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.M78L00 Series 3-Terminal Positive Voltage Regulators

National Semiconductor

LM78L00 Series 3-Terminal Positive Voltage Regulators

General Description

The LM78L00 series of 3-terminal positive voltage regulators employ internal current-limiting and thermal shutdown, making them essentially indestructible. If adequate heat sinking is provided, they can deliver up to 100 mA 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, they can be used with power pass elements to make high current voltage regulators. The LM78L00, used as a Zener diode/resistor combination replacement, offers an effective output impedance improvement of typically two orders of magnitude, along with lower quiescent current and lower noise.

Features

- Output current up to 100 mA
- No external components
- Internal thermal overload protection
- Internal short circuit current-limiting
- Available in JEDEC TO-92
- Output Voltages of 5.0V, 6.2V, 8.2V, 9.0V, 12V, 15V
 Output voltage tolerances of ±5% over the temperature range

TL/H/10051-1





Top View

Order Number LM78L05ACZ, LM78L09ACZ, LM78L12ACZ, LM78L15ACZ, LM78L62ACZ or LM78L82ACZ See NS Package Number Z03A

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Absolute Maximum Ratings	;		
If Military/Aerospace specified devices please contact the National Semicono Office/Distributors for availability and spe	are required, luctor Sales cifications.	Lead Temperature TO-92 Package/SO-8 (Soldering, 10 sec.)	265°C
Storage Temperature Range -65	°C to +150°C	Power Dissipation	Internally Limited
Operation Junction Temperature Range Commercial (LM78L00AC)	°C to +125°C	Input Voltage 5.0V to 15V ESD Susceptibility	35∨ to be determined

LM78L05AC Electrical Characteristics

 $0^{\circ}C \leq$ T_A \leq + 125°C, V_I = 10V, I_O = 40 mA, C_I = 0.33 μ F, C_O = 0.1 μ F, unless otherwise specified (Note 1)

				1	•	•	,	
Symbol	Paramete	er	Co	nditions	Min	Тур	Max	Units
Vo	Output Voltage		$T_J = 25^{\circ}C$		4.8	5.0	5.2	V
V _{R LINE}	Line Regulation		$T_{\rm J} = 25^{\circ}C$	$7.0V \leq V_{I} \leq 20V$		55	150	m\/
				$8.0V \leq V_{I} \leq 20V$		45	100	
V _{R LOAD}	Load Regulation		$T_{\rm J} = 25^{\circ}{\rm C}$	$1.0 \text{ mA} \leq I_O \leq 100 \text{V}$		11	60	mV
				$1.0 \text{ mA} \le I_O \le 40 \text{ mA}$		5.0	30	
Vo	Output Voltage		$7.0V \le V_I \le 20V$	$1.0 \text{ mA} \le I_O \le 40 \text{ mA}$	4.75		5.25	V
	(Note 2)		$7.0V \le V_I \le V_{Max}$	$1.0 \text{ mA} \le I_O \le 70 \text{ mA}$	4.75		5.25	
la	Quiescent Current					2.0	5.5	mA
ΔlQ	Quiescent Current	With Line	$8.0V \le V_I \le 20V$				1.5	mA
	Change	With Load	$1.0 \text{ mA} \le I_{O} \le 40 \text{ r}$	mA			0.1	
NO	Noise		T _A = 25°C, 10 Hz s	$\leq f \leq 100 \text{ kHz}$		40		μV
$\Delta V_{I} / \Delta V_{O}$	Ripple Rejection		f = 120 Hz, 8.0V \leq	$V_{I} \leq 18V, T_{J} = 25^{\circ}C$	41	49		dB
V _{DO}	Dropout Voltage		$T_J = 25^{\circ}C$			1.7		V
I _{pk} /I _{OS}	Peak Output/Outpu Short Circuit Curren	t t	$T_{J} = 25^{\circ}C$			140		mA
$\Delta V_O / \Delta T$	Average Temperatu Coefficient of Outpu	re t Voltage	I _O = 5.0 mA			-0.65		mV/°C

Note 1: The maximum steady state usable output current and input voltage are very dependent on the heat sinking and/or lead length of the package. The data above represent pulse test conditions with junction temperatures as indicated at the initiation of tests. Note 2: Power Dissipation \leq 0.75W.

0°C ≤ 1 ₄							1	1
Symbol	Paramete	er	Co	nditions	Min	Тур	Max	Units
VO	Output Voltage		$T_J = 25^{\circ}C$	1	5.95	6.2	6.45	V
V _{R LINE}	Line Regulation		$T_{J} = 25^{\circ}C$	$8.5V \leq V_{l} \leq 20V$		65	175	mV
				$9.0V \le V_I \le 20V$		55	125	
V _{R LOAD}	Load Regulation		$T_J = 25^{\circ}C$	$1.0 \text{ mA} \leq I_{O} \leq 100 \text{ mA}$		65 55 13 6.0 2.0 2.0 50 46 1.7 140	80	mV
				$1.0 \text{ mA} \leq I_{O} \leq 40 \text{ mA}$		6.0	40	
Vo	Output Voltage		$8.5V \leq V_{I} \leq 20V$	$1.0 \text{ mA} \leq I_{O} \leq 40 \text{ mA}$	5.90		6.5	v
	(Note 2)		$8.5V \leq V_I \leq V_{Max}$	$1.0~\text{mA} \leq \text{I}_{O} \leq 70~\text{mA}$	5.90		6.5	
lq	Quiescent Current					2.0	5.5	mA
ΔI_Q	Quiescent Current	With Line	$8.0V \leq V_{I} \leq 20V$				1.5	mA
	Change	With Load	$1.0~\text{mA} \leq I_{O} \leq 40~\text{mA}$				0.1	
NO	Noise		$T_A = 25^{\circ}C$, 10 Hz \leq	$\leq {\sf f} \leq {\sf 100 \ kHz}$		50		μV
$\Delta V_{I} / \Delta V_{O}$	Ripple Rejection		f = 120 Hz, 10V \leq	$V_{I} \leq$ 20V, $T_{J} =$ 25°C	40	46		dB
V _{DO}	Dropout Voltage		$T_J = 25^{\circ}C$			1.7		V
I _{pk} /I _{OS}	Peak Output/Output Short Circuit Current	1	$T_{J} = 25^{\circ}C$			140		mA
			I _O = 5.0 mA				1	1
LM78 Electr	Average Temperatu Coefficient of Outpu L82AC rical Characte	re t Voltage ristics	I _O = 5.0 mA			-0.75		mV/°C
ΔV ₀ /ΔT LM78 Electr 0°C ≤ T _A	Average Temperatu Coefficient of Outpu L82AC Cical Characte $\Delta \leq +125^{\circ}$ C, $V_{I} = 14$	re t Voltage ristics V, I _O = 40 m	$I_{O} = 5.0 \text{ mA}$ A, C ₁ = 0.33 µF, C _O	= 0.1 μ F, unless otherwis	se speci	-0.75	1)	mV/°C
LM78 Electr 0°C ≤ T ₄ Symbol	Average Temperatu Coefficient of Outpu L82AC rical Characte $\Delta \leq +125^{\circ}C, V_{I} = 14$ Paramet	re t Voltage ristics V, I _O = 40 m er	$I_{O} = 5.0 \text{ mA}$ A, C ₁ = 0.33 µF, C _O	= 0.1 μ F, unless otherwis	se specit Min	-0.75 fied (Note	1) Max	mV/°C
$\frac{LM78}{0^{\circ}C \leq T_{f}}$ Symbol V_{O}	Average Temperatu Coefficient of Outpu L82AC rical Characte $x \le +125^\circ$ C, V ₁ = 14 Paramet Output Voltage	re t Voltage ristics V, I _O = 40 m er	$I_{O} = 5.0 \text{ mA}$ A, C _I = 0.33 µF, C _O Cc T _J = 25°C	= 0.1 μF, unless otherwis	se specit Min 7.87	-0.75 fied (Note Typ 8.2	1) Max 8.53	mV/°C
$\frac{LM78}{Electi}$ $\frac{0^{\circ}C \leq T_{f}}{Symbol}$ $\frac{V_{O}}{V_{R LINE}}$	Average Temperatu Coefficient of Outpu L82AC Cical Characte $\Delta \leq +125^{\circ}$ C, $V_{I} = 14$ Paramet Output Voltage Line Regulation	re t Voltage ristics V, I _O = 40 m er	$I_{O} = 5.0 \text{ mA}$ A, C ₁ = 0.33 µF, C _O Cc T _J = 25°C T _J = 25°C	= 0.1 μ F, unless otherwis onditions 11V \leq V _I \leq 23V	se speci Min 7.87	-0.75 fied (Note Typ 8.2 80	1) Max 8.53 175	mV/°C Units V mV
$\Delta V_{O} / \Delta T$ $LM78$ Electi $0^{\circ}C \leq T_{A}$ Symbol V_{O} $V_{R LINE}$	Average Temperatu Coefficient of Output L82AC rical Characte $\Delta \leq +125^{\circ}$ C, $V_{I} = 14$ Paramet Output Voltage Line Regulation	re t Voltage ristics V, I _O = 40 m er	$I_{O} = 5.0 \text{ mA}$ A, $C_{I} = 0.33 \mu\text{F}$, C_{O} $T_{J} = 25^{\circ}\text{C}$ $T_{J} = 25^{\circ}\text{C}$	= 0.1 μ F, unless otherwis anditions $11V \le V_I \le 23V$ $12V \le V_I \le 23V$	e specit Min 7.87	-0.75 fied (Note Typ 8.2 80 70	1) Max 8.53 175 125	mV/°C Units V mV
$\Delta V_{O} / \Delta T$ $LM78$ Electin 0°C $\leq T_{A}$ Symbol V _O V _R LINE V _R LOAD	Average Temperatu Coefficient of Outpu L82AC rical Characte $\leq +125^{\circ}$ C, V _I = 14 Paramet Output Voltage Line Regulation	re t Voltage ristics V, $I_O = 40 \text{ m}$ er	$I_{O} = 5.0 \text{ mA}$ A, C ₁ = 0.33 µF, C _O $T_{J} = 25^{\circ}C$ T _J = 25^{\circ}C $T_{J} = 25^{\circ}C$	= 0.1 μ F, unless otherwis prditions 11V \leq V _I \leq 23V 12V \leq V _I \leq 23V 1.0 mA \leq I _O \leq 100 mA	e speci Min 7.87	-0.75 fied (Note Typ 8.2 80 70 15	1) Max 8.53 175 125 80	mV/°C Units V mV mA
$\Delta V_{O}/\Delta T$ $LM78$ Electi 0°C ≤ T _A Symbol V _O V _R LINE V _R LOAD	Average Temperatu Coefficient of Outpu L82AC rical Characte $x \le +125^\circ$ C, $V_I = 14^\circ$ Paramet Output Voltage Line Regulation Load Regulation	re t Voltage ristics V, $I_O = 40 \text{ m}$ er	$I_{O} = 5.0 \text{ mA}$ A, $C_{I} = 0.33 \mu\text{F}$, C_{O} $T_{J} = 25^{\circ}\text{C}$ $T_{J} = 25^{\circ}\text{C}$ $T_{J} = 25^{\circ}\text{C}$	= 0.1 μ F, unless otherwise ponditions 11V \leq V _I \leq 23V 12V \leq V _I \leq 23V 1.0 mA \leq I _O \leq 100 mA 1.0 mA \leq I _O \leq 40 mA	e specii Min 7.87	-0.75 fied (Note Typ 8.2 80 70 15 8.0	1) Max 8.53 175 125 80 40	mV/°C
$\Delta V_{O}/\Delta T$ $LM78$ Electi 0°C $\leq T_{A}$ Symbol V _O V _R LINE V _R LOAD V _O	Average Temperatu Coefficient of Outpu L82AC Tical Characte $x \le +125^\circ$ C, $V_1 = 14$ Paramet Output Voltage Line Regulation Load Regulation	re t Voltage ristics V, I _O = 40 m er	$I_{O} = 5.0 \text{ mA}$ A, C _I = 0.33 µF, C _O $T_{J} = 25^{\circ}C$ $T_{J} = 25^{\circ}C$ $T_{J} = 25^{\circ}C$ $11V \le V_{I} \le 23V$	= 0.1 μ F, unless otherwis onditions 11V \leq V _I \leq 23V 12V \leq V _I \leq 23V 1.0 mA \leq I _O \leq 100 mA 1.0 mA \leq I _O \leq 40 mA 1.0 mA \leq I _O \leq 40 mA	e specit Min 7.87	-0.75 fied (Note Typ 8.2 80 70 15 8.0	1) Max 8.53 175 125 80 40 8.5	mV/°C Units V mV mA
$\Delta V_{O}/\Delta T$ $LM78$ Electi 0°C < T _A Symbol V _O V _R LINE V _R LOAD V _O	Average Temperatu Coefficient of Outpu	re t Voltage ristics V, I _O = 40 m er	$\begin{split} I_{O} &= 5.0 \text{ mA} \\ \text{A, } C_{I} &= 0.33 \ \mu\text{F, } C_{O} \\ \hline & Cc \\ T_{J} &= 25^{\circ}\text{C} \\ T_{J} &= 25^{\circ}\text{C} \\ \hline T_{J} &= 25^{\circ}\text{C} \\ \hline 11V &\leq V_{I} &\leq 23V \\ \hline 11V &\leq V_{I} &\leq V_{Max} \end{split}$	= 0.1 μ F, unless otherwis onditions 11V $\leq V_{I} \leq 23V$ 12V $\leq V_{I} \leq 23V$ 1.0 mA $\leq I_{O} \leq 100$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 70$ mA	e specifi Min 7.87 7.8 7.8	-0.75 fied (Note Typ 8.2 80 70 15 8.0	1) Max 8.53 175 125 80 40 8.5 8.6	mV/°C Units V mV mA V
$\Delta V_{O}/\Delta T$ $LM78$ Electi 0°C < T _f Symbol V_{O} $V_{R LINE}$ $V_{R LOAD}$ V_{O} I_{Q}	Average Temperatu Coefficient of Output	re t Voltage ristics V, I _O = 40 m er	$I_{O} = 5.0 \text{ mA}$ A, C _I = 0.33 µF, C _O Cc T _J = 25°C T _J = 25°C T _J = 25°C I _J = 25°C I _{IV} ≤ V _I ≤ 23V I _{IV} ≤ V _I ≤ V _{Max}	$= 0.1 \ \mu\text{F, unless otherwis}$ onditions $11V \le V_{I} \le 23V$ $12V \le V_{I} \le 23V$ $1.0 \ \text{mA} \le I_{O} \le 100 \ \text{mA}$ $1.0 \ \text{mA} \le I_{O} \le 40 \ \text{mA}$ $1.0 \ \text{mA} \le I_{O} \le 70 \ \text{mA}$	e specif Min 7.87 7.8 7.8 7.8	-0.75 fied (Note 8.2 80 70 15 8.0 2.1	1) Max 8.53 175 125 80 40 8.5 8.6 5.5	mV/°C Units V mV mA V mA
$\Delta V_{O}/\Delta T$ $LM78$ Electi 0°C $\leq T_{A}$ Symbol V _O V _R LINE V _R LOAD V _O I_{Q} ΔI_{Q}	Average Temperatu Coefficient of Output L82AC Fical Characte \sigma + 125°C, V ₁ = 14 Paramet Output Voltage Line Regulation Load Regulation Output Voltage (Note 2) Quiescent Current Quiescent Current	re t Voltage ristics V, $I_O = 40 \text{ m}$ er With Line	$\begin{split} I_{O} &= 5.0 \text{ mA} \\ \\ A, C_{I} &= 0.33 \ \mu\text{F}, C_{O} \\ \hline \\ Cc \\ T_{J} &= 25^{\circ}\text{C} \\ T_{J} &= 25^{\circ}\text{C} \\ \hline \\ T_{J} &= 25^{\circ}\text{C} \\ \hline \\ 11V &\leq V_{I} &\leq 23V \\ \hline \\ 11V &\leq V_{I} &\leq V_{Max} \\ \hline \\ 12V &\leq V_{I} &\leq 23V \end{split}$	= 0.1 μ F, unless otherwise prditions 11V \leq V _I \leq 23V 12V \leq V _I \leq 23V 1.0 mA \leq I _O \leq 100 mA 1.0 mA \leq I _O \leq 40 mA 1.0 mA \leq I _O \leq 40 mA 1.0 mA \leq I _O \leq 70 mA	e speci Min 7.87 7.8 7.8 7.8	-0.75 fied (Note 8.2 80 70 15 8.0 2.1	1) Max 8.53 175 125 80 40 8.5 8.6 5.5 1.5	mV/°C Units V mV mA MA
$\Delta V_{O}/\Delta T$ $LM78$ Electi 0°C $\leq T_{A}$ Symbol V _O V _R LINE V _R LOAD V _O I _Q ΔI_Q	Average Temperatu Coefficient of Outpu L82AC rical Characte $\leq +125^\circ$ C, V ₁ = 14 Paramet Output Voltage Line Regulation Load Regulation Output Voltage (Note 2) Quiescent Current Quiescent Current Change	re t Voltage ristics V, I _O = 40 m er With Line With Load	$\begin{split} I_{O} &= 5.0 \text{ mA} \\ \text{A, } C_{I} &= 0.33 \ \mu\text{F, } C_{O} \\ \hline & Cc \\ T_{J} &= 25^{\circ}\text{C} \\ T_{J} &= 25^{\circ}\text{C} \\ \hline T_{J} &= 25^{\circ}\text{C} \\ \hline 11V &\leq V_{I} &\leq 23V \\ \hline 11V &\leq V_{I} &\leq V_{Max} \\ \hline & 12V &\leq V_{I} &\leq 23V \\ \hline 1.0 \ \text{mA} &\leq I_{O} &\leq 40 \end{split}$	= 0.1 μ F, unless otherwise ponditions 11V \leq V _I \leq 23V 12V \leq V _I \leq 23V 1.0 mA \leq I _O \leq 100 mA 1.0 mA \leq I _O \leq 40 mA 1.0 mA \leq I _O \leq 40 mA 1.0 mA \leq I _O \leq 70 mA	e speci Min 7.87 7.8 7.8 7.8	-0.75 fied (Note 8.2 80 70 15 8.0 2.1	1) Max 8.53 175 125 80 40 8.5 8.6 5.5 1.5 0.1	mV/°C Units V mV mA MA mA
$\Delta V_{O}/\Delta T$ $LM78$ Electi 0°C $\leq T_{A}$ Symbol Vo VR LINE VR LOAD Vo IQ AIQ No	Average Temperatu Coefficient of Output L82AC Tical Characte $x \le +125^\circ$ C, $V_I = 14$ Paramet Output Voltage Line Regulation Load Regulation Output Voltage (Note 2) Quiescent Current Quiescent Current Change Noise	re t Voltage ristics V, I _O = 40 m er With Line With Load	$\begin{split} I_{O} &= 5.0 \text{ mA} \\ \\ A, C_{I} &= 0.33 \ \mu\text{F}, C_{O} \\ \hline \\ Cc \\ T_{J} &= 25^{\circ}\text{C} \\ \\ T_{J} &= 25^{\circ}\text{C} \\ \hline \\ T_{J} &= 25^{\circ}\text{C} \\ \hline \\ 11V &\leq V_{I} &\leq 23V \\ \hline \\ 11V &\leq V_{I} &\leq 23V \\ \hline \\ 12V &\leq V_{I} &\leq 23V \\ \hline \\ 1.0 \ \text{mA} &\leq I_{O} &\leq 40 \\ \hline \\ T_{A} &= 25^{\circ}\text{C}, 10 \ \text{Hz} \end{split}$	= 0.1 μ F, unless otherwis nditions 11V $\leq V_{I} \leq 23V$ 12V $\leq V_{I} \leq 23V$ 1.0 mA $\leq I_{O} \leq 100$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 70$ mA mA $\leq f \leq 100$ kHz	e specifi Min 7.87 7.8 7.8	-0.75 fied (Note 8.2 80 70 15 8.0 2.1 60	1) Max 8.53 175 125 80 40 8.5 8.6 5.5 1.5 0.1	mV/°C Units V mV mA V mA mA
$\Delta V_{O}/\Delta T$ $LM78$ Electi 0°C $\leq T_{A}$ Symbol V _O V _R LINE V _R LOAD V _O I _Q ΔI_Q $\Delta V_{I}/\Delta V_{O}$	Average Temperatu Coefficient of Outpu L82AC rical Characte < + 125°C, V _I = 14 Paramet Output Voltage Line Regulation Load Regulation Output Voltage (Note 2) Quiescent Current Change Noise Ripple Rejection	re t Voltage ristics V, I _O = 40 m er With Line With Load	$\begin{split} I_{O} &= 5.0 \text{ mA} \\ \\ A, C_{I} &= 0.33 \ \mu\text{F}, C_{O} \\ \hline Cc \\ T_{J} &= 25^{\circ}\text{C} \\ T_{J} &= 25^{\circ}\text{C} \\ \hline T_{J} &= 25^{\circ}\text{C} \\ \hline 11V &\leq V_{I} &\leq 23V \\ \hline 11V &\leq V_{I} &\leq 23V \\ \hline 12V &\leq V_{I} &\leq 23V \\ \hline 1.0 \ \text{mA} &\leq I_{O} &\leq 40 \\ \hline T_{A} &= 25^{\circ}\text{C}, 10 \ \text{Hz} \\ f &= 120 \ \text{Hz}, 12V \leq 25V \\ \end{split}$	= 0.1 μ F, unless otherwis proditions 11V $\leq V_{I} \leq 23V$ 12V $\leq V_{I} \leq 23V$ 1.0 mA $\leq I_{O} \leq 100$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 70$ mA mA $\leq f \leq 100$ kHz $V_{I} \leq 22V, T_{J} = 25^{\circ}$ C	e specif Min 7.87 7.8 7.8 7.8 7.8 39	-0.75 fied (Note 8.2 80 70 15 8.0 2.1 2.1 60 45	1) Max 8.53 175 125 80 40 8.5 8.6 5.5 1.5 0.1	mV/°C Units V mV mA V mA mA MA dB
$\begin{array}{l} \Delta V_{O}/\Delta T \\ \\ \hline \begin{array}{c} LM78 \\ \hline \\ Electi \\ 0^{\circ}C \leq T_{A} \\ \hline \\ \hline \\ V_{O} \\ \hline \\ V_{R \ LINE} \\ \hline \\ V_{R \ LOAD} \\ \hline \\ \hline \\ V_{O} \\ \hline \\ \hline \\ V_{O} \\ \hline \\ \hline \\ \hline \\ \hline \\ \\ \hline \\ \\ \hline \\ \\ \hline \\ \\ \hline \\ \hline \\ \hline \\ \hline \\ \\ \hline \hline \\ \hline \\ \hline \hline \\ \hline \\ \hline \\ \hline \hline \\ \hline \\ \hline \hline \hline \hline \\ \hline \hline \hline \hline \hline \\ \hline \hline \hline \hline \hline \\ \hline \hline$	Average Temperatu Coefficient of Outpu L82AC Fical Characte S + 125°C, V ₁ = 14 Output Voltage Line Regulation Load Regulation Output Voltage (Note 2) Quiescent Current Quiescent Current Change Noise Ripple Rejection Dropout Voltage	re t Voltage ristics V, I _O = 40 m er With Line With Load	$\begin{split} I_{O} &= 5.0 \text{ mA} \\ \text{A, } C_{I} &= 0.33 \ \mu\text{F, } C_{O} \\ \hline & Cc \\ T_{J} &= 25^{\circ}\text{C} \\ T_{J} &= 25^{\circ}\text{C} \\ \hline T_{J} &= 25^{\circ}\text{C} \\ \hline 11V &\leq V_{I} &\leq 23V \\ \hline 11V &\leq V_{I} &\leq 23V \\ \hline 11V &\leq V_{I} &\leq 23V \\ \hline 12V &\leq V_{I} &\leq 23V \\ \hline 1.0 \ \text{mA} &\leq I_{O} &\leq 40 \\ \hline T_{A} &= 25^{\circ}\text{C}, \ 10 \ \text{Hz} \\ f &= 120 \ \text{Hz}, \ 12V &\leq \\ T_{J} &= 25^{\circ}\text{C} \\ \end{split}$	= 0.1 μ F, unless otherwise proditions 11V $\leq V_{I} \leq 23V$ 12V $\leq V_{I} \leq 23V$ 1.0 mA $\leq I_{O} \leq 100$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 70$ mA mA $\leq f \leq 100$ kHz $V_{I} \leq 22V, T_{J} = 25^{\circ}C$	e specif Min 7.87 7.8 7.8 7.8 7.8 39	-0.75 fied (Note 8.2 80 70 15 8.0 2.1 60 45 1.7	1) Max 8.53 175 125 80 40 8.5 8.6 5.5 1.5 0.1	mV/°C Units V mV MA μV dB V
$\begin{array}{l} \Delta V_{O}/\Delta T\\ \\ \hline \\ LM78\\ \hline \\ Electi\\ 0^{\circ}C \leq T_{A}\\ \hline \\ \hline \\ V_{O}\\ V_{R \ LINE}\\ \hline \\ V_{R \ LOAD}\\ \hline \\ V_{O}\\ \hline \\ V_{R \ LOAD}\\ \hline \\ V_{O}\\ \hline \\ V_{O}\\ \hline \\ V_{O}\\ \hline \\ \\ D_{O}\\ \hline \\ \\ D_{D}\\ \hline \\ \\ I_{pk}/I_{OS}\\ \hline \end{array}$	Average Temperatu Coefficient of Outpu L82AC Fical Characte S + 125°C, V ₁ = 14 Paramet Output Voltage Line Regulation Load Regulation Output Voltage (Note 2) Quiescent Current Quiescent Current Change Noise Ripple Rejection Dropout Voltage Peak Output/Outpu Short Circuit Curren	re t Voltage ristics V, I _O = 40 m er With Line With Load	$\begin{split} I_{O} &= 5.0 \text{ mA} \\ \\ A, C_{I} &= 0.33 \ \mu\text{F}, C_{O} \\ \hline & Cc \\ T_{J} &= 25^{\circ}\text{C} \\ T_{J} &= 25^{\circ}\text{C} \\ \hline T_{J} &= 25^{\circ}\text{C} \\ \hline 11V &\leq V_{I} &\leq 23V \\ \hline 11V &\leq V_{I} &\leq 23V \\ \hline 11V &\leq V_{I} &\leq 23V \\ \hline 12V &\leq V_{I} &\leq 23V \\ \hline 12V &\leq V_{I} &\leq 23V \\ \hline 1.0 \ \text{mA} &\leq I_{O} &\leq 40 \\ \hline T_{A} &= 25^{\circ}\text{C}, 10 \ \text{Hz} \\ f &= 120 \ \text{Hz}, 12V &\leq \\ \hline T_{J} &= 25^{\circ}\text{C} \\ \hline T_{J} &= 25^{\circ}\text{C} \\ \hline T_{J} &= 25^{\circ}\text{C} \\ \end{split}$	= 0.1 μ F, unless otherwise proditions 11V $\leq V_{I} \leq 23V$ 12V $\leq V_{I} \leq 23V$ 1.0 mA $\leq I_{O} \leq 100$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 70$ mA mA $\leq f \leq 100$ kHz $V_{I} \leq 22V, T_{J} = 25^{\circ}C$	e speci Min 7.87 7.8 7.8 7.8 39	-0.75 fied (Note 8.2 80 70 15 8.0 2.1 60 45 1.7 140	1) Max 8.53 175 125 80 40 8.5 8.6 5.5 1.5 0.1 	mV/°C Units V mV mA V mA V mA V mA V mA w mA w mA mA mA mA mA mA

Note 2: Power Dissipation \leq 0.75W.

LM78 Electr 0°C ≤ T _A	L09AC rical Characte $\zeta \leq +125^{\circ}C, V_{I} = 15$	eristics sv, I _O = 40 m	A, C _I = 0.33 μF, C _O =	= 0.1 μ F, unless otherwise	specifie	ed (Note	1)	
Symbol	Paramet	ter	Co	nditions	Min	Тур	Max	Units
Vo	Output Voltage		T _J = 25°C		8.64	9.0	9.36	v
V _{R LINE}	Line Regulation		$T_J = 25^{\circ}C$	$11.5V \le V_{ } \le 24V$		90	200	m\/
				$13V \leq V_{I} \leq 24V$		100	150	
V _{R LOAD}	Load Regulation		$T_{J} = 25^{\circ}C$	$1.0 \text{ mA} \leq I_O \leq 100 \text{ mA}$		20	90	mV
				$1.0 \text{ mA} \leq I_O \leq 40 \text{ mA}$		10	45	
VO	Output Voltage		$11.5V \leq V_{j} \leq 24V$	$1.0 \text{ mA} \le I_O \le 40 \text{ mA}$	8.55		9.45	v
	(Note 2)		$11.5V \leq V_{I} \leq V_{Max}$	$1.0 \text{ mA} \le I_O \le 70 \text{ mA}$	8.55		9.45	
lq	Quiescent Current	1				2.1	5.5	mA
ΔI_Q	Quiescent Current	With Line	$11.5V \leq V_{ } \leq 24V$		1.5		1.5	mA
	Change	With Load	$1.0 \text{ mA} \le I_O \le 40 \text{ m}$	A			0.1	
NO	Noise		$T_A = 25^{\circ}C$, 10 Hz \leq	$f \le 100 \text{ kHz}$		70		μV
$\Delta V_{I} / \Delta V_{O}$	Ripple Rejection		$f = 120 \text{ Hz}, 15 \text{V} \le \text{V}$	$I_{\rm I} \leq 25 V, T_{\rm J} = 25^\circ {\rm C}$	38	44		dB
V _{DO}	Dropout Voltage		$T_J = 25^{\circ}C$			1.7		V
I _{pk} /I _{OS}	Peak Output/Outpu Short Circuit Curren	t t	$T_{J} = 25^{\circ}C$			140		mA
$\Delta V_O / \Delta T$	Average Temperatu Coefficient of Outpu	re It Voltage	$I_{O} = 5.0 \text{ mA}$			-0.9		mV/°C
Electr 0°C ≤ T _A	rical Character $\leq +125^{\circ}$ C, V _I = 19	eristics ov, I _O = 40 m	A, C _I = 0.33 μF, C _O =	= 0.1 μ F, unless otherwise	specifie	ed (Note	1)	
$\begin{array}{c} \textbf{Electr}\\ \texttt{0^{\circ}C} \leq \texttt{T}_{A}\\ \hline \textbf{Symbol} \end{array}$	Fical Characte $\zeta \le +125^{\circ}C, V_{I} = 19$ Paramet	eristics _{OV} , I _O = 40 m er	A, C _I = 0.33 μF, C _O = Cor	= 0.1 μF, unless otherwise	specifie Min	ed (Note Typ	1) Max	Units
$\frac{\textbf{Electr}}{0^{\circ}C \leq T_{A}}$ $\frac{\textbf{Symbol}}{V_{O}}$	Fical Characte $\zeta \leq +125^{\circ}$ C, $V_{I} = 19$ Paramet Output Voltage	eristics _{OV, I_O = 40 m er}	A, $C_{I} = 0.33 \ \mu\text{F}$, $C_{O} = $ Con $T_{J} = 25^{\circ}\text{C}$	= 0.1 μF, unless otherwise ditions	Min 11.5	ed (Note Typ 12	1) Max 12.5	Units V
$\begin{tabular}{lllllllllllllllllllllllllllllllllll$	Fical Characte $\leq +125^{\circ}$ C, $V_{I} = 19$ Paramet Output Voltage Line Regulation	eristics _{DV} , I _O = 40 m er	A, $C_{I} = 0.33 \ \mu\text{F}$, $C_{O} = Cor$ $T_{J} = 25^{\circ}\text{C}$ $T_{J} = 25^{\circ}\text{C}$	= 0.1 μ F, unless otherwise ditions 14.5V \leq V _I \leq 27V	specifie Min 11.5	ed (Note Typ 12 120	1) Max 12.5 250	Units V mV
$\begin{tabular}{lllllllllllllllllllllllllllllllllll$	Parameter $\leq +125^{\circ}$ C, $V_{I} = 19$ Parameter Output Voltage Line Regulation	eristics _{VV, I_O = 40 m er}	A, $C_{I} = 0.33 \ \mu F$, $C_{O} =$ Con $T_{J} = 25^{\circ}C$ $T_{J} = 25^{\circ}C$	= 0.1 μ F, unless otherwise ditions 14.5V \leq V _I \leq 27V 16V \leq V _I \leq 27V	Min 11.5	ed (Note Typ 12 120 100	1) Max 12.5 250 200	Units V mV
$\begin{tabular}{c} \hline \textbf{Electr}\\ $0^\circ C \le T_A$ \\ \hline \textbf{Symbol} \\ \hline V_O \\ \hline V_R \\ \hline V_R \\ \hline V_R \\ \hline $LOAD$ \\ \hline \end{tabular}$	Fical Characte $(\Delta \le + 125^\circ C, V_l = 19)$ Paramet Output Voltage Line Regulation Load Regulation	eristics _{VV, IO} = 40 m er	A, $C_{I} = 0.33 \ \mu\text{F}$, $C_{O} =$ Con $T_{J} = 25^{\circ}\text{C}$ $T_{J} = 25^{\circ}\text{C}$ $T_{J} = 25^{\circ}\text{C}$	= 0.1 μ F, unless otherwise Iditions 14.5V \leq V _I \leq 27V 16V \leq V _I \leq 27V 1.0 mA \leq I _O \leq 100 mA	Min 11.5	ed (Note Typ 12 120 100 20	1) Max 12.5 250 200 100	Units V mV mV
$\begin{tabular}{c} \hline \textbf{Electr}\\ $0^\circ C \leq T_A$ \\ \hline \textbf{Symbol} \\ \hline V_O \\ \hline V_R \ LINE \\ \hline V_R \ LOAD \\ \hline \end{tabular}$	ical Characte $\leq +125^\circ$ C, $V_I = 19$ Paramet Output Voltage Line Regulation Load Regulation	eristics _{VV, IO} = 40 m er	A, $C_{I} = 0.33 \ \mu\text{F}$, $C_{O} = Corrightarrow Corrigh$	= 0.1 μ F, unless otherwise ditions 14.5V \leq V _I \leq 27V 16V \leq V _I \leq 27V 1.0 mA \leq I _O \leq 100 mA 1.0 mA \leq I _O \leq 40 mA	Min 11.5	ed (Note Typ 12 120 100 20 10	1) Max 12.5 250 200 100 50	Units V mV mV
$\begin{tabular}{c} \hline \textbf{Electr} & & \\ \hline 0^\circ C \leq T_A \\ \hline \textbf{Symbol} & & \\ \hline V_O & & \\ \hline V_R \ LINE & & \\ \hline V_R \ LOAD & & \\ \hline V_O & & \\ \hline \end{array}$	Fical Characte $\leq +125^{\circ}$ C, $V_I = 19$ Paramet Output Voltage Line Regulation Load Regulation Output Voltage (here 0)	eristics _{VV, IO} = 40 m er	A, $C_{I} = 0.33 \ \mu F$, $C_{O} =$ Con $T_{J} = 25^{\circ}C$ $T_{J} = 25^{\circ}C$ $T_{J} = 25^{\circ}C$ $T_{J} = 25^{\circ}C$ $14.5V \le V_{I} \le 27V$	= 0.1 μ F, unless otherwise ditions 14.5V $\leq V_{I} \leq 27V$ 16V $\leq V_{I} \leq 27V$ 1.0 mA $\leq I_{O} \leq 100$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 40$ mA	specifie Min 11.5 11.4	ed (Note Typ 12 120 100 20 10	1) Max 12.5 250 200 100 50 12.6	Units V mV mV
Symbol Vo VR LINE VR LOAD Vo	ical Characte ≤ +125°C, V _I = 19 Paramet Output Voltage Line Regulation Load Regulation Output Voltage (Note 2)	eristics _{IV} , I _O = 40 m er	A, $C_{I} = 0.33 \ \mu\text{F}$, $C_{O} =$ Con $T_{J} = 25^{\circ}\text{C}$ $T_{J} = 25^{\circ}\text{C}$ $T_{J} = 25^{\circ}\text{C}$ 14.5V $\leq V_{I} \leq 27\text{V}$ 14.5V $\leq V_{I} \leq V_{Max}$	= 0.1 μ F, unless otherwise iditions 14.5V $\leq V_{I} \leq 27V$ 16V $\leq V_{I} \leq 27V$ 1.0 mA $\leq I_{O} \leq 100$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 70$ mA	Specifie Min 11.5	ed (Note Typ 12 120 100 20 10	1) Max 12.5 250 200 100 50 12.6 12.6	Units V mV mV
$\begin{tabular}{l l l l l l l l l l l l l l l l l l l $	Fical Characte \leq + 125°C, V _I = 19 Paramet Output Voltage Line Regulation Load Regulation Output Voltage (Note 2) Quiescent Current	eristics W, I _O = 40 m er	A, $C_{I} = 0.33 \ \mu\text{F}$, $C_{O} =$ Cor $T_{J} = 25^{\circ}\text{C}$ $T_{J} = 25^{\circ}\text{C}$ $T_{J} = 25^{\circ}\text{C}$ $14.5V \le V_{I} \le 27V$ $14.5V \le V_{I} \le V_{Max}$	= 0.1 μ F, unless otherwise iditions 14.5V $\leq V_{I} \leq 27V$ 16V $\leq V_{I} \leq 27V$ 1.0 mA $\leq I_{O} \leq 100$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 70$ mA	Specifie Min 11.5 11.4 11.4	ed (Note Typ 12 120 100 20 10 20 10 2.1	1) Max 12.5 250 200 100 50 12.6 12.6 5.5	Units V mV mV V mA
$\begin{tabular}{l l l l l l l l l l l l l l l l l l l $	Characte \leq +125°C, V _I = 19 Paramet Output Voltage Line Regulation Load Regulation Output Voltage (Note 2) Quiescent Current Quiescent Current Characte	eristics _{bV} , I _O = 40 m er With Line	A, $C_{I} = 0.33 \ \mu\text{F}$, $C_{O} =$ Cor $T_{J} = 25^{\circ}\text{C}$ $T_{J} = 25^{\circ}\text{C}$ $T_{J} = 25^{\circ}\text{C}$ $14.5V \le V_{I} \le 27V$ $14.5V \le V_{I} \le V_{Max}$ $16V \le V_{I} \le 27V$	= 0.1 μ F, unless otherwise ditions 14.5V $\leq V_{I} \leq 27V$ 16V $\leq V_{I} \leq 27V$ 1.0 mA $\leq I_{O} \leq 100$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 70$ mA	Specific Min 11.5 11.4 11.4	ed (Note Typ 12 120 100 20 10 2.1	1) Max 12.5 250 200 100 50 12.6 12.6 5.5 1.5	Units V mV mV V mA mA
$\begin{tabular}{c} \hline \textbf{Electr}\\ \hline 0^\circ C &\leq T_A\\ \hline \textbf{Symbol}\\ \hline V_O\\ \hline V_R \ LINE\\ \hline \hline V_R \ LOAD\\ \hline \hline V_O\\ \hline \hline l_Q\\ \hline \hline \Delta l_Q\\ \hline \end{tabular}$	Characte \leq +125°C, V _I = 19 Paramet Output Voltage Line Regulation Load Regulation Output Voltage (Note 2) Quiescent Current Quiescent Current Character	eristics _{bV} , I _O = 40 m er With Line With Load	A, $C_{I} = 0.33 \ \mu\text{F}$, $C_{O} =$ Cor $T_{J} = 25^{\circ}\text{C}$ $T_{J} = 25^{\circ}\text{C}$ $T_{J} = 25^{\circ}\text{C}$ 14.5V $\leq V_{I} \leq 27V$ 14.5V $\leq V_{I} \leq 27V$ 14.5V $\leq V_{I} \leq 27V$ 16V $\leq V_{I} \leq 27V$ 1.0 mA $\leq I_{O} \leq 40$ m/	= 0.1 μ F, unless otherwise ditions 14.5V $\leq V_{I} \leq 27V$ 16V $\leq V_{I} \leq 27V$ 1.0 mA $\leq I_{O} \leq 100$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 70$ mA	Min 11.5 11.4 11.4	ed (Note Typ 12 120 100 20 10 2.1	1) Max 12.5 250 200 100 50 12.6 12.6 5.5 1.5 0.1	Units V mV mV V V mA mA
$\begin{tabular}{ c c c c } \hline Electr & & \\ \hline 0^\circ C &\leq T_A \\ \hline \hline V_O & \\ \hline V_O & \\ \hline V_R LINE & \\ \hline V_R LOAD & \\ \hline V_O & \\ \hline V_O & \\ \hline I_Q & \\ \hline AI_Q & \\ \hline N_O & \\ \hline \end{tabular}$	Fical Characte \leq + 125°C, V _I = 19 Paramet Output Voltage Line Regulation Load Regulation Output Voltage (Note 2) Quiescent Current Quiescent Current Change Noise	eristics _{IV} , I _O = 40 m er With Line With Load	A, $C_{I} = 0.33 \ \mu\text{F}$, $C_{O} =$ Cor $T_{J} = 25^{\circ}\text{C}$ $T_{J} = 25^{\circ}\text{C}$ $T_{J} = 25^{\circ}\text{C}$ 14.5V $\leq V_{I} \leq 27V$ 14.5V $\leq V_{I} \leq 27V$ 14.5V $\leq V_{I} \leq 27V$ 16V $\leq V_{I} \leq 27V$ 1.0 mA $\leq I_{O} \leq 40$ m/ $T_{A} = 25^{\circ}\text{C}$, 10 Hz \leq	= 0.1 μ F, unless otherwise iditions 14.5V \leq V ₁ \leq 27V 16V \leq V ₁ \leq 27V 1.0 mA \leq I ₀ \leq 100 mA 1.0 mA \leq I ₀ \leq 40 mA 1.0 mA \leq I ₀ \leq 40 mA 1.0 mA \leq I ₀ \leq 70 mA 4 4 5 4 4 4 4 4 4 4 4 4 4 4 4 4	Specifie Min 11.5 11.4 11.4	ed (Note Typ 12 120 100 20 10 20 10 80	1) Max 12.5 250 200 100 50 12.6 12.6 5.5 1.5 0.1	Units V mV mV V mA mA
$\begin{tabular}{l l l l l l l l l l l l l l l l l l l $	ical Characte \leq + 125°C, V _I = 19 Paramet Output Voltage Line Regulation Load Regulation Output Voltage (Note 2) Quiescent Current Quiescent Current Change Noise Ripple Rejection	eristics W, I _O = 40 m er With Line With Load	A, $C_{I} = 0.33 \ \mu F$, $C_{O} =$ Cor $T_{J} = 25^{\circ}C$ $T_{J} = 25^{\circ}C$ $T_{J} = 25^{\circ}C$ $14.5V \le V_{I} \le 27V$ $14.5V \le V_{I} \le V_{Max}$ $16V \le V_{I} \le 27V$ $1.0 \ mA \le I_{O} \le 40 \ m/$ $T_{A} = 25^{\circ}C$, $10 \ Hz \le V_{I} \le V_{I}$	= 0.1 μ F, unless otherwise iditions 14.5V $\leq V_{I} \leq 27V$ 16V $\leq V_{I} \leq 27V$ 1.0 mA $\leq I_{O} \leq 100$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 70$ mA 4.0 mA $\leq I_{O} \leq 70$ mA 5.0 mA ≤ 100 kHz 5.0 mA $\leq 25V, T_{J} = 25^{\circ}C$	Specific Min 11.5 11.4 11.4 37	ed (Note Typ 12 120 100 20 10 20 10 20 10 80 42	1) Max 12.5 250 200 100 50 12.6 12.6 5.5 1.5 0.1	Units V mV mV w μV μV dB
$\begin{tabular}{l l l l l l l l l l l l l l l l l l l $	Characte Comparison $\leq +125^\circ$ C, $V_I = 19$ Paramet Output Voltage Line Regulation Load Regulation Output Voltage (Note 2) Quiescent Current Quiescent Current Change Noise Ripple Rejection Dropout Voltage	eristics _{bV} , I _O = 40 m er With Line With Load	A, $C_I = 0.33 \ \mu F$, $C_O =$ Cor $T_J = 25^{\circ}C$ $T_J = 25^{\circ}C$ $T_J = 25^{\circ}C$ $14.5V \le V_I \le 27V$ $14.5V \le V_I \le 27V$ $14.5V \le V_I \le 27V$ $16V \le V_I \le 27V$ $1.0 \ mA \le I_O \le 40 \ mA$ $T_A = 25^{\circ}C$, $10 \ Hz \le V$ $f = 120 \ Hz$, $15V \le V$ $T_J = 25^{\circ}C$	= 0.1 μ F, unless otherwise ditions 14.5V $\leq V_{I} \leq 27V$ 16V $\leq V_{I} \leq 27V$ 1.0 mA $\leq I_{O} \leq 100$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 70$ mA f ≤ 100 kHz $\leq 25V$, T _J = 25°C	Specific Min 11.5 11.4 11.4 37	ed (Note Typ 12 120 100 20 10 20 10 20 10 40 42 1.7	1) 12.5 250 200 100 50 12.6 12.6 5.5 1.5 0.1	Units V mV mV w μV dB V
$\begin{tabular}{l l l l l l l l l l l l l l l l l l l $	ical Characte ≤ +125°C, V _I = 19 Paramet Output Voltage Line Regulation Load Regulation Output Voltage (Note 2) Quiescent Current Quiescent Current Change Noise Ripple Rejection Dropout Voltage Peak Output/Outpu Short Circuit Current	eristics _{bV} , I _O = 40 m er With Line With Load tt t	A, $C_I = 0.33 \ \mu F$, $C_O =$ Cor $T_J = 25^{\circ}C$ $T_J = 25^{\circ}C$ $T_J = 25^{\circ}C$ $14.5V \le V_I \le 27V$ $14.5V \le V_I \le 27V$ $14.5V \le V_I \le 27V$ $16V \le V_I \le 27V$ $1.0 \ mA \le I_O \le 40 \ m/$ $T_A = 25^{\circ}C$, $10 \ Hz \le V$ $T_J = 25^{\circ}C$ $T_J = 25^{\circ}C$	= 0.1 μ F, unless otherwise ditions 14.5V $\leq V_{I} \leq 27V$ 16V $\leq V_{I} \leq 27V$ 1.0 mA $\leq I_{O} \leq 100$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 70$ mA f ≤ 100 kHz $I_{S} \leq 25V$, $T_{J} = 25^{\circ}$ C	Min 11.5 11.4 11.4 37	ed (Note Typ 12 120 100 20 10 20 10 20 10 40 42 1.7 140	1) 12.5 250 200 100 50 12.6 12.6 5.5 1.5 0.1	Units V mV mV w μV dB V mA
$\begin{tabular}{l l l l l l l l l l l l l l l l l l l $	ical Characte ≤ +125°C, V _I = 19 Paramet Output Voltage Line Regulation Load Regulation Output Voltage (Note 2) Quiescent Current Quiescent Current Change Noise Ripple Rejection Dropout Voltage Peak Output/Outpu Short Circuit Current Average Temperatu Coefficient of Outpu	eristics bV, I _O = 40 m er With Line With Load With Load tt tt tt tt tt tvoltage	A, $C_I = 0.33 \ \mu F$, $C_O =$ Cor $T_J = 25^{\circ}C$ $T_J = 25^{\circ}C$ $T_J = 25^{\circ}C$ $14.5V \le V_I \le 27V$ $14.5V \le V_I \le 27V$ $14.5V \le V_I \le 27V$ $10 \ mA \le I_O \le 40 \ m/$ $T_A = 25^{\circ}C$, $10 \ Hz \le V$ $T_J = 25^{\circ}C$ $T_J = 25^{\circ}C$ $T_J = 25^{\circ}C$ $T_J = 25^{\circ}C$ $I_O = 5.0 \ mA$	= 0.1 μ F, unless otherwise ditions 14.5V $\leq V_{I} \leq 27V$ 16V $\leq V_{I} \leq 27V$ 1.0 mA $\leq I_{O} \leq 100$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 70$ mA f ≤ 100 kHz f $\leq 25V$, TJ = 25°C	Min 11.5 11.4 11.4 37	ed (Note Typ 12 120 100 20 10 20 10 2.1 80 42 1.7 140 -1.0	1) Max 12.5 250 200 100 50 12.6 1.5 0.1 	Units V mV mV w mA μV dB v mA
$\begin{tabular}{l l l l l l l l l l l l l l l l l l l $	ical Characte ≤ +125°C, VI = 19 Paramet Output Voltage Line Regulation Load Regulation Output Voltage (Note 2) Quiescent Current Quiescent Current Change Noise Ripple Rejection Dropout Voltage Peak Output/Output Short Circuit Current Average Temperatu Coefficient of Output	eristics V, I _O = 40 m er With Line With Load With Load t t t t t t t t t t t t t	A, $C_I = 0.33 \ \mu F$, $C_O =$ Cor $T_J = 25^{\circ}C$ $T_J = 25^{\circ}C$ $T_J = 25^{\circ}C$ $14.5V \le V_I \le 27V$ $14.5V \le V_I \le 27V$ $14.5V \le V_I \le 27V$ $1.0 \ MA \le I_O \le 40 \ m/V$ $T_A = 25^{\circ}C$, $10 \ Hz \le 100 \ Hz$ $f = 120 \ Hz$, $15V \le V$ $T_J = 25^{\circ}C$ $T_J = 25^{\circ}C$ $T_J = 25^{\circ}C$ $I_O = 5.0 \ MA$ and input voltage are very d	= 0.1 μ F, unless otherwise ditions 14.5V $\leq V_{I} \leq 27V$ 16V $\leq V_{I} \leq 27V$ 1.0 mA $\leq I_{O} \leq 100$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 40$ mA 1.0 mA $\leq I_{O} \leq 70$ mA f ≤ 100 kHz $\leq 25V$, T _J = 25°C appendent on the heat sinking and	Specific Min 11.5 11.4 11.4 11.4 37 37 /or lead lead	ed (Note Typ 12 120 100 20 10 10 20 10 10 10 10 10 10 10 10 10 1	1) 12.5 250 200 100 50 12.6 12.6 5.5 1.5 0.1 	Units V mV mV w mA μV dB V mA mV

Symbol	Paramete	er	Conditions		Min	Тур	Max	Units
V _O	Output Voltage		T _{.1} = 25°C		14.4	15	15.6	V
	Line Regulation		T _J = 25°C	$17.5V \le V_I \le 30V$		130	300	
			-	$20V \le V_I \le 30V$		110	250	mv
R LOAD	Load Regulation		$T_{J} = 25^{\circ}C$	$1.0 \text{ mA} \le I_{O} \le 100 \text{ mA}$		25	150	
				$1.0 \text{ mA} \le I_O \le 40 \text{ mA}$		12	75	niv
/o	Output Voltage		$17.5V \le V_{I} \le 30V$	$1.0 \text{ mA} \le I_{O} \le 40 \text{ mA}$	14.25		15.75	V
	(Note 2)		$17.5V \le V_I \le V_{Max}$	$1.0 \text{ mA} \le I_O \le 70 \text{ mA}$	14.25		15.75	v
Q	Quiescent Current			•		2.2	5.5	mA
٥ld	Quiescent Current	With Line	$20V \leq V_{I} \leq 30V$				1.5	^
	Change	With Load	$1.0 \text{ mA} \leq I_{O} \leq 40 \text{ m}$	A			0.1	
۹O	Noise		T_A = 25°C, 10 Hz \leq	$f \le 100 \text{ kHz}$		90		μV
ΔV _I /ΔV _O	Ripple Rejection		$f = 120 \text{ Hz}, 18.5 \text{V} \le \text{V}_{\text{I}} \le 28.5 \text{V}, \text{T}_{\text{J}} = 25^{\circ}\text{C}$		34	39		dB
/ _{DO}	Dropout Voltage		$T_{J} = 25^{\circ}C$			1.7		V
_{pk} /I _{OS}	Peak Output/Outpu Short Circuit Curren	t t	$T_{J} = 25^{\circ}C$			140		mA
ΔV _O /ΔT	Average Temperatu Coefficient of Output	ire it Voltage	I _O = 5.0 mA			-1.3		mV/°(
Equiv	alent Circuit	5			Q17		• IN	
				²	Ω	Ω	• OUT	

5

R4 0.805 kΩ

Q11

Q12

COMMON

TL/H/10051-2

03

Z, 5.6 V

R1 0.724 kΩ



Design Considerations

The LM78L series regulators have thermal overload protection from excessive power, internal short-circuit protection which limits each circuit's maximum current, and output transistor safe-area protection for reducing the output current as the voltage across each pass transistor is increased. Although the internal power dissipation is limited, the junction temperature must be kept below the maximum specified temperature (125°C) 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	Тур	Мах	Тур	Мах
	^θ јС	^θ JC	^Ө ЈА	^θ ЈА
TO-92			160	160

Thermal Considerations

The TO-92 molded package is capable of unusually high power dissipation due to the lead frame design. However, its thermal capabilities are generally overlooked because of a lack of understanding of the thermal paths from the semiconductor junction to ambient temperature. While thermal resistance is normally specified for the device mounted 1 cm above an infinite heat sink, very little has been mentioned of the options available to improve on the conservatively rated thermal capability.

An explanation of the thermal paths of the TO-92 will allow the designer to determine the thermal stress he is applying in any given application.

The TO-92 Package

The TO-92 package thermal paths are complex. In addition to the path through the molding compound to ambient temperature, there is another path through the leads, in parallel with the case path, to ambient temperature, as shown in *Figure 1*.

The total thermal resistance in this model is then:

$$\theta_{\mathsf{JA}} = \frac{(\theta_{\mathsf{JC}} + \theta_{\mathsf{CA}})(\theta_{\mathsf{JL}} + \theta_{\mathsf{LA}})}{\theta_{\mathsf{JC}} + \theta_{\mathsf{CA}} + \theta_{\mathsf{JL}} + \theta_{\mathsf{LA}}} \tag{1}$$

Where:

- θ_{JC} = thermal resistance of the case between the regulator die and a point on the case directly above the die location.
- θ_{CA} = thermal resistance between the case and air at ambient temperature.
- θ_{JL} = thermal resistance from regulator die through the input lead to a point $1/_{16}$ inch below the regulator case.
- θ_{LA} = total thermal resistance of the input/output ground leads to ambient temperature.
- θ_{JA} = junction to ambient thermal resistance.



FIGURE 1. TO-92 Thermal Equivalent Circuit

Methods of Heat Sinking

With two external thermal resistances in each leg of a parallel network available to the circuit designer as variables, he can choose the method of heat sinking most applicable to his particular situation. To demonstrate, consider the effect of placing a small 72 °C/W flag type heat sink, such as the Staver F1-7D-2, on the LM78L00 molded case. The heat sink effectively replaces the θ_{CA} (*Figure 2*) and the new thermal resistance, θ'_{JA} , equals 145 °C/W (assuming, 0.125 inch lead length).

The net change of 15 °C/W increases the allowable power dissipation to 0.86W with a minimal inserted cost. A still further decrease in θ_{JA} could be achieved by using a heat sink rated at 46 °C/W, such as the Staver FS-7A. Also, if the case sinking does not provide an adequate reduction in total θ_{JA} , the other external thermal resistance, θ_{LA} , may be reduced by shortening the lead length from package base to mounting medium. However, one point must be kept in mind. The lead thermal path includes a thermal resistance, θ_{SA} , from the leads at the mounting point to ambient, that is, the mounting medium. θ_{LA} is then equal to $\theta_{LS} + \theta_{SA}$. The new model is shown in *Figure 2*.

In the case of a socket, θ_{SA} could be as high as 270 °C/W, thus causing a net increase in θ_{JA} and a consequent decrease in the maximum dissipation capability. Shortening the lead length may return the net θ_{JA} to the original value, but lead sinking would not be accomplished.

In those cases where the regulator is inserted into a copper clad printed circuit board, it is advantageous to have a maximum area of copper at the entry points of the leads. While it would be desirable to rigorously define the effect of PC board copper, the real world variables are too great to allow anything more than a few general observations.

Methods of Heat Sinking (Continued)

The best analogy for PC board copper is to compare it with parallel resistors. Beyond some point, additional resistors are not significantly effective; beyond some point, additional copper area is not effective.





High Dissipation Applications





Where it is necessary to operate a LM78L00 regulator with a large input/output differential voltage, the addition of series resistor R1 will extend the output current range of the device by sharing the total power dissipation between R1 and the regulator.

$$R1 = \frac{V_{I \text{ Min}} - V_{O} - 2.0V}{I_{L \text{ Max}} + I_{Q}}$$
(2)

where:

IQ is the regulator quiescent current.

Regulator power dissipation at maximum input voltage and maximum load current is now

(3)

(4)

 $P_{D \text{ Max}} = (V_1 - V_0) I_{L \text{ Max}} + V_1 I_Q$ where:

$$V_1 = V_{IMax} - (I_{LMax} + I_Q) R1$$

The presence of R1 will affect load regulation according to the equation:

Load regulation (at constant V_I)

= load regulation (at constant V₁)

+ line regulation (mV per V)

imes (RI) imes (Δ IL).

As an example, consider a 15V regulator with a supply voltage of 30 $\pm5.0V$, required to supply a maximum load current of 30 mA. I_Q is 4.3 mA, and minimum load current is to be 10 mA.

$$\mathsf{R1} = \frac{25 - 15 - 2}{30 + 4.3} = \frac{8}{34.3} \approx 240\Omega \tag{5}$$

 $V_1 = 35 - (30 + 4.3) 0.24 = 35 - 8.2 = 26.8V$

$$P_{D Max} = (26.8 - 15) 30 + 26.8 (4.3)$$

Line regulation of this circuit is typically 110 mV for an input range of $25V{-}35V$ at a constant load current; i.e. 11 mV/V.

$$Load \ \text{regulation} = \begin{array}{l} \text{constant V}_1 \ \text{load regulation} & (6) \\ (typically 10 \ \text{mV}, 10 \ \text{mA}-30 \ \text{mA} \ \text{I}_L) \\ + (11 \ \text{mV/V}) \times 0.24 \times 20 \ \text{mA} \\ (typically 53 \ \text{mV}) \\ = 63 \ \text{mV} \ \text{for a load current change of}$$

20 mA at a constant V_{I} of 30V.

Typical Applications



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.





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