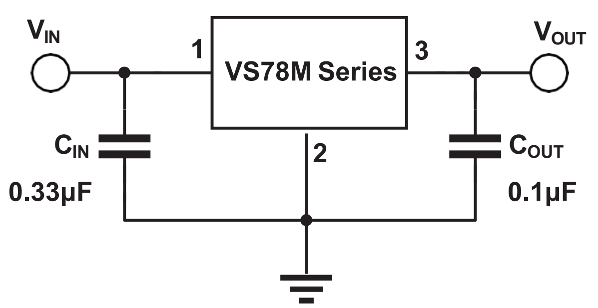
VS78M Series Three Terminal Positive Voltage Regulators

1 Introduction

The VS78M series is a group of three terminal positive voltage linear regulators with multiple fixed output voltages. In the case of good heat dissipation, it can provide an output current of 500mA, and has internal short-circuit protection and thermal shutdown protection, which makes it not affected by overload. In addition to being used as fixed voltage regulators, these devices can also be used with external components to obtain adjustable output voltage and current, and can also be used as power transmission elements in precision regulators.

2 Available Packages

PART NUMBER	PACKAGES
VS78M Series	TO-220-3L
	TO-251-3L
	TO-251S
	TO-252-2L



Fixed Output Voltage Regulator

3 Features

- Output Current:
  up to 500mA at T_J = 25°C
- Available Output Fixed Voltage:
  5.0V, 6.0V, 8.0V, 9.0V and 12V
- Output Voltage Tolerance:
  ±3% at T_J = 25°C
  ±5% over the Operating T_J
- Line Regulation:
  3.0 ~ 10mV (Typ.) at T_J = 25°C
- Load Regulation:
  15 ~ 25mV (Typ.) at T_J = 25°C
- Dropout Voltage: 2.0V@350mA
- Power Supply Rejection Ratio:
  80dB@120Hz (Typ.)
- Operating Junction Temperature:
  -40 ~ 125°C
- Built-in Current Limit
- Short Circuit Protection
- Thermal Shutdown Protection

4 Applications

- Appliances and White Goods
- Building Automation
- Computing & Servers
- Electronic Point-of-sale
- Motor Drives
- On-Card Regulation
- Portable Devices
- Telecommunications
- TVs and Set-top Boxes

5 Orderable Information

Note:

ECO PLAN: For the RoHS and Green certification standards of this product, please refer to the official report provided by JSVS.

MSL: Moisture Sensitivity Level. Determined according to JEDEC industry standard classification.

SORT: Specifically defined as follows:

Active: Recommended for new products;

Customized: Products manufactured to meet the specific needs of customers;

Preview: The device has been released and has not been fully mass produced. The sample may or may not be available;

NoRD: It is not recommended to use the device for new design. The device is only produced for the needs of existing customers;

Obsolete: The device has been discontinued.

7 Specifications

7.1 Absolute Maximum Ratings

(over operating free-air temperature range, unless otherwise specified)(1)

<table>
<tr><th colspan="3">CHARACTERISTIC</th><th>SYMBOL</th><th>VALUE</th><th>UNIT</th></tr>
<tr><td colspan="3">Maximum input voltage(2)</td><td>V_{IN}</td><td>35</td><td>V</td></tr>
<tr><td rowspan="4">Maximum power dissipation</td><td rowspan="4">VS78M Series</td><td>TO-220-3L</td><td rowspan="4">$P_{D\ Max}$</td><td rowspan="4">Internally Limited(3)</td><td rowspan="4">W</td></tr>
<tr><td>TO-251-3L</td></tr>
<tr><td>TO-251S</td></tr>
<tr><td>TO-252-2L</td></tr>
<tr><td colspan="3">Maximum junction temperature</td><td>$T_{J\ Max}$</td><td>150</td><td>°C</td></tr>
<tr><td colspan="3">Storage temperature</td><td>T_{stg}</td><td>-65 ~ 150</td><td>°C</td></tr>
<tr><td colspan="3">Soldering temperature & time</td><td>T_{solder}</td><td>260°C, 10s</td><td>-</td></tr>
</table>

(1) Stresses beyond those listed under *Absolute Maximum Rating*s may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute maximum rated conditions for extended periods may affect device reliability.
(2) All voltages are with respect to network ground terminal.
(3) Refer to *Thermal Information* for details.

7.2 Recommended Operating Conditions

PARAMETER	SYMBOL	MIN.	NOM.	MAX.	UNIT
Operating junction temperature	T_J	-40	-	125	°C
Operating ambient temperature	T_A	-	-(4)	-	°C

(4) It is necessary to ensure that the operating junction temperature of the equipment does not exceed the rated value of the recommended operating conditions when using the device for design.

7 Specifications

7.3 ESD Ratings

ESD RATINGS		SYMBOL	VALUE	UNIT
Electrostatic discharge(5)	Human body model	$V_{ESD-HBM}$	2000	V
	Machine model	V_{ESD-MM}	200	

(6) ESD testing is conducted in accordance with the relevant specifications formulated by the Joint Electronic Equipment Engineering Commission (JEDEC). The human body mode (HBM) electrostatic discharge test is based on the JESD22-114D test standard, using a 100pF capacitor and discharging to each pin of the device through a resistance of 1.5kΩ. The electrostatic discharge test in mechanical mode (MM) is based on the JESD22-A115-A test standard and uses a 200pF capacitor to discharge directly to each pin of the device.

7.4 Thermal Information

THERMAL METRIC(6)	SYMBOL	VS78M Series				UNIT
		TO-220-3L	TO-251-3L	TO-251S	TO-252-2L	
Junction-to-ambient thermal resistance	$R_{\Theta JA}$	66.7	80.0	80.0	80.0	°C/W
Junction-to-case thermal resistance	$R_{\Theta JC}$	5.5	9.0	9.5	6.0	°C/W
Reference maximum power dissipation	$P_{D\ Ref}$	1.50	1.25	1.25	1.25	W

(6) Thermal metric is measured in still air with T_A = 25°C and installed on a 1 in^2 FR-4 board covered with 2 ounces of copper, the thermal resistance test of TO-220-3L packages did not add additional radiators.

7 Specifications

7.5 Electrical Characteristics

VS78M05 (V_{IN} = 10V, I_{OUT} = 350mA, C_{IN} = 0.33μF, C_{OUT} = 0.1μF, T_J = 25°C, unless otherwise specified)

CHARACTERISTIC	SYMBOL	TEST CONDITIONS(7)	MIN.	TYP.(8)	MAX.	UNIT
Output voltage(9)	V_{OUT}	-	4.85	5.00	5.15	V
		V_{IN} = 7 to 20V, I_{OUT} = 5 to 350mA	4.75	5.00	5.25	
Line regulation	LNR	V_{IN} = 7 to 25V, I_{OUT} = 200mA	-	3.0	100	mV
		V_{IN} = 8 to 25V, I_{OUT} = 200mA	-	1.0	50	
Load regulation	LDR	I_{OUT} = 5 to 500mA	-	15	100	mV
		I_{OUT} = 5 to 200mA	-	5.0	50	
Quiescent current	I_Q	-	-	4.2	6.0	mA
Quiescent current change	ΔI_Q	V_{IN} = 8 to 25V, I_{OUT} = 200mA	-	-	0.8	mA
		I_{OUT} = 5 to 350mA	-	-	0.5	
Output noise voltage	V_N	f = 10 to 100kHz	-	40	200	μV
Ripple rejection	RR	V_{IN} = 8 to 18V, I_{OUT} = 300mA, f = 120Hz	62	80	-	dB
Dropout voltage(10)	V_D	I_{OUT} = 350mA	-	2.0	2.5	V
Short circuit current	I_{SC}	V_{IN} = 10V, OUT short to GND	-	300	-	mA
Peak current	I_{Peak}	-	-	0.5	-	A

VS78M06 (V_{IN} = 11V, I_{OUT} = 350mA, C_{IN} = 0.33μF, C_{OUT} = 0.1μF, T_J = 25°C, unless otherwise specified)

CHARACTERISTIC	SYMBOL	TEST CONDITIONS(7)	MIN.	TYP.(8)	MAX.	UNIT
Output voltage(9)	V_{OUT}	-	5.82	6.00	6.18	V
		V_{IN} = 8 to 21V, I_{OUT} = 5 to 350mA	5.70	6.00	6.30	
Line regulation	LNR	V_{IN} = 8 to 25V, I_{OUT} = 200mA	-	5.0	100	mV
		V_{IN} = 9 to 25V, I_{OUT} = 200mA	-	1.5	50	
Load regulation	LDR	I_{OUT} = 5 to 500mA	-	18	120	mV
		I_{OUT} = 5 to 200mA	-	10	60	
Quiescent current	I_Q	-	-	4.3	6.0	mA
Quiescent current change	ΔI_Q	V_{IN} = 9 to 25V, I_{OUT} = 200mA	-	-	0.8	mA
		I_{OUT} = 5 to 350mA	-	-	0.5	
Output noise voltage	V_N	f = 10 to 100kHz	-	45	-	μV
Ripple rejection	RR	V_{IN} = 9 to 19V, I_{OUT} = 300mA, f = 120Hz	59	80	-	dB
Dropout voltage(10)	V_D	I_{OUT} = 350mA	-	2.0	-	V
Short circuit current	I_{SC}	V_{IN} = 11V, OUT short to GND	-	270	-	mA
Peak current	I_{Peak}	-	-	0.5	-	A

7 Specifications

7.5 Electrical Characteristics (continued)

VS78M08 (V_{IN} = 14V, I_{OUT} = 350mA, C_{IN} = 0.33μF, C_{OUT} = 0.1μF, T_J = 25°C, unless otherwise specified)

CHARACTERISTIC	SYMBOL	TEST CONDITIONS(7)	MIN.	TYP.(8)	MAX.	UNIT
Output voltage(9)	V_{OUT}	-	7.76	8.00	8.24	V
		V_{IN} = 10.5 to 23V, I_{OUT} = 5 to 350mA	7.60	8.00	8.40	
Line regulation	LNR	V_{IN} = 10.5 to 25V, I_{OUT} = 200mA	-	6.0	100	mV
		V_{IN} = 11 to 25V, I_{OUT} = 200mA	-	2.0	50	
Load regulation	LDR	I_{OUT} = 5 to 500mA	-	20	160	mV
		I_{OUT} = 5 to 200mA	-	10	80	
Quiescent current	I_Q	-	-	4.6	6.0	mA
Quiescent current change	ΔI_Q	V_{IN} = 10.5 to 25V, I_{OUT} = 200mA	-	-	0.8	mA
		I_{OUT} = 5 to 350mA	-	-	0.5	
Output noise voltage	V_N	f = 10 to 100kHz	-	52	-	μV
Ripple rejection	RR	V_{IN} = 11.5 to 21.5V, I_{OUT} = 300mA, f = 120Hz	56	80	-	dB
Dropout voltage(10)	V_D	I_{OUT} = 350mA	-	2.0	-	V
Short circuit current	I_{SC}	V_{IN} = 14V, OUT short to GND	-	250	-	mA
Peak current	I_{Peak}	-	-	0.5	-	A

78M09 (V_{IN} = 16V, I_{OUT} = 350mA, C_{IN} = 0.33μF, C_{OUT} = 0.1μF, T_J = 25°C, unless otherwise specified)

CHARACTERISTIC	SYMBOL	TEST CONDITIONS(7)	MIN.	TYP.(8)	MAX.	UNIT
Output voltage(9)	V_{OUT}	-	8.73	9.00	9.27	V
		V_{IN} = 11.5 to 24V, I_{OUT} = 5 to 350mA	8.55	9.00	9.45	
Line regulation	LNR	V_{IN} = 11.5 to 26V, I_{OUT} = 200mA	-	6.0	100	mV
		V_{IN} = 12 to 26V, I_{OUT} = 200mA	-	2.0	50	
Load regulation	LDR	I_{OUT} = 5 to 500mA	-	20	180	mV
		I_{OUT} = 5 to 200mA	-	10	90	
Quiescent current	I_Q	-	-	4.6	6.0	mA
Quiescent current change	ΔI_Q	V_{IN} = 11.5 to 26V, I_{OUT} = 200mA	-	-	0.8	mA
		I_{OUT} = 5 to 350mA	-	-	0.5	
Output noise voltage	V_N	f = 10 to 100kHz	-	60	-	μV
Ripple rejection	RR	V_{IN} = 13 to 23V, I_{OUT} = 300mA, f = 120Hz	56	80	-	dB
Dropout voltage(10)	V_D	I_{OUT} = 350mA	-	2.0	-	V
Short circuit current	I_{SC}	V_{IN} = 16V, OUT short to GND	-	250	-	mA
Peak current	I_{Peak}	-	-	0.5	-	A

7 Specifications

7.5 Electrical Characteristics (continued)

VS78M12 (V_{IN} = 19V, I_{OUT} = 350mA, C_{IN} = 0.33μF, C_{OUT} = 0.1μF, T_J = 25°C, unless otherwise specified)

CHARACTERISTIC	SYMBOL	TEST CONDITIONS(7)	MIN.	TYP.(8)	MAX.	UNIT
Output voltage(9)	V_{OUT}	-	11.64	12.00	12.36	V
		V_{IN} = 14.5 to 27V, I_{OUT} = 5 to 350mA	11.40	12.00	12.60	
Line regulation	LNR	V_{IN} = 14.5 to 30V, I_{OUT} = 200mA	-	10	100	mV
		V_{IN} = 16 to 30V, I_{OUT} = 200mA	-	3.0	50	
Load regulation	LDR	I_{OUT} = 5 to 500mA	-	25	240	mV
		I_{OUT} = 5 to 200mA	-	10	120	
Quiescent current	I_Q	-	-	4.6	6.0	mA
Quiescent current change	ΔI_Q	V_{IN} = 14.5 to 30V, I_{OUT} = 200mA	-	-	0.8	mA
		I_{OUT} = 5 to 350mA	-	-	0.5	
Output noise voltage	V_N	f = 10 to 100kHz	-	75	-	μV
Ripple rejection	RR	V_{IN} = 15 to 25V, I_{OUT} = 300mA, f = 120Hz	55	80	-	dB
Dropout voltage(10)	V_D	I_{OUT} = 350mA	-	2.0	-	V
Short circuit current	I_{SC}	V_{IN} = 19V, OUT short to GND	-	240	-	mA
Peak current	I_{Peak}	-	-	0.7	-	A

Note:

(8) Pulse test technology is used to make T_J as close to T_A as possible. Thermal effects must be considered separately.

(9) Typical numbers are at 25°C (T_J) and represent the most likely norm.

(10) This specification only applies to the DC power consumption allowed by the absolute maximum rating.

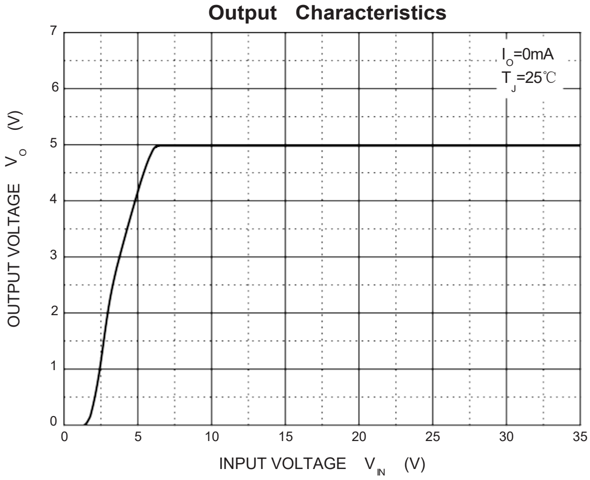
(11) The difference of output voltage and input voltage when input voltage is decreased gradually till output voltage equals to 95% of V_{OUT}.

7 Specifications

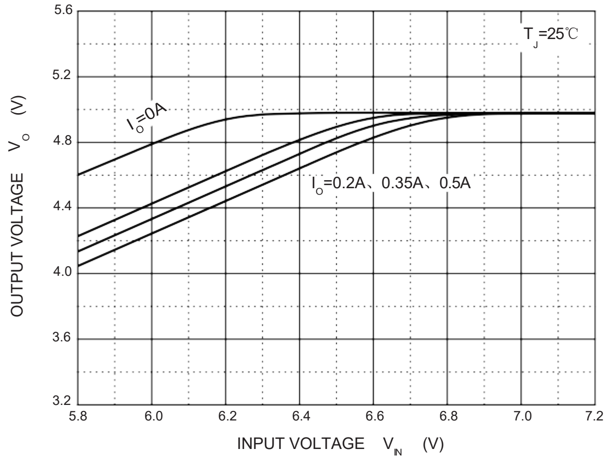
7.6 Typical Characteristics

VS78M05 (C_{IN} = 0.33µF, C_{OUT} = 0.1µF, T_J = 25°C, unless otherwise specified)

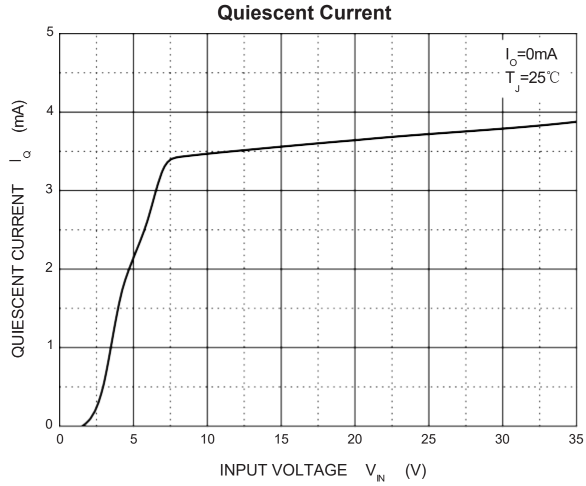
Output Characteristics



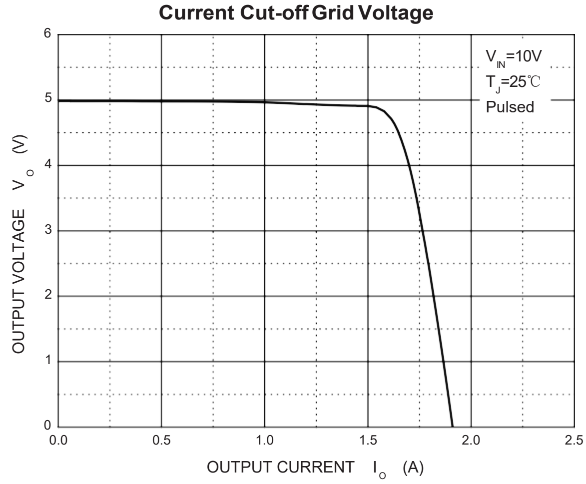
Dropout Characteristics



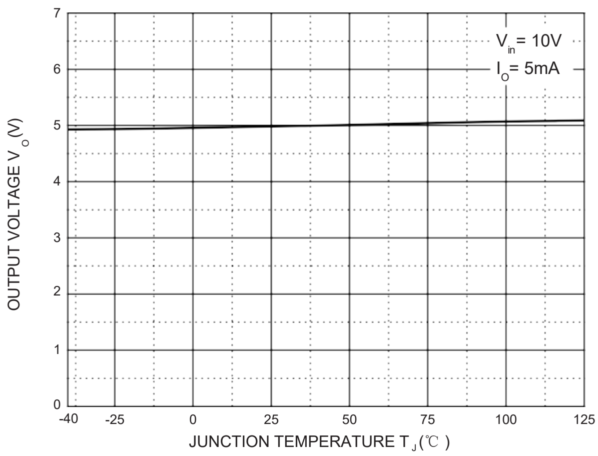
Quiescent Current



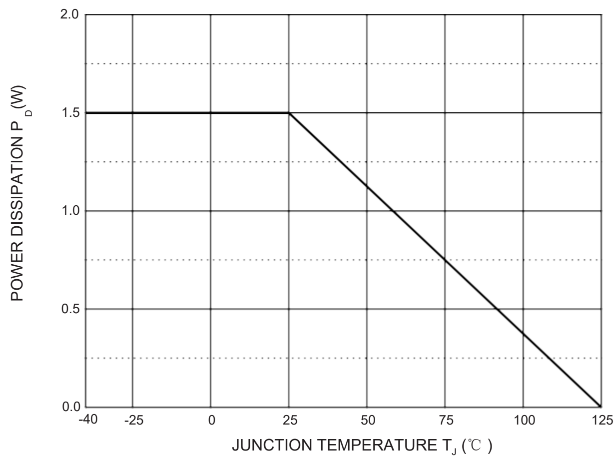
Current Cut-off Grid Voltage



Output Voltage vs Junction Temperature



Power Derating Curve

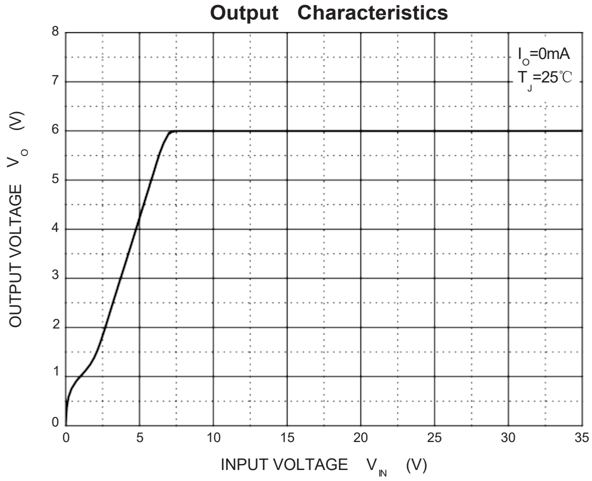


7 Specifications

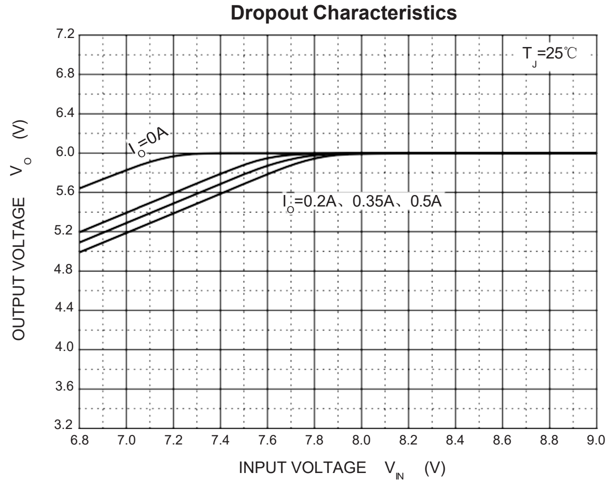
7.6 Typical Characteristics (continued)

VS78M06 (C_{IN} = 0.33µF, C_{OUT} = 0.1µF, T_J = 25°C, unless otherwise specified)

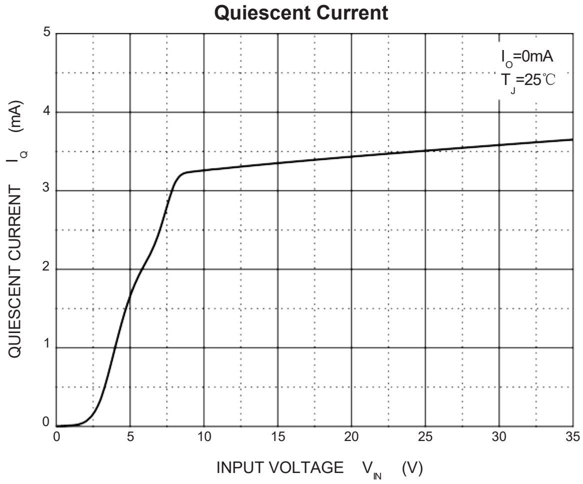
Output Characteristics



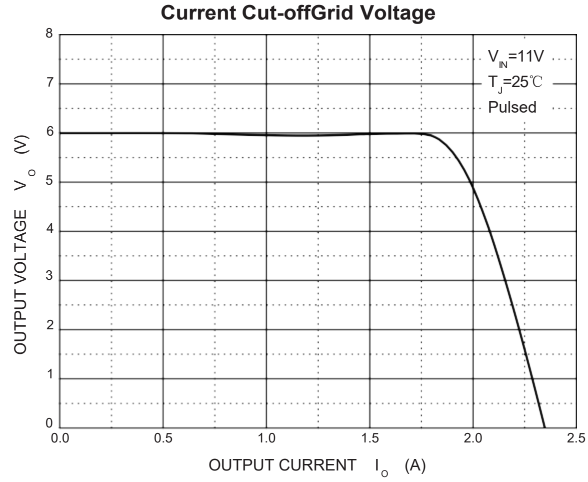
Dropout Characteristics



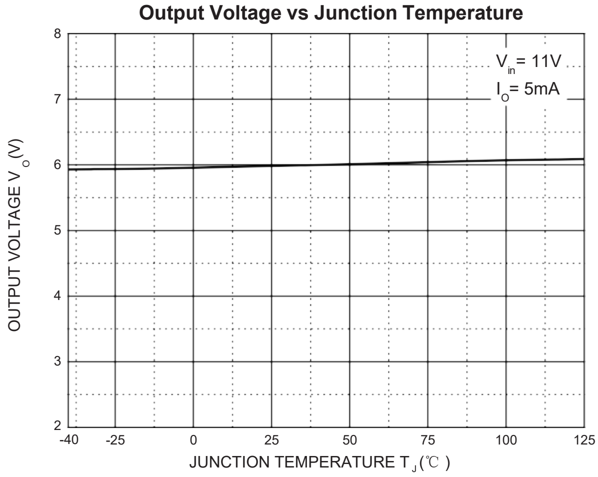
Quiescent Current



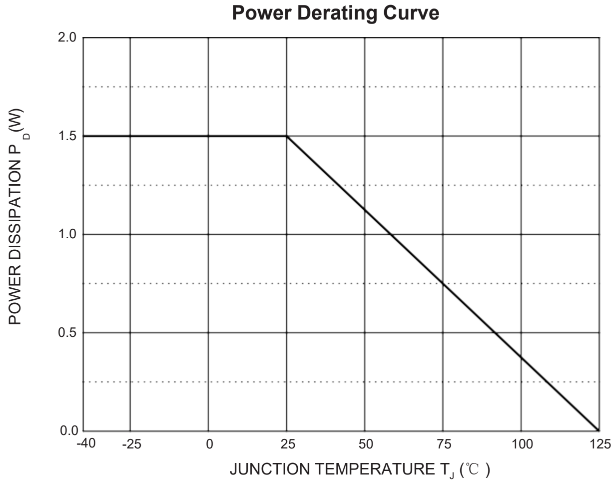
Current Cut-offGrid Voltage



Output Voltage vs Junction Temperature



Power Derating Curve

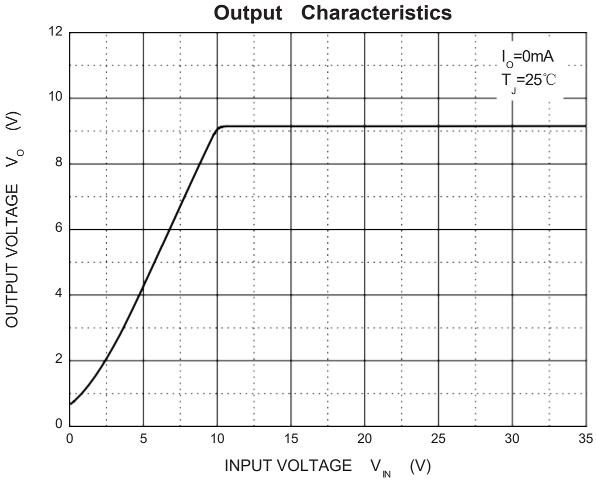


7 Specifications

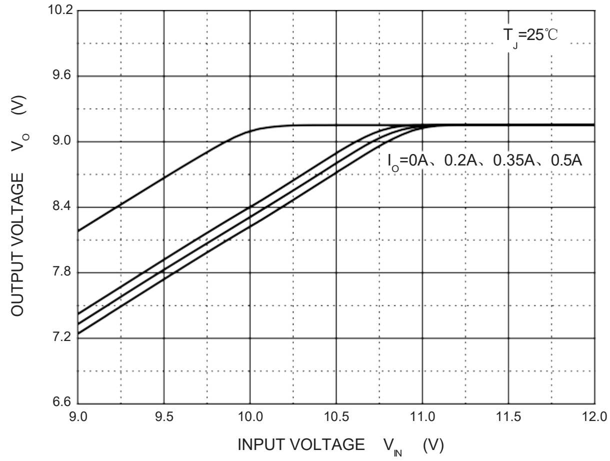
7.6 Typical Characteristics (continued)

VS78M08 (C_{IN} = 0.33μF, C_{OUT} = 0.1μF, T_J = 25°C, unless otherwise specified)

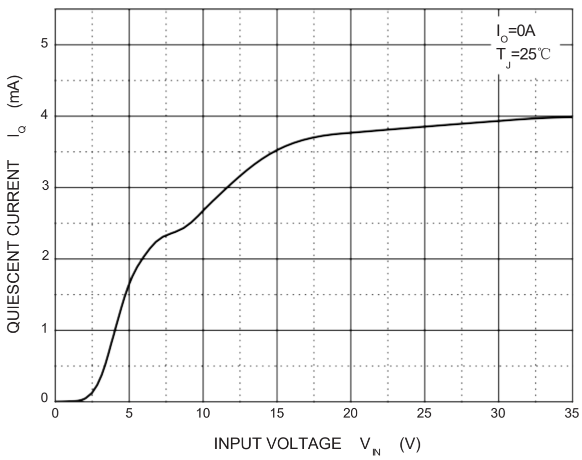
Output Characteristics



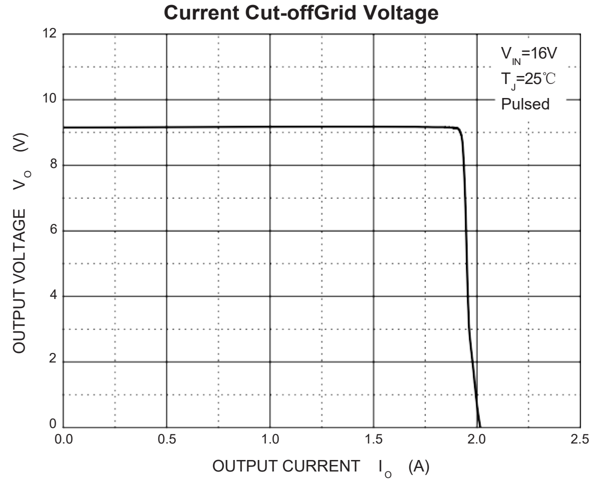
Dropout Characteristics



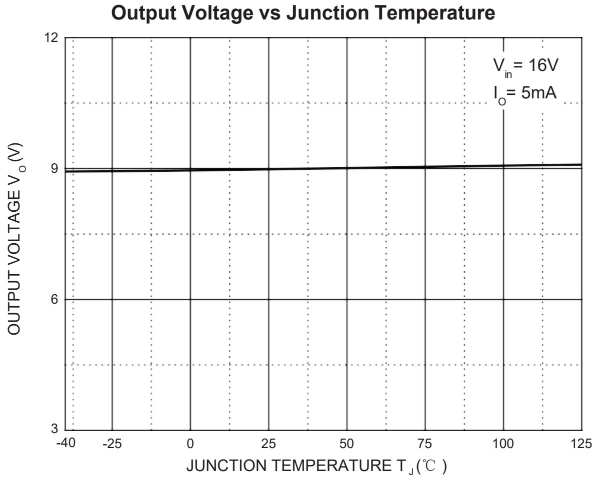
Quiescent Current



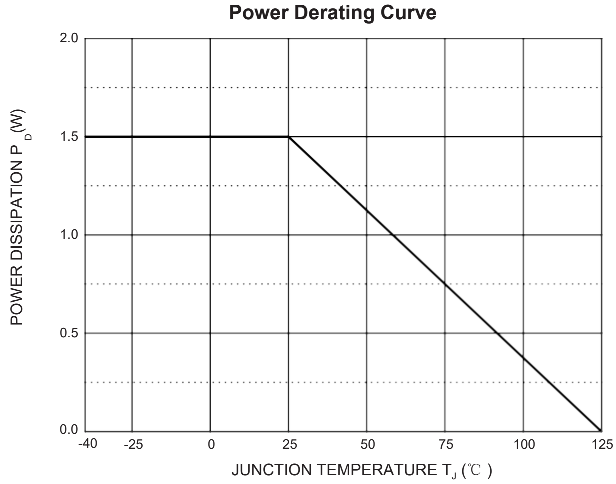
Current Cut-offGrid Voltage



Output Voltage vs Junction Temperature



Power Derating Curve

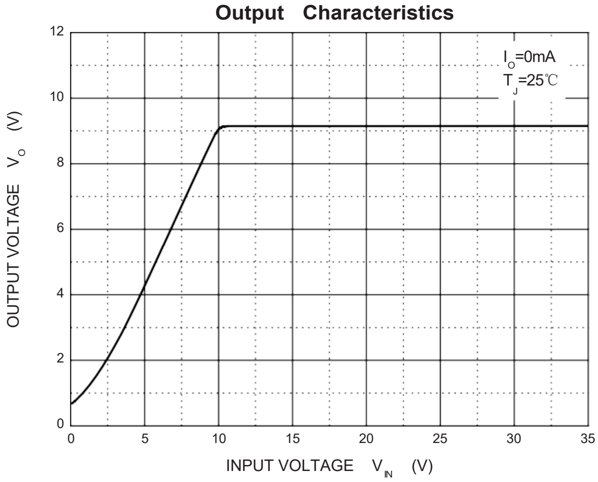


7 Specifications

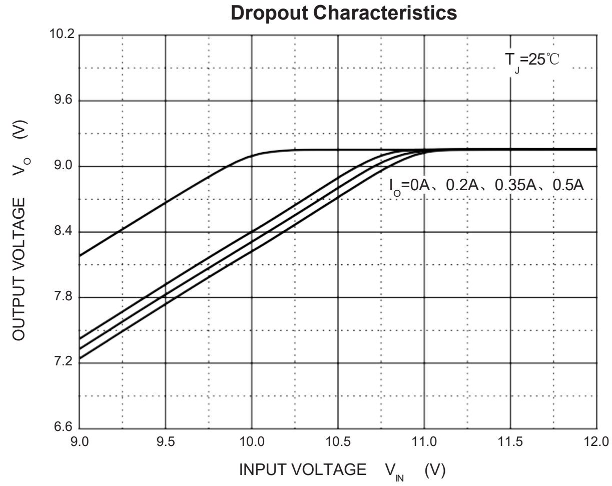
7.6 Typical Characteristics (continued)

78M09 (C_{IN} = 0.33μF, C_{OUT} = 0.1μF, T_J = 25°C, unless otherwise specified)

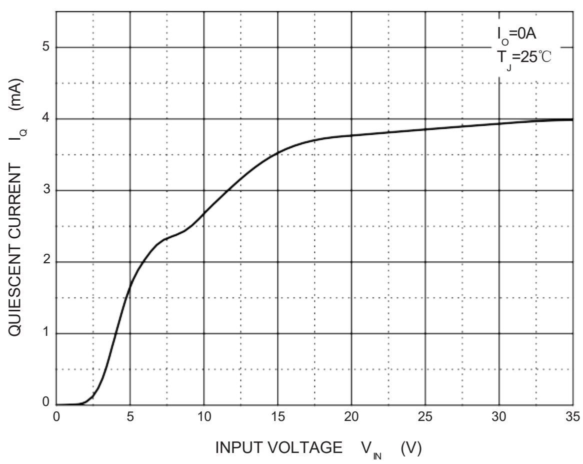
Output Characteristics



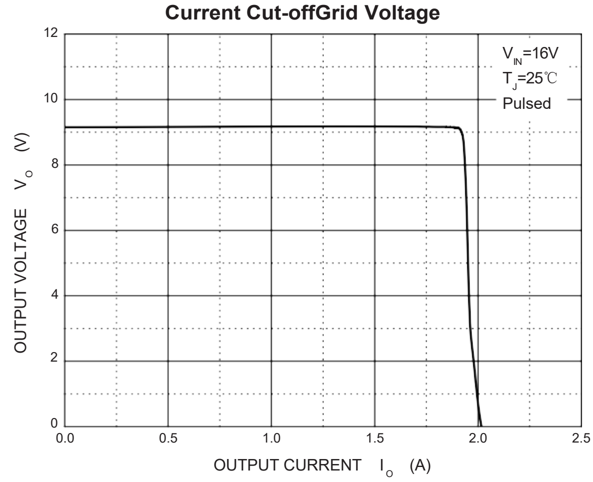
Dropout Characteristics



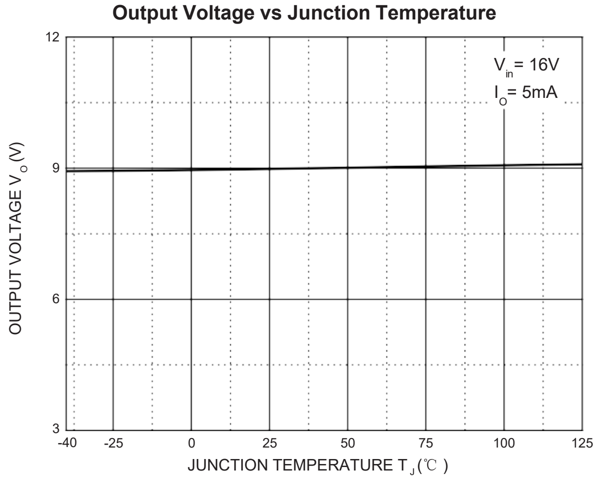
Quiescent Current



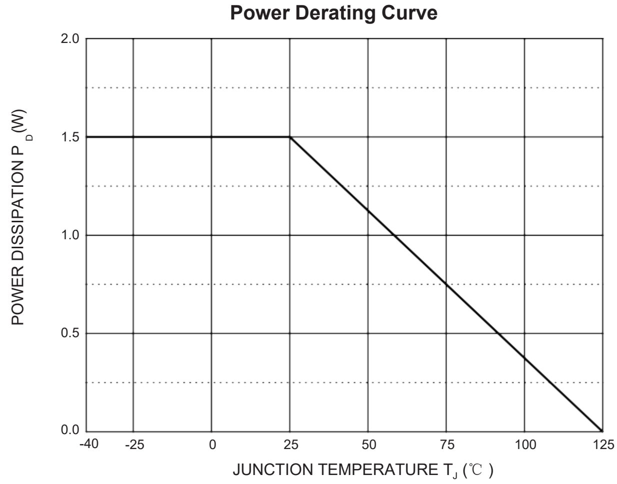
Current Cut-offGrid Voltage



Output Voltage vs Junction Temperature



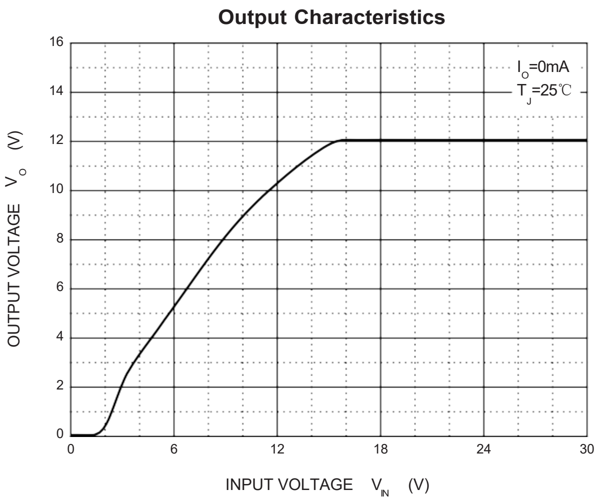
Power Derating Curve

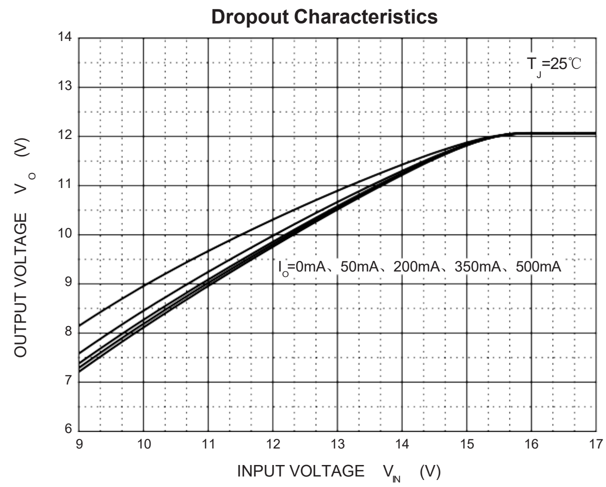


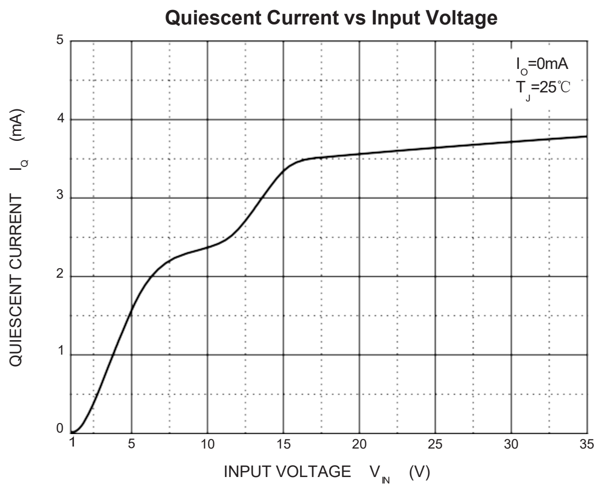
7 Specifications

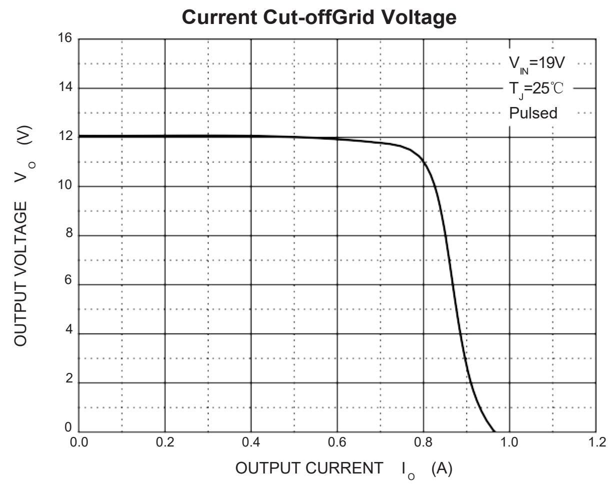
7.6 Typical Characteristics (continued)

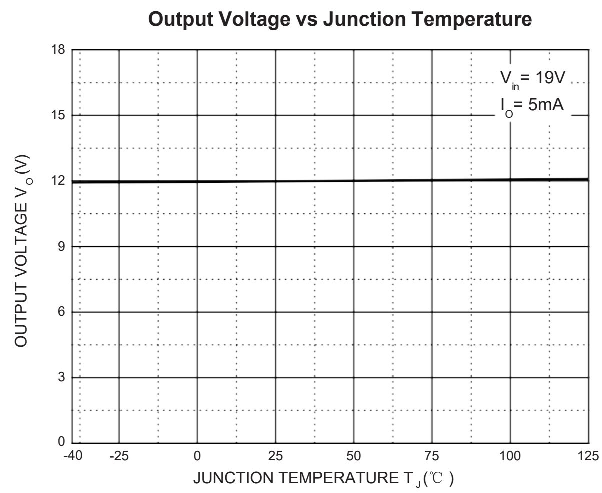
VS78M12 (C_{IN} = 0.33μF, C_{OUT} = 0.1μF, T_J = 25°C, unless otherwise specified)

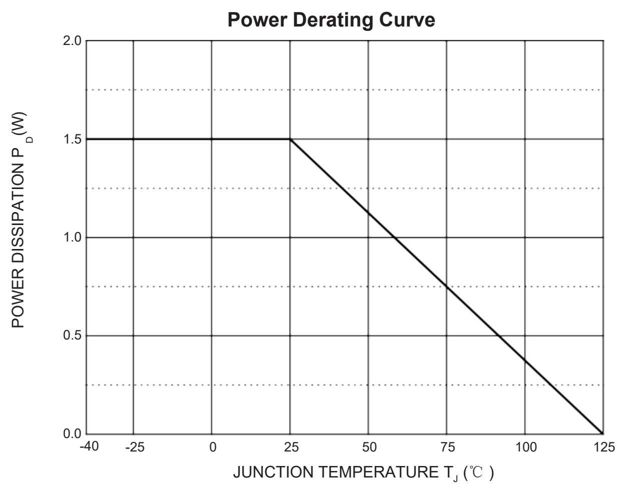










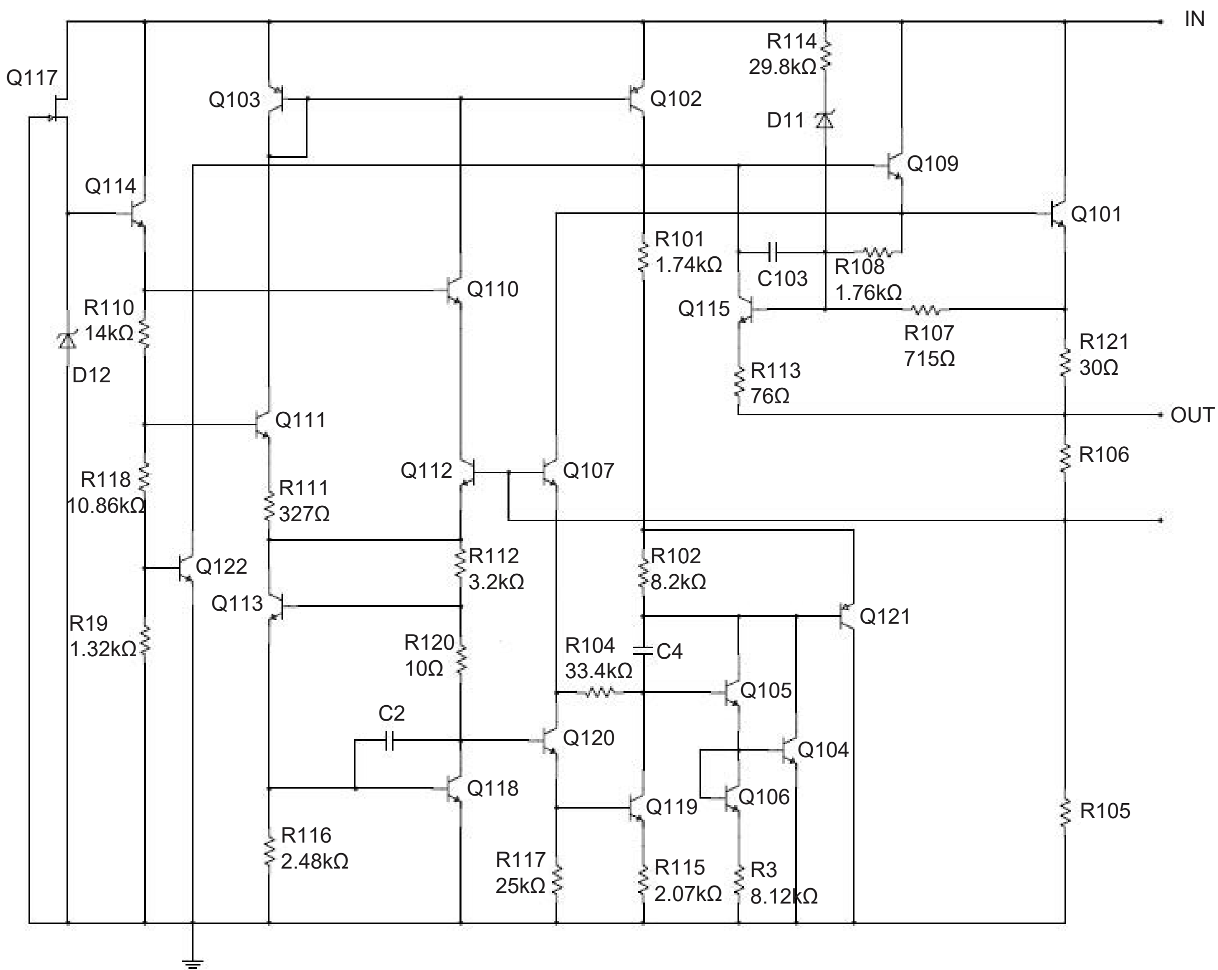


8 Detailed Description

8.1 Description

This series of fixed-voltage integrated-circuit voltage regulators is designed for a wide range of applications. The applications include on-card regulation for elimination of noise and distribution problems associated with single-point regulation. Each of these regulators can deliver up to 500mA of output current. The internal current-limiting and thermal-shutdown features of these regulators essentially make them immune to overload. In addition to use as fixed-voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents (not both) and also as the power-pass element in precision regulators.

8.2 Representative Schematic Diagram



8 Detailed Description

8.3 Feature Description

Input Voltage

When the input voltage is lower than the rated range of the data sheet, the device will lose the regulation function of stabilizing the output voltage, that is, it is unable to maintain the output voltage within the rated range. When the input voltage is higher than the rated range of the data sheet, the device may cause irreversible damage or failure due to exceeding the maximum rated range of electrical stress.

Built-in Current Limit & Short Circuit Protection

The VS78M series has built-in current limit and short circuit protection mechanism. When the output current of the device is too high, the output of the device will be shut down. When the output of the device is short circuited to ground, the output of the device will also be shut down and the output current will be maintained within a certain range.

Thermal Shutdown Protection

The VS78M series has thermal shutdown protection mechanism. If the junction temperature is allowed to rise to 145°C, the device will enter the thermal shutdown state. At this time, the output voltage of the device will be reduced to prevent catastrophic damage to the chip due to accidental heat. When the junction temperature decreases and no longer remains too high, the device will release the thermal shutdown and output normally. To ensure reliable operation, please limit the junction temperature to the specified range of *Recommended Operating Conditions* in the data sheet. Applications that exceed the recommended temperature range may cause the equipment to exceed its operating specifications.

Although the internal protection circuitry of the device is designed to protect against thermal overall conditions, this circuitry is not intended to replace proper heat sinking. Continuously running the device into thermal shutdown or above the maximum recommended junction temperature reduces long-term reliability.

Output Current

Due to the internal integration of thermal shutdown protection, in the case of large output current, the device may enter the thermal shutdown state because the junction temperature is higher than the rated value in the data sheet. Therefore, the appropriate package should be selected for circuit design according to the heat dissipation power consumption of the package and the effective connection thermal resistance with the environment, so as to make the device emit more heat energy, so as to ensure the maximum load current capacity of the device. If the circuit design is appropriate and the device has good heat dissipation conditions, the VS78M series can output a current of up to 500mA.

9 Application and Implementation

9.1 Risk Alert and Precautions

The VS78M series is designed for thermal shutdown protection, built-in current limit and output short circuit protection. However, like any IC regulator, precautions are necessary to reduce the possibility of accidental damage to the regulator. The following describes the possible causes of unit damage or failure:

Electrostatic Discharge (ESD)

Electrostatic discharge (ESD) is a common near-field hazard source. It comes from many sources, such as human body, mechanical equipment and electronic components themselves. ESD can cause phenomena such as high voltage and instantaneous high current in a very short time, resulting in damage or failure of the device due to electric shock.

Instantaneous Electrical Surge

In some applications, a short duration but high energy spike may occur in the circuit, including peak voltage and surge current. They may cause unstable operation of the regulator, accelerated aging and potential hazards, and even damage or malfunction of the regulator. These peaks are usually more likely to occur in hot-plug, switch inductance, heavy-load, and other types of circuits.

Precautions for ESD and Electrical Surge

In the practical application of the circuit, adopting the following suggestions can reduce the possibility of device failure due to the above reasons to a certain extent.

1. Place a TVS between the IN and GND of the voltage regulator to absorb the peak voltage that may be generated due to ESD or other reasons. As shown in Figure 9-1;
2. Place a resistor with appropriate resistance in series before the IN of the voltage regulator, which can help the voltage regulator share part of the energy in case of surge. The resistance value of the resistance should not be too large. The specific resistance value depends on the application of the circuit. Generally, the resistance value of this resistance does not exceed 20Ω. As shown in Figure 9-2.

For the VS78M series, it is recommended that the input voltage should not exceed 17V and the peak voltage should not exceed 35V. **When the input voltage is greater than 17V, or the peak voltage that may be greater than 35V may appear in the practical circuit, it is recommended to adopt the circuit layout shown in Figure 9-2 in the circuit design.**

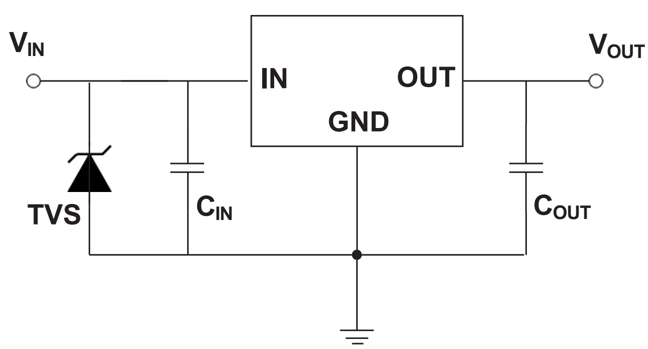


Figure 9-1. TVS is used at IN

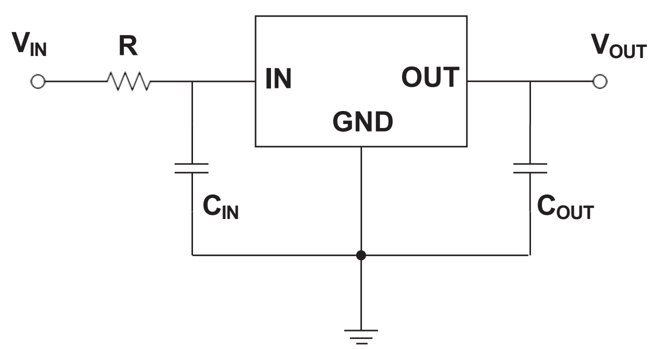


Figure 9-2. Resistance is used at IN

9 Application and Implementation

9.1 Risk Alert and Precautions (continued)

Large Output Capacitance

The VS78M series can obtain better transient response with the help of output capacitance. However, if the output capacitor is relatively large, the surge current generated by the charging of the output capacitor will also be large at the moment of power on of the regulator, and the large surge current passing through the regulator may damage the internal circuit. When the output capacitance is large, adopting the circuit design shown in Figure 9-2 will reduce the possibility of damage to the device due to large surge current to a certain extent. It is recommended that the selection of output capacitor should not exceed 20μF. **If the selection of output capacitor exceeds 20μF, it is recommended to adopt the circuit design in Figure 9-2 to reduce the possibility of accidental failure of the device due to large surge current during power on.**

9.2 Bypass Capacitance Selection

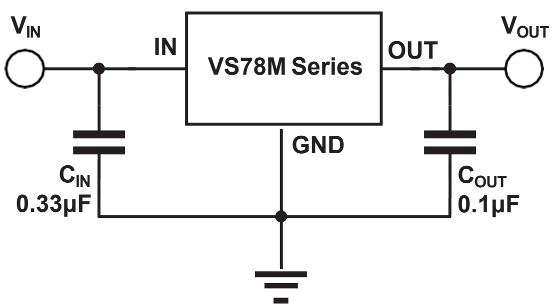
A capacitance between IN and GND (C_{IN}) is required if the regulator is located far from the power supply filter. It is recommended to use a 0.33μF capacitor for C_{IN}, and the capacitor (C_{IN}) should be placed as close to the device IN pin and GND pin as possible.

It is recommended to use a 0.1μF capacitor between OUT and GND (C_{OUT}), and the capacitor should be placed as close as possible between OUT and GND. The output capacitance can limit the high-frequency noise and help the device obtain the best stability and transient response.

The tolerance and temperature coefficient of the input and output capacitor (C_{IN} and C_{OUT}) must be considered to ensure that the capacitor can work normally within the rated working ambient temperature and rated working conditions of the equipment.

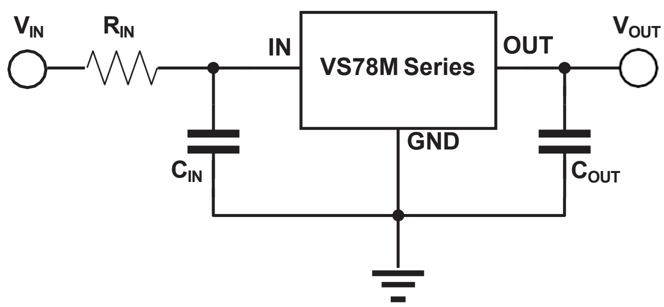
It is recommended that the output capacitor (C_{OUT}) should not exceed 20μF. When the output capacitor (C_{OUT}) exceeds 20μF, it is recommended to use the circuit layout shown in Figure 9-2. See *Large Output Capacitance* for more details.

9.3 System Example



(1) Conventional Circuit

Used for the normal form of circuit



(2) Resistance are used at IN

Used for circuits that may have large electrical surges or use large capacitors

Figure 9-3. Fixed Output Regulator