

# MC7800, MC7800A, LM340, LM340A Series, NCV7805



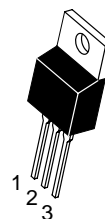
ON Semiconductor®

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## 1.0 A Positive Voltage Regulators

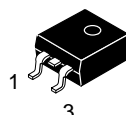
These voltage regulators are monolithic integrated circuits designed as fixed-voltage regulators for a wide variety of applications including local, on-card regulation. These regulators employ internal current limiting, thermal shutdown, and safe-area compensation. With adequate heatsinking they can deliver output currents in excess of 1.0 A. Although designed primarily as a fixed voltage regulator, these devices can be used with external components to obtain adjustable voltages and currents.

- Output Current in Excess of 1.0 A
- No External Components Required
- Internal Thermal Overload Protection
- Internal Short Circuit Current Limiting
- Output Transistor Safe-Area Compensation
- Output Voltage Offered in 2% and 4% Tolerance
- Available in Surface Mount D<sup>2</sup>PAK, DPAK and Standard 3-Lead Transistor Packages



TO-220  
T SUFFIX  
CASE 221A

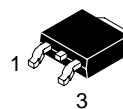
Heatsink surface connected to Pin 2.



D<sup>2</sup>PAK  
D2T SUFFIX  
CASE 936

Pin 1. Input  
2. Ground  
3. Output

Heatsink surface (shown as terminal 4 in case outline drawing) is connected to Pin 2.



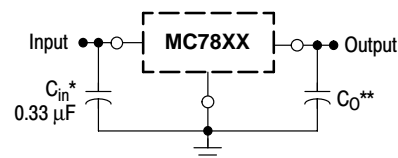
DPAK  
DT SUFFIX  
CASE 369A

### MAXIMUM RATINGS (T<sub>A</sub> = 25°C, unless otherwise noted.)

Rating	Symbol	Value	Unit
Input Voltage (5.0 – 18 V) (24 V)	V <sub>I</sub>	35 40	Vdc
Power Dissipation			
Case 221A (TO-220) T <sub>A</sub> = 25°C	P <sub>D</sub>	Internally Limited	W
Thermal Resistance, Junction-to-Ambient	R <sub>θJA</sub>	65	°C/W
Thermal Resistance, Junction-to-Case	R <sub>θJC</sub>	5.0	°C/W
Case 936 (D <sup>2</sup> PAK) T <sub>A</sub> = 25°C	P <sub>D</sub>	Internally Limited	W
Thermal Resistance, Junction-to-Ambient	R <sub>θJA</sub>	See Figure 14	°C/W
Thermal Resistance, Junction-to-Case	R <sub>θJA</sub>	5.0	°C/W
Case 369A (DPAK) T <sub>A</sub> = 25°C	P <sub>D</sub>	Internally Limited	W
Thermal Resistance, Junction-to-Ambient	R <sub>θJA</sub>	92	°C/W
Thermal Resistance, Junction-to-Case	R <sub>θJC</sub>	5.0	°C/W
Storage Junction Temperature Range	T <sub>stg</sub>	-65 to +150	°C
Operating Junction Temperature	T <sub>J</sub>	+150	°C

NOTE: ESD data available upon request.

### STANDARD APPLICATION



A common ground is required between the input and the output voltages. The input voltage must remain typically 2.0 V above the output voltage even during the low point on the input ripple voltage.

XX, These two digits of the type number indicate nominal voltage.

\* C<sub>in</sub> is required if regulator is located an appreciable distance from power supply filter.

\*\* C<sub>O</sub> is not needed for stability; however, it does improve transient response. Values of less than 0.1 μF could cause instability.

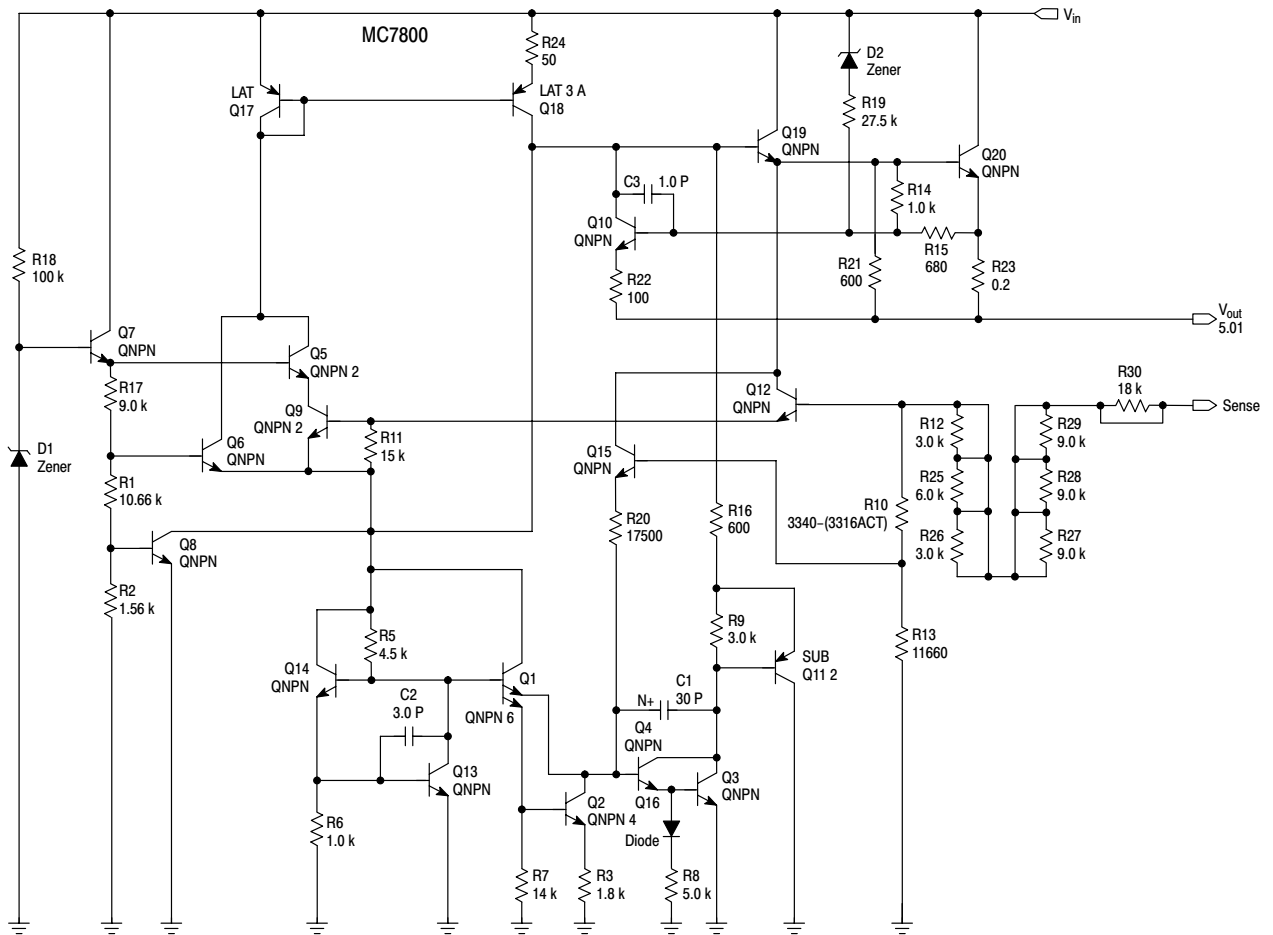
### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 16 of this data sheet.

### DEVICE MARKING INFORMATION

See general marking information in the device marking section on page 18 of this data sheet.

MC7800, MC7800A, LM340, LM340A Series, NCV7805



This device contains 22 active transistors.

Figure 1. Representative Schematic Diagram

# MC7800, MC7800A, LM340, LM340A Series, NCV7805

## ELECTRICAL CHARACTERISTICS ( $V_{in} = 10\text{ V}$ , $I_O = 500\text{ mA}$ , $T_J = T_{low}$ to $T_{high}$ [Note 1], unless otherwise noted.)

Characteristic	Symbol	MC7805B, NCV7805			MC7805C/LM340T-5			Unit
		Min	Typ	Max	Min	Typ	Max	
Output Voltage ( $T_J = 25^\circ\text{C}$ )	$V_O$	4.8	5.0	5.2	4.8	5.0	5.2	Vdc
Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ ) $7.0\text{ Vdc} \leq V_{in} \leq 20\text{ Vdc}$ $8.0\text{ Vdc} \leq V_{in} \leq 20\text{ Vdc}$	$V_O$	– 4.75	– 5.0	– 5.25	4.75 –	5.0 –	5.25 –	Vdc
Line Regulation (Note 2) $7.5\text{ Vdc} \leq V_{in} \leq 20\text{ Vdc}$ , $1.0\text{ A}$ $8.0\text{ Vdc} \leq V_{in} \leq 12\text{ Vdc}$	$Reg_{line}$	– –	5.0 1.3	100 50	– –	0.5 0.8	20 10	mV
Load Regulation (Note 2) $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ $5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$ ( $T_A = 25^\circ\text{C}$ )	$Reg_{load}$	– –	1.3 0.15	100 50	– –	1.3 1.3	25 25	mV
Quiescent Current	$I_B$	–	3.2	8.0	–	3.2	6.5	mA
Quiescent Current Change $7.0\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$ $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ ( $T_A = 25^\circ\text{C}$ )	$\Delta I_B$	– –	– –	– 0.5	– –	0.3 0.08	1.0 0.8	mA
Ripple Rejection $8.0\text{ Vdc} \leq V_{in} \leq 18\text{ Vdc}$ , $f = 120\text{ Hz}$	RR	–	68	–	62	83	–	dB
Dropout Voltage ( $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ )	$V_I - V_O$	–	2.0	–	–	2.0	–	Vdc
Output Noise Voltage ( $T_A = 25^\circ\text{C}$ ) $10\text{ Hz} \leq f \leq 100\text{ kHz}$	$V_n$	–	10	–	–	10	–	$\mu\text{V}/V_O$
Output Resistance $f = 1.0\text{ kHz}$	$r_O$	–	0.9	–	–	0.9	–	$\text{m}\Omega$
Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ ) $V_{in} = 35\text{ Vdc}$	$I_{SC}$	–	0.2	–	–	0.6	–	A
Peak Output Current ( $T_J = 25^\circ\text{C}$ )	$I_{max}$	–	2.2	–	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	$TCV_O$	–	–0.3	–	–	–0.3	–	$\text{mV}/^\circ\text{C}$

## ELECTRICAL CHARACTERISTICS ( $V_{in} = 10\text{ V}$ , $I_O = 1.0\text{ A}$ , $T_J = T_{low}$ to $T_{high}$ [Note 1], unless otherwise noted.)

Characteristic	Symbol	MC7805AB/MC7805AC/LM340AT-5			Unit
		Min	Typ	Max	
Output Voltage ( $T_J = 25^\circ\text{C}$ )	$V_O$	4.9	5.0	5.1	Vdc
Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ ) $7.5\text{ Vdc} \leq V_{in} \leq 20\text{ Vdc}$	$V_O$	4.8	5.0	5.2	Vdc
Line Regulation (Note 2) $7.5\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$ , $I_O = 500\text{ mA}$ $8.0\text{ Vdc} \leq V_{in} \leq 12\text{ Vdc}$ , $I_O = 1.0\text{ A}$ $8.0\text{ Vdc} \leq V_{in} \leq 12\text{ Vdc}$ , $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ $7.3\text{ Vdc} \leq V_{in} \leq 20\text{ Vdc}$ , $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$	$Reg_{line}$	– – – –	0.5 0.8 1.3 4.5	10 12 4.0 10	mV
Load Regulation (Note 2) $5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$ , $T_J = 25^\circ\text{C}$ $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ $250\text{ mA} \leq I_O \leq 750\text{ mA}$	$Reg_{load}$	– – –	1.3 0.8 0.53	25 25 15	mV
Quiescent Current	$I_B$	–	3.2	6.0	mA
Quiescent Current Change $8.0\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$ , $I_O = 500\text{ mA}$ $7.5\text{ Vdc} \leq V_{in} \leq 20\text{ Vdc}$ , $T_J = 25^\circ\text{C}$ $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$	$\Delta I_B$	– – –	0.3 – 0.08	0.8 0.8 0.5	mA

- $T_{low} = 0^\circ\text{C}$  for MC78XXAC, C, LM340AT-XX, LM340T-XX  
 $= -40^\circ\text{C}$  for MC78XXB, MC78XXAB, NCV7805  
 $T_{high} = +125^\circ\text{C}$  for MC78XXAC, C, LM340AT-XX, LM340T-XX, NCV7805
- Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

## MC7800, MC7800A, LM340, LM340A Series, NCV7805

**ELECTRICAL CHARACTERISTICS (continued)** ( $V_{in} = 10\text{ V}$ ,  $I_O = 1.0\text{ A}$ ,  $T_J = T_{low}$  to  $T_{high}$  [Note 1], unless otherwise noted.)

Characteristic	Symbol	MC7805AB/MC7805AC/LM340AT-5			Unit
		Min	Typ	Max	
Ripple Rejection $8.0\text{ Vdc} \leq V_{in} \leq 18\text{ Vdc}$ , $f = 120\text{ Hz}$ , $I_O = 500\text{ mA}$	RR	68	83	–	dB
Dropout Voltage ( $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ )	$V_I - V_O$	–	2.0	–	Vdc
Output Noise Voltage ( $T_A = 25^\circ\text{C}$ ) $10\text{ Hz} \leq f \leq 100\text{ kHz}$	$V_n$	–	10	–	$\mu\text{V}/V_O$
Output Resistance ( $f = 1.0\text{ kHz}$ )	$r_O$	–	0.9	–	$\text{m}\Omega$
Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ ) $V_{in} = 35\text{ Vdc}$	$I_{SC}$	–	0.2	–	A
Peak Output Current ( $T_J = 25^\circ\text{C}$ )	$I_{max}$	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	$TCV_O$	–	–0.3	–	$\text{mV}/^\circ\text{C}$

**ELECTRICAL CHARACTERISTICS** ( $V_{in} = 11\text{ V}$ ,  $I_O = 500\text{ mA}$ ,  $T_J = T_{low}$  to  $T_{high}$  [Note 1], unless otherwise noted.)

Characteristic	Symbol	MC7806B			MC7806C			Unit
		Min	Typ	Max	Min	Typ	Max	
Output Voltage ( $T_J = 25^\circ\text{C}$ )	$V_O$	5.75	6.0	6.25	5.75	6.0	6.25	Vdc
Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ ) $8.0\text{ Vdc} \leq V_{in} \leq 21\text{ Vdc}$ $9.0\text{ Vdc} \leq V_{in} \leq 21\text{ Vdc}$	$V_O$	– 5.7	– 6.0	– 6.3	5.7 –	6.0 –	6.3 –	Vdc
Line Regulation, $T_J = 25^\circ\text{C}$ (Note 2) $8.0\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$ $9.0\text{ Vdc} \leq V_{in} \leq 13\text{ Vdc}$	$Reg_{line}$	– –	5.5 1.4	120 60	– –	0.5 0.8	24 12	mV
Load Regulation, $T_J = 25^\circ\text{C}$ (Note 2) $5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$	$Reg_{load}$	–	1.3	120	–	1.3	30	mV
Quiescent Current ( $T_J = 25^\circ\text{C}$ )	$I_B$	–	3.3	8.0	–	3.3	8.0	mA
Quiescent Current Change $8.0\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$ $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$	$\Delta I_B$	– –	– –	– 0.5	– –	0.3 0.08	1.3 0.5	mA
Ripple Rejection $9.0\text{ Vdc} \leq V_{in} \leq 19\text{ Vdc}$ , $f = 120\text{ Hz}$	RR	–	65	–	58	65	–	dB
Dropout Voltage ( $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ )	$V_I - V_O$	–	2.0	–	–	2.0	–	Vdc
Output Noise Voltage ( $T_A = 25^\circ\text{C}$ ) $10\text{ Hz} \leq f \leq 100\text{ kHz}$	$V_n$	–	10	–	–	10	–	$\mu\text{V}/V_O$
Output Resistance $f = 1.0\text{ kHz}$	$r_O$	–	0.9	–	–	0.9	–	$\text{m}\Omega$
Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ ) $V_{in} = 35\text{ Vdc}$	$I_{SC}$	–	0.2	–	–	0.2	–	A
Peak Output Current ( $T_J = 25^\circ\text{C}$ )	$I_{max}$	–	2.2	–	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	$TCV_O$	–	–0.3	–	–	–0.3	–	$\text{mV}/^\circ\text{C}$

- $T_{low} = 0^\circ\text{C}$  for MC78XXAC, C, LM340AT-XX, LM340T-XX  $T_{high} = +125^\circ\text{C}$  for MC78XXAC, C, LM340AT-XX, LM340T-XX, NCV7805  
=  $-40^\circ\text{C}$  for MC78XXB, MC78XXAB, NCV7805
- Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

# MC7800, MC7800A, LM340, LM340A Series, NCV7805

## ELECTRICAL CHARACTERISTICS ( $V_{in} = 11\text{ V}$ , $I_O = 1.0\text{ A}$ , $T_J = T_{low}$ to $T_{high}$ [Note 1], unless otherwise noted.)

Characteristic	Symbol	MC7806AC			Unit
		Min	Typ	Max	
Output Voltage ( $T_J = 25^\circ\text{C}$ )	$V_O$	5.88	6.0	6.12	Vdc
Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ $8.6\text{ Vdc} \leq V_{in} \leq 21\text{ Vdc}$ )	$V_O$	5.76	6.0	6.24	Vdc
Line Regulation (Note 2) $8.6\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$ , $I_O = 500\text{ mA}$ $9.0\text{ Vdc} \leq V_{in} \leq 13\text{ Vdc}$ , $I_O = 1.0\text{ A}$	$Reg_{line}$	–	5.0 1.4	12 15	mV
Load Regulation (Note 2) $5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$ , $T_J = 25^\circ\text{C}$ $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ $250\text{ mA} \leq I_O \leq 750\text{ mA}$	$Reg_{load}$	–	1.3 0.9 0.2	25 25 15	mV
Quiescent Current	$I_B$	–	3.3	6.0	mA
Quiescent Current Change $9.0\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$ , $I_O = 500\text{ mA}$ $9.0\text{ Vdc} \leq V_{in} \leq 21\text{ Vdc}$ , $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$	$\Delta I_B$	–	–	0.8 0.8 0.5	mA
Ripple Rejection $9.0\text{ Vdc} \leq V_{in} \leq 19\text{ Vdc}$ , $f = 120\text{ Hz}$ , $I_O = 500\text{ mA}$	RR	58	65	–	dB
Dropout Voltage ( $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ )	$V_I - V_O$	–	2.0	–	Vdc
Output Noise Voltage ( $T_A = 25^\circ\text{C}$ ) $10\text{ Hz} \leq f \leq 100\text{ kHz}$	$V_n$	–	10	–	$\mu\text{V}/V_O$
Output Resistance ( $f = 1.0\text{ kHz}$ )	$r_O$	–	0.9	–	$\text{m}\Omega$
Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ ) $V_{in} = 35\text{ Vdc}$	$I_{SC}$	–	0.2	–	A
Peak Output Current ( $T_J = 25^\circ\text{C}$ )	$I_{max}$	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	$TCV_O$	–	–0.3	–	$\text{mV}/^\circ\text{C}$

## ELECTRICAL CHARACTERISTICS ( $V_{in} = 14\text{ V}$ , $I_O = 500\text{ mA}$ , $T_J = T_{low}$ to $T_{high}$ [Note 1], unless otherwise noted.)

Characteristic	Symbol	MC7808B			MC7808C			Unit
		Min	Typ	Max	Min	Typ	Max	
Output Voltage ( $T_J = 25^\circ\text{C}$ )	$V_O$	7.7	8.0	8.3	7.7	8.0	8.3	Vdc
Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ ) $10.5\text{ Vdc} \leq V_{in} \leq 23\text{ Vdc}$ $11.5\text{ Vdc} \leq V_{in} \leq 23\text{ Vdc}$	$V_O$	– 7.6	– 8.0	– 8.4	7.6 –	8.0 –	8.4 –	Vdc
Line Regulation, $T_J = 25^\circ\text{C}$ , (Note 2) $10.5\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$ $11\text{ Vdc} \leq V_{in} \leq 17\text{ Vdc}$	$Reg_{line}$	– –	6.0 1.7	160 80	– –	6.0 1.7	32 16	mV
Load Regulation, $T_J = 25^\circ\text{C}$ (Note 2) $5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$	$Reg_{load}$	–	1.4	160	–	1.4	35	mV
Quiescent Current	$I_B$	–	3.3	8.0	–	3.3	8.0	mA
Quiescent Current Change $10.5\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$ $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$	$\Delta I_B$	– –	– –	– 0.5	– –	– –	1.0 0.5	mA

- $T_{low} = 0^\circ\text{C}$  for MC78XXAC, C, LM340AT–XX, LM340T–XX  
=  $-40^\circ\text{C}$  for MC78XXB, MC78XXAB, NCV7805  
 $T_{high} = +125^\circ\text{C}$  for MC78XXAC, C, LM340AT–XX, LM340T–XX, NCV7805
- Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

## MC7800, MC7800A, LM340, LM340A Series, NCV7805

**ELECTRICAL CHARACTERISTICS (continued)** ( $V_{in} = 14\text{ V}$ ,  $I_O = 500\text{ mA}$ ,  $T_J = T_{low}$  to  $T_{high}$  [Note 1], unless otherwise noted.)

Characteristic	Symbol	MC7808B			MC7808C			Unit
		Min	Typ	Max	Min	Typ	Max	
Ripple Rejection $11.5\text{ Vdc} \leq V_{in} \leq 18\text{ Vdc}$ , $f = 120\text{ Hz}$	RR	–	62	–	56	62	–	dB
Dropout Voltage ( $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ )	$V_I - V_O$	–	2.0	–	–	2.0	–	Vdc
Output Noise Voltage ( $T_A = 25^\circ\text{C}$ ) $10\text{ Hz} \leq f \leq 100\text{ kHz}$	$V_n$	–	10	–	–	10	–	$\mu\text{V}/V_O$
Output Resistance $f = 1.0\text{ kHz}$	$r_O$	–	0.9	–	–	0.9	–	$\text{m}\Omega$
Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ ) $V_{in} = 35\text{ Vdc}$	$I_{SC}$	–	0.2	–	–	0.2	–	A
Peak Output Current ( $T_J = 25^\circ\text{C}$ )	$I_{max}$	–	2.2	–	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	$TCV_O$	–	–0.4	–	–	–0.4	–	$\text{mV}/^\circ\text{C}$

**ELECTRICAL CHARACTERISTICS** ( $V_{in} = 14\text{ V}$ ,  $I_O = 1.0\text{ A}$ ,  $T_J = T_{low}$  to  $T_{high}$  [Note 1], unless otherwise noted.)

Characteristic	Symbol	MC7808AB/MC7808AC			Unit
		Min	Typ	Max	
Output Voltage ( $T_J = 25^\circ\text{C}$ )	$V_O$	7.84	8.0	8.16	Vdc
Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ ) $10.6\text{ Vdc} \leq V_{in} \leq 23\text{ Vdc}$	$V_O$	7.7	8.0	8.3	Vdc
Line Regulation (Note 2) $10.6\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$ , $I_O = 500\text{ mA}$ $11\text{ Vdc} \leq V_{in} \leq 17\text{ Vdc}$ , $I_O = 1.0\text{ A}$ $10.4\text{ Vdc} \leq V_{in} \leq 23\text{ Vdc}$ , $T_J = 25^\circ\text{C}$	$Reg_{line}$	–	6.0	15	mV
Load Regulation (Note 2) $5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$ , $T_J = 25^\circ\text{C}$ $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ $250\text{ mA} \leq I_O \leq 750\text{ mA}$	$Reg_{load}$	–	1.4	25	mV
Quiescent Current	$I_B$	–	3.3	6.0	mA
Quiescent Current Change $11\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$ , $I_O = 500\text{ mA}$ $10.6\text{ Vdc} \leq V_{in} \leq 23\text{ Vdc}$ , $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$	$\Delta I_B$	–	–	0.8	mA
Ripple Rejection $11.5\text{ Vdc} \leq V_{in} \leq 21.5\text{ Vdc}$ , $f = 120\text{ Hz}$ , $I_O = 500\text{ mA}$	RR	56	62	–	dB
Dropout Voltage ( $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ )	$V_I - V_O$	–	2.0	–	Vdc
Output Noise Voltage ( $T_A = 25^\circ\text{C}$ ) $10\text{ Hz} \leq f \leq 100\text{ kHz}$	$V_n$	–	10	–	$\mu\text{V}/V_O$
Output Resistance $f = 1.0\text{ kHz}$	$r_O$	–	0.9	–	$\text{m}\Omega$
Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ ) $V_{in} = 35\text{ Vdc}$	$I_{SC}$	–	0.2	–	A
Peak Output Current ( $T_J = 25^\circ\text{C}$ )	$I_{max}$	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	$TCV_O$	–	–0.4	–	$\text{mV}/^\circ\text{C}$

1.  $T_{low} = 0^\circ\text{C}$  for MC78XXAC, C, LM340AT–XX, LM340T–XX  $T_{high} = +125^\circ\text{C}$  for MC78XXAC, C, LM340AT–XX, LM340T–XX, NCV7805  
=  $-40^\circ\text{C}$  for MC78XXB, MC78XXAB, NCV7805

2. Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

# MC7800, MC7800A, LM340, LM340A Series, NCV7805

## ELECTRICAL CHARACTERISTICS ( $V_{in} = 15\text{ V}$ , $I_O = 500\text{ mA}$ , $T_J = T_{low}$ to $T_{high}$ [Note 1], unless otherwise noted.)

Characteristic	Symbol	MC7809B			MC7809C			Unit
		Min	Typ	Max	Min	Typ	Max	
Output Voltage ( $T_J = 25^\circ\text{C}$ )	$V_O$	8.65	9.0	9.35	8.65	9.0	9.35	Vdc
Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ ) $11.5\text{ Vdc} \leq V_{in} \leq 24\text{ Vdc}$	$V_O$	8.55	9.0	9.45	8.55	9.0	9.45	Vdc
Line Regulation, $T_J = 25^\circ\text{C}$ (Note 2) $11\text{ Vdc} \leq V_{in} \leq 26\text{ Vdc}$ $11.5\text{ Vdc} \leq V_{in} \leq 17\text{ Vdc}$	$\text{Reg}_{line}$	–	6.2 1.8	32 16	–	6.2 1.8	32 16	mV
Load Regulation, $T_J = 25^\circ\text{C}$ (Note 2) $5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$	$\text{Reg}_{load}$	–	1.5	35	–	1.5	35	mV
Quiescent Current	$I_B$	–	3.4	8.0	–	3.4	8.0	mA
Quiescent Current Change $11.5\text{ Vdc} \leq V_{in} \leq 26\text{ Vdc}$ $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$	$\Delta I_B$	–	–	1.0 0.5	–	–	1.0 0.5	mA
Ripple Rejection $11.5\text{ Vdc} \leq V_{in} \leq 21.5\text{ Vdc}$ , $f = 120\text{ Hz}$	RR	56	61	–	56	61	–	dB
Dropout Voltage ( $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ )	$V_I - V_O$	–	2.0	–	–	2.0	–	Vdc
Output Noise Voltage ( $T_A = 25^\circ\text{C}$ ) $10\text{ Hz} \leq f \leq 100\text{ kHz}$	$V_n$	–	10	–	–	10	–	$\mu\text{V}/V_O$
Output Resistance $f = 1.0\text{ kHz}$	$r_O$	–	1.0	–	–	1.0	–	$\text{m}\Omega$
Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ ) $V_{in} = 35\text{ Vdc}$	$I_{SC}$	–	0.2	–	–	0.2	–	A
Peak Output Current ( $T_J = 25^\circ\text{C}$ )	$I_{max}$	–	2.2	–	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	$\text{TCV}_O$	–	–0.5	–	–	–0.5	–	$\text{mV}/^\circ\text{C}$

## ELECTRICAL CHARACTERISTICS ( $V_{in} = 19\text{ V}$ , $I_O = 500\text{ mA}$ , $T_J = T_{low}$ to $T_{high}$ [Note 1], unless otherwise noted.)

Characteristic	Symbol	MC7812B			MC7812C/LM340T–12			Unit
		Min	Typ	Max	Min	Typ	Max	
Output Voltage ( $T_J = 25^\circ\text{C}$ )	$V_O$	11.5	12	12.5	11.5	12	12.5	Vdc
Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ ) $14.5\text{ Vdc} \leq V_{in} \leq 27\text{ Vdc}$ $15.5\text{ Vdc} \leq V_{in} \leq 27\text{ Vdc}$	$V_O$	– 11.4	– 12	– 12.6	11.4 –	12 –	12.6 –	Vdc
Line Regulation, $T_J = 25^\circ\text{C}$ (Note 2) $14.5\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ $16\text{ Vdc} \leq V_{in} \leq 22\text{ Vdc}$ $14.8\text{ Vdc} \leq V_{in} \leq 27\text{ Vdc}$ , $I_O = 1.0\text{ A}$	$\text{Reg}_{line}$	–	7.5 2.2 –	240 120 –	–	3.8 0.3 –	24 24 48	mV
Load Regulation, $T_J = 25^\circ\text{C}$ (Note 2) $5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$	$\text{Reg}_{load}$	–	1.6	240	–	8.1	60	mV
Quiescent Current	$I_B$	–	3.4	8.0	–	3.4	6.5	mA
Quiescent Current Change $14.5\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ , $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ $15\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$	$\Delta I_B$	–	–	– 1.0 0.5	–	–	0.7 0.8 0.5	mA
Ripple Rejection $15\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$ , $f = 120\text{ Hz}$	RR	–	60	–	55	60	–	dB
Dropout Voltage ( $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ )	$V_I - V_O$	–	2.0	–	–	2.0	–	Vdc

- $T_{low} = 0^\circ\text{C}$  for MC78XXAC, C, LM340AT–XX, LM340T–XX  $T_{high} = +125^\circ\text{C}$  for MC78XXAC, C, LM340AT–XX, LM340T–XX, NCV7805  
=  $-40^\circ\text{C}$  for MC78XXB, MC78XXAB, NCV7805
- Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

## MC7800, MC7800A, LM340, LM340A Series, NCV7805

**ELECTRICAL CHARACTERISTICS (continued)** ( $V_{in} = 19\text{ V}$ ,  $I_O = 500\text{ mA}$ ,  $T_J = T_{low}$  to  $T_{high}$  [Note 1], unless otherwise noted.)

Characteristic	Symbol	MC7812B			MC7812C/LM340T-12			Unit
		Min	Typ	Max	Min	Typ	Max	
Output Noise Voltage ( $T_A = 25^\circ\text{C}$ ) $10\text{ Hz} \leq f \leq 100\text{ kHz}$	$V_n$	–	10	–	–	10	–	$\mu\text{V}/V_O$
Output Resistance $f = 1.0\text{ kHz}$	$r_O$	–	1.1	–	–	1.1	–	$\text{m}\Omega$
Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ ) $V_{in} = 35\text{ Vdc}$	$I_{SC}$	–	0.2	–	–	0.2	–	A
Peak Output Current ( $T_J = 25^\circ\text{C}$ )	$I_{max}$	–	2.2	–	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	$TCV_O$	–	–0.8	–	–	–0.8	–	$\text{mV}/^\circ\text{C}$

**ELECTRICAL CHARACTERISTICS** ( $V_{in} = 19\text{ V}$ ,  $I_O = 1.0\text{ A}$ ,  $T_J = T_{low}$  to  $T_{high}$  [Note 1], unless otherwise noted.)

Characteristic	Symbol	MC7812AB/MC7812AC/LM340AT-12			Unit
		Min	Typ	Max	
Output Voltage ( $T_J = 25^\circ\text{C}$ )	$V_O$	11.75	12	12.25	Vdc
Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ ) $14.8\text{ Vdc} \leq V_{in} \leq 27\text{ Vdc}$	$V_O$	11.5	12	12.5	Vdc
Line Regulation (Note 2) $14.8\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ , $I_O = 500\text{ mA}$ $16\text{ Vdc} \leq V_{in} \leq 22\text{ Vdc}$ , $I_O = 1.0\text{ A}$ $14.5\text{ Vdc} \leq V_{in} \leq 27\text{ Vdc}$ , $T_J = 25^\circ\text{C}$	$Reg_{line}$	–	3.8	18	mV
Load Regulation (Note 2) $5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$ , $T_J = 25^\circ\text{C}$ $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$	$Reg_{load}$	–	–	25	mV
Quiescent Current	$I_B$	–	3.4	6.0	mA
Quiescent Current Change $15\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ , $I_O = 500\text{ mA}$ $14.8\text{ Vdc} \leq V_{in} \leq 27\text{ Vdc}$ , $T_J = 25^\circ\text{C}$ $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$	$\Delta I_B$	–	–	0.8	mA
Ripple Rejection $15\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$ , $f = 120\text{ Hz}$ , $I_O = 500\text{ mA}$	RR	55	60	–	dB
Dropout Voltage ( $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ )	$V_I - V_O$	–	2.0	–	Vdc
Output Noise Voltage ( $T_A = 25^\circ\text{C}$ ) $10\text{ Hz} \leq f \leq 100\text{ kHz}$	$V_n$	–	10	–	$\mu\text{V}/V_O$
Output Resistance ( $f = 1.0\text{ kHz}$ )	$r_O$	–	1.1	–	$\text{m}\Omega$
Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ ) $V_{in} = 35\text{ Vdc}$	$I_{SC}$	–	0.2	–	A
Peak Output Current ( $T_J = 25^\circ\text{C}$ )	$I_{max}$	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	$TCV_O$	–	–0.8	–	$\text{mV}/^\circ\text{C}$

1.  $T_{low} = 0^\circ\text{C}$  for MC78XXAC, C, LM340AT-XX, LM340T-XX  
 $T_{high} = +125^\circ\text{C}$  for MC78XXAC, C, LM340AT-XX, LM340T-XX, NCV7805  
 $= -40^\circ\text{C}$  for MC78XXB, MC78XXAB, NCV7805

2. Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.



## MC7800, MC7800A, LM340, LM340A Series, NCV7805

### ELECTRICAL CHARACTERISTICS ( $V_{in} = 23\text{ V}$ , $I_O = 500\text{ mA}$ , $T_J = T_{low}$ to $T_{high}$ [Note 1], unless otherwise noted.)

Characteristic	Symbol	MC7815B			MC7815C/LM340T-15			Unit
		Min	Typ	Max	Min	Typ	Max	
Output Voltage ( $T_J = 25^\circ\text{C}$ )	$V_O$	14.4	15	15.6	14.4	15	15.6	Vdc
Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ ) $17.5\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ $18.5\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$	$V_O$	– 14.25	– 15	– 15.75	14.25 –	15 –	15.75 –	Vdc
Line Regulation, $T_J = 25^\circ\text{C}$ (Note 2) $17.9\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ $20\text{ Vdc} \leq V_{in} \leq 26\text{ Vdc}$	$\text{Reg}_{line}$	– –	8.5 3.0	300 150	– –	8.5 3.0	30 28	mV
Load Regulation, $T_J = 25^\circ\text{C}$ (Note 2) $5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$	$\text{Reg}_{load}$	–	1.8	300	–	1.8	55	mV
Quiescent Current	$I_B$	–	3.5	8.0	–	3.5	6.5	mA
Quiescent Current Change $17.5\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ $17.5\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ , $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$	$\Delta I_B$	– – –	– – –	– 1.0 0.5	– – –	– – –	0.8 0.7 0.5	mA
Ripple Rejection $18.5\text{ Vdc} \leq V_{in} \leq 28.5\text{ Vdc}$ , $f = 120\text{ Hz}$	RR	–	58	–	54	58	–	dB
Dropout Voltage ( $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ )	$V_I - V_O$	–	2.0	–	–	2.0	–	Vdc
Output Noise Voltage ( $T_A = 25^\circ\text{C}$ ) $10\text{ Hz} \leq f \leq 100\text{ kHz}$	$V_n$	–	10	–	–	10	–	$\mu\text{V}/V_O$
Output Resistance $f = 1.0\text{ kHz}$	$r_O$	–	1.2	–	–	1.2	–	$\text{m}\Omega$
Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ ) $V_{in} = 35\text{ Vdc}$	$I_{SC}$	–	0.2	–	–	0.2	–	A
Peak Output Current ( $T_J = 25^\circ\text{C}$ )	$I_{max}$	–	2.2	–	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	$\text{TCV}_O$	–	–1.0	–	–	–1.0	–	$\text{mV}/^\circ\text{C}$

### ELECTRICAL CHARACTERISTICS ( $V_{in} = 23\text{ V}$ , $I_O = 1.0\text{ A}$ , $T_J = T_{low}$ to $T_{high}$ [Note 1], unless otherwise noted.)

Characteristic	Symbol	MC7815AB/MC7815AC/LM340AT-15			Unit
		Min	Typ	Max	
Output Voltage ( $T_J = 25^\circ\text{C}$ )	$V_O$	14.7	15	15.3	Vdc
Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ ) $17.9\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$	$V_O$	14.4	15	15.6	Vdc
Line Regulation (Note 2) $17.9\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ , $I_O = 500\text{ mA}$ $20\text{ Vdc} \leq V_{in} \leq 26\text{ Vdc}$ $17.5\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ , $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$	$\text{Reg}_{line}$	– – –	8.5 3.0 7.0	20 22 20	mV
Load Regulation (Note 2) $5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$ , $T_J = 25^\circ\text{C}$ $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ $250\text{ mA} \leq I_O \leq 750\text{ mA}$	$\text{Reg}_{load}$	– – –	1.8 1.5 1.2	25 25 15	mV
Quiescent Current	$I_B$	–	3.5	6.0	mA
Quiescent Current Change $17.5\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ , $I_O = 500\text{ mA}$ $17.5\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ , $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$	$\Delta I_B$	– – –	– – –	0.8 0.8 0.5	mA

- $T_{low} = 0^\circ\text{C}$  for MC78XXAC, C, LM340AT-XX, LM340T-XX  $T_{high} = +125^\circ\text{C}$  for MC78XXAC, C, LM340AT-XX, LM340T-XX, NCV7805  
=  $-40^\circ\text{C}$  for MC78XXB, MC78XXAB, NCV7805
- Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

## MC7800, MC7800A, LM340, LM340A Series, NCV7805

**ELECTRICAL CHARACTERISTICS (continued)** ( $V_{in} = 23\text{ V}$ ,  $I_O = 1.0\text{ A}$ ,  $T_J = T_{low}$  to  $T_{high}$  [Note 1], unless otherwise noted.)

Characteristic	Symbol	MC7815AB/MC7815AC/LM340AT-15			Unit
		Min	Typ	Max	
Ripple Rejection $18.5\text{ Vdc} \leq V_{in} \leq 28.5\text{ Vdc}$ , $f = 120\text{ Hz}$ , $I_O = 500\text{ mA}$	RR	60	80	–	dB
Dropout Voltage ( $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ )	$V_I - V_O$	–	2.0	–	Vdc
Output Noise Voltage ( $T_A = 25^\circ\text{C}$ ) $10\text{ Hz} \leq f \leq 100\text{ kHz}$	$V_n$	–	10	–	$\mu\text{V}/V_O$
Output Resistance $f = 1.0\text{ kHz}$	$r_O$	–	1.2	–	$\text{m}\Omega$
Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ ) $V_{in} = 35\text{ Vdc}$	$I_{SC}$	–	0.2	–	A
Peak Output Current ( $T_J = 25^\circ\text{C}$ )	$I_{max}$	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	$TCV_O$	–	–1.0	–	$\text{mV}/^\circ\text{C}$

**ELECTRICAL CHARACTERISTICS** ( $V_{in} = 27\text{ V}$ ,  $I_O = 500\text{ mA}$ ,  $T_J = T_{low}$  to  $T_{high}$  [Note 1], unless otherwise noted.)

Characteristic	Symbol	MC7818B			MC7818C			Unit
		Min	Typ	Max	Min	Typ	Max	
Output Voltage ( $T_J = 25^\circ\text{C}$ )	$V_O$	17.3	18	18.7	17.3	18	18.7	Vdc
Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ ) $21\text{ Vdc} \leq V_{in} \leq 33\text{ Vdc}$ $22\text{ Vdc} \leq V_{in} \leq 33\text{ Vdc}$	$V_O$	– 17.1	– 18	– 18.9	17.1 –	18 –	18.9 –	Vdc
Line Regulation, (Note 2) $21\text{ Vdc} \leq V_{in} \leq 33\text{ Vdc}$ $24\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$	$Reg_{line}$	– –	9.5 3.2	360 180	– –	9.5 3.2	50 25	mV
Load Regulation, (Note 2) $5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$	$Reg_{load}$	–	2.0	360	–	2.0	55	mV
Quiescent Current	$I_B$	–	3.5	8.0	–	3.5	6.5	mA
Quiescent Current Change $21\text{ Vdc} \leq V_{in} \leq 33\text{ Vdc}$ $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$	$\Delta I_B$	– –	– –	– 0.5	– –	– –	1.0 0.5	mA
Ripple Rejection $22\text{ Vdc} \leq V_{in} \leq 33\text{ Vdc}$ , $f = 120\text{ Hz}$	RR	–	57	–	53	57	–	dB
Dropout Voltage ( $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ )	$V_{I1} - V_O$	–	2.0	–	–	2.0	–	Vdc
Output Noise Voltage ( $T_A = 25^\circ\text{C}$ ) $10\text{ Hz} \leq f \leq 100\text{ kHz}$	$V_n$	–	10	–	–	10	–	$\mu\text{V}/V_O$
Output Resistance $f = 1.0\text{ kHz}$	$r_O$	–	1.3	–	–	1.3	–	$\text{m}\Omega$
Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ ) $V_{in} = 35\text{ Vdc}$	$I_{SC}$	–	0.2	–	–	0.2	–	A
Peak Output Current ( $T_J = 25^\circ\text{C}$ )	$I_{max}$	–	2.2	–	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	$TCV_O$	–	–1.5	–	–	–1.5	–	$\text{mV}/^\circ\text{C}$

- $T_{low} = 0^\circ\text{C}$  for MC78XXAC, C, LM340AT-XX, LM340T-XX  
 $T_{high} = +125^\circ\text{C}$  for MC78XXAC, C, LM340AT-XX, LM340T-XX, NCV7805  
 $= -40^\circ\text{C}$  for MC78XXB, MC78XXAB, NCV7805
- Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

## MC7800, MC7800A, LM340, LM340A Series, NCV7805

### ELECTRICAL CHARACTERISTICS ( $V_{in} = 27\text{ V}$ , $I_O = 1.0\text{ A}$ , $T_J = T_{low}$ to $T_{high}$ [Note 1], unless otherwise noted.)

Characteristic	Symbol	MC7818AC			Unit
		Min	Typ	Max	
Output Voltage ( $T_J = 25^\circ\text{C}$ )	$V_O$	17.64	18	18.36	Vdc
Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ $21\text{ Vdc} \leq V_{in} \leq 33\text{ Vdc}$ )	$V_O$	17.3	18	18.7	Vdc
Line Regulation (Note 2) $21\text{ Vdc} \leq V_{in} \leq 33\text{ Vdc}$ , $I_O = 500\text{ mA}$ $24\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ , $I_O = 1.0\text{ A}$ $24\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ , $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ $20.6\text{ Vdc} \leq V_{in} \leq 33\text{ Vdc}$ , $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$	$Reg_{line}$	–	9.5	22	mV
Load Regulation (Note 2) $5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$ , $T_J = 25^\circ\text{C}$ $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ $250\text{ mA} \leq I_O \leq 750\text{ mA}$	$Reg_{load}$	–	2.0	25	mV
Quiescent Current	$I_B$	–	3.5	6.0	mA
Quiescent Current Change $21\text{ Vdc} \leq V_{in} \leq 33\text{ Vdc}$ , $I_O = 500\text{ mA}$ $21.5\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ , $T_J = 25^\circ\text{C}$ $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$	$\Delta I_B$	–	–	0.8	mA
Ripple Rejection $22\text{ Vdc} \leq V_{in} \leq 32\text{ Vdc}$ , $f = 120\text{ Hz}$ , $I_O = 500\text{ mA}$	RR	53	57	–	dB
Dropout Voltage ( $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ )	$V_I - V_O$	–	2.0	–	Vdc
Output Noise Voltage ( $T_A = 25^\circ\text{C}$ ) $10\text{ Hz} \leq f \leq 100\text{ kHz}$	$V_n$	–	10	–	$\mu\text{V}/V_O$
Output Resistance $f = 1.0\text{ kHz}$	$r_O$	–	1.3	–	$\text{m}\Omega$
Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ ) $V_{in} = 35\text{ Vdc}$	$I_{sc}$	–	0.2	–	A
Peak Output Current ( $T_J = 25^\circ\text{C}$ )	$I_{max}$	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	$TCV_O$	–	–1.5	–	$\text{mV}/^\circ\text{C}$

### ELECTRICAL CHARACTERISTICS ( $V_{in} = 33\text{ V}$ , $I_O = 500\text{ mA}$ , $T_J = T_{low}$ to $T_{high}$ [Note 1], unless otherwise noted.)

Characteristic	Symbol	MC7824B			MC7824C			Unit
		Min	Typ	Max	Min	Typ	Max	
Output Voltage ( $T_J = 25^\circ\text{C}$ )	$V_O$	23	24	25	23	24	25	Vdc
Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ ) $27\text{ Vdc} \leq V_{in} \leq 38\text{ Vdc}$ $28\text{ Vdc} \leq V_{in} \leq 38\text{ Vdc}$	$V_O$	– 22.8	– 24	– 25.2	22.8 –	24 –	25.2 –	Vdc
Line Regulation, (Note 2) $27\text{ Vdc} \leq V_{in} \leq 38\text{ Vdc}$ $30\text{ Vdc} \leq V_{in} \leq 36\text{ Vdc}$	$Reg_{line}$	–	11.5 3.8	480 240	–	2.7 2.7	60 48	mV
Load Regulation, (Note 2) $5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$	$Reg_{load}$	–	2.1	480	–	4.4	65	mV
Quiescent Current	$I_B$	–	3.6	8.0	–	3.6	6.5	mA
Quiescent Current Change $27\text{ Vdc} \leq V_{in} \leq 38\text{ Vdc}$ $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$	$\Delta I_B$	–	–	– 0.5	–	–	1.0 0.5	mA

- $T_{low} = 0^\circ\text{C}$  for MC78XXAC, C, LM340AT–XX, LM340T–XX  
 $T_{high} = +125^\circ\text{C}$  for MC78XXAC, C, LM340AT–XX, LM340T–XX, NCV7805  
 $= -40^\circ\text{C}$  for MC78XXB, MC78XXAB, NCV7805
- Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

## MC7800, MC7800A, LM340, LM340A Series, NCV7805

**ELECTRICAL CHARACTERISTICS (continued)** ( $V_{in} = 33\text{ V}$ ,  $I_O = 500\text{ mA}$ ,  $T_J = T_{low}$  to  $T_{high}$  [Note 1], unless otherwise noted.)

Characteristic	Symbol	MC7824B			MC7824C			Unit
		Min	Typ	Max	Min	Typ	Max	
Ripple Rejection $28\text{ Vdc} \leq V_{in} \leq 38\text{ Vdc}$ , $f = 120\text{ Hz}$	RR	–	54	–	50	54	–	dB
Dropout Voltage ( $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ )	$V_I - V_O$	–	2.0	–	–	2.0	–	Vdc
Output Noise Voltage ( $T_A = 25^\circ\text{C}$ ) $10\text{ Hz} \leq f \leq 100\text{ kHz}$	$V_n$	–	10	–	–	10	–	$\mu\text{V}/V_O$
Output Resistance $f = 1.0\text{ kHz}$	$r_O$	–	1.4	–	–	1.4	–	$\text{m}\Omega$
Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ ) $V_{in} = 35\text{ Vdc}$	$I_{SC}$	–	0.2	–	–	0.2	–	A
Peak Output Current ( $T_J = 25^\circ\text{C}$ )	$I_{max}$	–	2.2	–	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	$TCV_O$	–	–2.0	–	–	–2.0	–	$\text{mV}/^\circ\text{C}$

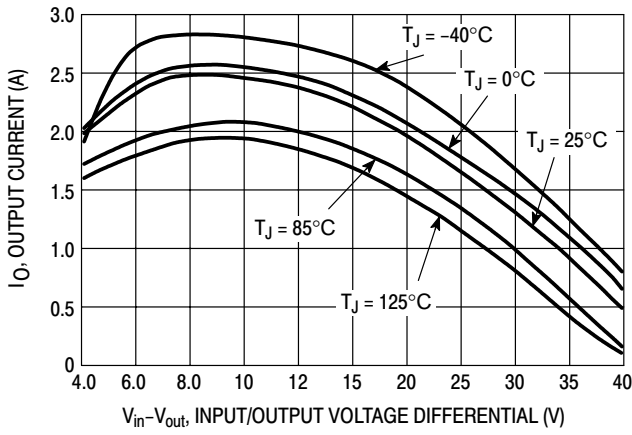
**ELECTRICAL CHARACTERISTICS** ( $V_{in} = 33\text{ V}$ ,  $I_O = 1.0\text{ A}$ ,  $T_J = T_{low}$  to  $T_{high}$  [Note 1], unless otherwise noted.)

Characteristic	Symbol	MC7824AC			Unit
		Min	Typ	Max	
Output Voltage ( $T_J = 25^\circ\text{C}$ )	$V_O$	23.5	24	24.5	Vdc
Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ ) $27.3\text{ Vdc} \leq V_{in} \leq 38\text{ Vdc}$	$V_O$	23.2	24	25.8	Vdc
Line Regulation (Note 2) $27\text{ Vdc} \leq V_{in} \leq 38\text{ Vdc}$ , $I_O = 500\text{ mA}$ $30\text{ Vdc} \leq V_{in} \leq 36\text{ Vdc}$ , $I_O = 1.0\text{ A}$ $30\text{ Vdc} \leq V_{in} \leq 36\text{ Vdc}$ , $T_J = 25^\circ\text{C}$ $26.7\text{ Vdc} \leq V_{in} \leq 38\text{ Vdc}$ , $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$	$Reg_{line}$	–	11.5	25	mV
Load Regulation (Note 2) $5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$ , $T_J = 25^\circ\text{C}$ $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ $250\text{ mA} \leq I_O \leq 750\text{ mA}$	$Reg_{load}$	–	2.1	15	mV
Quiescent Current	$I_B$	–	3.6	6.0	mA
Quiescent Current Change $27.3\text{ Vdc} \leq V_{in} \leq 38\text{ Vdc}$ , $I_O = 500\text{ mA}$ $27\text{ Vdc} \leq V_{in} \leq 38\text{ Vdc}$ , $T_J = 25^\circ\text{C}$ $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$	$\Delta I_B$	–	–	0.8	mA
Ripple Rejection $28\text{ Vdc} \leq V_{in} \leq 38\text{ Vdc}$ , $f = 120\text{ Hz}$ , $I_O = 500\text{ mA}$	RR	45	54	–	dB
Dropout Voltage ( $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ )	$V_I - V_O$	–	2.0	–	Vdc
Output Noise Voltage ( $T_A = 25^\circ\text{C}$ ) $10\text{ Hz} \leq f \leq 100\text{ kHz}$	$V_n$	–	10	–	$\mu\text{V}/V_O$
Output Resistance ( $f = 1.0\text{ kHz}$ )	$r_O$	–	1.4	–	$\text{m}\Omega$
Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ ) $V_{in} = 35\text{ Vdc}$	$I_{SC}$	–	0.2	–	A
Peak Output Current ( $T_J = 25^\circ\text{C}$ )	$I_{max}$	–	2.2	–	A
Average Temperature Coefficient of Output Voltage	$TCV_O$	–	–2.0	–	$\text{mV}/^\circ\text{C}$

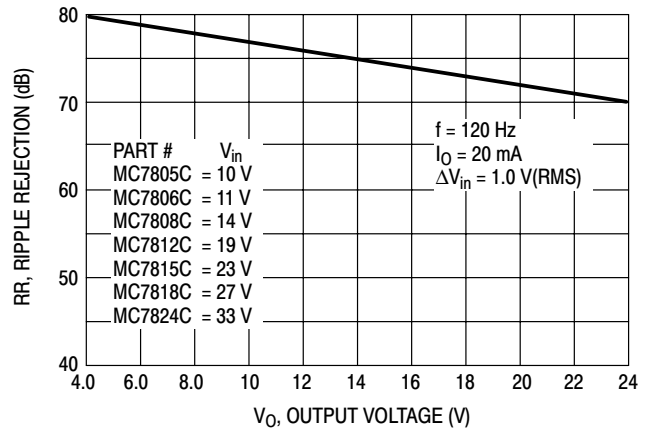
1.  $T_{low} = 0^\circ\text{C}$  for MC78XXAC, C, LM340AT–XX, LM340T–XX  $T_{high} = +125^\circ\text{C}$  for MC78XXAC, C, LM340AT–XX, LM340T–XX, NCV7805  
=  $-40^\circ\text{C}$  for MC78XXB, MC78XXAB, NCV7805

2. Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

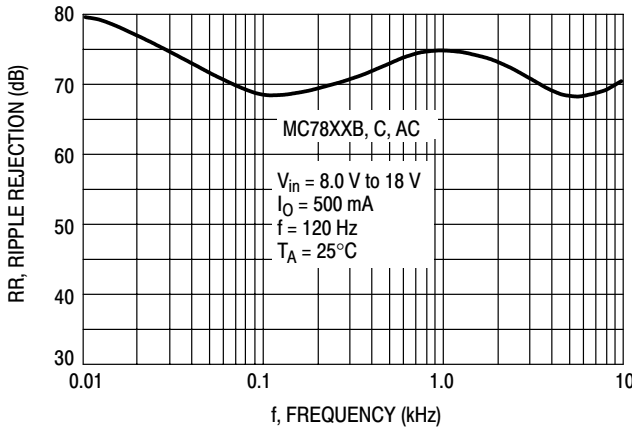
# MC7800, MC7800A, LM340, LM340A Series, NCV7805



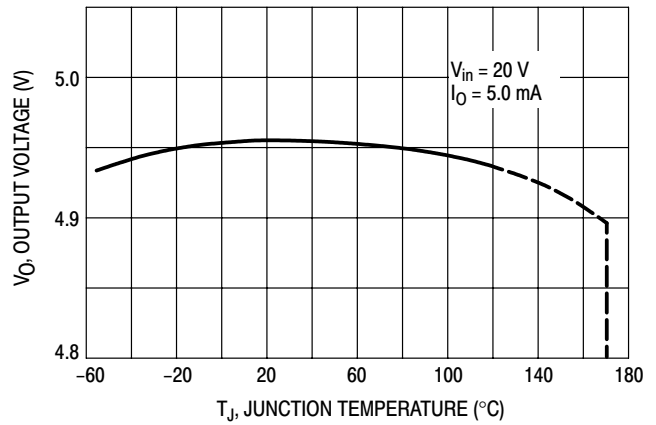
**Figure 2. Peak Output Current as a Function of Input/Output Differential Voltage (MC78XXC, AC, B)**



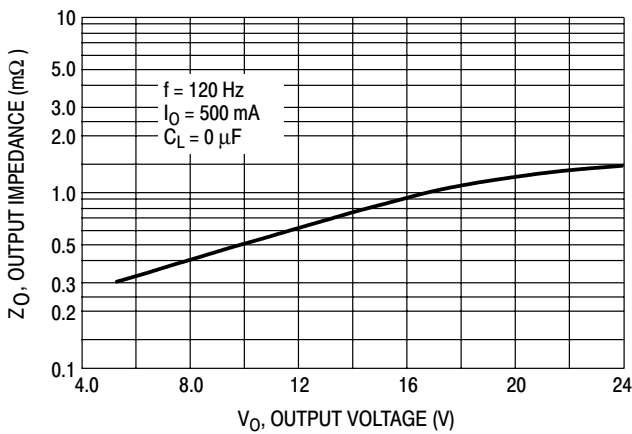
**Figure 3. Ripple Rejection as a Function of Output Voltages (MC78XXC, AC, B)**



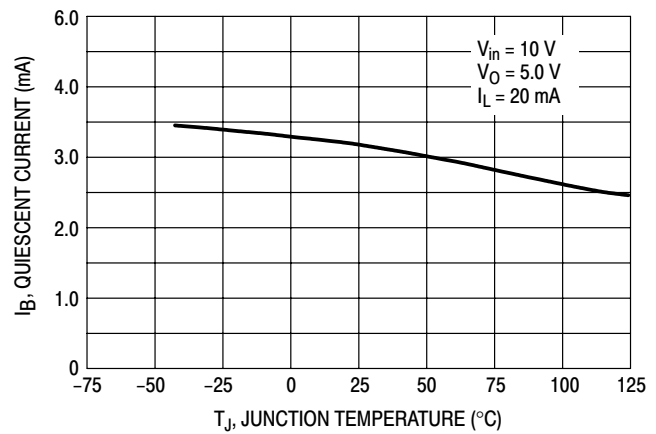
**Figure 4. Ripple Rejection as a Function of Frequency (MC78XXC, AC, B)**



**Figure 5. Output Voltage as a Function of Junction Temperature (MC7805C, AC, B)**



**Figure 6. Output Impedance as a Function of Output Voltage (MC78XXC, AC, B)**



**Figure 7. Quiescent Current as a Function of Temperature (MC78XXC, AC, B)**

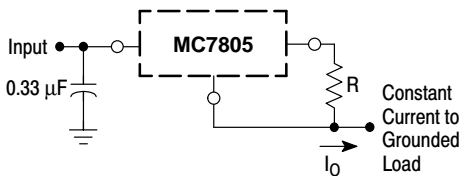
APPLICATIONS INFORMATION

Design Considerations

The MC7800 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 0.33 μF 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 regulators 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.



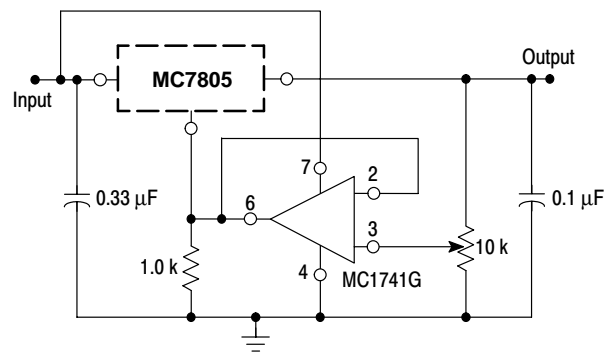
The MC7800 regulators can also be used as a current source when connected as above. In order to minimize dissipation the MC7805C is chosen in this application. Resistor R determines the current as follows:

$$I_O = \frac{5.0V}{R} + I_B$$

$I_B \cong 3.2 \text{ mA}$  over line and load changes.

For example, a 1.0 A current source would require R to be a 5.0 Ω, 10 W resistor and the output voltage compliance would be the input voltage less 7.0 V.

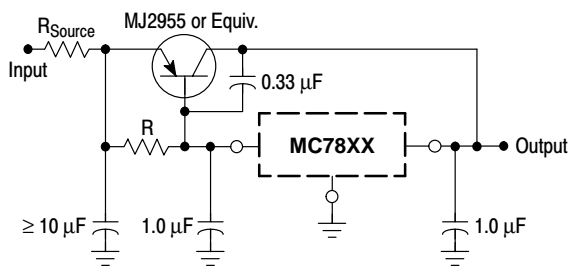
Figure 8. Current Regulator



$V_O = 7.0 \text{ V to } 20 \text{ V}$   
 $V_{IN} = V_O \geq 2.0 \text{ V}$

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 2.0 V greater than the regulator voltage.

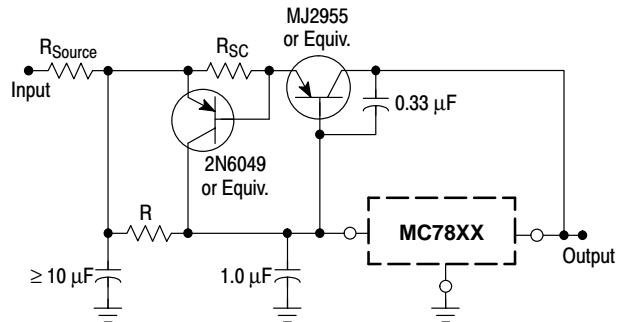
Figure 9. Adjustable Output Regulator



XX = 2 digits of type number indicating voltage.

The MC7800 series can be current boosted with a PNP transistor. The MJ2955 provides current to 5.0 A. Resistor R in conjunction with the  $V_{BE}$  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  $V_{BE}$  of the pass transistor.

Figure 10. Current Boost Regulator



XX = 2 digits of type number indicating voltage.

The circuit of Figure 10 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, a four-ampere plastic power transistor is specified.

Figure 11. Short Circuit Protection

MC7800, MC7800A, LM340, LM340A Series, NCV7805

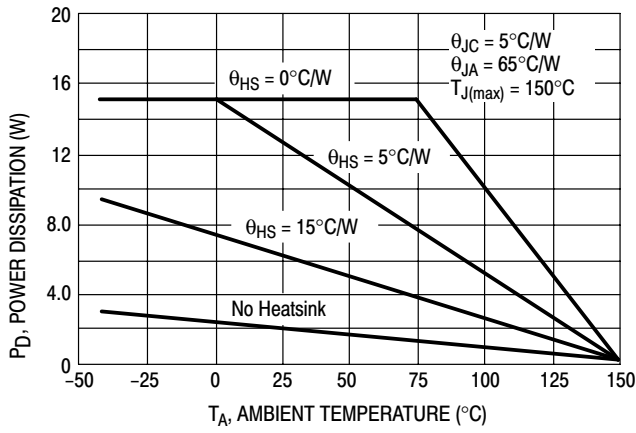


Figure 12. Worst Case Power Dissipation versus Ambient Temperature (Case 221A)

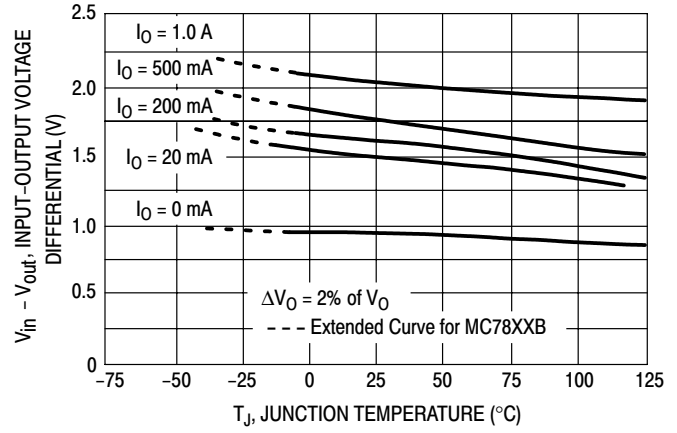


Figure 13. Input Output Differential as a Function of Junction Temperature (MC78XXC, AC, B)

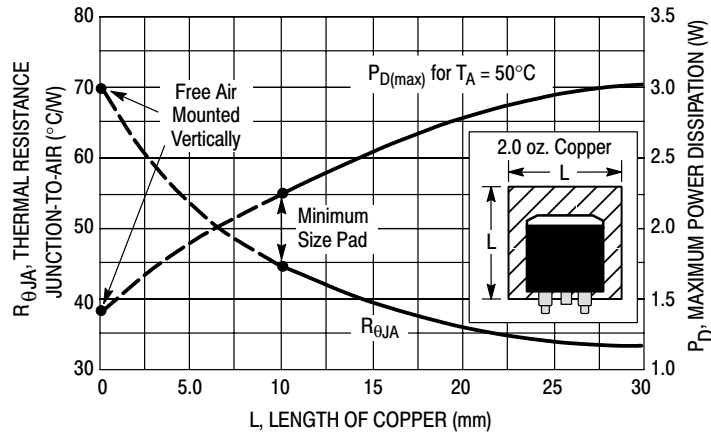


Figure 14. D<sup>2</sup>PAK Thermal Resistance and Maximum Power Dissipation versus P.C.B. Copper Length

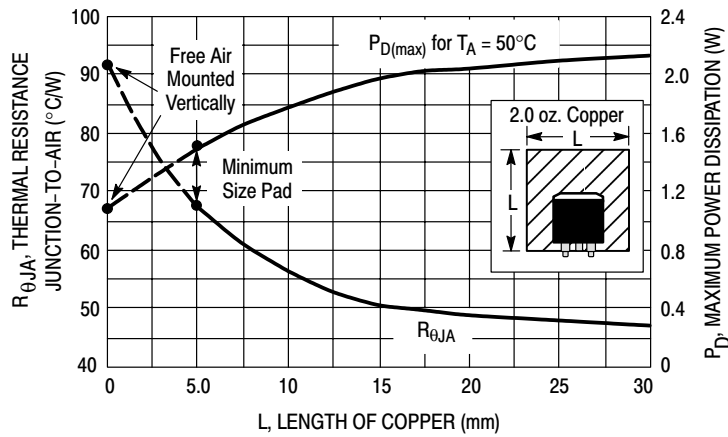


Figure 15. DPAK Thermal Resistance and Maximum Power Dissipation versus P.C.B. Copper Length

# MC7800, MC7800A, LM340, LM340A Series, NCV7805

## DEFINITIONS

**Line Regulation** – The change in output voltage for a change in the input voltage. The measurement is made under conditions of low dissipation or by using pulse techniques such that the average chip temperature is not significantly affected.

**Load Regulation** – The change in output voltage for a change in load current at constant chip temperature.

**Maximum Power Dissipation** – The maximum total device dissipation for which the regulator will operate within specifications.

**Quiescent Current** – That part of the input current that is not delivered to the load.

**Output Noise Voltage** – The rms ac voltage at the output, with constant load and no input ripple, measured over a specified frequency range.

**Long Term Stability** – Output voltage stability under accelerated life test conditions with the maximum rated voltage listed in the devices' electrical characteristics and maximum power dissipation.

## ORDERING INFORMATION

Device	Output Voltage	Temperature Range	Package	Shipping	
				Rails (No Suffix)	Tape & Reel (R4 Suffix)
MC7805.2CT	5.0 V	T <sub>J</sub> = 0° to +125°C	TO-220	50 Units/Rail	–
MC7805ACD2T/R4			D2PAK		800 Units/Reel
MC7805ACT			TO-220		–
MC7805CD2T/R4			D2PAK		800 Units/Reel
MC7805CT			TO-220	–	
MC7805CDT/RK			DPAK	75 Units/Rail	2500 Units/Reel
LM340T-5			TO-220	–	
LM340AT-5		T <sub>J</sub> = –40° to +125°C	D2PAK	50 Units/Rail	800 Units/Reel
MC7805BD2T/R4			TO-220	–	
MC7805BT			–		
NCV7805BT*			–		
MC7805BDT/RK			DPAK	75 Units/Rail	2500 Units/Reel
MC7805ABD2T/R4			D2PAK	800 Units/Reel	
MC7805ABT			TO-220	–	
MC7806ACT	6.0 V	T <sub>J</sub> = 0° to +125°C	TO-220	–	
MC7806CT		T <sub>J</sub> = –40° to +125°C	D2PAK	50 Units/Rail	800 Units/Reel
MC7806BD2T/R4			TO-220	–	
MC7806BT			–		
MC7808ACT	8.0 V	T <sub>J</sub> = 0° to +125°C	D2PAK	800 Units/Reel	
MC7808CD2T/R4			TO-220	–	
MC7808CT			D2PAK	800 Units/Reel	
MC7808CDT/RK/T5			DPAK	75 Units/Rail	2500 Units/Reel
MC7808BD2T/R4		T <sub>J</sub> = –40° to +125°C	D2PAK	50 Units/Rail	800 Units/Reel
MC7808BT			TO-220	–	
MC7808BDT/RK			DPAK	75 Units/Rail	2500 Units/Reel
MC7808ABD2T/R4			D2PAK	800 Units/Reel	
MC7808ABT			TO-220	50 Units/Rail	800 Units/Reel
					–

\*NCV7805: T<sub>low</sub> = –40°C, T<sub>high</sub> = +125°C. Guaranteed by design. NCV prefix is for automotive and other applications requiring site and change control.



# MC7800, MC7800A, LM340, LM340A Series, NCV7805

## ORDERING INFORMATION (continued)

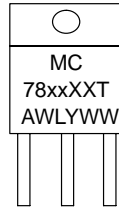
Device	Output Voltage	Temperature Range	Package	Shipping	
				Rails (No Suffix)	Tape & Reel (R4 Suffix)
MC7809ACT	9.0 V	$T_J = 0^\circ \text{ to } +125^\circ\text{C}$	TO-220	50 Units/Rail	-
MC7809CD2T/R4			D2PAK		800 Units/Reel
MC7809CT		$T_J = -40^\circ \text{ to } +125^\circ\text{C}$	TO-220		-
MC7809BT			-		
MC7812ACD2T/R4	12 V	$T_J = 0^\circ \text{ to } +125^\circ\text{C}$	D2PAK		800 Units/Reel
MC7812ACT			TO-220		-
MC7812CD2T/R4			D2PAK		800 Units/Reel
MC7812CT			TO-220		-
MC7812CDT/RK			DPAK	75 Units/Rail	2500 Units/Reel
LM340T-12			TO-220	-	
LM340AT-12		-			
MC7812BD2T/R4		$T_J = -40^\circ \text{ to } +125^\circ\text{C}$	D2PAK	50 Units/Rail	800 Units/Reel
MC7812BT			TO-220	-	
MC7812BDT/RK			DPAK	75 Units/Rail	2500 Units/Reel
MC7812ABD2T/R4			D2PAK	50 Units/Rail	800 Units/Reel
MC7812ABT			TO-220		-
MC7815ACD2T/R4			D2PAK		800 Units/Reel
MC7815ACT		TO-220	-		
MC7815CD2T/R4	D2PAK	800 Units/Reel			
MC7815CT	15 V	$T_J = 0^\circ \text{ to } +125^\circ\text{C}$	TO-220	-	
LM340T-15			-		
LM340AT-15			-		
MC7815CDT/RK			DPAK	75 Units/Rail	2500 Units/Reel
MC7815BD2T/R4		D2PAK	50 Units/Rail	800 Units/Reel	
MC7815BT		TO-220	-		
MC7815BDT/RK		DPAK	75 Units/Rail	2500 Units/Reel	
MC7815ABD2T/R4		D2PAK	50 Units/Rail	800 Units/Reel	
MC7815ABT		TO-220		-	
MC7818ACT		TO-220		-	
MC7818CD2T/R4	D2PAK	800 Units/Reel			
MC7818CT	18 V	$T_J = 0^\circ \text{ to } +125^\circ\text{C}$	TO-220	-	
MC7818BT				$T_J = -40^\circ \text{ to } +125^\circ\text{C}$	-
MC7824ACT	24 V	$T_J = 0^\circ \text{ to } +125^\circ\text{C}$		50 Units/Rail	-
MC7824CD2T					D2PAK
MC7824CT			TO-220		-
MC7824BD2T/R4		D2PAK	800 Units/Reel		
MC7824BT		TO-220	-		
			$T_J = -40^\circ \text{ to } +125^\circ\text{C}$		

# MC7800, MC7800A, LM340, LM340A Series, NCV7805

## MARKING DIAGRAMS

TO-220  
T SUFFIX  
CASE 221A

MC7800, MC7800A Series, NCV7805



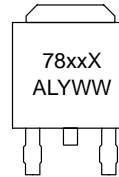
LM340, LM340A Series



D2PAK  
D2T SUFFIX  
CASE 936



DPAK  
DT SUFFIX  
CASE 369A

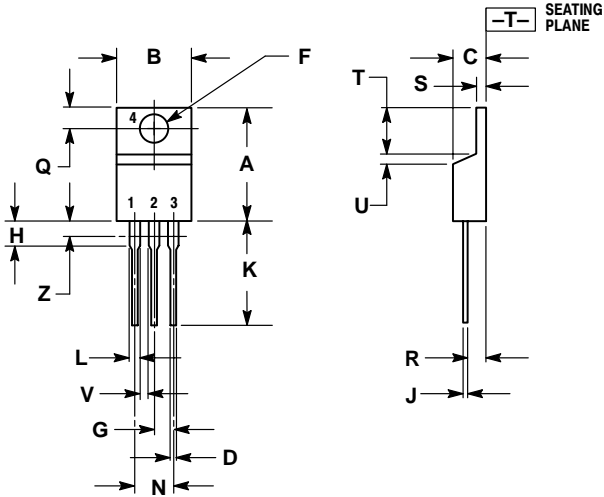


xx = Voltage Option  
XX = Appropriate Suffix Options  
A = Assembly Location  
WL, L = Wafer Lot  
Y = Year  
WW = Work Week

# MC7800, MC7800A, LM340, LM340A Series, NCV7805

## PACKAGE DIMENSIONS

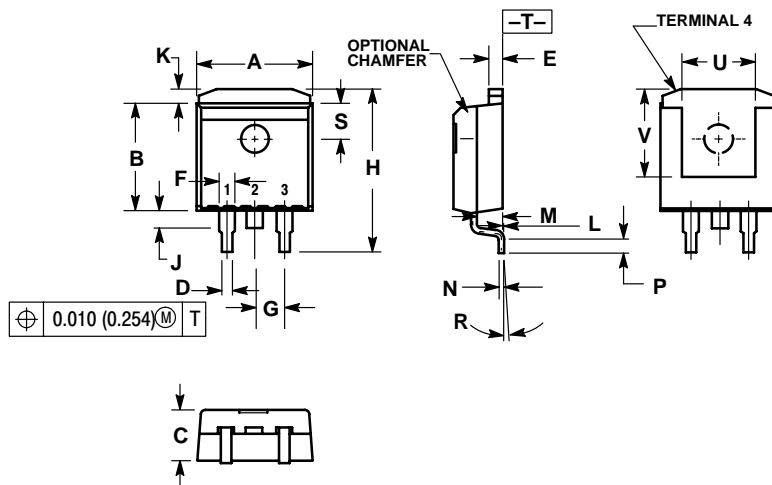
### TO-220 T SUFFIX CASE 221A-09 ISSUE AA



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  2. CONTROLLING DIMENSION: INCH.
  3. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.570	0.620	14.48	15.75
B	0.380	0.405	9.66	10.28
C	0.160	0.190	4.07	4.82
D	0.025	0.035	0.64	0.88
F	0.142	0.147	3.61	3.73
G	0.095	0.105	2.42	2.66
H	0.110	0.155	2.80	3.93
J	0.018	0.025	0.46	0.64
K	0.500	0.562	12.70	14.27
L	0.045	0.060	1.15	1.52
N	0.190	0.210	4.83	5.33
Q	0.100	0.120	2.54	3.04
R	0.080	0.110	2.04	2.79
S	0.045	0.055	1.15	1.39
T	0.235	0.255	5.97	6.47
U	0.000	0.050	0.00	1.27
V	0.045	---	1.15	---
Z	---	0.080	---	2.04

### D2PAK D2T SUFFIX CASE 936-03 ISSUE B



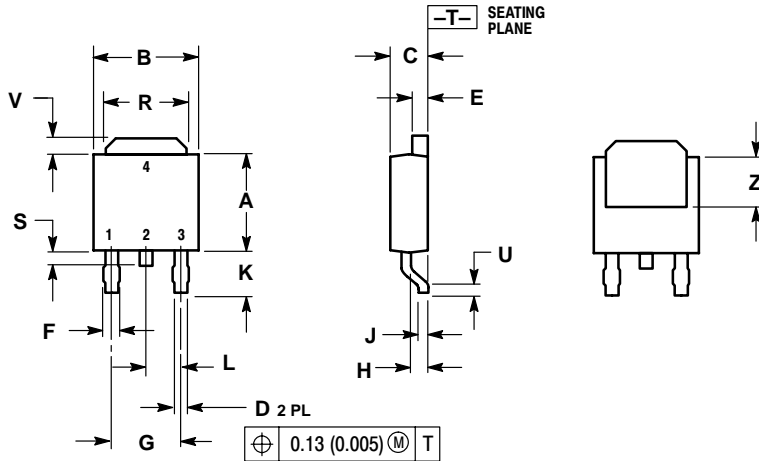
- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  2. CONTROLLING DIMENSION: INCH.
  3. TAB CONTOUR OPTIONAL WITHIN DIMENSIONS A AND K.
  4. DIMENSIONS U AND V ESTABLISH A MINIMUM MOUNTING SURFACE FOR TERMINAL 4.
  5. DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH OR GATE PROTRUSIONS. MOLD FLASH AND GATE PROTRUSIONS NOT TO EXCEED 0.025 (0.635) MAXIMUM.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.386	0.403	9.804	10.236
B	0.356	0.368	9.042	9.347
C	0.170	0.180	4.318	4.572
D	0.026	0.036	0.660	0.914
E	0.045	0.055	1.143	1.397
F	0.051	REF	1.295	REF
G	0.100	BSC	2.540	BSC
H	0.539	0.579	13.691	14.707
J	0.125	MAX	3.175	MAX
K	0.050	REF	1.270	REF
L	0.000	0.010	0.000	0.254
M	0.088	0.102	2.235	2.591
N	0.018	0.026	0.457	0.660
P	0.058	0.078	1.473	1.981
R	5°	REF	5°	REF
S	0.116	REF	2.946	REF
U	0.200	MIN	5.080	MIN
V	0.250	MIN	6.350	MIN

# MC7800, MC7800A, LM340, LM340A Series, NCV7805


## PACKAGE DIMENSIONS

DPAK  
DT SUFFIX  
CASE 369A-13  
ISSUE AB



- NOTES:  
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.  
2. CONTROLLING DIMENSION: INCH.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.235	0.250	5.97	6.35
B	0.250	0.265	6.35	6.73
C	0.086	0.094	2.19	2.38
D	0.027	0.035	0.69	0.88
E	0.033	0.040	0.84	1.01
F	0.037	0.047	0.94	1.19
G	0.180 BSC		4.58 BSC	
H	0.034	0.040	0.87	1.01
J	0.018	0.023	0.46	0.58
K	0.102	0.114	2.60	2.89
L	0.090 BSC		2.29 BSC	
R	0.175	0.215	4.45	5.46
S	0.020	0.050	0.51	1.27
U	0.020	---	0.51	---
V	0.030	0.050	0.77	1.27
Z	0.138	---	3.51	---

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