National Semiconductor

LM7800 Series
3-Terminal Positive Voltage Regulators

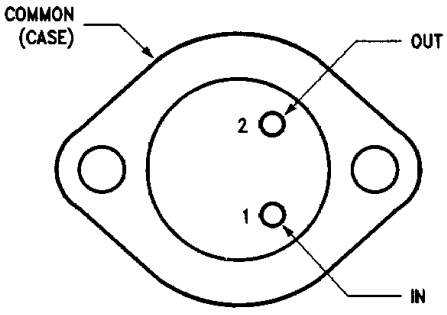
General Description

The LM7800 series of monolithic 3-terminal positive voltage regulators employ internal current-limiting, thermal shutdown and safe-area compensation, making them essentially indestructible. If adequate heat sinking is provided, they can deliver over 1.0A output current. They are intended as fixed voltage regulators in a wide range of applications including local (on-card) regulation for elimination of noise and distribution problems associated with single-point regulation. In addition to use as fixed voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents.

Features

- Output current in excess of 1.0A
- No external components
- Internal thermal overload protection
- Internal short circuit current-limiting
- Output transistor safe-area compensation
- Available in JEDEC TO-220 and TO-3 packages
- Output voltages of 6V, 8V, 18V and 24V (See Note)
- Available in extended temperature range

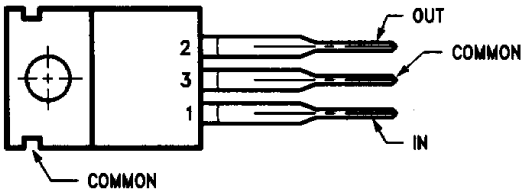
Connection Diagrams



TL/H/10052–1

Top View

Order Number LM7806K, LM7808K, LM7818K, LM7824K, LM7806CK, LM7808CK, LM7818CK or LM7824CK
See NS Package Number K02A



Lead 3 connected to tab.

TL/H/10052–2

Top View

Order Number LM7806CT, LM7808CT LM7818CT or LM7824CT
See NS Package Number T03B

Note: See General Purpose Linear Databook for specifications on similar devices with 5V, 12V, or 15V outputs. These parts can be found under LM140/LM340, LM140A/LM340A (for tighter output tolerance) and LM78XX datasheets.

Absolute Maximum Ratings

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Storage Temperature Range
- TO-3 Metal Can: −65°C to +175°C
- TO-220 Package: −65°C to +150°C

Operating Junction Temperature Range
- Extended (LM7800): −55°C to +150°C
- Commercial (LM7800C): 0°C to +150°C

Lead Temperature
- TO-3 Metal Can (Soldering, 60 sec.): 300°C
- TO-220 Package (Soldering, 10 sec.): 265°C

Power Dissipation: Internally Limited

Input Voltage
- 6.0V to 18V: 35V
- 24V: 40V

ESD Susceptibility: (to be determined)

LM7806C
Electrical Characteristics

$0°C \le T_A \le +125°C$, $V_I = 11V$, $I_O = 500$ mA, $C_I = 0.33\ \mu F$, $C_O = 0.1\ \mu F$, unless otherwise specified

Symbol	Parameter		Conditions (Note 1)		Min	Typ	Max	Units
V_O	Output Voltage		$T_J = 25°C$		5.75	6.0	6.25	V
$V_{R\ LINE}$	Line Regulation		$T_J = 25°C$	$8.0V \le V_I \le 25V$		5.0	120	mV
				$9.0V \le V_I \le 13V$		1.5	60	
$V_{R\ LOAD}$	Load Regulation		$T_J = 25°C$	$5.0\ mA \le I_O \le 1.5A$		14	120	mV
				$250\ mA \le I_O \le 750\ mA$		4.0	60	
V_O	Output Voltage		$8.0V \le V_I \le 21V$, $5.0\ mA \le I_O \le 1.0A$, $P \le 15W$		5.7		6.3	V
I_Q	Quiescent Current		$T_J = 25°C$			4.3	8.0	mA
ΔI_Q	Quiescent Current Change	With Line	$8.0V \le V_I \le 25V$				1.3	mA
		With Load	$5.0\ mA \le I_O \le 1.0A$				0.5	
N_O	Noise		$T_A = 25°C$, $10\ Hz \le f \le 100\ kHz$			45		μV
$\Delta V_I/\Delta V_O$	Ripple Rejection		$f = 2400\ Hz$, $I_O = 350\ mA$, $T_J = 25°C$		59	75		dB
V_{DO}	Dropout Voltage		$I_O = 1.0A$, $T_J = 25°C$			2.0		V
R_O	Output Resistance		$f = 1.0\ kHz$			19		mΩ
I_{OS}	Output Short Circuit Current		$T_J = 25°C$, $V_I = 35V$			550		mA
I_{pk}	Peak Output Current		$T_J = 25°C$			2.2		A
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage		$I_O = 5.0\ mA$, $0°C \le T_A \le +125°C$			0.8		mV/°C

LM7808
Electrical Characteristics

$-55°C \le T_A \le +125°C$, $V_I = 14V$, $I_O = 500$ mA, $C_I = 0.33\ \mu F$, $C_O = 0.1\ \mu F$, unless otherwise specified

Symbol	Parameter		Conditions (Note 1)		Min	Typ	Max	Units
V_O	Output Voltage		$T_J = 25°C$		7.7	8.0	8.3	V
$V_{R\ LINE}$	Line Regulation		$T_J = 25°C$	$10.5V \le V_I \le 25V$		6.0	80	mV
				$11V \le V_I \le 17V$		2.0	40	
$V_{R\ LOAD}$	Load Regulation		$T_J = 25°C$	$5.0\ mA \le I_O \le 1.5A$		12	100	mV
				$250\ mA \le I_O \le 750\ mA$		4.0	40	
V_O	Output Voltage		$11.5V \le V_I \le 23V$, $5.0\ mA \le I_O \le 1.0A$, $P \le 15W$		7.6		8.4	V
I_Q	Quiescent Current		$T_J = 25°C$			4.3	6.0	mA
ΔI_Q	Quiescent Current Change	With Line	$11.5V \le V_I \le 25V$				0.8	mA
		With Load	$5.0\ mA \le I_O \le 1.0A$				0.5	

LM7808
Electrical Characteristics (Continued)

$-55°C \le T_A \le +125°C$, $V_I = 14V$, $I_O = 500$ mA, $C_I = 0.33\ \mu F$, $C_O = 0.1\ \mu F$, unless otherwise specified

Symbol	Parameter	Conditions (Note 1)		Min	Typ	Max	Units
N_O	Noise	$T_A = 25°C$, 10 Hz ≤ f ≤ 100 kHz			8.0	40	$\mu V/V_O$
$\Delta V_I/\Delta V_O$	Ripple Rejection	f = 2400 Hz, I_O = 350 mA, $T_J = 25°C$		62	72		dB
V_{DO}	Dropout Voltage	$I_O = 1.0A$, $T_J = 25°C$			2.0	2.5	V
R_O	Output Resistance	f = 1.0 kHz			16		mΩ
I_{OS}	Output Short Circuit Current	$T_J = 25°C$, $V_I = 35V$			0.75	1.2	A
I_{pk}	Peak Output Current	$T_J = 25°C$		1.3	2.2	3.3	A
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage	I_O = 5.0 mA	$-55°C \le T_A \le +25°C$			0.4	mV/°C/ V_O
			$+25°C \le T_A \le +125°C$			0.3	

LM7808C
Electrical Characteristics

$0°C \le T_A \le +125°C$, $V_I = 14V$, $I_O = 500$ mA, $C_I = 0.33\ \mu F$, $C_O = 0.1\ \mu F$, unless otherwise specified

Symbol	Parameter		Conditions (Note 1)		Min	Typ	Max	Units
V_O	Output Voltage		$T_J = 25°C$		7.7	8.0	8.3	V
$V_{R\ LINE}$	Line Regulation		$T_J = 25°C$	10.5V ≤ V_I ≤ 25V		6.0	160	mV
				11V ≤ V_I ≤ 17V		2.0	80	
$V_{R\ LOAD}$	Load Regulation		$T_J = 25°C$	5.0 mA ≤ I_O ≤ 1.5A		12	160	mV
				250 mA ≤ I_O ≤ 750 mA		4.0	80	
V_O	Output Voltage		10.5V ≤ V_I ≤ 23V, 5.0 mA ≤ I_O ≤ 1.0A, P ≤ 15W		7.6		8.4	V
I_Q	Quiescent Current		$T_J = 25°C$			4.3	8.0	mA
ΔI_Q	Quiescent Current Change	With Line	10.5V ≤ V_I ≤ 25V				1.0	mA
		With Load	5.0 mA ≤ I_O ≤ 1.0A				0.5	
N_O	Noise		$T_A = 25°C$, 10 Hz ≤ f ≤ 100 kHz			52		μV
$\Delta V_I/\Delta V_O$	Ripple Rejection		f = 2400 Hz, I_O = 350 mA, $T_J = 25°C$		56	72		dB
V_{DO}	Dropout Voltage		$I_O = 1.0A$, $T_J = 25°C$			2.0		V
R_O	Output Resistance		f = 1.0 kHz			16		mΩ
I_{OS}	Output Short Circuit Current		$T_J = 25°C$, $V_I = 35V$			450		mA
I_{pk}	Peak Output Current		$T_J = 25°C$			2.2		A
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage		I_O = 5.0 mA			0.8		mV/°C

LM7818
Electrical Characteristics

$-55°C \le T_A \le +125°C$, $V_I = 27V$, $I_O = 500$ mA, $C_I = 0.33\ \mu F$, $C_O = 0.1\ \mu F$, unless otherwise specified

Symbol	Parameter		Conditions (Note 1)		Min	Typ	Max	Units
V_O	Output Voltage		$T_J = 25°C$		17.3	18.0	18.7	V
$V_{R\ LINE}$	Line Regulation		$T_J = 25°C$	$21V \le V_I \le 33V$		15	180	mV
				$24V \le V_I \le 30V$		5.0	90	
$V_{R\ LOAD}$	Load Regulation		$T_J = 25°C$	$5.0\ mA \le I_O \le 1.5A$		12	180	mV
				$250\ mA \le I_O \le 750\ mA$		4.0	90	
V_O	Output Voltage		$22V \le V_I \le 33V$, $5.0\ mA \le I_O \le 1.0A$, $P \le 15W$		17.1		18.9	V
I_Q	Quiescent Current		$T_J = 25°C$			4.5	6.0	mA
ΔI_Q	Quiescent Current Change	With Line	$22V \le V_I \le 33V$				0.8	mA
		With Load	$5.0\ mA \le I_O \le 1.0A$				0.5	
N_O	Noise		$T_A = 25°C$, $10\ Hz \le f \le 100\ kHz$			8.0	40	$\mu V/V_O$
$\Delta V_I/\Delta V_O$	Ripple Rejection		$f = 2400\ Hz$, $I_O = 350\ mA$, $T_J = 25°C$		59	69		dB
V_{DO}	Dropout Voltage		$I_O = 1.0A$, $T_J = 25°C$			2.0		V
R_O	Output Resistance		$f = 1.0\ kHz$			22		mΩ
I_{OS}	Output Short Circuit Current		$T_J = 25°C$, $V_I = 35V$			0.75		A
I_{pk}	Peak Output Current		$T_J = 25°C$		1.3	2.2	3.3	A
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage		$I_O = 5.0\ mA$	$-55°C \le T_A \le +25°C$			0.4	mV/°C/ V_O
				$+25°C \le T_A \le +125°C$			0.3	

LM7818C
Electrical Characteristics

$0°C \le T_A \le +125°C$, $V_I = 27V$, $I_O = 500$ mA, $C_I = 0.33\ \mu F$, $C_O = 0.1\ \mu F$, unless otherwise specified.

Symbol	Parameter	Conditions (Note 1)		Min	Typ	Max	Units
V_O	Output Voltage	$T_J = 25°C$		17.3	18.0	18.7	V
$V_{R\ LINE}$	Line Regulation	$T_J = 25°C$	$21V \le V_I \le 33V$		15	360	mV
			$24V \le V_I \le 30V$		5.0	180	
$V_{R\ LOAD}$	Load Regulation	$T_J = 25°C$	$5.0\ mA \le I_O \le 1.5A$		12	360	mV
			$250\ mA \le I_O \le 750\ mA$		4.0	180	
V_O	Output Voltage	$21V \le V_I \le 33V$, $5.0\ mA \le I_O \le 1.0A$, $P \le 15W$		17.1		18.9	V
I_Q	Quiescent Current	$T_J = 25°C$			4.5	8.0	mA

LM7818C
Electrical Characteristics (Continued)

$0°C \le T_A \le +125°C$, $V_I = 27V$, $I_O = 500\ mA$, $C_I = 0.33\ \mu F$, $C_O = 0.1\ \mu F$, unless otherwise specified

Symbol	Parameter		Conditions (Note 1)	Min	Typ	Max	Units
ΔI_Q	Quiescent Current Change	With Line	$21V \le V_I \le 33V$			1.0	mA
		With Load	$5.0\ mA \le I_O \le 1.0A$			0.5	
N_O	Noise		$T_A = 25°C$, $10\ Hz \le f \le 100\ kHz$		110		μV
$\Delta V_I/\Delta V_O$	Ripple Rejection		$f = 2400\ Hz$, $I_O = 350\ mA$, $T_J = 25°C$	53	69		dB
V_{DO}	Dropout Voltage		$I_O = 1.0A$, $T_J = 25°C$		2.0		V
R_O	Output Resistance		$f = 1.0\ kHz$		22		$m\Omega$
I_{OS}	Output Short Circuit Current		$T_J = 25°C$, $V_I = 35V$		200		mA
I_{pk}	Peak Output Current		$T_J = 25°C$		2.1		A
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage		$I_O = 5.0\ mA$		1.0		mV/°C

LM7824
Electrical Characteristics

$-55°C \le T_A \le +125°C$, $V_I = 33V$, $I_O = 500\ mA$, $C_I = 0.33\ \mu F$, $C_O = 0.1\ \mu F$, unless otherwise specified

Symbol	Parameter		Conditions (Note 1)		Min	Typ	Max	Units
V_O	Output Voltage		$T_J = 25°C$		23.0	24.0	25.0	V
$V_{R\ LINE}$	Line Regulation		$T_J = 25°C$	$27V \le V_I \le 38V$		18	240	mV
				$30V \le V_I \le 36V$		6.0	120	
$V_{R\ LOAD}$	Load Regulation		$T_J = 25°C$	$5.0\ mA \le I_O \le 1.5A$		12	240	mV
				$250\ mA \le I_O \le 750\ mA$		4.0	120	
V_O	Output Voltage		$28V \le V_I \le 38V$, $5.0\ mA \le I_O \le 1.0A$, $P \le 15W$		22.8		25.2	V
I_Q	Quiescent Current		$T_J = 25°C$			4.6	6.0	mA
ΔI_Q	Quiescent Current Change	With Line	$28V \le V_I \le 38V$				0.8	mA
		With Load	$5.0\ mA \le I_O \le 1.0A$				0.5	
N_O	Noise		$T_A = 25°C$, $10\ Hz \le f \le 100\ kHz$			8.0	40	$\mu V/V_O$
$\Delta V_I/\Delta V_O$	Ripple Rejection		$f = 2400\ Hz$, $I_O = 350\ mA$, $T_J = 25°C$		56	66		dB
V_{DO}	Dropout Voltage		$I_O = 1.0A$, $T_J = 25°C$			2.0	2.5	V
R_O	Output Resistance		$f = 1.0\ kHz$			28		$m\Omega$
I_{OS}	Output Short Circuit Current		$T_J = 25°C$, $V_I = 35V$			0.75	1.2	A
I_{pk}	Peak Output Current		$T_J = 25°C$		1.3	2.2	3.3	A
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage		$I_O = 5.0\ mA$	$-55°C \le T_A \le +25°C$			0.4	mV/°C/ V_O
				$+25°C \le T_A \le +125°C$			0.3	

LM7824C
Electrical Characteristics

$0°C \le T_A \le +125°C$, $V_I = 33V$, $I_O = 500\ mA$, $C_I = 0.33\ \mu F$, $C_O = 0.1\ \mu F$, unless otherwise specified

Symbol	Characteristics	Conditions (Note 1)		Min	Typ	Max	Units
V_O	Output Voltage	$T_J = 25°C$		23.0	24.0	25.0	V
$V_{R\ LINE}$	Line Regulation	$T_J = 25°C$	$27V \le V_I \le 38V$		18	480	mV
			$30V \le V_I \le 36V$		6.0	240	
$V_{R\ LOAD}$	Load Regulation	$T_J = 25°C$	$5.0\ mA \le I_O \le 1.5A$		12	480	mV
			$250\ mA \le I_O \le 750\ mA$		4.0	240	
V_O	Output Voltage	$27V \le V_I \le 38V$, $5.0\ mA \le I_O \le 1.0A$, $P \le 15W$		22.8		25.2	V
I_Q	Quiescent Current	$T_J = 25°C$			4.6	8.0	mA

LM7824C

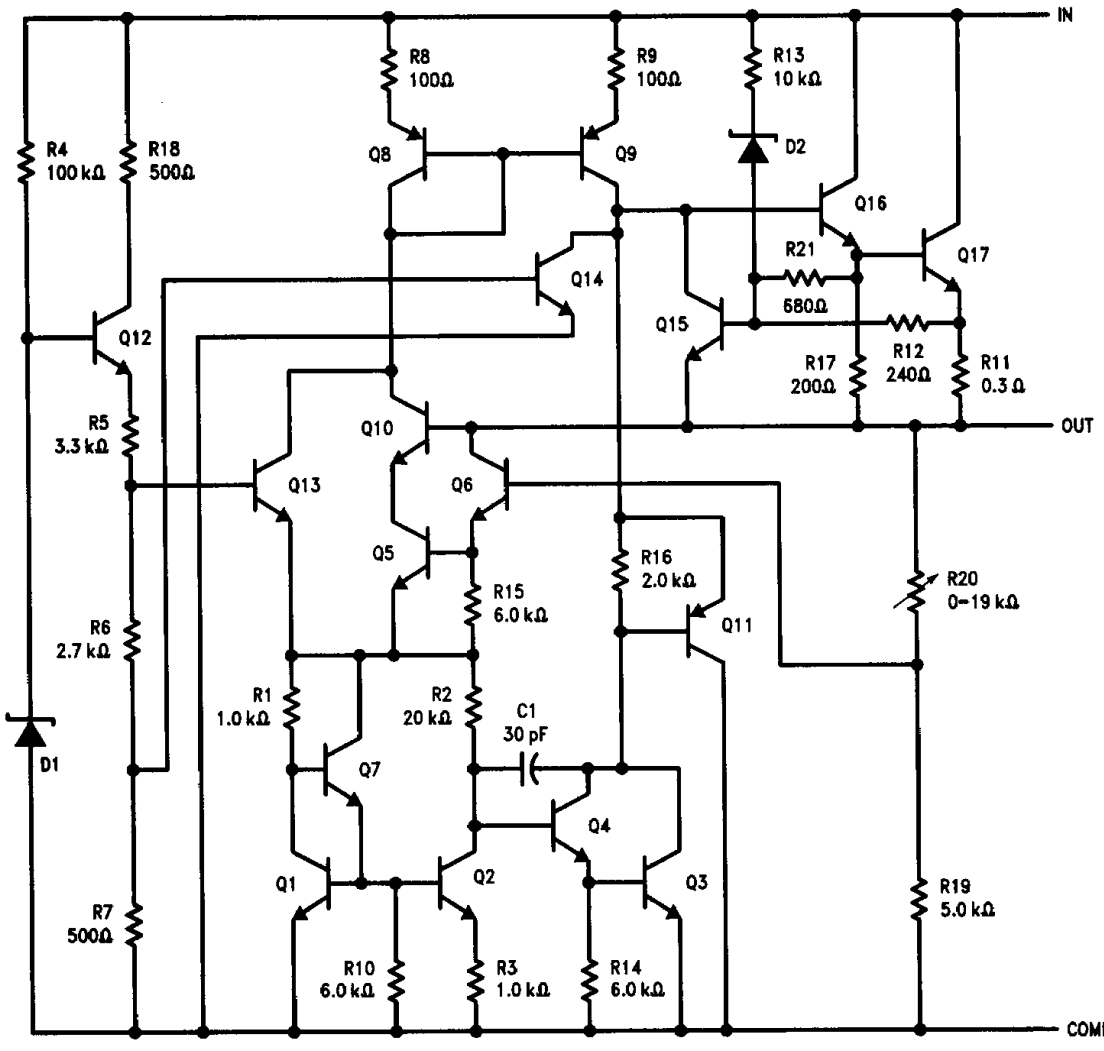
Electrical Characteristics (Continued)

$0°C \le T_A \le +125°C$, $V_I = 33V$, $I_O = 500$ mA, $C_I = 0.33\ \mu F$, $C_O = 0.1\ \mu F$, unless otherwise specified

Symbol	Parameter		Conditions (Note 1)	Min	Typ	Max	Units
ΔI_Q	Quiescent Current Change	With Line	$27V \le V_I \le 38V$			1.0	mA
		With Load	$5.0\ mA \le I_O \le 1.0A$			0.5	
N_O	Noise		$T_A = 25°C$, $10\ Hz \le f \le 100\ kHz$		170		μV
$\Delta V_I/\Delta V_O$	Ripple Rejection		$f = 2400\ Hz$, $I_O = 350\ mA$, $T_J = 25°C$	50	66		dB
V_{DO}	Dropout Voltage		$I_O = 1.0A$, $T_J = 25°C$		2.0		V
R_O	Output Resistance		$f = 1.0\ kHz$		28		mΩ
I_{OS}	Output Short Circuit Current		$T_J = 25°C$, $V_I = 35V$		150		mA
I_{pk}	Peak Output Current		$T_J = 25°C$		2.1		A
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage		$I_O = 5.0\ mA$		1.5		mV/°C

Note 1: For all tables, all characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_W \le 10$ ms, duty cycle $\le 5\%$). Output voltage changes due to changes in internal temperature must be taken into account separately.

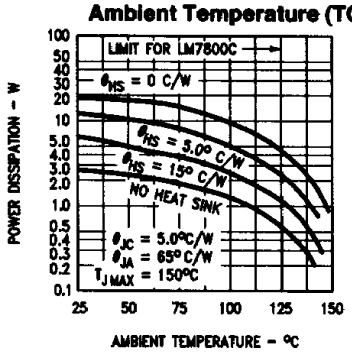
Equivalent Circuit



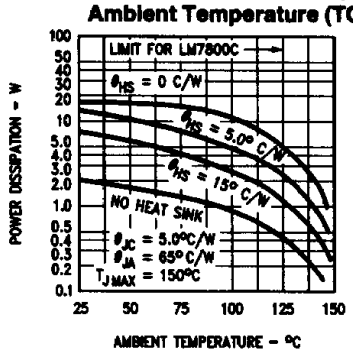
TL/H/10052–3

Typical Performance Characteristics

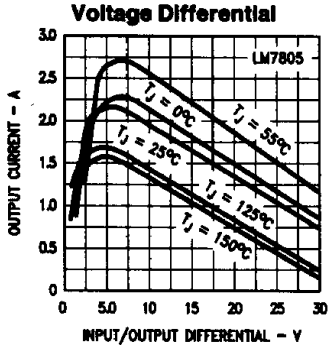
Worst Case Power Dissipation vs Ambient Temperature (TO-3)



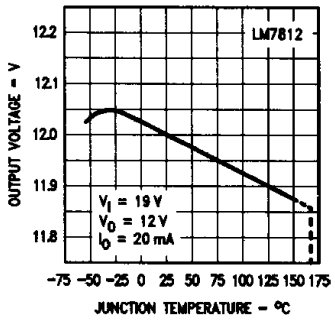
Worst Case Power Dissipation vs Ambient Temperature (TO-220)



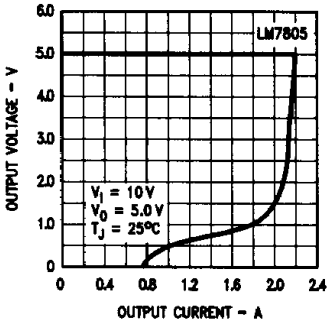
Peak Output Current vs Input/Output Voltage Differential



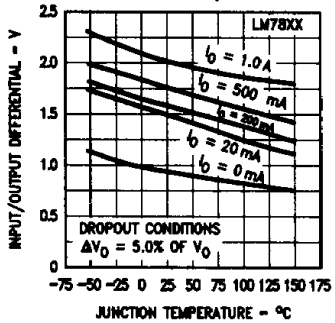
Output Voltage vs Junction Temperature



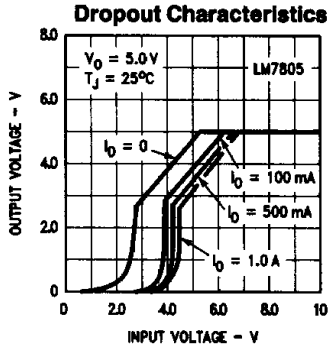
Current-Limiting Characteristics



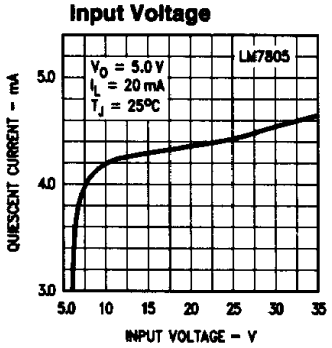
Dropout Voltage vs Junction Temperature



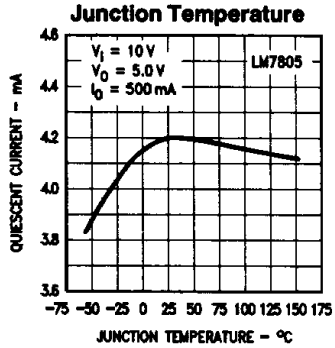
Dropout Characteristics



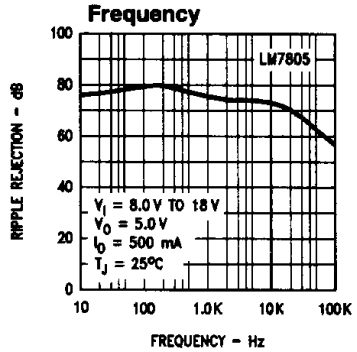
Quiescent Current vs Input Voltage



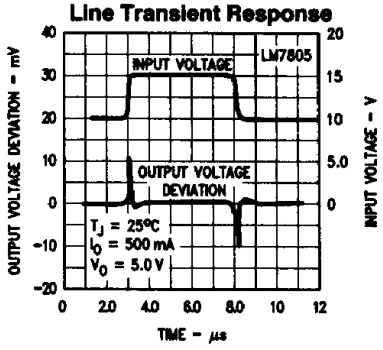
Quiescent Current vs Junction Temperature



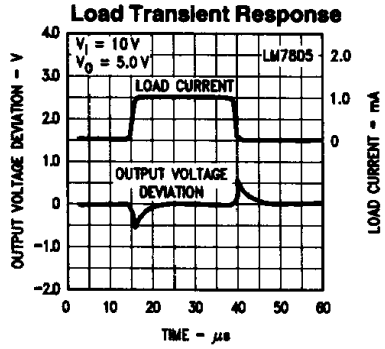
Ripple Rejection vs Frequency



Line Transient Response



Load Transient Response



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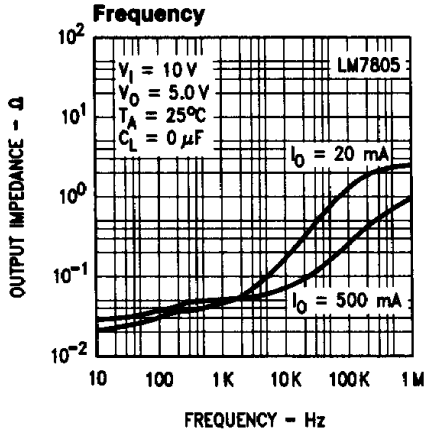
Typical Performance Characteristics (Continued)

Output Impedance vs Frequency



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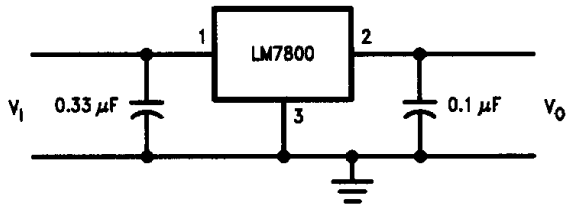
Note: The other LM7800 series devices have similar curves.

DC Parameter Test Circuit



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Design Considerations

The LM7800 fixed voltage regulator series has thermal overload protection from excessive power dissipation, internal short circuit protection which limits the regulator's maximum current, and output transistor safe-area compensation for reducing the output current as the voltage across the pass transistor is increased.

Although the internal power dissipation is limited, the junction temperature must be kept below the maximum specified temperature (150°C for LM7800, 125°C for LM7800C) in order to meet data sheet specifications. To calculate the maximum junction temperature or heat sink required, the following thermal resistance values should be used:

Package	Typ θ_{JC} °C/W	Max θ_{JC} °C/W	Typ θ_{JA} °C/W	Max θ_{JA} °C/W
TO-3	3.5	5.5	35	40
TO-220	3.0	5.0	40	60

$$P_{D\,Max} = \frac{T_{J\,Max} - T_A}{\theta_{JC} + \theta_{CA}} \text{ or}$$

$$= \frac{T_{J\,Max}\, T_A}{\theta_{JA}} \text{ (without heat sink)}$$

$\theta_{CA} = \theta_{CS} + \theta_{SA}$

Solving for T_J:

$T_J = T_A + P_D(\theta_{JC} + \theta_{CA})$ or

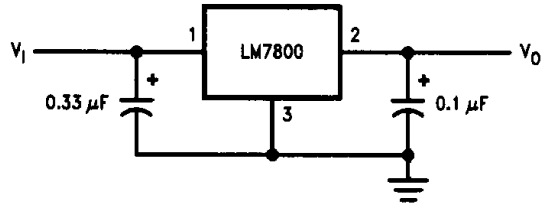
$= T_A + P_D\theta_{JA}$ (without heat sink)

Where:

T_J = Junction Temperature
T_A = Ambient Temperature
P_D = Power Dissipation
θ_{JC} = Junction-to-Case Thermal Resistance
θ_{CA} = Case-to-Ambient Thermal Resistance
θ_{CS} = Case-to-Heat Sink to Thermal Resistance
θ_{SA} = Heat Sink-to-Ambient Thermal Resistance
θ_{JA} = Junction-to-Ambient Thermal Resistance

Typical Applications

Fixed Output Regulator



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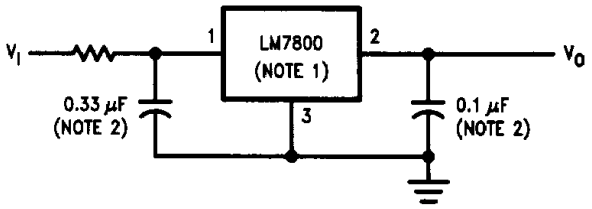
Note 1: To specify an output voltage, substitute voltage value for "00".

Note 2: Bypass capacitors are recommended for optimum stability and transient response, and should be located as close as possible to the regulator.

High Input Voltage Circuits



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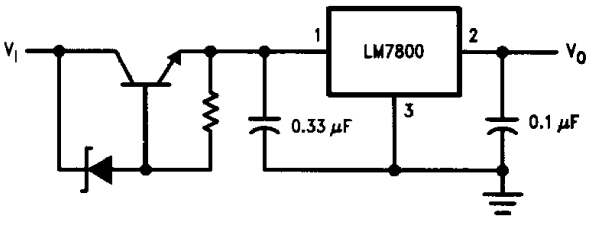

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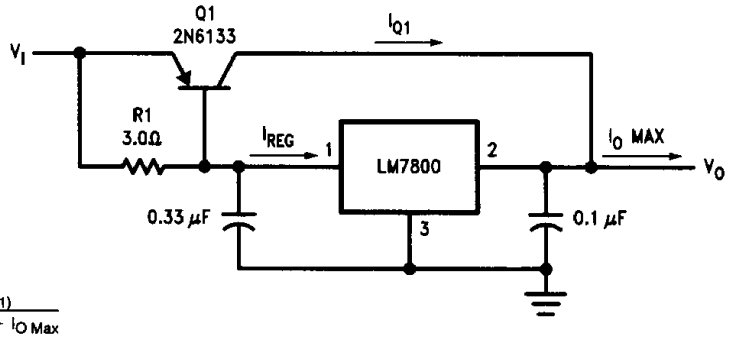
High Current Voltage Regulator



$$\beta(Q1) \geq \frac{I_{O\,Max}}{I_{REG\,Max}}$$

$$R1 = \frac{0.9}{I_{REG}} = \frac{\beta(Q1)\, V_{BE(Q1)}}{I_{REG\,Max}(\beta + 1) - I_{O\,Max}}$$

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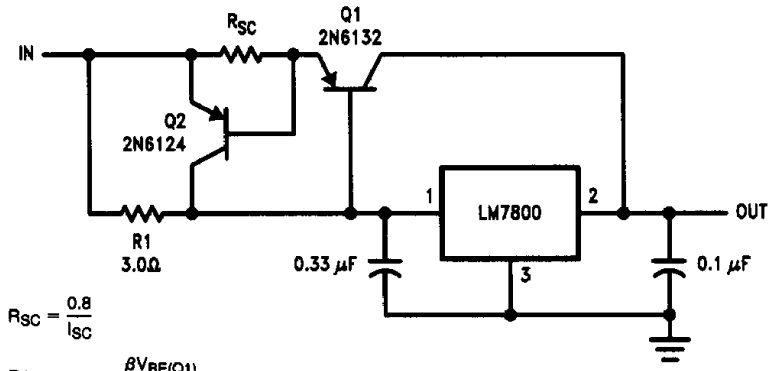
Typical Applications (Continued)

High Output Current, Short Circuit Protected



$$R_{SC} = \frac{0.8}{I_{SC}}$$

$$R1 = \frac{\beta V_{BE(Q1)}}{I_{REG\ Max}(\beta + 1) - I_{O\ Max}}$$

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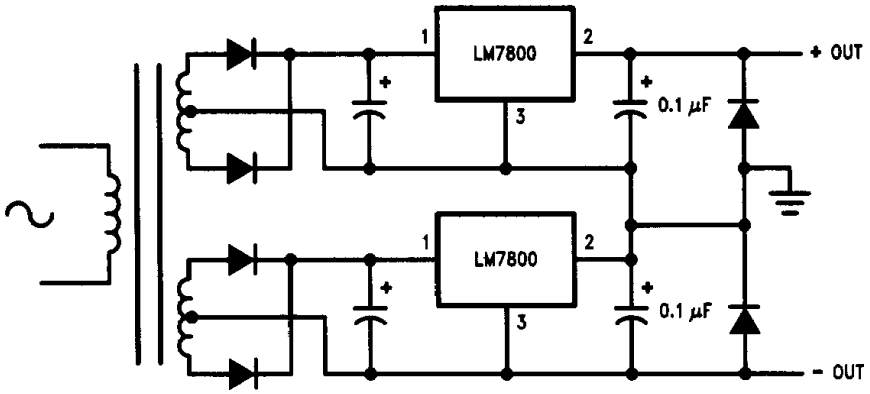
Positive and Negative Regulator



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