VS78M00E Series Three Terminal Positive Voltage Regulator

1 Introduction

The VS78M00E 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	PACKAGE
VS78M00ESeries	TO-220-3L(A)
	TO-251-3L
	TO-251S
	TO-252-2L/TO-252-2L(B)

Note: For more detailed packaging information, see the part *Pin Configuration and Function* and the part *Mechanical Information*.

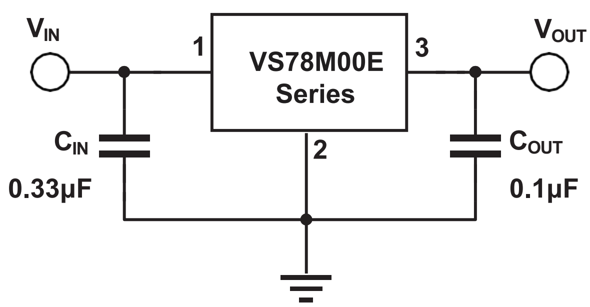


Figure 2-1. Fixed Output Voltage Regulator

3 Features

- Output Current:
  up to 500mA at T_J = 25°C
- Available Output Fixed Voltage: 5.0V,
- Output Voltage Tolerance at T_J = 25°C:
  ±2% for Conventional Device
  ±1% can be Customized
  ±5% over the Operating T_J
- Dropout Voltage: 2.0V@350mA
- Power Supply Rejection Ratio:
  70dB@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

6 Specifications

6.1 Absolute Maximum Ratings(1)

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

<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="5">Maximum power dissipation</td><td rowspan="5">VS78M00E Series</td><td>TO-220-3L(A)</td><td rowspan="5">$P_{D\ Max}$</td><td rowspan="5">Internally Limited(3)</td><td rowspan="5">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>TO-252-2L(B)</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 Ratings* 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.

6.2 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.

6 Specifications

6.3 ESD Ratings

ESD RATINGS		SYMBOL	VALUE	UNIT
Electrostatic discharge[5]	Human body model	$V_{ESD\text{-}HBM}$	6000	V

(5) 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 JESD22-115-A test standard and uses a 200pF capacitor to discharge directly to each pin of the device.

6.4 Thermal Information

THERMAL METRIC[6]	SYMBOL	VS78M00E Series		UNIT
Junction-to-ambient thermal resistance	$R_{\Theta JA}$	**TO-220-3L(A)**	**TO-251-3L**	°C/W
		66.7	80.0	
		TO-251S	**TO-252-2L**	
		80.0	80.0	
		TO-252-2L(B)		
		80.0		
Reference maximum power dissipation for continuous operation	$P_{D\ Ref}$	**TO-220-3L**	**TO-251-3L**	W
		1.50	1.25	
		TO-251S	**TO-252-2L**	
		1.25	1.25	
		TO-252-2L(B)		
		1.25		

(6) T_A = 25°C, the thermal resistance test of TO-220-3L packages did not add additional radiators, see the part *Notes* for more information about thermal metrics.

6 Specifications

6.5 Electrical Characteristics

VS78M05E (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}	T_J = 25°C, ±2% grade(10)	4.90	5.00	5.10	V
		T_J = 25°C, ±1% grade(10)	4.95		5.05	
		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	-	6.0	100	mV
		V_{IN} = 8 to 25V, I_{OUT} = 200mA	-	2.0	50	
Load regulation	LDR	I_{OUT} = 5 to 500mA	-	15	100	mV
		I_{OUT} = 5 to 200mA	-	5.0	50	
Quiescent current	I_Q	-	-	3.3	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	-	μV
Ripple rejection	RR	V_{IN} = 8 to 18V, I_{OUT} = 300mA, f = 120Hz	-	70	-	dB
Dropout voltage(11)	V_D	I_{OUT} = 350mA	-	2.0	-	V
Short circuit current	I_{SC}	V_{IN} = 10V, OUT short to GND	-	400	-	mA
Peak current	I_{Peak}	-	-	0.9	-	A

Note:

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

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

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

(10) ±2% for conventional device, ±1% can be customized.

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

6 Specifications

6.5 Electrical Characteristics

VS78M06E (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}	T_J = 25°C	±2% grade[10]	5.88	6.00	6.12	V
			±1% grade[10]	5.94		6.06	
		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		-	6.0	100	mV
		V_{IN} = 9 to 25V, I_{OUT} = 200mA		-	2.0	50	
Load regulation	LDR	I_{OUT} = 5 to 500mA		-	18	120	mV
		I_{OUT} = 5 to 200mA		-	8.0	60	
Quiescent current	I_Q	-		-	3.3	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		-	70	-	dB
Dropout voltage[11]	V_D	I_{OUT} = 350mA		-	2.0	-	V
Short circuit current	I_{SC}	V_{IN} = 11V, OUT short to GND		-	380	-	mA
Peak current	I_{Peak}	-		-	0.9	-	A

Note:

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

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

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

(10) ±2% for conventional device, ±1% can be customized.

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

6 Specifications

6.5 Electrical Characteristics

VS78M08E (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}	T_J = 25°C	±2% grade[10]	7.84	8.00	8.16	V
			±1% grade[10]	7.92		8.08	
		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	-		-	3.3	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		-	70	-	dB
Dropout voltage[11]	V_D	I_{OUT} = 350mA		-	2.0	-	V
Short circuit current	I_{SC}	V_{IN} = 14V, OUT short to GND		-	380	-	mA
Peak current	I_{Peak}	-		-	0.9	-	A

Note:

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

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

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

(10) ±2% for conventional device, ±1% can be customized.

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

6 Specifications

6.5 Electrical Characteristics

VS78M09E (V_{IN} = 15V, 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}	T_J = 25°C	±2% grade(10)	8.82	9.00	9.18	V
			±1% grade(10)	8.91		9.09	
		V_{IN} = 11.5 to 22V, I_{OUT} = 5 to 350mA		8.55	9.00	9.45	
Line regulation	LNR	V_{IN} = 11.5 to 25V, I_{OUT} = 200mA		-	8.0	100	mV
		V_{IN} = 12 to 25V, I_{OUT} = 200mA		-	3.0	50	
Load regulation	LDR	I_{OUT} = 5 to 500mA		-	20	180	mV
		I_{OUT} = 5 to 200mA		-	10	90	
Quiescent current	I_Q	-		-	3.3	6.0	mA
Quiescent current change	ΔI_Q	V_{IN} = 11.5 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} = 12.5 to 23V, I_{OUT} = 300mA, f = 120Hz		-	68	-	dB
Dropout voltage(11)	V_D	I_{OUT} = 350mA		-	2.0	-	V
Short circuit current	I_{SC}	V_{IN} = 15V, OUT short to GND		-	360	-	mA
Peak current	I_{Peak}	-		-	0.9	-	A

Note:

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

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

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

(10) ±2% for conventional device, ±1% can be customized.

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

6 Specifications

6.5 Electrical Characteristics

VS78M10E (V_{IN} = 16V, I_{OUT} = 350mA, C_{IN} = 0.33μF, C_{OUT} = 0.1μF, T_J = 25°C, unless otherwise specified)

<table>
<tr><th>CHARACTERISTIC</th><th>SYMBOL</th><th colspan="2">TEST CONDITIONS(7)</th><th>MIN.</th><th>TYP.(8)</th><th>MAX.</th><th>UNIT</th></tr>
<tr><td rowspan="3">Output voltage(9)</td><td rowspan="3">V_{OUT}</td><td rowspan="2">T_J = 25°C</td><td>±2% grade(10)</td><td>9.80</td><td rowspan="2">10.00</td><td>10.20</td><td rowspan="3">V</td></tr>
<tr><td>±1% grade(10)</td><td>9.90</td><td>10.10</td></tr>
<tr><td colspan="2">V_{IN} = 13 to 30V,
I_{OUT} = 5 to 350mA</td><td>9.50</td><td>10.00</td><td>10.50</td></tr>
<tr><td rowspan="2">Line regulation</td><td rowspan="2">LNR</td><td colspan="2">V_{IN} = 12.5 to 30V, I_{OUT} = 200mA</td><td>-</td><td>9.0</td><td>100</td><td rowspan="2">mV</td></tr>
<tr><td colspan="2">V_{IN} = 13 to 30V, I_{OUT} = 200mA</td><td>-</td><td>3.0</td><td>50</td></tr>
<tr><td rowspan="2">Load regulation</td><td rowspan="2">LDR</td><td colspan="2">I_{OUT} = 5 to 500mA</td><td>-</td><td>22</td><td>200</td><td rowspan="2">mV</td></tr>
<tr><td colspan="2">I_{OUT} = 5 to 200mA</td><td>-</td><td>10</td><td>100</td></tr>
<tr><td>Quiescent current</td><td>I_Q</td><td colspan="2">-</td><td>-</td><td>3.3</td><td>6.0</td><td>mA</td></tr>
<tr><td rowspan="2">Quiescent current change</td><td rowspan="2">ΔI_Q</td><td colspan="2">V_{IN} = 12.5 to 30V, I_{OUT} = 200mA</td><td>-</td><td>-</td><td>0.8</td><td rowspan="2">mA</td></tr>
<tr><td colspan="2">I_{OUT} = 5 to 350mA</td><td>-</td><td>-</td><td>0.5</td></tr>
<tr><td>Output noise voltage</td><td>V_N</td><td colspan="2">f = 10 to 100kHz</td><td>-</td><td>64</td><td>-</td><td>μV</td></tr>
<tr><td>Ripple rejection</td><td>RR</td><td colspan="2">V_{IN} = 13.5 to 24V, I_{OUT} = 300mA, f = 120Hz</td><td>-</td><td>68</td><td>-</td><td>dB</td></tr>
<tr><td>Dropout voltage(11)</td><td>V_D</td><td colspan="2">I_{OUT} = 350mA</td><td>-</td><td>2.0</td><td>-</td><td>V</td></tr>
<tr><td>Short circuit current</td><td>I_{SC}</td><td colspan="2">V_{IN} = 16V, OUT short to GND</td><td>-</td><td>360</td><td>-</td><td>mA</td></tr>
<tr><td>Peak current</td><td>I_{Peak}</td><td colspan="2">-</td><td>-</td><td>0.9</td><td>-</td><td>A</td></tr>
</table>

Note:

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

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

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

(10) ±2% for conventional device, ±1% can be customized.

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

6 Specifications

6.5 Electrical Characteristics

VS78M12E (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}	T_J = 25°C	±2% grade(10)	11.76	12.00	12.24	V
			±1% grade(10)	11.88		12.12	
		V_{IN} = 14.5 to 26V, 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		-	4.0	50	
Load regulation	LDR	I_{OUT} = 5 to 500mA		-	25	240	mV
		I_{OUT} = 5 to 200mA		-	10	120	
Quiescent current	I_Q	-		-	3.3	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		-	66	-	dB
Dropout voltage(11)	V_D	I_{OUT} = 350mA		-	2.0	-	V
Short circuit current	I_{SC}	V_{IN} = 19V, OUT short to GND		-	320	-	mA
Peak current	I_{Peak}	-		-	0.9	-	A

Note:

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

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

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

(10) ±2% for conventional device, ±1% can be customized.

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

6 Specifications

6.5 Electrical Characteristics

VS78M15E (V_{IN} = 23V, 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}	T_J = 25°C	±2% grade[10]	14.70	15.00	15.30	V
			±1% grade[10]	14.85		15.15	
		V_{IN} = 17.5 to 27V, I_{OUT} = 5 to 350mA		14.25	15.00	15.75	
Line regulation	LNR	V_{IN} = 17.5 to 30V, I_{OUT} = 200mA		-	12	100	mV
		V_{IN} = 20 to 30V, I_{OUT} = 200mA		-	5.0	50	
Load regulation	LDR	I_{OUT} = 5 to 500mA		-	27	300	mV
		I_{OUT} = 5 to 200mA		-	11	150	
Quiescent current	I_Q	-		-	3.3	6.0	mA
Quiescent current change	ΔI_Q	V_{IN} = 17.5 to 30V, I_{OUT} = 200mA		-	-	0.8	mA
		I_{OUT} = 5 to 350mA		-	-	0.5	
Output noise voltage	V_N	f = 10 to 100kHz		-	90	-	μV
Ripple rejection	RR	V_{IN} =18.5 to 28.5V, I_{OUT} = 300mA, f = 120Hz		-	65	-	dB
Dropout voltage[11]	V_D	I_{OUT} = 350mA		-	2.0	-	V
Short circuit current	I_{SC}	V_{IN} = 23V, OUT short to GND		-	300	-	mA
Peak current	I_{Peak}	-		-	0.9	-	A

Note:

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

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

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

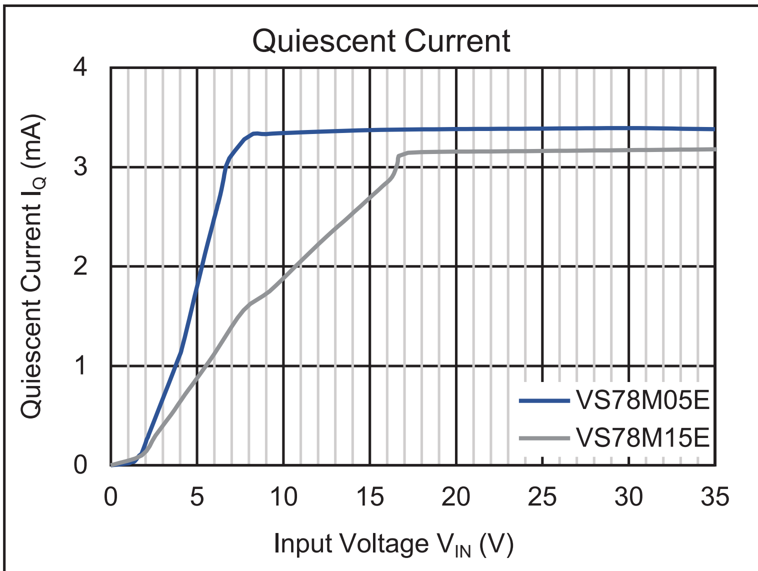
(10) ±2% for conventional device, ±1% can be customized.

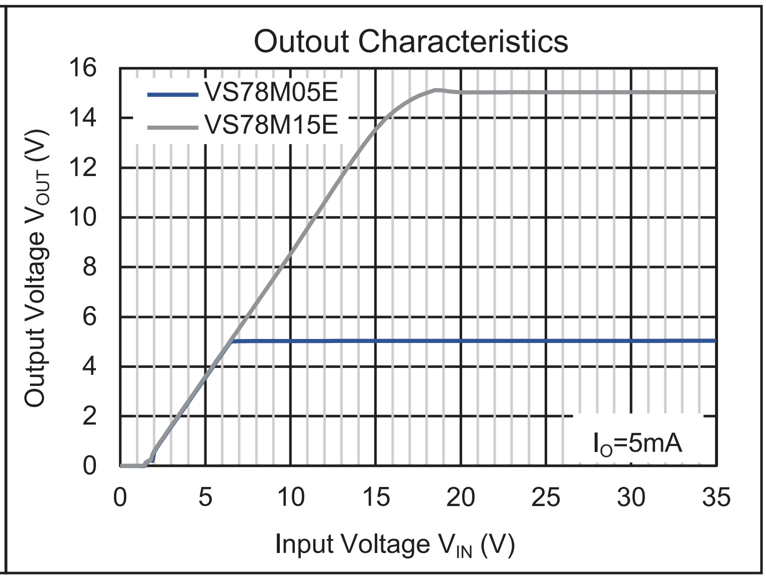
(11) The difference of output voltage and input voltage when input voltage is decreased gradually till output voltage equals to 95% of V_{OUT}.

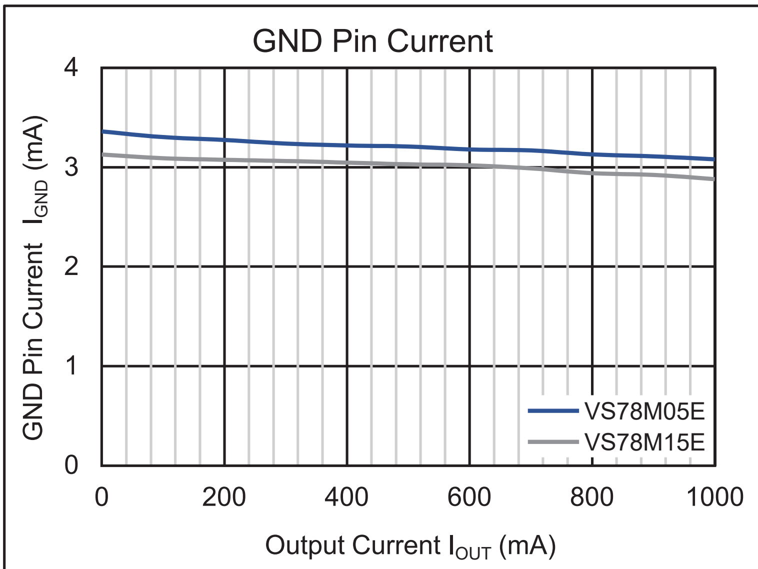
6 Specifications

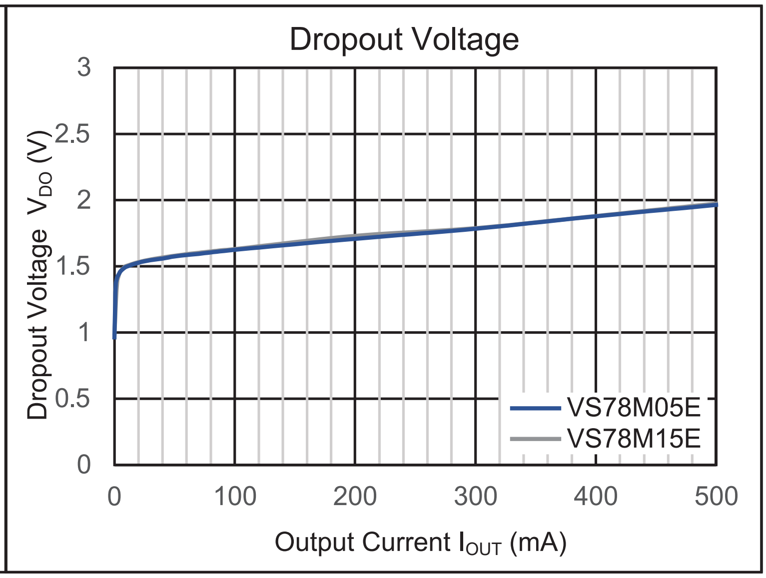
6.6 Typical Characteristics

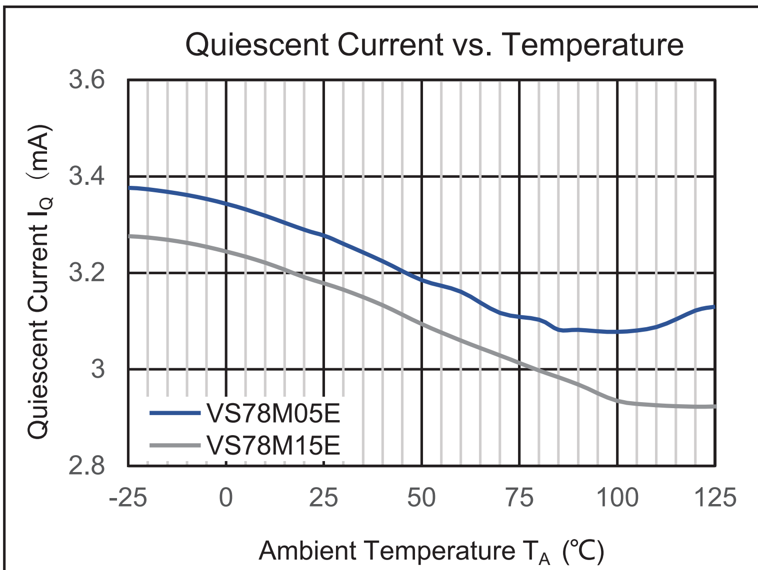
VS78M05E (C_{IN} = 0.33μF, C_{OUT} = 0.1μF, T_J = 25°C, unless otherwise specified)

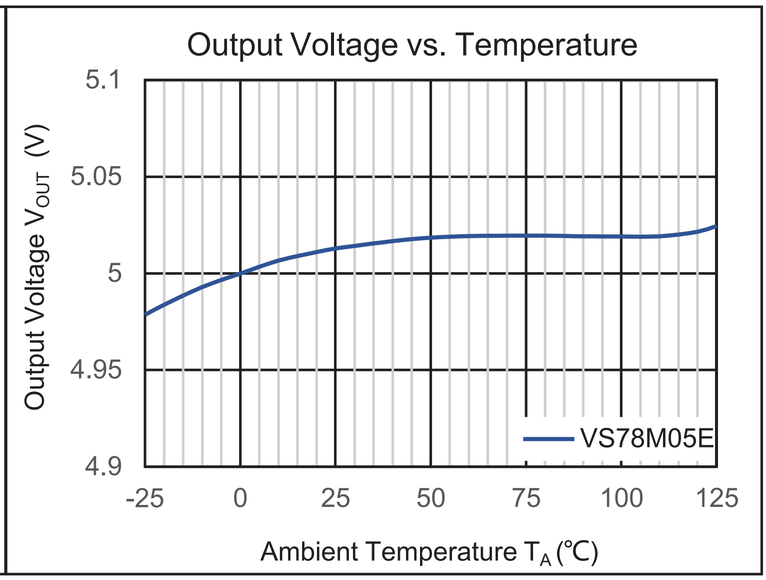








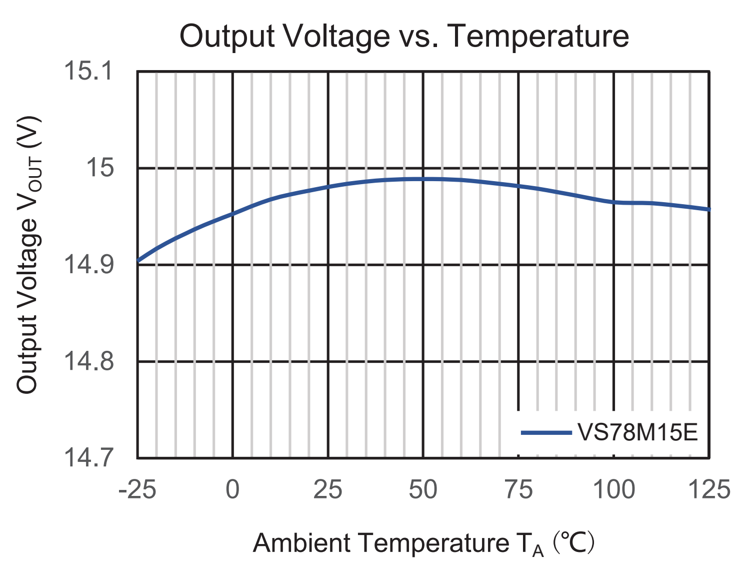


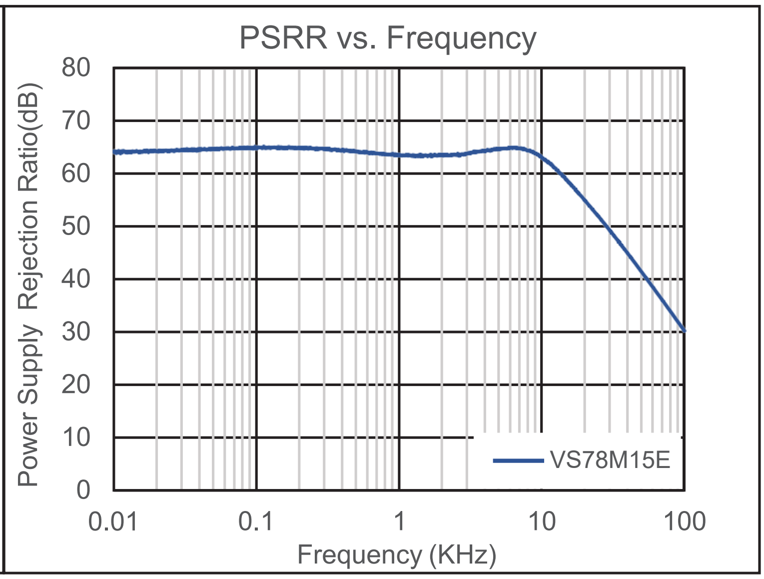


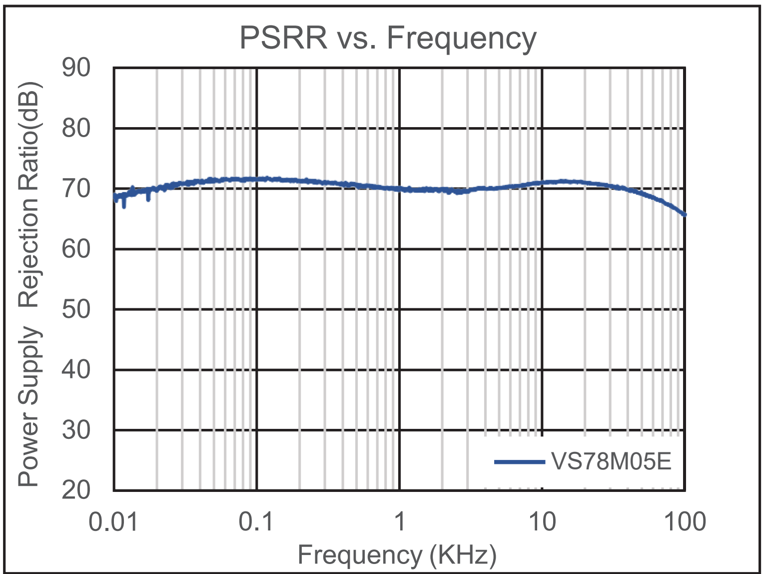
6 Specifications

6.6 Typical Characteristics (continued)

VS78M05E (C_{IN} = 0.33μF, C_{OUT} = 0.1μF, T_J = 25°C, unless otherwise specified)







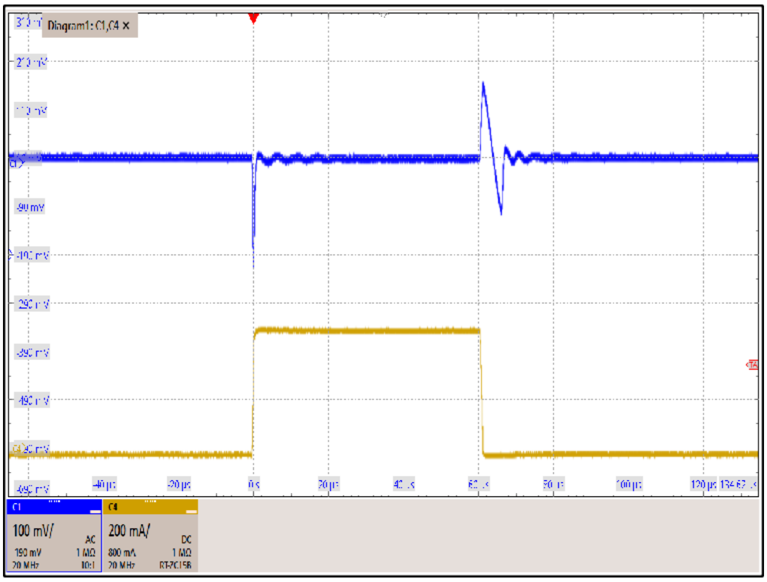
6 Specifications

6.6 Typical Characteristics (continued)

VS78M05E (C_{IN} = 0.33μF, C_{OUT} = 0.1μF, T_J = 25°C, unless otherwise specified)

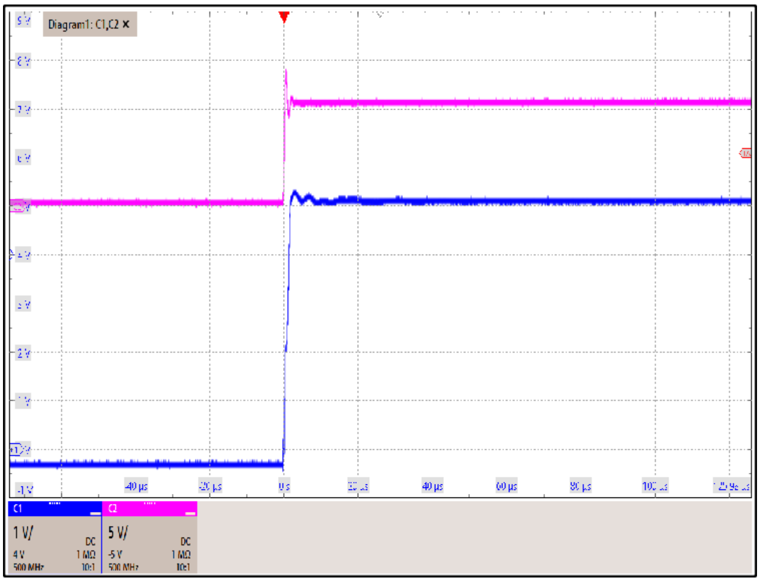
Load Transient

VS78M05E, V_{IN} = 10V, I_{OUT} = 5 ~ 500mA (CH1: V_{OUT}, CH4: I_{OUT})



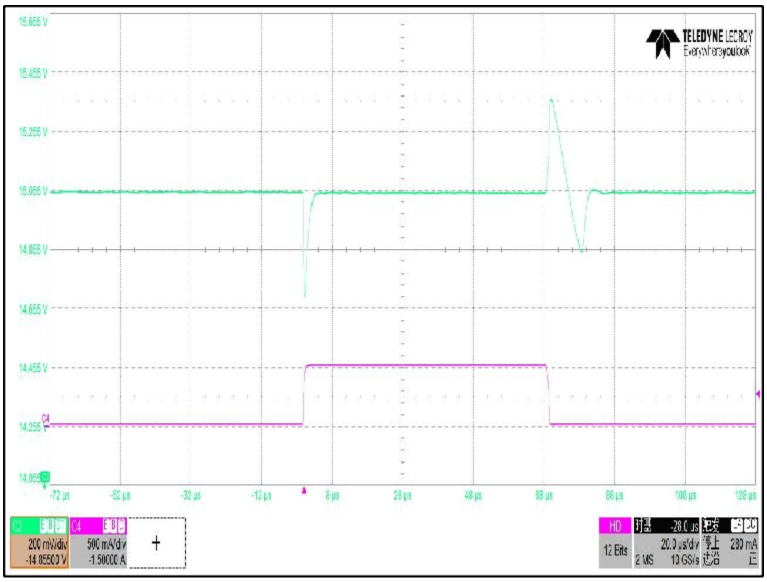
Power-up Response

VS78M05E, V_{IN} = 0 ~ 10V (CH1: V_{OUT}, CH2: V_{IN})



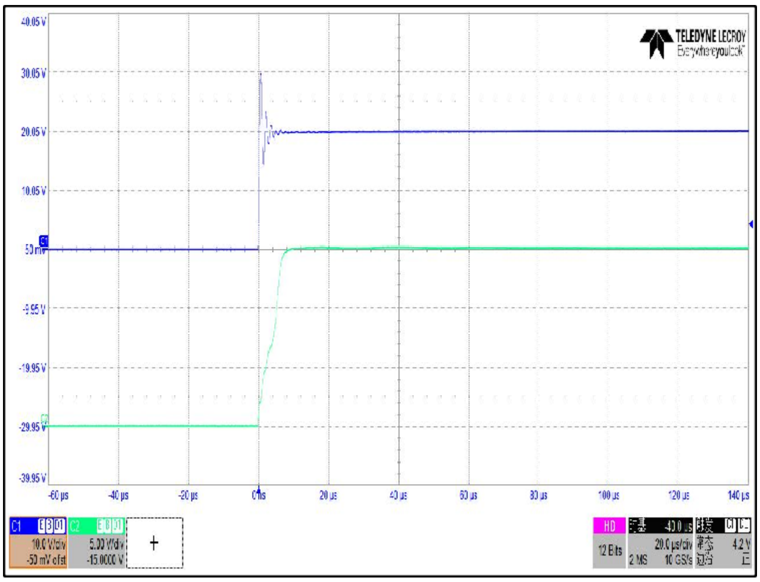
Load Transient

VS78M15E, V_{IN} = 20V, I_{OUT} = 5 ~ 500mA (CH2: V_{OUT}, CH4: I_{OUT})



Power-up Response

VS78M15E, V_{IN} = 0 ~ 20V (CH1: V_{IN}, CH2: V_{OUT})

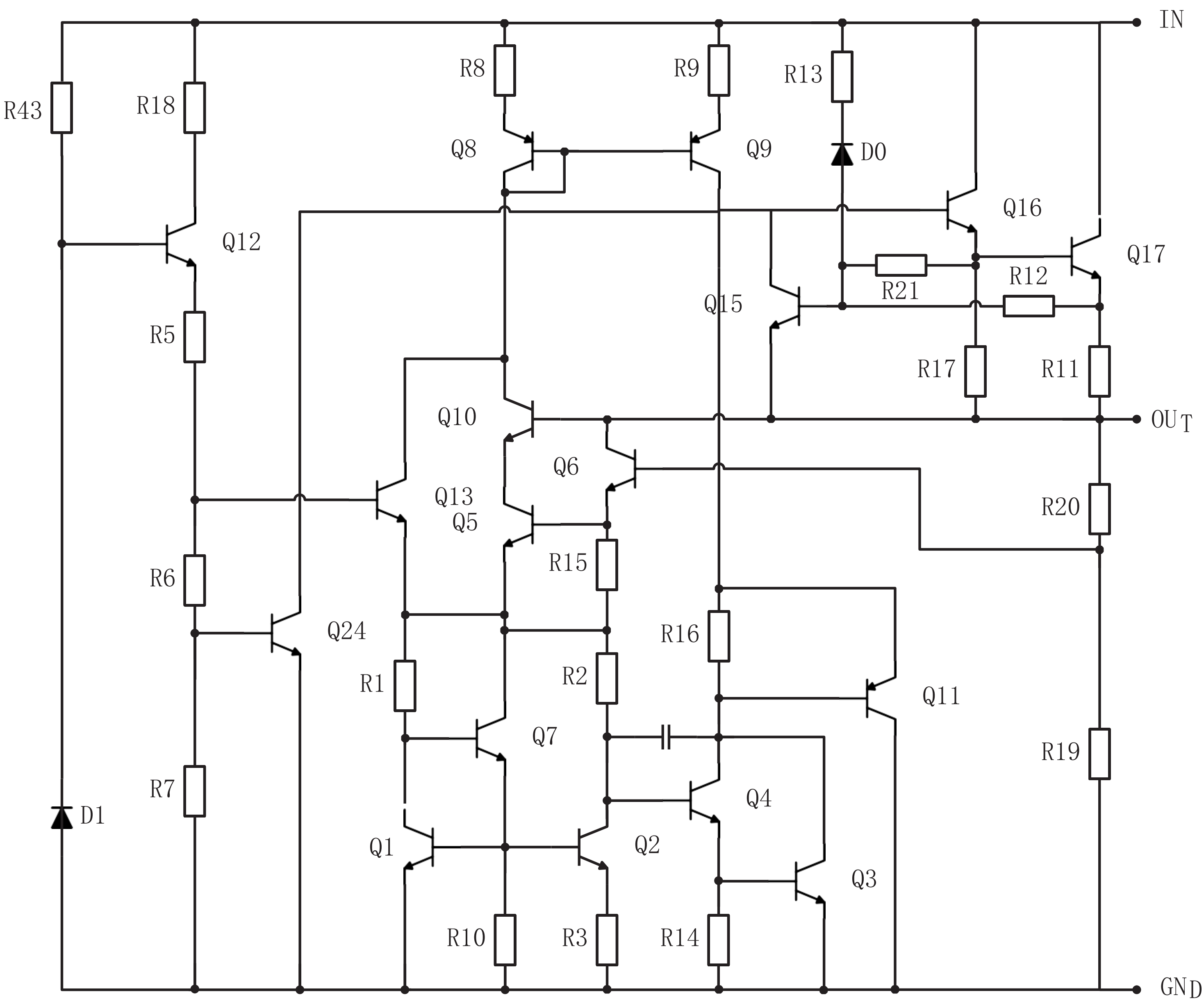


7 Detailed Description

7.1 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.

7.2 Representative Schematic Diagram



7 Detailed Description

7.3 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 VS78M00E 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 VS78M00E series has thermal shutdown protection mechanism. When the junction temperature exceeds the rated temperature range for normal operation in the data sheet, 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 VS78M00E series can output a current of up to 500mA.

8 Application and Implementation

8.1 Risk Alert and Precautions

The VS78M00E 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 8-1;
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 8-2.

For the VS78M00E 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 8-2 in the circuit design.**

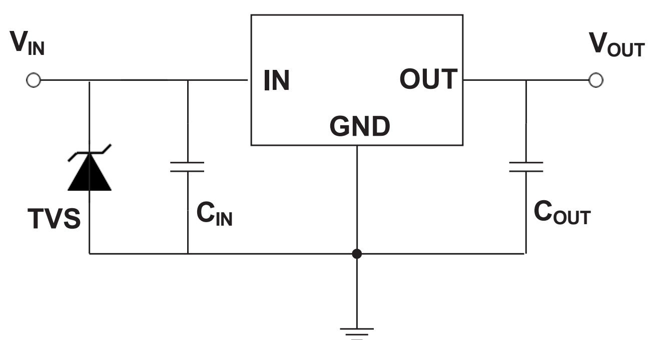


Figure 8-1. TVS is used at IN

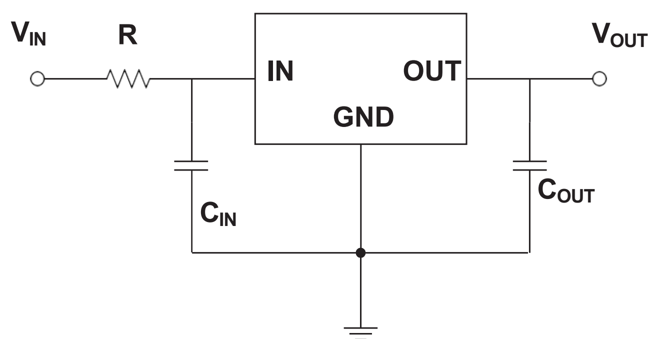


Figure 8-2. Resistance is used at IN

8 Application and Implementation

8.1 Risk Alert and Precautions (continued)

Large Output Capacitance

The VS78M00E 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 8-2 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 8-2 to reduce the possibility of accidental failure of the device due to large surge current during power on.**

Junction-to-ambientThermal Resistance $R_{\Theta JA}$

Definition: The junction to ambient thermal resistance $R_{\Theta JA}$ is a metric of the thermal performance of the device's packages. By comparing the metric of different companies on the same product package, the thermal performance of the product can be roughly estimated in a relative sense. $R_{\Theta JA}$ is measured under the conditions specified in the corresponding specifications. If the measurement of $R_{\Theta JA}$ of two products follows different specifications and standards, or although the same specifications and standards are adopted, it is not tested in strict accordance with the specifications, then the $R_{\Theta JA}$ of two products will lose the meaning of comparison. This product follows the test specified by JEDEC in the EIA/JESD51-x series documents. $R_{\Theta JA}$ 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.

Usage: Junction to ambient thermal resistance $R_{\Theta JA}$ is a parameter defined at the system level rather than on a single device or chip. In the test of $R_{\Theta JA}$ provided in the data sheet, most of the heat generated by the operation of the device is dissipated through the test board rather than the packaging surface of the device. In fact, the design and layout of PCB (such as chip or pad size, internal package geometry, etc.) will significantly affect $R_{\Theta JA}$. At this time, any calculation of the junction temperature or thermal power consumption of the device by applying $R_{\Theta JA}$ in the data sheet will have a very large error, so that it does not match the real performance of the device.

Therefore, $R_{\Theta JA}$ should be used as the relative comparison of product packaging thermal performance between different companies, rather than directly using $R_{\Theta JA}$ in the data sheet in the actual calculation.

Reference Maximum Power Dissipation for Continuous Operation $P_{D\ Ref}$

The reference maximum power dissipation for continuous operation $P_{D\ Ref}$ is not an accurate value obtained from the actual test. It is a theoretical value obtained according to the heat dissipation capacity of packaging combined with practical application. It is used to compare the differences of heat dissipation capacity more intuitively between products of different companies. This value is only for estimation reference and cannot be used as an index of the actual performance of the device for circuit design.

8.2 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 8-2. See *Large Output Capacitance* for more details.