National Semiconductor

LM78MXX Series
3-Terminal Positive Voltage Regulators

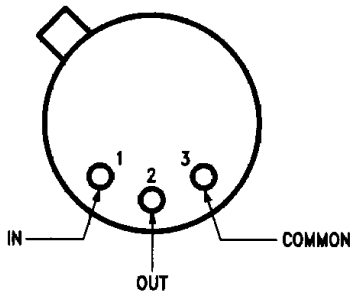
General Description

The LM78M00 series of 3-terminal medium current 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 in excess of 0.5A 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 0.5A
- No external components
- Internal thermal overload protection
- Internal short circuit current-limiting
- Output transistor safe-area compensation
- Available in JEDEC TO-220 and TO-39 packages
- Output voltages of 5V, 6V, 8V, 12V, 15V, and 24V

Connection Diagrams

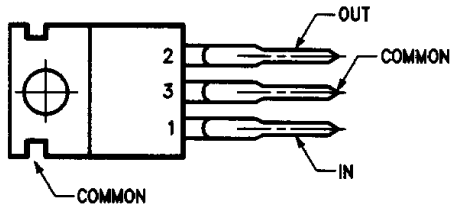


TL/H/10053–1

Lead 3 connected to case.

Top View

Order Number LM78M05CH, LM78M06CH, LM78M08CH, LM78M12CH, LM78M15CH or LM78M24CH
See NS Package Number H03B



TL/H/10053–2

Top View

Lead 3 connected to tab.

Order Number LM78M05CT, LM78M06CT, LM78M08CT, LM78M12CT, LM78M15CT or LM78M24CT
See NS Package Number T03B

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-39 Metal Can: −65°C to +175°C
- TO-220 Package: −65°C to +150°C

Operating Junction Temperature Range: 0°C to +150°C

Lead Temperature
- TO-39 Metal Can (Soldering, 60 sec.): 300°C
- TO-220 Package (Soldering, 60 sec.): 265°C

Power Dissipation: Internally Limited

Input Voltage
- 5.0V to 15V: 35V
- 24V: 40V

ESD Susceptibility: (to be determined)

LM78M05C Electrical Characteristics

$0°C \le T_A \le 125°C$, $V_I = 10V$, $I_O = 350$ 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		$T_J = 25°C$		4.8	5.0	5.2	V
$V_{R\ LINE}$	Line Regulation		$T_J = 25°C$	$7.0V \le V_I \le 25V$, $I_O = 200$ mA		3.0	100	mV
				$8.0V \le V_I \le 20V$, $I_O = 200$ mA		1.0	50	
$V_{R\ LOAD}$	Load Regulation		$T_J = 25°C$	$5.0\ mA \le I_O \le 500$ mA		20	100	mV
				$5.0\ mA \le I_O \le 200$ mA		10	50	
V_O	Output Voltage		$7.0V \le V_I \le 20V$, $5.0\ mA \le I_O \le 350$ mA		4.75		5.25	V
I_Q	Quiescent Current		$T_J = 25°C$			4.5	8.0	mA
ΔI_Q	Quiescent Current Change	with Line	$8.0V \le V_I \le 25V$, $I_O = 200$ mA				0.8	mA
		with Load	$5.0\ mA \le I_O \le 350$ mA				0.5	
N_O	Noise		$T_A = 25°C$, $10\ Hz \le f \le 100\ kHz$			40		μV
$\Delta V_I/\Delta V_O$	Ripple Rejection		$f = 2400$ Hz, $I_O = 125$ mA, $T_J = 25°C$		62	80		dB
V_{DO}	Dropout Voltage		$T_A = 25°C$			2.0		V
I_{OS}	Output Short Circuit Current		$T_J = 25°C$, $V_I = 35V$			300		mA
I_{pk}	Peak Output Current		$T_J = 25°C$			700		mA
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage		$I_O = 5.0$ mA			1.0		mV/°C

LM78M06C Electrical Characteristics

$0°C \le T_A \le 125°C$, $V_I = 11V$, $I_O = 350$ 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		$T_J = 25°C$	$8.0V \le V_I \le 25V$, $I_O = 200$ mA		5.0	100	mV
				$9.0V \le V_I \le 20V$, $I_O = 200$ mA		1.5	50	
$V_{R\ LOAD}$	Load Regulation		$T_J = 25°C$	$5.0\ mA \le I_O \le 500$ mA		20	120	mV
				$5.0\ mA \le I_O \le 200$ mA		10	60	
V_O	Output Voltage		$8.0V \le V_I \le 21V$, $5.0\ mA \le I_O \le 350$ mA		5.7		6.3	V
I_Q	Quiescent Current		$T_J = 25°C$			4.5	8.0	mA
ΔI_Q	Quiescent Current Change	with Line	$9.0V \le V_I \le 25V$, $I_O = 200$ mA				0.8	mA
		with Load	$5.0\ mA \le I_O \le 350$ mA				0.5	

LM78M06C
Electrical Characteristics (Continued)

$0°C \le T_A \le 125°C$, $V_I = 11V$, $I_O = 350$ 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		45		μV
$\Delta V_I/\Delta V_O$	Ripple Rejection	f = 2400 Hz, $I_O = 125$ mA, $T_J = 25°C$	59	80		dB
V_{DO}	Dropout Voltage	$T_A = 25°C$		2.0		V
I_{OS}	Output Short Circuit Current	$T_J = 25°C$, $V_I = 35V$		270		mA
I_{pk}	Peak Output Current	$T_J = 25°C$		700		mA
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage	$I_O = 5.0$ mA		0.5		mV/°C

LM78M08C
Electrical Characteristics

$0°C \le T_A \le 125°C$, $V_I = 14V$, $I_O = 350$ 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, I_O = 200 mA		6.0	100	mV
				11V ≤ V_I ≤ 20V, I_O = 200 mA		2.0	50	
$V_{R\ LOAD}$	Load Regulation		$T_J = 25°C$	5.0 mA ≤ I_O ≤ 500 mA		25	160	mV
				5.0 mA ≤ I_O ≤ 200 mA		10	80	
V_O	Output Voltage		10.5V ≤ V_I ≤ 23V, 5.0 mA ≤ I_O ≤ 350 mA		7.6		8.4	V
I_Q	Quiescent Current		$T_J = 25°C$			4.6	8.0	mA
ΔI_Q	Quiescent Current Change	with Line	10.5V ≤ V_I ≤ 25V, I_O = 200 mA				0.8	mA
		with Load	5.0 mA ≤ I_O ≤ 350 mA				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, $I_O = 125$ mA, $T_J = 25°C$		56	80		dB
V_{DO}	Dropout Voltage		$T_A = 25°C$			2.0		V
I_{OS}	Output Short Circuit Current		$T_J = 25°C$, $V_I = 35V$			250		mA
I_{pk}	Peak Output Current		$T_J = 25°C$			700		mA
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage		$I_O = 5.0$ mA			0.5		mV/°C

LM78M12C
Electrical Characteristics

$0°C \le T_A \le 125°C$, $V_I = 19V$, $I_O = 350$ 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	$T_J = 25°C$		11.5	12.0	12.5	V
$V_{R\ LINE}$	Line Regulation	$T_J = 25°C$	14.5V ≤ V_I ≤ 30V, I_O = 200 mA		8.0	100	mV
			16V ≤ V_I ≤ 25V, I_O = 200 mA		2.0	50	

LM78M12C
Electrical Characteristics (Continued)

$0°C \le T_A \le 125°C$, $V_I = 19V$, $I_O = 350$ 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
$V_{R\ LOAD}$	Load Regulation		$T_J = 25°C$	5.0 mA ≤ I_O ≤ 500 mA		25	240	mV
				5.0 mA ≤ I_O ≤ 200 mA		10	120	
V_O	Output Voltage		14.5V ≤ V_I ≤ 27V, 5.0 mA ≤ I_O ≤ 350 mA		11.4		12.6	V
I_Q	Quiescent Current		$T_J = 25°C$			4.8	8.0	mA
ΔI_Q	Quiescent Current Change	with Line	14.5V ≤ V_I ≤ 30V, I_O = 200 mA				0.8	mA
		with Load	5.0 mA ≤ I_O ≤ 350 mA				0.5	
N_O	Noise		$T_A = 25°C$, 10 Hz ≤ f ≤ 100 kHz			75		μV
$\Delta V_I/\Delta V_O$	Ripple Rejection		f = 2400 Hz, I_O = 125 mA, V_I = 17V, $T_J = 25°C$		55	80		dB
V_{DO}	Dropout Voltage		$T_A = 25°C$			2.0		V
I_{OS}	Output Short Circuit Current		$T_J = 25°C$, V_I = 35V			240		mA
I_{pk}	Peak Output Current		$T_J = 25°C$			700		mA
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage		I_O = 5.0 mA			1.0		mV/°C

LM78M15C
Electrical Characteristics

$0°C \le T_A \le 125°C$, $V_I = 23V$, $I_O = 350$ mA, $C_I = 0.33\ \mu F$, $C_O = 0.1\ \mu F$, unless otherwise specified (Continued)

Symbol	Parameter		Conditions (Note 1)		Min	Typ	Max	Units
V_O	Output Voltage		$T_J = 25°C$		14.4	15.0	15.6	V
$V_{R\ LINE}$	Line Regulation		$T_J = 25°C$	17.5V ≤ V_I ≤ 30V, I_O = 200 mA		10	100	mV
				20V ≤ V_I ≤ 28V, I_O = 200 mA		3.0	50	
$V_{R\ LOAD}$	Load Regulation		$T_J = 25°C$	5.0 mA ≤ I_O ≤ 500 mA		25	300	mV
				5.0 mA ≤ I_O ≤ 200 mA		10	150	
V_O	Output Voltage		17.5V ≤ V_I ≤ 30V, 5.0 mA ≤ I_O ≤ 350 mA		14.25		15.75	V
I_Q	Quiescent Current		$T_J = 25°C$			4.8	8.0	mA
ΔI_Q	Quiescent Current Change	with Line	17.5V ≤ V_I ≤ 30V, I_O = 200 mA				0.8	mA
		with Load	5.0 mA ≤ I_O ≤ 350 mA				0.5	
N_O	Noise		$T_A = 25°C$, 10 Hz ≤ f ≤ 100 kHz			90		μV
$\Delta V_I/\Delta V_O$	Ripple Rejection		f = 2400 Hz, I_O = 125 mA, V_I = 20V, $T_J = 25°C$		54	70		dB
V_{DO}	Dropout Voltage		$T_A = 25°C$			2.0		V
I_{OS}	Output Short Circuit Current		$T_J = 25°C$, V_I = 35V			240		mA
I_{pk}	Peak Output Current		$T_J = 25°C$			700		mA
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage		I_O = 5.0 mA			1.0		mV/°C

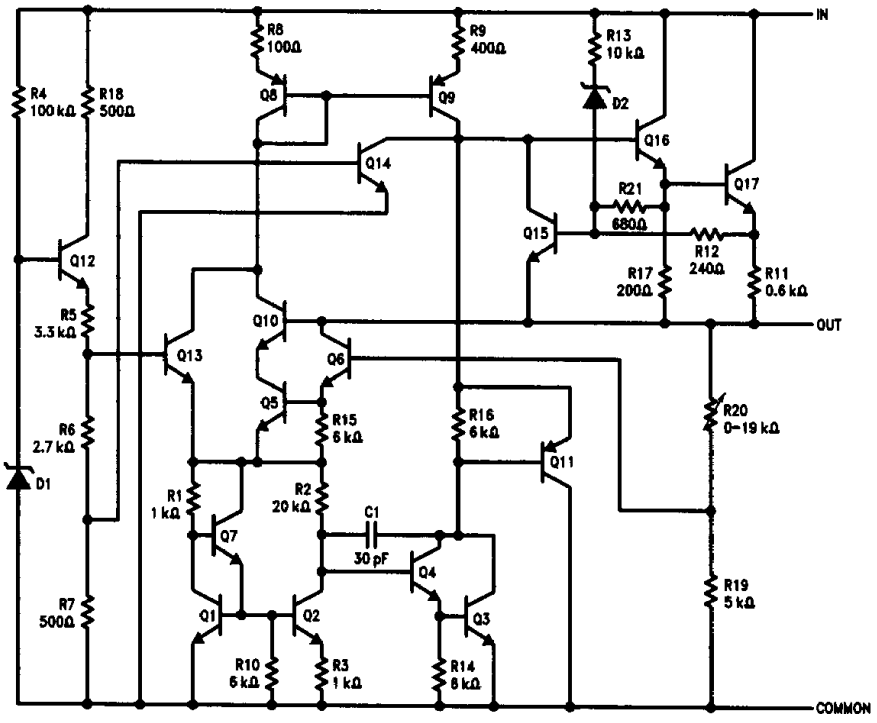
LM78M24C
Electrical Characteristics

$0°C \le T_A \le 125°C$, $V_I = 33V$, $I_O = 350$ 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		$T_J = 25°C$	$27V \le V_I \le 38V$, $I_O = 200$ mA		10	100	mV
				$28V \le V_I \le 36V$, $I_O = 200$ mA		5.0	50	
$V_{R\ LOAD}$	Load Regulation		$T_J = 25°C$	$5.0\ mA \le I_O \le 500$ mA		30	480	mV
				$5.0\ mA \le I_O \le 200$ mA		10	240	
V_O	Output Voltage		$27V \le V_I \le 38V$, $5.0\ mA \le I_O \le 350$ mA		22.8		25.2	V
I_Q	Quiescent Current		$T_J = 25°C$			5.0	8.0	mA
ΔI_Q	Quiescent Current Change	with Line	$27V \le V_I \le 38V$, $I_O = 200$ mA				0.8	mA
		with Load	$5.0\ mA \le I_O \le 350$ mA				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, $I_O = 125$ mA, $V_I = 30V$, $T_J = 25°C$		50	70		dB
V_{DO}	Dropout Voltage		$T_A = 25°C$			2.0		V
I_{OS}	Output Short Circuit Current		$T_J = 35°C$, $V_I = 35V$			240		mA
I_{pk}	Peak Output Current		$T_J = 25°C$			700		mA
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage		$I_O = 5.0$ mA			1.2		mV/°C

Note 1: 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.

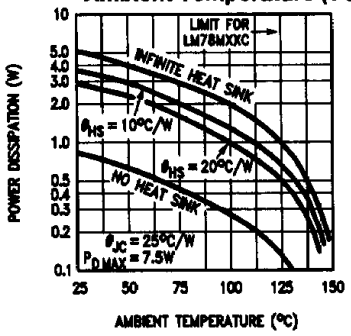
Equivalent Circuit



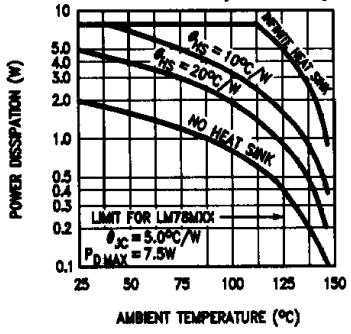
TL/H/10053–3

Typical Performance Characteristics

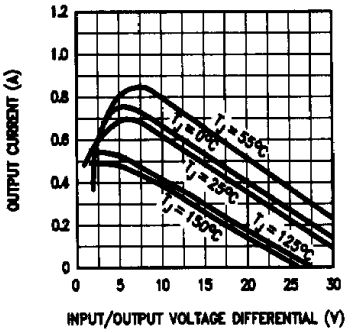
Worst Case Power Dissipation vs Ambient Temperature (TO-39)



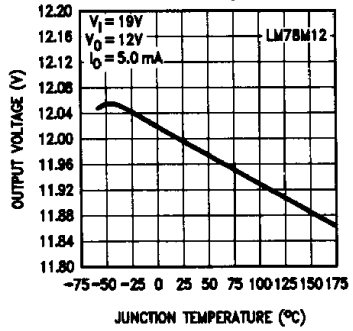
Worst Case Power Dissipation vs Ambient Temperature (TO-220)



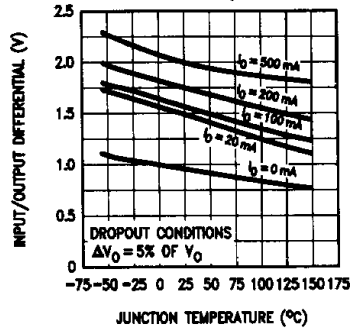
Peak Output Current vs Input/Output Voltage Differential



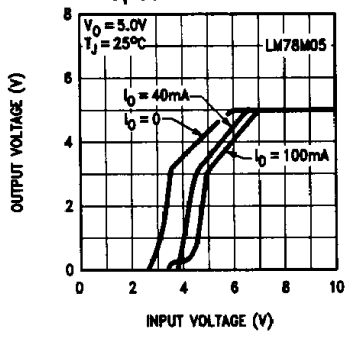
Output Voltage vs Junction Temperature



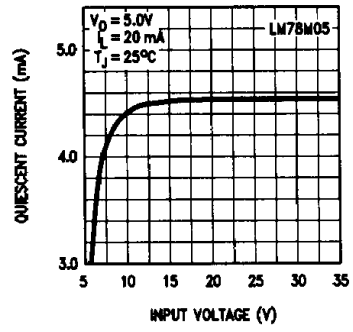
Dropout Voltage vs Junction Temperature



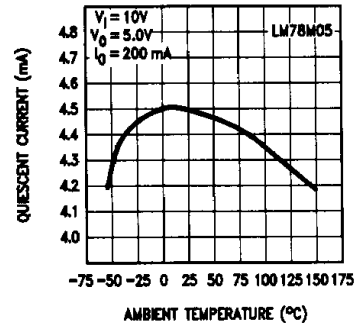
Dropout Characteristics



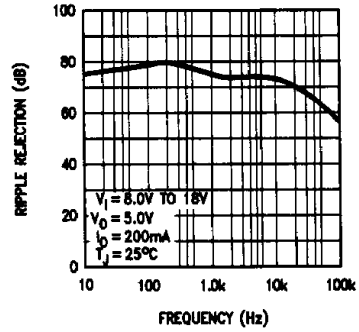
Quiescent Current vs Input Voltage



Quiescent Current vs Temperature



Ripple Rejection vs Frequency



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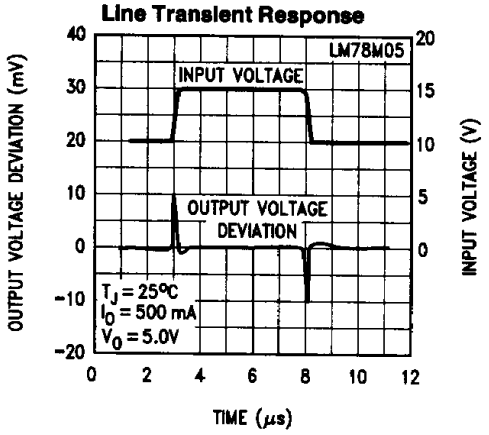
Note: Other LM78M00 Series devices have similar curves.

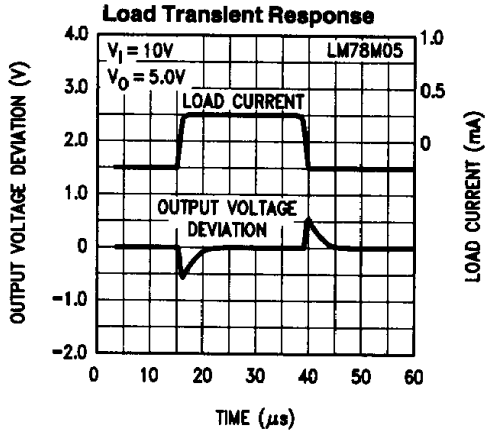
Typical Performance Characteristics (Continued)

Line Transient Response



TL/H/10053–5

Load Transient Response



TL/H/10053–6

Design Considerations

The LM78MXX fixed voltage regulator series has thermal-overload protection from excessive power, internal short circuit protection which limits the circuit's maximum current, and output transistor safe-area compensation for reducing the output short circuit 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 (+125°C for LM78MXXC) 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 θJ_C	Max θJ_C	Typ θJ_A	Max θJ_A
TO-39	18	25	120	140
TO-220	3.0	5.0	60	40

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

$$= \frac{T_{J\,Max} - T_A}{\theta_{JA}} \text{ (Without a Heat Sink)}$$

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

Solving for T_J:

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

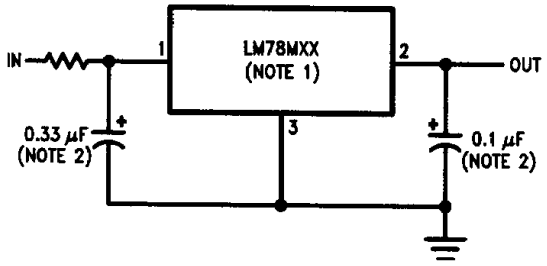
$$= T_A + P_D\,\theta_{JA} \text{ (Without a Heat Sink)}$$

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 Resistance
θ_{SA} = Heat Sink-to-Ambient Thermal Resistance
θ_{JA} = Junction-to-Ambient Thermal Resistance

Typical Applications

Fixed Output Regulator



TL/H/10053–7

Note 1: To specify an output voltage, substitue voltage value for "XX".

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