

# MC78M00, MC78M00A Series

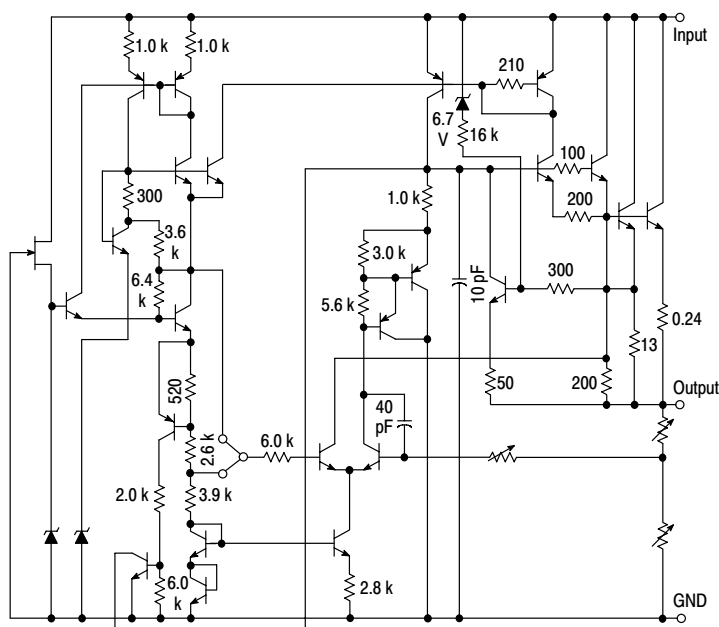
## 500 mA Positive Voltage Regulators

The MC78M00/MC78M00A Series positive voltage regulators are identical to the popular MC7800 Series devices, except that they are specified for only half the output current. Like the MC7800 devices, the MC78M00 three-terminal regulators are intended for local, on-card voltage regulation.

Internal current limiting, thermal shutdown circuitry and safe-area compensation for the internal pass transistor combine to make these devices remarkably rugged under most operating conditions. Maximum output current, with adequate heatsinking is 500 mA.

### Features

- No External Components Required
- Internal Thermal Overload Protection
- Internal Short Circuit Current Limiting
- Output Transistor Safe-Area Compensation
- MC78M00A High Accuracy ( $\pm 2\%$ )  
Available for 5.0 V, 8.0 V, 12 V and 15 V
- Pb-Free Packages are Available\*



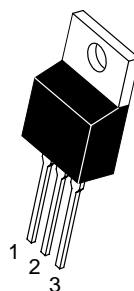
This device contains 28 active transistors.

Figure 1. Representative Schematic Diagram



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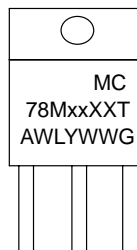
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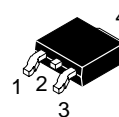
TO-220  
T SUFFIX  
CASE 221A

Heatsink surface  
connected to Pin 2.

### MARKING DIAGRAMS



xx = Voltage Option  
XX = Appropriate Suffix Options  
A = Assembly Location  
WL = Wafer Lot  
Y = Year  
WW = Work Week  
G = Pb-Free Package



DPAK-3  
DT SUFFIX  
CASE 369C

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



xxxxx = Device Type and Voltage Option Code  
A = Assembly Location  
L = Wafer Lot  
Y = Year  
WW = Work Week  
G = Pb-Free Package

Pin 1. Input  
2. Ground  
3. Output

### ORDERING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 10-14 of this data sheet.

### DEVICE MARKING INFORMATION

See general marking information in the device marking section on page 10 of this data sheet.

\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

## MC78M00, MC78M00A Series

### MAXIMUM RATINGS ( $T_A = 25^\circ\text{C}$ , unless otherwise noted) (Note 1)

Rating	Symbol	Value	Unit
Input Voltage (5.0 V–18 V) (20 V–24V)	$V_I$	35 40	Vdc
Power Dissipation (Package Limitation)			
Plastic Package, T Suffix			
$T_A = 25^\circ\text{C}$	$P_D$	Internally Limited	
Thermal Resistance, Junction–to–Air	$\theta_{JA}$	70	$^\circ\text{C/W}$
Thermal Resistance, Junction–to–Case	$\theta_{JC}$	5.0	$^\circ\text{C/W}$
Plastic Package, DT Suffix			
$T_A = 25^\circ\text{C}$	$P_D$	Internally Limited	
Thermal Resistance, Junction–to–Air	$\theta_{JA}$	92	$^\circ\text{C/W}$
Thermal Resistance, Junction–to–Case	$\theta_{JC}$	5.0	$^\circ\text{C/W}$
Operating Junction Temperature Range	$T_J$	+150	$^\circ\text{C}$
Storage Temperature Range	$T_{stg}$	–65 to +150	$^\circ\text{C}$

Maximum ratings are those values beyond which device damage can occur. Maximum ratings applied to the device are individual stress limit values (not normal operating conditions) and are not valid simultaneously. If these limits are exceeded, device functional operation is not implied, damage may occur and reliability may be affected.

1. This device series contains ESD protection and exceeds the following tests:

Human Body Model 2000 V per MIL–STD–883, Method 3015.

Machine Model Method 200 V.

### MC78M05C/AC/B/AB ELECTRICAL CHARACTERISTICS ( $V_I = 10\text{ V}$ , $I_O = 350\text{ mA}$ , $T_J = T_{low}$ to $T_{high}$ , $P_D \leq 5.0\text{ W}$ , unless otherwise noted) (Note 2)

Characteristics	Symbol	Min	Typ	Max	Unit
Output Voltage ( $T_J = 25^\circ\text{C}$ ) MC78M05C MC78M05AC	$V_O$	4.8 4.9	5.0 5.0	5.2 5.1	Vdc
Output Voltage Variation ( $7.0\text{ Vdc} \leq V_I \leq 20\text{ Vdc}$ , $5.0\text{ mA} \leq I_O \leq 350\text{ mA}$ ) MC78M05C MC78M05AC	$V_O$	4.75 4.80	– –	5.25 5.20	Vdc
Line Regulation ( $T_J = 25^\circ\text{C}$ , $7.0\text{ Vdc} \leq V_I \leq 25\text{ Vdc}$ , $I_O = 200\text{ mA}$ )	$Reg_{line}$	–	3.0	50	mV
Load Regulation ( $T_J = 25^\circ\text{C}$ , $5.0\text{ mA} \leq I_O \leq 500\text{ mA}$ ) ( $T_J = 25^\circ\text{C}$ , $5.0\text{ mA} \leq I_O \leq 200\text{ mA}$ )	$Reg_{load}$	– –	20 10	100 50	mV
Input Bias Current ( $T_J = 25^\circ\text{C}$ )	$I_{IB}$	–	3.2	6.0	mA
Quiescent Current Change ( $8.0\text{ Vdc} \leq V_I \leq 25\text{ Vdc}$ , $I_O = 200\text{ mA}$ ) ( $5.0\text{ mA} \leq I_O \leq 350\text{ mA}$ )	$\Delta I_{IB}$	– –	– –	0.8 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 ( $I_O = 100\text{ mA}$ , $f = 120\text{ Hz}$ , $8.0\text{ V} \leq V_I \leq 18\text{ V}$ ) ( $I_O = 300\text{ mA}$ , $f = 120\text{ Hz}$ , $8.0\text{ V} \leq V_I \leq 18\text{ V}$ , $T_J = 25^\circ\text{C}$ )	RR	62 62	– 80	– –	dB
Dropout Voltage ( $T_J = 25^\circ\text{C}$ )	$V_I - V_O$	–	2.0	–	Vdc
Short Circuit Current Limit ( $T_J = 25^\circ\text{C}$ , $V_I = 35\text{ V}$ )	$I_{OS}$	–	50	–	mA
Average Temperature Coefficient of Output Voltage ( $I_O = 5.0\text{ mA}$ )	$\Delta V_O / \Delta T$	–	$\pm 0.2$	–	$\text{mV}/^\circ\text{C}$
Peak Output Current ( $T_J = 25^\circ\text{C}$ )	$I_O$	–	700	–	mA

2.  $T_{low} = 0^\circ\text{C}$  for MC78MxxAC, C  
=  $-40^\circ\text{C}$  for MC78MxxAB, B

$T_{high} = +125^\circ\text{C}$  for MC78MxxAB, AC, B, C

## MC78M00, MC78M00A Series

### MC78M06C ELECTRICAL CHARACTERISTICS ( $V_I = 11\text{ V}$ , $I_O = 350\text{ mA}$ , $0^\circ\text{C} < T_J < 125^\circ\text{C}$ , $P_D \leq 5.0\text{ W}$ , 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
Output Voltage Variation ( $8.0\text{ Vdc} \leq V_I \leq 21\text{ Vdc}$ , $5.0\text{ mA} \leq I_O \leq 350\text{ mA}$ )	$V_O$	5.7	–	6.3	Vdc
Line Regulation ( $T_J = 25^\circ\text{C}$ , $8.0\text{ Vdc} \leq V_I \leq 25\text{ Vdc}$ , $I_O = 200\text{ mA}$ )	$\text{Reg}_{\text{line}}$	–	5.0	50	mV
Load Regulation ( $T_J = 25^\circ\text{C}$ , $5.0\text{ mA} \leq I_O \leq 500\text{ mA}$ ) ( $T_J = 25^\circ\text{C}$ , $5.0\text{ mA} \leq I_O \leq 200\text{ mA}$ )	$\text{Reg}_{\text{load}}$	– –	20 10	120 60	mV
Input Bias Current ( $T_J = 25^\circ\text{C}$ )	$I_{\text{IB}}$	–	3.2	6.0	mA
Quiescent Current Change ( $9.0\text{ Vdc} \leq V_I \leq 25\text{ Vdc}$ , $I_O = 200\text{ mA}$ ) ( $5.0\text{ mA} \leq I_O \leq 350\text{ mA}$ )	$\Delta I_{\text{IB}}$	– –	– –	0.8 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 ( $I_O = 100\text{ mA}$ , $f = 120\text{ Hz}$ , $9.0\text{ V} \leq V_I \leq 19\text{ V}$ ) ( $I_O = 300\text{ mA}$ , $f = 120\text{ Hz}$ , $9.0\text{ V} \leq V_I \leq 19\text{ V}$ , $T_J = 25^\circ\text{C}$ )	RR	59 59	– 80	– –	dB
Dropout Voltage ( $T_J = 25^\circ\text{C}$ )	$V_I - V_O$	–	2.0	–	Vdc
Short Circuit Current Limit ( $T_J = 25^\circ\text{C}$ , $V_I = 35\text{ V}$ )	$I_{\text{OS}}$	–	50	–	mA
Average Temperature Coefficient of Output Voltage ( $I_O = 5.0\text{ mA}$ )	$\Delta V_O / \Delta T$	–	$\pm 0.2$	–	$\text{mV}/^\circ\text{C}$
Peak Output Current ( $T_J = 25^\circ\text{C}$ )	$I_O$	–	700	–	mA

### MC78M08C/AC/B/AB ELECTRICAL CHARACTERISTICS ( $V_I = 14\text{ V}$ , $I_O = 350\text{ mA}$ , $T_J = T_{\text{low}}$ to $T_{\text{high}}$ , $P_D \leq 5.0\text{ W}$ , unless otherwise noted) (Note 3)

Characteristics	Symbol	Min	Typ	Max	Unit
Output Voltage ( $T_J = 25^\circ\text{C}$ ) MC78M08C MC78M08AC	$V_O$	7.70 7.84	8.0 8.0	8.30 8.16	Vdc
Output Voltage Variation ( $10.5\text{ Vdc} \leq V_I \leq 23\text{ Vdc}$ , $5.0\text{ mA} \leq I_O \leq 350\text{ mA}$ ) MC78M08C MC78M08AC	$V_O$	7.6 7.7	– –	8.4 8.3	Vdc
Line Regulation ( $T_J = 25^\circ\text{C}$ , $10.5\text{ Vdc} \leq V_I \leq 25\text{ Vdc}$ , $I_O = 200\text{ mA}$ )	$\text{Reg}_{\text{line}}$	–	6.0	50	mV
Load Regulation ( $T_J = 25^\circ\text{C}$ , $5.0\text{ mA} \leq I_O \leq 500\text{ mA}$ ) ( $T_J = 25^\circ\text{C}$ , $5.0\text{ mA} \leq I_O \leq 200\text{ mA}$ )	$\text{Reg}_{\text{load}}$	– –	25 10	160 80	mV
Input Bias Current ( $T_J = 25^\circ\text{C}$ )	$I_{\text{IB}}$	–	3.2	6.0	mA
Quiescent Current Change ( $10.5\text{ Vdc} \leq V_I \leq 25\text{ Vdc}$ , $I_O = 200\text{ mA}$ ) ( $5.0\text{ mA} \leq I_O \leq 350\text{ mA}$ )	$\Delta I_{\text{IB}}$	– –	– –	0.8 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 ( $I_O = 100\text{ mA}$ , $f = 120\text{ Hz}$ , $11.5\text{ V} \leq V_I \leq 21.5\text{ V}$ ) ( $I_O = 300\text{ mA}$ , $f = 120\text{ Hz}$ , $11.5\text{ V} \leq V_I \leq 21.5\text{ V}$ , $T_J = 25^\circ\text{C}$ )	RR	56 56	– 80	– –	dB
Dropout Voltage ( $T_J = 25^\circ\text{C}$ )	$V_I - V_O$	–	2.0	–	Vdc
Short Circuit Current Limit ( $T_J = 25^\circ\text{C}$ , $V_I = 35\text{ V}$ )	$I_{\text{OS}}$	–	50	–	mA
Average Temperature Coefficient of Output Voltage ( $I_O = 5.0\text{ mA}$ )	$\Delta V_O / \Delta T$	–	$\pm 0.2$	–	$\text{mV}/^\circ\text{C}$
Peak Output Current ( $T_J = 25^\circ\text{C}$ )	$I_O$	–	700	–	mA

3.  $T_{\text{low}} = 0^\circ\text{C}$  for MC78MxxAC, C  
=  $-40^\circ\text{C}$  for MC78MxxAB, B

$T_{\text{high}} = +125^\circ\text{C}$  for MC78MxxAB, AC, B, C

## MC78M00, MC78M00A Series

**MC78M09C/B ELECTRICAL CHARACTERISTICS** ( $V_I = 15\text{ V}$ ,  $I_O = 350\text{ mA}$ ,  $T_J = T_{\text{low}}$  to  $T_{\text{high}}$ ,  $P_D \leq 5.0\text{ W}$ , unless otherwise noted) (Note 4)

Characteristics	Symbol	Min	Typ	Max	Unit
Output Voltage ( $T_J = 25^\circ\text{C}$ )	$V_O$	8.64	9.0	9.45	Vdc
Output Voltage Variation ( $11.5\text{ Vdc} \leq V_I \leq 23\text{ Vdc}$ , $5.0\text{ mA} \leq I_O \leq 350\text{ mA}$ )	$V_O$	8.55	–	9.45	Vdc
Line Regulation ( $T_J = 25^\circ\text{C}$ , $11.5\text{ Vdc} \leq V_I \leq 25\text{ Vdc}$ , $I_O = 200\text{ mA}$ )	$\text{Reg}_{\text{line}}$	–	6.0	50	mV
Load Regulation ( $T_J = 25^\circ\text{C}$ , $5.0\text{ mA} \leq I_O \leq 500\text{ mA}$ ) ( $T_J = 25^\circ\text{C}$ , $5.0\text{ mA} \leq I_O \leq 200\text{ mA}$ )	$\text{Reg}_{\text{load}}$	–	25 10	180 90	mV
Input Bias Current ( $T_J = 25^\circ\text{C}$ )	$I_{\text{IB}}$	–	3.2	6.0	mA
Quiescent Current Change ( $11.5\text{ Vdc} \leq V_I \leq 25\text{ Vdc}$ , $I_O = 200\text{ mA}$ ) ( $5.0\text{ mA} \leq I_O \leq 350\text{ mA}$ )	$\Delta I_{\text{IB}}$	–	–	0.8 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 ( $I_O = 100\text{ mA}$ , $f = 120\text{ Hz}$ , $12.5\text{ V} \leq V_I \leq 22.5\text{ V}$ ) ( $I_O = 300\text{ mA}$ , $f = 120\text{ Hz}$ , $12.5\text{ V} \leq V_I \leq 22.5\text{ V}$ , $T_J = 25^\circ\text{C}$ )	RR	56 56	– 80	–	dB
Dropout Voltage ( $T_J = 25^\circ\text{C}$ )	$V_I - V_O$	–	2.0	–	Vdc
Short Circuit Current Limit ( $T_J = 25^\circ\text{C}$ , $V_I = 35\text{ V}$ )	$I_{\text{OS}}$	–	50	–	mA
Average Temperature Coefficient of Output Voltage ( $I_O = 5.0\text{ mA}$ )	$\Delta V_O / \Delta T$	–	$\pm 0.2$	–	$\text{mV}/^\circ\text{C}$
Peak Output Current ( $T_J = 25^\circ\text{C}$ )	$I_O$	–	700	–	mA

**MC78M12C/AC/B/AB ELECTRICAL CHARACTERISTICS** ( $V_I = 19\text{ V}$ ,  $I_O = 350\text{ mA}$ ,  $T_J = T_{\text{low}}$  to  $T_{\text{high}}$ ,  $P_D \leq 5.0\text{ W}$ , unless otherwise noted) (Note 4)

Characteristics	Symbol	Min	Typ	Max	Unit
Output Voltage ( $T_J = 25^\circ\text{C}$ ) MC78M12C MC78M12AC	$V_O$	11.50 11.76	12 12	12.50 12.24	Vdc
Output Voltage Variation ( $14.5\text{ Vdc} \leq V_I \leq 27\text{ Vdc}$ , $5.0\text{ mA} \leq I_O \leq 350\text{ mA}$ ) MC78M12C MC78M12AC	$V_O$	11.4 11.5	– –	12.6 12.5	Vdc
Line Regulation ( $T_J = 25^\circ\text{C}$ , $14.5\text{ Vdc} \leq V_I \leq 30\text{ Vdc}$ , $I_O = 200\text{ mA}$ )	$\text{Reg}_{\text{line}}$	–	8.0	50	mV
Load Regulation ( $T_J = 25^\circ\text{C}$ , $5.0\text{ mA} \leq I_O \leq 500\text{ mA}$ ) ( $T_J = 25^\circ\text{C}$ , $5.0\text{ mA} \leq I_O \leq 200\text{ mA}$ )	$\text{Reg}_{\text{load}}$	–	25 10	240 120	mV
Input Bias Current ( $T_J = 25^\circ\text{C}$ )	$I_{\text{IB}}$	–	3.2	6.0	mA
Quiescent Current Change ( $14.5\text{ Vdc} \leq V_I \leq 30\text{ Vdc}$ , $I_O = 200\text{ mA}$ ) ( $5.0\text{ mA} \leq I_O \leq 350\text{ mA}$ )	$\Delta I_{\text{IB}}$	–	–	0.8 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 ( $I_O = 100\text{ mA}$ , $f = 120\text{ Hz}$ , $15\text{ V} \leq V_I \leq 25\text{ V}$ ) ( $I_O = 300\text{ mA}$ , $f = 120\text{ Hz}$ , $15\text{ V} \leq V_I \leq 25\text{ V}$ , $T_J = 25^\circ\text{C}$ )	RR	55 55	– 80	–	dB
Dropout Voltage ( $T_J = 25^\circ\text{C}$ )	$V_I - V_O$	–	2.0	–	Vdc
Short Circuit Current Limit ( $T_J = 25^\circ\text{C}$ , $V_I = 35\text{ V}$ )	$I_{\text{OS}}$	–	50	–	mA
Average Temperature Coefficient of Output Voltage ( $I_O = 5.0\text{ mA}$ )	$\Delta V_O / \Delta T$	–	$\pm 0.3$	–	$\text{mV}/^\circ\text{C}$
Peak Output Current ( $T_J = 25^\circ\text{C}$ )	$I_O$	–	700	–	mA

4.  $T_{\text{low}} = 0^\circ\text{C}$  for MC78MxxAC, C  
=  $-40^\circ\text{C}$  for MC78MxxAB, B

$T_{\text{high}} = +125^\circ\text{C}$  for MC78MxxAB, AC, B, C

## MC78M00, MC78M00A Series

**MC78M15C/AC/B/AB ELECTRICAL CHARACTERISTICS** ( $V_I = 23\text{ V}$ ,  $I_O = 350\text{ mA}$ ,  $T_J = T_{low}$  to  $T_{high}$ ,  $P_D \leq 5.0\text{ W}$ , unless otherwise noted) (Note 5)

Characteristics	Symbol	Min	Typ	Max	Unit
Output Voltage ( $T_J = 25^\circ\text{C}$ ) MC78M15C MC78M15AC	$V_O$	14.4 14.7	15 15	15.6 15.3	Vdc
Output Voltage Variation ( $17.5\text{ Vdc} \leq V_I \leq 30\text{ Vdc}$ , $5.0\text{ mA} \leq I_O \leq 350\text{ mA}$ ) MC78M15C MC78M15AC	$V_O$	14.25 14.40	– –	15.75 15.60	Vdc
Input Regulation ( $T_J = 25^\circ\text{C}$ , $17.5\text{ Vdc} \leq V_I \leq 30\text{ Vdc}$ , $I_O = 200\text{ mA}$ )	$Reg_{line}$	–	10	50	mV
Load Regulation ( $T_J = 25^\circ\text{C}$ , $5.0\text{ mA} \leq I_O \leq 500\text{ mA}$ ) ( $T_J = 25^\circ\text{C}$ , $5.0\text{ mA} \leq I_O \leq 200\text{ mA}$ )	$Reg_{load}$	– –	25 10	300 150	mV
Input Bias Current ( $T_J = 25^\circ\text{C}$ )	$I_{IB}$	–	3.2	6.0	mA
Quiescent Current Change ( $17.5\text{ Vdc} \leq V_I \leq 30\text{ Vdc}$ , $I_O = 200\text{ mA}$ ) ( $5.0\text{ mA} \leq I_O \leq 350\text{ mA}$ )	$\Delta I_{IB}$	– –	– –	0.8 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 ( $I_O = 100\text{ mA}$ , $f = 120\text{ Hz}$ , $18.5\text{ V} \leq V_I \leq 28.5\text{ V}$ ) ( $I_O = 300\text{ mA}$ , $f = 120\text{ Hz}$ , $18.5\text{ V} \leq V_I \leq 28.5\text{ V}$ , $T_J = 25^\circ\text{C}$ )	RR	54 54	– 70	– –	dB
Dropout Voltage ( $T_J = 25^\circ\text{C}$ )	$V_I - V_O$	–	2.0	–	Vdc
Short Circuit Current Limit ( $T_J = 25^\circ\text{C}$ , $V_I = 35\text{ V}$ )	$I_{OS}$	–	50	–	mA
Average Temperature Coefficient of Output Voltage ( $I_O = 5.0\text{ mA}$ )	$\Delta V_O / \Delta T$	–	$\pm 0.3$	–	$\text{mV}/^\circ\text{C}$
Peak Output Current ( $T_J = 25^\circ\text{C}$ )	$I_O$	–	700	–	mA

**MC78M18C/B ELECTRICAL CHARACTERISTICS** ( $V_I = 27\text{ V}$ ,  $I_O = 350\text{ mA}$ ,  $T_J = T_{low}$  to  $T_{high}$ ,  $P_D \leq 5.0\text{ W}$ , unless otherwise noted) (Note 5)

Characteristics	Symbol	Min	Typ	Max	Unit
Output Voltage ( $T_J = 25^\circ\text{C}$ )	$V_O$	17.3	18	18.7	Vdc
Output Voltage Variation ( $21\text{ Vdc} \leq V_I \leq 33\text{ Vdc}$ , $5.0\text{ mA} \leq I_O \leq 350\text{ mA}$ )	$V_O$	17.1	–	18.9	Vdc
Line Regulation ( $T_J = 25^\circ\text{C}$ , $21\text{ Vdc} \leq V_I \leq 33\text{ Vdc}$ , $I_O = 200\text{ mA}$ )	$Reg_{line}$	–	10	50	mV
Load Regulation ( $T_J = 25^\circ\text{C}$ , $5.0\text{ mA} \leq I_O \leq 500\text{ mA}$ ) ( $T_J = 25^\circ\text{C}$ , $5.0\text{ mA} \leq I_O \leq 200\text{ mA}$ )	$Reg_{load}$	– –	30 10	360 180	mV
Input Bias Current ( $T_J = 25^\circ\text{C}$ )	$I_{IB}$	–	3.2	6.5	mA
Quiescent Current Change ( $21\text{ Vdc} \leq V_I \leq 33\text{ Vdc}$ , $I_O = 200\text{ mA}$ ) ( $5.0\text{ mA} \leq I_O \leq 350\text{ mA}$ )	$\Delta I_{IB}$	– –	– –	0.8 0.5	mA
Output Noise Voltage ( $T_A = 25^\circ\text{C}$ , $10\text{ Hz} \leq f \leq 100\text{ kHz}$ )	$V_n$	–	100	–	$\mu\text{V}$
Ripple Rejection ( $I_O = 100\text{ mA}$ , $f = 120\text{ Hz}$ , $22\text{ V} \leq V_I \leq 32\text{ V}$ ) ( $I_O = 300\text{ mA}$ , $f = 120\text{ Hz}$ , $22\text{ V} \leq V_I \leq 32\text{ V}$ , $T_J = 25^\circ\text{C}$ )	RR	53 53	– 70	– –	dB
Dropout Voltage ( $T_J = 25^\circ\text{C}$ )	$V_I - V_O$	–	2.0	–	Vdc
Short Circuit Current Limit ( $T_J = 25^\circ\text{C}$ , $V_I = 35\text{ V}$ )	$I_{OS}$	–	50	–	mA
Average Temperature Coefficient of Output Voltage ( $I_O = 5.0\text{ mA}$ )	$\Delta V_O / \Delta T$	–	$\pm 0.3$	–	$\text{mV}/^\circ\text{C}$
Peak Output Current ( $T_J = 25^\circ\text{C}$ )	$I_O$	–	700	–	mA

5.  $T_{low} = 0^\circ\text{C}$  for MC78MxxAC, C  
=  $-40^\circ\text{C}$  for MC78MxxAB, B

$T_{high} = +125^\circ\text{C}$  for MC78MxxAB, AC, B, C

## MC78M00, MC78M00A Series

**MC78M20C/B ELECTRICAL CHARACTERISTICS** ( $V_I = 29\text{ V}$ ,  $I_O = 350\text{ mA}$ ,  $T_J = T_{\text{low}}$  to  $T_{\text{high}}$ ,  $P_D \leq 5.0\text{ W}$ , unless otherwise noted) (Note 6)

Characteristics	Symbol	Min	Typ	Max	Unit
Output Voltage ( $T_J = 25^\circ\text{C}$ )	$V_O$	19.2	20	20.8	Vdc
Output Voltage Variation ( $23\text{ Vdc} \leq V_I \leq 35\text{ Vdc}$ , $5.0\text{ mA} \leq I_O \leq 350\text{ mA}$ )	$V_O$	19	–	21	Vdc
Line Regulation ( $T_J = 25^\circ\text{C}$ , $23\text{ Vdc} \leq V_I \leq 35\text{ Vdc}$ , $I_O = 200\text{ mA}$ )	$\text{Reg}_{\text{line}}$	–	10	50	mV
Load Regulation ( $T_J = 25^\circ\text{C}$ , $5.0\text{ mA} \leq I_O \leq 500\text{ mA}$ ) ( $T_J = 25^\circ\text{C}$ , $5.0\text{ mA} \leq I_O \leq 200\text{ mA}$ )	$\text{Reg}_{\text{load}}$	– –	30 10	400 200	mV
Input Bias Current ( $T_J = 25^\circ\text{C}$ )	$I_{\text{IB}}$	–	3.2	6.5	mA
Quiescent Current Change ( $23\text{ Vdc} \leq V_I \leq 35\text{ Vdc}$ , $I_O = 200\text{ mA}$ ) ( $5.0\text{ mA} \leq I_O \leq 350\text{ mA}$ )	$\Delta I_{\text{IB}}$	– –	– –	0.8 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 ( $I_O = 100\text{ mA}$ , $f = 120\text{ Hz}$ , $24\text{ V} \leq V_I \leq 34\text{ V}$ ) ( $I_O = 300\text{ mA}$ , $f = 120\text{ Hz}$ , $24\text{ V} \leq V_I \leq 34\text{ V}$ , $T_J = 25^\circ\text{C}$ )	RR	52 52	– 70	– –	dB
Dropout Voltage ( $T_J = 25^\circ\text{C}$ )	$V_I - V_O$	–	2.0	–	Vdc
Short Circuit Current Limit ( $T_J = 25^\circ\text{C}$ , $V_I = 35\text{ V}$ )	$I_{\text{OS}}$	–	50	–	mA
Average Temperature Coefficient of Output Voltage ( $I_O = 5.0\text{ mA}$ )	$\Delta V_O / \Delta T$	–	$\pm 0.5$	–	$\text{mV}/^\circ\text{C}$
Peak Output Current ( $T_J = 25^\circ\text{C}$ )	$I_O$	–	700	–	mA

**MC78M24C/B ELECTRICAL CHARACTERISTICS** ( $V_I = 33\text{ V}$ ,  $I_O = 350\text{ mA}$ ,  $T_J = T_{\text{low}}$  to  $T_{\text{high}}$ ,  $P_D \leq 5.0\text{ W}$ , unless otherwise noted) (Note 6)

Characteristics	Symbol	Min	Typ	Max	Unit
Output Voltage ( $T_J = 25^\circ\text{C}$ )	$V_O$	23	24	25	Vdc
Output Voltage Variation ( $27\text{ Vdc} \leq V_I \leq 38\text{ Vdc}$ , $5.0\text{ mA} \leq I_O \leq 350\text{ mA}$ )	$V_O$	22.8	–	25.2	Vdc
Line Regulation ( $T_J = 25^\circ\text{C}$ , $27\text{ Vdc} \leq V_I \leq 38\text{ Vdc}$ , $I_O = 200\text{ mA}$ )	$\text{Reg}_{\text{line}}$	–	10	50	mV
Load Regulation ( $T_J = 25^\circ\text{C}$ , $5.0\text{ mA} \leq I_O \leq 500\text{ mA}$ ) ( $T_J = 25^\circ\text{C}$ , $5.0\text{ mA} \leq I_O \leq 200\text{ mA}$ )	$\text{Reg}_{\text{load}}$	– –	30 10	480 240	mV
Input Bias Current ( $T_J = 25^\circ\text{C}$ )	$I_{\text{IB}}$	–	3.2	7.0	mA
Quiescent Current Change ( $27\text{ Vdc} \leq V_I \leq 38\text{ Vdc}$ , $I_O = 200\text{ mA}$ ) ( $5.0\text{ mA} \leq I_O \leq 350\text{ mA}$ )	$\Delta I_{\text{IB}}$	– –	– –	0.8 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 ( $I_O = 100\text{ mA}$ , $f = 120\text{ Hz}$ , $28\text{ V} \leq V_I \leq 38\text{ V}$ ) ( $I_O = 300\text{ mA}$ , $f = 120\text{ Hz}$ , $28\text{ V} \leq V_I \leq 38\text{ V}$ , $T_J = 25^\circ\text{C}$ )	RR	50 50	– 70	– –	dB
Dropout Voltage ( $T_J = 25^\circ\text{C}$ )	$V_I - V_O$	–	2.0	–	Vdc
Short Circuit Current Limit ( $T_J = 25^\circ\text{C}$ )	$I_{\text{OS}}$	–	50	–	mA
Average Temperature Coefficient of Output Voltage ( $I_O = 5.0\text{ mA}$ )	$\Delta V_O / \Delta T$	–	$\pm 0.5$	–	$\text{mV}/^\circ\text{C}$
Peak Output Current ( $T_J = 25^\circ\text{C}$ )	$I_O$	–	700	–	mA

6.  $T_{\text{low}} = 0^\circ\text{C}$  for MC78MxxAC, C  
=  $-40^\circ\text{C}$  for MC78MxxAB, B

$T_{\text{high}} = +125^\circ\text{C}$  for MC78MxxAB, AC, B, C

# MC78M00, MC78M00A Series

## 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.

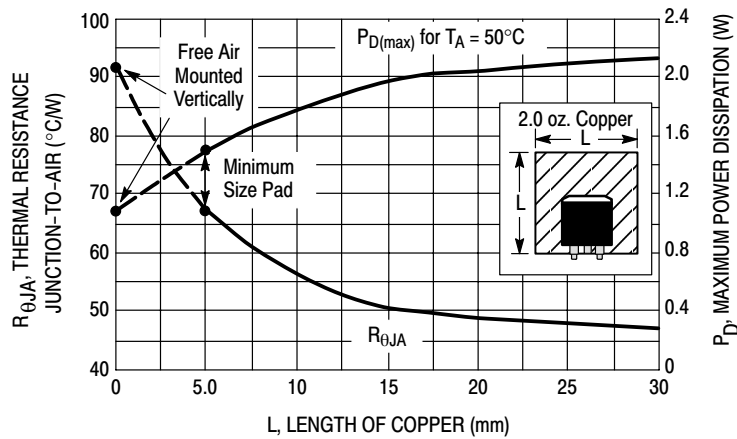
**Load Regulation** – The change in output voltage for a change in load current at constant chip temperature.

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

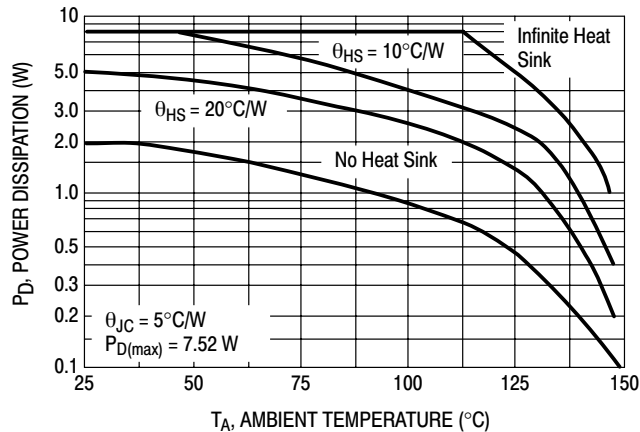
**Input Bias Current** – That part of the input current that is not delivered to the load.

**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.

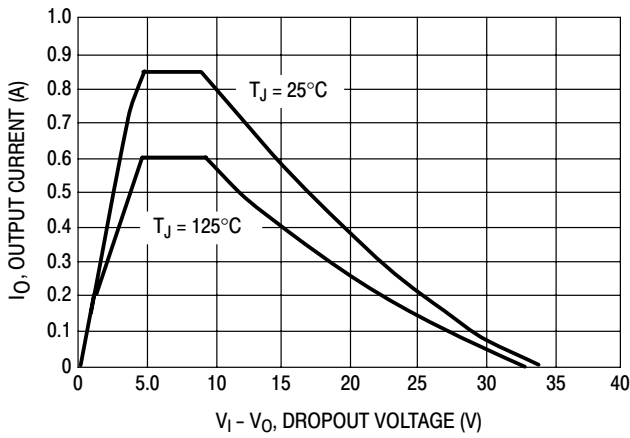


**Figure 2. DPAK Thermal Resistance and Maximum Power Dissipation versus P.C.B. Copper Length**

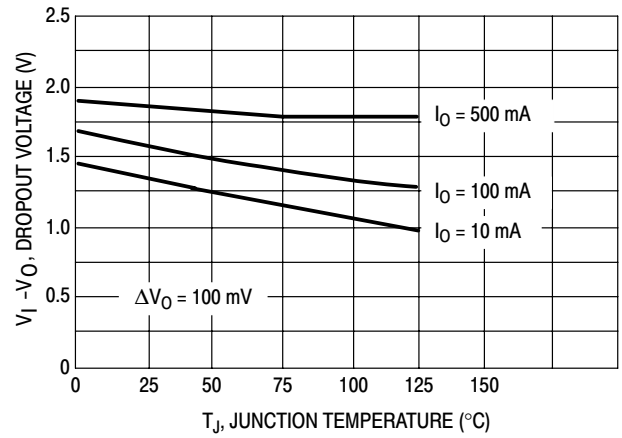


**Figure 3. Worst Case Power Dissipation versus Ambient Temperature (TO-220)**

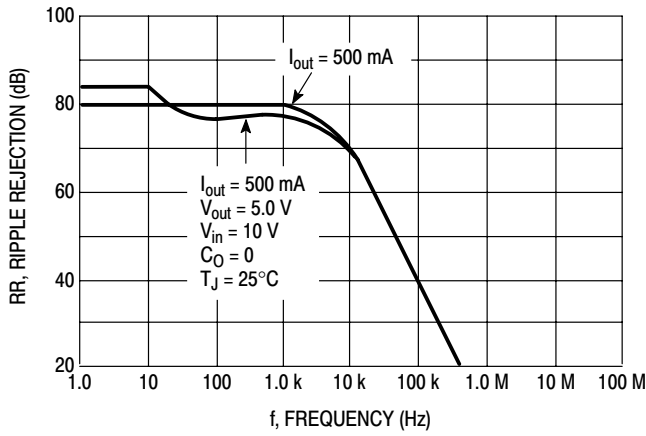
# MC78M00, MC78M00A Series



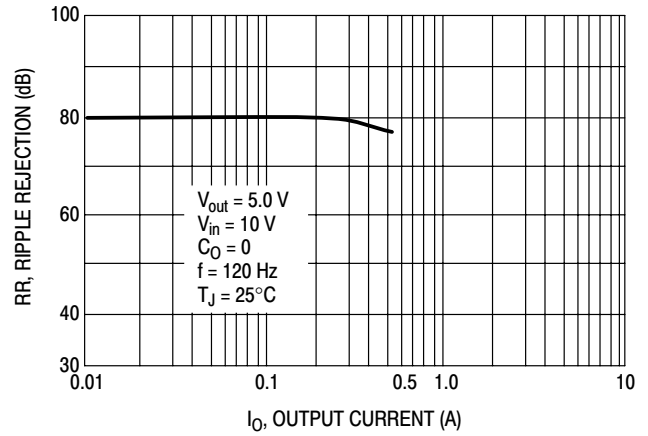
**Figure 4. Peak Output Current versus Dropout Voltage**



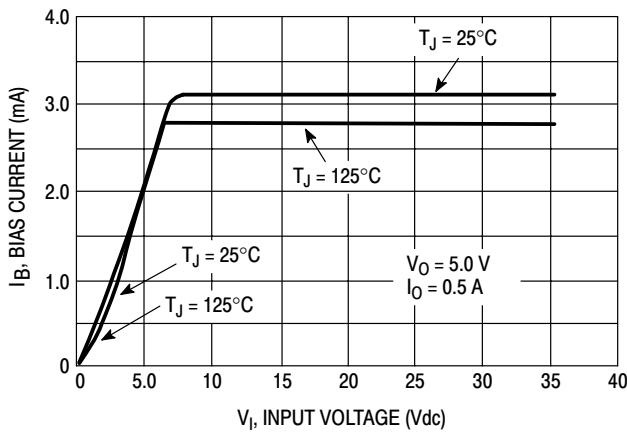
**Figure 5. Dropout Voltage versus Junction Temperature**



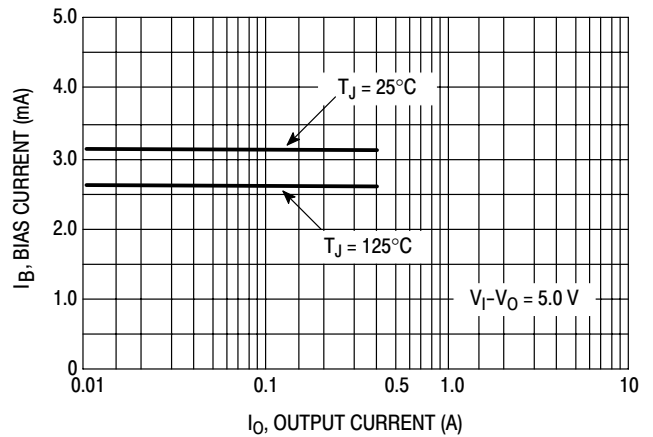
**Figure 6. Ripple Rejection versus Frequency**



**Figure 7. Ripple Rejection versus Output Current**



**Figure 8. Bias Current versus Input Voltage**



**Figure 9. Bias Current versus Output Current**





## MC78M00, MC78M00A Series

### ORDERING INFORMATION

Device	Output Voltage	Temperature Range	Package	Marking	Shipping <sup>†</sup>
MC78M05CDT	5.0 V	$T_J = 0^\circ \text{ to } +125^\circ\text{C}$	DPAK-3	78M05	75 Units / Rail
MC78M05CDTG			DPAK-3 (Pb-Free)	78M05	
MC78M05CDTRK			DPAK-3	78M05	2500 Units / Tape & Reel
MC78M05CDTRKG			DPAK-3 (Pb-Free)	78M05	
MC78M05ACDT			DPAK-3	8M05D	75 Units / Rail
MC78M05ACDTG			DPAK-3 (Pb-Free)	8M05D	
MC78M05ACDTRK			DPAK-3	8M05D	2500 Units / Tape & Reel
MC78M05ACDTRKG			DPAK-3 (Pb-Free)	8M05D	
MC78M05CT			TO-220	78M05CT	50 Units / Rail
MC78M05CTG			TO-220 (Pb-Free)	78M05CT	
MC78M05ACT			TO-220	78M05ACT	50 Units / Rail
MC78M05ACTG			TO-220 (Pb-Free)	78M05ACT	
MC78M05ABDT		$T_J = -40^\circ \text{ to } +125^\circ\text{C}$	DPAK-3	8M05A	75 Units / Rail
MC78M05ABDTG			DPAK-3 (Pb-Free)	8M05A	
MC78M05ABDTRK			DPAK-3	8M05A	2500 Units / Tape & Reel
MC78M05ABDTRKG			DPAK-3 (Pb-Free)	8M05A	
MC78M05ABT			TO-220	78M05ABT	50 Units / Rail
MC78M05ABTG			TO-220 (Pb-Free)	78M05ABT	
MC78M05BDT			DPAK-3	8M05B	75 Units / Rail
MC78M05BDTG			DPAK-3 (Pb-Free)	8M05B	
MC78M05BDTRK	DPAK-3		8M05B	2500 Units / Tape & Reel	
MC78M05BDTRKG	DPAK-3 (Pb-Free)		8M05B		
MC78M05BT	TO-220		78M05BT	50 Units / Rail	
MC78M05BTG	TO-220 (Pb-Free)		78M05BT		

<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

## MC78M00, MC78M00A Series

### ORDERING INFORMATION

Device	Output Voltage	Temperature Range	Package	Marking	Shipping <sup>†</sup>		
MC78M06CDT	6.0 V	T <sub>J</sub> = 0° to +125°C	DPAK-3	78M06	75 Units / Rail		
MC78M06CDTG			DPAK-3 (Pb-Free)	78M06			
MC78M06CDTRK			DPAK-3	78M06	2500 Units / Tape & Reel		
MC78M06CDTRKG			DPAK-3 (Pb-Free)	78M06			
MC78M06CT		T <sub>J</sub> = -40° to +125°C		TO-220	78M06CT	50 Units / Rail	
MC78M06CTG				TO-220 (Pb-Free)	78M06CT		
MC78M06BT				TO-220	78M06BT		
MC78M06BTG				TO-220 (Pb-Free)	78M06BT		
MC78M08CDT	8.0 V			T <sub>J</sub> = 0° to +125°C	DPAK-3	78M08	75 Units / Rail
MC78M08CDTG					DPAK-3 (Pb-Free)	78M08	
MC78M08CDTRK		DPAK-3	78M08		2500 Units / Tape & Reel		
MC78M08CDTRKG		DPAK-3 (Pb-Free)	78M08				
MC78M08ACDT		DPAK-3	8M08D		75 Units / Rail		
MC78M08ACDTG		DPAK-3 (Pb-Free)	8M08D				
MC78M08ACDTRK		DPAK-3	8M08D		2500 Units / Tape & Reel		
MC78M08ACDTRKG		DPAK-3 (Pb-Free)	8M08D				
MC78M08CT		TO-220	78M08CT		50 Units / Rail		
MC78M08CTG		TO-220 (Pb-Free)	78M08CT				
MC78M08ACT		TO-220	78M08ACT				
MC78M08ACTG		TO-220 (Pb-Free)	78M08ACT				
MC78M08ABDT		T <sub>J</sub> = -40° to +125°C		DPAK-3	8M08A	75 Units / Rail	
MC78M08ABDTG				DPAK-3	8M08A		
MC78M08ABDTRK				DPAK-3	8M08A	2500 Units / Tape & Reel	
MC78M08ABDTRKG				DPAK-3 (Pb-Free)	8M08A		
MC78M08ABT				TO-220	78M08ABT	50 Units / Rail	
MC78M08ABTG				TO-220 (Pb-Free)	78M08ABT		
MC78M08BDT	DPAK-3			8M08B	75 Units / Rail		
MC78M08BDTG	DPAK-3 (Pb-Free)			8M08B			
MC78M08BDTRK	DPAK-3			8M08B	2500 Units / Tape & Reel		
MC78M08BDTRKG	DPAK-3 (Pb-Free)			8M08B			
MC78M08BT	TO-220			78M08BT	50 Units / Rail		
MC78M08BTG	TO-220 (Pb-Free)			78M08BT			

<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

## MC78M00, MC78M00A Series

### ORDERING INFORMATION

Device	Output Voltage	Temperature Range	Package	Marking	Shipping <sup>†</sup>
MC78M09CDT	9.0 V	$T_J = 0^\circ \text{ to } +125^\circ\text{C}$	DPAK-3	78M09	75 Units / Rail
MC78M09CDTG			DPAK-3 (Pb-Free)	78M09	75 Units / Rail
MC78M09CDTRK			DPAK-3	78M09	2500 Units / Tape & Reel
MC78M09CDTRKG			DPAK-3 (Pb-Free)	78M09	2500 Units / Tape & Reel
MC78M09CT			TO-220	78M09CT	50 Units / Rail
MC78M09CTG			TO-220 (Pb-Free)	78M09CT	50 Units / Rail
MC78M09BDT		$T_J = -40^\circ \text{ to } +125^\circ\text{C}$	DPAK-3	8M09B	75 Units / Rail
MC78M09BDTG			DPAK-3 (Pb-Free)	8M09B	75 Units / Rail
MC78M09BDTRK			DPAK-3	8M09B	2500 Units / Tape & Reel
MC78M09BDTRKG			DPAK-3 (Pb-Free)	8M09B	2500 Units / Tape & Reel
MC78M12CDT	12 V	$T_J = 0^\circ \text{ to } +125^\circ\text{C}$	DPAK-3	78M12	75 Units / Rail
MC78M12CDTG			DPAK-3 (Pb-Free)	78M12	
MC78M12CDTRK			DPAK-3	78M12	2500 Units / Tape & Reel
MC78M12CDTRKG			DPAK-3 (Pb-Free)	78M12	
MC78M12ACDT			DPAK-3	8M12D	75 Units / Rail
MC78M12ACDTG			DPAK-3 (Pb-Free)	8M12D	
MC78M12ACDTRK			DPAK-3	8M12D	2500 Units / Tape & Reel
MC78M12ACDTRKG			DPAK-3 (Pb-Free)	8M12D	
MC78M12CT			TO-220	78M12CT	50 Units / Rail
MC78M12CTG			TO-220	78M12CT	
MC78M12ACT		TO-220	78M12ACT		
MC78M12ACTG		TO-220 (Pb-Free)	78M12ACT		
MC78M12ABDT		$T_J = -40^\circ \text{ to } +125^\circ\text{C}$	DPAK-3	8M12A	75 Units / Rail
MC78M12ABDTG			DPAK-3 (Pb-Free)	8M12A	
MC78M12ABDTRK			DPAK-3	8M12A	2500 Units / Tape & Reel
MC78M12ABDTRKG			DPAK-3 (Pb-Free)	8M12A	
MC78M12ABT			TO-220	78M12ABT	50 Units / Rail
MC78M12ABTG			TO-220 (Pb-Free)	78M12ABT	
MC78M12BDT			DPAK-3	8M12B	75 Units / Rail
MC78M12BDTG			DPAK-3 (Pb-Free)	8M12B	
MC78M12BDTRK	DPAK-3		8M12B	2500 Units / Tape & Reel	
MC78M12BDTRKG	DPAK-3 (Pb-Free)		8M12B		
MC78M12BT	TO-220		78M12BT	50 Units / Rail	
MC78M12BTG	TO-220 (Pb-Free)		78M12BT		

<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

## MC78M00, MC78M00A Series

### ORDERING INFORMATION

Device	Output Voltage	Temperature Range	Package	Marking	Shipping <sup>†</sup>	
MC78M15CDT	15 V	$T_J = 0^\circ \text{ to } +125^\circ\text{C}$	DPAK-3	78M15	75 Units / Rail	
MC78M15CDTG			DPAK-3 (Pb-Free)	78M15		
MC78M15CDTRK			DPAK-3	78M15	2500 Units / Tape & Reel	
MC78M15CDTRKG			DPAK-3 (Pb-Free)	78M15		
MC78M15ACDT			DPAK-3	8M15D	75 Units / Rail	
MC78M15ACDTG			DPAK-3 (Pb-Free)	8M15D		
MC78M15ACDTRK			DPAK-3	8M15D	2500 Units / Tape & Reel	
MC78M15ACDTRKG			DPAK-3 (Pb-Free)	8M15D		
MC78M15CT			TO-220	78M15CT	50 Units / Rail	
MC78M15CTG			TO-220 (Pb-Free)	78M15CT		
MC78M15ACT			TO-220	78M15ACT		
MC78M15ACTG			TO-220 (Pb-Free)	78M15ACT		
MC78M15ABDT		$T_J = -40^\circ \text{ to } +125^\circ\text{C}$		DPAK-3	8M15A	75 Units / Rail
MC78M15ABDTG				DPAK-3 (Pb-Free)	8M15A	
MC78M15ABDTRK				DPAK-3	8M15A	2500 Units / Tape & Reel
MC78M15ABDTRKG				DPAK-3 (Pb-Free)	8M15A	
MC78M15ABT				TO-220	78M15ABT	50 Units / Rail
MC78M15ABTG				TO-220 (Pb-Free)	78M15ABT	
MC78M15BDT			DPAK-3	8M15B	75 Units / Rail	
MC78M15BDTG			DPAK-3 (Pb-Free)	8M15B		
MC78M15BDTRK	DPAK-3		8M15B	2500 Units / Tape & Reel		
MC78M15BDTRKG	DPAK-3 (Pb-Free)		8M15B			
MC78M15BT	TO-220		78M15BT	50 Units / Rail		
MC78M15BTG	TO-220 (Pb-Free)		78M15BT			

<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

## MC78M00, MC78M00A Series

### ORDERING INFORMATION

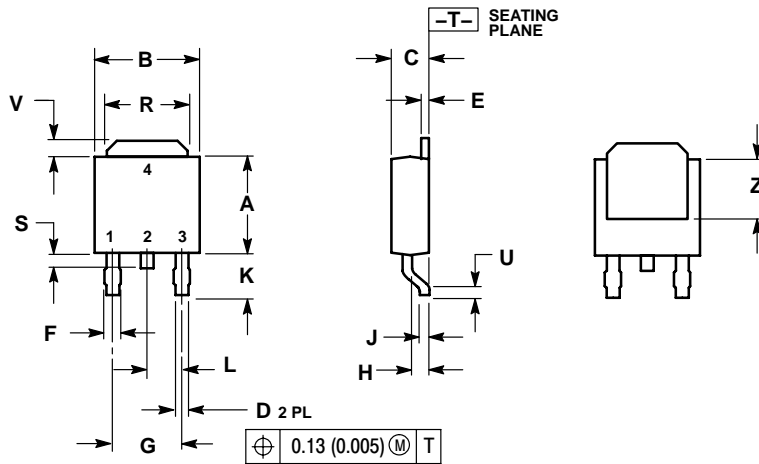
Device	Output Voltage	Temperature Range	Package	Marking	Shipping <sup>†</sup>
MC78M18CDT	18 V	$T_J = 0^\circ \text{ to } +125^\circ\text{C}$	DPAK-3	78M18	75 Units / Rail
MC78M18CDTG			DPAK-3 (Pb-Free)	78M18	
MC78M18CDTRK			DPAK-3	78M18	2500 Units / Tape & Reel
MC78M18CDTRKG			DPAK-3 (Pb-Free)	78M18	
MC78M18CT		$T_J = -40^\circ \text{ to } +125^\circ\text{C}$	TO-220	78M18CT	50 Units / Rail
MC78M18CTG			TO-220 (Pb-Free)	78M18CT	
MC78M18BT			TO-220	78M18BT	
MC78M18BTG			TO-220 (Pb-Free)	78M18BT	
MC78M20CT	20 V	$T_J = 0^\circ \text{ to } +125^\circ\text{C}$	TO-220	78M20CT	50 Units / Rail
MC78M20CTG			TO-220 (Pb-Free)	78M20CT	
MC78M20BT	24 V	$T_J = -40^\circ \text{ to } +125^\circ\text{C}$	TO-220	78M20BT	
MC78M24CT		$T_J = 0^\circ \text{ to } +125^\circ\text{C}$	TO-220	78M24CT	
MC78M24CTG			TO-220 (Pb-Free)	78M24CT	
MC78M24BT		$T_J = -40^\circ \text{ to } +125^\circ\text{C}$	TO-220	78M24BT	
MC78M24BTG	TO-220 (Pb-Free)		78M24BT		

<sup>†</sup>For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

# MC78M00, MC78M00A Series

## PACKAGE DIMENSIONS

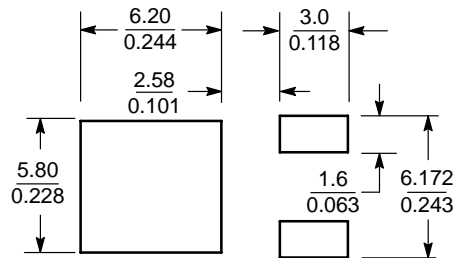
DPAK-3  
DT SUFFIX  
CASE 369C-01  
ISSUE O



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

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.235	0.245	5.97	6.22
B	0.250	0.265	6.35	6.73
C	0.086	0.094	2.19	2.38
D	0.027	0.035	0.69	0.88
E	0.018	0.023	0.46	0.58
F	0.037	0.045	0.94	1.14
G	0.180 BSC		4.58 BSC	
H	0.034	0.040	0.87	1.01
J	0.018	0.023	0.46	0.58
K	0.102	0.114	2.60	2.89
L	0.090 BSC		2.29 BSC	
R	0.180	0.215	4.57	5.45
S	0.025	0.040	0.63	1.01
U	0.020	---	0.51	---
V	0.035	0.050	0.89	1.27
Z	0.155	---	3.93	---

### SOLDERING FOOTPRINT\*



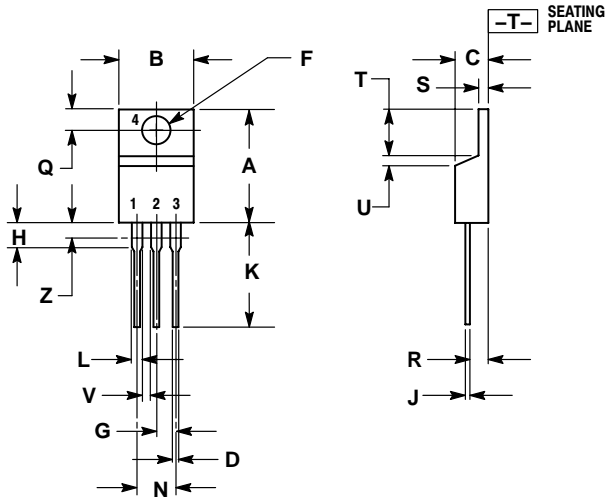
SCALE 3:1  $\left(\frac{\text{mm}}{\text{inches}}\right)$

\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

# MC78M00, MC78M00A Series

## PACKAGE DIMENSIONS

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



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

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

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