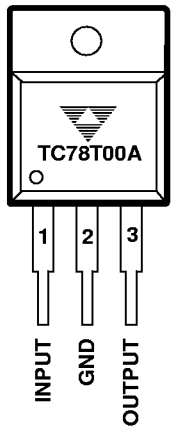
THREE-AMPERE POSITIVE VOLTAGE REGULATORS

FEATURES

- **Output Current in Excess of 3.0A**
- **Power Dissipation: 25W**
- **No External Components Required**
- **Output Voltage Offered in 2% Tolerance**
- **Thermal Regulation is Specified**
- **Internal Thermal Overload Protection**
- **Internal Short Circuit Current Limiting**
- **Output Transistor Safe–Area Compensation**

PIN CONFIGURATIONS

3-Pin TO-220B



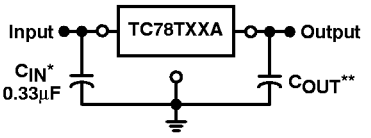
Heatsink surface is connected to Pin 2.

GENERAL DESCRIPTION

This family of fixed voltage regulators are monolithic integrated circuits capable of driving loads in excess of 3.0A. These three–terminal regulators employ internal current limiting, thermal shutdown, and safe–area compensation. Devices are available with improved specifications, including a 2% output voltage tolerance, on AC–suffix 5.0, 12 and 15V device types.

Although designed primarily as a fixed voltage regulator, these devices can be used with external components to obtain adjustable voltages and currents. This series of devices can be used with a series–pass transistor to supply up to 15A at the nominal output voltage.

Simplified Application



A common ground is required between the input and the output voltages. The input voltage must remain typically 2.2V above the output voltage even during the low point on the input ripple voltage.

XX these two digits of the type number indicate voltage.

***C_{IN} is required if regulator is located an appreciable distance from power supply filter. (See Applications Information for details.)**
****C_{OUT} is not needed for stability; however, it does improve transient response.**

ORDERING INFORMATION

Part Number	Voltage	Package	V_{OUT} Tol.	Temperature Range
TC78T05A-5.0VBB	5.0V	3-Pin TO-220B	2%	–40˚ to +125°C
TC78T12A-12.0VBB	12V	3-Pin TO-220B	2%	–40˚ to +125°C
TC78T15A-15.0VBB	15V	3-Pin TO-220B	2%	–40˚ to +125°C

Note: Contact company about other voltage and package options.

TC78T00A Series

ABSOLUTE MAXIMUM RATINGS*

(T_A = +25˚C, unless otherwise noted)

Input Voltage
- (5.0V – 12V) ..... V_{IN} = 35Vdc
- (15V) ..... V_{IN} = 40Vdc

Power Dissipation and Thermal Characteristics

Plastic Package (Note 1)
- T_A = +25˚C ..... P_D = Internally Limited

Thermal Resistance,
Junction-to-Air ..... Θ_{JA} = 65˚C/W
T_C = +25˚C ..... P_D = Internally Limited
Thermal Resistance,
Junction-to-Case ..... Θ_{JC} = 2.5˚C/W

Storage Junction Temperature ..... T_{STG} = +150˚C

Operating Junction Temperature Range TJ = 0 to +125˚C

*Although power dissipation is internally limited, specifications apply only for $P_{OUT} \leq P_{MAX}$, P_{MAX} = 25W.

ELECTRICAL CHARACTERISTICS: V_{IN} = 10V, I_{OUT} = 3.0A, 0˚C ≤ T_J ≤ 125˚C, $P_{OUT} \leq P_{MAX}$ [Note 1], unless otherwise specified).

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
TC78T05A						
V_{OUT}	Output Voltage	5.0mA ≤ I_{OUT} ≤ 3.0A, T_J = +25˚C 5.0mA ≤ I_{OUT} ≤ 3.0A; 5.0mA ≤ I_{OUT} ≤ 2.0A, 7.3V_{DC} ≤ V_{IN} ≤ 20V_{DC}	4.9 4.8	5.0 5.0	5.1 5.2	V_{DC}
REG_{LINE}	Line Regulation (Note 2)	7.2V_{DC} ≤ V_{IN} ≤ 35V_{DC}, I_{OUT} = 5.0mA, T_J = +25˚C; 7.2V_{DC} ≤ V_{IN} ≤ 35V_{DC}, I_{OUT} = 1.0A, T_J = +25˚C; 8.0V_{DC} ≤ V_{IN} ≤ 12V_{DC}, I_{OUT} = 3.0A, T_J = +25˚C; 7.5V_{DC} ≤ V_{IN} ≤ 20V_{DC}, I_{OUT} = 1.0A	–	3.0	25	mV
REG_{LOAD}	Load Regulation (Note 2)	5.0mA ≤ I_{OUT} ≤ 3.0A, T_J = +25˚C 5.0mA ≤ I_{OUT} ≤ 3.0A	– –	10 15	30 80	mV
$THERM_{REG}$	Thermal Regulation	Pulse = 10msec, P = 20W, T_A = +25˚C	–	0.001	0.01	%V_{OUT}/W
I_B	Quescent Current	5.0mA ≤ I_{OUT} ≤ 3.0A, T_J = +25˚C 5.0mA ≤ I_{OUT} ≤ 3.0A	– –	3.5 4.0	5.0 6.0	mA
ΔI_B	Quescent Current Change	7.2V_{DC} ≤ V_{IN} ≤ 35V_{DC}, I_{OUT} = 5.0mA, T_J = +25˚C; 5.0mA ≤ I_{OUT} ≤ 3.0A, T_J = +25˚C 7.5V_{DC} ≤ V_{IN} ≤ 20V_{DC}, I_{OUT} = 1.0A	–	0.3	1.0	mA
RR	Ripple Rejection	8.0V_{DC} ≤ V_{IN} ≤ 18V_{DC}, f = 120Hz, I_{OUT} ≤ 2.0A, T_J = +25˚C	62	75	–	dB
$V_{IN} – V_{OUT}$	Dropout Voltage	I_{OUT} = 3.0A, T_J = +25˚C	–	2.2	2.5	V_{DC}
V_N	Output Noise Voltage	10Hz ≤ f ≤ 100kHz, T_J = +25˚C	–	10	–	μV/V_{OUT}
R_{OUT}	Output Resistance	f = 1.0kHz	–	2.0	–	mΩ
I_{SC}	Short Circuit Limit	V_{IN} = 35V_{DC}, T_J = +25˚C	–	1.5	–	A
I_{MAX}	Peak Output Current	T_J = +25˚C	–	5.0	–	A
TCV_{OUT}	Average Temperature Coefficient of Output Voltage	I_{OUT} ≤ 5.0mA	–	0.2	–	mV/˚C

NOTES: 1. Although power dissipation is internally limited, specifications apply only for $P_{OUT} \leq P_{MAX}$, P_{MAX} = 25W
2. Line and load regulation are specified at constant junction temperature. Changes in V_{OUT} due to heating effects must be taken into account seperately. Pulse testing with low duty cycle is used.

ELECTRICAL CHARACTERISTICS: V_{IN} = 17V, I_{OUT} = 3.0A, 0˚C ≤ T_J ≤ 125˚C, P_{OUT} ≤ P_{MAX} [Note 1], unless otherwise specified).

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
TC78T12A						
V_{OUT}	Output Voltage	5.0mA ≤ I_{OUT} ≤ 3.0A, T_J = +25˚C 5.0mA ≤ I_{OUT} ≤ 3.0A; 5.0mA ≤ I_{OUT} ≤ 2.0A, 14.5V_{DC} ≤ V_{IN} ≤ 27V_{DC}	11.75 11.5	12 12	12.25 12.5	V_{DC}
REG_{LINE}	Line Regulation (Note 2)	14.5V_{DC} ≤ V_{IN} ≤ 35V_{DC}, I_{OUT} = 5.0mA, T_J = +25˚C; 14.5V_{DC} ≤ V_{IN} ≤ 35V_{DC}, I_{OUT} = 1.0A, T_J = +25˚C; 16V_{DC} ≤ V_{IN} ≤ 22V_{DC}, I_{OUT} = 3.0A, T_J = +25˚C; 14.9V_{DC} ≤ V_{IN} ≤ 27V_{DC}, I_{OUT} = 1.0A	–	6.0	45	mV
REG_{LOAD}	Load Regulation (Note 2)	5.0mA ≤ I_{OUT} ≤ 3.0A, T_J = +25˚C 5.0mA ≤ I_{OUT} ≤ 3.0A	– –	10 15	30 80	mV
$THERM_{REG}$	Thermal Regulation	Pulse = 10msec, P = 20W, T_A = +25˚C	–	0.001	0.01	%V_{OUT}/W
I_B	Quescent Current	5.0mA ≤ I_{OUT} ≤ 3.0A, T_J = +25˚C 5.0mA ≤ I_{OUT} ≤ 3.0A	– –	3.5 4.0	5.0 6.0	mA
ΔI_B	Quescent Current Change	14.5V_{DC} ≤ V_{IN} ≤ 35V_{DC}, I_{OUT} = 5.0mA, T_J = +25˚C; 5.0mA ≤ I_{OUT} ≤ 3.0A, T_J = +25˚C 14.9V_{DC} ≤ V_{IN} ≤ 27V_{DC}, I_{OUT} = 1.0A	–	0.3	1.0	mA
RR	Ripple Rejection	15V_{DC} ≤ V_{IN} ≤ 25V_{DC}, f = 120Hz, I_{OUT} ≤ 2.0A, T_J = +25˚C	57	67	–	dB
$V_{IN} - V_{OUT}$	Dropout Voltage	I_{OUT} = 3.0A, T_J = +25˚C	–	2.2	2.5	V_{DC}
V_N	Output Noise Voltage	10Hz ≤ f ≤ 100kHz, T_J = +25˚C	–	10	–	μV/V_{OUT}
R_{OUT}	Output Resistance	f = 1.0kHz	–	2.0	–	mΩ
I_{SC}	Short Circuit Limit	V_{IN} = 35V_{DC}, T_J = +25˚C	–	1.5	–	A
I_{MAX}	Peak Output Current	T_J = +25˚C	–	5.0	–	A
TCV_{OUT}	Average Temperature Coefficient of Output Voltage	I_{OUT} ≤ 5.0mA	–	0.5	–	mV/˚C

NOTES: 1. Although power dissipation is internally limited, specifications apply only for P_{OUT} ≤ P_{MAX}, P_{MAX} = 25W
2. Line and load regulation are specified at constant junction temperature. Changes in V_{OUT} due to heating effects must be taken into account seperately. Pulse testing with low duty cycle is used.

TC78T00A Series

ELECTRICAL CHARACTERISTICS: V_{IN} = 20V, I_{OUT} = 3.0A, 0˚C ≤ T_J ≤ 125˚C, P_{OUT} ≤ P_{MAX} [Note 1], unless otherwise specified).

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
TC78T15A						
V_{OUT}	Output Voltage	5.0mA ≤ I_{OUT} ≤ 3.0A, T_J = +25˚C 5.0mA ≤ I_{OUT} ≤ 3.0A; 5.0mA ≤ I_{OUT} ≤ 2.0A, 17.5V_{DC} ≤ V_{IN} ≤ 30V_{DC}	14.7 14.4	15 15	15.3 15.6	V_{DC}
REG_{LINE}	Line Regulation (Note 2)	17.6V_{DC} ≤ V_{IN} ≤ 40V_{DC}, I_{OUT} = 5.0mA, T_J = +25˚C; 17.6V_{DC} ≤ V_{IN} ≤ 40V_{DC}, I_{OUT} = 1.0A, T_J = +25˚C; 20V_{DC} ≤ V_{IN} ≤ 26V_{DC}, I_{OUT} = 3.0A, T_J = +25˚C; 18V_{DC} ≤ V_{IN} ≤ 30V_{DC}, I_{OUT} = 1.0A	–	7.5	55	mV
REG_{LOAD}	Load Regulation (Note 2)	5.0mA ≤ I_{OUT} ≤ 3.0A, T_J = +25˚C 5.0mA ≤ I_{OUT} ≤ 3.0A	– –	10 15	30 80	mV
$THERM_{REG}$	Thermal Regulation	Pulse = 10msec, P = 20W, T_A = +25˚C	–	0.001	0.01	%V_{OUT}/W
I_B	Quescent Current	5.0mA ≤ I_{OUT} ≤ 3.0A, T_J = +25˚C 5.0mA ≤ I_{OUT} ≤ 3.0A	– –	3.5 4.0	5.0 6.0	mA
ΔI_B	Quescent Current Change	17.6V_{DC} ≤ V_{IN} ≤ 40V_{DC}, I_{OUT} = 5.0mA, T_J = +25˚C; 5.0mA ≤ I_{OUT} ≤ 3.0A, T_J = +25˚C 18V_{DC} ≤ V_{IN} ≤ 30V_{DC}, I_{OUT} = 1.0A	–	0.3	1.0	mA
RR	Ripple Rejection	18.5V_{DC} ≤ V_{IN} ≤ 28.5V_{DC}, f = 120Hz, I_{OUT} ≤ 2.0A, T_J = +25˚C	55	65	–	dB
$V_{IN} - V_{OUT}$	Dropout Voltage	I_{OUT} = 3.0A, T_J = +25˚C	–	2.2	2.5	V_{DC}
V_N	Output Noise Voltage	10Hz ≤ f ≤ 100kHz, T_J = +25˚C	–	10	–	μV/V_{OUT}
R_{OUT}	Output Resistance	f = 1.0kHz	–	2.0	–	mΩ
I_{SC}	Short Circuit Limit	V_{IN} = 40V_{DC}, T_J = +25˚C	–	1.5	–	A
I_{MAX}	Peak Output Current	T_J = +25˚C	–	5.0	–	A
TCV_{OUT}	Average Temperature Coefficient of Output Voltage	I_{OUT} ≤ 5.0mA	–	0.6	–	mV/˚C

NOTES: 1. Although power dissipation is internally limited, specifications apply only for P_{OUT} ≤ P_{MAX}, P_{MAX} = 25W
2. Line and load regulation are specified at constant junction temperature. Changes in V_{OUT} due to heating effects must be taken into account seperately. Pulse testing with low duty cycle is used.

VOLTAGE REGULATOR PERFORMANCE

The performance of a voltage regulator is specified by its immunity to changes in load, input voltage, power dissipation, and temperature. Line and load regulation are tested with a pulse of short duration (< 100msec) and are strictly a function of electrical gain. However, pulse widths of longer duration (>1.0msec) are sufficient to affect temperature gradients across the die. These temperature gradients can cause a change in the output voltage, in addition to changes caused by line and load regulation. Longer pulse widths and thermal gradients make it desirable to specify thermal regulation.

Thermal regulation is defined as the change in output voltage caused by a change in dissipated power for a specified time, and is expressed as a percentage output voltage change per watt. The change in dissipated power can be caused by a change in either the input voltage or the load current. Thermal regulation is a function of IC layout and die attach techniques, and usually occurs within 10msec of a change in power dissipation. After 10msec, additional changes in the output voltage are due to the temperature coefficient of the device.

Figure 1 shows the line and thermal regulation response of a typical TC78T05A to a 20W input pulse. The variation of the output voltage due to line regulation is labeled and the thermal regulation component is labeled. Figure 2 shows the load and thermal regulation response of a typical TC78T05A to a 20W load pulse. The output voltage variation due to load regulation is labeled and the thermal regulation component is labeled.

Figure 1. TC78T05A Line and Thermal Regulation

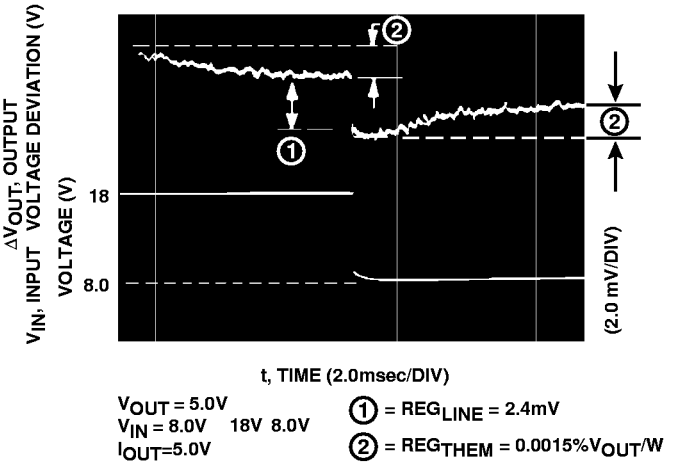
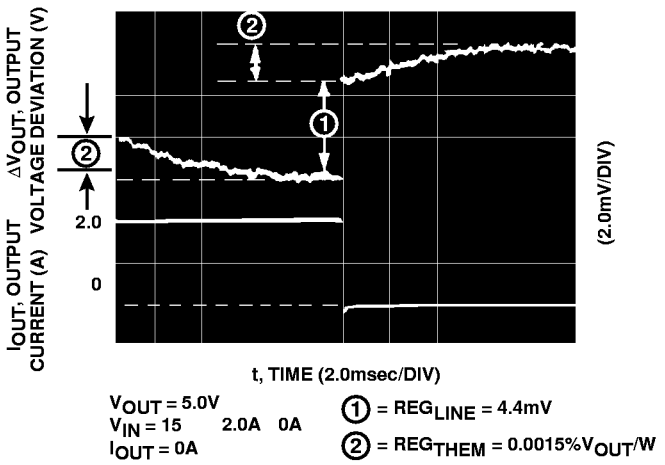
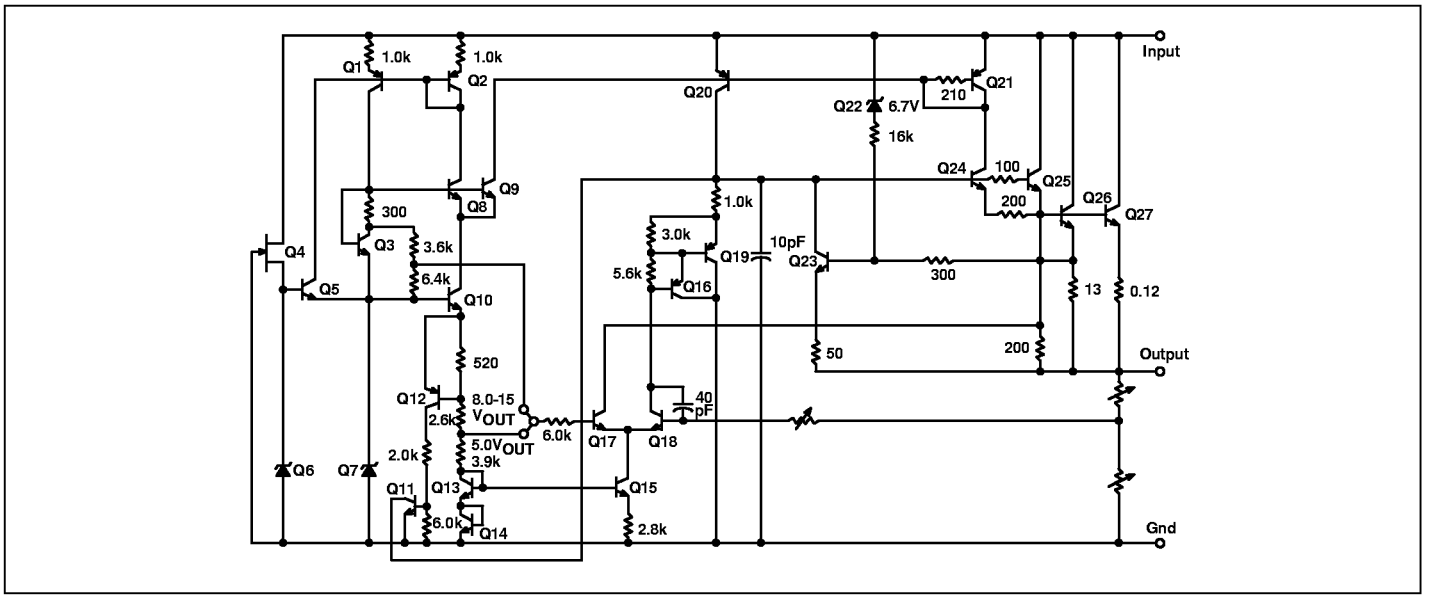


Figure 2. TC78T05A Load and Thermal Regulation



REPRESENTATIVE SCHEMATIC DIAGRAM



TC78T00A Series

Figure 3. Temperature Stability

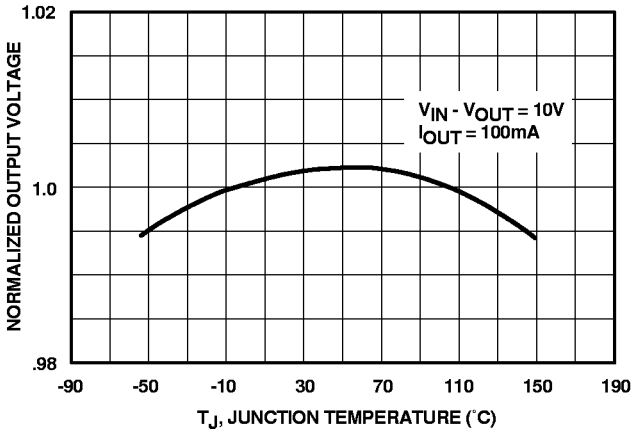


Figure 4. Output Impedance

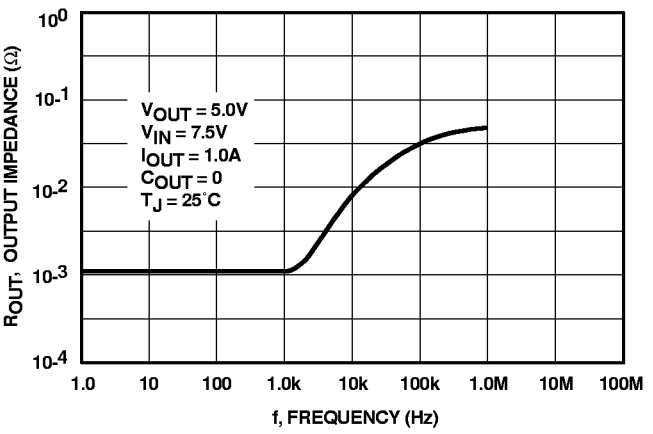


Figure 5. Ripple Rejection versus Frequency

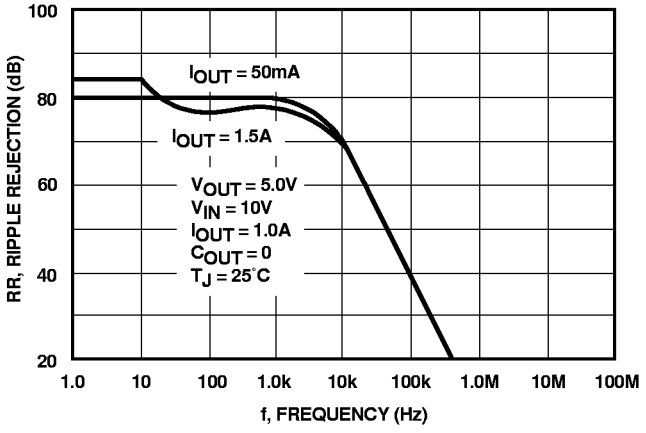


Figure 6. Ripple Rejection versus Output Current

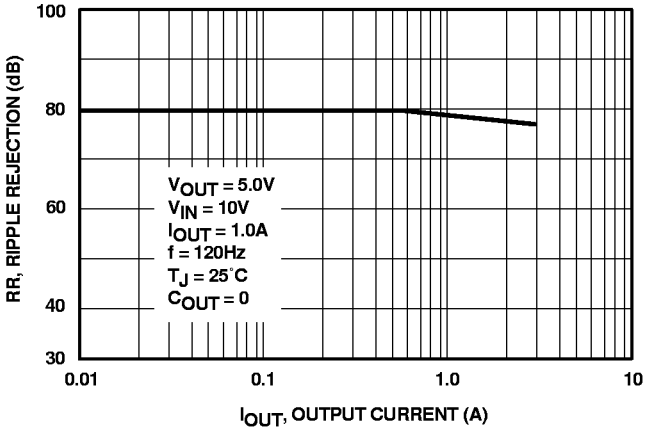


Figure 7. Quiescent Current versus Input Voltage

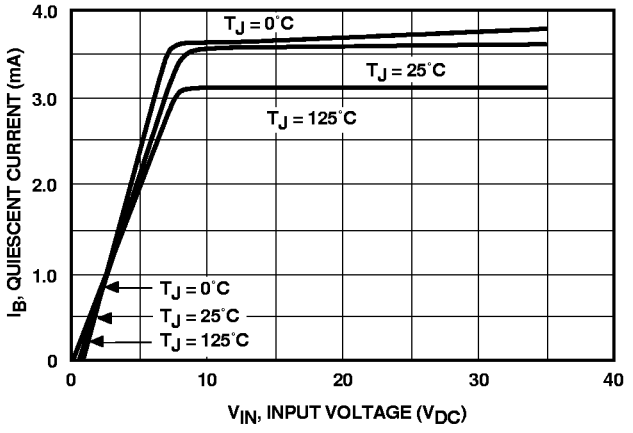


Figure 8. Quiescent Current versus Output Current

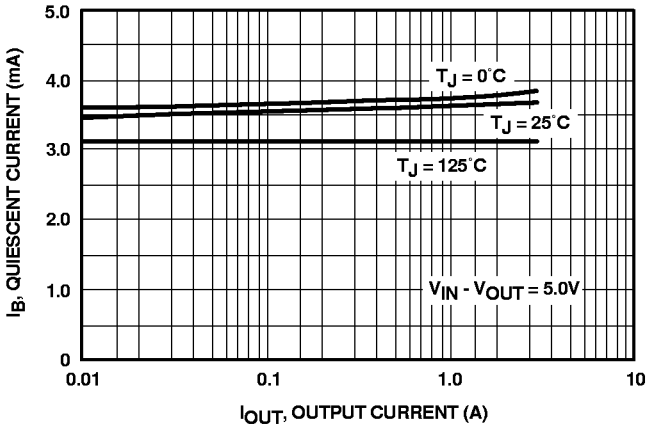


Figure 9. Dropout Voltage

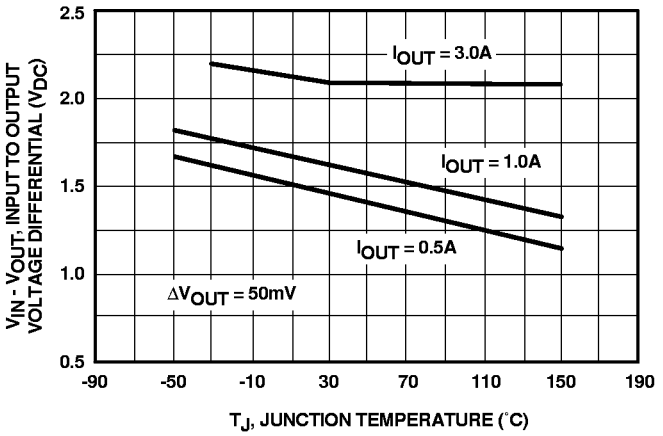


Figure 10. Peak Output Current

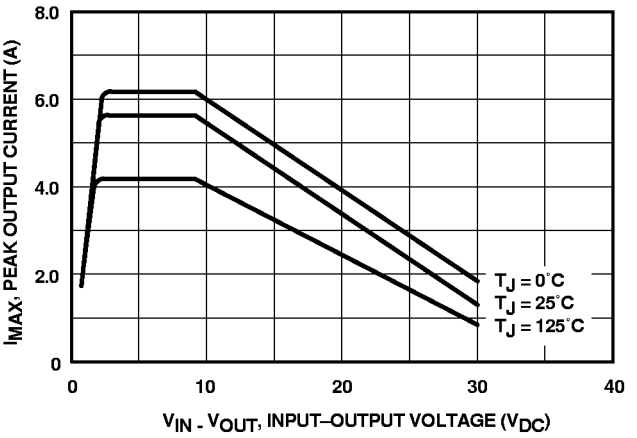


Figure 11. Line Transient Response

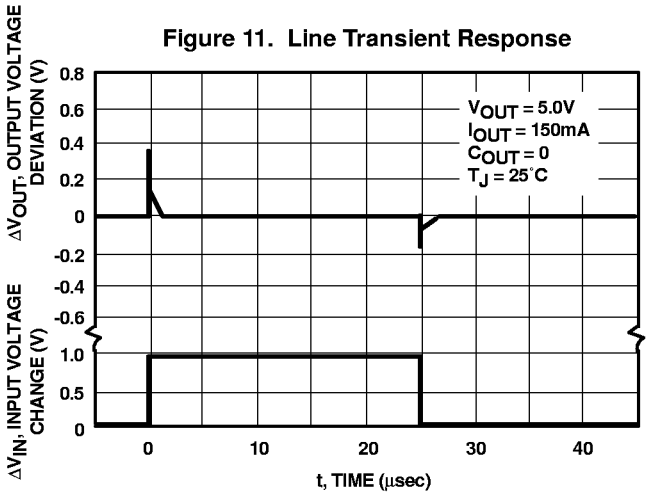


Figure 12. Load Transient Response

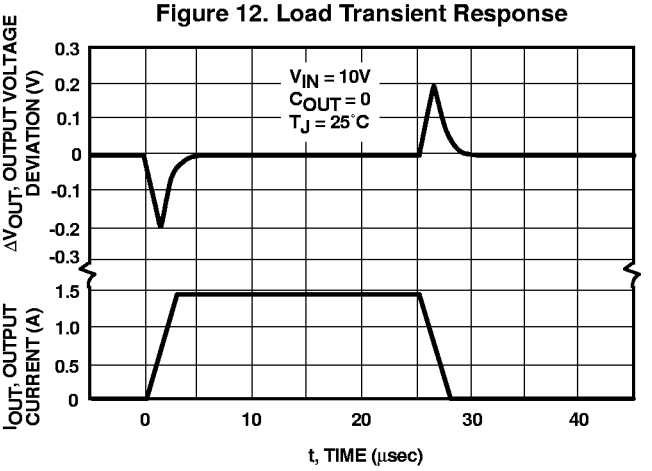
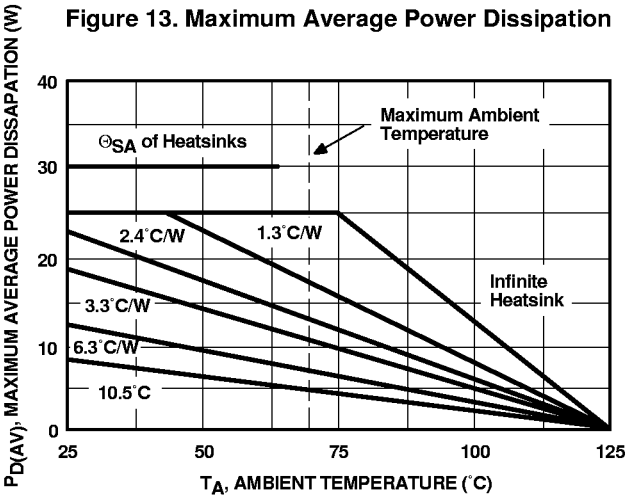


Figure 13. Maximum Average Power Dissipation



TC78T00A Series

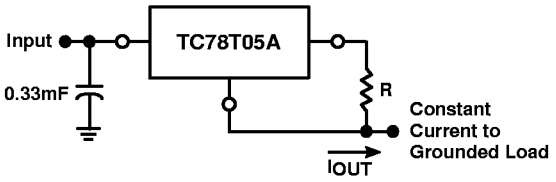
APPLICATIONS INFORMATION

Design Considerations

The MC78T00A Series of fixed voltage regulators are designed with Thermal Overload Protection that shuts down the circuit when subjected to an excessive power overload condition, Internal Short Circuit Protection that limits the maximum current the circuit will pass, and Output Transistor Safe–Area Compensation that reduces the output short circuit current as the voltage across the pass transistor is increased.

In many low current applications, compensation capacitors are not required. However, it is recommended that the regulator input be bypassed with a capacitor if the regulator is connected to the power supply filter with long wire lengths, or if the output load capacitance is large. An input bypass capacitor should be selected to provide good high frequency characteristics to insure stable operation under all load conditions. A 0.33μF or larger tantalum, mylar, or other capacitor having low internal impedance at high frequencies should be chosen. The bypass capacitor should be mounted with the shortest possible leads directly across the regulator's input terminals. Normally good construction techniques should be used to minimize ground loops and lead resistance drops since the regulator has no external sense lead.

Figure 14. Current Regulator

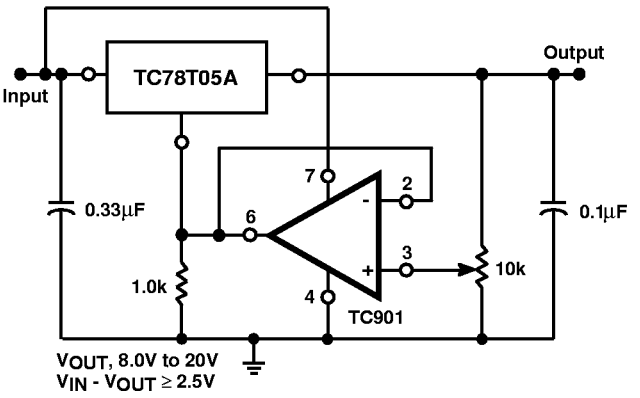


The TC78T05A regulator can also be used as a current source when connected as above. In order to minimize dissipation the TC78T05 is chosen in this application. Resistor R determines the current as follows:

$$I_{OUT} = \frac{5.0V}{R} + I_B$$

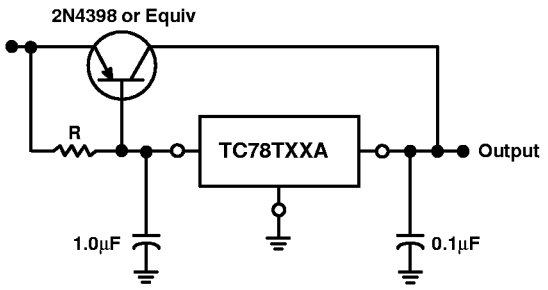
$\Delta I_B \cong 0.7mA$ over line, load and Temperature changes
$I_B \cong 3.5mA$ over line, load and Temperature changes
For example, a 2.0A current source would require R to be a 2.5Ω 10W resistor and the output voltage compliance would be the input voltage less 7.0V

Figure 15. Adjustable Output Regulator



The addition of an operational amplifier allows adjustment to higher or intermediate values while retaining regulation characteristics. The minimum voltage obtainable with this arrangement is 3.0V greater than the regulator voltage.

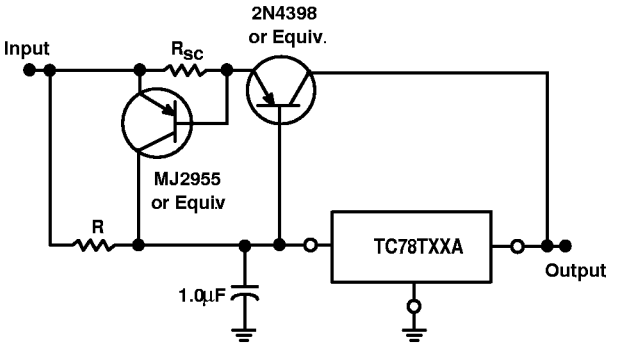
Figure 16. Current Boost Regulator



XX = 2 digits of type number indicating voltage.

The TC78T00A series can be current boosted with a PNP transistor. The 2N4398 provides current to 15A. Resistor R in conjuction with the VBE of the PNP determines when the pass transistor begins conducting; this circuit is not short circuit proof. Input-output differential voltage minimum is increased by the VBE of the pass transistor.

Figure 17. Current Boost With Short Circuit Protection

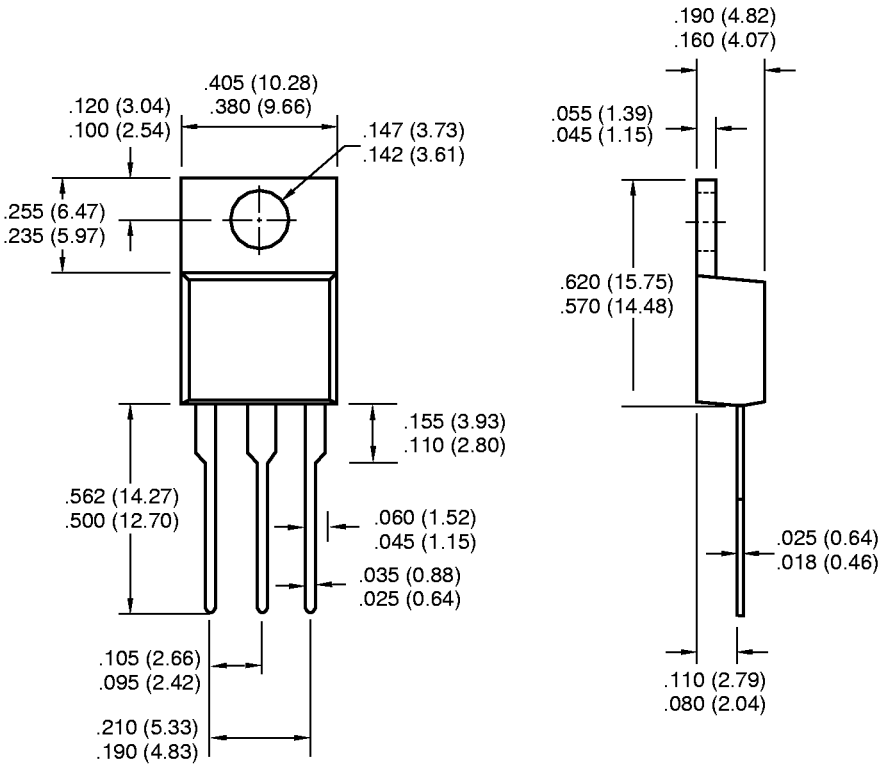


XX = 2 digits of type number indicating voltage.

The circuit of Figure 17 can be modified to provide supply protection against short circuits by adding a short circuit sense resistor, R_{SC}, and an additional PNP transistor. The current sensing PNP must be able to handle the short circuit current of the three–terminal regulator. Therefore, an eight–ampere power transistor is specified.

PACKAGE DIMENSIONS

3-PIN TO-220B



Dimensions: inches (mm)

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