VS78 Series Three Terminal Voltage Regulators

1 Introduction

The VS78 series is a group of three terminal positive voltage linear regulators with multiple fixed output voltages. Under the condition of good heat dissipation, it can provide output current up to 1.5A, and has the functions of internal current limit, short circuit protection, thermal shutdown protection and output transistor SOA protection, which make it relatively difficult to damage. Although designed as fixed voltage regulators without external components, these devices can be used with external components to obtain adjustable voltage and current. Therefore, the VS78 series is widely used as fixed voltage regulators, including local (on card) regulators, to eliminate noise and power distribution problems associated with single point regulation.

2 Applications

- AC Inventors
- DC Motor Drivers
- Household Electric Appliances
- HVAC Systems
- Industrial Power Supplies
- SMPS Post Regulation
- Solar Energy String Inventors
- Test and Measurement Equipment

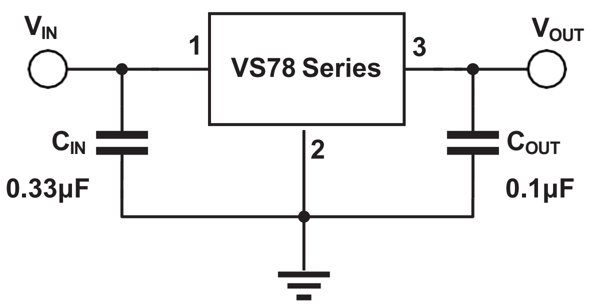


Figure 2-1. Fixed Output Voltage Regulator

3 Features

- Output Current:
  up to 1.5A at T_J = 25°C
- Available in Fixed 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:
  4.0 ~ 12mV (Typ.) at T_J = 25°C
- Load Regulation:
  9.0 ~ 14mV (Typ.) at T_J = 25°C
- Dropout Voltage:
  2V@1A (V_{OUT} = 5.0V)
- Power Supply Rejection Ratio:
  >55dB@120Hz (V_{OUT} = 5.0V)
- Operating Junction Temperature:
  -40 ~ 125°C
- Internal Current Limit
- Output Transistor SOA Protection
- Short Circuit Protection
- Thermal Shutdown Protection

4 Available Packages

PART NUMBER	PACKAGE
VS78 Series	TO-251-3L
	TO-251S
	TO-220-3L
	TO-220F
	TO-252-2L
	TO-263-2L

Note: For all available packages, please refer to the part *Orderable Information*.

5 Orderable Information

MODEL	DEVICE	PACKAGE	OP T_J	ECO PLAN	MSL	PACKING OPTION	SORT
VS78-5.0	VS7805	TO-220-3L	-40 ~ 125°C	RoHS & Green	N / A for Pkg Type	Tube 50 Units / Rail	Active
	VS7805	TO-220-3L	-40 ~ 125°C	RoHS & non Green	N / A for Pkg Type	Tube 50 Units / Rail	NoRD
VS78-6.0	VS7806	TO-220-3L	-40 ~ 125°C	RoHS & Green	N / A for Pkg Type	Tube 50 Units / Rail	Active
	VS7806	TO-220-3L	-40 ~ 125°C	RoHS & non Green	N / A for Pkg Type	Tube 50 Units / Rail	NoRD
VS78-8.0	7808	TO-220-3L	-40 ~ 125°C	RoHS & Green	N / A for Pkg Type	Tube 50 Units / Rail	Active
	7808	TO-220-3L	-40 ~ 125°C	RoHS & non Green	N / A for Pkg Type	Tube 50 Units / Rail	NoRD
VS78-9.0	VS7809	TO-220-3L	-40 ~ 125°C	RoHS & Green	N / A for Pkg Type	Tube 50 Units / Rail	Active
	VS7809	TO-220-3L	-40 ~ 125°C	RoHS & non Green	N / A for Pkg Type	Tube 50 Units / Rail	NoRD
VS78-12	VS7812	TO-220-3L	-40 ~ 125°C	RoHS & Green	N / A for Pkg Type	Tube 50 Units / Rail	Active
	VS7812	TO-220-3L	-40 ~ 125°C	RoHS & non Green	N / A for Pkg Type	Tube 50 Units / Rail	NoRD
VS78-5.0	VS7805F	TO-220F	-40 ~ 125°C	RoHS & Green	N / A for Pkg Type	Tube 50 Units / Rail	Active
	VS7805F	TO-220F	-40 ~ 125°C	RoHS & non Green	N / A for Pkg Type	Tube 50 Units / Rail	NoRD
VS78-9.0	VS7809F	TO-220F	-40 ~ 125°C	RoHS & Green	N / A for Pkg Type	Tube 50 Units / Rail	Active
	VS7809F	TO-220F	-40 ~ 125°C	RoHS & non Green	N / A for Pkg Type	Tube 50 Units / Rail	NoRD
VS78-12	VS7812F	TO-220F	-40 ~ 125°C	RoHS & Green	N / A for Pkg Type	Tube 50 Units / Rail	Active
	VS7812F	TO-220F	-40 ~ 125°C	RoHS & non Green	N / A for Pkg Type	Tube 50 Units / Rail	NoRD

7 Specifications

7.1 Absolute Maximum Ratings

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

CHARACTERISTIC			SYMBOL	VALUE	UNIT
Maximum input voltage(2)			V_{IN}	35	V
Maximum power dissipation	VS78 Series	TO-251-3L	$P_{D\ Max}$	Internally Limited(3)	W
		TO-251S			
		TO-220-3L			
		TO-220F			
		TO-252-2L			
		TO-263-2L			
Maximum junction temperature			$T_{J\ Max}$	150	°C
Storage temperature			T_{stg}	-65 ~ 150	°C
Soldering temperature & time			T_{solder}	260°C, 10s	-

(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.

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 device does not exceed the rated value of the recommended operating conditions when using the device for design.

7.3 ESD Ratings

ESD RATINGS		SYMBOL	VALUE	UNIT
Electrostatic discharge(5)	Human body model	$V_{ESD\text{-}HBM}$	1000	V
	Machine model	$V_{ESD\text{-}MM}$	200	

(5) ESD testing is conducted in accordance with the relevant specifications formulated by the Joint Electronic Equipment Engineering Commission (JEDEC). The human body model (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 model (MM) is based on the JESD22-115-A test standard and uses a 200pF capacitor to discharge directly to each pin of the device.

7 Specifications

7.4 Thermal Information

THERMAL METRIC(6)	SYMBOL	VS78 Series			UNIT
Junction-to-ambient thermal resistance	$R_{\Theta JA}$	**TO-220-3L**	**TO-220F**	**TO-251-3L**	°C/W
		64.3	66.7	80.1	
		TO-251S	**TO-252-2L**	**TO-263-2L**	
		81.2	78.2	60.5	
Junction-to-case thermal resistance	$R_{\Theta JC}$	**TO-220-3L**	**TO-220F**	**TO-251-3L**	°C/W
		5.5	6.0	9.1	
		TO-251S	**TO-252-2L**	**TO-263-2L**	
		9.4	5.4	5.0	
Reference maximum power dissipation for continuous operation	$P_{D\ Ref}$	**TO-220-3L**	**TO-220F**	**TO-251-3L**	W
		1.53	1.51	1.25	
		TO-251S	**TO-252-2L**	**TO-263-2L**	
		1.23	1.25	1.60	

(6) T_A = 25°C, all numbers are typical, and apply for packages soldered directly onto a PCB board in still air without extra heat dissipation pads.

7 Specifications

7.5 Electrical Characteristics

VS7805 (V_{IN} = 10V, I_{OUT} = 500mA, C_{IN} = 0.33μF, C_{OUT} = 0.1μF, T_J = 25°C, unless otherwise specified)

CHARACTERISTIC	SYMBOL	TEST CONDITIONS	MIN.	TYP.[7]	MAX.	UNIT
Output voltage	V_{OUT}	T_J = 25°C	4.85	5.00	5.15	V
		I_{OUT} = 5mA to 1A, V_{IN} = 7 to 20V, T_J = 0 to 125°C	4.75	5.00	5.25	
Line regulation	ΔV_{OUT}	V_{IN} = 7 to 25V	-	4	100	mV
		V_{IN} = 8 to 12V	-	1.6	50	
Load regulation	ΔV_{OUT}	I_{OUT} = 5mA to 1.5A	-	9	100	mV
		I_{OUT} = 250 to 750mA	-	4	50	
Quiescent current	I_Q	T_J = 25°C	-	5	8	mA
Quiescent current change	ΔI_Q	I_{OUT} = 5mA to 1A	-	0.03	0.5	mA
		V_{IN} = 7 to 25V	-	0.3	1.3	
Output voltage drift	$\Delta V_{OUT}/\Delta T$	I_{OUT} = 5mA	-	-1.1	-	mV/°C
Output noise voltage	V_N	f = 10 to 100k Hz	-	42	-	μV
Ripple rejection	RR	f = 120Hz, V_{IN} = 8 to 18V	62	73	-	dB
Dropout voltage[8]	V_D	I_{OUT} = 1A	-	2	-	V
Output resistance	R_{OUT}	f = 1kHz	-	10	-	mΩ
Short circuit current	I_{SC}	-		230	-	mA
Peak current	I_{PK}	-	-	2.2	-	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. Typical numbers are at 25°C and represent the most likely norm.

(8) 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

7.5 Electrical Characteristics (continued)

VS7806 (V_{IN} = 11V, I_{OUT} = 500mA, C_{IN} = 0.33μF, C_{OUT} = 0.1μF, T_J = 25°C, unless otherwise specified)

CHARACTERISTIC	SYMBOL	TEST CONDITIONS	MIN.	TYP.(7)	MAX.	UNIT
Output voltage	V_{OUT}	T_J = 25°C	5.82	6.00	6.18	V
		I_{OUT} = 5mA to 1A, V_{IN} = 8 to 21V, T_J = 0 to 125°C	5.70	6.00	6.30	
Line regulation	ΔV_{OUT}	V_{IN} = 8 to 25V	-	5	120	mV
		V_{IN} = 9 to 13V	-	1.5	60	
Load regulation	ΔV_{OUT}	I_{OUT} = 5mA to 1.5A	-	14	120	mV
		I_{OUT} = 250 to 750mA	-	4	60	
Quiescent current	I_Q	-	-	4.3	8	mA
Quiescent current change	ΔI_Q	I_{OUT} = 5mA to 1A	-	-	0.5	mA
		V_{IN} = 8 to 25V	-	-	1.3	
Output voltage drift	$\Delta V_{OUT}/\Delta T$	I_{OUT} = 5mA	-	-0.8	-	mV/°C
Output noise voltage	V_N	f = 10 to 100k Hz	-	45	-	μV
Ripple rejection	RR	f = 120Hz, V_{IN} = 9 to 19V	59	75	-	dB
Dropout voltage(8)	V_D	I_{OUT} = 1A	-	2	-	V
Output resistance	R_{OUT}	f = 1kHz	-	10	-	mΩ
Short circuit current	I_{SC}	-	-	550	-	mA
Peak current	I_{PK}	-	-	2.1	-	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. Typical numbers are at 25°C and represent the most likely norm.

(8) 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

7.5 Electrical Characteristics (continued)

7808 (V_{IN} = 14V, I_{OUT} = 500mA, C_{IN} = 0.33μF, C_{OUT} = 0.1μF, T_J = 25°C, unless otherwise specified)

CHARACTERISTIC	SYMBOL	TEST CONDITIONS	MIN.	TYP.(7)	MAX.	UNIT
Output voltage	V_{OUT}	T_J = 25°C	7.76	8.00	8.24	V
		I_{OUT} = 5mA to 1A, V_{IN} = 10.5 to 23V, T_J = 0°C to 125°C	7.60	8.00	8.40	
Line regulation	ΔV_{OUT}	V_{IN} = 10.5 to 25V	-	6	160	mV
		V_{IN} = 11 to 17V	-	2	80	
Load regulation	ΔV_{OUT}	I_{OUT} = 5mA to 1.5A	-	12	160	mV
		I_{OUT} = 250 to 750mA	-	4	80	
Quiescent current	I_Q	-	-	4.3	8	mA
Quiescent current change	ΔI_Q	I_{OUT} = 5mA to 1A	-	-	0.5	mA
		V_{IN} = 10.5 to 25V	-	-	1.0	
Output voltage drift	$\Delta V_{OUT}/\Delta T$	I_{OUT} = 5mA	-	-0.8	-	mV/°C
Output noise voltage	V_N	f = 10 to 100k Hz	-	52	-	μV
Ripple rejection	RR	f = 120Hz, V_{IN} = 11.5 to 21.5V	55	72	-	dB
Dropout voltage(8)	V_D	I_{OUT} = 1A	-	2	-	V
Output resistance	R_{OUT}	f = 1kHz	-	10	-	mΩ
Short circuit current	I_{SC}	-		450	-	mA
Peak current	I_{PK}	-	-	2.2	-	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. Typical numbers are at 25°C and represent the most likely norm.

(8) 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

7.5 Electrical Characteristics (continued)

VS7809 (V_{IN} = 16V, I_{OUT} = 500mA, C_{IN} = 0.33μF, C_{OUT} = 0.1μF, T_J = 25°C, unless otherwise specified)

CHARACTERISTIC	SYMBOL	TEST CONDITIONS	MIN.	TYP.[7]	MAX.	UNIT
Output voltage	V_{OUT}	T_J = 25°C	8.73	9.00	9.27	V
		I_{OUT} = 5mA to 1A, V_{IN} = 11.5 to 24V, T_J = 0°C to 125°C	8.55	9.00	9.45	
Line regulation	ΔV_{OUT}	V_{IN} = 11.5 to 27V	-	7	180	mV
		V_{IN} = 13 to 19V	-	2	90	
Load regulation	ΔV_{OUT}	I_{OUT} = 5mA to 1.5A	-	12	180	mV
		I_{OUT} = 250 to 750mA	-	4	90	
Quiescent current	I_Q	-	-	4.3	8	mA
Quiescent current change	ΔI_Q	I_{OUT} = 5mA to 1A	-	-	0.5	mA
		V_{IN} = 11.5 to 27V	-	-	1.0	
Output voltage drift	$\Delta V_{OUT}/\Delta T$	I_{OUT} = 5mA	-	-1	-	mV/°C
Output noise voltage	V_N	f = 10 to 100k Hz	-	60	-	μV
Ripple rejection	RR	f = 120Hz, V_{IN} = 12 to 22V	55	70	-	dB
Dropout voltage[8]	V_D	I_{OUT} = 1A	-	2	-	V
Output resistance	R_{OUT}	f = 1kHz	-	18	-	mΩ
Short circuit current	I_{SC}	-		400	-	mA
Peak current	I_{PK}	-	-	2.2	-	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. Typical numbers are at 25°C and represent the most likely norm.

(8) 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

7.5 Electrical Characteristics (continued)

VS7812 (V_{IN} = 19V, I_{OUT} = 500mA, C_{IN} = 0.33μF, C_{OUT} = 0.1μF, T_J = 25°C, unless otherwise specified)

CHARACTERISTIC	SYMBOL	TEST CONDITIONS	MIN.	TYP.(7)	MAX.	UNIT
Output voltage	V_{OUT}	T_J = 25°C	11.64	12.00	12.36	V
		I_{OUT} = 5mA to 1A, V_{IN} = 14.5V to 27V, T_J = 0°C to 125°C	11.40	12.00	12.60	
Line regulation	ΔV_{OUT}	V_{IN} = 14.5 to 30V	-	12	240	mV
		V_{IN} = 16 to 22V	-	4	120	
Load regulation	ΔV_{OUT}	I_{OUT} = 5mA to 1.5A	-	10	240	mV
		I_{OUT} = 250 to 750mA	-	3	120	
Quiescent current	I_Q	-	-	4.3	8	mA
Quiescent current change	ΔI_Q	I_{OUT} = 5mA to 1A	-	-	0.5	mA
		V_{IN} = 14.5 to 30V	-	-	1.0	
Output voltage drift	$\Delta V_{OUT}/\Delta T$	I_{OUT} = 5mA	-	-1	-	mV/°C
Output noise voltage	V_N	f = 10 to 100k Hz	-	75	-	μV
Ripple rejection	RR	f = 120Hz, V_{IN} = 15 to 25V	55	71	-	dB
Dropout voltage(8)	V_D	I_{OUT} = 1A	-	2	-	V
Output resistance	R_{OUT}	f = 1kHz	-	18	-	mΩ
Short circuit current	I_{SC}	-		350	-	mA
Peak current	I_{PK}	-	-	2.2	-	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. Typical numbers are at 25°C and represent the most likely norm.

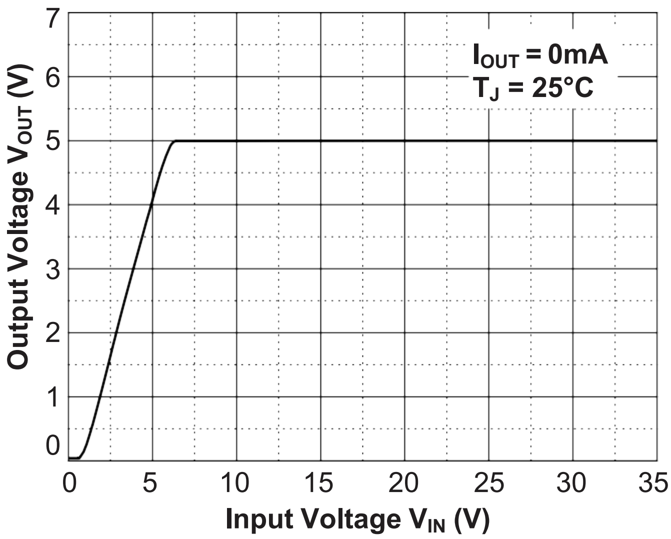
(8) The difference of output voltage and input voltage when input voltage is decreased gradually till output voltage equals to 95% of V_{OUT}.

7 Specifications

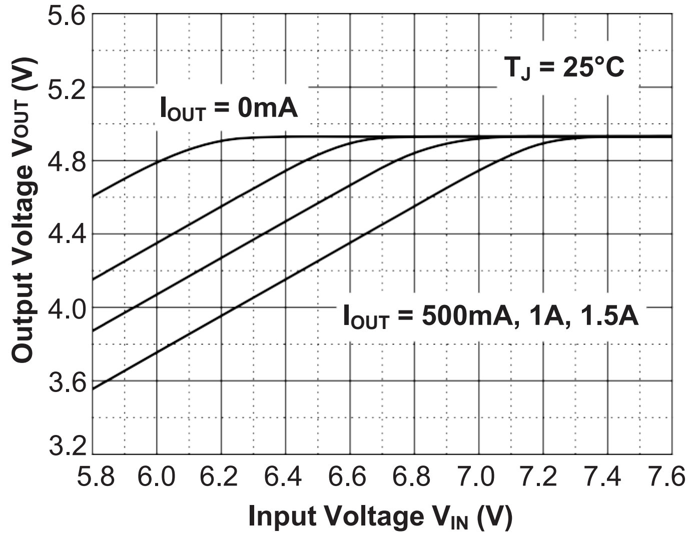
7.6 Typical Characteristics

VS7805 (V_{OUT} = 5.0V, C_{IN} = 0.33μF, C_{OUT} = 0.1μF, T_J = 25°C, unless otherwise specified)

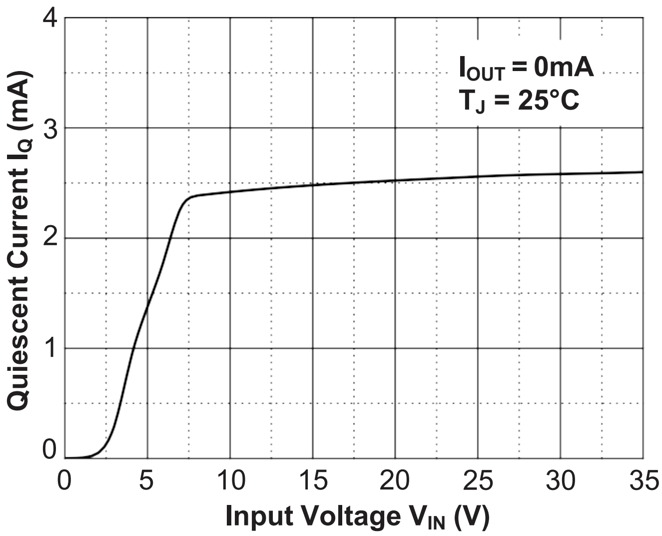
Output Characteristics



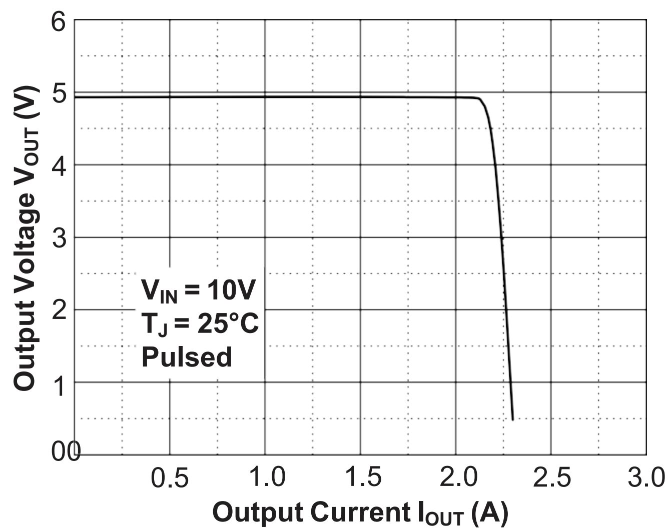
Dropout Characteristics



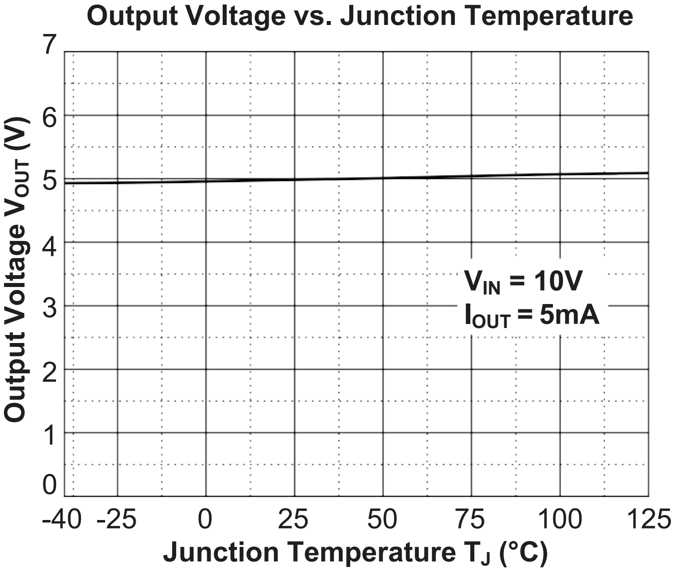
Quiescent Current



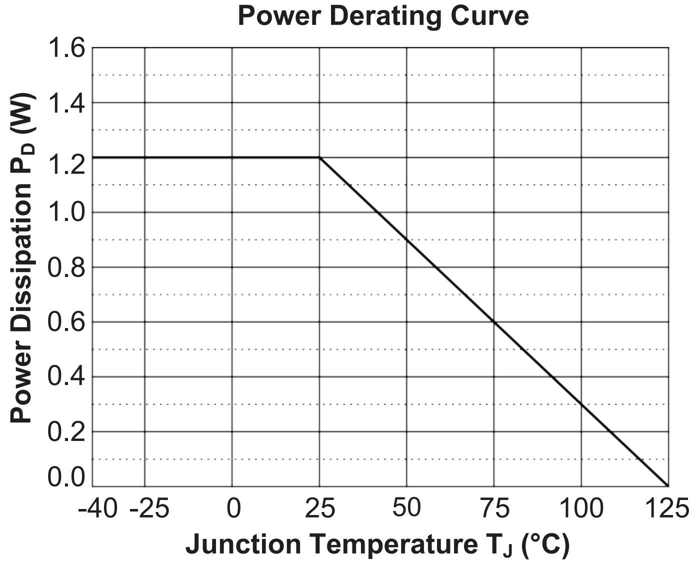
Current Cut-off Grid Voltage



Output Voltage vs. Junction Temperature



Power Derating Curve

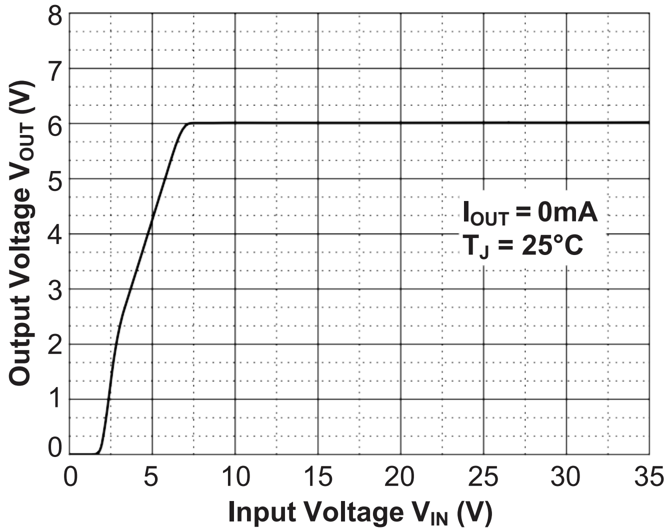


7 Specifications

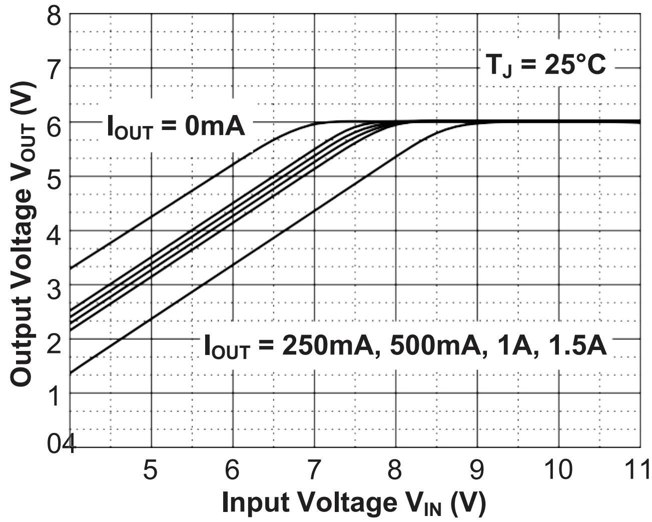
7.6 Typical Characteristics (continued)

VS7806 (V_{OUT} = 6.0V, C_{IN} = 0.33μF, C_{OUT} = 0.1μF, T_J = 25°C, unless otherwise specified)

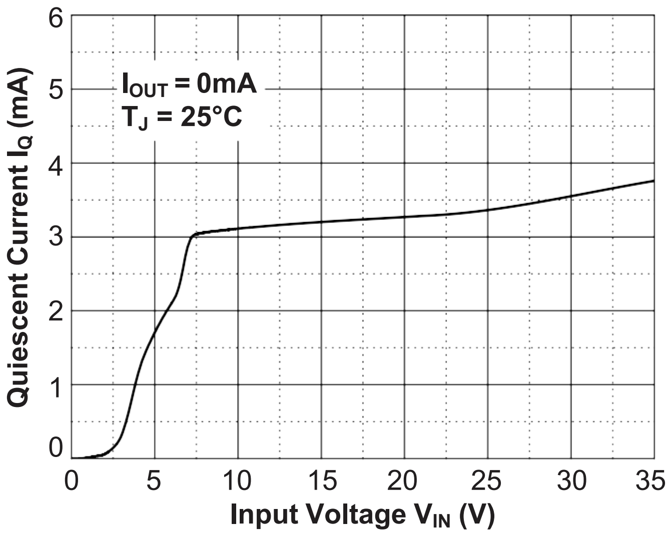
Output Characteristics



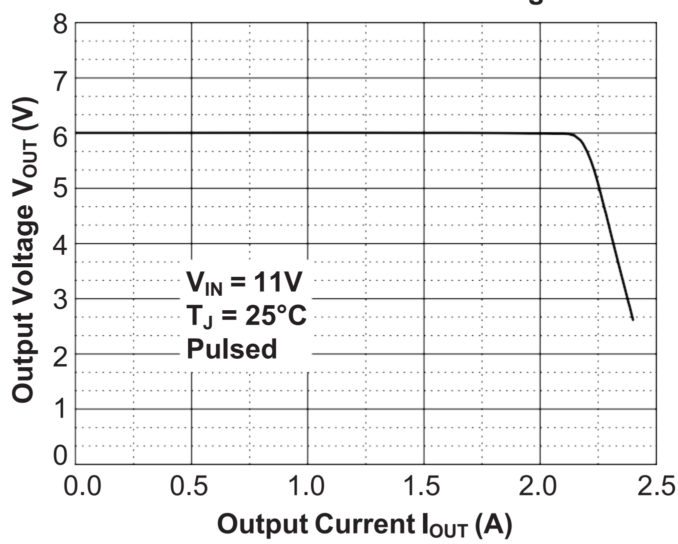
Dropout Characteristics



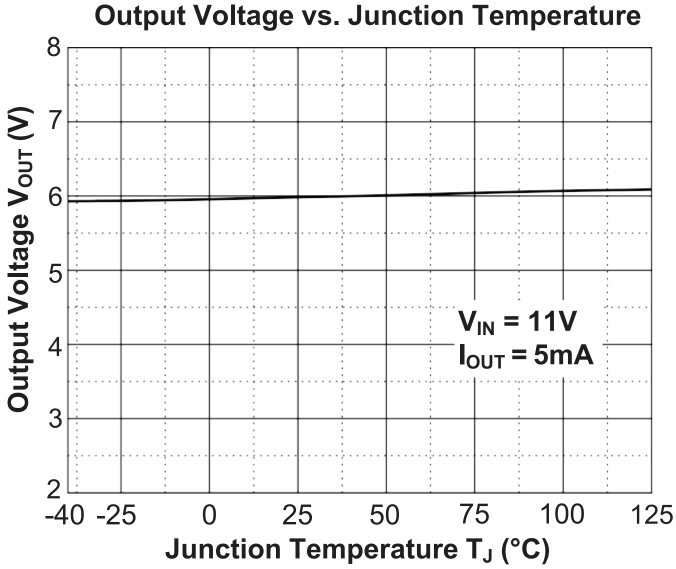
Quiescent Current



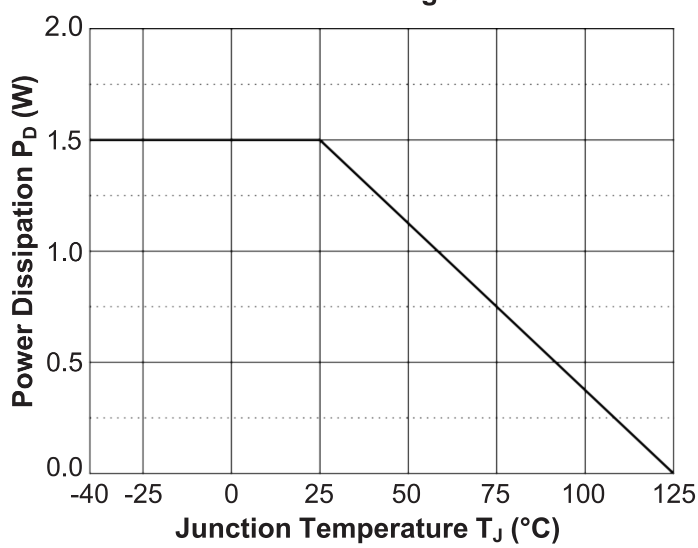
Current Cut-off Grid Voltage



Output Voltage vs. Junction Temperature



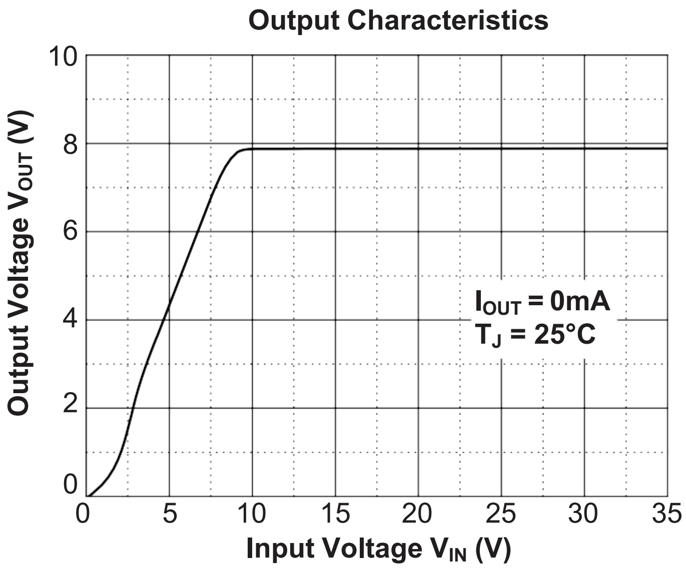
Power Derating Curve

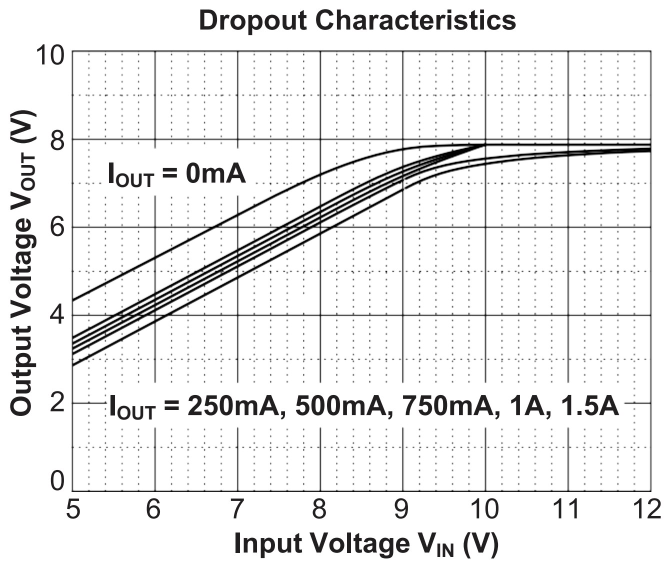


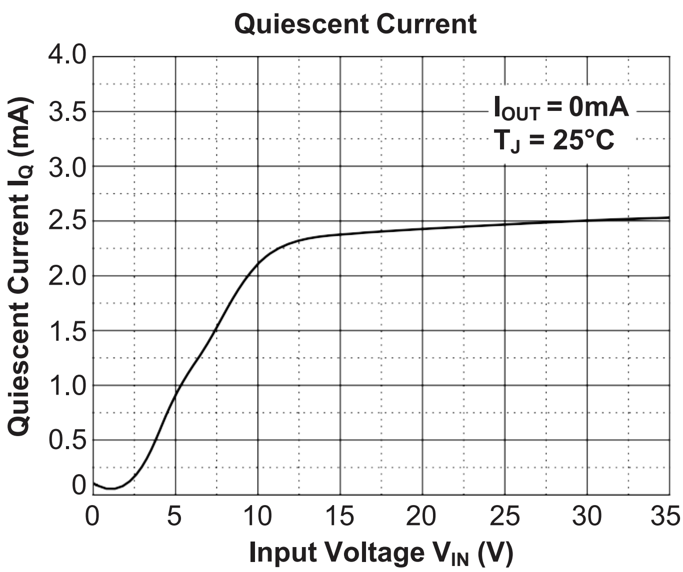
7 Specifications

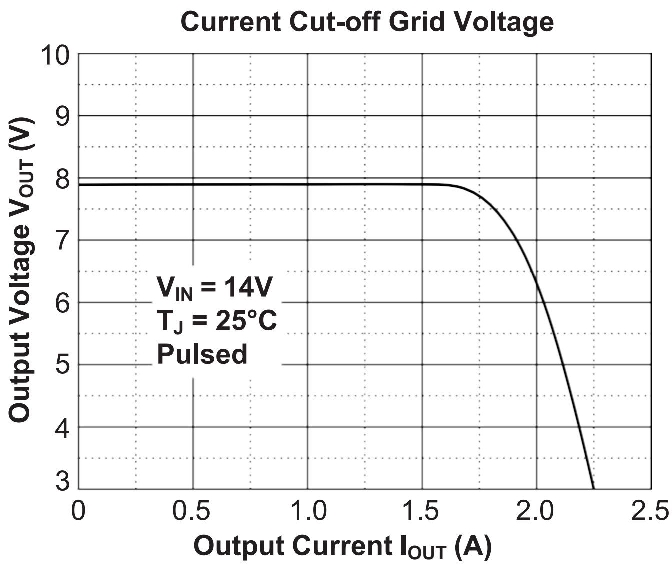
7.6 Typical Characteristics (continued)

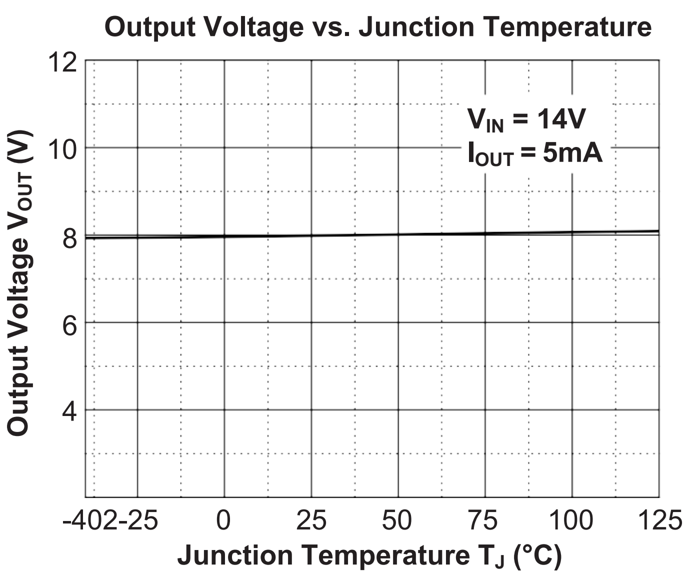
7808 (V_{OUT} = 8.0V, C_{IN} = 0.33µF, C_{OUT} = 0.1µF, T_J = 25°C, unless otherwise specified)

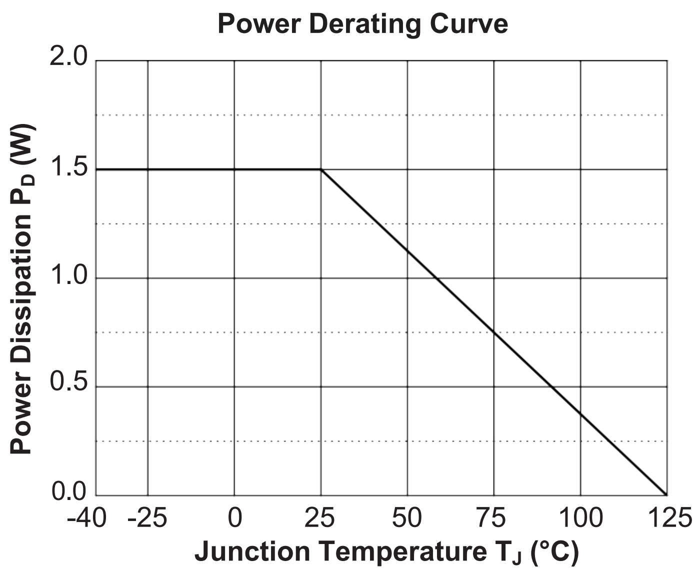










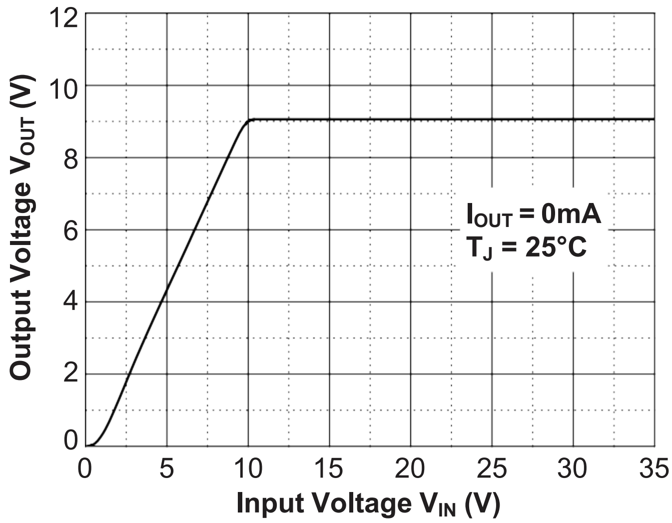


7 Specifications

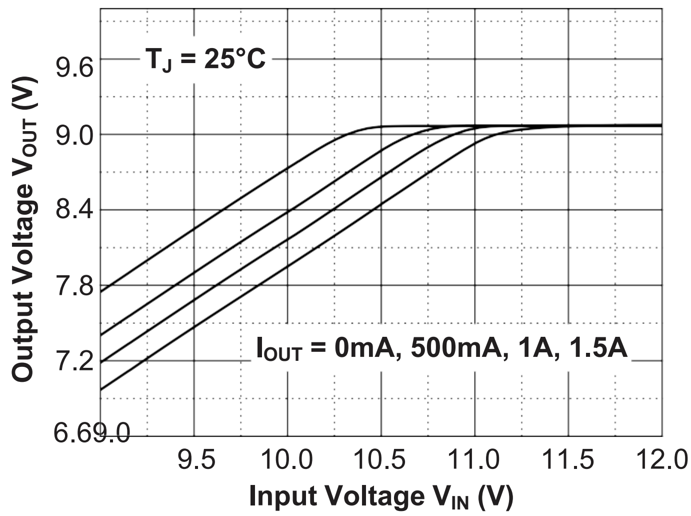
7.6 Typical Characteristics (continued)

VS7809 (V_{OUT} = 9.0V, C_{IN} = 0.33µF, C_{OUT} = 0.1µF, T_J = 25°C, unless otherwise specified)

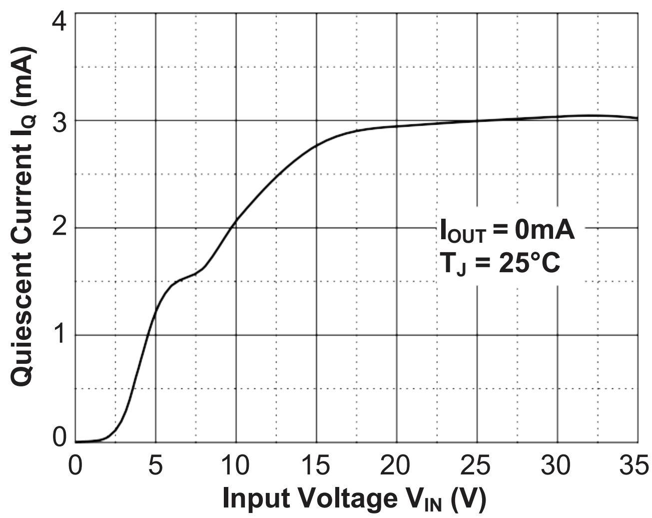
Output Characteristics



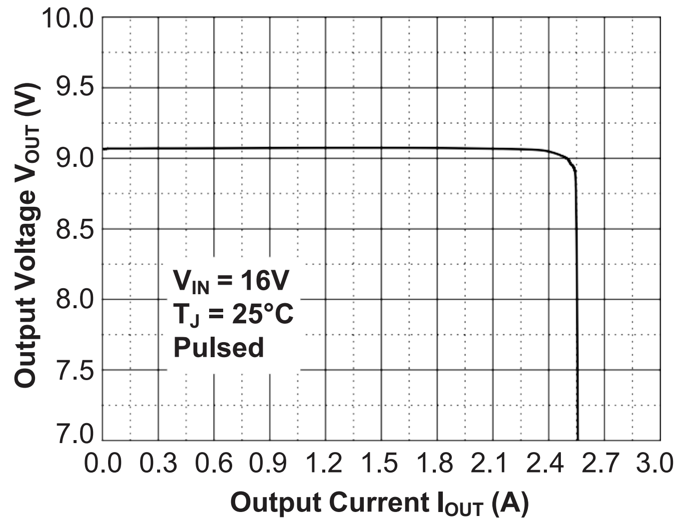
Dropout Characteristics



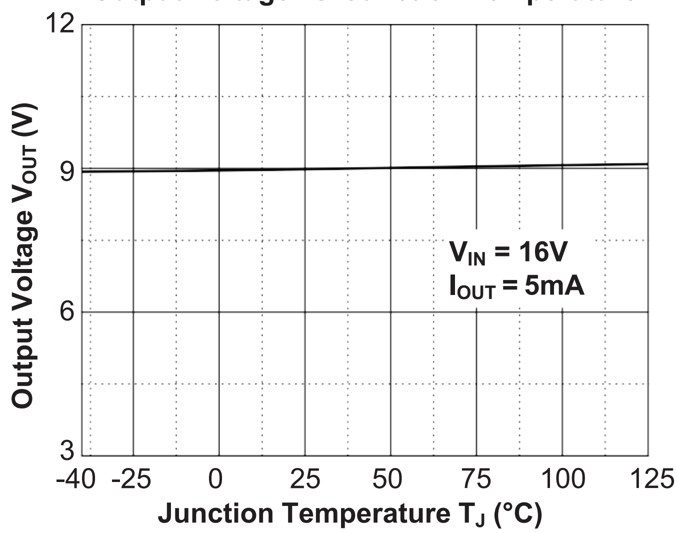
Quiescent Current



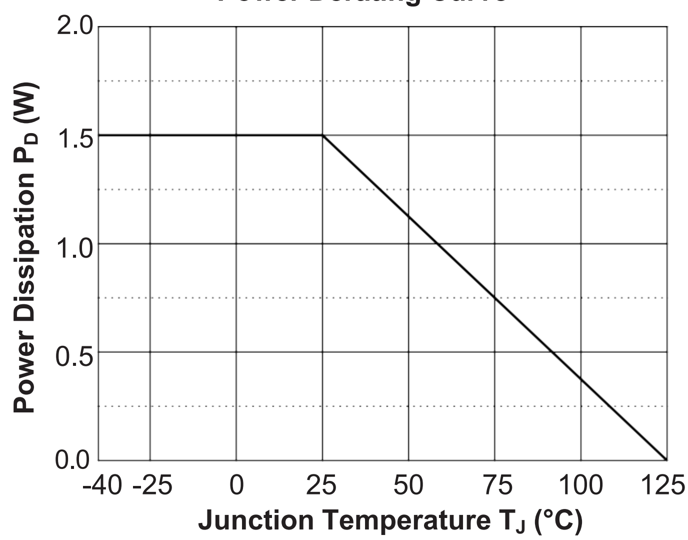
Current Cut-off Grid Voltage



Output Voltage vs. Junction Temperature



Power Derating Curve

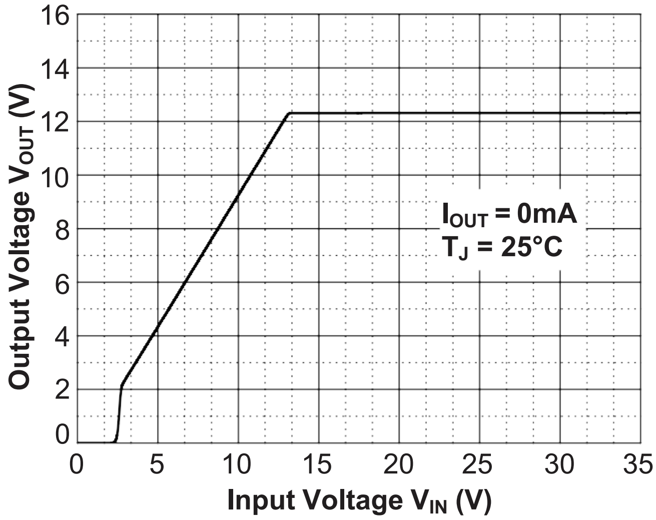


7 Specifications

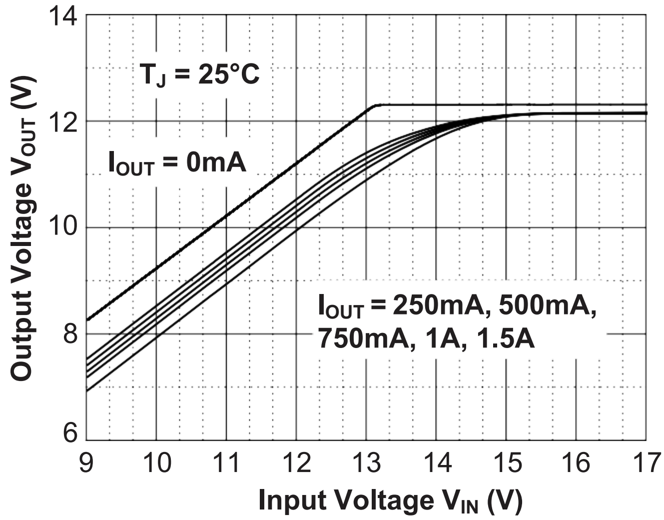
7.6 Typical Characteristics (continued)

VS7812 (V_{OUT} = 12V, C_{IN} = 0.33μF, C_{OUT} = 0.1μF, T_J = 25°C, unless otherwise specified)

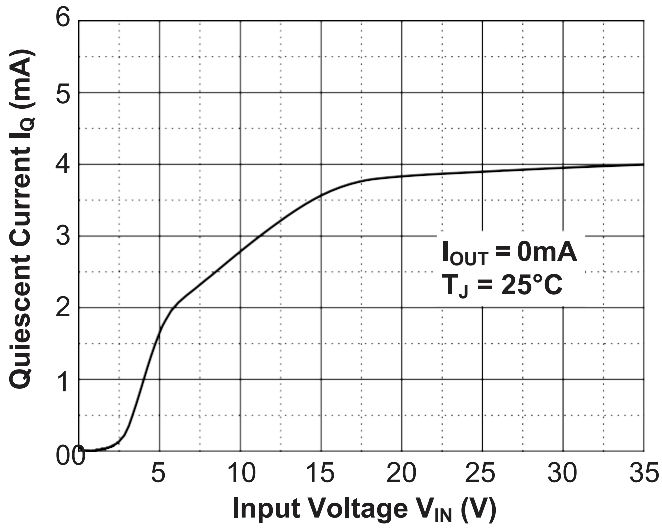
Output Characteristics



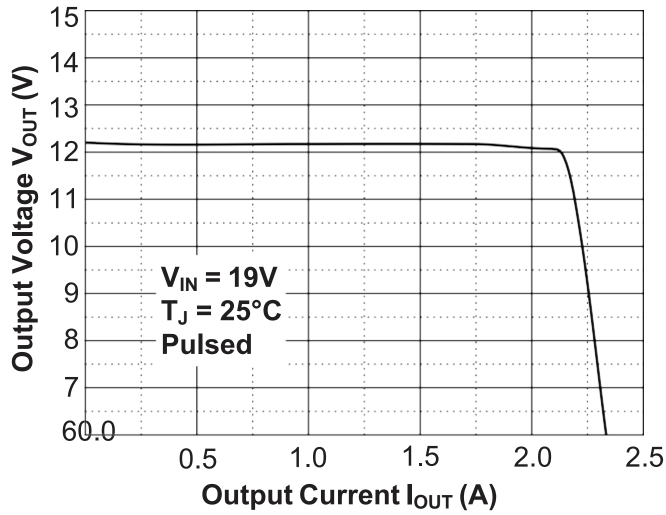
Dropout Characteristics



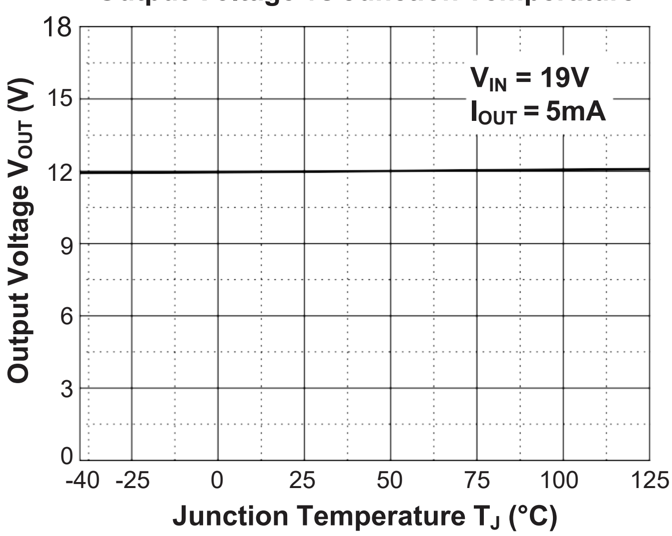
Quiescent Current



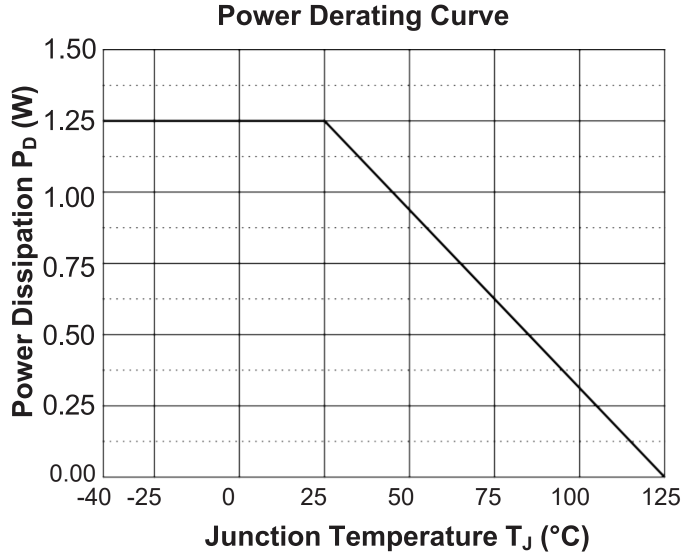
Current Cut-off Grid Voltage



Output Voltage vs Junction Temperature



Power Derating Curve

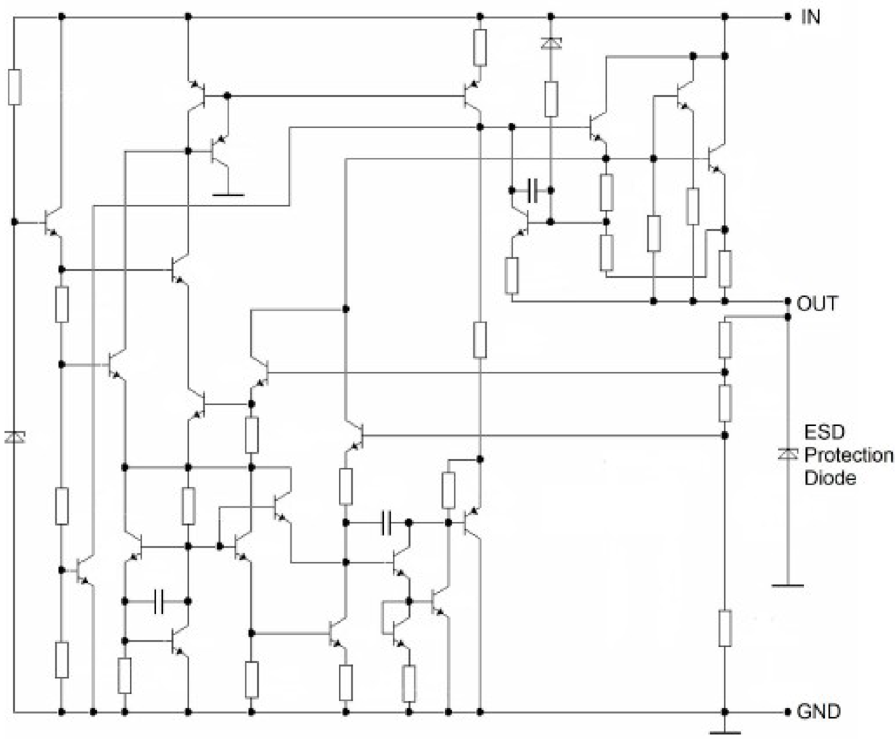


8 Detailed Description

8.1 Description

The VS78 series is a group of fixed output positive voltage regulators. It integrates current limit, short-circuit protection, thermal overload protection and safe working area protection of output transistor, which makes it relatively difficult to be damaged. By setting the resistance value of peripheral resistance, the VS78 series can also be used as adjustable voltage output regulator.

8.2 Representative Schematic Diagram



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.

Internal Current Limit & Short Circuit Protection

The VS78 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.

8 Detailed Description

8.3 Feature Description (continued)

Thermal Shutdown Protection

The VS78 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 VS78 series can output a current of up to 1.5A.

9 Application and Implementation

9.1 Risk Alert and Precautions

The VS78 series is designed for thermal protection, output short circuit protection and output transistor SOA 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 VS78 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.**

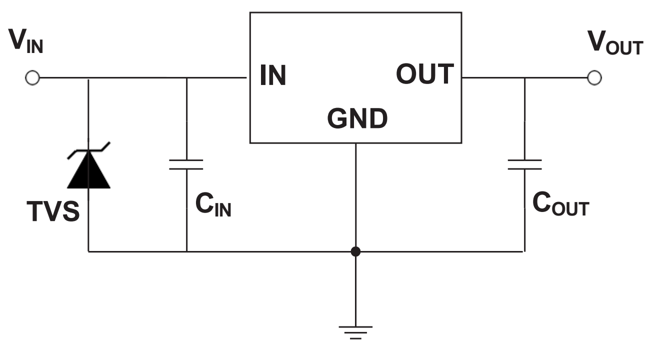


Figure 9-1. TVS is used at IN

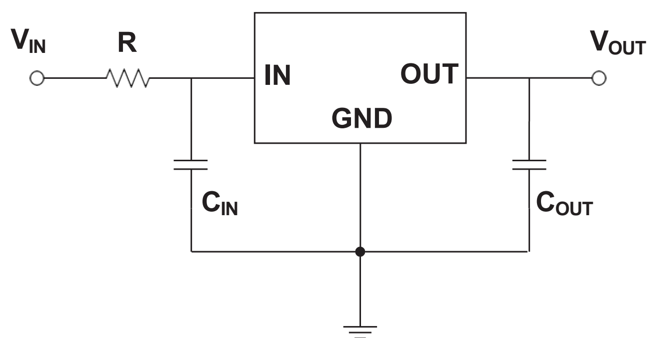


Figure 9-2. Resistance is used at IN

9 Application and Implementation

9.1 Risk Alert and Precautions (continued)

Regulator Input Short Circuit

In case of short circuit to ground at the input of the voltage regulator, the input of the voltage regulator will be pulled down to the ground potential. At this time, if the capacitance value of the output pin is large, a large amount of charge stored in it will enter the regulator from the output pin of the regulator and generate internal discharge, which may damage the output diodes and transistors inside the regulator, resulting in damage to the regulator. As shown in Figure 9-3.

This phenomenon may be avoided by connecting a protection diode at the input and output pins. The diode can shunt the discharge current of the capacitor to achieve protection in the case of short circuit to ground at the input pin. If the output capacitance is small (Capacitance value is less than 10μF), the protection diode is generally not required.

Increase the Output Voltage above the Input Voltage

If the output voltage is forcibly increased above the input voltage, because the potential at the output pin of the regulator is higher than the input pin, the internal working of the regulator under low current conditions may be damaged due to reverse internal discharge. Such damage mechanism is similar to the *Regulator Input Short Circuit*.

Float the Ground Pin of the Regulator

When the ground pin of the regulator floats, the voltage at the output is close to the voltage at the input, which may damage the internal circuit of the regulator. Even if the ground terminal is connected to the ground terminal from floating under the power on state, it may still cause damage to the voltage regulator. This kind of situation usually occurs when the voltage regulator module on the card is connected to the power supply. To reduce the possibility of such faults, the regulator ground terminal should be grounded before the regulator is connected to the power supply. Before the voltage regulator on the card is inserted into the power on socket, the power supply shall be turned off and the thermal shutdown shall stop working. If the power on state must be maintained, the voltage regulator must be grounded. As shown in Figure 9-4.

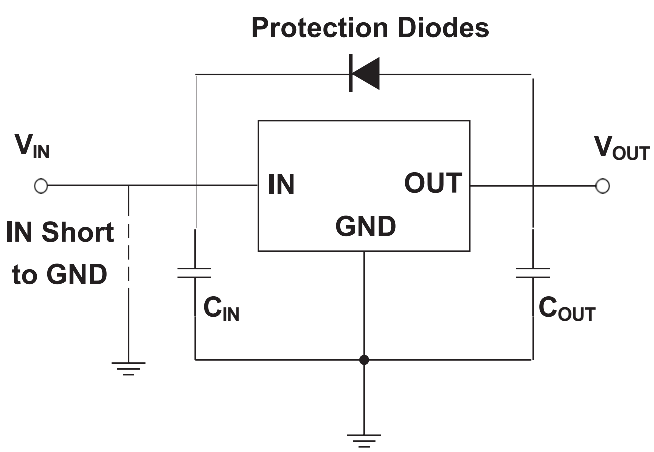


Figure 9-3. Regulator Input Short Circuit

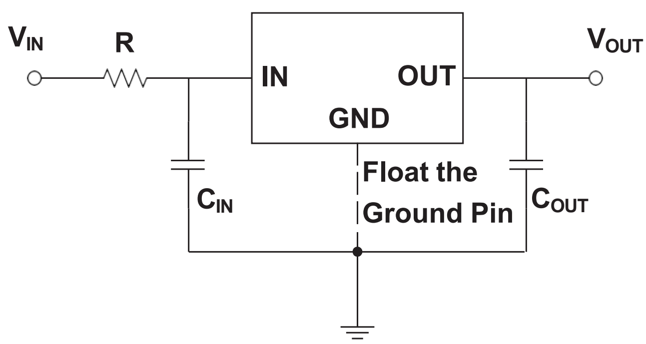


Figure 9-4. Float the Ground Pin

9 Application and Implementation

9.1 Risk Alert and Precautions (continued)

Large Output Capacitance

The VS78 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 Application Information

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.

Design Requirements and Procedure

The VS78 series is mainly used to provide fixed output voltage regulation, the output voltage is set based on the device variant, which is available in 5.0V, 6.0V, 8.0V, 9.0V and 12V regulator options, and it requires a very small number of equipment components. If the regulator is far from the power filter, the input capacitor C_{IN} is required. The bypass capacitor C_{OUT} is used at the output to obtain the best stability and transient response. These capacitors must be as close to the regulator as possible. The simplest implementation of the VS78 series is shown in Figure 9-8.

9 Application and Implementation

9.3 Test Circuits

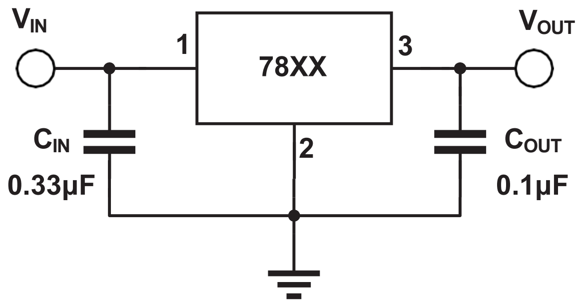


Figure 9-5. DC Parameters

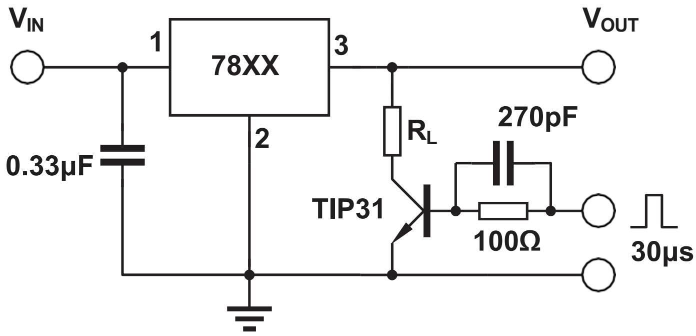


Figure 9-6. Load Regulation

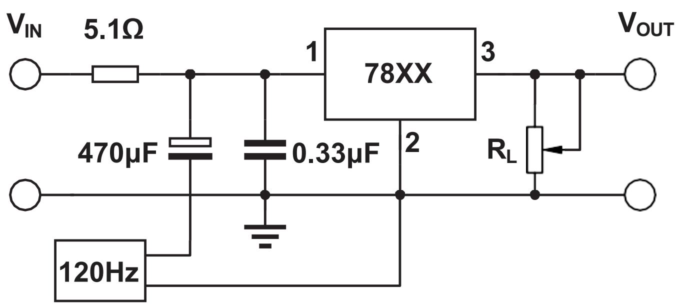
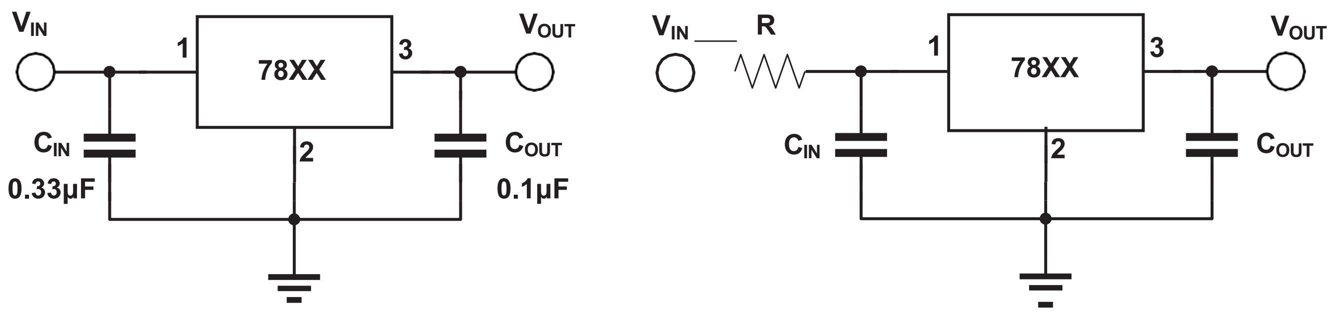


Figure 9-7. Ripple Rejection

9.4 System Example

The "XX" in the "78XX" represents the output voltage, for example, if V_{OUT} = 5.0V, the "78XX" is "7805".



(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 9-8. Fixed Output Regulator

Note: For more details, see the part *Risk Alert and Precautions*.

9 Application and Implementation

9.4 System Example(continued)

The "XX" in the "78XX" represents the output voltage, for example, if V_{OUT} = 5.0V, the "78XX" is "7805".

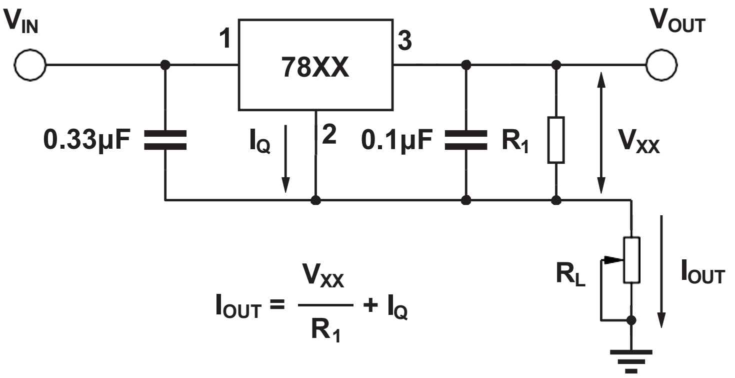


Figure 9-9. Constant Current Regulator

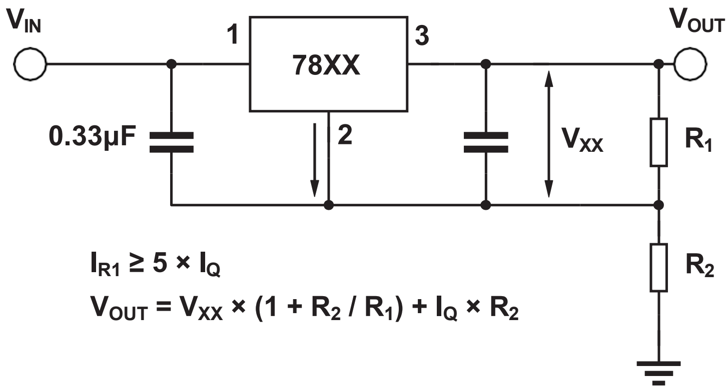


Figure 9-10. Circuit for Increasing Regulator Output Voltage

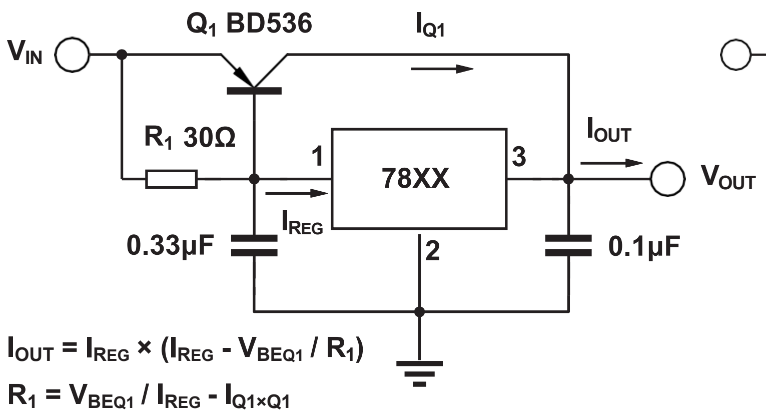


Figure 9-11. High Current with Voltage Regulator

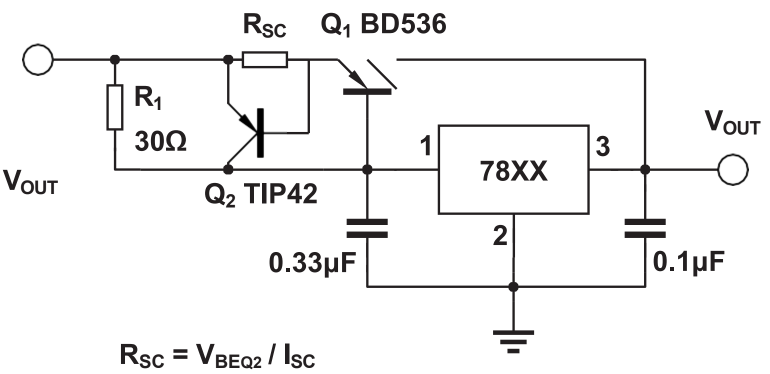


Figure 9-12. High Output Current Short Circuit Protection

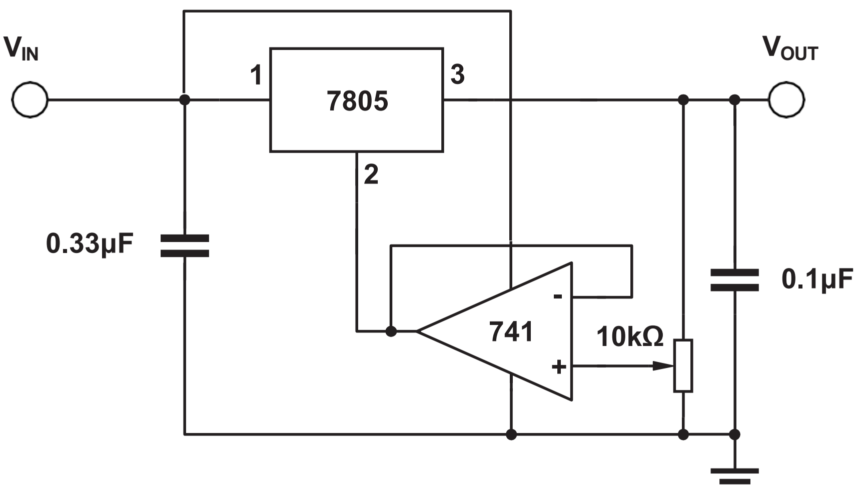


Figure 9-13. Adjustable Output

9 Application and Implementation

9.4 System Example(continued)

The "XX" in the "78XX" represents the output voltage, for example, if V_{OUT} = 5.0V, the "78XX" is "7805".

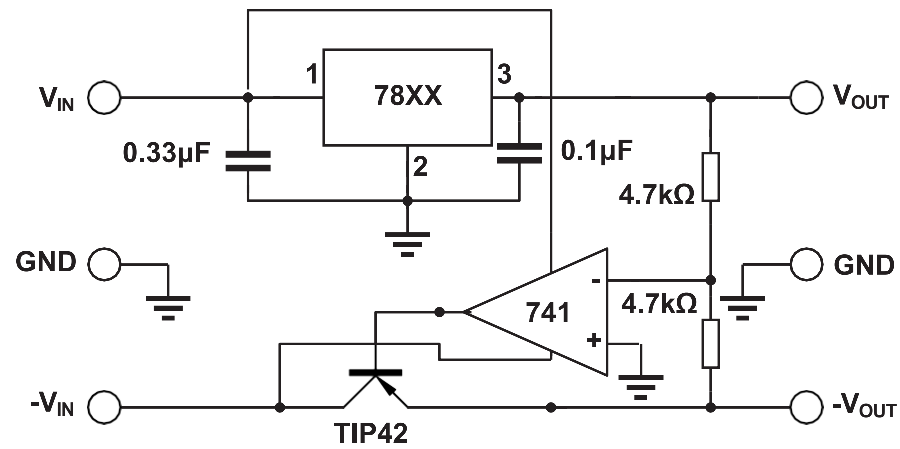


Figure 9-14. Tracking Voltage Regulator

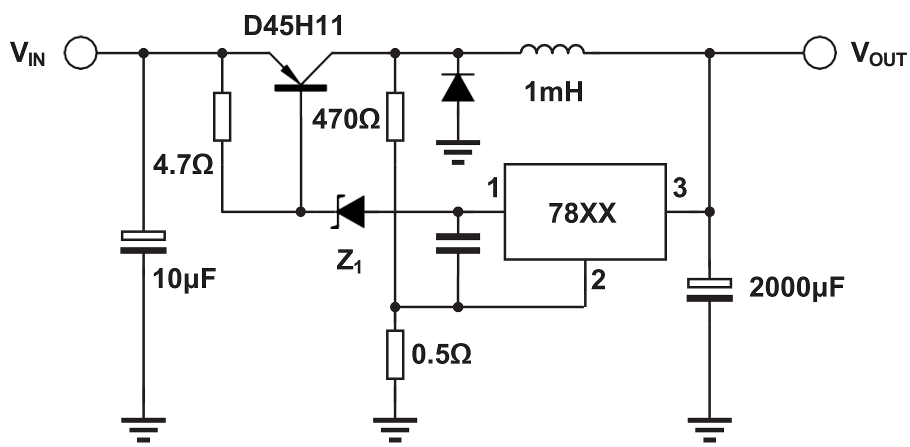


Figure 9-15. Switching Regulator