

# Three-Terminal 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 and Standard 3-Lead Transistor Packages
- Previous Commercial Temperature Range has been Extended to a Junction Temperature Range of -40°C to +125°C

## DEVICE TYPE/NOMINAL OUTPUT VOLTAGE

|  |       |  |      |
|--|-------|--|------|
| MC7805AC<br>LM340AT-5<br>MC7805C<br>LM340T-5 | 5.0 V | MC7812C<br>LM340T-12                           | 12 V |
| MC7806AC<br>MC7806C                          | 6.0 V | MC7815AC<br>LM340AT-15<br>MC7815C<br>LM340T-15 | 15 V |
| MC7808AC<br>MC7808C                          | 8.0 V | MC7818AC<br>MC7818C                            | 18 V |
| MC7809C                                      | 9.0 V | MC7824AC<br>MC7824C                            | 24 V |
| MC7812AC<br>LM340AT-12                       | 12 V  |  |      |

## ORDERING INFORMATION

| Device      | Output Voltage Tolerance | Operating Temperature Range     | Package         |
|-------------|--------------------------|---------------------------------|-----------------|
| MC78XXACT   | 2%                       | T <sub>J</sub> = −40° to +125°C | Insertion Mount |
| LM340AT−XX  |                          |                                 |                 |
| MC78XXACD2T |                          |                                 | Surface Mount   |
| MC78XXCT    | 4%                       |                                 | Insertion Mount |
| LM340T−XX   |                          |                                 |                 |
| MC78XXCD2T  |                          |                                 | Surface Mount   |

XX indicates nominal voltage.

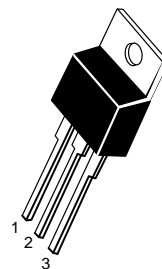
# MC7800, MC7800A, LM340, LM340A Series

## THREE-TERMINAL POSITIVE FIXED VOLTAGE REGULATORS

### SEMICONDUCTOR TECHNICAL DATA

#### T SUFFIX PLASTIC PACKAGE CASE 221A

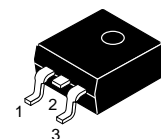
Heatsink surface  
connected to Pin 2.



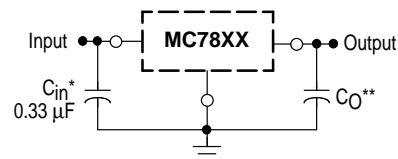
Pin 1. Input  
2. Ground  
3. Output

#### D<sup>2</sup>T SUFFIX PLASTIC PACKAGE CASE 936 (D<sup>2</sup>PAK)

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



## 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.

\*  $C_{in}$  is required if regulator is located an appreciable distance from power supply filter.

\*\*  $C_O$  is not needed for stability; however, it does improve transient response. Values of less than 0.1  $\mu\text{F}$  could cause instability.

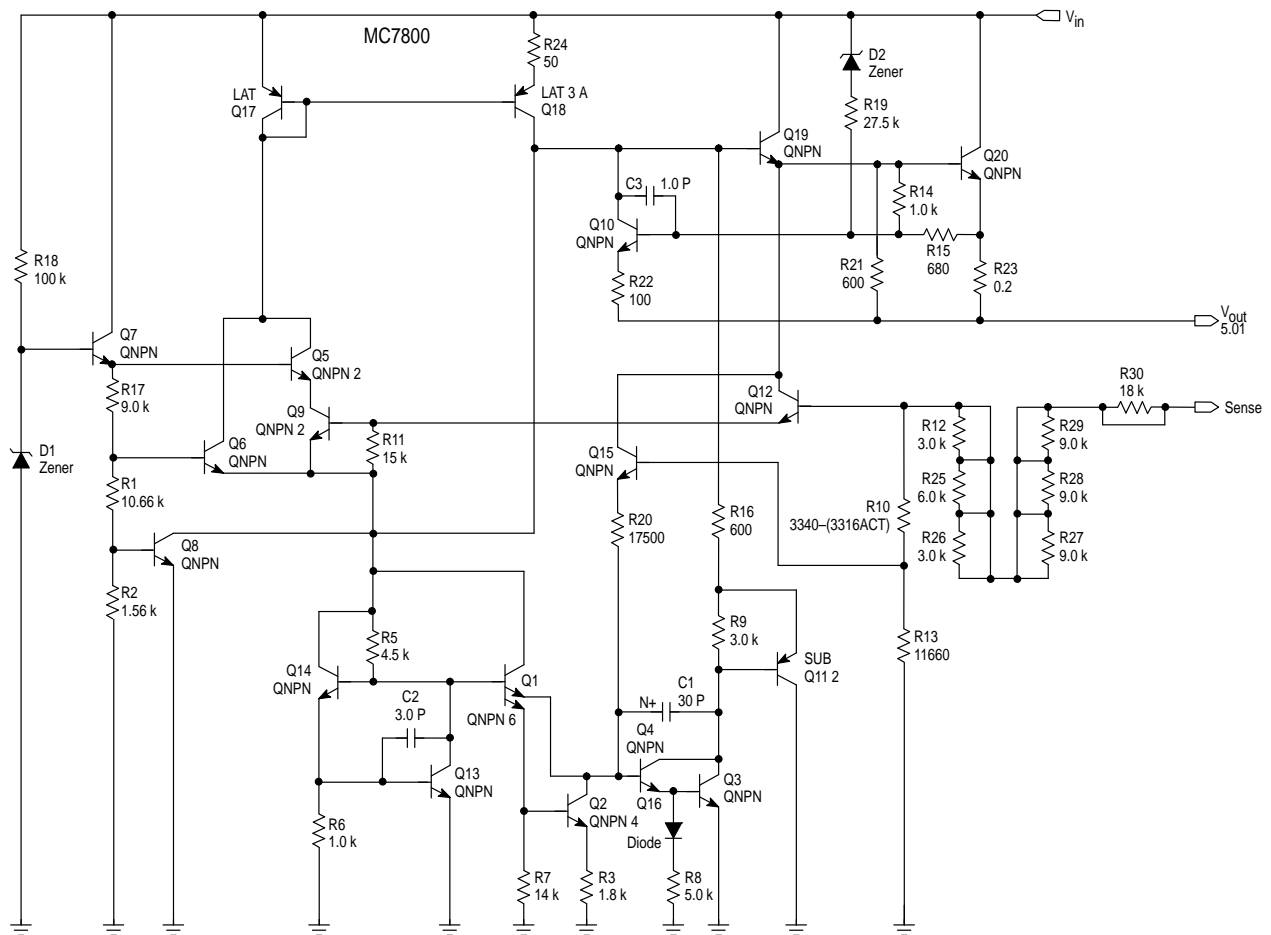
## MC7800, MC7800A, LM340, LM340A Series

**MAXIMUM RATINGS** ( $T_A = 25^\circ\text{C}$ , unless otherwise noted.)

| Rating  | Symbol   | Value   | Unit   |
|---|--|---|--|
| Input Voltage (5.0 – 18 V)<br>(24 V)  | $V_I$  | 35<br>40  | Vdc  |
| Power Dissipation<br>Case 221A<br>$T_A = 25^\circ\text{C}$<br>Thermal Resistance, Junction-to-Ambient<br>Thermal Resistance, Junction-to-Case<br>Case 936 (D <sup>2</sup> PAK)<br>$T_A = 25^\circ\text{C}$<br>Thermal Resistance, Junction-to-Ambient<br>Thermal Resistance, Junction-to-Case | $P_D$<br>$R_{\theta JA}$<br>$R_{\theta JC}$<br>$P_D$<br>$R_{\theta JA}$<br>$R_{\theta JC}$ | Internally Limited<br>65<br>5.0<br>Internally Limited<br>See Figure 13<br>5.0 | W<br>$^\circ\text{C/W}$<br>$^\circ\text{C/W}$<br>W<br>$^\circ\text{C/W}$<br>$^\circ\text{C/W}$ |
| Storage Junction Temperature Range  | $T_{stg}$  | -65 to +150   | $^\circ\text{C}$   |
| Operating Junction Temperature  | $T_J$  | +150  | $^\circ\text{C}$   |

**NOTE:** ESD data available upon request.

**Representative Schematic Diagram**



This device contains 22 active transistors.

# MC7800, MC7800A, LM340, LM340A Series

**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              | MC7805C/LM340T-5 |             |            | Unit                       |
|--|---------------------|------------------|-------------|------------|----------------------------|
|  |                     | Min              | Typ         | Max        |                            |
| Output Voltage ( $T_J = 25^\circ\text{C}$ )  | $V_O$               | 4.8              | 5.0         | 5.2        | Vdc                        |
| Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ )<br>$7.0\text{ Vdc} \leq V_{in} \leq 20\text{ Vdc}$<br>$8.0\text{ Vdc} \leq V_{in} \leq 20\text{ Vdc}$ | $V_O$               | 4.75<br>—        | 5.0<br>—    | 5.25<br>—  | Vdc                        |
| Line Regulation (Note 2)<br>$7.5\text{ Vdc} \leq V_{in} \leq 20\text{ Vdc}$ , $1.0\text{ A}$<br>$8.0\text{ Vdc} \leq V_{in} \leq 12\text{ Vdc}$  | Reg <sub>line</sub> | —<br>—           | 0.5<br>0.8  | 20<br>10   | mV                         |
| Load Regulation (Note 2)<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$ ( $T_A = 25^\circ\text{C}$ )  | Reg <sub>load</sub> | —<br>—           | 1.3<br>1.3  | 25<br>25   | mV                         |
| Quiescent Current  | $I_B$               | —                | 3.2         | 6.5        | mA                         |
| Quiescent Current Change<br>$7.0\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ ( $T_A = 25^\circ\text{C}$ )                                       | $\Delta I_B$        | —<br>—           | 0.3<br>0.08 | 1.0<br>0.8 | mA                         |
| Ripple Rejection<br>$8.0\text{ Vdc} \leq V_{in} \leq 18\text{ Vdc}$ , $f = 120\text{ Hz}$  | RR                  | 62               | 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 ( $T_A = 25^\circ\text{C}$ )<br>$10\text{ Hz} \leq f \leq 100\text{ kHz}$   | $V_n$               | —                | 10          | —          | $\mu\text{V}/V_O$          |
| Output Resistance $f = 1.0\text{ kHz}$   | $r_O$               | —                | 0.9         | —          | $\text{m}\Omega$           |
| Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ )<br>$V_{in} = 35\text{ Vdc}$   | $I_{SC}$            | —                | 0.6         | —          | 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** ( $V_{in} = 10\text{ V}$ ,  $I_O = 1.0\text{ A}$ ,  $T_J = T_{low}$  to  $T_{high}$  [Note 1], unless otherwise noted.)

| Characteristic  | Symbol              | 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 ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ )<br>$7.5\text{ Vdc} \leq V_{in} \leq 20\text{ Vdc}$   | $V_O$               | 4.8                | 5.0                      | 5.2                   | Vdc  |
| Line Regulation (Note 2)<br>$7.5\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$ , $I_O = 500\text{ mA}$<br>$8.0\text{ Vdc} \leq V_{in} \leq 12\text{ Vdc}$ , $I_O = 1.0\text{ A}$<br>$8.0\text{ Vdc} \leq V_{in} \leq 12\text{ Vdc}$ , $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$<br>$7.3\text{ Vdc} \leq V_{in} \leq 20\text{ Vdc}$ , $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ | Reg <sub>line</sub> | —<br>—<br>—<br>—   | 0.5<br>0.8<br>1.3<br>4.5 | 10<br>12<br>4.0<br>10 | mV   |
| Load Regulation (Note 2)<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$ , $T_J = 25^\circ\text{C}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$<br>$250\text{ mA} \leq I_O \leq 750\text{ mA}$  | Reg <sub>load</sub> | —<br>—<br>—        | 1.3<br>0.8<br>0.53       | 25<br>25<br>15        | mV   |
| Quiescent Current   | $I_B$               | —                  | 3.2                      | 6.0                   | mA   |
| Quiescent Current Change<br>$8.0\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$ , $I_O = 500\text{ mA}$<br>$7.5\text{ Vdc} \leq V_{in} \leq 20\text{ Vdc}$ , $T_J = 25^\circ\text{C}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$   | $\Delta I_B$        | —<br>—<br>—        | 0.3<br>—<br>0.08         | 0.8<br>0.8<br>0.5     | mA   |
| Ripple Rejection<br>$8.0\text{ Vdc} \leq V_{in} \leq 18\text{ Vdc}$ , $f = 120\text{ Hz}$ , $I_O = 500\text{ mA}$   | 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  |

**NOTES:** 1.  $T_{low} = -40^\circ\text{C}$  for MC78XXAC, C, LM340AT-XX, LM340T-XX  $T_{high} = +125^\circ\text{C}$  for MC78XXAC, C, LM340AT-XX, LM340T-XX  
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

**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    | MC7805AC/LM340AT-5 |      |     | Unit                       |
|--|-----------|--------------------|------|-----|----------------------------|
|  |           | Min                | Typ  | Max |                            |
| Output Noise Voltage ( $T_A = 25^\circ\text{C}$ )<br>$10\text{ Hz} \leq f \leq 100\text{ kHz}$ | $V_n$     | —                  | 10   | —   | $\mu\text{V}/V_O$          |
| Output Resistance ( $f = 1.0\text{ kHz}$ )   | $r_O$     | —                  | 0.9  | —   | $\text{m}\Omega$           |
| Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ )<br>$V_{in} = 35\text{ Vdc}$           | $I_{SC}$  | —                  | 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 | —   | $\text{mV}/^\circ\text{C}$ |

**NOTES:** 1.  $T_{low} = -40^\circ\text{C}$  for MC78XXAC, C, LM340AT-XX, LM340T-XX  $T_{high} = +125^\circ\text{C}$  for MC78XXAC, C, LM340AT-XX, LM340T-XX  
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.

**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              | MC7806C  |             |            | Unit                       |
|--|---------------------|----------|-------------|------------|----------------------------|
|  |                     | Min      | Typ         | Max        |                            |
| Output Voltage ( $T_J = 25^\circ\text{C}$ )  | $V_O$               | 5.75     | 6.0         | 6.25       | Vdc                        |
| Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ )<br>$8.0\text{ Vdc} \leq V_{in} \leq 21\text{ Vdc}$<br>$9.0\text{ Vdc} \leq V_{in} \leq 21\text{ Vdc}$ | $V_O$               | 5.7<br>— | 6.0<br>—    | 6.3<br>—   | Vdc                        |
| Line Regulation, $T_J = 25^\circ\text{C}$ (Note 2)<br>$8.0\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$<br>$9.0\text{ Vdc} \leq V_{in} \leq 13\text{ Vdc}$                                     | Reg <sub>line</sub> | —<br>—   | 0.5<br>0.8  | 24<br>12   | mV                         |
| Load Regulation, $T_J = 25^\circ\text{C}$ (Note 2)<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$   | Reg <sub>load</sub> | —        | 1.3         | 30         | mV                         |
| Quiescent Current ( $T_J = 25^\circ\text{C}$ )   | $I_B$               | —        | 3.3         | 8.0        | mA                         |
| Quiescent Current Change<br>$8.0\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$  | $\Delta I_B$        | —<br>—   | 0.3<br>0.08 | 1.3<br>0.5 | mA                         |
| Ripple Rejection<br>$9.0\text{ Vdc} \leq V_{in} \leq 19\text{ Vdc}$ , $f = 120\text{ Hz}$  | 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 ( $T_A = 25^\circ\text{C}$ )<br>$10\text{ Hz} \leq f \leq 100\text{ kHz}$   | $V_n$               | —        | 10          | —          | $\mu\text{V}/V_O$          |
| Output Resistance $f = 1.0\text{ kHz}$   | $r_O$               | —        | 0.9         | —          | $\text{m}\Omega$           |
| Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ )<br>$V_{in} = 35\text{ Vdc}$   | $I_{SC}$            | —        | 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        | —          | $\text{mV}/^\circ\text{C}$ |

**NOTES:** 1.  $T_{low} = -40^\circ\text{C}$  for MC78XXAC, C  $T_{high} = +125^\circ\text{C}$  for MC78XXAC, C  
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

**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 ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ )<br>$8.6\text{ Vdc} \leq V_{in} \leq 21\text{ Vdc}$  | $V_O$               | 5.76        | 6.0               | 6.24              | Vdc                        |
| Line Regulation (Note 2)<br>$8.6\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$ , $I_O = 500\text{ mA}$<br>$9.0\text{ Vdc} \leq V_{in} \leq 13\text{ Vdc}$ , $I_O = 1.0\text{ A}$  | Reg <sub>line</sub> | –<br>–      | 5.0<br>1.4        | 12<br>15          | mV                         |
| Load Regulation (Note 2)<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$ , $T_J = 25^\circ\text{C}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$<br>$250\text{ mA} \leq I_O \leq 750\text{ mA}$   | Reg <sub>load</sub> | –<br>–<br>– | 1.3<br>0.9<br>0.2 | 25<br>25<br>15    | mV                         |
| Quiescent Current  | $I_B$               | –           | 3.3               | 6.0               | mA                         |
| Quiescent Current Change<br>$9.0\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$ , $I_O = 500\text{ mA}$<br>$9.0\text{ Vdc} \leq V_{in} \leq 21\text{ Vdc}$ , $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ | $\Delta I_B$        | –<br>–<br>– | –<br>–<br>–       | 0.8<br>0.8<br>0.5 | mA                         |
| Ripple Rejection<br>$9.0\text{ Vdc} \leq V_{in} \leq 19\text{ Vdc}$ , $f = 120\text{ Hz}$ , $I_O = 500\text{ mA}$  | 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 ( $T_A = 25^\circ\text{C}$ )<br>$10\text{ Hz} \leq f \leq 100\text{ kHz}$   | $V_n$               | –           | 10                | –                 | $\mu\text{V}/V_O$          |
| Output Resistance ( $f = 1.0\text{ kHz}$ )   | $r_O$               | –           | 0.9               | –                 | $\text{m}\Omega$           |
| Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ )<br>$V_{in} = 35\text{ Vdc}$   | $I_{SC}$            | –           | 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              | MC7808C |            |            | Unit              |
|--|---------------------|---------|------------|------------|-------------------|
|  |                     | Min     | Typ        | Max        |                   |
| Output Voltage ( $T_J = 25^\circ\text{C}$ )  | $V_O$               | 7.7     | 8.0        | 8.3        | Vdc               |
| Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ )<br>$10.5\text{ Vdc} \leq V_{in} \leq 23\text{ Vdc}$                 | $V_O$               | 7.6     | 8.0        | 8.4        | Vdc               |
| Line Regulation, $T_J = 25^\circ\text{C}$ , (Note 2)<br>$10.5\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$<br>$11\text{ Vdc} \leq V_{in} \leq 17\text{ Vdc}$ | Reg <sub>line</sub> | –<br>–  | 6.0<br>1.7 | 32<br>16   | mV                |
| Load Regulation, $T_J = 25^\circ\text{C}$ (Note 2)<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$   | Reg <sub>load</sub> | –       | 1.4        | 35         | mV                |
| Quiescent Current  | $I_B$               | –       | 3.3        | 8.0        | mA                |
| Quiescent Current Change<br>$10.5\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$                                 | $\Delta I_B$        | –<br>–  | –<br>–     | 1.0<br>0.5 | mA                |
| Ripple Rejection<br>$11.5\text{ Vdc} \leq V_{in} \leq 18\text{ Vdc}$ , $f = 120\text{ Hz}$   | 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 ( $T_A = 25^\circ\text{C}$ )<br>$10\text{ Hz} \leq f \leq 100\text{ kHz}$   | $V_n$               | –       | 10         | –          | $\mu\text{V}/V_O$ |

**NOTES:** 1.  $T_{low} = -40^\circ\text{C}$  for MC78XXAC, C  $T_{high} = +125^\circ\text{C}$  for MC78XXAC, C

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

**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    | MC7808C |      |     | Unit                |
|--|-----------|---------|------|-----|---------------------|
|  |           | Min     | Typ  | Max |                     |
| Output Resistance $f = 1.0\text{ kHz}$   | $r_O$     | —       | 0.9  | —   | $m\Omega$           |
| Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ )<br>$V_{in} = 35\text{ Vdc}$ | $I_{SC}$  | —       | 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 | —   | $mV/^\circ\text{C}$ |

**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              | MC7808AC    |                    |                   | Unit                |
|--|---------------------|-------------|--------------------|-------------------|---------------------|
|  |                     | Min         | Typ                | Max               |                     |
| Output Voltage ( $T_J = 25^\circ\text{C}$ )  | $V_O$               | 7.84        | 8.0                | 8.16              | Vdc                 |
| Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ )<br>$10.6\text{ Vdc} \leq V_{in} \leq 23\text{ Vdc}$   | $V_O$               | 7.7         | 8.0                | 8.3               | Vdc                 |
| Line Regulation (Note 2)<br>$10.6\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$ , $I_O = 500\text{ mA}$<br>$11\text{ Vdc} \leq V_{in} \leq 17\text{ Vdc}$ , $I_O = 1.0\text{ A}$<br>$10.4\text{ Vdc} \leq V_{in} \leq 23\text{ Vdc}$ , $T_J = 25^\circ\text{C}$ | Reg <sub>line</sub> | —<br>—<br>— | 6.0<br>1.7<br>5.0  | 15<br>18<br>15    | mV                  |
| Load Regulation (Note 2)<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$ , $T_J = 25^\circ\text{C}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$<br>$250\text{ mA} \leq I_O \leq 750\text{ mA}$   | Reg <sub>load</sub> | —<br>—<br>— | 1.4<br>1.0<br>0.22 | 25<br>25<br>15    | mV                  |
| Quiescent Current  | $I_B$               | —           | 3.3                | 6.0               | mA                  |
| Quiescent Current Change<br>$11\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$ , $I_O = 500\text{ mA}$<br>$10.6\text{ Vdc} \leq V_{in} \leq 23\text{ Vdc}$ , $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$       | $\Delta I_B$        | —<br>—<br>— | —<br>—<br>—        | 0.8<br>0.8<br>0.5 | mA                  |
| Ripple Rejection<br>$11.5\text{ Vdc} \leq V_{in} \leq 21.5\text{ Vdc}$ , $f = 120\text{ Hz}$ , $I_O = 500\text{ mA}$   | 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 ( $T_A = 25^\circ\text{C}$ )<br>$10\text{ Hz} \leq f \leq 100\text{ kHz}$   | $V_n$               | —           | 10                 | —                 | $\mu\text{V}/V_O$   |
| Output Resistance $f = 1.0\text{ kHz}$   | $r_O$               | —           | 0.9                | —                 | $m\Omega$           |
| Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ )<br>$V_{in} = 35\text{ Vdc}$   | $I_{SC}$            | —           | 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               | —                 | $mV/^\circ\text{C}$ |

**NOTES:** 1.  $T_{low} = -40^\circ\text{C}$  for MC78XXAC, C  $T_{high} = +125^\circ\text{C}$  for MC78XXAC, C

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

**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              | MC7809CT |            |            | Unit                       |
|--|---------------------|----------|------------|------------|----------------------------|
|  |                     | Min      | Typ        | Max        |                            |
| Output Voltage ( $T_J = 25^\circ\text{C}$ )  | $V_O$               | 8.65     | 9.0        | 9.35       | Vdc                        |
| Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ )<br>$11.5\text{ Vdc} \leq V_{in} \leq 24\text{ Vdc}$               | $V_O$               | 8.55     | 9.0        | 9.45       | Vdc                        |
| Line Regulation, $T_J = 25^\circ\text{C}$ (Note 2)<br>$11\text{ Vdc} \leq V_{in} \leq 26\text{ Vdc}$<br>$11.5\text{ Vdc} \leq V_{in} \leq 17\text{ Vdc}$ | Reg <sub>line</sub> | —<br>—   | 6.2<br>1.8 | 32<br>16   | mV                         |
| Load Regulation, $T_J = 25^\circ\text{C}$ (Note 2)<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$   | Reg <sub>load</sub> | —        | 1.5        | 35         | mV                         |
| Quiescent Current  | $I_B$               | —        | 3.4        | 8.0        | mA                         |
| Quiescent Current Change<br>$11.5\text{ Vdc} \leq V_{in} \leq 26\text{ Vdc}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$                               | $\Delta I_B$        | —<br>—   | —<br>—     | 1.0<br>0.5 | mA                         |
| Ripple Rejection<br>$11.5\text{ Vdc} \leq V_{in} \leq 21.5\text{ Vdc}$ , $f = 120\text{ Hz}$   | RR                  | 56       | 61         | —          | 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 ( $T_A = 25^\circ\text{C}$ )<br>$10\text{ Hz} \leq f \leq 100\text{ kHz}$   | $V_n$               | —        | 10         | —          | $\mu\text{V}/V_O$          |
| Output Resistance $f = 1.0\text{ kHz}$   | $r_O$               | —        | 1.0        | —          | $\text{m}\Omega$           |
| Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ )<br>$V_{in} = 35\text{ Vdc}$   | $I_{SC}$            | —        | 0.2        | —          | A                          |
| Peak Output Current ( $T_J = 25^\circ\text{C}$ )   | $I_{max}$           | —        | 2.2        | —          | A                          |
| Average Temperature Coefficient of Output Voltage  | $TCV_O$             | —        | −0.5       | —          | $\text{mV}/^\circ\text{C}$ |

**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              | MC7812C/LM340T−12 |                 |                   | Unit |
|---|---------------------|-------------------|-----------------|-------------------|------|
|   |                     | Min               | Typ             | Max               |      |
| Output Voltage ( $T_J = 25^\circ\text{C}$ )   | $V_O$               | 11.5              | 12              | 12.5              | Vdc  |
| Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ )<br>$14.5\text{ Vdc} \leq V_{in} \leq 27\text{ Vdc}$  | $V_O$               | 11.4              | 12              | 12.6              | Vdc  |
| Line Regulation, $T_J = 25^\circ\text{C}$ (Note 2)<br>$14.5\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$<br>$16\text{ Vdc} \leq V_{in} \leq 22\text{ Vdc}$<br>$14.8\text{ Vdc} \leq V_{in} \leq 27\text{ Vdc}$ , $I_O = 1.0\text{ A}$ | Reg <sub>line</sub> | —<br>—<br>—       | 3.8<br>0.3<br>— | 24<br>24<br>48    | mV   |
| Load Regulation, $T_J = 25^\circ\text{C}$ (Note 2)<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$  | Reg <sub>load</sub> | —                 | 8.1             | 60                | mV   |
| Quiescent Current   | $I_B$               | —                 | 3.4             | 6.5               | mA   |
| Quiescent Current Change<br>$14.5\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ , $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$<br>$15\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$      | $\Delta I_B$        | —<br>—<br>—       | —<br>—<br>—     | 0.7<br>0.8<br>0.5 | mA   |
| Ripple Rejection<br>$15\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$ , $f = 120\text{ Hz}$  | 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  |

**NOTES:** 1.  $T_{low} = -40^\circ\text{C}$  for MC78XXAC, C, LM340AT−XX, LM340T−XX  $T_{high} = +125^\circ\text{C}$  for MC78XXAC, C, LM340AT−XX, LM340T−XX

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

**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    | MC7812C/LM340T-12 |      |     | Unit                       |
|--|-----------|-------------------|------|-----|----------------------------|
|  |           | Min               | Typ  | Max |                            |
| Output Noise Voltage ( $T_A = 25^\circ\text{C}$ )<br>$10\text{ Hz} \leq f \leq 100\text{ kHz}$ | $V_n$     | —                 | 10   | —   | $\mu\text{V}/V_O$          |
| Output Resistance $f = 1.0\text{ kHz}$   | $r_O$     | —                 | 1.1  | —   | $\text{m}\Omega$           |
| Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ )<br>$V_{in} = 35\text{ Vdc}$           | $I_{SC}$  | —                 | 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 | —   | $\text{mV}/^\circ\text{C}$ |

**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              | 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 ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ )<br>$14.8\text{ Vdc} \leq V_{in} \leq 27\text{ Vdc}$   | $V_O$               | 11.5                | 12                | 12.5              | Vdc                        |
| Line Regulation (Note 2)<br>$14.8\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ , $I_O = 500\text{ mA}$<br>$16\text{ Vdc} \leq V_{in} \leq 22\text{ Vdc}$ , $I_O = 1.0\text{ A}$<br>$14.5\text{ Vdc} \leq V_{in} \leq 27\text{ Vdc}$ , $T_J = 25^\circ\text{C}$ | $\text{Reg}_{line}$ | —<br>—<br>—         | 3.8<br>2.2<br>6.0 | 18<br>20<br>120   | mV                         |
| Load Regulation (Note 2)<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$ , $T_J = 25^\circ\text{C}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$  | $\text{Reg}_{load}$ | —<br>—              | —<br>—            | 25<br>25          | mV                         |
| Quiescent Current  | $I_B$               | —                   | 3.4               | 6.0               | mA                         |
| Quiescent Current Change<br>$15\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ , $I_O = 500\text{ mA}$<br>$14.8\text{ Vdc} \leq V_{in} \leq 27\text{ Vdc}$ , $T_J = 25^\circ\text{C}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$   | $\Delta I_B$        | —<br>—<br>—         | —<br>—<br>—       | 0.8<br>0.8<br>0.5 | mA                         |
| Ripple Rejection<br>$15\text{ Vdc} \leq V_{in} \leq 25\text{ Vdc}$ , $f = 120\text{ Hz}$ , $I_O = 500\text{ mA}$   | 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 ( $T_A = 25^\circ\text{C}$ )<br>$10\text{ Hz} \leq f \leq 100\text{ kHz}$   | $V_n$               | —                   | 10                | —                 | $\mu\text{V}/V_O$          |
| Output Resistance ( $f = 1.0\text{ kHz}$ )   | $r_O$               | —                   | 1.1               | —                 | $\text{m}\Omega$           |
| Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ )<br>$V_{in} = 35\text{ Vdc}$   | $I_{SC}$            | —                   | 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              | —                 | $\text{mV}/^\circ\text{C}$ |

**NOTES:** 1.  $T_{low} = -40^\circ\text{C}$  for MC78XXAC, C, LM340AT-XX, LM340T-XX  $T_{high} = +125^\circ\text{C}$  for MC78XXAC, C, LM340AT-XX, LM340T-XX

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

**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              | MC7815C/LM340T-15 |             |                   | Unit                       |
|--|---------------------|-------------------|-------------|-------------------|----------------------------|
|  |                     | Min               | Typ         | Max               |                            |
| Output Voltage ( $T_J = 25^\circ\text{C}$ )  | $V_O$               | 14.4              | 15          | 15.6              | Vdc                        |
| Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ )<br>$17.5\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$   | $V_O$               | 14.25             | 15          | 15.75             | Vdc                        |
| Line Regulation, $T_J = 25^\circ\text{C}$ (Note 2)<br>$17.9\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$<br>$20\text{ Vdc} \leq V_{in} \leq 26\text{ Vdc}$   | Reg <sub>line</sub> | —<br>—            | 8.5<br>3.0  | 30<br>28          | mV                         |
| Load Regulation, $T_J = 25^\circ\text{C}$ (Note 2)<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$   | Reg <sub>load</sub> | —                 | 1.8         | 55                | mV                         |
| Quiescent Current  | $I_B$               | —                 | 3.5         | 6.5               | mA                         |
| Quiescent Current Change<br>$17.5\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$<br>$17.5\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ , $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ | $\Delta I_B$        | —<br>—<br>—       | —<br>—<br>— | 0.8<br>0.7<br>0.5 | mA                         |
| Ripple Rejection<br>$18.5\text{ Vdc} \leq V_{in} \leq 28.5\text{ Vdc}$ , $f = 120\text{ Hz}$   | RR                  | 54                | 58          | —                 | 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 ( $T_A = 25^\circ\text{C}$ )<br>$10\text{ Hz} \leq f \leq 100\text{ kHz}$   | $V_n$               | —                 | 10          | —                 | $\mu\text{V}/V_O$          |
| Output Resistance $f = 1.0\text{ kHz}$   | $r_O$               | —                 | 1.2         | —                 | $\text{m}\Omega$           |
| Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ )<br>$V_{in} = 35\text{ Vdc}$   | $I_{SC}$            | —                 | 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** ( $V_{in} = 23\text{ V}$ ,  $I_O = 1.0\text{ A}$ ,  $T_J = T_{low}$  to  $T_{high}$  [Note 1], unless otherwise noted.)

| Characteristic   | Symbol              | 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 ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ )<br>$17.9\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$   | $V_O$               | 14.4                | 15                | 15.6              | Vdc  |
| Line Regulation (Note 2)<br>$17.9\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ , $I_O = 500\text{ mA}$<br>$20\text{ Vdc} \leq V_{in} \leq 26\text{ Vdc}$<br>$17.5\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ , $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ | Reg <sub>line</sub> | —<br>—<br>—         | 8.5<br>3.0<br>7.0 | 20<br>22<br>20    | mV   |
| Load Regulation (Note 2)<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$ , $T_J = 25^\circ\text{C}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$<br>$250\text{ mA} \leq I_O \leq 750\text{ mA}$   | Reg <sub>load</sub> | —<br>—<br>—         | 1.8<br>1.5<br>1.2 | 25<br>25<br>15    | mV   |
| Quiescent Current  | $I_B$               | —                   | 3.5               | 6.0               | mA   |
| Quiescent Current Change<br>$17.5\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ , $I_O = 500\text{ mA}$<br>$17.5\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ , $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$     | $\Delta I_B$        | —<br>—<br>—         | —<br>—<br>—       | 0.8<br>0.8<br>0.5 | mA   |

**NOTES:** 1.  $T_{low} = -40^\circ\text{C}$  for MC78XXAC, C, LM340AT-XX, LM340T-XX  $T_{high} = +125^\circ\text{C}$  for MC78XXAC, C, LM340AT-XX, LM340T-XX

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

**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      | MC7815AC/LM340AT-15 |      |     | Unit                          |
|--|-------------|---------------------|------|-----|-------------------------------|
|  |             | Min                 | Typ  | Max |                               |
| Ripple Rejection<br>$18.5\text{ Vdc} \leq V_{in} \leq 28.5\text{ Vdc}$ , $f = 120\text{ Hz}$ , $I_O = 500\text{ mA}$ | 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 ( $T_A = 25^\circ\text{C}$ )<br>$10\text{ Hz} \leq f \leq 100\text{ kHz}$                       | $V_n$       | —                   | 10   | —   | $\mu\text{V}/\sqrt{\text{O}}$ |
| Output Resistance $f = 1.0\text{ kHz}$   | $r_O$       | —                   | 1.2  | —   | $\text{m}\Omega$              |
| Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ )<br>$V_{in} = 35\text{ Vdc}$                                 | $I_{SC}$    | —                   | 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         | MC7818C |            |            | Unit                          |
|--|----------------|---------|------------|------------|-------------------------------|
|  |                | Min     | Typ        | Max        |                               |
| Output Voltage ( $T_J = 25^\circ\text{C}$ )  | $V_O$          | 17.3    | 18         | 18.7       | Vdc                           |
| Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ )<br>$21\text{ Vdc} \leq V_{in} \leq 33\text{ Vdc}$ | $V_O$          | 17.1    | 18         | 18.9       | Vdc                           |
| Line Regulation, (Note 2)<br>$21\text{ Vdc} \leq V_{in} \leq 33\text{ Vdc}$<br>$24\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$            | Regline        | —<br>—  | 9.5<br>3.2 | 50<br>25   | mV                            |
| Load Regulation, (Note 2)<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$  | Regload        | —       | 2.0        | 55         | mV                            |
| Quiescent Current  | $I_B$          | —       | 3.5        | 6.5        | mA                            |
| Quiescent Current Change<br>$21\text{ Vdc} \leq V_{in} \leq 33\text{ Vdc}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$                 | $\Delta I_B$   | —<br>—  | —<br>—     | 1.0<br>0.5 | mA                            |
| Ripple Rejection<br>$22\text{ Vdc} \leq V_{in} \leq 33\text{ Vdc}$ , $f = 120\text{ Hz}$   | RR             | 53      | 57         | —          | dB                            |
| Dropout Voltage ( $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ )  | $V_{I1} - V_O$ | —       | 2.0        | —          | Vdc                           |
| Output Noise Voltage ( $T_A = 25^\circ\text{C}$ )<br>$10\text{ Hz} \leq f \leq 100\text{ kHz}$   | $V_n$          | —       | 10         | —          | $\mu\text{V}/\sqrt{\text{O}}$ |
| Output Resistance $f = 1.0\text{ kHz}$   | $r_O$          | —       | 1.3        | —          | $\text{m}\Omega$              |
| Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ )<br>$V_{in} = 35\text{ Vdc}$   | $I_{SC}$       | —       | 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       | —          | $\text{mV}/^\circ\text{C}$    |

**NOTES:** 1.  $T_{low} = -40^\circ\text{C}$  for MC78XXAC, C  $T_{high} = +125^\circ\text{C}$  for MC78XXAC, C

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

**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 ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ )<br>$21\text{ Vdc} \leq V_{in} \leq 33\text{ Vdc}$  | $V_O$               | 17.3     | 18                       | 18.7                   | Vdc                        |
| Line Regulation (Note 2)<br>$21\text{ Vdc} \leq V_{in} \leq 33\text{ Vdc}$ , $I_O = 500\text{ mA}$<br>$24\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ , $I_O = 1.0\text{ A}$<br>$24\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ , $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$<br>$20.6\text{ Vdc} \leq V_{in} \leq 33\text{ Vdc}$ , $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ | Reg <sub>line</sub> | –        | 9.5<br>3.2<br>3.2<br>8.0 | 22<br>25<br>10.5<br>22 | mV                         |
| Load Regulation (Note 2)<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$ , $T_J = 25^\circ\text{C}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$<br>$250\text{ mA} \leq I_O \leq 750\text{ mA}$  | Reg <sub>load</sub> | –        | 2.0<br>1.8<br>1.5        | 25<br>25<br>15         | mV                         |
| Quiescent Current   | $I_B$               | –        | 3.5                      | 6.0                    | mA                         |
| Quiescent Current Change<br>$21\text{ Vdc} \leq V_{in} \leq 33\text{ Vdc}$ , $I_O = 500\text{ mA}$<br>$21.5\text{ Vdc} \leq V_{in} \leq 30\text{ Vdc}$ , $T_J = 25^\circ\text{C}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$   | $\Delta I_B$        | –        | –                        | 0.8<br>0.8<br>0.5      | mA                         |
| Ripple Rejection<br>$22\text{ Vdc} \leq V_{in} \leq 32\text{ Vdc}$ , $f = 120\text{ Hz}$ , $I_O = 500\text{ mA}$  | 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 ( $T_A = 25^\circ\text{C}$ )<br>$10\text{ Hz} \leq f \leq 100\text{ kHz}$  | $V_n$               | –        | 10                       | –                      | $\mu\text{V}/V_O$          |
| Output Resistance $f = 1.0\text{ kHz}$  | $r_O$               | –        | 1.3                      | –                      | $\text{m}\Omega$           |
| Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ )<br>$V_{in} = 35\text{ Vdc}$  | $I_{SC}$            | –        | 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              | MC7824C |            |            | Unit |
|--|---------------------|---------|------------|------------|------|
|  |                     | Min     | Typ        | Max        |      |
| Output Voltage ( $T_J = 25^\circ\text{C}$ )  | $V_O$               | 23      | 24         | 25         | Vdc  |
| Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ )<br>$27\text{ Vdc} \leq V_{in} \leq 38\text{ Vdc}$ | $V_O$               | 22.8    | 24         | 25.2       | Vdc  |
| Line Regulation, (Note 2)<br>$27\text{ Vdc} \leq V_{in} \leq 38\text{ Vdc}$<br>$30\text{ Vdc} \leq V_{in} \leq 36\text{ Vdc}$            | Reg <sub>line</sub> | –       | 2.7<br>2.7 | 60<br>48   | mV   |
| Load Regulation, (Note 2)<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$  | Reg <sub>load</sub> | –       | 4.4        | 65         | mV   |
| Quiescent Current  | $I_B$               | –       | 3.6        | 6.5        | mA   |
| Quiescent Current Change<br>$27\text{ Vdc} \leq V_{in} \leq 38\text{ Vdc}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$                 | $\Delta I_B$        | –       | –          | 1.0<br>0.5 | mA   |

**NOTES:** 1.  $T_{low} = -40^\circ\text{C}$  for MC78XXAC, C  $T_{high} = +125^\circ\text{C}$  for MC78XXAC, C

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

**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      | MC7824C |      |     | Unit                       |
|--|-------------|---------|------|-----|----------------------------|
|  |             | Min     | Typ  | Max |                            |
| Ripple Rejection<br>$28\text{ Vdc} \leq V_{in} \leq 38\text{ Vdc}$ , $f = 120\text{ Hz}$       | RR          | 50      | 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 ( $T_A = 25^\circ\text{C}$ )<br>$10\text{ Hz} \leq f \leq 100\text{ kHz}$ | $V_n$       | —       | 10   | —   | $\mu\text{V}/V_O$          |
| Output Resistance $f = 1.0\text{ kHz}$   | $r_O$       | —       | 1.4  | —   | $\text{m}\Omega$           |
| Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ )<br>$V_{in} = 35\text{ Vdc}$           | $I_{SC}$    | —       | 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 | —   | $\text{mV}/^\circ\text{C}$ |

**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.)

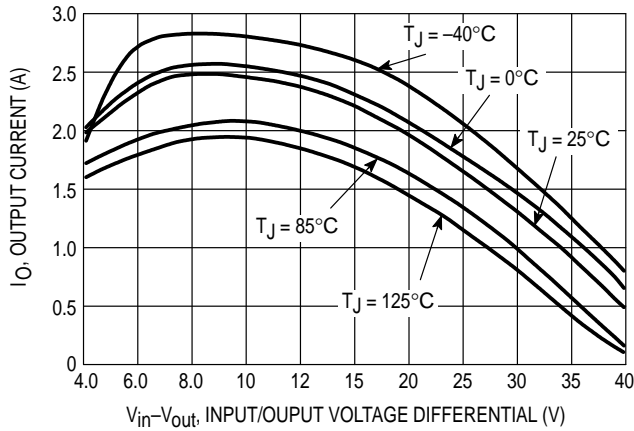
| Characteristic   | Symbol              | MC7824AC         |                          |                      | Unit                       |
|--|---------------------|------------------|--------------------------|----------------------|----------------------------|
|  |                     | Min              | Typ                      | Max                  |                            |
| Output Voltage ( $T_J = 25^\circ\text{C}$ )  | $V_O$               | 23.5             | 24                       | 24.5                 | Vdc                        |
| Output Voltage ( $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P_D \leq 15\text{ W}$ )<br>$27.3\text{ Vdc} \leq V_{in} \leq 38\text{ Vdc}$   | $V_O$               | 23.2             | 24                       | 25.8                 | Vdc                        |
| Line Regulation (Note 2)<br>$27\text{ Vdc} \leq V_{in} \leq 38\text{ Vdc}$ , $I_O = 500\text{ mA}$<br>$30\text{ Vdc} \leq V_{in} \leq 36\text{ Vdc}$ , $I_O = 1.0\text{ A}$<br>$30\text{ Vdc} \leq V_{in} \leq 36\text{ Vdc}$ , $T_J = 25^\circ\text{C}$<br>$26.7\text{ Vdc} \leq V_{in} \leq 38\text{ Vdc}$ , $I_O = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$ | Reg <sub>line</sub> | —<br>—<br>—<br>— | 11.5<br>3.8<br>3.8<br>10 | 25<br>28<br>12<br>25 | mV                         |
| Load Regulation (Note 2)<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$ , $T_J = 25^\circ\text{C}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$<br>$250\text{ mA} \leq I_O \leq 750\text{ mA}$   | Reg <sub>load</sub> | —<br>—<br>—      | 2.1<br>2.0<br>1.8        | 15<br>25<br>15       | mV                         |
| Quiescent Current  | $I_B$               | —                | 3.6                      | 6.0                  | mA                         |
| Quiescent Current Change<br>$27.3\text{ Vdc} \leq V_{in} \leq 38\text{ Vdc}$ , $I_O = 500\text{ mA}$<br>$27\text{ Vdc} \leq V_{in} \leq 38\text{ Vdc}$ , $T_J = 25^\circ\text{C}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$  | $\Delta I_B$        | —<br>—<br>—      | —<br>—<br>—              | 0.8<br>0.8<br>0.5    | mA                         |
| Ripple Rejection<br>$28\text{ Vdc} \leq V_{in} \leq 38\text{ Vdc}$ , $f = 120\text{ Hz}$ , $I_O = 500\text{ mA}$   | 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 ( $T_A = 25^\circ\text{C}$ )<br>$10\text{ Hz} \leq f \leq 100\text{ kHz}$   | $V_n$               | —                | 10                       | —                    | $\mu\text{V}/V_O$          |
| Output Resistance ( $f = 1.0\text{ kHz}$ )   | $r_O$               | —                | 1.4                      | —                    | $\text{m}\Omega$           |
| Short Circuit Current Limit ( $T_A = 25^\circ\text{C}$ )<br>$V_{in} = 35\text{ Vdc}$   | $I_{SC}$            | —                | 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                     | —                    | $\text{mV}/^\circ\text{C}$ |

**NOTES:** 1.  $T_{low} = -40^\circ\text{C}$  for MC78XXAC, C  $T_{high} = +125^\circ\text{C}$  for MC78XXAC, C

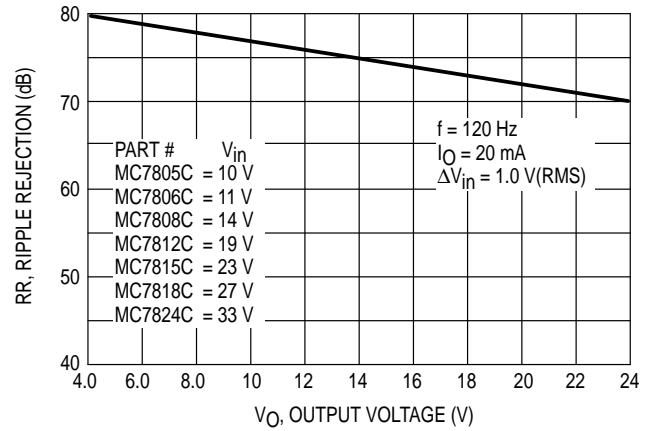
2. Load and line regulation are specified at constant junction temperature. Changes in  $V_O$  due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

# MC7800, MC7800A, LM340, LM340A Series

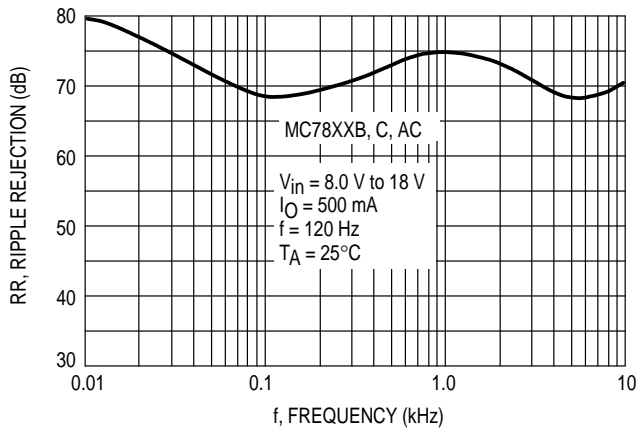
**Figure 1. Peak Output Current as a Function of Input/Output Differential Voltage (MC78XXC, AC)**



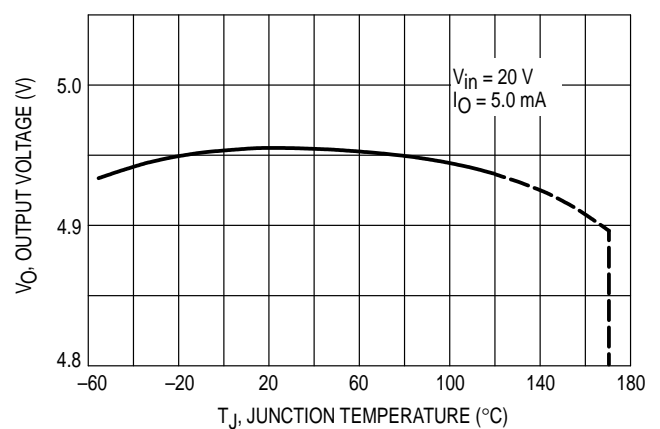
**Figure 2. Ripple Rejection as a Function of Output Voltages (MC78XXC, AC)**



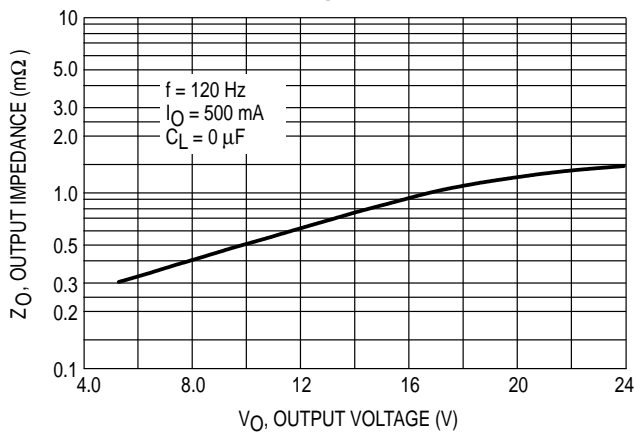
**Figure 3. Ripple Rejection as a Function of Frequency (MC78XXC, AC)**



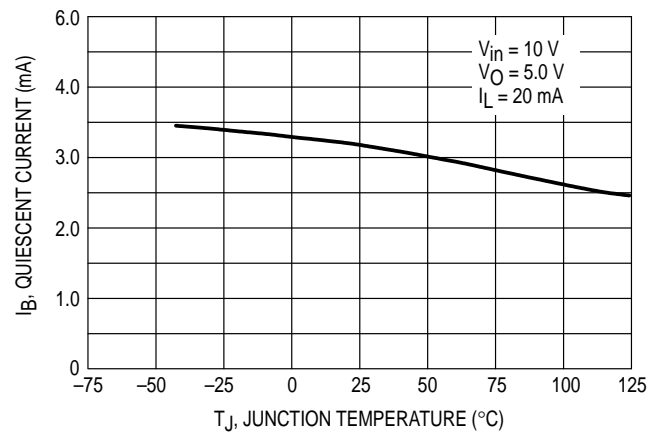
**Figure 4. Output Voltage as a Function of Junction Temperature (MC7805C, AC)**



**Figure 5. Output Impedance as a Function of Output Voltage (MC78XXC, AC)**



**Figure 6. Quiescent Current as a Function of Temperature (MC78XXC, AC)**



# MC7800, MC7800A, LM340, LM340A Series

## APPLICATIONS INFORMATION

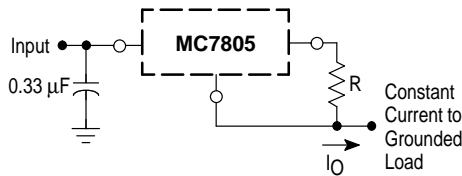
### Design Considerations

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  $\mu\text{F}$  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.

**Figure 7. Current Regulator**



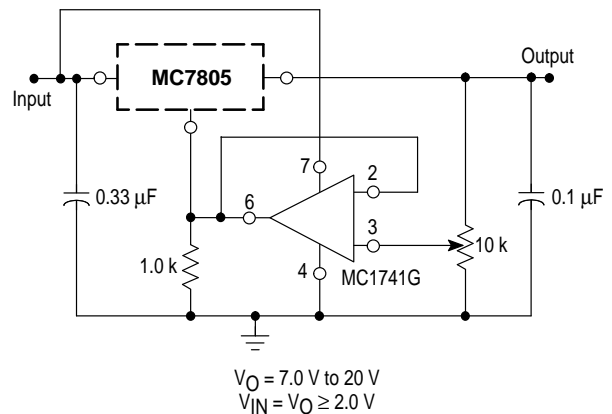
The MC7800 regulators can also be used as a current source when connected as above. In order to minimize dissipation the MC7805C is chosen in this application. Resistor R determines the current as follows:

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

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

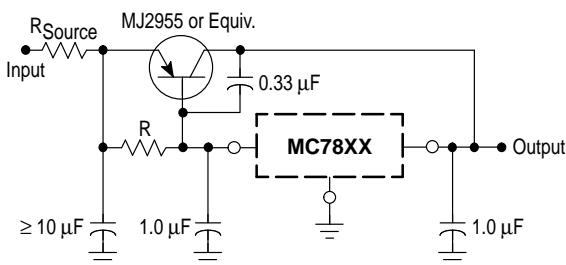
For example, a 1.0 A current source would require R to be a 5.0  $\Omega$ , 10 W resistor and the output voltage compliance would be the input voltage less 7.0 V.

**Figure 8. Adjustable Output Regulator**



The addition of an operational amplifier allows adjustment to higher or intermediate values while retaining regulation characteristics. The minimum voltage obtainable with this arrangement is 2.0 V greater than the regulator voltage.

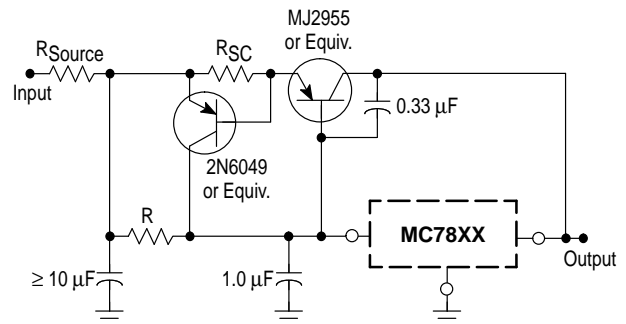
**Figure 9. Current Boost Regulator**



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. Short Circuit Protection**



XX = 2 digits of type number indicating voltage.

The circuit of Figure 9 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.

## MC7800, MC7800A, LM340, LM340A Series

Figure 11. Worst Case Power Dissipation versus Ambient Temperature (Case 221A)

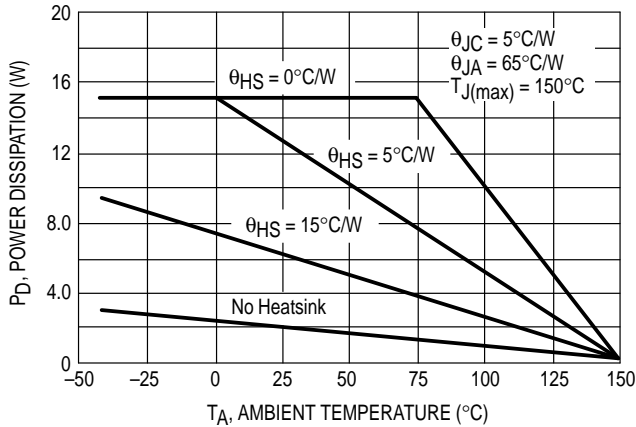


Figure 12. Input Output Differential as a Function of Junction Temperature (MC78XXC, AC)

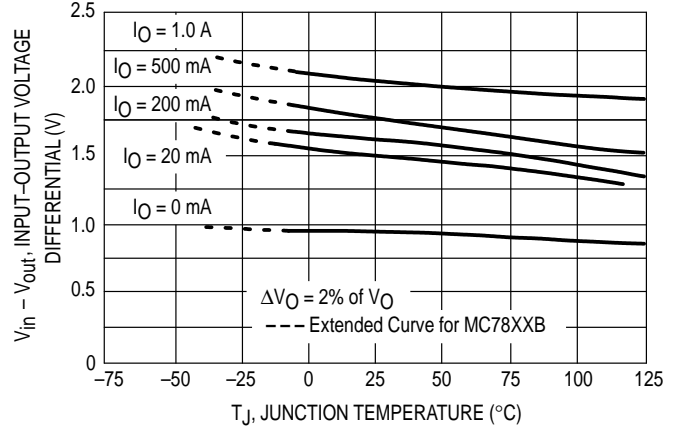
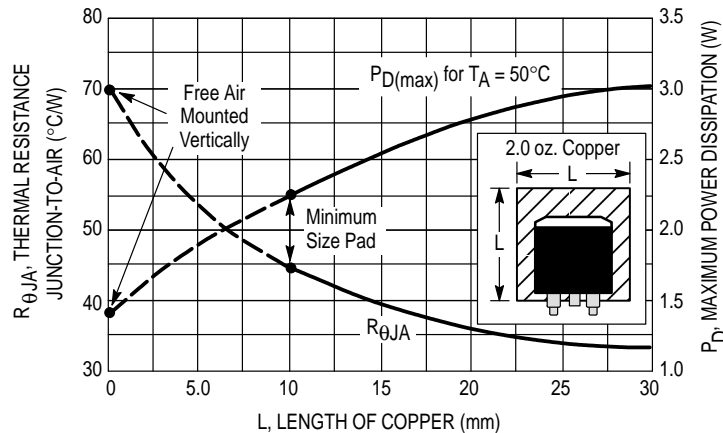


Figure 13. D<sup>2</sup>PAK Thermal Resistance and Maximum Power Dissipation versus P.C.B. Copper Length



## 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.

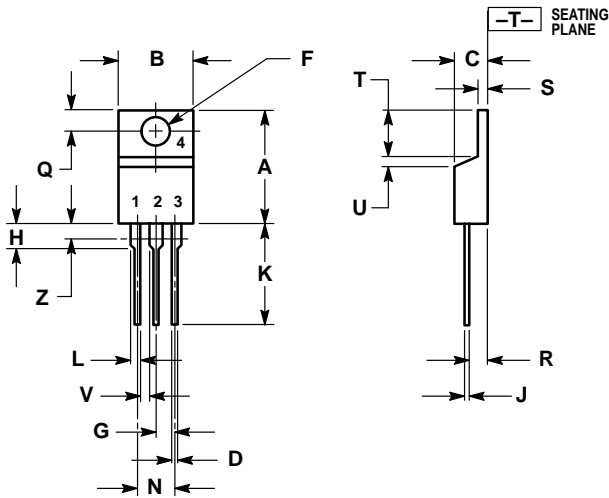
**Long Term Stability** – Output voltage stability under accelerated life test conditions with the maximum rated voltage listed in the devices' electrical characteristics and maximum power dissipation.

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# MC7800, MC7800A, LM340, LM340A Series

## OUTLINE DIMENSIONS

### T SUFFIX PLASTIC PACKAGE CASE 221A-06 ISSUE Y

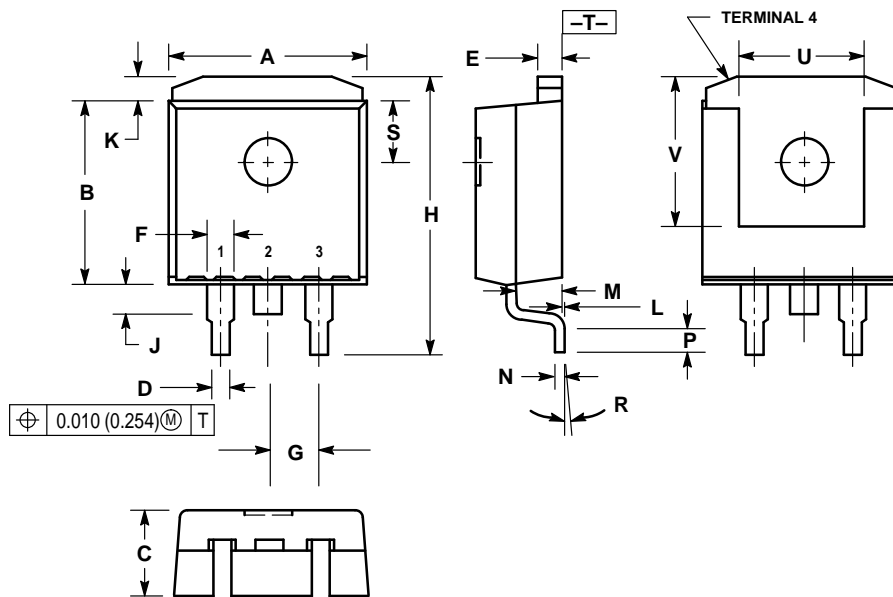


#### NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIM 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  |

### D2T SUFFIX PLASTIC PACKAGE CASE 936-03 (D<sup>2</sup>PAK) 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   |        |

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