



April 1991

# LM78MG/LM79MG

## 4-Terminal Adjustable Voltage Regulators

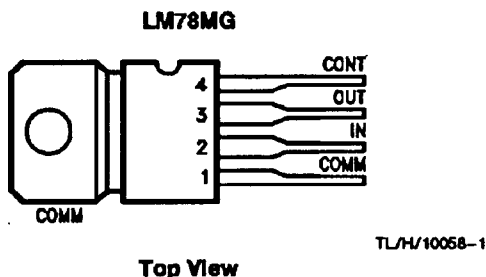
### General Description

The LM78MG and LM79MG are 4-terminal adjustable voltage regulators. They are designed to deliver continuous load currents of up to 500 mA with a maximum input voltage of +40V for the positive regulator LM78MG and -40V for the negative regulator LM79MG. Output current capability can be increased to greater than 10A through use of one or more external transistors. The output voltage range of the LM78MG positive voltage regulator is 5.0V to 30V and the output voltage range of the negative LM79MG is -30V to -2.6V. For systems requiring both a positive and negative, the LM78MG and LM79MG are excellent for use as a dual tracking regulator.

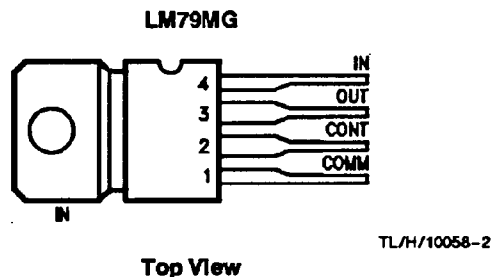
### Features

- Output current in excess of 0.5A
- LM78MG positive output voltage +5.0V to +30V
- LM79MG negative output voltage -30V to -2.6V
- Internal thermal overload protection
- Internal short circuit current protection
- Output transistor safe-area protection

### Connection Diagrams



Heat sink tabs connected to input through device substrate. Not recommended for direct electrical connection.



Heat sink tabs connected to input through device substrate. Not recommended for direct electrical connection.

### Ordering Information

Device Type	Device Code	Package Code	Package Description
Positive Adjustable Regulator	LM78MGCP	P04A	Molded 4-Lead TO-202
Negative Adjustable Regulator	LM79MGCP	P04A	Molded 4-Lead TO-202

LM78MG/LM79MG 4-Terminal Adjustable Voltage Regulators

## Absolute Maximum Ratings

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Storage Temperature Range	-65°C to +150°C
Operating Junction Temperature Range	0°C to +150°C
Lead Temperature (Soldering, 10 sec.)	265°C
Internal Power Dissipation	Internally Limited

Input Voltage	LM78MGC +40V
	LM79MGC -40V
Control Lead Voltage	LM78MGC $0V \leq V^+ \leq V_O$
	LM79MGC $V_O^- \leq V^- \leq 0V$

## LM78MGC

**Electrical Characteristics**  $0^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$  for LM78MGC,  $V_I = 10\text{V}$ ,  $I_O = 350\text{mA}$ ,  $C_I = 0.33\text{ }\mu\text{F}$ ,  $C_O = 0.1\text{ }\mu\text{F}$ , Test Circuit 1, unless otherwise specified

Symbol	Parameter	Conditions (Notes 1, 3)	Min	Typ	Max	Units
$V_{IR}$	Input Voltage Range	$T_J = 25^\circ\text{C}$	7.5		40	V
$V_{OR}$	Output Voltage Range	$V_I = V_O + 5.0\text{V}$	5.0		30	V
$V_O$	Output Voltage Tolerance	$(V_O + 3.0\text{V}) \leq V_I \leq (V_O + 15\text{V})$ , $5.0\text{mA} \leq I_O \leq 350\text{mA}$ , $P_D \leq 5.0\text{W}$ , $V_{I\text{Max}} = 38\text{V}$			4.0	% ( $V_O$ )
		$T_J = 25^\circ\text{C}$			5.0	
$V_{O\text{ LINE}}$	Line Regulation	$T_J = 25^\circ\text{C}$ , $I_O = 200\text{mA}$ , $V_O \leq 10\text{V}$ , $(V_O + 2.5\text{V}) \leq V_I \leq (V_O + 20\text{V})$ , $T_J = 25^\circ\text{C}$ , $I_O = 200\text{mA}$ , $V_O \geq 10\text{V}$			1.0	%( $V_O$ )
$V_{O\text{ LOAD}}$	Load Regulation	$T_J = 25^\circ\text{C}$ , $5.0\text{mA} \leq I_O \leq 500\text{mA}$ , $V_I = V_O + 7.0\text{V}$			1.0	%( $V_O$ )
$I_C$	Control Lead Current	$T_J = 25^\circ\text{C}$		1.0	6.0	$\mu\text{A}$
					7.0	
$I_Q$	Quiescent Current	$T_J = 25^\circ\text{C}$		2.8	5.0	mA
					6.0	
RR	Ripple Rejection	$I_O = 125\text{mA}$ , $8.0\text{V} \leq V_I \leq 18\text{V}$ , $V_O = 5.0\text{V}$ , $f = 2400\text{Hz}$	62	80		dB
$N_O$	Output Noise Voltage	$10\text{Hz} \leq f \leq 100\text{kHz}$ , $V_O = 5.0\text{V}$		8	40	$\mu\text{V}/V_O$
$V_{DO}$	Dropout Voltage (Note 2)			2	2.5	V
$I_{OS}$	Short Circuit Current	$V_I = 35\text{V}$ , $T_J = 25^\circ\text{C}$			600	mA
$I_{PK}$	Peak Output Current	$T_J = 25^\circ\text{C}$	0.4	0.8	1.4	A
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage	$V_O = 5.0\text{V}$ , $I_O = 5.0\text{mA}$			0.4	$\text{mV}/^\circ\text{C}/V_O$
		$T_A = -55^\circ\text{C}$ to $+25^\circ\text{C}$ $T_A = 25^\circ\text{C}$ to $125^\circ\text{C}$			0.3	
$V_C$	Control Lead Voltage (Reference)	$T_J = 25^\circ\text{C}$	4.8	5.0	5.2	V
			4.75		5.25	

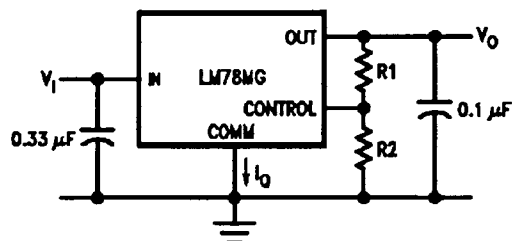
LM78MG Test Circuit 1

$$V_O = \left( \frac{R_1 + R_2}{R_2} \right) V_{\text{CONT}}$$

$V_{\text{CONT}}$  Nominally = 5V

Recommended  $R_2$  current  $\approx 1\text{mA}$

$R_2 = 5\text{ k}\Omega$



TL/HV10058-20

# LM79MGC

**Electrical Characteristics**  $0^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$  for LM79MGC,  $V_I = -14\text{V}$ ,  $I_O = 350\text{ mA}$ ,  $C_I = 2.0\text{ }\mu\text{F}$ ,  $C_O = 1.0\text{ }\mu\text{F}$ , Test Circuit 2, unless otherwise specified

Symbol	Parameter	Conditions (Notes 1, 3 & 4)	Min	Typ	Max	Units
$V_{IR}$	Input Voltage Range	$T_J = 25^{\circ}\text{C}$	-40		-7.0	V
$V_{OR}$	Output Voltage Range	$V_I = V_O - 5.0\text{V}$	-30		-2.55	V
$V_O$	Output Voltage Tolerance	$(V_O - 15\text{V}) \leq V_I \leq (V_O - 3.0\text{V})$ , $5.0\text{ mA} \leq I_O \leq 350\text{ mA}$ , $P_D \leq 5.0\text{W}$ , $V_{I\text{Max}} = -38\text{V}$	$T_J = 25^{\circ}\text{C}$		4.0	% ( $V_O$ )
					5.0	
$V_{O\text{ LINE}}$	Line Regulation	$T_J = 25^{\circ}\text{C}$ , $I_O = 200\text{ mA}$ , $V_O \leq -10\text{V}$ , $(V_O - 20\text{V}) \leq V_I \leq (V_O - 2.5\text{V})$ , $T_J = 25^{\circ}\text{C}$ , $I_O = 200\text{ mA}$ , $V_O \leq -10\text{V}$			1.0	% ( $V_O$ )
$V_{O\text{ LOAD}}$	Load Regulation	$V_I = V_O - 7.0\text{V}$ , $5.0\text{ mA} \leq I_O \leq 500\text{ mA}$ , $T_J = 25^{\circ}\text{C}$			1.0	% ( $V_O$ )
$I_C$	Control Lead Current	$T_J = 25^{\circ}\text{C}$			2.0	$\mu\text{A}$
					3.0	
$I_Q$	Quiescent Current	$T_J = 25^{\circ}\text{C}$		2.1	7.0	mA
					8.0	
RR	Ripple Rejection	$T_J = 25^{\circ}\text{C}$ , $I_O = 125\text{ mA}$ , $V_I = -13\text{V}$ , $V_O = -5.0\text{V}$ , $f = 2400\text{ Hz}$	50			dB
$N_O$	Noise	$10\text{ Hz} \leq f \leq 100\text{ kHz}$ , $V_O = -8.0\text{V}$ , $I_L = 50\text{ mA}$		25	80	$\mu\text{V}/V_O$
$V_{DO}$	Dropout Voltage (Note 2)			-1.1	-2.3	V
$I_{OS}$	Short Circuit Current	$V_I = 35\text{V}$ , $T_J = 25^{\circ}\text{C}$			600	mA
$I_{pk}$	Peak Output Current		0.4	0.65	1.4	A
$\Delta V_O/\Delta T$	Average Temperature Coefficient of Output Voltage	$V_O = -5.0\text{V}$ , $I_O = -5.0\text{ mA}$	$T_A = -55^{\circ}\text{C}$ to $+25^{\circ}\text{C}$		0.3	$\text{mV}/^{\circ}\text{C}/V_O$
			$T_A = 25^{\circ}\text{C}$ to $125^{\circ}\text{C}$		0.3	
$V_C$	Control Lead Voltage (Reference)	$T_J = 25^{\circ}\text{C}$	-2.65	-2.55	-2.45	V
			-2.68		-2.43	

Note 1:  $V_O$  is defined for the LM78MGC as  $V_O = \frac{R1 + R2}{R2} (5.0)$ ; the LM79MGC as  $V_O = \frac{R1 + R2}{R2} (-2.55)$ .

Note 2: Dropout voltage is defined as that input/output voltage differential which causes the output voltage to decrease by 5% of its initial value.

Note 3: All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ( $t_W \leq 10\text{ ms}$ , duty cycle  $\leq 5\%$ ). Output voltage changes due to changes in internal temperature must be taken into account separately.

Note 4: The convention for negative regulators is the Algebraic value, thus  $-15\text{V}$  is less than  $-10\text{V}$ .

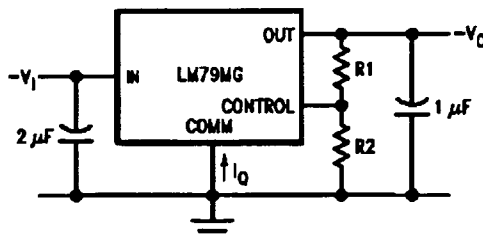
LM79MG Test Circuit 2

$$V_O = \left( \frac{R1 + R2}{R2} \right) V_{CONT}$$

$V_{CONT}$  Nominally =  $-2.55\text{V}$

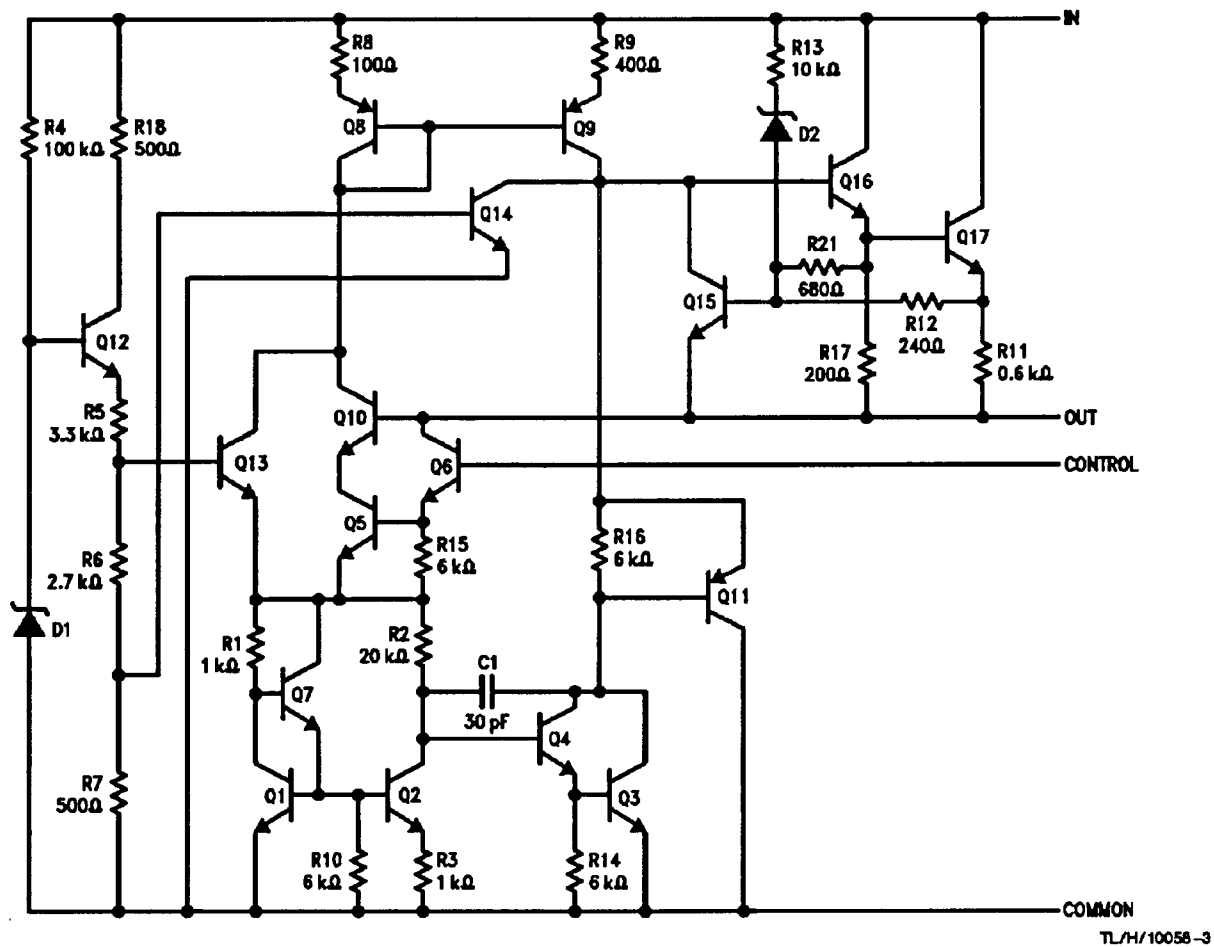
Recommended  $R2$  current  $\approx 1\text{ mA}$

$\therefore R2 = 2.6\text{ k}\Omega$



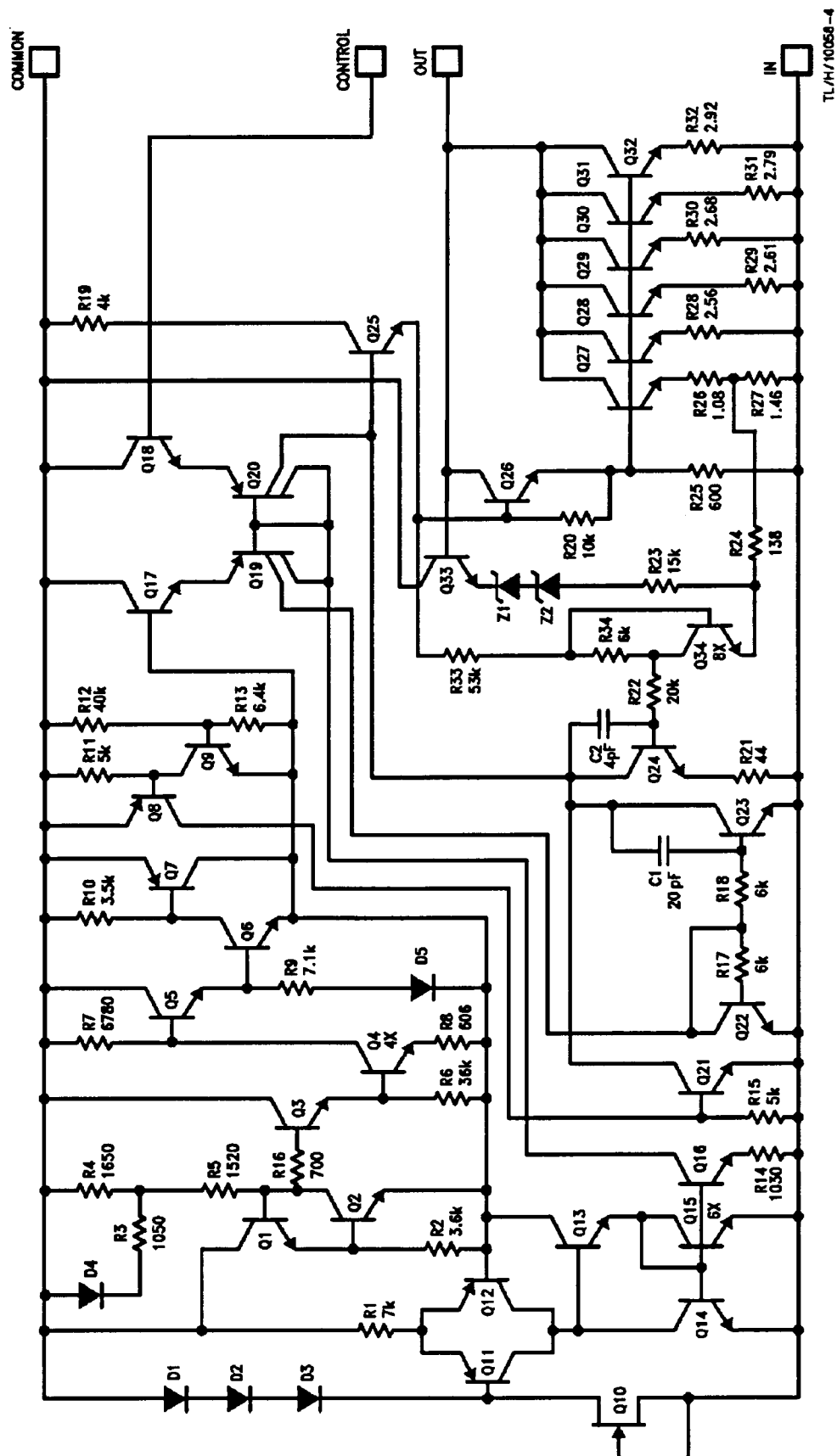
TL/H/10058-22

# LM78MG Equivalent Circuit



TL/H/10058-3

# LM79MG Equivalent Circuit (Note 1)



Note 1: Resistor values in  $\Omega$  unless otherwise noted.

TL/H/10058-4

## Design Considerations

The LM78MG and LM79MG variable voltage regulators have an output voltage which varies from  $V_{CONT}$  to typically

$$V_I - 2.0V \text{ by } V_O = V_{CONT} \frac{(R1 + R2)}{R2}$$

The nominal reference in the LM78MG is 5.0V and LM79MG is -2.55V. If we allow 1.0 mA to flow in the control swing to eliminate bias current effects, we can make  $R2 = 5 \text{ k}\Omega$  in the LM78MG. The output voltage is then:  $V_O = (R1 + R2) \text{ Volts}$ , where  $R1$  and  $R2$  are in  $\text{k}\Omega$ s.

Example: If  $R2 = 5.0 \text{ k}\Omega$  and  $R1 = 10 \text{ k}\Omega$  then

$V_O = 15V$  nominal, for the LM78MG;

$R2 = 2.6 \text{ k}\Omega$  and  $R1 = 13 \text{ k}\Omega$  then

$V_O = -15.3V$  nominal, for the LM79MG.

By proper wiring of the feedback resistors, load regulation of the devices can be improved significantly.

Both LM78MG and LM79MG regulators have thermal overload protection from excessive power, internal short circuit protection which limits each circuit's maximum current, and output transistor safe-area protection for reducing the output current as the voltage across each pass transistor is increased.

Although the internal power dissipation is limited, the junction temperature must be kept below the maximum specified temperature in order to meet data sheet specifications. To calculate the maximum junction temperature or heat sink required, the following thermal resistance values should be used:

Package	Typ $\theta_{JC}$	Max $\theta_{JC}$	Typ $\theta_{JA}$	Max $\theta_{JA}$
Power Watt	8.0	12.0	70	75

$$P_{D \text{ Max}} = \frac{T_{J \text{ Max}} - T_A}{\theta_{JC} + \theta_{CA}} \text{ or}$$

$$\frac{T_{J \text{ Max}} - T_A}{\theta_{JA}} \text{ (without a heat sink)}$$

$$\theta_{CA} = \theta_{CS} + \theta_{SA}$$

Solving for  $T_J$ :

$$T_J = T_A + P_D(\theta_{JC} + \theta_{CA}) \text{ or}$$

$$T_A + P_D\theta_{JA} \text{ (without heat sink)}$$

Where

$T_J$  = Junction Temperature

$T_A$  = Ambient Temperature

$P_D$  = Power Dissipation

$\theta_{JC}$  = Junction-to-Case Thermal Resistance

$\theta_{CA}$  = Case-to-Ambient Thermal Resistance

$\theta_{CS}$  = Case-to-Heat Sink Thermal Resistance

$\theta_{SA}$  = Heat Sink-to-Ambient Thermal Resistance

$\theta_{JA}$  = Junction-to-Ambient Thermal Resistance

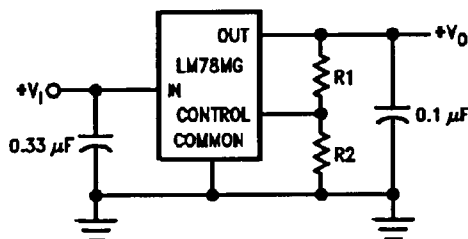
## Typical Applications for LM78MG (Note 1)

Bypass capacitors are recommended for stable operation of the LM78MG over the input voltage and output current ranges. Output bypass capacitors will improve the transient response of the regulator.

The bypass capacitors, (0.33  $\mu\text{F}$  on the input, 0.1  $\mu\text{F}$  on the output) should be ceramic or solid tantalum which have good high frequency characteristics. The bypass capacitors should be mounted with the shortest leads, and if possible, directly across the regulator terminals.

Note 1: All resistor values in ohms.

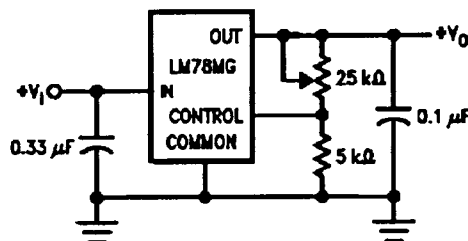
### Basic Positive Regulator



TL/H/10058-8

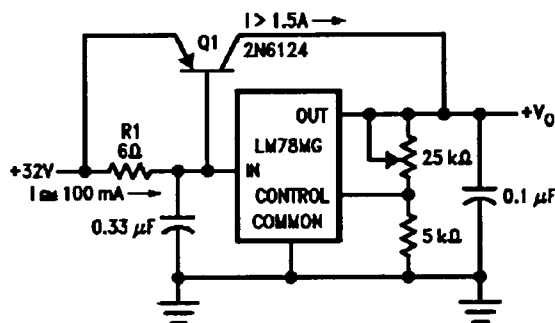
$$V_O = V_{CONT} \left( \frac{R1 + R2}{R2} \right)$$

### Positive 5.0V to 30V Adjustable Regulator



TL/H/10058-9

### Positive 5.0V to 30V Adjustable Regulator $I_O > 1.5A$

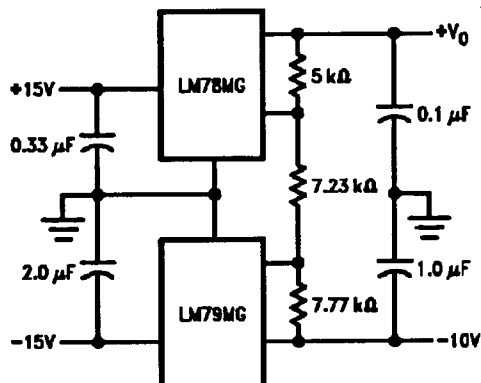


TL/H/10058-10

$$R1 = \frac{\beta V_{BE}(Q1)}{I_{R \text{ Max}}(\beta) - I_O}$$

# Typical Applications for LM78MG (Note 1) (Continued)

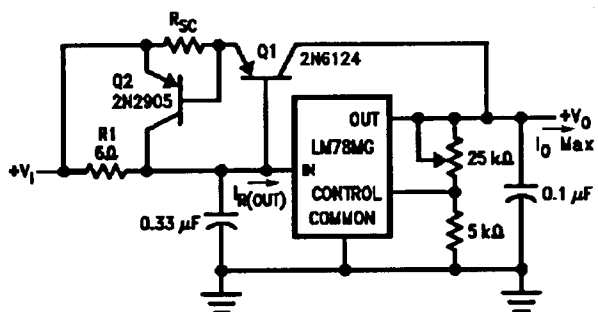
## ± 10V, 500 mA Dual Tracking Regulator



TL/H/10058-11

Note: External series pass device is not short circuit protected.

## Positive High Current Short Circuit Protected Regulator

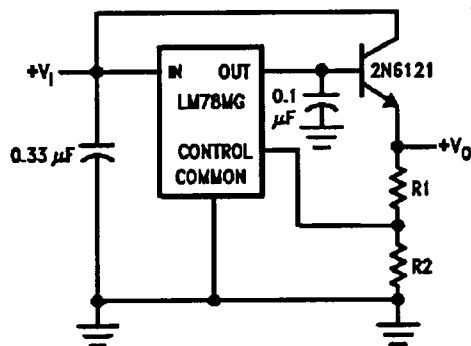


TL/H/10058-14

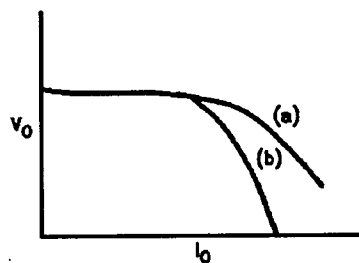
$$R1 = \frac{BV_{BE}(Q1)}{V_{R\text{ Max}}(\beta + 1) - I_0 \text{ Max}}$$

If load is not ground referenced, connect reverse biased diodes from outputs to ground.

## Positive High-Current Voltage Regulator

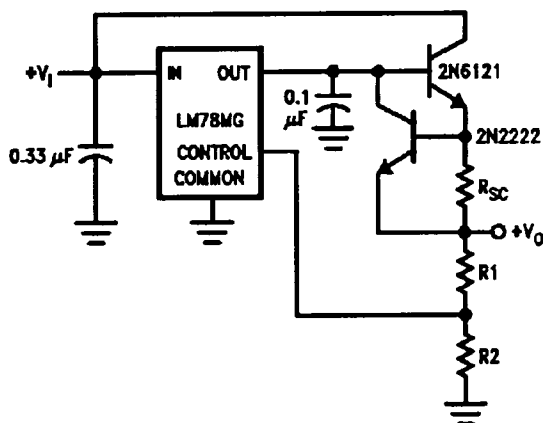


TL/H/10058-12



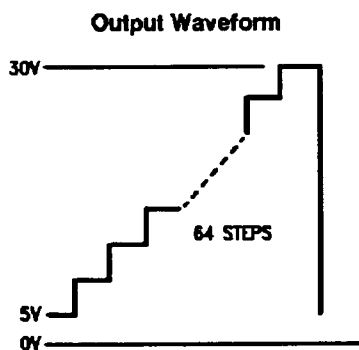
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## External Series Pass (a)



TL/H/10058-15

## Short-Circuit Limit (b)



TL/H/10058-16

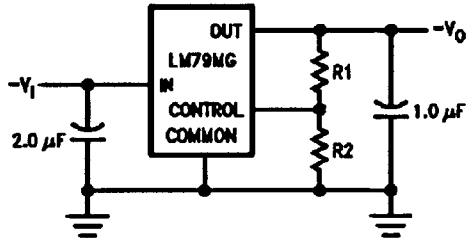
Note 1: All resistor values in ohms.

## Typical Applications for LM79MG (Note 1)

Bypass capacitors are recommended for stable operation of the LM79MG over the input voltage and output current ranges. Output bypass capacitors will improve the transient response of the regulator.

The bypass capacitors, (2.0  $\mu\text{F}$  on the input, 1.0  $\mu\text{F}$  on the output) should be ceramic or solid tantalum which have good high frequency characteristics. If aluminum electrolytics are used, their values should be 10  $\mu\text{F}$  or larger. The bypass capacitors should be mounted with the shortest leads, and if possible, directly across the regulator terminals.

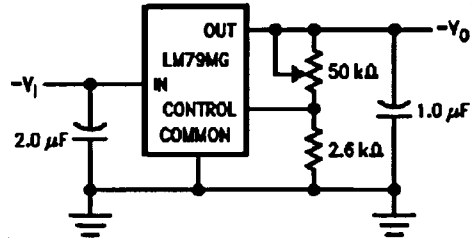
### Basic Negative Regulator



TL/H/10058-19

$$V_O = -V_{\text{CONT}} \left( \frac{R1 + R2}{R2} \right)$$

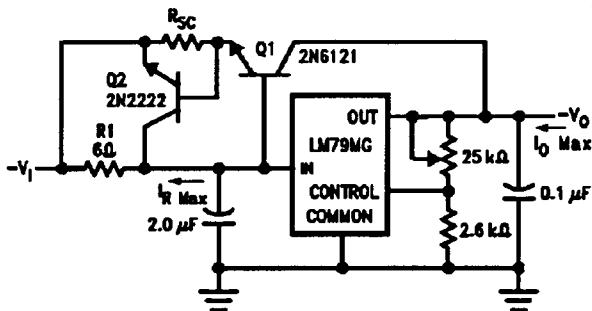
### -30V to -2.6V Adjustable Regulator



TL/H/10058-21

Note 1: All resistor values in ohms.

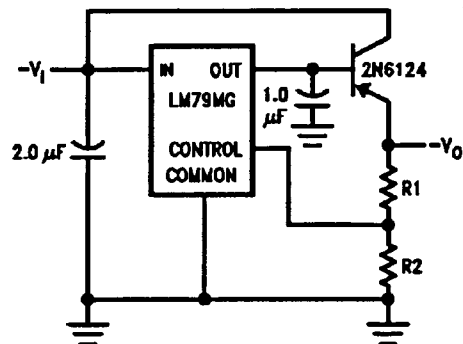
### Negative High Current Short Circuit Protected Regulator



TL/H/10058-17

$$R1 = \frac{\beta V_{BE}(Q1)}{I_{R \text{ Max}} - I_{O \text{ Max}}}$$

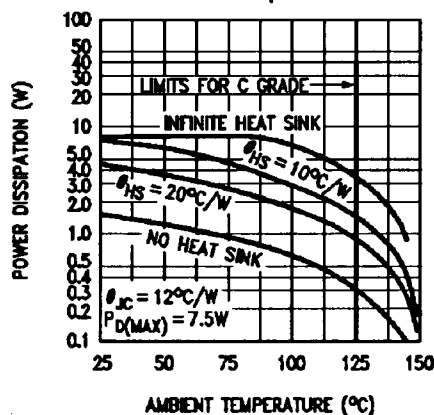
### Negative High Current Voltage Regulator



TL/H/10058-18

## Typical Performance Characteristics for LM78MG and LM79MG

### Worst Case Power Dissipation vs Ambient Temperature

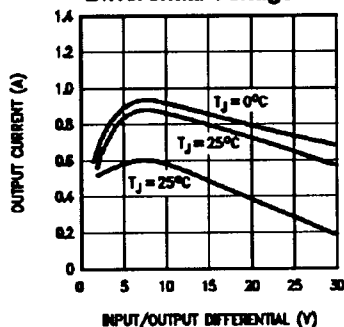


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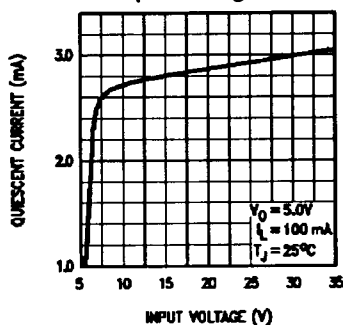


# Typical Performance Characteristics for LM78MG

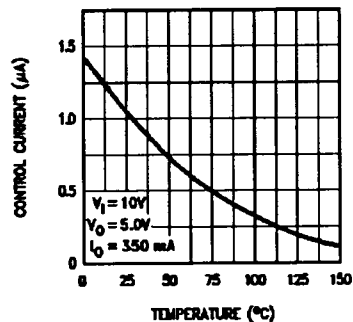
**Peak Output Current vs Input/Output Differential Voltage**



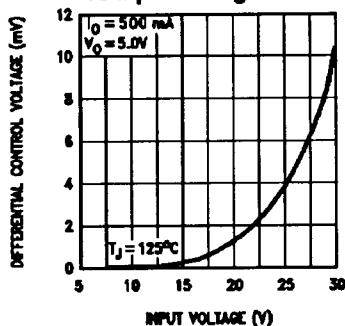
**Quiescent Current vs Input Voltage**



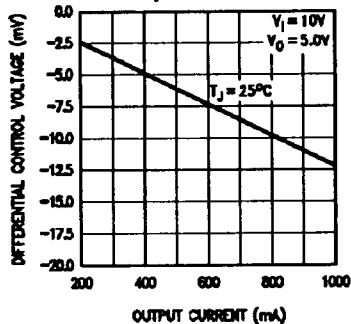
**Control Current vs Temperature**



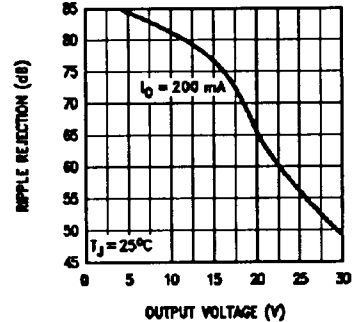
**Differential Control Voltage vs Input Voltage**



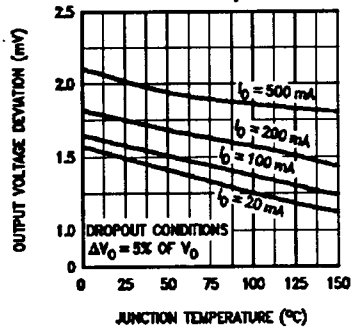
**Differential Control Voltage vs Output Current**



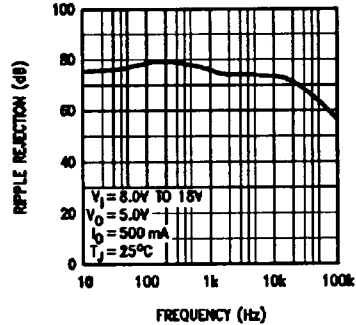
**Ripple Rejection vs Output Voltage**



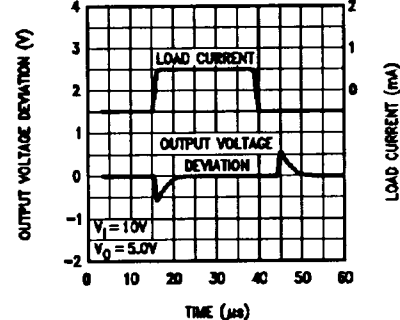
**Dropout Voltage vs Junction Temperature**



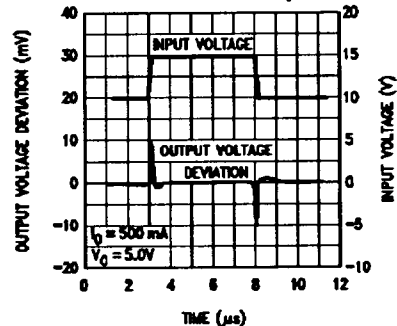
**Ripple Rejection vs Frequency**



**Load Transient Response**



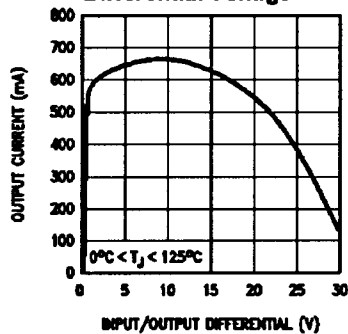
**Line Transient Response**



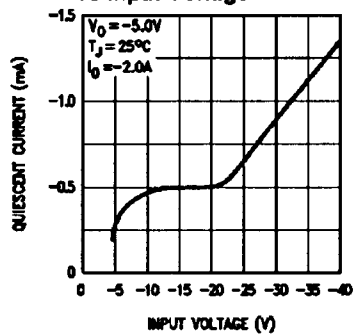
TL/H/10058-5

# Typical Performance Characteristics for LM79MG

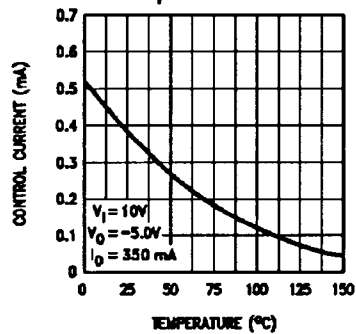
**Peak Output Current  
vs Input/Output  
Differential Voltage**



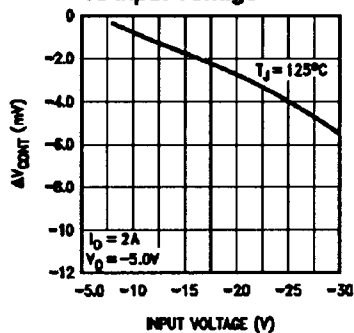
**Quiescent Current  
vs Input Voltage**



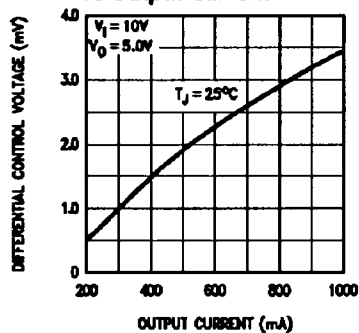
**Control Current  
vs Temperature**



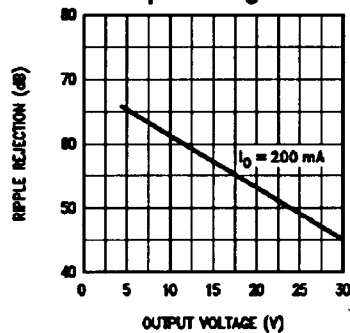
**Differential Control Voltage  
vs Input Voltage**



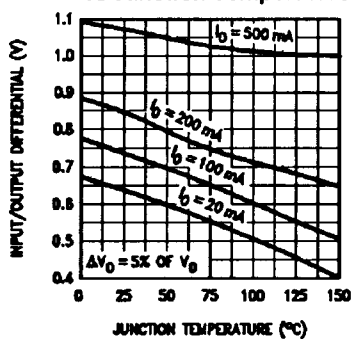
**Differential Control Voltage  
vs Output Current**



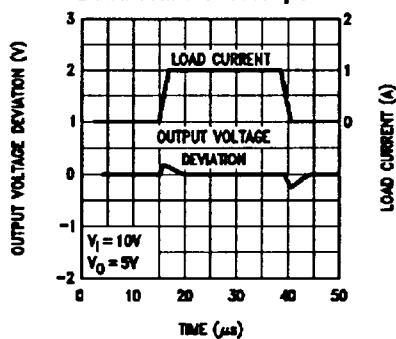
**Ripple Rejection  
vs Output Voltage**



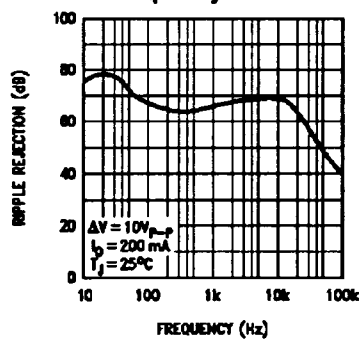
**Dropout Voltage  
vs Junction Temperature**



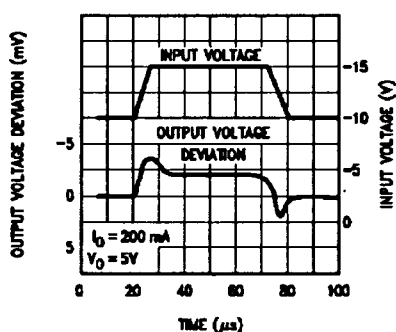
**Load Transient Response**



**Ripple Rejection  
vs Frequency**

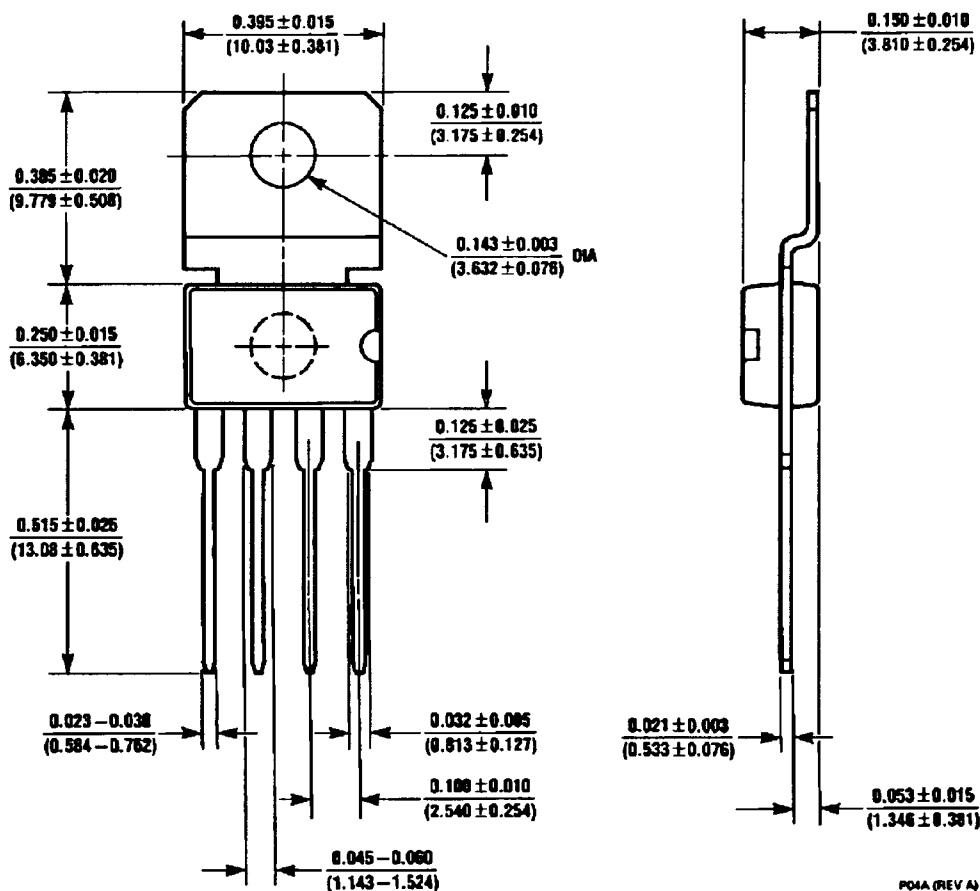


**Line Transient Response**



TL/H/10058-6

## Physical Dimensions inches (millimeters)



4-Lead Molded TO-202 (P)  
Order Number LM78MGCT or LM79MGCT  
NS Package Number P04A

P04A (REV A)

## LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.



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