mA**
- **Reverse Battery Protection**
- **−50V Reverse Transient Protection**
- **Internal Short Circuit Current Limit**
- **Internal Thermal Shutdown Protection**
- **40V Operating Voltage Limit**

DESCRIPTION

The SM74501 ultra-low quiescent current regulator features low dropout voltage and low current in the standby mode. With less than 15 µA quiescent current at a 100 µA load, the SM74501 is ideally suited for photovoltaic and other battery operated systems. The SM74501 retains all of the features that are common to low dropout regulators including a low dropout PNP pass device, short circuit protection, reverse battery protection, and thermal shutdown. The SM74501 has a 40V maximum operating voltage limit, a −40°C to +125°C operating temperature range, and ±3% output voltage tolerance over the entire output current, input voltage, and temperature range. The SM74501 is available in SOT–223 surface mount package.

Typical Application



* Required if regulator is located more than 2 inches from power supply filter capacitor.
** Required for stability. See Electrical Characteristics for required values. Must be rated over intended operating temperature range. Effective series resistance (ESR) is critical, see curve. Locate capacitor as close as possible to the regulator output and ground pins. Capacitance may be increased without bound.

Connection Diagram

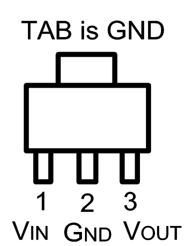


Figure 1. SOT-223 Top View

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

Absolute Maximum Ratings (1) (2)

Input Voltage (Survival)	+60V, −50V
ESD Susceptibility (3)	2000V
Power Dissipation (4)	Internally limited
Junction Temperature (T_{Jmax})	150°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec.)	260°C

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. DC and AC electrical specifications do not apply when operating the device beyond its specified operating ratings.
(2) If Military/Aerospace specified devices are required, please contact the TI Sales Office/Distributors for availability and specifications.
(3) Human body model, 100 pF discharge through a 1.5 kΩ resistor.
(4) The maximum power dissipation is a function of T_{Jmax}, θ_{JA}, and T_A. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{Jmax} - T_A)/\theta_{JA}$. If this dissipation is exceeded, the die temperature will rise above 150°C and the SM74501 will go into thermal shutdown.

Operating Ratings

Operating Temperature Range	−40°C to +125°C
Maximum Operating Input Voltage	+40V
θ_{JA}	149°C/W
θ_{JC}	36°C/W

Electrical Characteristics for SM74501–3.3

V_{IN} = 14V, I_O = 10 mA, T_J = 25°C, unless otherwise specified. **Boldface** limits apply over entire operating temperature range

Parameter	Conditions	Min (1)	Typical (2)	Max (1)	Units
All SM74501–3.3					
Output Voltage		3.234	3.300	3.366	V
	4.0V ≤ V_{IN} ≤ 26V, 100 µA ≤ I_O ≤ 50 mA (3)	**3.201**	**3.300**	**3.399**	
Quiescent Current	I_O = 100 µA, 8V ≤ V_{IN} ≤ 24V		15	20	µA
	I_O = 10 mA, 8V ≤ V_{IN} ≤ 24V		0.20	0.50	mA
	I_O = 50 mA, 8V ≤ V_{IN} ≤ 24V		1.5	2.5	mA
Line Regulation	9V ≤ V_{IN} ≤ 16V		5	10	mV
	6V ≤ V_{IN} ≤ 40V, I_O = 1 mA		10	30	
Load Regulation	100 µA ≤ I_O ≤ 5 mA		10	30	mV
	5 mA ≤ I_O ≤ 50 mA		10	30	
Dropout Voltage	I_O = 100 µA		0.05	0.10	V
	I_O = 50 mA		0.20	0.40	V
Short Circuit Current	V_O = 0V	65	120	250	mA
Output Impedance	I_O = 30 mAdc and 10 mArms,		450		mΩ
	$_f$ = 1000 Hz				
Output Noise Voltage	10 Hz–100 kHz		500		µV
Long Term Stability			20		mV/1000 Hr
Ripple Rejection	V_{ripple} = 1V_{rms}, f_{ripple} = 120 Hz	−40	−60		dB
Reverse Polarity	R_L = 500Ω, T = 1 ms	−50	−80		V
Transient Input Voltage					

(1) Datasheet min/max specification limits are guaranteed by design, test, or statistical analysis.
(2) Typicals are at 25°C (unless otherwise specified) and represent the most likely parametric norm.
(3) To ensure constant junction temperature, pulse testing is used.

Electrical Characteristics for SM74501–3.3 (continued)

V_{IN} = 14V, I_O = 10 mA, T_J = 25°C, unless otherwise specified. **Boldface** limits apply over entire operating temperature range

Parameter	Conditions	Min (1)	Typical (2)	Max (1)	Units
Output Voltage with	V_{IN} = −15V, R_L = 500Ω		0.00	−0.30	V
Reverse Polarity Input					
Maximum Line Transient	R_L = 500Ω, V_O ≤ 3.63V, T = 40ms	60			V
Output Bypass Capacitance (C_{OUT}) ESR	C_{OUT} = 22µF 0.1mA ≤ I_{OUT} ≤ 50mA	0.3		8	Ω

Electrical Characteristics for SM74501–5.0

V_{IN} = 14V, I_O = 10 mA, T_J = 25°C, unless otherwise specified. **Boldface** limits apply over entire operating temperature range

Parameter	Conditions	Min (1)	Typical (2)	Max (1)	Units
SM74501–5.0					
Output Voltage		4.90	5.00	5.10	V
	5.5V ≤ V_{IN} ≤ 26V, 100 µA ≤ I_O ≤ 50 mA (3)	**4.85**	**5.00**	**5.15**	
Quiescent Current	I_O = 100 µA, 8V ≤ V_{IN} ≤ 24V		9	15	µA
	I_O = 10 mA, 8V ≤ V_{IN} ≤ 24V		0.20	0.50	mA
	I_O = 50 mA, 8V ≤ V_{IN} ≤ 24V		1.5	2.5	mA
Line Regulation	9V ≤ V_{IN} ≤ 16V		5	10	mV
	6V ≤ V_{IN} ≤ 40V, I_O = 1 mA		10	30	
Load Regulation	100 µA ≤ I_O ≤ 5 mA		10	30	mV
	5 mA ≤ I_O ≤ 50 mA		10	30	
Dropout Voltage	I_O = 100 µA		0.05	0.10	V
	I_O = 50 mA		0.20	0.40	V
Short Circuit Current	V_O = 0V	65	120	250	mA
Output Impedance	I_O = 30 mAdc and 10 mArms,		450		mΩ
	$_f$ = 1000 Hz				
Output Noise Voltage	10 Hz–100 kHz		500		µV
Long Term Stability			20		mV/1000 Hr
Ripple Rejection	V_{ripple} = 1V_{rms}, $_{fripple}$ = 120 Hz	−40	−60		dB
Reverse Polarity	R_L = 500Ω, T = 1 ms	−50	−80		V
Transient Input Voltage					
Output Voltage with	V_{IN} = −15V, R_L = 500Ω		0.00	−0.30	V
Reverse Polarity Input					
Maximum Line Transient	R_L = 500Ω, V_O ≤ 5.5V, T = 40ms	60			V
Output Bypass Capacitance (C_{OUT}) ESR	C_{OUT} = 10µF 0.1mA ≤ I_{OUT} ≤ 50mA	0.3		8	Ω

(1) Datasheet min/max specification limits are guaranteed by design, test, or statistical analysis.
(2) Typicals are at 25°C (unless otherwise specified) and represent the most likely parametric norm.
(3) To ensure constant junction temperature, pulse testing is used.

Typical Performance Characteristics

Dropout Voltage

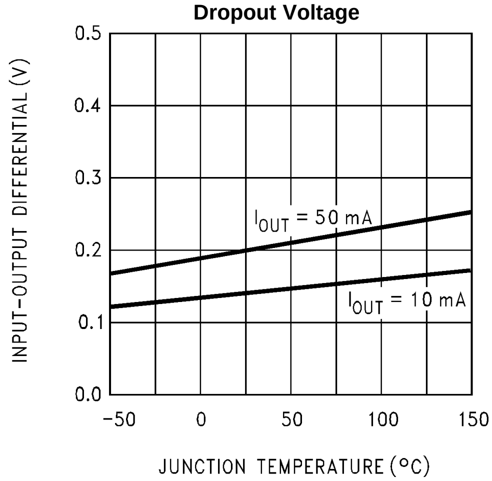


Figure 2.

Dropout Voltage

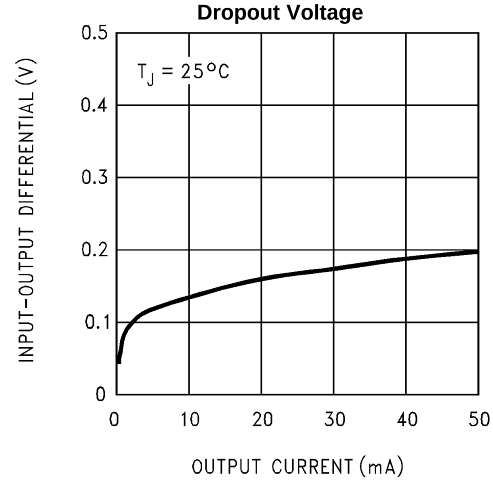


Figure 3.

Quiescent Current

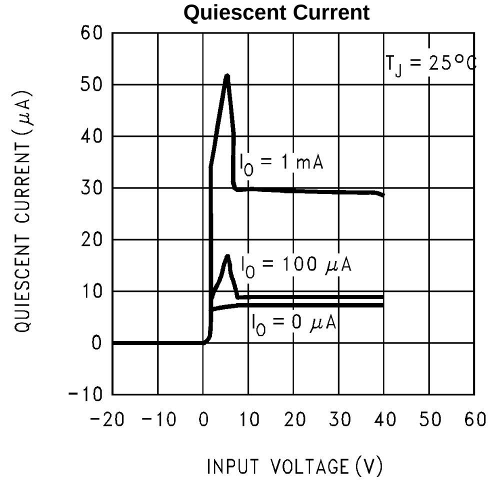


Figure 4.

Quiescent Current

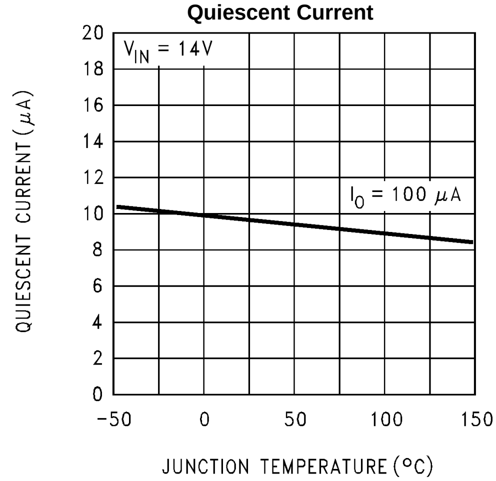


Figure 5.

Quiescent Current

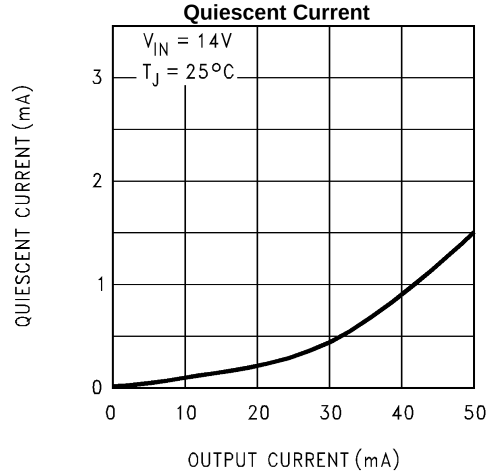


Figure 6.

Quiescent Current

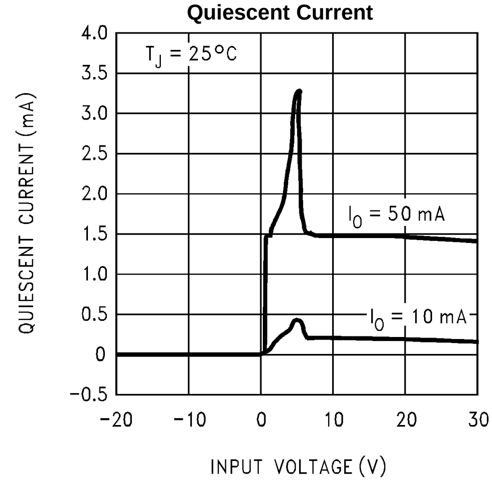


Figure 7.

Typical Performance Characteristics (continued)

Quiescent Current

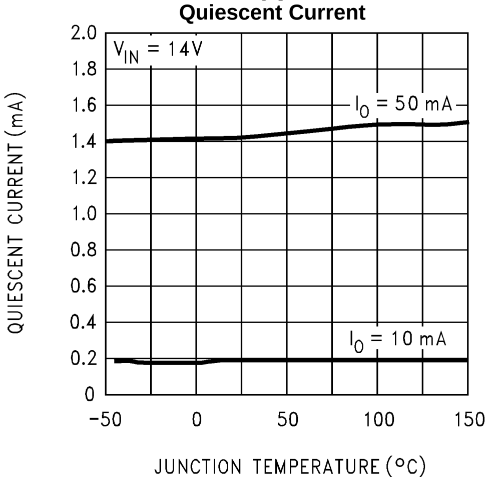


Figure 8.

SM74501–5.0 C_{OUT} ESR

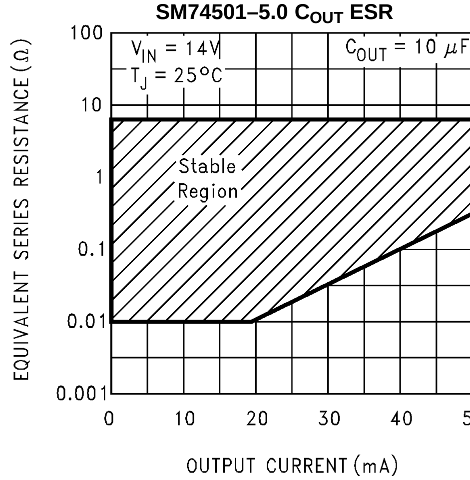


Figure 9.

SM74501–3.3 C_{OUT} ESR

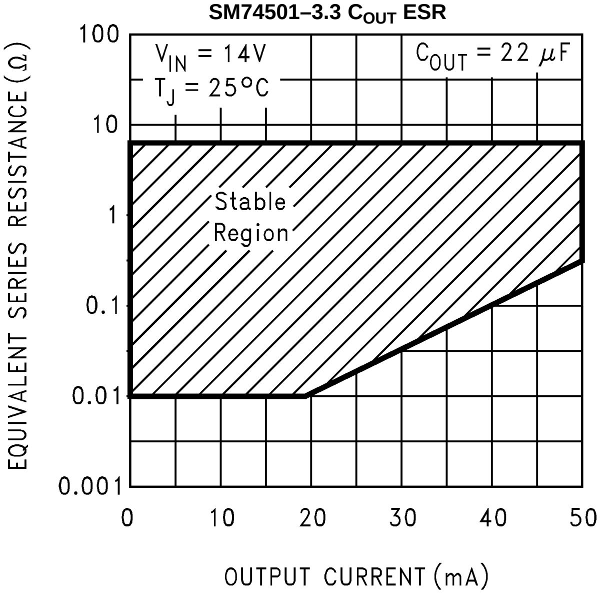


Figure 10.

Peak Output Current

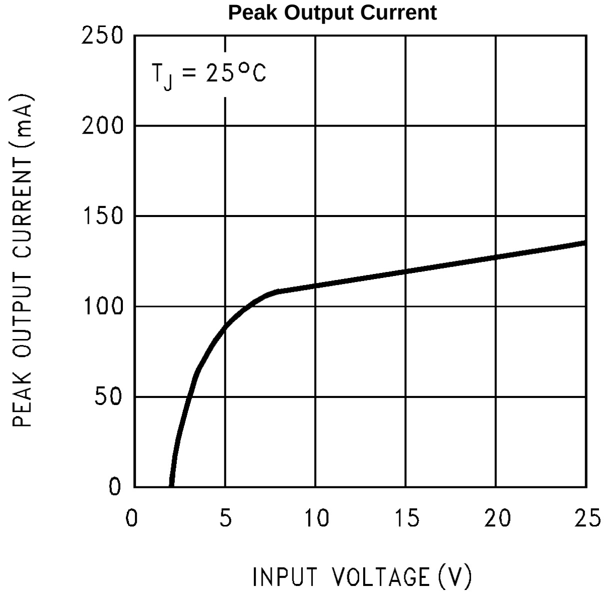


Figure 11.

Peak Output Current

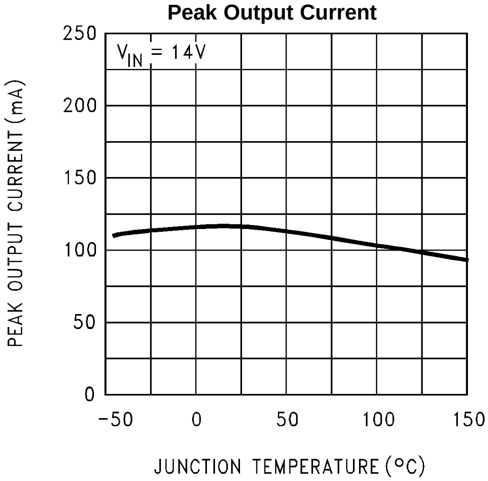


Figure 12.

SM74501–5.0 Current Limit

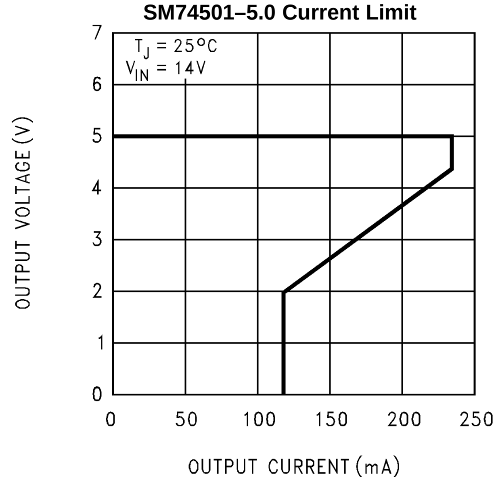


Figure 13.

Typical Performance Characteristics (continued)

SM74501–5.0 Line Transient Response

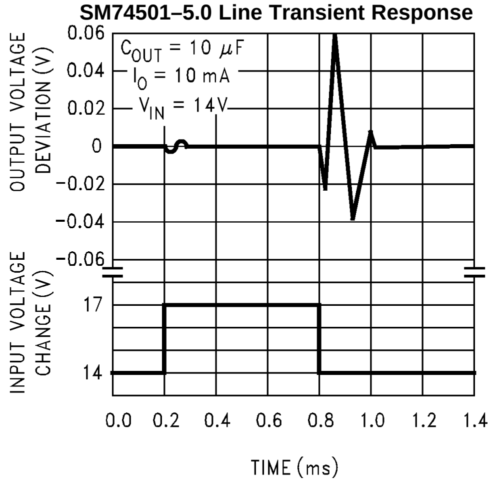


Figure 14.

SM74501–5.0 Output at Voltage Extremes

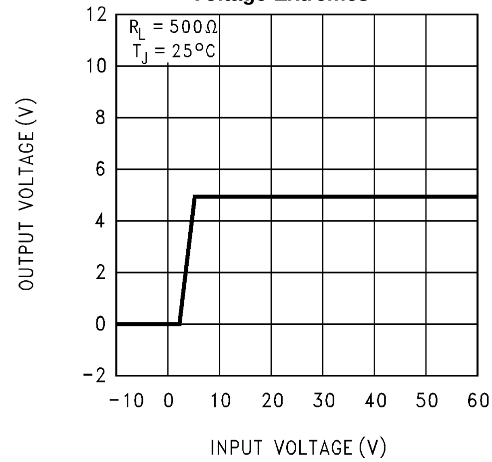


Figure 15.

SM74501–5.0 Ripple Rejection

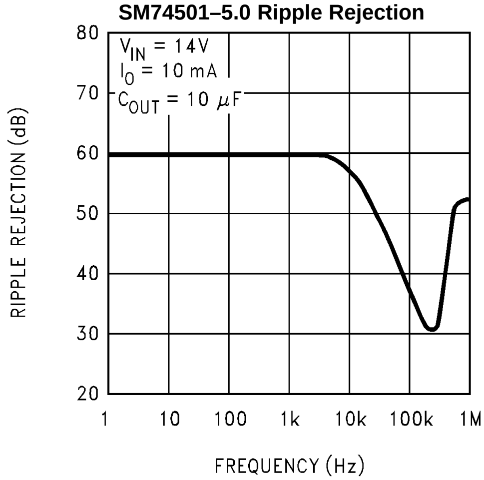


Figure 16.

SM74501–5.0 Load Transient Response

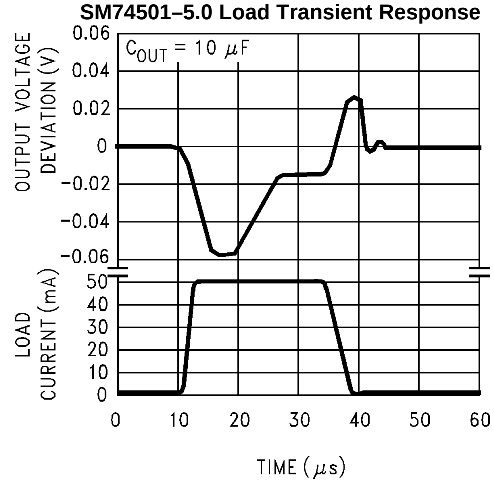


Figure 17.

SM74501–5.0 Low Voltage Behavior

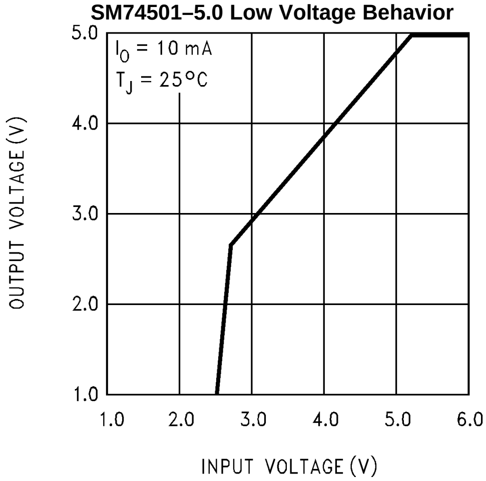


Figure 18.

SM74501–5.0 Output Impedance

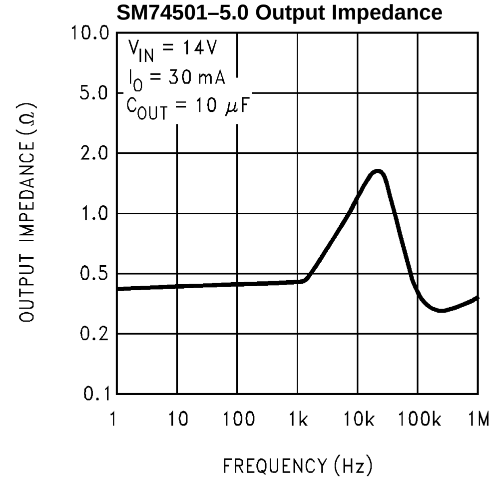


Figure 19.

APPLICATIONS INFORMATION

Unlike other PNP low dropout regulators, the SM74501 remains fully operational to 40V. Owing to power dissipation characteristics of the available packages, full output current cannot be guaranteed for all combinations of ambient temperature and input voltage. As an example, consider an SM74501–5.0 operating at 25°C ambient. Using the formula for maximum allowable power dissipation given in [1] , we find that P_{Dmax} = 839mW at 25°C. Including the small contribution of the quiescent current to total power dissipation the maximum input voltage (while still delivering 50 mA output current) is 20.9V. The SM74501–5.0 will go into thermal shutdown if it attempts to deliver full output current with an input voltage of more than 20.9V. Similarly, at 40V input and 25°C ambient the SM74501–5.0 can deliver 21.4 mA maximum.

Under conditions of higher ambient temperatures, the voltage and current calculated in the previous examples will drop. For instance, at the maximum ambient of 125°C the SM74501–5.0 can only dissipate 167 mW, limiting the input voltage to 8.2V for a 50 mA load, or 2.3 mA output current for a 40V input.

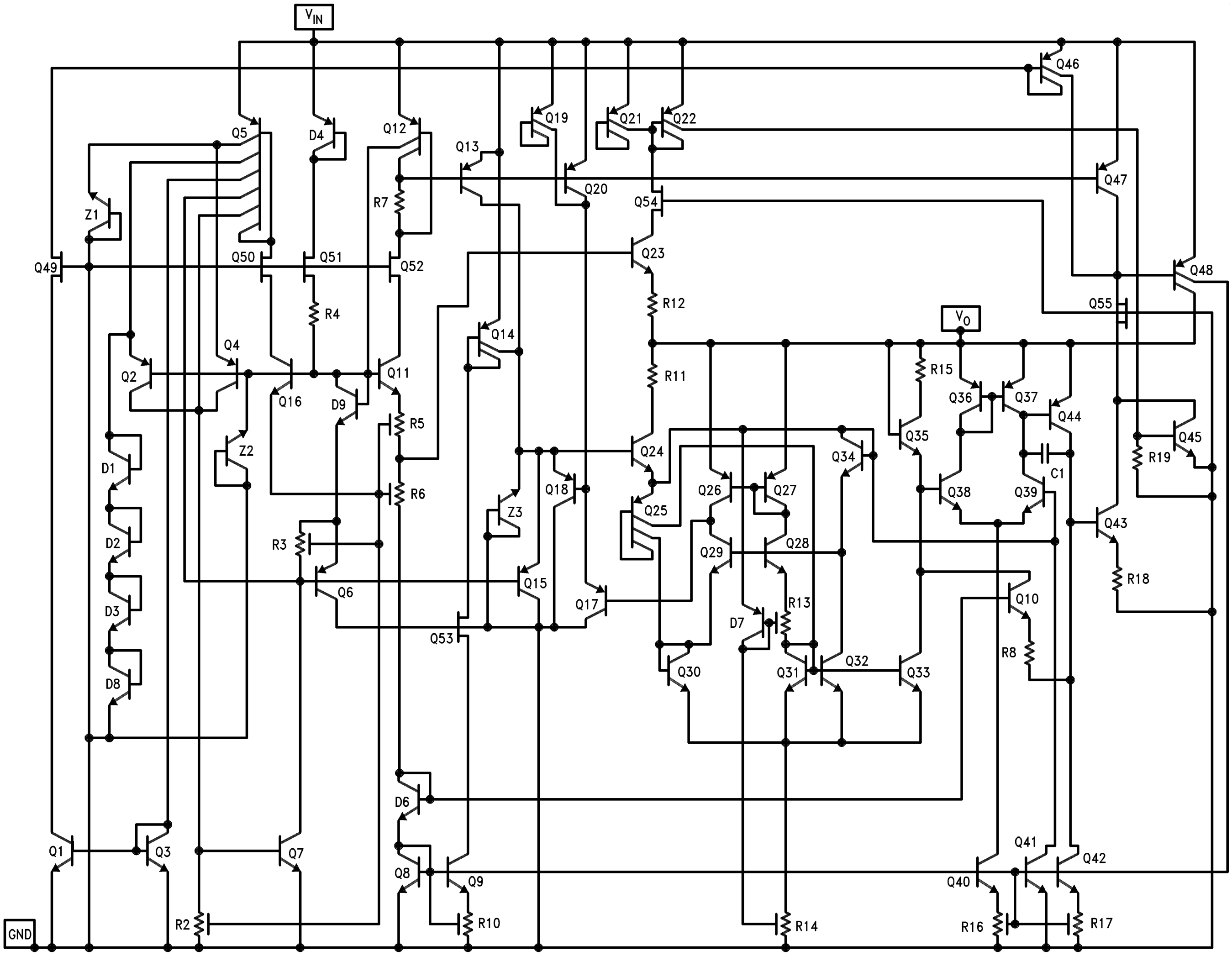
The junction to ambient thermal resistance θ_{JA} rating has two distinct components: the junction to case thermal resistance rating θ_{JC}; and the case to ambient thermal resistance rating θ_{CA}. The relationship is defined as: $\theta_{JA} = \theta_{JC} + \theta_{CA}$.

While the SM74501 has an internally set thermal shutdown point of typically 160°C, this is intended as a safety feature only. Continuous operation near the thermal shutdown temperature should be avoided as it may have a negative affect on the life of the device.

While the SM74501 maintains regulation to 60V, it will not withstand a short circuit above 40V because of safe operating area limitations in the internal PNP pass device. Above 60V the SM74501 will break down with catastrophic effects on the regulator and possibly the load as well. Do not use this device in a design where the input operating voltage may exceed 40V, or where transients are likely to exceed 60V.

(1) The maximum power dissipation is a function of T_{Jmax}, θ_{JA}, and T_A. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{Jmax} - T_A)/\theta_{JA}$. If this dissipation is exceeded, the die temperature will rise above 150°C and the SM74501 will go into thermal shutdown.

Equivalent Schematic Diagram



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