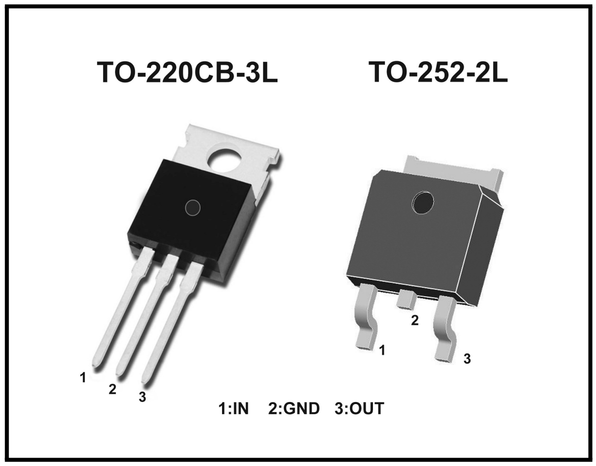
BX78xxA Series

Wide Input Voltage Three Terminal Positive Voltage Regulator

Features

- Output Current:up to 1A at T_J=25°C
- Dropout Voltage: 2V@1A
- Power Supply Rejection Ratio: 70dB@120Hz (V_{OUT}= 5.0V)
- Output Transistor SOA Protection
- Internal Current Limit
- Short Circuit Protection
- Thermal Shutdown Protection

Package



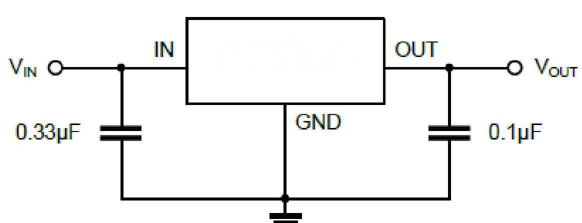
Application

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

Introduction

The BX78xxA 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 1A, andhas 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 BX78xxA 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.

Typical Application Circuit



Ordering information

Order code	Package	Marking	Base qty
BX7805EA	TO-220CB-3L	7805EA	50pcs/tube
BX7805IA	TO-252-2L	7805IA	2500/reel
BX7809EA	TO-220CB-3L	7809EA	50pcs/tube
BX7809IA	TO-252-2L	7809IA	2500/reel
BX7812EA	TO-220CB-3L	7812EA	50pcs/tube
BX7812IA	TO-252-2L	7812IA	2500/reel

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

Symbol	Characteristics		Value	Units
$V_{IN(MAX)}$	Maximum input voltage range(2)		36	V
$I_{OUT(OUT)}$	Maximum output current		1.0	A
$R_{\theta JA}$	Junction-to-ambient thermal resistance	TO-220CB-3L	65.1	°C/W
		TO-252-2L	78.9	
$R_{\theta JC}$	Junction-to-case thermal resistance	TO-220CB-3L	9	°C/W
		TO-252-2L	16	
$P_{D(Ref)}$	Reference maximum power dissipation for continuous operation	TO-220CB-3L	1.53	W
		TO-252-2L	1.25	
$T_{J(MAX)}$	Maximum junction temperature		150	°C
T_{stg}	Storage Temperature		-55 to +150	°C
T_{solder}	Soldering temperature & time		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.

Recommend Operating Conditions

Symbol	Thermal Metric		MIN.	NOM.	MAX.	Units
V_{IN}	Input voltage range	BX7805	–	–	25	V
		BX7809	–	–	29	
		BX7812	–	–	32	
T_J	Operating junction temperature		-40	–	125	°C
T_A	Operating ambient temperature		–	–(3)	–	°C

(3) 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.

ESD Ratings

Symbol	ESD Ratings		Value	Units
$V_{ESD-HBM}$	Electrostatic discharge(4)	Human body model	6000	V
V_{ESD-MM}		Machine model	500	

(4) 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.

BX7805 – Electrical Characteristics- (V_{IN}= 10V, I_{OUT}=1A,T_J=-40 to +125°C, unless otherwise specified)

Symbol	Thermal Metric	Test Conditions	MIN.	TYP.	MAX.	Units
V_{OUT}	Output voltage	T_J=25°C	4.90	5.00	5.10	V
		I_{OUT}=5mA to 1A, V_{IN}=7.5 to 20V, P_D≤ 15W	4.80	–	5.20	
ΔV_{RLINE}	Line regulation	V_{IN}=7.5 to 20V, I_{OUT}=500mA,T_J=25°C	–	25	50	mV
ΔV_{RLOAD}	Load regulation	V_{IN}=10V, I_{OUT}=5mA to 1A,T_J=25°C	–	20	50	mV
I_Q	Quiescent current	V_{IN}= 10V, T_J=-40 to 125°C, I_{OUT}=0mA	–	3.2	6.0	mA
ΔI_Q	Quiescent current change	V_{IN}=8 to 25V, I_{OUT}=500mA,T_J=25°C	–	0.3	0.8	mA
		I_{OUT}=5mA to 1A,T_J=25°C	–	0.08	0.5	
$\Delta V_{OUT}/\Delta T$	Output voltage temperature coefficient	–	–	0.4	–	mV/°C
ΔV_{OUT}/ ($V_{OUT}\times\Delta T$)	Quiescent current	–	–	80	–	ppm/°C
V_N	Output noise voltage	f=10Hz to 100kHz,T_A=25°C	–	10	–	μV/V_O
PSRR	Ripple rejection	f=120Hz,V_{IN}=8 to 18V,I_{OUT}=500mA	–	70	–	dB
V_D	Dropout voltage	ΔV_{OUT}=1%,I_{OUT}=1A,T_J=25°C	–	2.0	–	V
R_{OUT}	Output resistance	f= 1kHz	–	10	–	mΩ
I_{SC}	Short circuit current	V_{IN}=35V,T_A=25°C	–	50	–	mA
I_{PK}	Peak current	V_{IN}=10V	–	2.2	–	A

BX7809 – Electrical Characteristics (V_{IN}= 15V, I_{OUT}=1A,T_J=-40 to +125°C, unless otherwise specified)

Symbol	Thermal Metric	Test Conditions	MIN.	TYP.	MAX.	Units
V_{OUT}	Output voltage	T_J=25°C	8.82	9.00	9.18	V
		I_{OUT}=5mA to 1A, V_{IN}=11.5 to 23V, P_D≤ 15W	8.65	–	9.35	
ΔV_{RLINE}	Line regulation	V_{IN}=11.5 to 23V, I_{OUT}=500mA,T_J=25°C	–	25	90	mV
ΔV_{RLOAD}	Load regulation	V_{IN}=14V, I_{OUT}=5mA to 1A,T_J=25°C	–	25	100	mV
I_Q	Quiescent current	V_{IN}= 15V, I_{OUT}=0mA	–	3.2	6.0	mA
ΔI_Q	Quiescent current change	V_{IN}=11.5V to 23V, I_{OUT}=500mA,T_J=25°C	–	0.3	0.8	mA
		I_{OUT}=5mA to 1A,T_J=25°C	–	0.08	0.5	
$\Delta V_{OUT}/\Delta T$	Output voltage temperature coefficient	–	–	0.72	–	mV/°C
$\Delta V_{OUT}/(V_{OUT}\times\Delta T)$	Quiescent current	–	–	80	–	ppm/°C
V_N	Output noise voltage	f=10Hz to 100kHz,T_A=25°C	–	10	–	μV/V_O
PSRR	Ripple rejection	f=120Hz,V_{IN}=11.5V to 21.5V,I_{OUT}=500mA	–	61	–	dB
V_D	Dropout voltage	ΔV_{OUT}=1%,I_{OUT}=1A,T_J=25°C	–	2.0	–	V
R_{OUT}	Output resistance	f= 1kHz	–	10	–	mΩ
I_{SC}	Short circuit current	V_{IN}=35V,T_A=25°C	–	0.2	–	A
I_{PK}	Peak current	V_{IN}=10V	–	2.2	–	A

BX7812 – Electrical Characteristics (V_{IN}= 19V, I_{OUT}=1A,T_J=-40 to +125°C, unless otherwise specified)

Symbol	Thermal Metric	Test Conditions	MIN.	TYP.	MAX.	Units
V_{OUT}	Output voltage	T_J=25°C	11.75	12.00	12.25	V
		I_{OUT}=5mA to 1A, V_{IN}=14.8 to 27V, P_D≤ 15W	11.5	–	12.5	
ΔV_{RLINE}	Line regulation	V_{IN}=14.8V to 27V, I_{OUT}=500mA,T_J=25°C	–	25	120	mV
ΔV_{RLOAD}	Load regulation	V_{IN}=19V, I_{OUT}=5mA to 1A,T_J=25°C	–	40	120	mV
I_Q	Quiescent current	V_{IN}= 19V, I_{OUT}=0mA	–	3.4	6.0	mA
ΔI_Q	Quiescent current change	V_{IN}=14.8V to 30V, I_{OUT}=500mA,T_J=25°C	–	0.3	0.8	mA
		I_{OUT}=5mA to 1A,T_J=25°C	–	0.08	0.5	
$\Delta V_{OUT}/\Delta T$	Output voltage temperature coefficient	–	–	0.96	–	mV/°C
$\Delta V_{OUT}/(V_{OUT}\times\Delta T)$	Quiescent current	–	–	80	–	ppm/°C
V_N	Output noise voltage	f=10Hz to 100kHz,T_A=25°C	–	10	–	μV/V_O
PSRR	Ripple rejection	f=120Hz,V_{IN}=15V to 25V,I_{OUT}=500mA	–	60	–	dB
V_D	Dropout voltage	ΔV_{OUT}=1%,I_{OUT}=1A,T_J=25°C	–	2.0	–	V
R_{OUT}	Output resistance	f= 1kHz	–	11	–	mΩ
I_{SC}	Short circuit current	V_{IN}=35V,T_A=25°C	–	0.2	–	A
I_{PK}	Peak current	V_{IN}=18V, T_J=25°C	–	2.2	–	A

Typical Performance Characteristics

Fig 1: Line Regulation

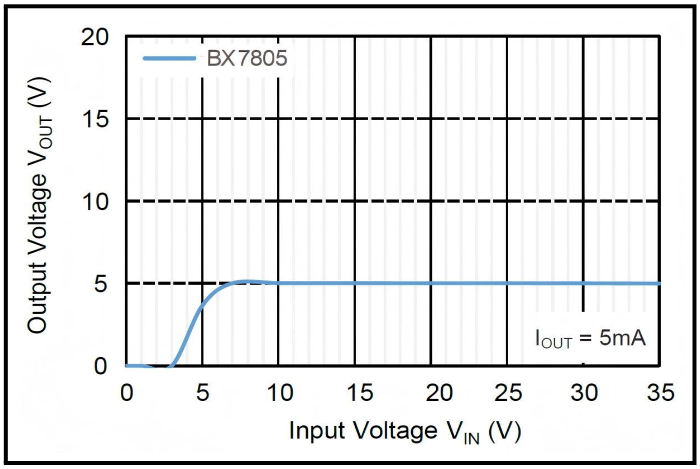


Fig 2:Load Regulation

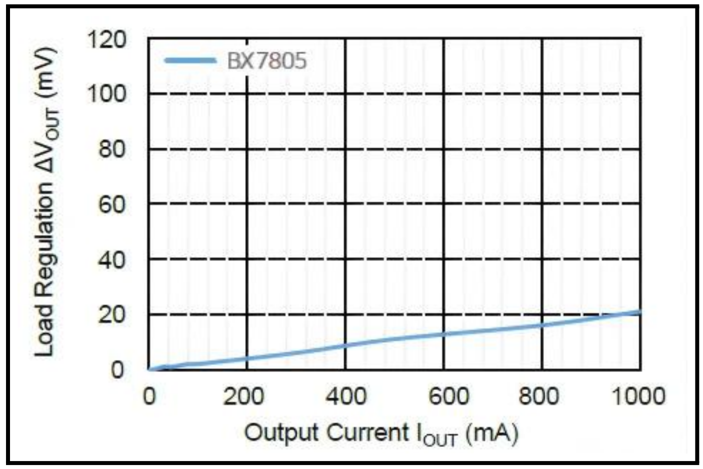


Fig 3: Temperature Characteristics

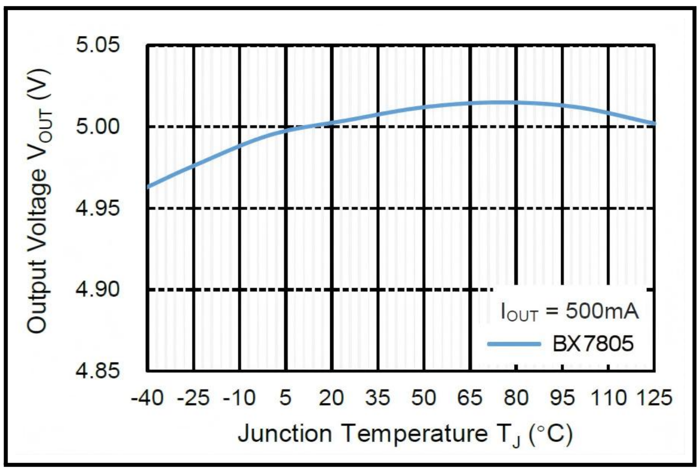


Fig 4:Dropout Voltage

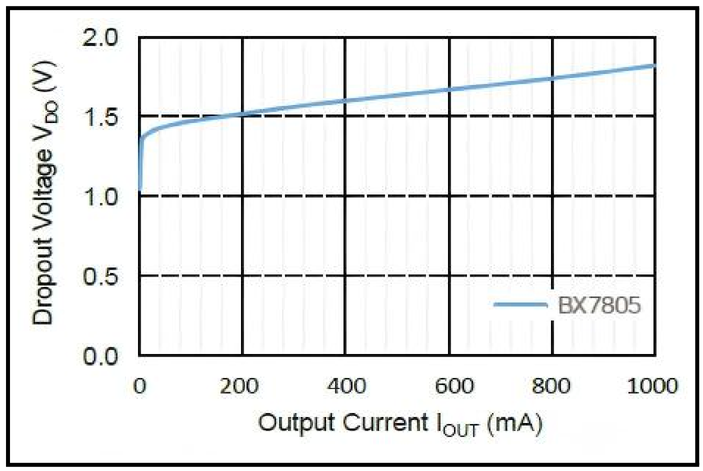


Fig 5: Quiescent Current

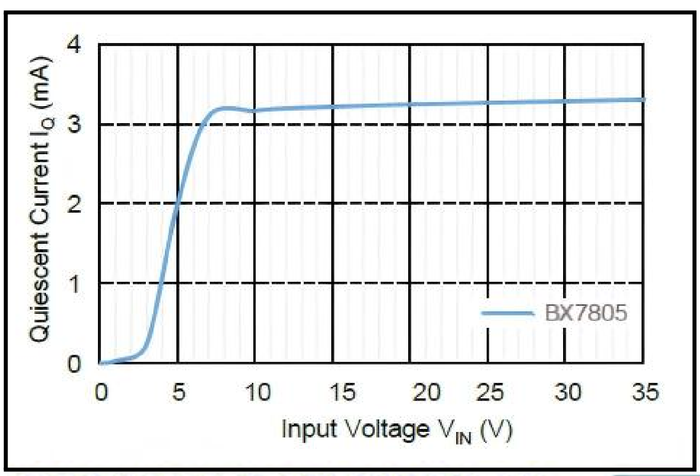
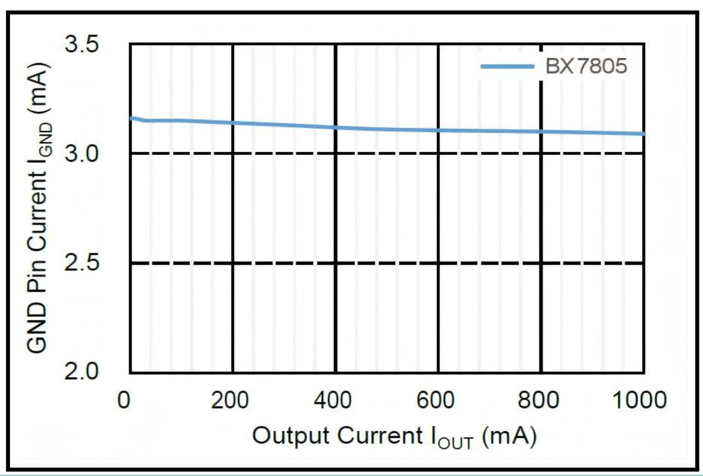


Fig 6:GND Pin Current



Typical Performance Characteristics

Fig 7: GND Pin Current

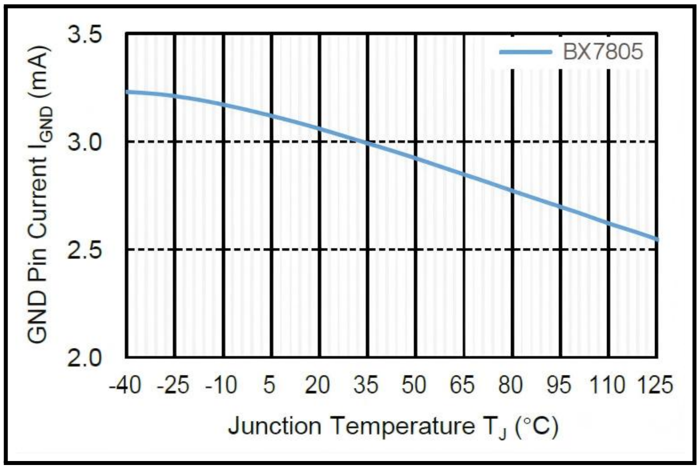


Fig 8: Output Current Limit

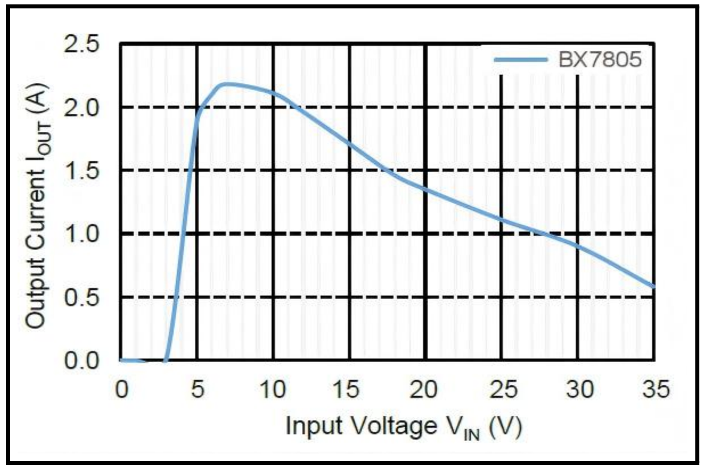


Fig 9: Ripple Rejection

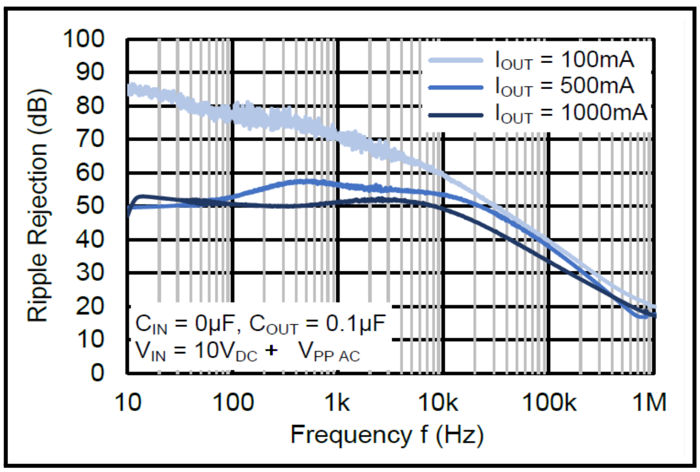


Fig 10: Ripple Rejection

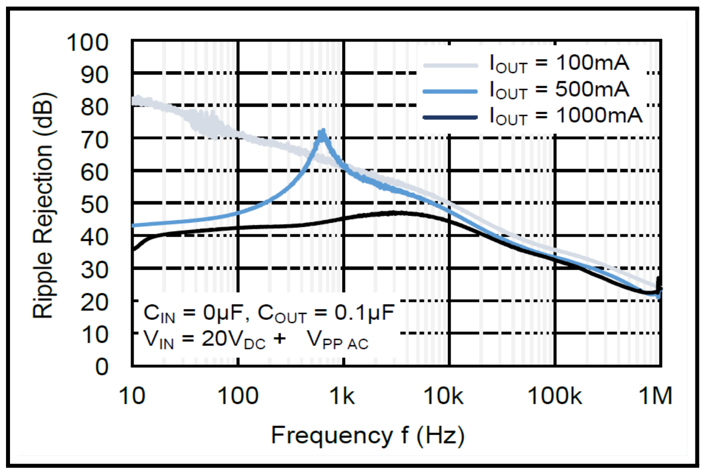
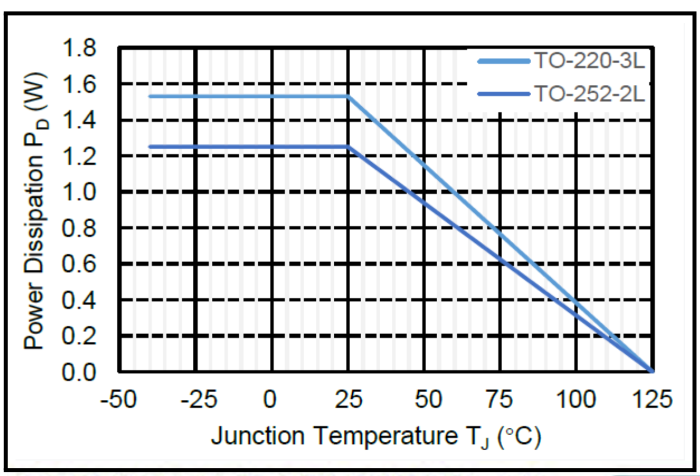


Fig 11: Power Dissipation

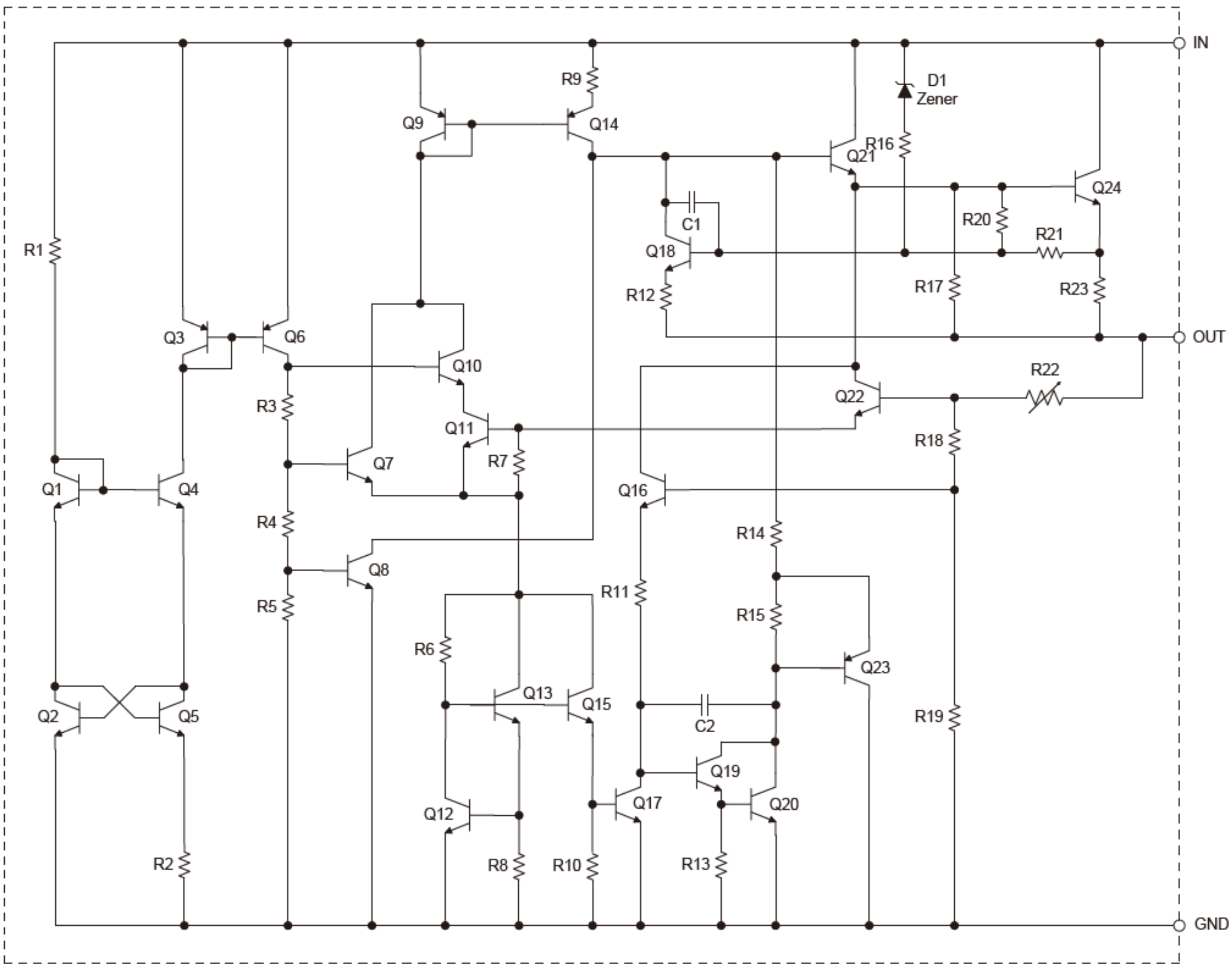


Detailed Description

Description

The BX78xxA series is a group of fixed output positive voltage regulators. It integrates built-in current limit, short-circuit protection, thermal overload protection and safe operating area protection of output transistor, which makes it relatively difficult to be damaged. By setting the resistance value of peripheral resistance, the BX78xxA series can also be used as adjustable voltage output regulator.

Representative Schematic Diagram



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 BX78xxA series has built-in current limit and short circuit protection. 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. The typical current limits for the BX78xxA series is 2.2A.

Thermal Shutdown Protection

The BX78xxA series has thermal shutdown protection. 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 device 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 BX78xxA series can output a current of up to 1A.

Application and Implementation

Risk Alert and Precautions

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 BX78xxA series can output a current of up to 1A.

Electrostatic Discharge (ESD) and Instantaneous Electrical Surge

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.

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.

Using TVS:

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 Fig. 15;

Using Input Resistor:

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 Fig.16;

Using Electrolytic Capacitor:

For the application circuit using the low ESR multilayer ceramic capacitor (MLCC) type input capacitor, the LC resonant voltage spike caused by hot plugging or power transmission line inductance can be suppressed by using RC suppression circuit for parallel connection of the input capacitor. A very simple method is to parallel a suitable electrolytic capacitor to the input capacitor. As shown in Fig.17. For most 100μF/25V electrolytic capacitor has an ESR of about 0.2Ω at 100kHz. This can completely suppress the overshoot phenomenon of the input and minimize the possibility of IC damage due to input voltage spikes.

Fig.12 and Fig.13 show the impact of not using electrolytic capacitor [Test circuit is shown in Fig.14] and using 100μF/25V electrolytic capacitor parallel to the input capacitor [Test circuit is shown in Fig.17] on suppressing surge voltage. As shown in Fig.12, when the input is powered on from 0 to 10V, a peak voltage of up to 20V (shown in the RED part) is generated in front of the input terminal of the device. When the electrolytic capacitor is used, as shown in Fig. 13, the peak voltage generated by power on is effectively suppressed (shown in the GREEN part).

Application and Implementation

Risk Alert and Precautions (continued)

BX7805 (C_{IN}= 10μF(MLCC),C_{OUT}=100μF,V_{IN}=0 to 10V,I_{OUT}= 100mA, CH1: V_{IN}, CH2: V_{OUT}.)

For the BX78xxA series, it is recommended that the input peak voltage should not exceed 36V. When the input voltage of the operating circuit may not meet the application conditions described above, it is recommended to adopt the circuit layout shown in Fig.5 in the circuit design.

Fig 12:Test with the conventional circuit

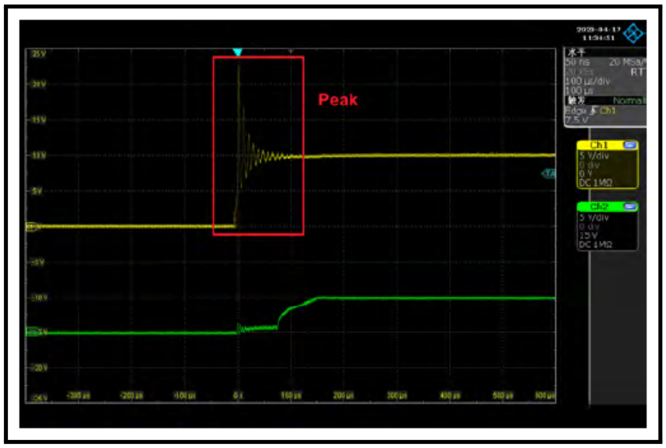
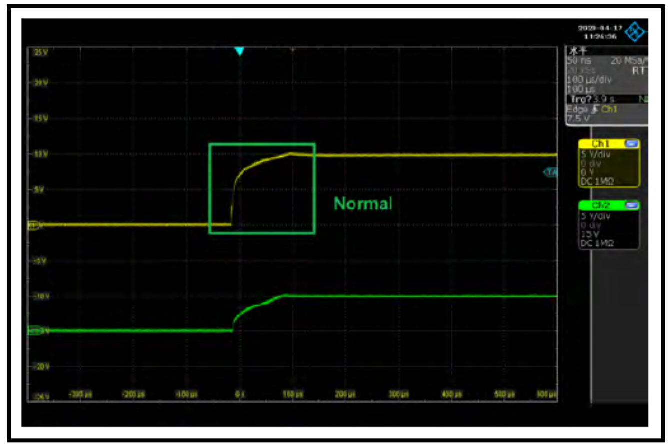


Fig 13:Test with the circuit that a 100μF/25V electrolytic capacitor parallel to the C_{IN}



Large Output Capacitance

The BX78xxA 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 Fig.16 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 Fig.16 to reduce the possibility of accidental failure of the device due to large surge current during power on.

Typical Application Circuits

Fig 14:Conventional Circuit

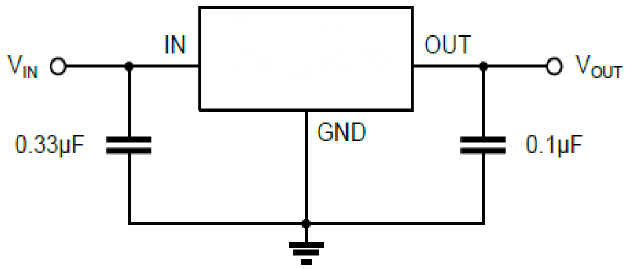


Fig 15:TVS is used at IN

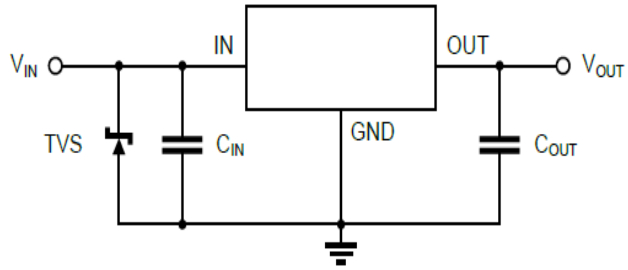


Fig 16:Resistance is used at IN

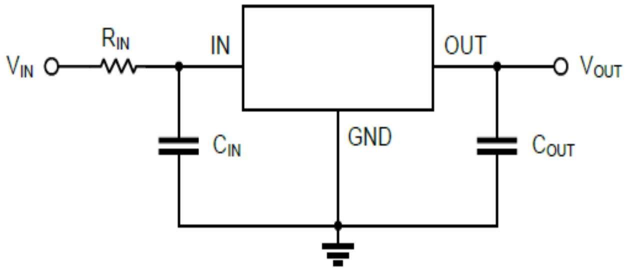
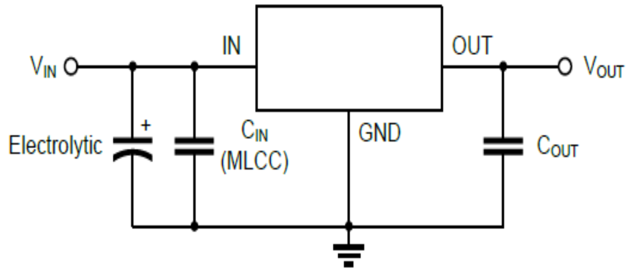


Fig 17:Electrolytic capacitor is used at IN



Bypass Capacitance Selection

A capacitance between IN and GND (CIN) is required if the regulator is located far from the power supply filter. It is recommended to use a 0.33μF capacitor for CIN, and the CIN 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 (COUT), and the COUT 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 CIN and COUT must be considered to ensure that the capacitor can work normally within the rated working ambient temperature and rated working conditions of the device.

It is recommended that the COUT should not exceed 20μF. When the COUT exceeds 20μF, it is recommended to use the circuit layout shown in Fig 13. See Large Output Capacitance for more details.

Design Requirements and Procedure

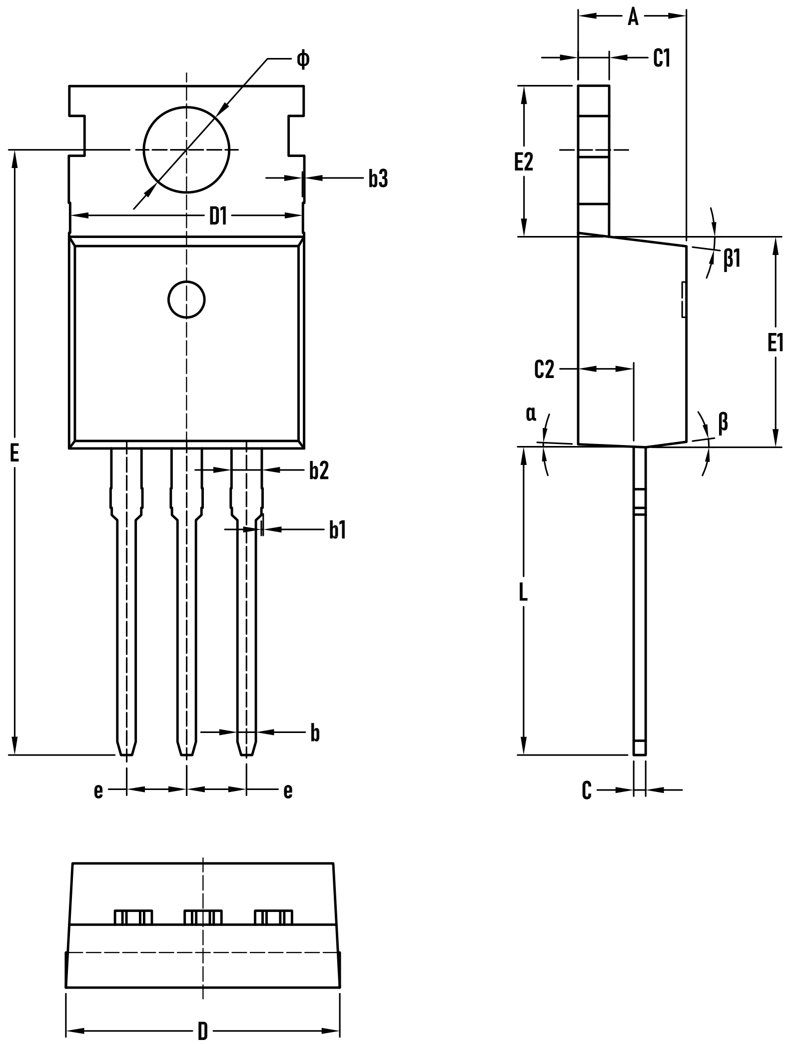
The BX78xxA series is mainly used to provide fixed output voltage regulation, the output voltage is selected based on the device variant, which is available in 5.0V, 9.0V and 12V regulator options, and it requires a very small number of device components. If the regulator is far from the power filter, the input capacitor CIN is required. The bypass capacitor COUT is used at the output to obtain the best stability and transient response. These capacitors must be as close to the regulator as possible.

Power Supply Recommendation

The linear regulator input supply must be well regulated and kept at a voltage level to not exceed the maximum input to output voltage differential allowed by the device. The minimum dropout voltage (VDO) must be meet with extra headroom when possible to keep the output well regulated.

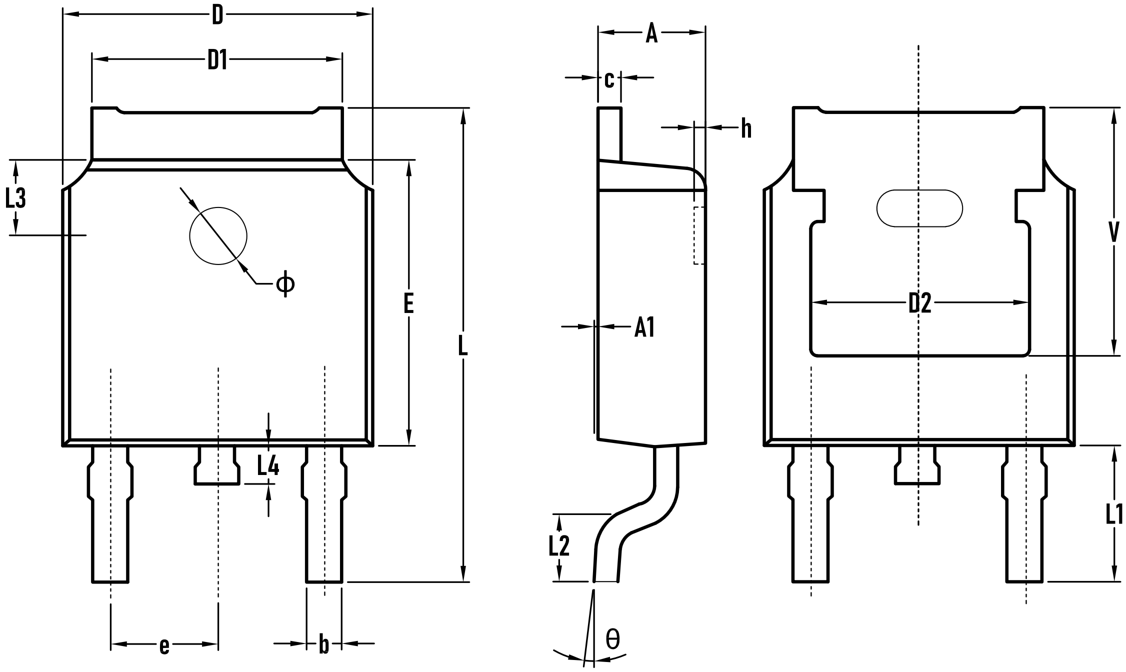
For the best overall performance, some layout guidelines may be disregarded. Place all circuit components on the same side of the circuit board and as near as practical to the respective linear regulator pins. Traces must be kept short and wide to reduce the amount of parasitic elements in the system. The actual width and thickness of traces depends on the current carrying capability and heat dissipation required by the end system.

Outline Drawing -TO-220CB-3L



SYMBOL	MILLIMETER		
	MIN.	Typ.	MAX.
A	4.40	4.60	4.80
b	0.72	0.82	0.92
b1	–	–	0.10
b2	1.12	1.27	1.42
b3	–	–	0.10
C	0.40	0.50	0.60
C1	1.20	1.30	1.40
C2	2.25	2.40	2.55
D	9.65	10.00	10.35
D1	9.70	9.88	10.06
e	2.54BSC		
E	25.82	26.12	26.42
E1	8.80	9.10	9.40
E2	6.25	6.50	6.85
L	13.06	13.26	13.46
φ	3.40	3.60	3.80
α	2 °	3°	4°
β	6 °	7°	8°
β1	6 °	7°	8°

Packaging Tape - TO-252-2L



SYMBOL	Millimeters		Inches	
	MIN.	MAX.	MIN.	MAX.
A	2.200	2.400	0.087	0.094
A1	0.000	0.127	0.000	0.005
b	0.660	0.860	0.026	0.034
c	0.460	0.580	0.018	0.023
D	6.500	6.700	0.256	0.264
D1	5.100	5.460	0.201	0.215
D2	4.830 TYP.		0.190 TYP.	
E	6.000	6.200	0.236	0.244
e	2.186	2.386	0.086	0.094
L	9.800	10.400	0.386	0.409
L1	2.900 TYP.		0.114 TYP.	
L2	1.400	1.700	0.055	0.067
L3	1.600 TYP.		0.063 TYP.	
L4	0.600	1.000	0.024	0.039
ϕ	1.100	1.300	0.043	0.051
θ	0°	8°	0°	8°
h	0.000	0.300	0.000	0.012
V	5.350 TYP.		0.211 TYP.	