

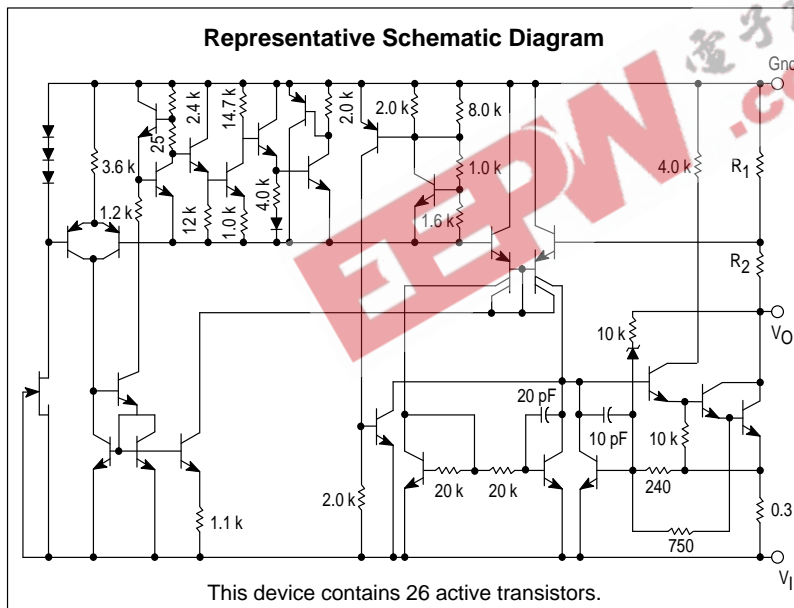


# Three-Terminal Negative Voltage Regulators

The MC7900 series of fixed output negative voltage regulators are intended as complements to the popular MC7800 series devices. These negative regulators are available in the same seven-voltage options as the MC7800 devices. In addition, one extra voltage option commonly employed in MECL systems is also available in the negative MC7900 series.

Available in fixed output voltage options from -5.0 V to -24 V, these regulators employ current limiting, thermal shutdown, and safe-area compensation - making them remarkably rugged under most operating conditions. With adequate heatsinking they can deliver output currents in excess of 1.0 A.

- No External Components Required
- Internal Thermal Overload Protection
- Internal Short Circuit Current Limiting
- Output Transistor Safe-Area Compensation
- Available in 2% Voltage Tolerance (See Ordering Information)



### ORDERING INFORMATION

| Device      | Output Voltage Tolerance | Operating Temperature Range                      | Package         |
|-------------|--------------------------|--|-----------------|
| MC79XXACD2T | 2%                       | $T_J = 0^\circ \text{ to } +125^\circ\text{C}$   | Surface Mount   |
| MC79XXCD2T  | 4%                       |  |                 |
| MC79XXACT   | 2%                       |  | Insertion Mount |
| MC79XXCT    | 4%                       |  |                 |
| MC79XXBD2T  | 4%                       | $T_J = -40^\circ \text{ to } +125^\circ\text{C}$ | Surface Mount   |
| MC79XXBT    |                          |  | Insertion Mount |

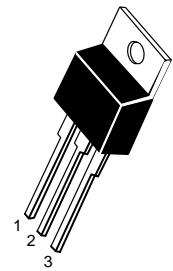
XX indicates nominal voltage.

## MC7900 Series

### THREE-TERMINAL NEGATIVE FIXED VOLTAGE REGULATORS

**T SUFFIX**  
PLASTIC PACKAGE  
CASE 221A

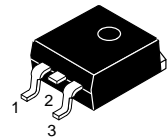
Heatsink surface connected to Pin 2.



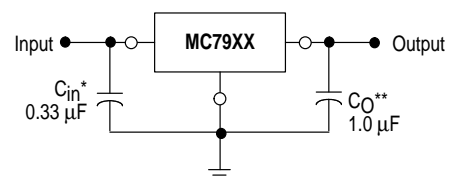
Pin 1. Ground  
Pin 2. Input  
Pin 3. Output

**D2T 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 more negative even during the high point of 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.

\*\*  $C_o$  improve stability and transient response.

### DEVICE TYPE/NOMINAL OUTPUT VOLTAGE

|          |       |        |      |
|----------|-------|--------|------|
| MC7905   | 5.0 V | MC7912 | 12 V |
| MC7905.2 | 5.2 V | MC7915 | 15 V |
| MC7906   | 6.0 V | MC7918 | 28 V |
| MC7908   | 8.0 V | MC7924 | 24 V |

## MC7900

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

| Rating  | Symbol   | Value  | Unit   |
|---|--|--|--|
| Input Voltage ( $-5.0\text{ V} \geq V_O \geq -18\text{ V}$ )<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>$\theta_{JA}$<br>$\theta_{JC}$<br>$P_D$<br>$\theta_{JA}$<br>$\theta_{JC}$ | Internally Limited<br>65<br>5.0<br>Internally Limited<br>70<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  | $^\circ\text{C}$   |
| Junction Temperature  | $T_J$  | +150   | $^\circ\text{C}$   |

### THERMAL CHARACTERISTICS

| Characteristics                         | Symbol          | Max | Unit               |
|---|-----------------|-----|--------------------|
| Thermal Resistance, Junction-to-Ambient | $R_{\theta JA}$ | 65  | $^\circ\text{C/W}$ |
| Thermal Resistance, Junction-to-Case    | $R_{\theta JC}$ | 5.0 | $^\circ\text{C/W}$ |

### MC7905C

**ELECTRICAL CHARACTERISTICS** ( $V_I = -10\text{ V}$ ,  $I_O = 500\text{ mA}$ ,  $0^\circ\text{C} < T_J < +125^\circ\text{C}$ , unless otherwise noted.)

| Characteristics  | Symbol                  | Min    | Typ        | Max        | Unit                       |
|--|-------------------------|--------|------------|------------|----------------------------|
| Output Voltage ( $T_J = +25^\circ\text{C}$ )   | $V_O$                   | -4.8   | -5.0       | -5.2       | Vdc                        |
| Line Regulation (Note 1)<br>( $T_J = +25^\circ\text{C}$ , $I_O = 100\text{ mA}$ )<br>$-7.0\text{ Vdc} \geq V_I \geq -25\text{ Vdc}$<br>$-8.0\text{ Vdc} \geq V_I \geq -12\text{ Vdc}$<br>( $T_J = +25^\circ\text{C}$ , $I_O = 500\text{ mA}$ )<br>$-7.0\text{ Vdc} \geq V_I \geq -25\text{ Vdc}$<br>$-8.0\text{ Vdc} \geq V_I \geq -12\text{ Vdc}$ | Reg <sub>line</sub>     | -<br>- | 7.0<br>2.0 | 50<br>25   | mV                         |
| Load Regulation, $T_J = +25^\circ\text{C}$ (Note 1)<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$<br>$250\text{ mA} \leq I_O \leq 750\text{ mA}$   | Reg <sub>load</sub>     | -<br>- | 11<br>4.0  | 100<br>50  | mV                         |
| Output Voltage<br>$-7.0\text{ Vdc} \geq V_I \geq -20\text{ Vdc}$ , $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P \leq 15\text{ W}$   | $V_O$                   | -4.75  | -          | -5.25      | Vdc                        |
| Input Bias Current ( $T_J = +25^\circ\text{C}$ )   | $I_{IB}$                | -      | 4.3        | 8.0        | mA                         |
| Input Bias Current Change<br>$-7.0\text{ Vdc} \geq V_I \geq -25\text{ Vdc}$<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$  | $\Delta I_{IB}$         | -<br>- | -<br>-     | 1.3<br>0.5 | mA                         |
| Output Noise Voltage ( $T_A = +25^\circ\text{C}$ , $10\text{ Hz} \leq f \leq 100\text{ kHz}$ )   | $V_n$                   | -      | 40         | -          | $\mu\text{V}$              |
| Ripple Rejection ( $I_O = 20\text{ mA}$ , $f = 120\text{ Hz}$ )  | RR                      | -      | 70         | -          | dB                         |
| Dropout Voltage<br>$I_O = 1.0\text{ A}$ , $T_J = +25^\circ\text{C}$  | $V_I - V_O$             | -      | 2.0        | -          | Vdc                        |
| Average Temperature Coefficient of Output Voltage<br>$I_O = 5.0\text{ mA}$ , $0^\circ\text{C} \leq T_J \leq +125^\circ\text{C}$  | $\Delta V_O / \Delta T$ | -      | -1.0       | -          | $\text{mV}/^\circ\text{C}$ |

**NOTE:** 1. 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.

## MC7900

### MC7905AC

**ELECTRICAL CHARACTERISTICS** ( $V_I = -10\text{ V}$ ,  $I_O = 500\text{ mA}$ ,  $0^\circ\text{C} < T_J < +125^\circ\text{C}$ , unless otherwise noted.)

| Characteristics   | Symbol                  | Min   | Typ                      | Max                  | Unit                 |
|---|-------------------------|-------|--------------------------|----------------------|----------------------|
| Output Voltage ( $T_J = +25^\circ\text{C}$ )  | $V_O$                   | -4.9  | -5.0                     | -5.1                 | Vdc                  |
| Line Regulation (Note 1)<br>-8.0 Vdc $\geq V_I \geq -12\text{ Vdc}$ ; $I_O = 1.0\text{ A}$ , $T_J = +25^\circ\text{C}$<br>-8.0 Vdc $\geq V_I \geq -12\text{ Vdc}$ ; $I_O = 1.0\text{ A}$<br>-7.5 Vdc $\geq V_I \geq -25\text{ Vdc}$ ; $I_O = 500\text{ mA}$<br>-7.0 Vdc $\geq V_I \geq -20\text{ Vdc}$ ; $I_O = 1.0\text{ A}$ , $T_J = +25^\circ\text{C}$ | Reg <sub>line</sub>     | -     | 2.0<br>7.0<br>7.0<br>6.0 | 25<br>50<br>50<br>50 | mV                   |
| Load Regulation (Note 1)<br>5.0 mA $\leq I_O \leq 1.5\text{ A}$ , $T_J = +25^\circ\text{C}$<br>250 mA $\leq I_O \leq 750\text{ mA}$<br>5.0 mA $\leq I_O \leq 1.0\text{ A}$  | Reg <sub>load</sub>     | -     | 11<br>4.0<br>9.0         | 100<br>50<br>100     | mV                   |
| Output Voltage<br>-7.5 Vdc $\geq V_I \geq -20\text{ Vdc}$ , 5.0 mA $\leq I_O \leq 1.0\text{ A}$ , $P \leq 15\text{ W}$  | $V_O$                   | -4.80 | -                        | -5.20                | Vdc                  |
| Input Bias Current  | $I_{IB}$                | -     | 4.4                      | 8.0                  | mA                   |
| Input Bias Current Change<br>-7.5 Vdc $\geq V_I \geq -25\text{ Vdc}$<br>5.0 mA $\leq I_O \leq 1.0\text{ A}$<br>5.0 mA $\leq I_O \leq 1.5\text{ A}$ , $T_J = +25^\circ\text{C}$  | $\Delta I_{IB}$         | -     | -                        | 1.3<br>0.5<br>0.5    | mA                   |
| Output Noise Voltage ( $T_A = +25^\circ\text{C}$ , 10 Hz $\leq f \leq 100\text{ kHz}$ )   | $V_n$                   | -     | 40                       | -                    | $\mu\text{V}$        |
| Ripple Rejection ( $I_O = \text{mA}$ , $f = 120\text{ Hz}$ )  | RR                      | -     | 70                       | -                    | dB                   |
| Dropout Voltage<br>$I_O = 1.0\text{ A}$ , $T_J = +25^\circ\text{C}$   | $V_I - V_O$             | -     | 2.0                      | -                    | Vdc                  |
| Average Temperature Coefficient of Output Voltage<br>$I_O = 5.0\text{ A}$ , $0^\circ\text{C} \leq T_J \leq +125^\circ\text{C}$  | $\Delta V_O / \Delta T$ | -     | -1.0                     | -                    | mV/ $^\circ\text{C}$ |

### MC7905.2C

**ELECTRICAL CHARACTERISTICS** ( $V_I = -10\text{ V}$ ,  $I_O = 500\text{ mA}$ ,  $0^\circ\text{C} < T_J < +125^\circ\text{C}$ , unless otherwise noted.)

| Characteristics  | Symbol                  | Min   | Typ                     | Max                   | Unit                 |
|--|-------------------------|-------|-------------------------|-----------------------|----------------------|
| Output Voltage ( $T_J = +25^\circ\text{C}$ )   | $V_O$                   | -5.0  | -5.2                    | -5.4                  | Vdc                  |
| Line Regulation (Note 1)<br>( $T_J = +25^\circ\text{C}$ , $I_O = 100\text{ mA}$ )<br>-7.2 Vdc $\geq V_I \geq -25\text{ Vdc}$<br>-8.0 Vdc $\geq V_I \geq -12\text{ Vdc}$<br>( $T_J = +25^\circ\text{C}$ , $I_O = 500\text{ mA}$ )<br>-7.2 Vdc $\geq V_I \geq -25\text{ Vdc}$<br>-8.0 Vdc $\geq V_I \geq -12\text{ Vdc}$ | Reg <sub>line</sub>     | -     | 8.0<br>2.2<br>37<br>8.5 | 52<br>27<br>105<br>52 | mV                   |
| Load Regulation, $T_J = +25^\circ\text{C}$ (Note 1)<br>5.0 mA $\leq I_O \leq 1.5\text{ A}$<br>250 mA $\leq I_O \leq 750\text{ mA}$   | Reg <sub>load</sub>     | -     | 12<br>4.5               | 105<br>52             | mV                   |
| Output Voltage<br>-7.2 Vdc $\geq V_I \geq -20\text{ Vdc}$ , 5.0 mA $\leq I_O \leq 1.0\text{ A}$ , $P \leq 15\text{ W}$   | $V_O$                   | -4.95 | -                       | -5.45                 | Vdc                  |
| Input Bias Current ( $T_J = +25^\circ\text{C}$ )   | $I_{IB}$                | -     | 4.3                     | 8.0                   | mA                   |
| Input Bias Current Change<br>-7.2 Vdc $\geq V_I \geq -25\text{ Vdc}$<br>5.0 mA $\leq I_O \leq 1.5\text{ A}$  | $\Delta I_{IB}$         | -     | -                       | 1.3<br>0.5            | mA                   |
| Output Noise Voltage ( $T_A = +25^\circ\text{C}$ , 10 Hz $\leq f \leq 100\text{ kHz}$ )  | $V_n$                   | -     | 42                      | -                     | $\mu\text{V}$        |
| Ripple Rejection ( $I_O = 20\text{ mA}$ , $f = 120\text{ Hz}$ )  | RR                      | -     | 68                      | -                     | dB                   |
| Dropout Voltage<br>$I_O = 1.0\text{ A}$ , $T_J = +25^\circ\text{C}$  | $V_I - V_O$             | -     | 2.0                     | -                     | Vdc                  |
| Average Temperature Coefficient of Output Voltage<br>$I_O = 5.0\text{ mA}$ , $0^\circ\text{C} \leq T_J \leq +125^\circ\text{C}$  | $\Delta V_O / \Delta T$ | -     | -1.0                    | -                     | mV/ $^\circ\text{C}$ |

**NOTE:** 1. 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.

## MC7900

### MC7906C

**ELECTRICAL CHARACTERISTICS** ( $V_I = -11\text{ V}$ ,  $I_O = 500\text{ mA}$ ,  $0^\circ\text{C} < T_J < +125^\circ\text{C}$ , unless otherwise noted.)

| Characteristics  | Symbol                  | Min   | Typ        | Max        | Unit                       |
|--|-------------------------|-------|------------|------------|----------------------------|
| Output Voltage ( $T_J = +25^\circ\text{C}$ )   | $V_O$                   | -5.75 | -6.0       | -6.25      | Vdc                        |
| Line Regulation (Note 1)<br>( $T_J = +25^\circ\text{C}$ , $I_O = 100\text{ mA}$ )<br>$-8.0\text{ Vdc} \geq V_I \geq -25\text{ Vdc}$<br>$-9.0\text{ Vdc} \geq V_I \geq -13\text{ Vdc}$<br>( $T_J = +25^\circ\text{C}$ , $I_O = 500\text{ mA}$ )<br>$-8.0\text{ Vdc} \geq V_I \geq -25\text{ Vdc}$<br>$-9.0\text{ Vdc} \geq V_I \geq -13\text{ Vdc}$ | Regline                 | -     | 9.0<br>3.0 | 60<br>30   | mV                         |
| Load Regulation, $T_J = +25^\circ\text{C}$ (Note 1)<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$<br>$250\text{ mA} \leq I_O \leq 750\text{ mA}$   | Regload                 | -     | 13<br>5.0  | 120<br>60  | mV                         |
| Output Voltage<br>$-8.0\text{ Vdc} \geq V_I \geq -21\text{ Vdc}$ , $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P \leq 15\text{ W}$   | $V_O$                   | -5.7  | -          | -6.3       | Vdc                        |
| Input Bias Current ( $T_J = +25^\circ\text{C}$ )   | $I_{IB}$                | -     | 4.3        | 8.0        | mA                         |
| Input Bias Current Change<br>$-8.0\text{ Vdc} \geq V_I \geq -25\text{ Vdc}$<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$  | $\Delta I_{IB}$         | -     | -          | 1.3<br>0.5 | mA                         |
| Output Noise Voltage ( $T_A = +25^\circ\text{C}$ , $10\text{ Hz} \leq f \leq 100\text{ kHz}$ )   | $V_n$                   | -     | 45         | -          | $\mu\text{V}$              |
| Ripple Rejection ( $I_O = 20\text{ mA}$ , $f = 120\text{ Hz}$ )  | RR                      | -     | 65         | -          | dB                         |
| Dropout Voltage<br>$I_O = 1.0\text{ A}$ , $T_J = +25^\circ\text{C}$  | $V_I - V_O$             | -     | 2.0        | -          | Vdc                        |
| Average Temperature Coefficient of Output Voltage<br>$I_O = 5.0\text{ A}$ , $0^\circ\text{C} \leq T_J \leq +125^\circ\text{C}$   | $\Delta V_O / \Delta T$ | -     | -1.0       | -          | $\text{mV}/^\circ\text{C}$ |

### MC7908C

**ELECTRICAL CHARACTERISTICS** ( $V_I = -14\text{ V}$ ,  $I_O = 500\text{ mA}$ ,  $0^\circ\text{C} < T_J < +125^\circ\text{C}$ , unless otherwise noted.)

| Characteristics  | Symbol                  | Min  | Typ       | Max        | Unit                       |
|--|-------------------------|------|-----------|------------|----------------------------|
| Output Voltage ( $T_J = +25^\circ\text{C}$ )   | $V_O$                   | -7.7 | -8.0      | -8.3       | Vdc                        |
| Line Regulation (Note 1)<br>( $T_J = +25^\circ\text{C}$ , $I_O = 100\text{ mA}$ )<br>$-10.5\text{ Vdc} \geq V_I \geq -25\text{ Vdc}$<br>$-11\text{ Vdc} \geq V_I \geq -17\text{ Vdc}$<br>( $T_J = +25^\circ\text{C}$ , $I_O = 500\text{ mA}$ )<br>$-10.5\text{ Vdc} \geq V_I \geq -25\text{ Vdc}$<br>$-11\text{ Vdc} \geq V_I \geq -17\text{ Vdc}$ | Regline                 | -    | 12<br>5.0 | 80<br>40   | mV                         |
| Load Regulation, $T_J = +25^\circ\text{C}$ (Note 1)<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$<br>$250\text{ mA} \leq I_O \leq 750\text{ mA}$   | Regload                 | -    | 26<br>9.0 | 160<br>80  | mV                         |
| Output Voltage<br>$-10.5\text{ Vdc} \geq V_I \geq -23\text{ Vdc}$ , $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P \leq 15\text{ W}$  | $V_O$                   | -7.6 | -         | -8.4       | Vdc                        |
| Input Bias Current ( $T_J = +25^\circ\text{C}$ )   | $I_{IB}$                | -    | 4.3       | 8.0        | mA                         |
| Input Bias Current Change<br>$-10.5\text{ Vdc} \geq V_I \geq -25\text{ Vdc}$<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$   | $\Delta I_{IB}$         | -    | -         | 1.0<br>0.5 | mA                         |
| Output Noise Voltage ( $T_A = +25^\circ\text{C}$ , $10\text{ Hz} \leq f \leq 100\text{ kHz}$ )   | $V_n$                   | -    | 52        | -          | $\mu\text{V}$              |
| Ripple Rejection ( $I_O = 20\text{ mA}$ , $f = 120\text{ Hz}$ )  | RR                      | -    | 62        | -          | dB                         |
| Dropout Voltage<br>$I_O = 1.0\text{ A}$ , $T_J = +25^\circ\text{C}$  | $V_I - V_O$             | -    | 2.0       | -          | Vdc                        |
| Average Temperature Coefficient of Output Voltage<br>$I_O = 5.0\text{ mA}$ , $0^\circ\text{C} \leq T_J \leq +125^\circ\text{C}$  | $\Delta V_O / \Delta T$ | -    | -1.0      | -          | $\text{mV}/^\circ\text{C}$ |

**NOTE:** 1. 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.

## MC7900

### MC7912C

**ELECTRICAL CHARACTERISTICS** ( $V_I = -19\text{ V}$ ,  $I_O = 500\text{ mA}$ ,  $0^\circ\text{C} < T_J < +125^\circ\text{C}$ , unless otherwise noted.)

| Characteristics  | Symbol                  | Min   | Typ       | Max        | Unit                 |
|--|-------------------------|-------|-----------|------------|----------------------|
| Output Voltage ( $T_J = +25^\circ\text{C}$ )   | $V_O$                   | -11.5 | -12       | -12.5      | Vdc                  |
| Line Regulation (Note 1)<br>( $T_J = +25^\circ\text{C}$ , $I_O = 100\text{ mA}$ )<br>-14.5 Vdc $\geq V_I \geq -30\text{ Vdc}$<br>-16 Vdc $\geq V_I \geq -22\text{ Vdc}$<br>( $T_J = +25^\circ\text{C}$ , $I_O = 500\text{ mA}$ )<br>-14.5 Vdc $\geq V_I \geq -30\text{ Vdc}$<br>-16 Vdc $\geq V_I \geq -22\text{ Vdc}$ | Regline                 | -     | 13<br>6.0 | 120<br>60  | mV                   |
| Load Regulation, $T_J = +25^\circ\text{C}$ (Note 1)<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$<br>$250\text{ mA} \leq I_O \leq 750\text{ mA}$   | Regload                 | -     | 46<br>17  | 240<br>120 | mV                   |
| Output Voltage<br>-14.5 Vdc $\geq V_I \geq -27\text{ Vdc}$ , $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P \leq 15\text{ W}$   | $V_O$                   | -11.4 | -         | -12.6      | Vdc                  |
| Input Bias Current ( $T_J = +25^\circ\text{C}$ )   | $I_{IB}$                | -     | 4.4       | 8.0        | mA                   |
| Input Bias Current Change<br>-14.5 Vdc $\geq V_I \geq -30\text{ Vdc}$<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$  | $\Delta I_{IB}$         | -     | -         | 1.0<br>0.5 | mA                   |
| Output Noise Voltage ( $T_A = +25^\circ\text{C}$ , $10\text{ Hz} \leq f \leq 100\text{ kHz}$ )   | $V_n$                   | -     | 75        | -          | $\mu\text{V}$        |
| Ripple Rejection ( $I_O = 20\text{ mA}$ , $f = 120\text{ Hz}$ )  | RR                      | -     | 61        | -          | dB                   |
| Dropout Voltage<br>$I_O = 1.0\text{ A}$ , $T_J = +25^\circ\text{C}$  | $V_I - V_O$             | -     | 2.0       | -          | Vdc                  |
| Average Temperature Coefficient of Output Voltage<br>$I_O = 5.0\text{ mA}$ , $0^\circ\text{C} \leq T_J \leq +125^\circ\text{C}$  | $\Delta V_O / \Delta T$ | -     | -1.0      | -          | mV/ $^\circ\text{C}$ |

### MC7912AC

**ELECTRICAL CHARACTERISTICS** ( $V_I = -19\text{ V}$ ,  $I_O = 500\text{ mA}$ ,  $0^\circ\text{C} < T_J < +125^\circ\text{C}$ , unless otherwise noted.)

| Characteristics   | Symbol                  | Min    | Typ                   | Max                     | Unit                 |
|---|-------------------------|--------|-----------------------|-------------------------|----------------------|
| Output Voltage ( $T_J = +25^\circ\text{C}$ )  | $V_O$                   | -11.75 | -12                   | -12.25                  | Vdc                  |
| Line Regulation (Note 1)<br>-16 Vdc $\geq V_I \geq -22\text{ Vdc}$ ; $I_O = 1.0\text{ A}$ , $T_J = +25^\circ\text{C}$<br>-16 Vdc $\geq V_I \geq -22\text{ Vdc}$ ; $I_O = 1.0\text{ A}$<br>-14.8 Vdc $\geq V_I \geq -30\text{ Vdc}$ ; $I_O = 500\text{ mA}$<br>-14.5 Vdc $\geq V_I \geq -27\text{ Vdc}$ ; $I_O = 1.0\text{ A}$ , $T_J = +25^\circ\text{C}$ | Regline                 | -      | 6.0<br>24<br>24<br>13 | 60<br>120<br>120<br>120 | mV                   |
| Load Regulation (Note 1)<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$ , $T_J = +25^\circ\text{C}$<br>$250\text{ mA} \leq I_O \leq 750\text{ mA}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$   | Regload                 | -      | 46<br>17<br>35        | 150<br>75<br>150        | mV                   |
| Output Voltage<br>-14.8 Vdc $\geq V_I \geq -27\text{ Vdc}$ , $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P \leq 15\text{ W}$  | $V_O$                   | -11.5  | -                     | -12.5                   | Vdc                  |
| Input Bias Current  | $I_{IB}$                | -      | 4.4                   | 8.0                     | mA                   |
| Input Bias Current Change<br>-15 Vdc $\geq V_I \geq -30\text{ Vdc}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$ , $T_J = +25^\circ\text{C}$   | $\Delta I_{IB}$         | -      | -                     | 0.8<br>0.5<br>0.5       | mA                   |
| Output Noise Voltage ( $T_A = +25^\circ\text{C}$ , $10\text{ Hz} \leq f \leq 100\text{ kHz}$ )  | $V_n$                   | -      | 75                    | -                       | $\mu\text{V}$        |
| Ripple Rejection ( $I_O = 20\text{ mA}$ , $f = 120\text{ Hz}$ )   | RR                      | -      | 61                    | -                       | dB                   |
| Dropout Voltage<br>$I_O = 1.0\text{ A}$ , $T_J = +25^\circ\text{C}$   | $V_I - V_O$             | -      | 2.0                   | -                       | Vdc                  |
| Average Temperature Coefficient of Output Voltage<br>$I_O = 5.0\text{ mA}$ , $0^\circ\text{C} \leq T_J \leq +125^\circ\text{C}$   | $\Delta V_O / \Delta T$ | -      | -1.0                  | -                       | mV/ $^\circ\text{C}$ |

**NOTE:** 1. 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.

## MC7900

### MC7915C

**ELECTRICAL CHARACTERISTICS** ( $V_I = -23\text{ V}$ ,  $I_O = 500\text{ mA}$ ,  $0^\circ\text{C} < T_J < +125^\circ\text{C}$ , unless otherwise noted.)

| Characteristics  | Symbol                  | Min    | Typ       | Max        | Unit                 |
|--|-------------------------|--------|-----------|------------|----------------------|
| Output Voltage ( $T_J = +25^\circ\text{C}$ )   | $V_O$                   | -14.4  | -15       | -15.6      | Vdc                  |
| Line Regulation (Note 1)<br>( $T_J = +25^\circ\text{C}$ , $I_O = 100\text{ mA}$ )<br>-17.5 Vdc $\geq V_I \geq -30\text{ Vdc}$<br>-20 Vdc $\geq V_I \geq -26\text{ Vdc}$<br>( $T_J = +25^\circ\text{C}$ , $I_O = 500\text{ mA}$ )<br>-17.5 Vdc $\geq V_I \geq -30\text{ Vdc}$<br>-20 Vdc $\geq V_I \geq -26\text{ Vdc}$ | Regline                 | -      | 14<br>6.0 | 150<br>75  | mV                   |
| Load Regulation, $T_J = +25^\circ\text{C}$ (Note 1)<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$<br>$250\text{ mA} \leq I_O \leq 750\text{ mA}$   | Regload                 | -      | 68<br>25  | 300<br>150 | mV                   |
| Output Voltage<br>-17.5 Vdc $\geq V_I \geq -30\text{ Vdc}$ , $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P \leq 15\text{ W}$   | $V_O$                   | -14.25 | -         | -15.75     | Vdc                  |
| Input Bias Current ( $T_J = +25^\circ\text{C}$ )   | $I_{IB}$                | -      | 4.4       | 8.0        | mA                   |
| Input Bias Current Change<br>-17.5 Vdc $\geq V_I \geq -30\text{ Vdc}$<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$  | $\Delta I_{IB}$         | -      | -         | 1.0<br>0.5 | mA                   |
| Output Noise Voltage ( $T_A = +25^\circ\text{C}$ , $10\text{ Hz} \leq f \leq 100\text{ kHz}$ )   | $V_n$                   | -      | 90        | -          | $\mu\text{V}$        |
| Ripple Rejection ( $I_O = 20\text{ mA}$ , $f = 120\text{ Hz}$ )  | RR                      | -      | 60        | -          | dB                   |
| Dropout Voltage<br>$I_O = 1.0\text{ A}$ , $T_J = +25^\circ\text{C}$  | $V_I - V_O$             | -      | 2.0       | -          | Vdc                  |
| Average Temperature Coefficient of Output Voltage<br>$I_O = 5.0\text{ A}$ , $0^\circ\text{C} \leq T_J \leq +125^\circ\text{C}$   | $\Delta V_O / \Delta T$ | -      | -1.0      | -          | mV/ $^\circ\text{C}$ |

### MC7915AC

**ELECTRICAL CHARACTERISTICS** ( $V_I = -23\text{ V}$ ,  $I_O = 500\text{ mA}$ ,  $0^\circ\text{C} < T_J < +125^\circ\text{C}$ , unless otherwise noted.)

| Characteristics   | Symbol                  | Min   | Typ                  | Max                     | Unit                 |
|---|-------------------------|-------|----------------------|-------------------------|----------------------|
| Output Voltage ( $T_J = +25^\circ\text{C}$ )  | $V_O$                   | -14.7 | -15                  | -15.3                   | Vdc                  |
| Line Regulation (Note 1)<br>-20 Vdc $\geq V_I \geq -26\text{ Vdc}$ , $I_O = 1.0\text{ A}$ , $T_J = +25^\circ\text{C}$<br>-20 Vdc $\geq V_I \geq -26\text{ Vdc}$ , $I_O = 1.0\text{ A}$ ,<br>-17.9 Vdc $\geq V_I \geq -30\text{ Vdc}$ , $I_O = 500\text{ mA}$<br>-17.5 Vdc $\geq V_I \geq -30\text{ Vdc}$ , $I_O = 1.0\text{ A}$ , $T_J = +25^\circ\text{C}$ | Regline                 | -     | 27<br>57<br>57<br>57 | 75<br>150<br>150<br>150 | mV                   |
| Load Regulation (Note 1)<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$ , $T_J = +25^\circ\text{C}$<br>$250\text{ mA} \leq I_O \leq 750\text{ mA}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$   | Regload                 | -     | 68<br>25<br>40       | 150<br>75<br>150        | mV                   |
| Output Voltage<br>-17.9 Vdc $\geq V_I \geq -30\text{ Vdc}$ , $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P \leq 15\text{ W}$  | $V_O$                   | -14.4 | -                    | -15.6                   | Vdc                  |
| Input Bias Current  | $I_{IB}$                | -     | 4.4                  | 8.0                     | mA                   |
| Input Bias Current Change<br>-17.5 Vdc $\geq V_I \geq -30\text{ Vdc}$<br>$5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$ , $T_J = +25^\circ\text{C}$   | $\Delta I_{IB}$         | -     | -                    | 0.8<br>0.5<br>0.5       | mA                   |
| Output Noise Voltage ( $T_A = +25^\circ\text{C}$ , $10\text{ Hz} \leq f \leq 100\text{ kHz}$ )  | $V_n$                   | -     | 90                   | -                       | $\mu\text{V}$        |
| Ripple Rejection ( $I_O = 20\text{ mA}$ , $f = 120\text{ Hz}$ )   | RR                      | -     | 60                   | -                       | dB                   |
| Dropout Voltage<br>$I_O = 1.0\text{ A}$ , $T_J = +25^\circ\text{C}$   | $V_I - V_O$             | -     | 2.0                  | -                       | Vdc                  |
| Average Temperature Coefficient of Output Voltage<br>$I_O = 5.0\text{ mA}$ , $0^\circ\text{C} \leq T_J \leq +125^\circ\text{C}$   | $\Delta V_O / \Delta T$ | -     | -1.0                 | -                       | mV/ $^\circ\text{C}$ |

**NOTE:** 1. 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.

## MC7900

### MC7918C

**ELECTRICAL CHARACTERISTICS** ( $V_I = -27\text{ V}$ ,  $I_O = 500\text{ mA}$ ,  $0^\circ\text{C} < T_J < +125^\circ\text{C}$ , unless otherwise noted.)

| Characteristics  | Symbol                  | Min   | Typ       | Max        | Unit                 |
|--|-------------------------|-------|-----------|------------|----------------------|
| Output Voltage ( $T_J = +25^\circ\text{C}$ )   | $V_O$                   | -17.3 | -18       | -18.7      | Vdc                  |
| Line Regulation (Note 1)<br>( $T_J = +25^\circ\text{C}$ , $I_O = 100\text{ mA}$ )<br>-21 Vdc $\geq V_I \geq -33\text{ Vdc}$<br>-24 Vdc $\geq V_I \geq -30\text{ Vdc}$<br>( $T_J = +25^\circ\text{C}$ , $I_O = 500\text{ mA}$ )<br>-21 Vdc $\geq V_I \geq -33\text{ Vdc}$<br>-24 Vdc $\geq V_I \geq -30\text{ Vdc}$ | Regline                 | -     | 25<br>10  | 180<br>90  | mV                   |
| Load Regulation, $T_J = +25^\circ\text{C}$ (Note 1)<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$<br>$250\text{ mA} \leq I_O \leq 750\text{ mA}$   | Regload                 | -     | 110<br>55 | 360<br>180 | mV                   |
| Output Voltage<br>-21 Vdc $\geq V_I \geq -33\text{ Vdc}$ , $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P \leq 15\text{ W}$   | $V_O$                   | -17.1 | -         | -18.9      | Vdc                  |
| Input Bias Current ( $T_J = +25^\circ\text{C}$ )   | $I_{IB}$                | -     | 4.5       | 8.0        | mA                   |
| Input Bias Current Change<br>-21 Vdc $\geq V_I \geq -33\text{ Vdc}$<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$  | $\Delta I_{IB}$         | -     | -         | 1.0<br>0.5 | mA                   |
| Output Noise Voltage ( $T_A = +25^\circ\text{C}$ , $10\text{ Hz} \leq f \leq 100\text{ kHz}$ )   | $V_n$                   | -     | 110       | -          | $\mu\text{V}$        |
| Ripple Rejection ( $I_O = 20\text{ mA}$ , $f = 120\text{ Hz}$ )  | RR                      | -     | 59        | -          | dB                   |
| Dropout Voltage<br>$I_O = 1.0\text{ A}$ , $T_J = +25^\circ\text{C}$  | $V_I - V_O$             | -     | 2.0       | -          | Vdc                  |
| Average Temperature Coefficient of Output Voltage<br>$I_O = 5.0\text{ mA}$ , $0^\circ\text{C} \leq T_J \leq +125^\circ\text{C}$  | $\Delta V_O / \Delta T$ | -     | -1.0      | -          | mV/ $^\circ\text{C}$ |

### MC7924C

**ELECTRICAL CHARACTERISTICS** ( $V_I = -33\text{ V}$ ,  $I_O = 500\text{ mA}$ ,  $0^\circ\text{C} < T_J < +125^\circ\text{C}$ , unless otherwise noted.)

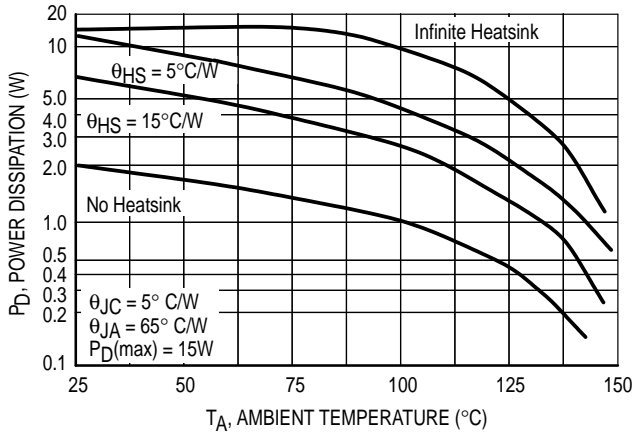
| Characteristics  | Symbol                  | Min   | Typ       | Max        | Unit                 |
|--|-------------------------|-------|-----------|------------|----------------------|
| Output Voltage ( $T_J = +25^\circ\text{C}$ )   | $V_O$                   | -23   | -24       | -25        | Vdc                  |
| Line Regulation (Note 1)<br>( $T_J = +25^\circ\text{C}$ , $I_O = 100\text{ mA}$ )<br>-27 Vdc $\geq V_I \geq -38\text{ Vdc}$<br>-30 Vdc $\geq V_I \geq -36\text{ Vdc}$<br>( $T_J = +25^\circ\text{C}$ , $I_O = 500\text{ mA}$ )<br>-27 Vdc $\geq V_I \geq -38\text{ Vdc}$<br>-30 Vdc $\geq V_I \geq -36\text{ Vdc}$ | Regline                 | -     | 31<br>14  | 240<br>120 | mV                   |
| Load Regulation, $T_J = +25^\circ\text{C}$ (Note 1)<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$<br>$250\text{ mA} \leq I_O \leq 750\text{ mA}$   | Regload                 | -     | 150<br>85 | 480<br>240 | mV                   |
| Output Voltage<br>-27 Vdc $\geq V_I \geq -38\text{ Vdc}$ , $5.0\text{ mA} \leq I_O \leq 1.0\text{ A}$ , $P \leq 15\text{ W}$   | $V_O$                   | -22.8 | -         | -25.2      | Vdc                  |
| Input Bias Current ( $T_J = +25^\circ\text{C}$ )   | $I_{IB}$                | -     | 4.6       | 8.0        | mA                   |
| Input Bias Current Change<br>-27 Vdc $\geq V_I \geq -38\text{ Vdc}$<br>$5.0\text{ mA} \leq I_O \leq 1.5\text{ A}$  | $\Delta I_{IB}$         | -     | -         | 1.0<br>0.5 | mA                   |
| Output Noise Voltage ( $T_A = +25^\circ\text{C}$ , $10\text{ Hz} \leq f \leq 100\text{ kHz}$ )   | $V_n$                   | -     | 170       | -          | $\mu\text{V}$        |
| Ripple Rejection ( $I_O = 20\text{ mA}$ , $f = 120\text{ Hz}$ )  | RR                      | -     | 56        | -          | dB                   |
| Dropout Voltage<br>$I_O = 1.0\text{ A}$ , $T_J = +25^\circ\text{C}$  | $V_I - V_O$             | -     | 2.0       | -          | Vdc                  |
| Average Temperature Coefficient of Output Voltage<br>$I_O = 5.0\text{ mA}$ , $0^\circ\text{C} \leq T_J \leq +125^\circ\text{C}$  | $\Delta V_O / \Delta T$ | -     | -1.0      | -          | mV/ $^\circ\text{C}$ |

**NOTE:** 1. 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.

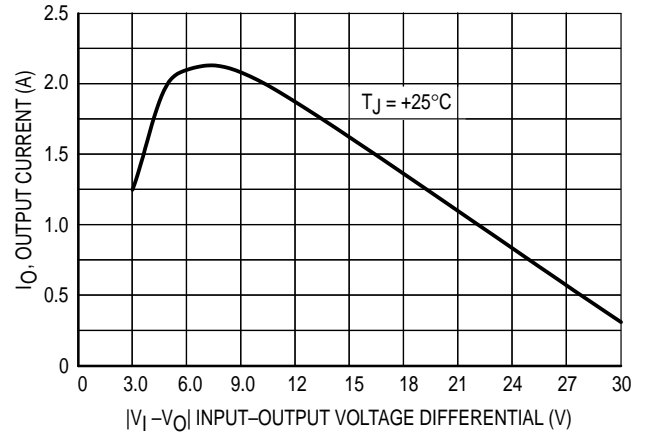


# MC7900

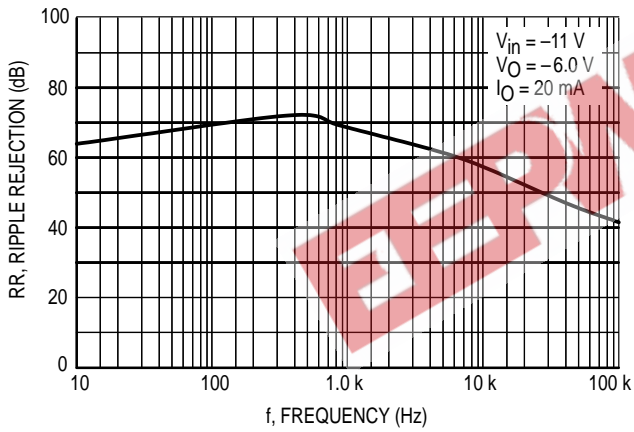
**Figure 1. Worst Case Power Dissipation as a Function of Ambient Temperature**



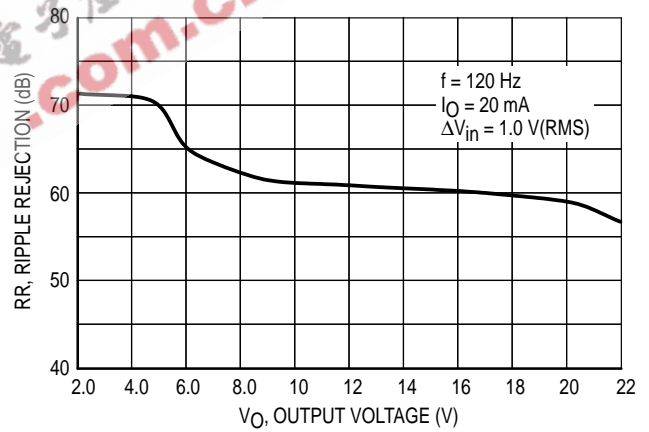
**Figure 2. Peak Output Current as a Function of Input-Output Differential Voltage**



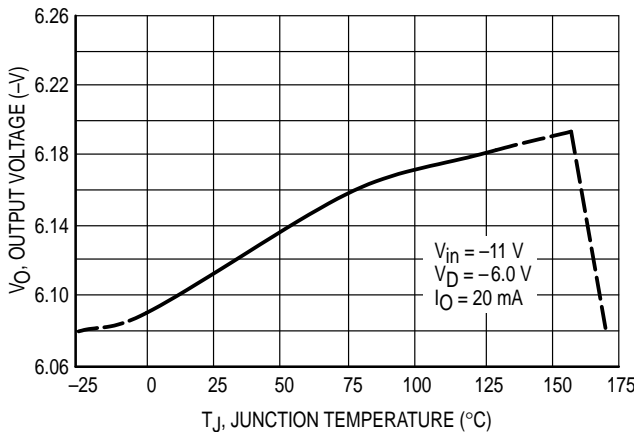
**Figure 3. Ripple Rejection as a Function of Frequency**



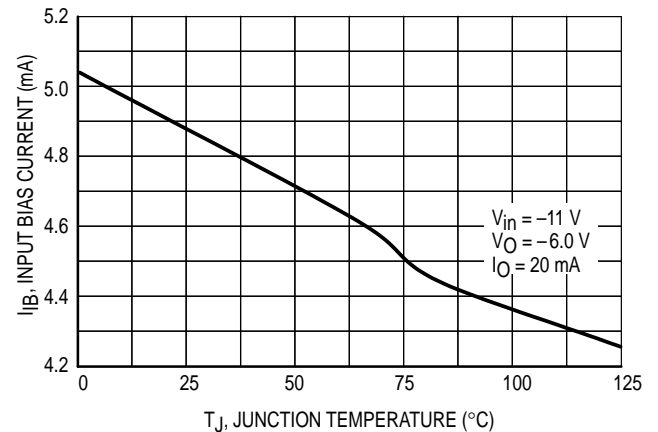
**Figure 4. Ripple Rejection as a Function of Output Voltage**



**Figure 5. Output Voltage as a Function of Junction Temperature**



**Figure 6. Quiescent Current as a Function of Temperature**





## MC7900

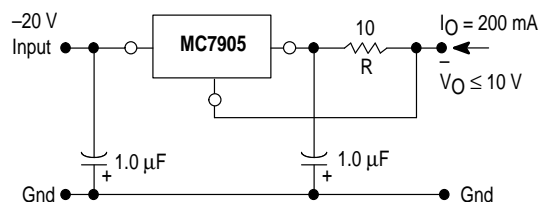
### APPLICATIONS INFORMATION

#### Design Considerations

The MC7900 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 capacitor chosen should have an equivalent series resistance of less than 0.7  $\Omega$ . 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. Bypassing the output is also recommended.

**Figure 7. Current Regulator**



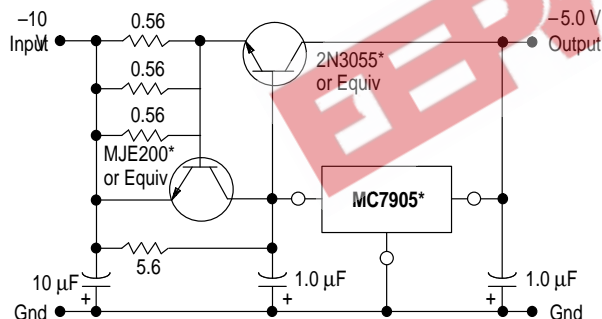
The MC7905, -5.0 V regulator can be used as a constant current source when connected as above. The output current is the sum of resistor R current and quiescent bias current as follows.

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

The quiescent current for this regulator is typically 4.3 mA. The 5.0 V regulator was chosen to minimize dissipation and to allow the output voltage to operate to within 6.0 V below the input voltage.

**Figure 8. Current Boost Regulator**

(-5.0 V @ 4.0 A, with 5.0 A Current Limiting)

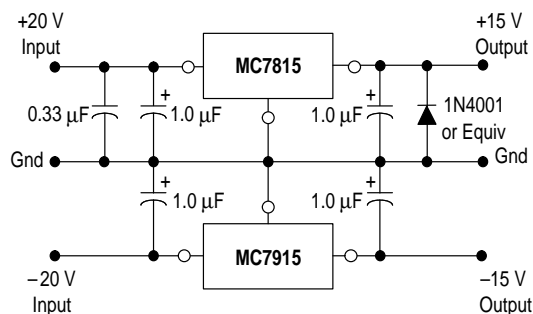


\*Mounted on heatsink.

When a boost transistor is used, short circuit currents are equal to the sum of the series pass and regulator limits, which are measured at 3.2 A and 1.8 A respectively in this case. Series pass limiting is approximately equal to  $0.6 \text{ V}/R_{SC}$ . Operation beyond this point to the peak current capability of the MC7905C is possible if the regulator is mounted on a heatsink; otherwise thermal shutdown will occur when the additional load current is picked up by the regulator.

**Figure 9. Operational Amplifier Supply**

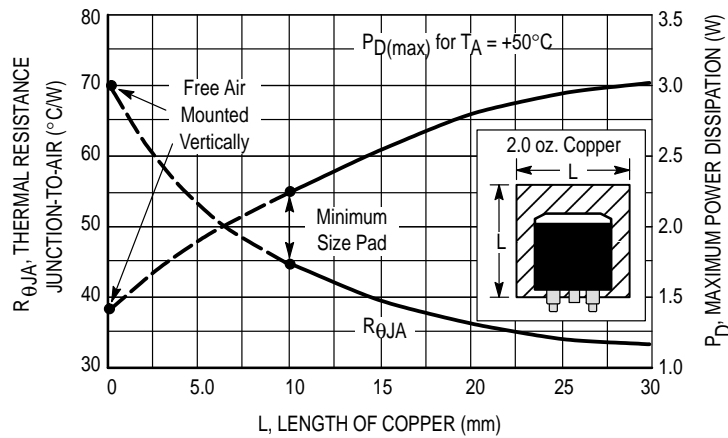
( $\pm 15 \text{ V}$  @ 1.0 A)



The MC7815 and MC7915 positive and negative regulators may be connected as shown to obtain a dual power supply for operational amplifiers. A clamp diode should be used at the output of the MC7815 to prevent potential latch-up problems whenever the output of the positive regulator (MC7815) is drawn below ground with an output current greater than 200 mA.

## MC7900

Figure 10. 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.

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

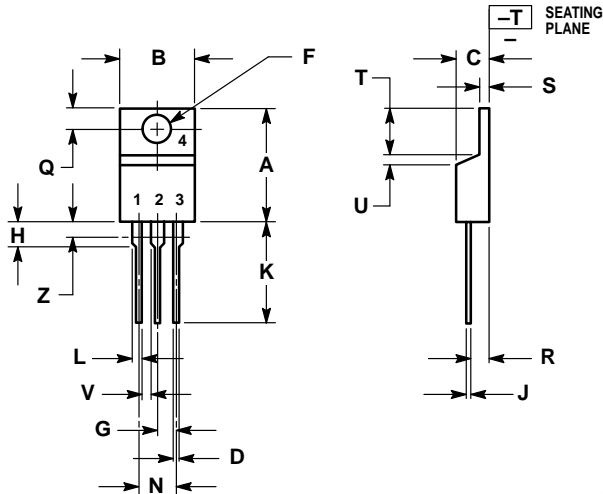
**Output Noise Voltage** – The rms AC voltage at the output, with constant load and no input ripple, measured over a specified frequency range.

**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.

# MC7900

## OUTLINE DIMENSIONS

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

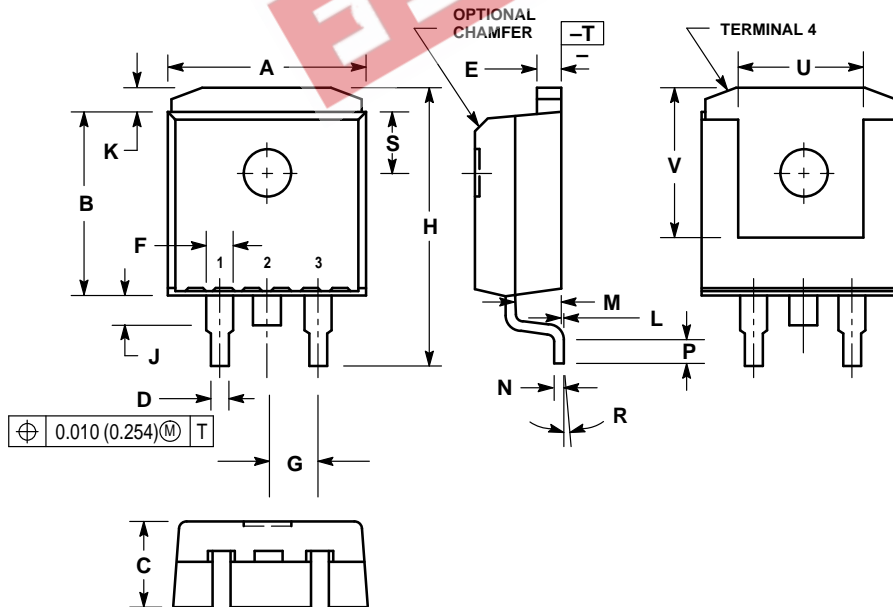


NOTES:

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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