National Semiconductor

April 1991

LM78MG/LM79MG
4-Terminal Adjustable Voltage Regulators

General Description

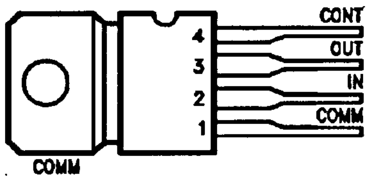
The LM78MG and LM79MG are 4-terminal adjustable voltage regulators. They are designed to deliver continuous load currents of up to 500 mA with a maximum input voltage of +40V for the positive regulator LM78MG and −40V for the negative regulator LM79MG. Output current capability can be increased to greater 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

LM78MG



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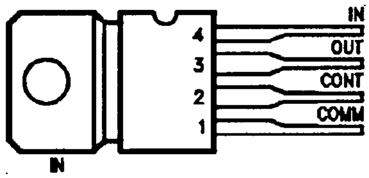
Top View

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

LM79MG



TL/H/10058–2

Top View

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

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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

$0°C \leq T_A \leq 125°C$ for LM78MGC, $V_I = 10V$, $I_O = 350$ mA, $C_I = 0.33$ μF, $C_O = 0.1$ μF, Test Circuit 1, unless otherwise specified

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

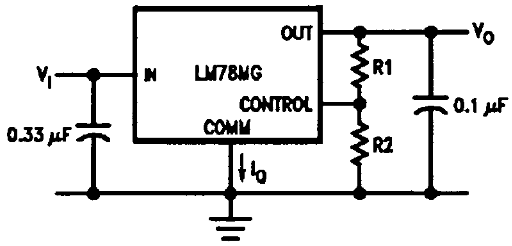
LM78MG Test Circuit 1

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

V_{CONT} Nominally = 5V

Recommended R2 current ≈ 1 mA

R2 = 5 kΩ



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LM79MGC

Electrical Characteristics

$0°C \le T_J \le 125°C$ for LM79MGC, $V_I = -14V$, $I_O = 350$ mA, $C_I = 2.0$ µF, $C_O = 1.0$ µF, Test Circuit 2, unless otherwise specified

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

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 ($t_W \le 10$ ms, duty cycle $\le 5\%$). 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 −15V is less than −10V.

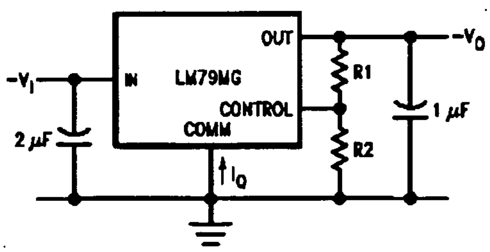
LM79MG Test Circuit 2

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

V_{CONT} Nominally = −2.55V

Recommended R2 current ≈ 1 mA

∴R2 = 2.6 kΩ



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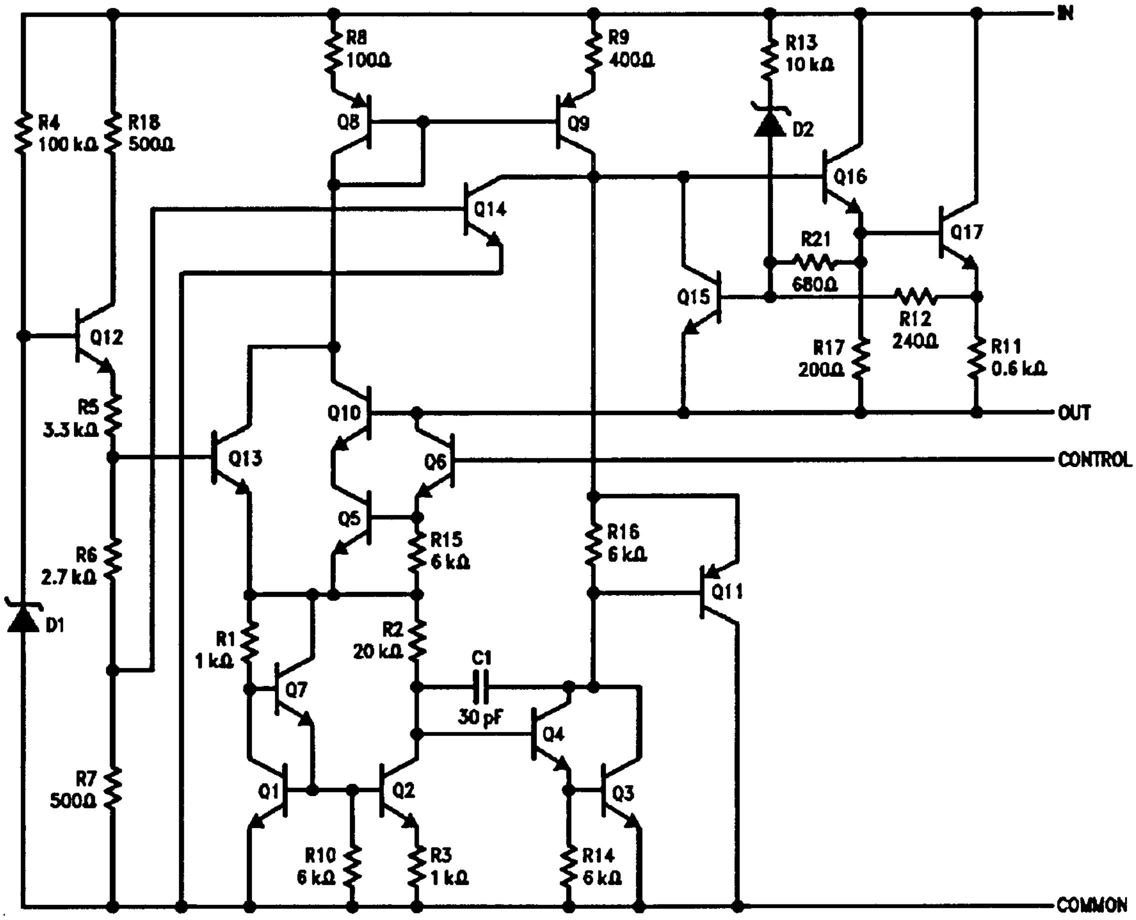
LM78MG Equivalent Circuit



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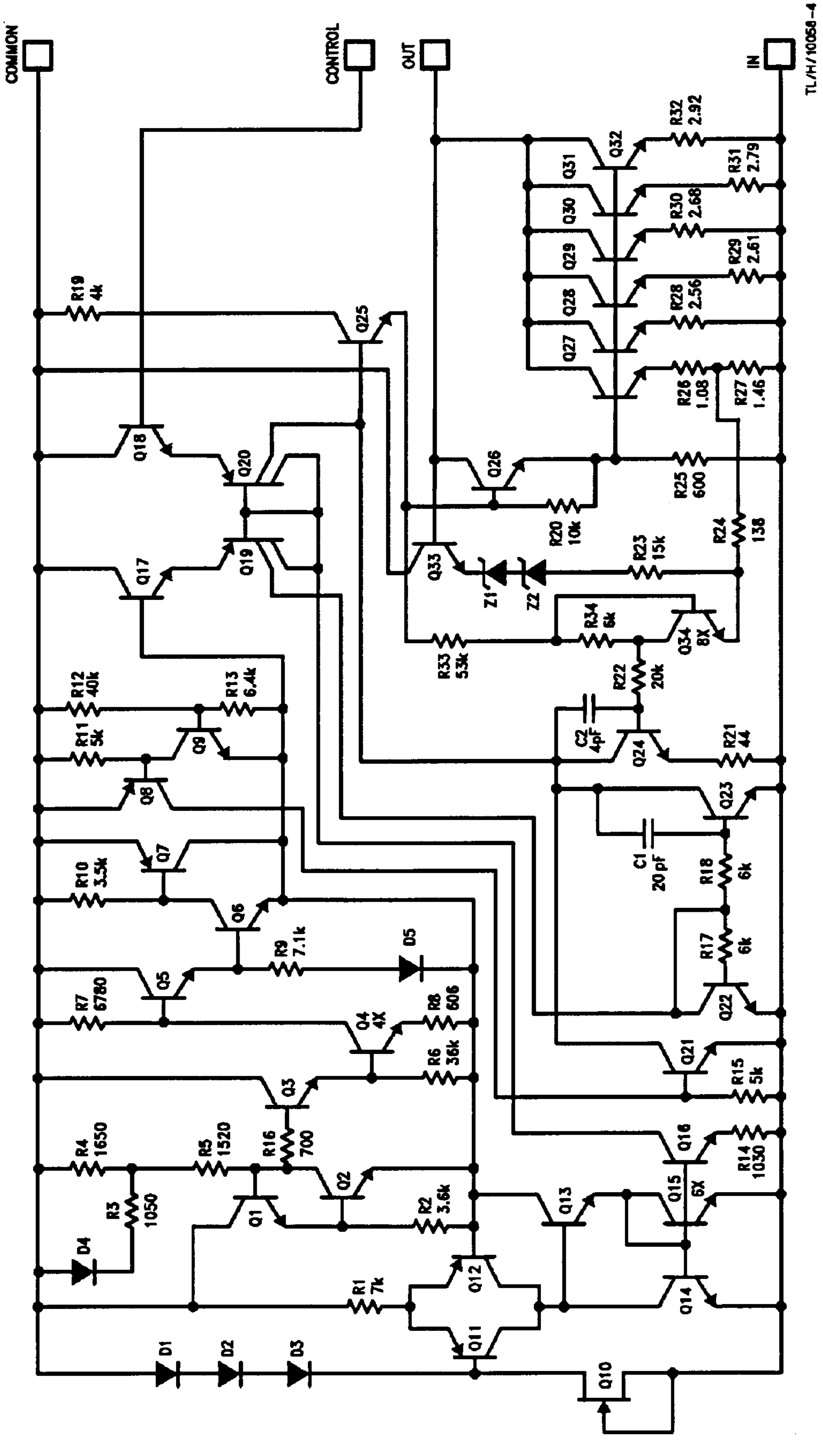
LM79MG Equivalent Circuit (Note 1)



Note 1: Resistor values in Ω unless otherwise noted.

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 kΩ in the LM78MG. The output voltage is then: V_O = (R1 + R2) Volts, where R1 and R2 are in kΩs.

Example: If R2 = 5.0 kΩ and R1 = 10 kΩ then
V_O = 15V nominal, for the LM78MG;
R2 = 2.6 kΩ and R1 = 13 kΩ 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 θ_{JC}	Max θ_{JC}	Typ θ_{JA}	Max θ_{JA}
Power Watt	8.0	12.0	70	75

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

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

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

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
θ_{JC} = Junction-to-Case Thermal Resistance
θ_{CA} = Case-to-Ambient Thermal Resistance
θ_{CS} = Case-to-Heat Sink Thermal Resistance
θ_{SA} = Heat Sink-to-Ambient Thermal Resistance
θ_{JA} = Junction-to-Ambient Thermal Resistance

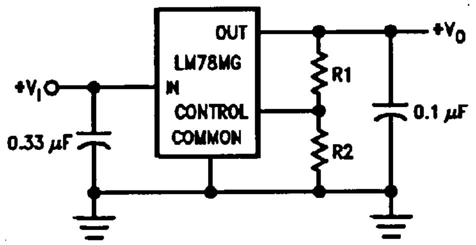
Typical Applications for LM78MG (Note 1)

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 μF on the input, 0.1 μF 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



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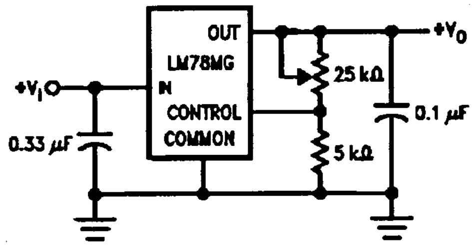
$$V_O = V_{CONT}\left(\frac{R1 + R2}{R2}\right)$$

Positive 5.0V to 30V Adjustable Regulator



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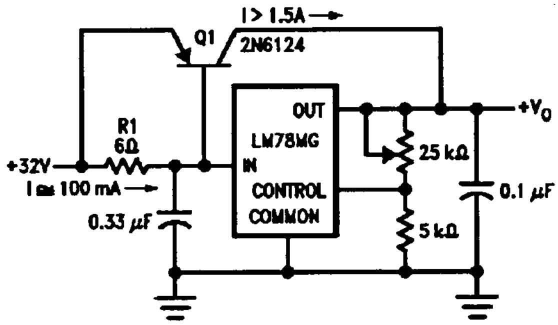
Positive 5.0V to 30V Adjustable Regulator I_O > 1.5A



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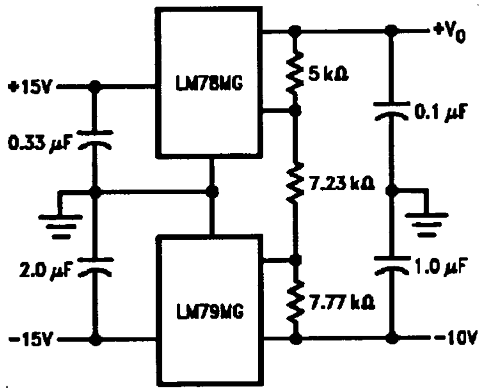
$$R1 = \frac{\beta V_{BE(Q1)}}{I_{R\,Max(\beta)} - I_O}$$

Typical Applications for LM78MG (Note 1) (Continued)

±10V, 500 mA Dual Tracking Regulator



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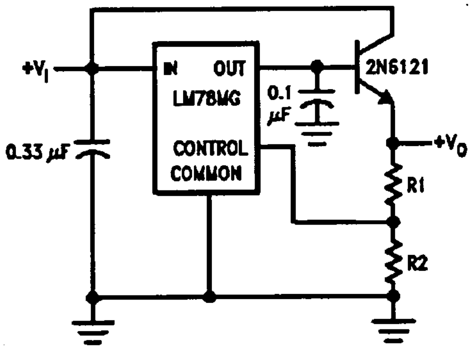
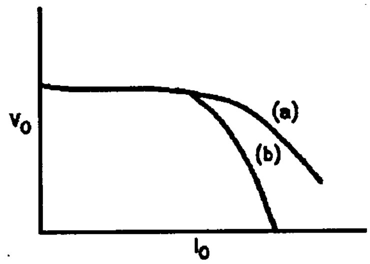
Note: External series pass device is not short circuit protected.

Positive High-Current Voltage Regulator



TL/H/10058–12



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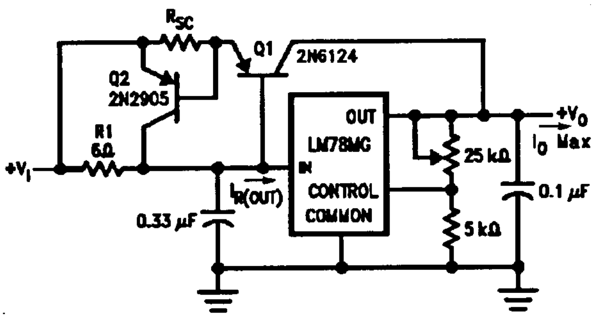
Positive High Current Short Circuit Protected Regulator



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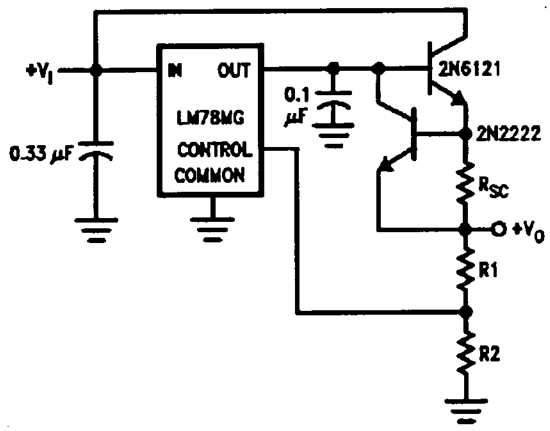
$$R1 = \frac{\beta V_{BE(Q1)}}{V_{R\,Max}(\beta + 1) - I_{O\,Max}}$$

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

External Series Pass (a)



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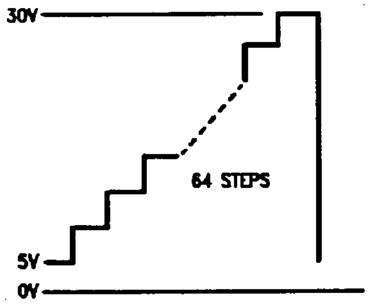
Short-Circuit Limit (b)

Output Waveform



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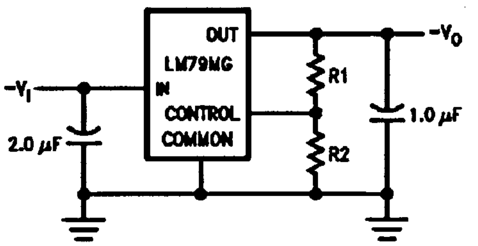
Note 1: All resistor values in ohms.

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 µF on the input, 1.0 µF 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 µF or larger. The bypass capacitors should be mounted with the shortest leads, and if possible, directly across the regulator terminals.

Basic Negative Regulator



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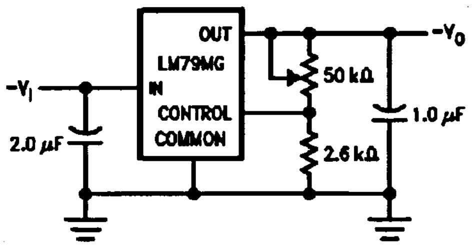
$$V_O = -V_{CONT}\left(\frac{R1 + R2}{R2}\right)$$

−30V to −2.6V Adjustable Regulator



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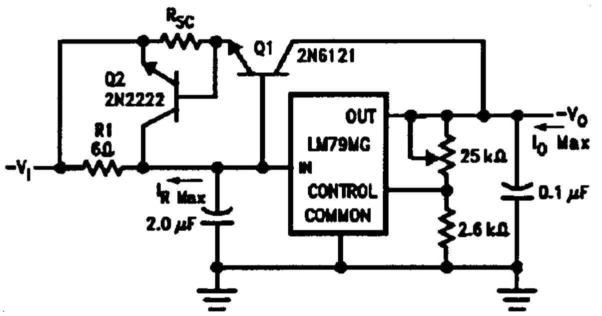
Note 1: All resistor values in ohms.

Negative High Current Short Circuit Protected Regulator



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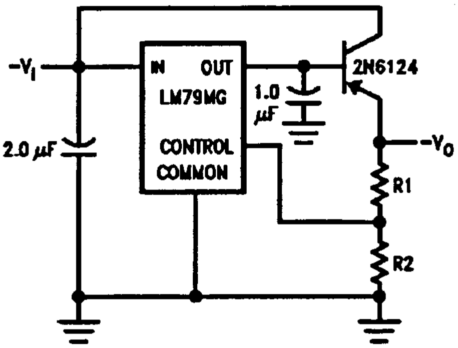
$$R1 = \frac{\beta V_{BE(Q1)}}{I_{R\,Max(\beta)} - I_{O\,Max}}$$

Negative High Current Voltage Regulator



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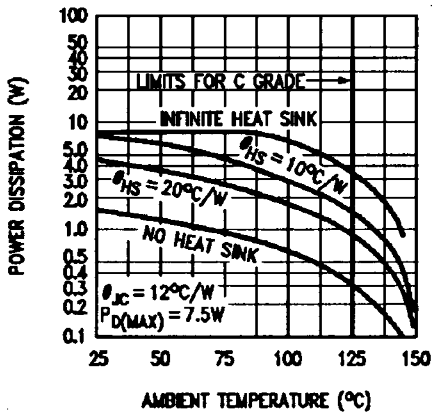
Typical Performance Characteristics for LM78MG and LM79MG

Worst Case Power Dissipation vs Ambient Temperature



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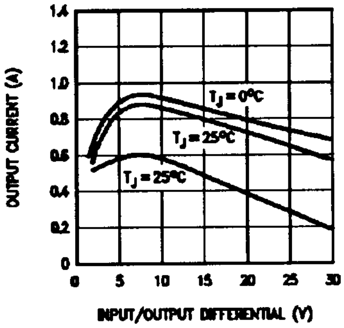
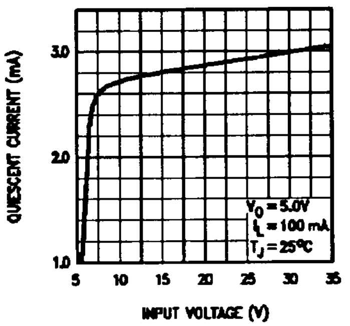
Typical Performance Characteristics for LM78MG

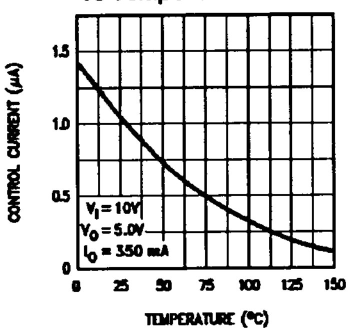
Peak Output Current vs Input/Output Differential Voltage



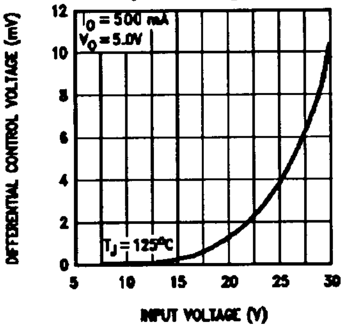
Quiescent Current vs Input Voltage



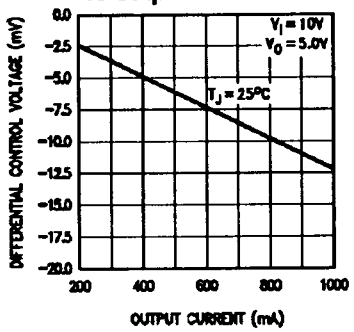
Control Current vs Temperature



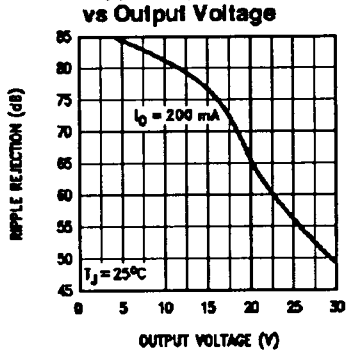
Differential Control Voltage vs Input Voltage



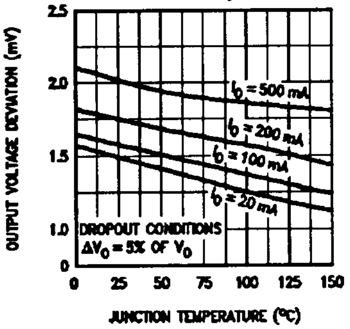
Differential Control Voltage vs Output Current



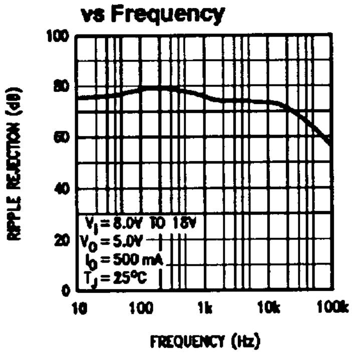
Ripple Rejection vs Output Voltage



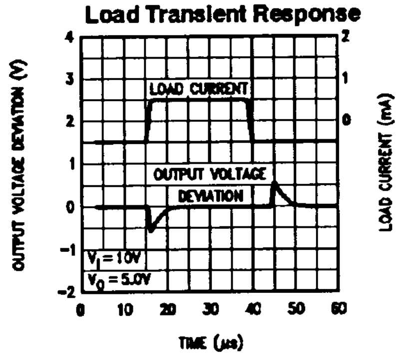
Dropout Voltage vs Junction Temperature



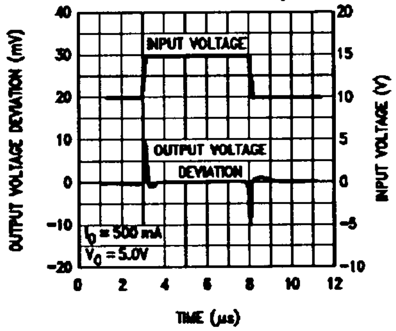
Ripple Rejection vs Frequency



Load Transient Response



Line Transient Response



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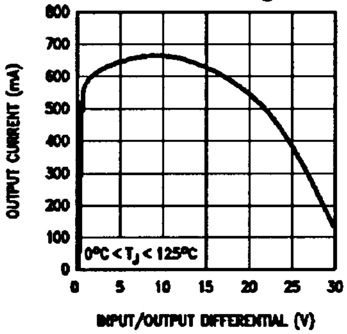
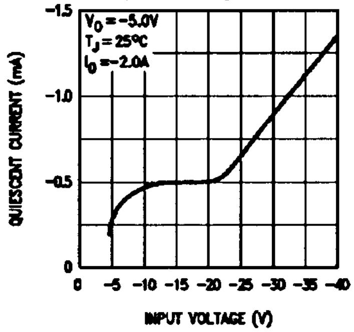
Typical Performance Characteristics for LM79MG

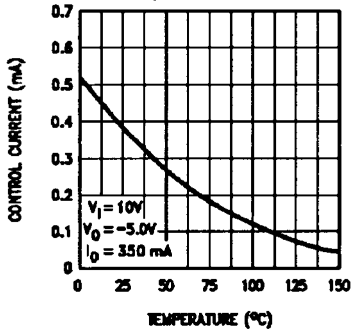
Peak Output Current vs Input/Output Differential Voltage



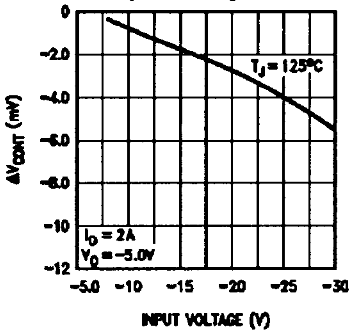
Quiescent Current vs Input Voltage



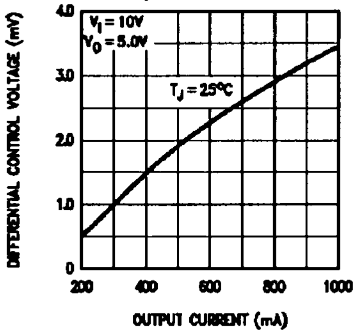
Control Current vs Temperature



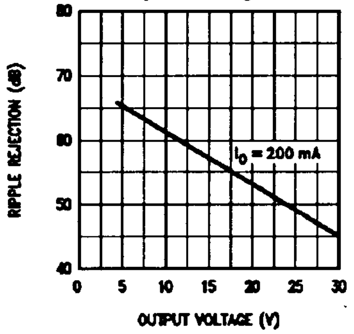
Differential Control Voltage vs Input Voltage



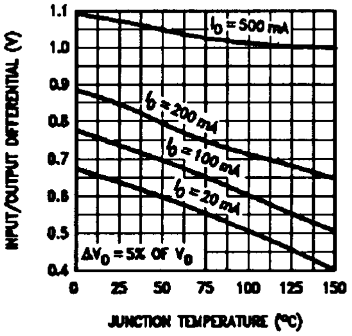
Differential Control Voltage vs Output Current



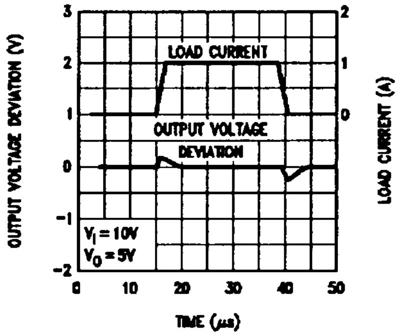
Ripple Rejection vs Output Voltage



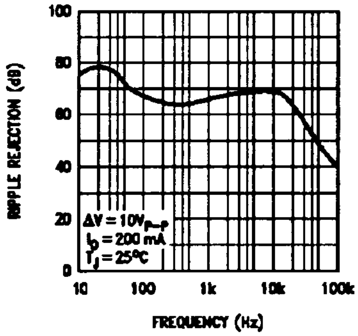
Dropout Voltage vs Junction Temperature



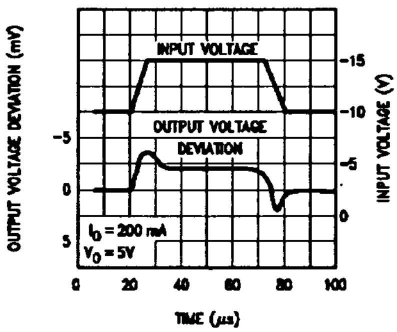
Load Transient Response



Ripple Rejection vs Frequency

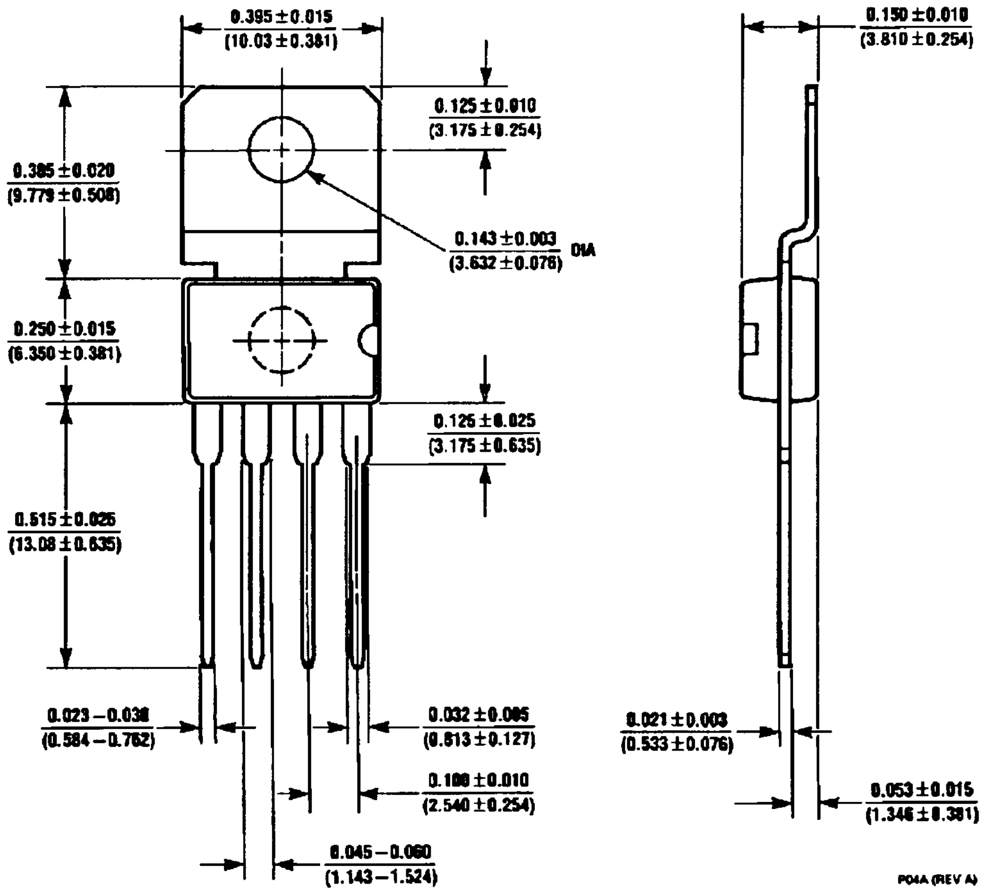


Line Transient Response



TL/H/10056–6

Physical Dimensions inches (millimeters)



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

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