



# TS78M00

## 3-Terminal Medium Current Positive Voltage Regulators

 TO-220	 TO-252	Voltage Range 5 to 24 Volts Current 0.5 Ampere
Pin: 1. Input 2. Ground 3. Output		

<b>Features</b> <ul style="list-style-type: none"> <li>✧ No External Components Required</li> <li>✧ Internal Thermal Overload Protection</li> <li>✧ Internal Short Circuit Current Limiting</li> <li>✧ Output Transistor Safe-Area Compensation</li> <li>✧ Output Voltage Offered in 4% Tolerance</li> </ul>	<b>Ordering Informations</b>		
	<b>Device</b>	<b>Operating Temperature (Ambient)</b>	<b>Package</b>
	TS78MxxCZ	-20 °C ~ +85°C	TO-220
	TS78MxxCP		TO-252

### Absolute Maximum Ratings (TA=25°C, unless otherwise noted.)<sup>1</sup>

Rating	Symbol	Value	Unit
Input Voltage (5.0V – 18V) (18V – 24V)	V <sub>in</sub>	35 40	Vdc
Power Dissipation (Package Limitation) Plastic Package, T Suffix TA=25°C	P <sub>D</sub>	Internally Limited	
Thermal Resistance, Junction-to-Air	θ <sub>JA</sub>	70	°C/W
Thermal Resistance, Junction-to-Case	θ <sub>JC</sub>	5.0	°C/W
Plastic Package, DT Suffix TA=25°C	P <sub>D</sub>	Internally Limited	
Thermal Resistance, Junction-to-Air	θ <sub>JA</sub>	92	°C/W
Thermal Resistance, Junction-to-Case	θ <sub>JC</sub>	5.0	°C/W
Operating Junction Temperature Range	T <sub>J</sub>	+150	°C
Storage Temperature Range	T <sub>stg</sub>	-65 to +150	°C

Note: (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 200V.



<b>TS78M05 Electrical Characteristics</b> ( $V_{in}=10V$ , $I_o=350mA$ , $0^{\circ}C \leq T_j \leq 125^{\circ}C$ , $PD \leq 5.0W$ )					
Characteristics	Symbol	Min	Typ	Max	Unit
Output Voltage ( $T_J=25^{\circ}C$ ) TS78M05	$V_o$	4.8	5.0	5.2	Vdc
Output Voltage Variation ( $7.0Vdc \leq V_I \leq 20Vdc$ , $5.0mA \leq I_o \leq 350mA$ ) TS78M05	$V_o$	4.75	5.0	5.25	Vdc
Line Regulation ( $T_J=25^{\circ}C$ , $7.0Vdc \leq V_I \leq 25Vdc$ , $I_o=200mA$ )	Regline	--	3.0	50	mV
Load Regulation ( $T_J=25^{\circ}C$ , $5.0mA \leq I_o \leq 500mA$ ) ( $T_J=25^{\circ}C$ , $5.0mA \leq I_o \leq 200mA$ )	Regload	-- --	20 10	100 50	mV
Input Bias Current ( $T_J=25^{\circ}C$ )	$I_{IB}$	--	3.2	6.0	mA
Quiescent Current Change ( $8.0Vdc \leq V_I \leq 25Vdc$ , $I_o=200mA$ ) ( $5.0mA \leq I_o \leq 350mA$ )	$\Delta I_{IB}$	-- --	-- --	0.8 0.5	mA
Output Noise Voltage ( $T_A=25^{\circ}C$ , $10Hz \leq f \leq 100kHz$ )	$V_n$	--	40	--	$\mu A$
Ripple Rejection ( $I_o=100mA$ , $f=120Hz$ , $9.0V \leq V_I \leq 19V$ ) ( $I_o=300mA$ , $f=120Hz$ , $9.0V \leq V_I \leq 19V$ , $T_J=25^{\circ}C$ )	RR	62 62	-- 80	-- --	dB
Dropout Voltage ( $T_J=25^{\circ}C$ )	$V_I-V_o$	--	2.0	--	Vdc
Short Circuit Current Limit ( $T_J=25^{\circ}C$ , $V_I=35V$ )	$I_{os}$	--	50	--	mA
Average Temperature Coefficient of Output Voltage ( $I_o=5.0mA$ )	$\Delta V_o/\Delta T$	--	$\pm 0.2$	--	$mV/^{\circ}C$
Peak Output Current ( $T_J=25^{\circ}C$ )	$I_o$	--	700	--	mA
<b>TS78M06 Electrical Characteristics</b> ( $V_{in}=11V$ , $I_o=350mA$ , $0^{\circ}C \leq T_j \leq 125^{\circ}C$ , $PD \leq 5.0W$ ), unless otherwise noted)					
Characteristics	Symbol	Min	Typ	Max	Unit
Output Voltage ( $T_J=25^{\circ}C$ )	$V_o$	5.75	6.0	6.25	Vdc
Output Voltage Variation ( $8.0Vdc \leq V_I \leq 21Vdc$ , $5.0mA \leq I_o \leq 350mA$ )	$V_o$	5.7	6.0	6.30	Vdc
Line Regulation ( $T_J=25^{\circ}C$ , $8.0Vdc \leq V_I \leq 25Vdc$ , $I_o=200mA$ )	Regline	--	3.0	50	mV
Load Regulation ( $T_J=25^{\circ}C$ , $5.0mA \leq I_o \leq 500mA$ ) ( $T_J=25^{\circ}C$ , $5.0mA \leq I_o \leq 200mA$ )	Regload	-- --	20 10	120 60	mV
Input Bias Current ( $T_J=25^{\circ}C$ )	$I_{IB}$	--	3.2	6.0	mA
Quiescent Current Change ( $9.0Vdc \leq V_I \leq 25Vdc$ , $I_o=200mA$ ) ( $5.0mA \leq I_o \leq 350mA$ )	$\Delta I_{IB}$	-- --	-- --	0.8 0.5	mA
Output Noise Voltage ( $T_A=25^{\circ}C$ , $10Hz \leq f \leq 100kHz$ )	$V_n$	--	45	--	$\mu A$
Ripple Rejection ( $I_o=100mA$ , $f=120Hz$ , $9.0V \leq V_I \leq 19V$ ) ( $I_o=300mA$ , $f=120Hz$ , $9.0V \leq V_I \leq 19V$ , $T_J=25^{\circ}C$ )	RR	59 59	-- 80	-- --	dB
Dropout Voltage ( $T_J=25^{\circ}C$ )	$V_I-V_o$	--	2.0	--	Vdc
Short Circuit Current Limit ( $T_J=25^{\circ}C$ , $V_I=35V$ )	$I_{os}$	--	50	--	mA
Average Temperature Coefficient of Output Voltage ( $I_o=5.0mA$ )	$\Delta V_o/\Delta T$	--	$\pm 0.2$	--	$mV/^{\circ}C$
Peak Output Current ( $T_J=25^{\circ}C$ )	$I_o$	--	700	--	mA

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### TS78M08 Electrical Characteristics

( $V_{in}=14V$ ,  $I_o=350mA$ ,  $0^{\circ}C \leq T_j \leq 125^{\circ}C$ ,  $PD \leq 5.0W$ ), unless otherwise noted)<sup>2</sup>

Characteristics	Symbol	Min	Typ	Max	Unit
Output Voltage (T <sub>J</sub> =25°C) TS78M08	V <sub>o</sub>	7.70	8	8.30	Vdc
Output Voltage Variation (10.5Vdc ≤ V <sub>I</sub> ≤ 23Vdc, 5.0mA ≤ I <sub>o</sub> ≤ 350mA)	V <sub>o</sub>	7.84	8	8.16	Vdc
Line Regulation (T <sub>J</sub> =25°C, 10.5Vdc ≤ V <sub>I</sub> ≤ 25Vdc, I <sub>o</sub> =200mA)	Regline	--	60	50	mV
Load Regulation (T <sub>J</sub> =25°C, 5.0mA ≤ I <sub>o</sub> ≤ 500mA) (T <sub>J</sub> =25°C, 5.0mA ≤ I <sub>o</sub> ≤ 200mA)	Regload	--	25 10	160 80	mV
Input Bias Current (T <sub>J</sub> =25°C)	I <sub>IB</sub>	--	3.2	6.0	mA
Quiescent Current Change (10.5Vdc ≤ V <sub>I</sub> ≤ 25Vdc, I <sub>o</sub> =200mA) (5.0mA ≤ I <sub>o</sub> ≤ 350mA)	ΔI <sub>IB</sub>	--	--	0.8 0.5	mA
Output Noise Voltage (T <sub>A</sub> =25°C, 10Hz ≤ f ≤ 100kHz)	V <sub>n</sub>	--	52	--	μV
Ripple Rejection (I <sub>o</sub> =100mA, f=120Hz, 11.5V ≤ V <sub>I</sub> ≤ 21.5V) (I <sub>o</sub> =300mA, f=120Hz, 11.5V ≤ V <sub>I</sub> ≤ 21.5V, T <sub>J</sub> =25°C)	RR	56 56	-- 80	-- --	dB
Dropout Voltage (T <sub>J</sub> =25°C)	V <sub>I</sub> -V <sub>o</sub>	--	2.0	--	Vdc
Short Circuit Current Limit (T <sub>J</sub> =25°C, V <sub>I</sub> =35V)	I <sub>os</sub>	--	50	--	mA
Average Temperature Coefficient of Output Voltage (I <sub>o</sub> =5.0mA)	ΔV <sub>o</sub> /ΔT	--	±0.2	--	mV/°C
Peak Output Current (T <sub>J</sub> =25°C)	I <sub>o</sub>	--	700	--	mA

### TS78M09 Electrical Characteristics

( $V_{in}=15V$ ,  $I_o=350mA$ ,  $0^{\circ}C \leq T_j \leq 125^{\circ}C$ ,  $PD \leq 5.0W$ ), unless otherwise noted)<sup>2</sup>

Characteristics	Symbol	Min	Typ	Max	Unit
Output Voltage (T <sub>J</sub> =25°C)	V <sub>o</sub>	8.64	9	9.36	Vdc
Output Voltage Variation (11.5Vdc ≤ V <sub>I</sub> ≤ 23Vdc, 5.0mA ≤ I <sub>o</sub> ≤ 350mA)	V <sub>o</sub>	8.55	9	9.45	Vdc
Line Regulation (T <sub>J</sub> =25°C, 11.5Vdc ≤ V <sub>I</sub> ≤ 25Vdc, I <sub>o</sub> =200mA)	Regline	--	60	50	mV
Load Regulation (T <sub>J</sub> =25°C, 5.0mA ≤ I <sub>o</sub> ≤ 500mA) (T <sub>J</sub> =25°C, 5.0mA ≤ I <sub>o</sub> ≤ 200mA)	Regload	--	25 10	180 90	mV
Input Bias Current (T <sub>J</sub> =25°C)	I <sub>IB</sub>	--	3.2	6.0	mA
Quiescent Current Change (11.5Vdc ≤ V <sub>I</sub> ≤ 25Vdc, I <sub>o</sub> =200mA) (5.0mA ≤ I <sub>o</sub> ≤ 350mA)	ΔI <sub>IB</sub>	--	--	0.8 0.5	mA
Output Noise Voltage (T <sub>A</sub> =25°C, 10Hz ≤ f ≤ 100kHz)	V <sub>n</sub>	--	52	--	μV
Ripple Rejection (I <sub>o</sub> =100mA, f=120Hz, 12.5V ≤ V <sub>I</sub> ≤ 22.5V) (I <sub>o</sub> =300mA, f=120Hz, 12.5V ≤ V <sub>I</sub> ≤ 22.5V, T <sub>J</sub> =25°C)	RR	56 56	-- 80	-- --	dB
Dropout Voltage (T <sub>J</sub> =25°C)	V <sub>I</sub> -V <sub>o</sub>	--	2.0	--	Vdc
Short Circuit Current Limit (T <sub>J</sub> =25°C, V <sub>I</sub> =35V)	I <sub>os</sub>	--	50	--	mA
Average Temperature Coefficient of Output Voltage (I <sub>o</sub> =5.0mA)	ΔV <sub>o</sub> /ΔT	--	±0.2	--	mV/°C
Peak Output Current (T <sub>J</sub> =25°C)	I <sub>o</sub>	--	700	--	mA

Note: (2) T<sub>low</sub>=0°C for TS78Mxx T<sub>high</sub>=+125°C for TS78Mxx  
=-40°C for TS78Mxx

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<b>TS78M12 Electrical Characteristics</b>					
(Vin=19V, Io=350mA, 0°C ≤ Tj ≤ 125°C, PD ≤ 5.0W), unless otherwise noted) <sup>2</sup>					
Characteristics	Symbol	Min	Typ	Max	Unit
Output Voltage (TJ=25°C) TS78M12	Vo	11.52	12	12.48	Vdc
Output Voltage Variation (14.5Vdc ≤ VI ≤ 27Vdc, 5.0mA ≤ Io ≤ 350mA)	Vo	11.40	12	12.60	Vdc
Line Regulation (TJ=25°C, 14.5Vdc ≤ VI ≤ 30Vdc, Io=200mA)	Regline	--	80	50	mV
Load Regulation (TJ=25°C, 5.0mA ≤ Io ≤ 500mA) (TJ=25°C, 5.0mA ≤ Io ≤ 200mA)	Regload	-- --	25 10	240 120	mV
Input Bias Current (TJ=25°C)	IIB	--	3.2	6.0	mA
Quiescent Current Change (14.5Vdc ≤ VI ≤ 30Vdc, Io=200mA) (5.0mA ≤ Io ≤ 350mA)	ΔIIB	-- --	-- --	0.8 0.5	mA
Output Noise Voltage (TA=25°C, 10Hz ≤ f ≤ 100kHz)	Vn	--	75	--	μV
Ripple Rejection (Io=100mA, f=120Hz, 15V ≤ VI ≤ 25V) (Io=300mA, f=120Hz, 15V ≤ VI ≤ 25V, TJ=25°C)	RR	55 55	-- 80	-- --	dB
Dropout Voltage (TJ=25°C)	VI-Vo	--	2.0	--	Vdc
Short Circuit Current Limit (TJ=25°C, VI=35V)	Ios	--	50	--	mA
Average Temperature Coefficient of Output Voltage (Io=5.0mA)	ΔVo/ΔT	--	±0.3	--	mV/°C
Peak Output Current (TJ=25°C)	Io	--	700	--	mA
<b>TS78M15 Electrical Characteristics</b>					
(Vin=19V, Io=350mA, 0°C ≤ Tj ≤ 125°C, PD ≤ 5.0W), unless otherwise noted) <sup>2</sup>					
Characteristics	Symbol	Min	Typ	Max	Unit
Output Voltage (TJ=25°C) TS78M15	Vo	14.40	15	15.60	Vdc
Output Voltage Variation (17.5Vdc ≤ VI ≤ 30Vdc, 5.0mA ≤ Io ≤ 350mA)	Vo	14.25	15	15.75	Vdc
Line Regulation (TJ=25°C, 17.5Vdc ≤ VI ≤ 30Vdc, Io=200mA)	Regline	--	10	50	mV
Load Regulation (TJ=25°C, 5.0mA ≤ Io ≤ 500mA) (TJ=25°C, 5.0mA ≤ Io ≤ 200mA)	Regload	-- --	25 10	300 150	mV
Input Bias Current (TJ=25°C)	IIB	--	3.2	6.0	mA
Quiescent Current Change (17.8Vdc ≤ VI ≤ 30Vdc, Io=200mA) (5.0mA ≤ Io ≤ 350mA)	ΔIIB	-- --	-- --	0.8 0.5	mA
Output Noise Voltage (TA=25°C, 10Hz ≤ f ≤ 100kHz)	Vn	--	90	--	μV
Ripple Rejection (Io=100mA, f=120Hz, 18.5V ≤ VI ≤ 28.5V) (Io=300mA, f=120Hz, 18.5V ≤ VI ≤ 28.5V, TJ=25°C)	RR	54 54	-- 70	-- --	dB
Dropout Voltage (TJ=25°C)	VI-Vo	--	2.0	--	Vdc
Short Circuit Current Limit (TJ=25°C, VI=35V)	Ios	--	50	--	mA
Average Temperature Coefficient of Output Voltage (Io=5.0mA)	ΔVo/ΔT	--	±0.3	--	mV/°C
Peak Output Current (TJ=25°C)	Io	--	700	--	mA

Note: (2) Tlow=0°C for TS78Mxx Thigh=+125°C for TS78Mxx  
=-40°C for TS78Mxx

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<b>TS78M18 Electrical Characteristics</b>					
(Vin=23V, Io=350mA, 0°C≤Tj≤125°C, PD≤5.0W), PD≤5.0W, unless otherwise noted)					
Characteristics	Symbol	Min	Typ	Max	Unit
Output Voltage (TJ=25°C)	Vo	17.28	18	18.72	Vdc
Output Voltage Variation (21Vdc≤VI≤33Vdc, 5.0mA≤Io≤350mA)	Vo	17.10	18	18.90	Vdc
Line Regulation (TJ=25°C, 21Vdc≤VI≤33Vdc, Io=200mA)	Regline	--	10	50	mV
Load Regulation (TJ=25°C, 5.0mA≤Io≤500mA) (TJ=25°C, 5.0mA≤Io≤200mA)	Regload	-- --	30 10	360 180	mV
Input Bias Current (TJ=25°C)	IIB	--	3.2	6.5	mA
Quiescent Current Change (21Vdc≤VI≤33Vdc, Io=200mA) (5.0mA≤Io≤350mA)	ΔIIB	-- --	-- --	0.8 0.5	mA
Output Noise Voltage (TA=25°C, 10Hz≤f≤100kHz)	Vn	--	100	--	μV
Ripple Rejection (Io=100mA, f=120Hz, 22V≤VI≤32V) (Io=300mA, f=120Hz, 22V≤VI≤32V, TJ=25°C)	RR	53 53	-- 70	-- --	dB
Dropout Voltage (TJ=25°C)	VI-Vo	--	2.0	--	Vdc
Short Circuit Current Limit (TJ=25°C, VI=35V)	Ios	--	50	--	mA
Average Temperature Coefficient of Output Voltage (Io=5.0mA)	ΔVo/ΔT	--	±0.3	--	mV/°C
Peak Output Current (TJ=25°C)	Io	--	700	--	mA
<b>TS78M24 Electrical Characteristics</b>					
(Vin=27V, Io=350mA, 0°C≤Tj≤125°C, PD≤5.0W), unless otherwise noted)					
Characteristics	Symbol	Min	Typ	Max	Unit
Output Voltage (TJ=25°C)	Vo	23.0	24	25.0	Vdc
Output Voltage Variation (27Vdc≤VI≤38Vdc, 5.0mA≤Io≤350mA)	Vo	22.8	24	25.2	Vdc
Line Regulation (TJ=25°C, 27Vdc≤VI≤38Vdc, Io=200mA)	Regline	--	10	50	mV
Load Regulation (TJ=25°C, 5.0mA≤Io≤500mA) (TJ=25°C, 5.0mA≤Io≤200mA)	Regload	-- --	30 10	480 240	mV
Input Bias Current (TJ=25°C)	IIB	--	3.2	6.5	mA
Quiescent Current Change (27Vdc≤VI≤38Vdc, Io=200mA) (5.0mA≤Io≤350mA)	ΔIIB	-- --	-- --	0.8 0.5	mA
Output Noise Voltage (TA=25°C, 10Hz≤f≤100kHz)	Vn	--	170	--	μV
Ripple Rejection (Io=100mA, f=120Hz, 28V≤VI≤38V) (Io=300mA, f=120Hz, 28V≤VI≤38V, TJ=25°C)	RR	50 50	-- 70	-- --	dB
Dropout Voltage (TJ=25°C)	VI-Vo	--	2.0	--	Vdc
Short Circuit Current Limit (TJ=25°C, VI=35V)	Ios	--	50	--	mA
Average Temperature Coefficient of Output Voltage (Io=5.0mA)	ΔVo/ΔT	--	±0.5	--	mV/°C
Peak Output Current (TJ=25°C)	Io	--	700	--	mA

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**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.

FIG.1 - Worst Case Power Dissipation versus Ambient Temperature (TO-220)

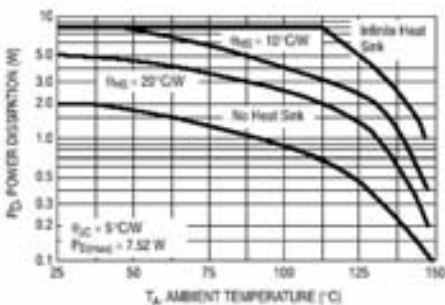


FIG.2 - DPAK Thermal Resistance and Maximum Power Dissipation versus P.C.B. Copper Length

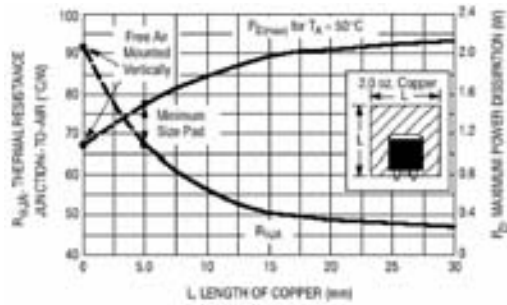


FIG.3 - Bias Current versus Input Voltage

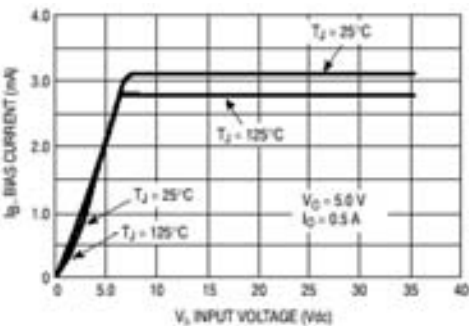


FIG.4 - Bias Current versus Output Current

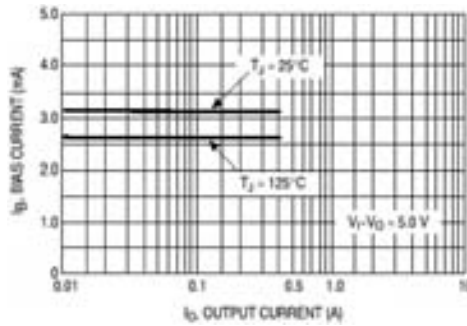




FIG.5 - Peak Output Current versus Dropout Voltage

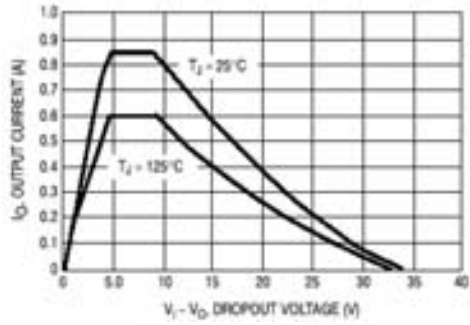


FIG.6 - Dropout Voltage versus Junction Temperature

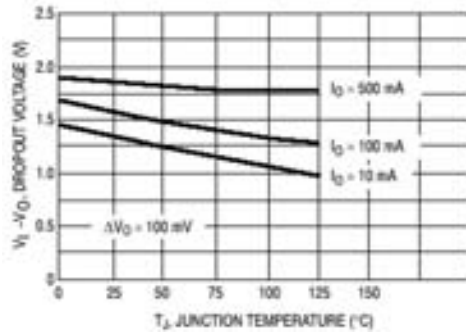


FIG.7 - Ripple Rejection versus Frequency

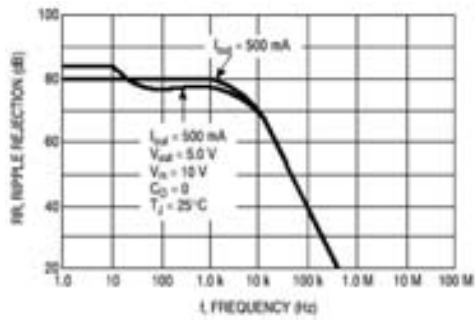
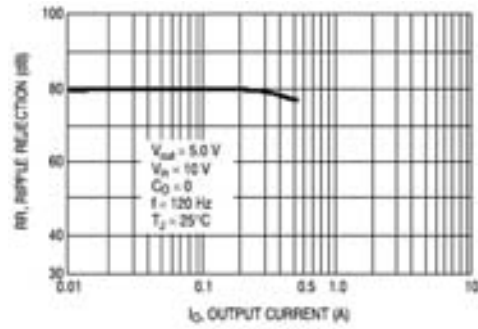


FIG.8 - Ripple Rejection versus Output Current



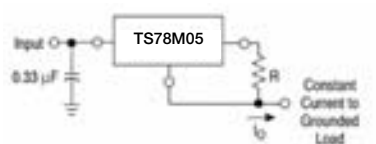
## Applications Information

### Design Considerations

The TS78Mxx 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 mF or larger tantalum, mylar, or other capacitor having low internal impedance at high frequencies should be chosen. The bypass capacitor should be mounted with the shortest possible leads directly across the regulator's 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.

FIG.9 - Current Regulator



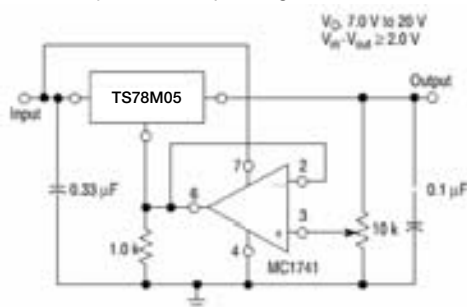
The MC78M00 regulators can also be used as a current source when connected as above. In order to minimize dissipation the MC78M05C is chosen in this application. Resistor R determines the current as follows:

$$I_O = \frac{5.5V}{R} + I_{BQ}$$

$$I_{BQ} = 1.5 \text{ mA over line and load changes.}$$

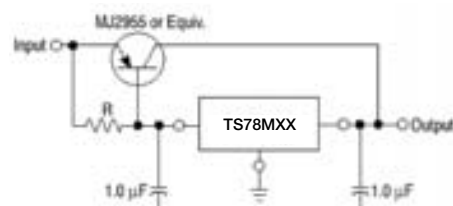
For example, a 500 mA current source would require R to be a 5.5 Ω, 10 W resistor and the output voltage compliance would be the input voltage less 7.5 V.

FIG.10 - Adjustable Output Regulator



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

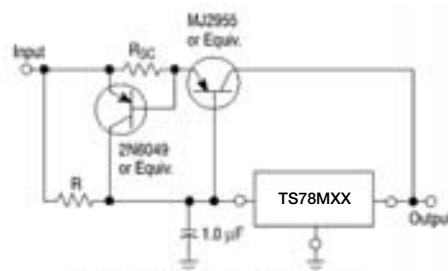
FIG.11 - Current Boost Regulator



XX = 2 digits of type number indicating voltage.

The MC78M00 series can be current boosted with a PNP transistor. The MJ2955 provides current to 5.0 A. Resistor R in conjunction with the  $V_{BE}$  of the PNP determines when the pass transistor begins conducting; this circuit is not short circuit proof. Input-output differential voltage minimum is increased by  $V_{BE}$  of the pass transistor.

FIG.12 - Current Boost with Short Circuit Protection



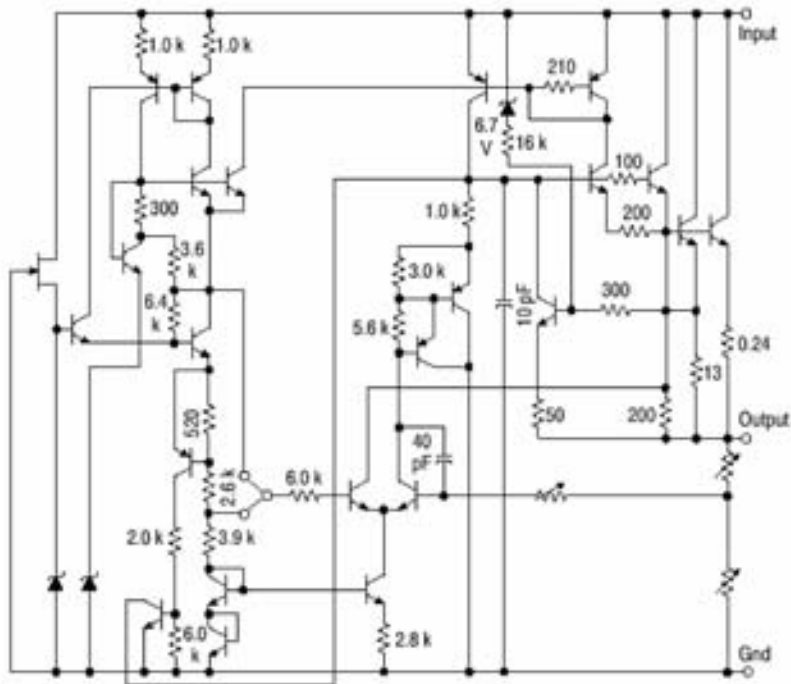
XX = 2 digits of type number indicating voltage.

The circuit of Figure 11 can be modified to provide supply protection against short circuits by adding a short circuit sense resistor,  $R_{SC}$ , and an additional PNP transistor. The current sensing PNP must be able to handle the short circuit current of the three-terminal regulator. Therefore, a 4.0 A plastic power transistor is specified.



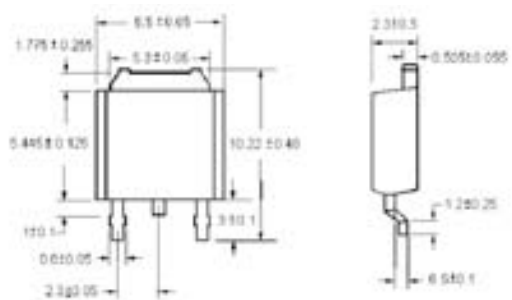
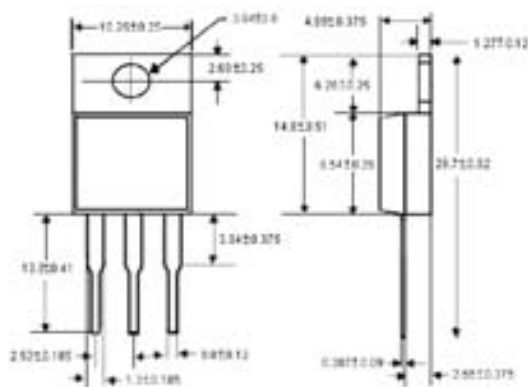


FIG.13 - Representative Schematic Diagram



TO-220 Unit: mm

TO-252 Unit: mm



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