# LINEAR INTEGRATED CIRCUITS

## POSITIVE VOLTAGE REGULATORS

- OUTPUT CURRENT UP TO 0.5A
- OUTPUT VOLTAGES OF 5; 6; 8; 12; 15; 18; 20; 24V
- THERMAL OVERLOAD PROTECTION
- SHORT CIRCUIT PROTECTION
- OUTPUT TRANSISTOR SOA PROTECTION

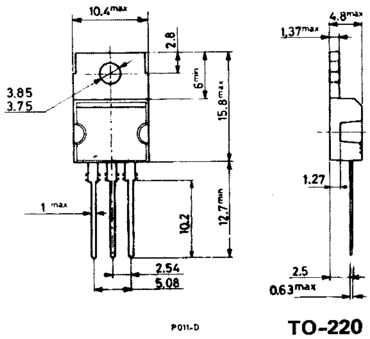
The L78M00 series of three-terminal positive regulators is available in TO-220 and SOT-82 packages and with several fixed output voltages, making it useful in a wide range of applications. These regulators can provide local on-card regulation, eliminating the distribution problems associated with single point regulation. Each type employs internal current limiting, thermal shut-down and safe area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 0.5A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.

## ABSOLUTE MAXIMUM RATINGS

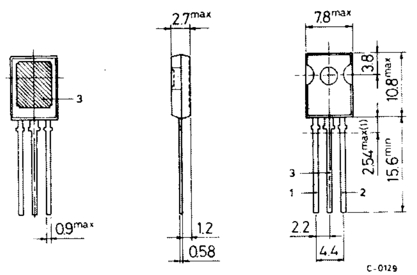
| | | | |
|---|---|---|---|
| $V_i$ | DC input voltage (for $V_o$ = 5 to 18V) | 35 | V |
| | (for $V_o$ = 20, 24V) | 40 | V |
| $I_o$ | Output current | Internally limited | |
| $P_{tot}$ | Power dissipation | Internally limited | |
| $T_{stg}$ | Storage temperature | -65 to +150 | °C |
| $T_{op}$ | Operating junction temperature | 0 to +150 | °C |

## MECHANICAL DATA

Dimensions in mm



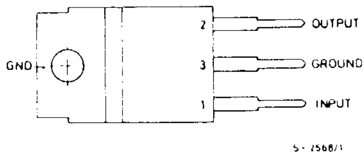

TO-220



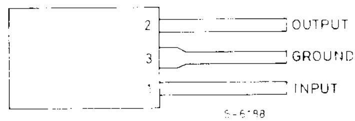

(1) Within this region the cross-section of the leads is uncontrolled

SOT-82

## CONNECTION DIAGRAM AND ORDERING NUMBERS
(top view)



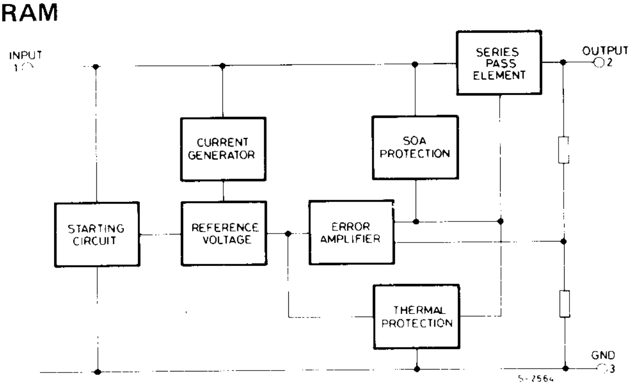

TO-220



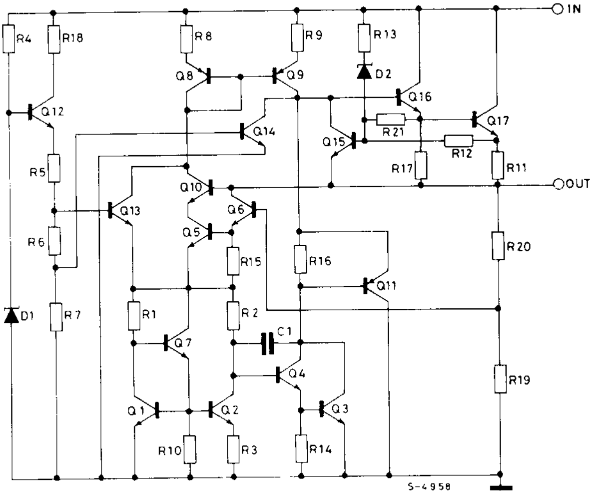

SOT-82

| Ordering Numbers | | Output Voltage |
|---|---|---|
| TO-220 | SOT-82 | |
| L78M05CV | L78M05CX | 5V |
| L78M06CV | L78M06CX | 6V |
| L78M08CV | L78M08CX | 8V |
| L78M12CV | L78M12CX | 12V |
| L78M15CV | L78M15CX | 15V |
| L78M18CV | L78M18CX | 18V |
| L78M20CV | L78M20CX | 20V |
| L78M24CV | L78M24CX | 24V |

## BLOCK DIAGRAM



## SCHEMATIC DIAGRAM




## TEST CIRCUITS

Fig. 1 - DC parameters

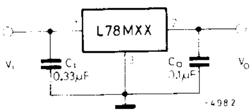



Fig. 2 - Load regulation

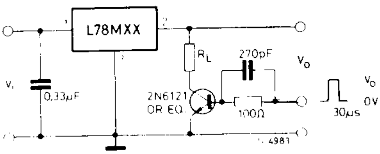
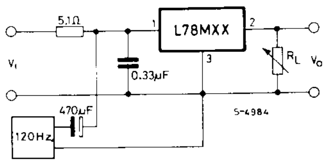



Fig. 3 - Ripple rejection




## THERMAL DATA

| | | | SOT-82 | TO-220 |
|---|---|---|---|---|
| $R_{th\ j\text{-}case}$ | Thermal resistance junction-case | max | 8 °C/W | 3 °C/W |
| $R_{th\ j\text{-}amb}$ | Thermal resistance junction-ambient | max | 100 °C/W | 50 °C/W |

## ELECTRICAL CHARACTERISTICS L78M00C (Refer to the test circuits, $T_j = 25°C$, $I_o = 350$ mA unless otherwise specified, $C_i = 0.33\ \mu F$, $C_o = 0.1\ \mu F$)

| OUTPUT VOLTAGE | | | 5 | | | 6 | | | 8 | | | 12 | | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INPUT VOLTAGE (Unless otherwise specified) | | | 10 | | | 11 | | | 14 | | | 19 | | | |
| Parameter | | Test conditions | Min. | Typ. | Max. | Min. | Typ. | Max. | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| $V_o$ | Output voltage | | 4.8 | 5 | 5.2 | 5.75 | 6 | 6.25 | 7.7 | 8 | 8.3 | 11.5 | 12 | 12.5 | V |
| | | $I_o$ = 5 to 350 mA | 4.75 | 5 | 5.25<br>($V_i$ = 7 to 20V) | 5.7 | 6 | 6.3<br>($V_i$ = 8 to 21V) | 7.6 | 8 | 8.4<br>($V_i$ = 10.5 to 23V) | 11.4 | 12 | 12.6<br>($V_i$ = 14.5 to 27V) | V |
| $\Delta V_o$ | Line regulation | $I_o$ = 200 mA | | | 100<br>($V_i$ = 7 to 25V) | | | 100<br>($V_i$ = 8 to 25V) | | | 100<br>($V_i$ = 10.5 to 25V) | | | 100<br>($V_i$ = 14.5 to 30V) | mV |
| | | | | | 50<br>($V_i$ = 8 to 25V) | | | 50<br>($V_i$ = 9 to 25V) | | | 50<br>($V_i$ = 11 to 25V) | | | 50<br>($V_i$ = 16 to 30V) | mV |
| $\Delta V_o$ | Load regulation | $I_o$ = 5 mA to 0.5A | | | 100 | | | 120 | | | 160 | | | 240 | mV |
| | | $I_o$ = 5 mA to 200 mA | | | 50 | | | 60 | | | 80 | | | 120 | mV |
| $I_d$ | Quiescent current | | | | 6 | | | 6 | | | 6 | | | 6 | mA |
| $\Delta I_d$ | Quiescent current change | $I_o$ = 5 mA to 350 mA | | | 0.5 | | | 0.5 | | | 0.5 | | | 0.5 | mA |
| | | $I_o$ = 200 mA | | | 0.8<br>($V_i$ = 8 to 25V) | | | 0.8<br>($V_i$ = 9 to 25V) | | | 0.8<br>($V_i$ = 10.5 to 25) | | | 0.8<br>($V_i$ = 14.5 to 30V) | mA |
| $\frac{\Delta V_o}{\Delta T}$ | Output Voltage drift | $I_o$ = 5 mA<br>$T_j$ = 0 to 125°C | | -0.5 | | | -0.5 | | | -0.5 | | | -1.0 | | mV/°C |
| $e_N$ | Output noise voltage | B = 10Hz to 100KHz | | 40 | | | 45 | | | 52 | | | 75 | | µV |
| SVR | Supply voltage rejection | f = 120 Hz<br>$I_o$ = 300 mA | 62<br>($V_i$ = 8 to 18V) | | | 59<br>($V_i$ = 9 to 19V) | | | 56<br>($V_i$ = 11.5 to 21.5V) | | | 55<br>($V_i$ = 15 to 25V) | | | dB |
| $V_d$ | Dropout voltage | | | 2 | | | 2 | | | 2 | | | 2 | | V |
| $I_{sc}$ | Short circuit current | $V_i$ = 35V | | 300 | | | 270 | | | 250 | | | 240 | | mA |
| $I_{scp}$ | Short circ. peak current | | | 700 | | | 700 | | | 700 | | | 700 | | mA |

## ELECTRICAL CHARACTERISTICS L78M00C (continued)

| OUTPUT VOLTAGE | | | 15 | | | 18 | | | 20 | | | 24 | | | Unit |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| INPUT VOLTAGE (Unless otherwise specified) | | | 23 | | | 26 | | | 29 | | | 33 | | | |
| Parameter | | Test conditions | Min. | Typ. | Max. | Min. | Typ. | Max. | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| $V_O$ | Output Voltage | | 14.4 | 15 | 15.6 | 17.3 | 18 | 18.7 | 19.2 | 20 | 20.8 | 23 | 24 | 25 | V |
| | | $I_O$ = 5 to 350 mA | 14.25 | 15<br>($V_i$ = 17.5 to 30V) | 15.75 | 17.1 | 18<br>($V_i$ = 20.5 to 33V) | 18.9 | 19 | 20<br>($V_i$ = 23 to 35V) | 21 | 22.8 | 24<br>($V_i$ = 27 to 38V) | 25.2 | V |
| $\Delta V_O$ | Line regulation | $I_O$ = 200 mA | | | 100<br>($V_i$ = 17.5 to 30V) | | | 100<br>($V_i$ = 21 to 33V) | | | 100<br>($V_i$ = 23 to 35V) | | | 100<br>($V_i$ = 27 to 38V) | mV |
| | | | | | 50<br>($V_i$ = 20 to 30V) | | | 50<br>($V_i$ = 24 to 33V) | | | 50<br>($V_i$ = 24 to 35V) | | | 50<br>($V_i$ = 28 to 38V) | mV |
| $\Delta V_O$ | Load regulation | $I_O$ = 5 mA to 0.5A | | | 300 | | | 360 | | | 400 | | | 480 | mV |
| | | $I_O$ = 5 mA to 200 mA | | | 150 | | | 180 | | | 200 | | | 240 | mV |
| $I_d$ | Quiescent current | | | | 6 | | | 6 | | | 6 | | | 6 | mA |
| $\Delta I_d$ | Quiescent current change | $I_O$ = 5 mA to 350 mA | | | 0.5 | | | 0.5 | | | 0.5 | | | 0.5 | mA |
| | | $I_O$ = 200 mA | | | 0.8<br>($V_i$ = 17.5 to 30V) | | | 0.8<br>($V_i$ = 21 to 33V) | | | 0.8<br>($V_i$ = 23 to 35V) | | | 0.8<br>($V_i$ = 27 to 38V) | mA |
| $\frac{\Delta V_O}{\Delta T}$ | Output voltage drift | $I_O$ = 5 mA<br>$T_{amb}$ = 0 to 125°C | | -1 | | | -1.1 | | | -1.1 | | | -1.2 | | mV/°C |
| $e_N$ | Output noise voltage | B = 10Hz to 100KHz | | 90 | | | 100 | | | 110 | | | 170 | | µV |
| SVR | Supply voltage rejection | f = 120 Hz<br>$I_O$ = 300 mA | 54<br>($V_i$ = 18.5 to 28.5V) | | | 53<br>($V_i$ = 22 to 32V) | | | 53<br>($V_i$ = 24 to 34V) | | | 50<br>($V_i$ = 28 to 38V) | | | dB |
| $V_d$ | Dropout Voltage | | | 2 | | | 2 | | | 2 | | | 2 | | V |
| $I_{sc}$ | Short circuit current | $V_i$ = 35V | | 240 | | | 240 | | | 240 | | | 240 | | mA |
| $I_{scp}$ | Short circ. peak current | | | 700 | | | 700 | | | 700 | | | 700 | | mA |

Fig. 4 - Dropout voltage vs. junction temperature

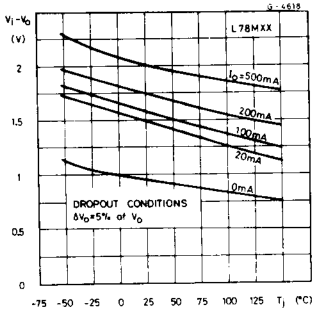



Fig. 5 - Dropout characteristics

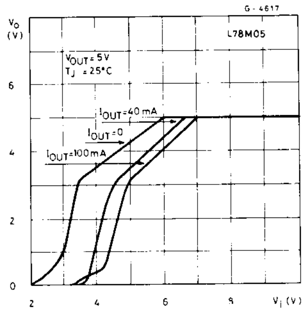



Fig. 6 - Peak output current vs. input-output differential voltage

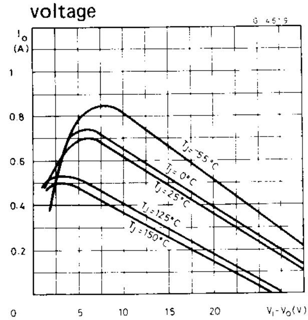



Fig. 7 - Output voltage vs. junction temperature

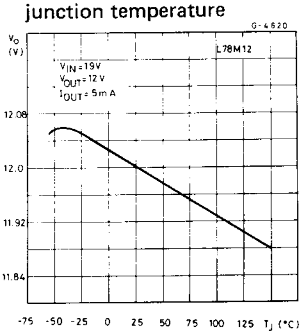



Fig. 8 - Supply voltage rejection vs. frequency

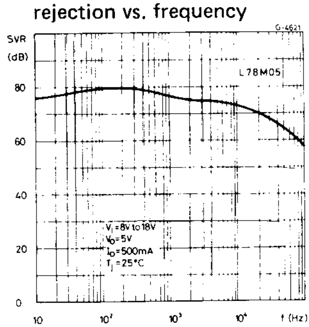



Fig. 9 - Quiescent current vs. junction temperature

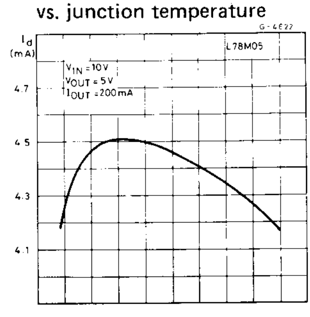



Fig. 10 - Load transient response

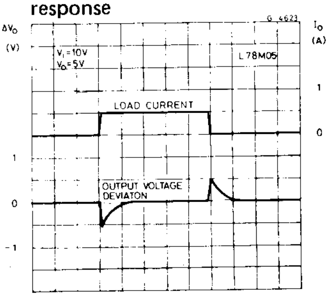



Fig. 11 - Line transient response

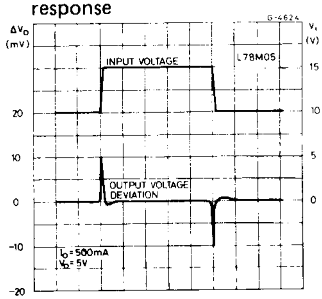
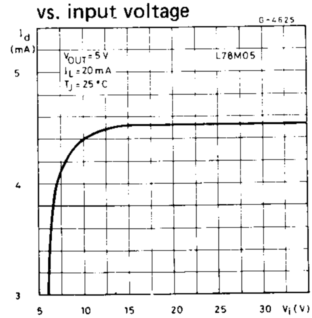
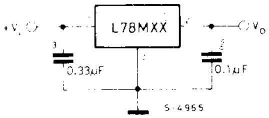



Fig. 12 - Quiescent current vs. input voltage



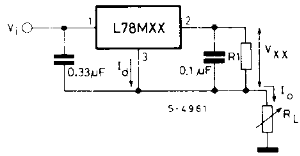
## APPLICATION INFORMATION (continued)

Fig. 13 - Fixed output regulator



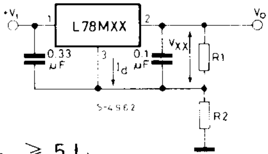

**Notes:**
(1) To specify an output voltage, substitute voltage value for "XX".
(2) Although no output capacitor is needed for stability, it does improve transient response.
(3) Required if regulator is located an appreciable distance from power supply filter.

Fig. 14 - Costant current regulator




$$I_o = \frac{V_{XX}}{R_1} + I_d$$

Fig. 15 - Circuit for increasing output voltage




$$I_{R_1} \geq 5\, I_d$$

$$V_o = V_{XX}\left(1 + \frac{R_2}{R_1}\right) + I_d R_2$$

Fig. 16 - Adjustable output regulator (7 to 30V)

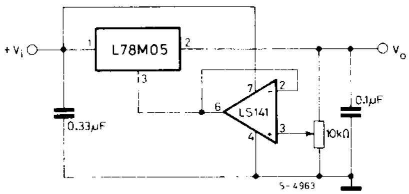
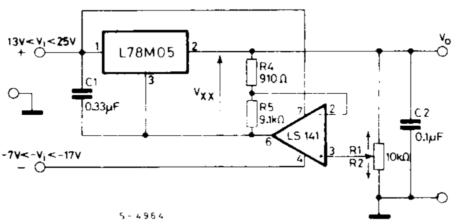
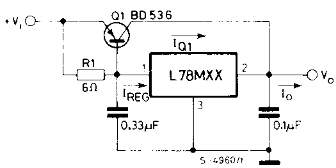



Fig. 17 - 0.5 to 10V regulator




$$V_o = V_{XX}\,\frac{R_4}{R_1}$$

Fig. 18 High current voltage regulator

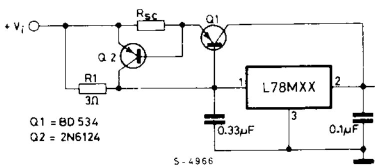



$$R_1 = \frac{V_{BEQ_1}}{I_{REG} - \dfrac{I_{Q_1}}{\beta_{Q_1}}}$$

$$I_o = I_{REG} + \beta_{Q_1}\left[I_{REG} - \frac{V_{BEQ_1}}{R_1}\right]$$

## APPLICATION INFORMATION (continued)

Fig. 19 - High output current with short circuit protection




$$R_{SC} = \frac{V_{BEQ_2}}{I_{SC}}$$

Fig. 20 - Tracking voltage regulator

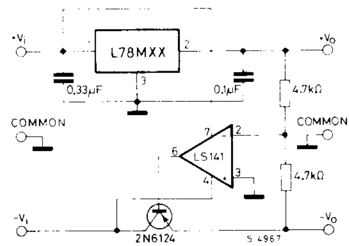
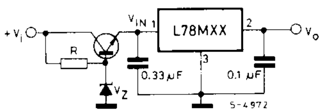
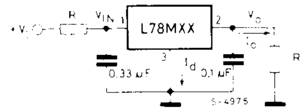



Fig. 21 - High input voltage circuit



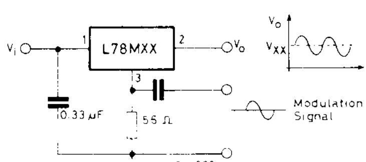

$$V_{IN} = V_Z - V_{BE}$$

Fig. 22 - Reducing power dissipation with dropping resistor



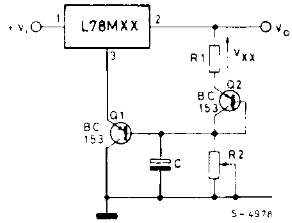

$$R = \frac{V_{i(min)} - V_{XX} - V_{DROP(max)}}{I_{o(max)} + I_{d(max)}}$$

Fig. 23 - Power AM modulator (unity voltage gain; $I_o \leqslant 0.5$)




Note: The circuit performs well up to 100 KHz.

Fig. 24 - Adjustable output voltage with temperature compensation




**Note:** $Q_2$ is connected as a diode in order to compensate the variation of the $Q_1$ $V_{BE}$ with the temperature. C allows a slow rise-time of the $V_o$

$$V_o = V_{XX}\left(1 + \frac{R_2}{R_1}\right) + V_{BE}$$