National Semiconductor

April 1991

LM78MG/LM79MG 4-Terminal Adjustable Voltage Regulators

General Description

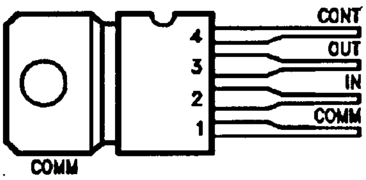
The LM78MG and LM79MG are 4-terminal adjustable voltage regulators. They are designed to deliver continuous load currents of up to 500 mA with a maximum input voltage of +40V for the positive regulator LM78MG and −40V for the negative regulator LM79MG. Output current capability can be increased to greater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

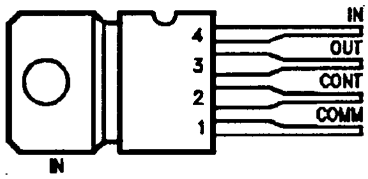


TL/H/10058-1

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

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	$0V \le V^+ \le V_O$
LM79MGC	$V_O^- \le V^- \le 0V$

LM78MGC

Electrical Characteristics

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

Symbol	Parameter	Conditions (Notes 1, 3)		Min	Typ	Max	Units
V_{IR}	Input Voltage Range	$T_J = 25°C$		7.5		40	V
V_{OR}	Output Voltage Range	$V_I = V_O + 5.0V$		5.0		30	V
V_O	Output Voltage Tolerance	$(V_O + 3.0V) \le V_I \le (V_O + 15V)$, $5.0\ mA \le I_O \le 350\ mA$, $P_D \le 5.0W$, $V_{I\ Max} = 38V$	$T_J = 25°C$			4.0	% (V_O)
						5.0	
$V_{O\ LINE}$	Line Regulation	$T_J = 25°C$, $I_O = 200$ mA, $V_O \le 10V$, $(V_O + 2.5V) \le V_I \le (V_O + 20V)$, $T_J = 25°C$, $I_O = 200$ mA, $V_O \ge 10V$				1.0	%(V_O)
$V_{O\ LOAD}$	Load Regulation	$T_J = 25°C$, $5.0\ mA \le I_O \le 500\ mA$, $V_I = V_O + 7.0V$				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, $8.0V \le V_I \le 18V$, $V_O = 5.0V$, 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	

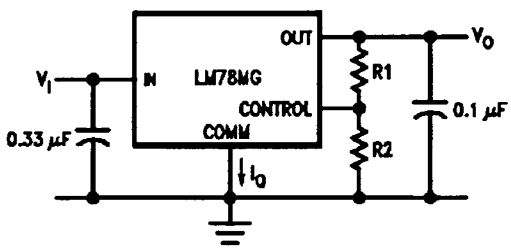
$$V_O = \left(\frac{R1 + R2}{R2}\right) V_{CONT}$$

V_{CONT} Nominally = 5V

Recommended R2 current ≈ 1 mA

R2 = 5 kΩ

LM78MG Test Circuit 1



TL/H/10058-20

LM79MGC

Electrical Characteristics

0°C ≤ T_J ≤ 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) ≤ V_I ≤ (V_O − 3.0V), 5.0 mA ≤ I_O ≤ 350 mA, P_D ≤ 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 ≤ −10V, (V_O − 20V) ≤ V_I ≤ (V_O − 2.5V), T_J = 25°C, I_O = 200 mA, V_O ≤ −10V				1.0	%(V_O)
$V_{O\,LOAD}$	Load Regulation	V_I = V_O − 7.0V, 5.0 mA ≤ I_O ≤ 500 mA, T_J = 25°C				1.0	%(V_O)
I_C	Control Lead Current	T_J = 25°C				2.0	µA
						3.0	
I_Q	Quiescent Current	T_J = 25°C			2.1	7.0	mA
						8.0	
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 ≤ f ≤ 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	
V_C	Control Lead Voltage (Reference)	T_J = 25°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 ≤ 10 ms, duty cycle ≤ 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.

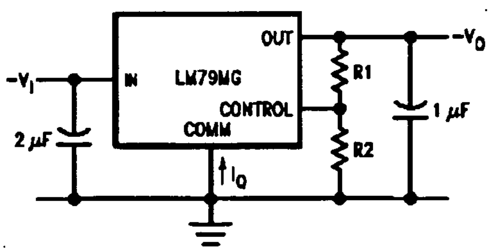
LM79MG Test Circuit 2

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

V_{CONT} Nominally = −2.55V

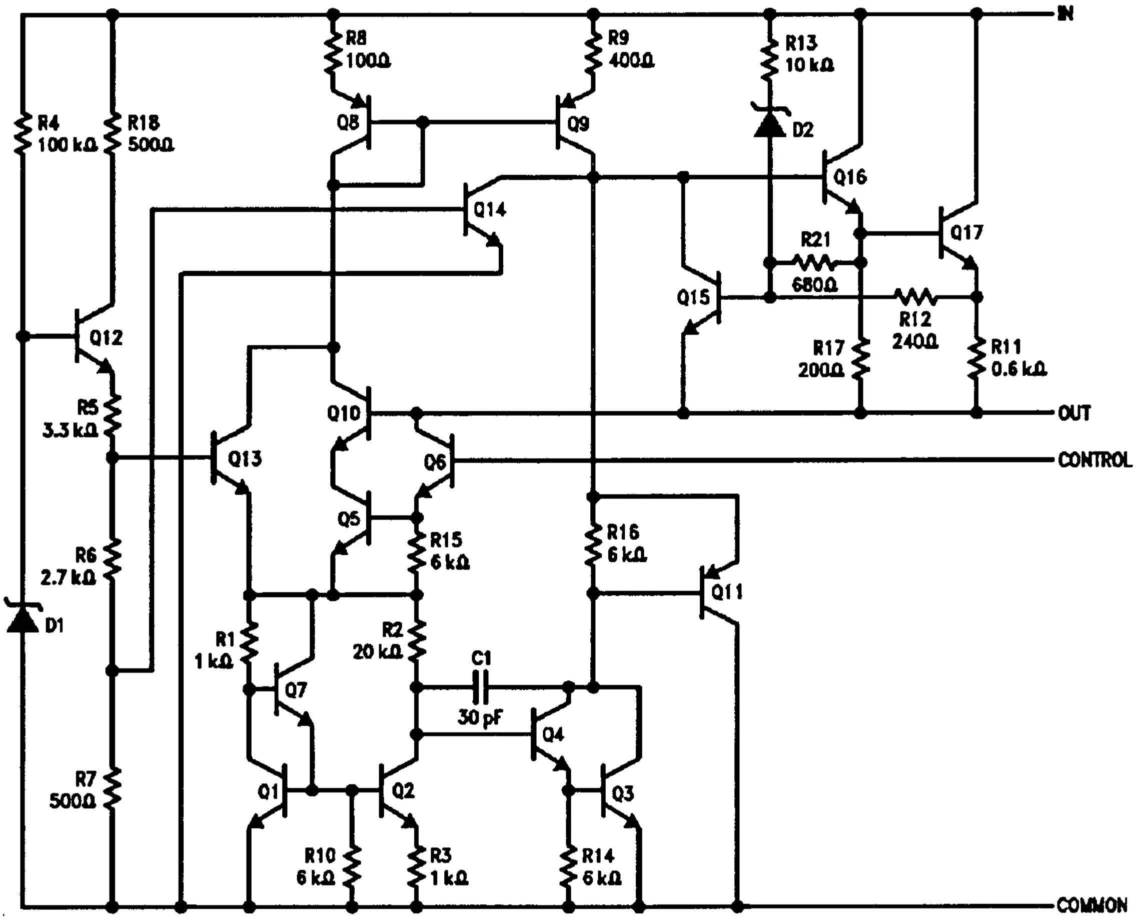
Recommended R2 current ≈ 1 mA

∴R2 = 2.6 kΩ



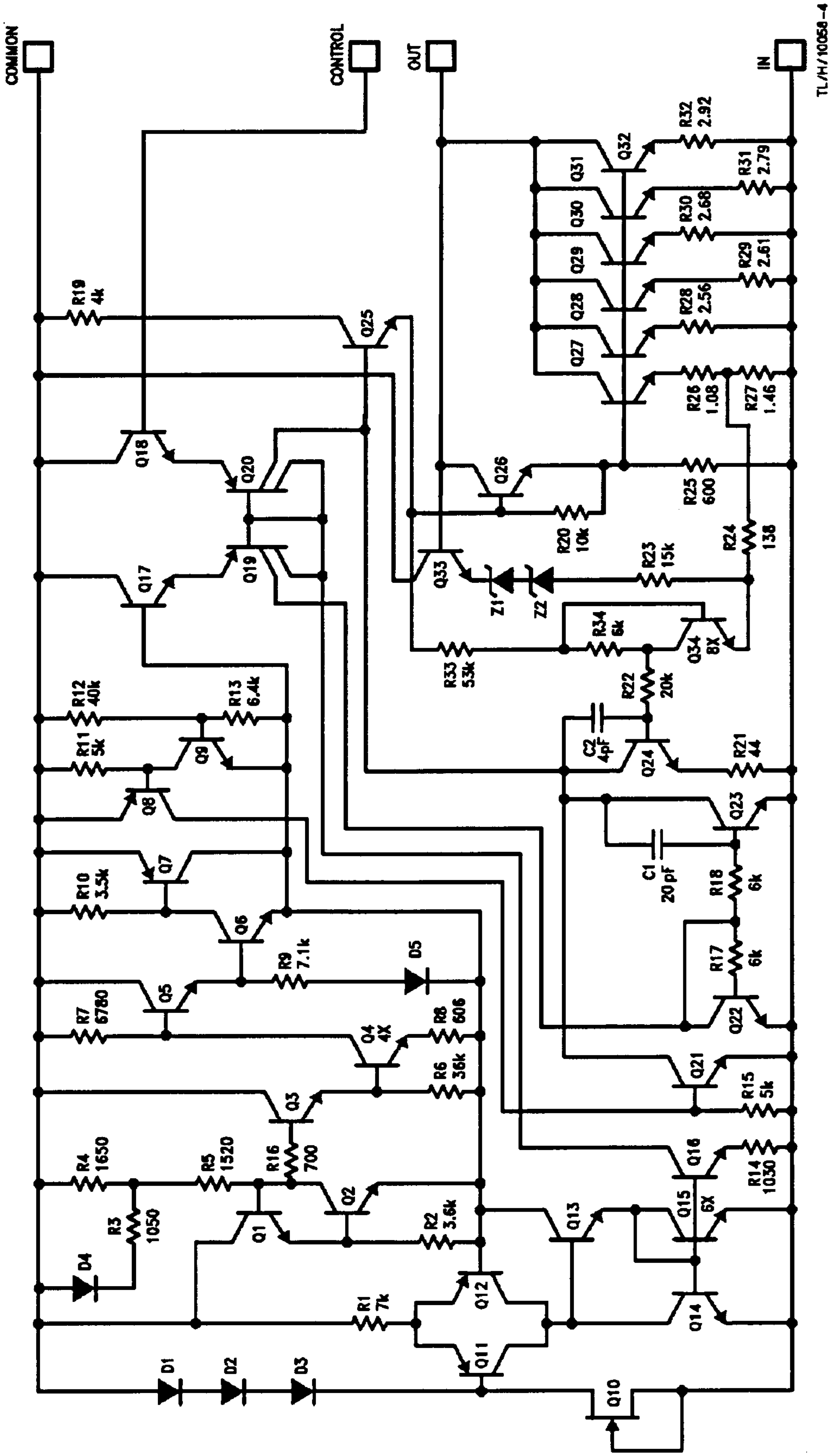
TL/H/10058–22

LM78MG Equivalent Circuit



TL/H/10058–3

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

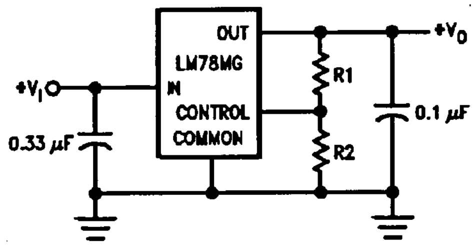
Typical Applications for LM78MG (Note 1)

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.

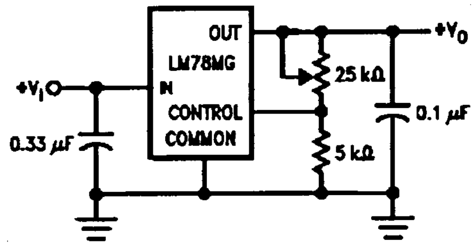
Basic Positive Regulator



TL/H/10058-8

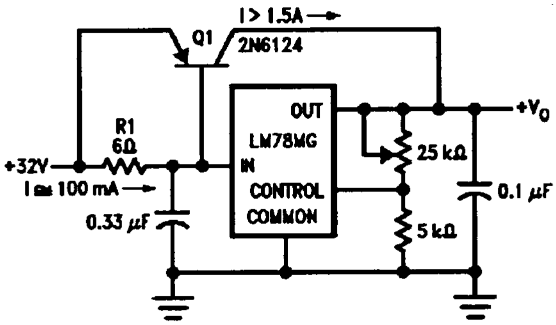
$$V_O = V_{CONT}\left(\frac{R1 + R2}{R2}\right)$$

Positive 5.0V to 30V Adjustable Regulator



TL/H/10058-9

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

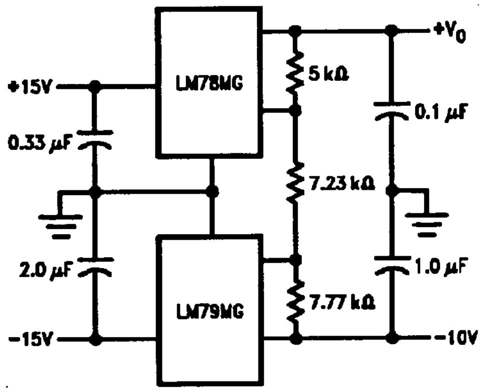


TL/H/10058-10

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

Typical Applications for LM78MG (Note 1) (Continued)

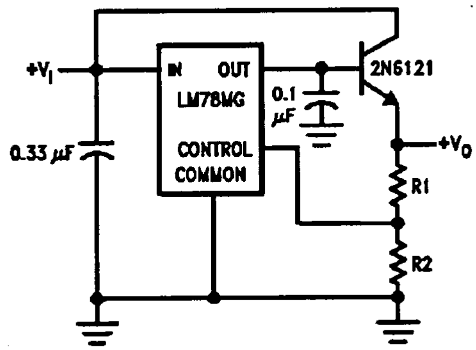
± 10V, 500 mA Dual Tracking Regulator



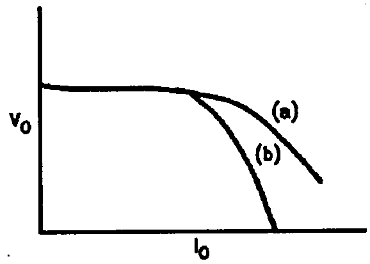
TL/H/10058–11

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

Positive High-Current Voltage Regulator

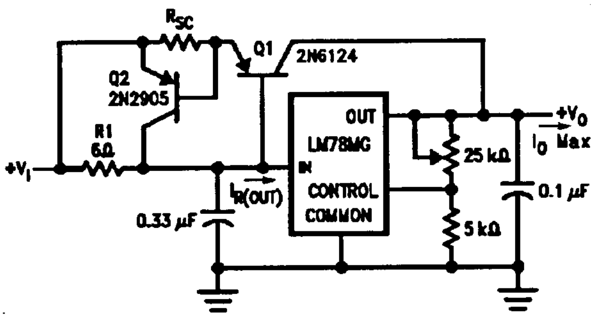


TL/H/10058–12



TL/H/10058–13

Positive High Current Short Circuit Protected Regulator

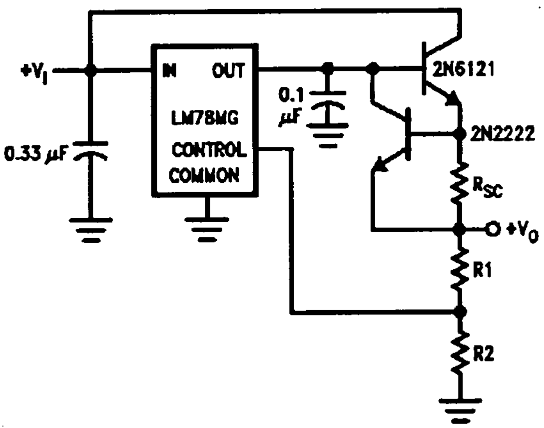


TL/H/10058–14

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

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

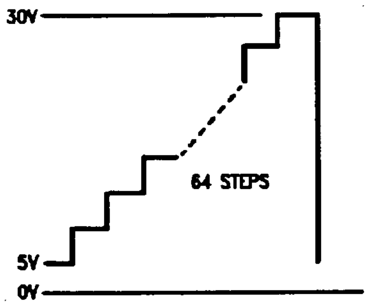
External Series Pass (a)



TL/H/10058–15

Short-Circuit Limit (b)

Output Waveform



TL/H/10058–16

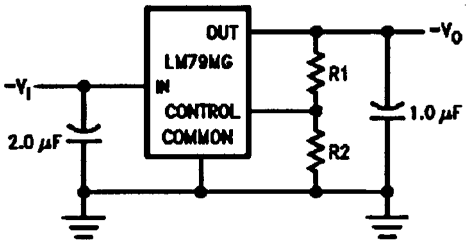
Note 1: All resistor values in ohms.

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 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.

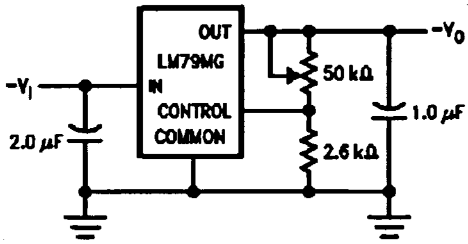
Basic Negative Regulator



TL/H/10058-19

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

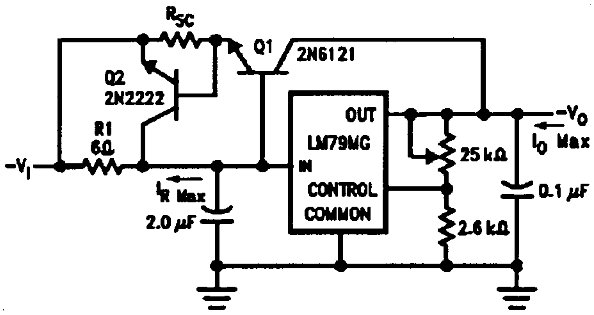
−30V to −2.6V Adjustable Regulator



TL/H/10058-21

Note 1: All resistor values in ohms.

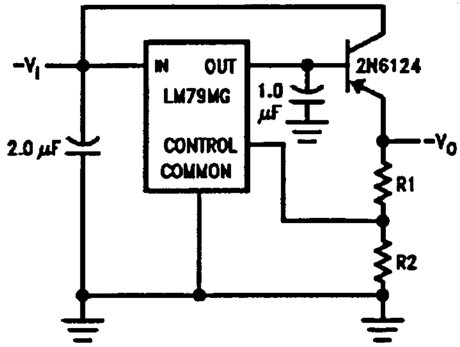
Negative High Current Short Circuit Protected Regulator



TL/H/10058-17

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

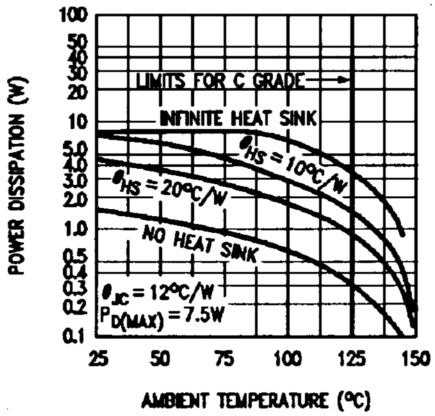
Negative High Current Voltage Regulator



TL/H/10058-18

Typical Performance Characteristics for LM78MG and LM79MG

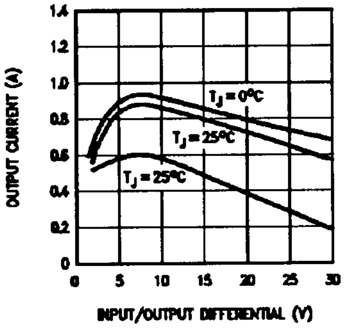
Worst Case Power Dissipation vs Ambient Temperature



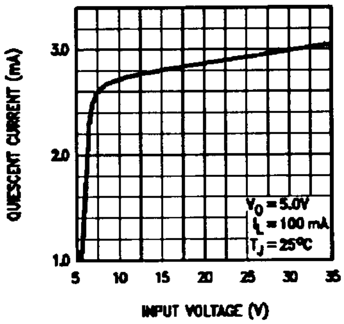
TL/H/10058-7

Typical Performance Characteristics for LM78MG

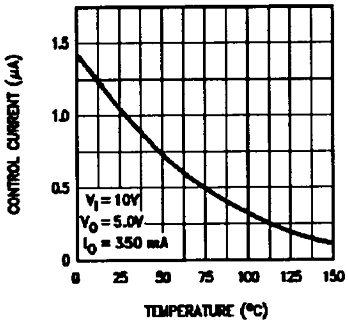
Peak Output Current vs Input/Output Differential Voltage



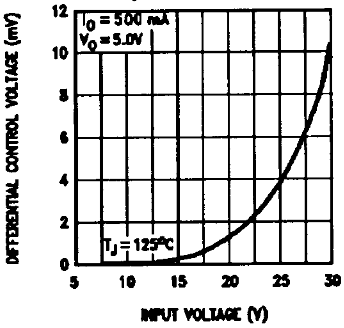
Quiescent Current vs Input Voltage



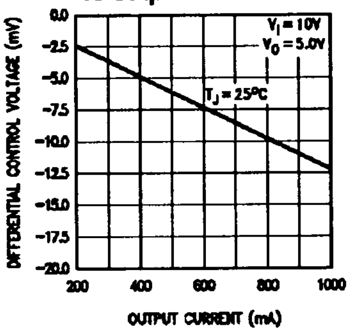
Control Current vs Temperature



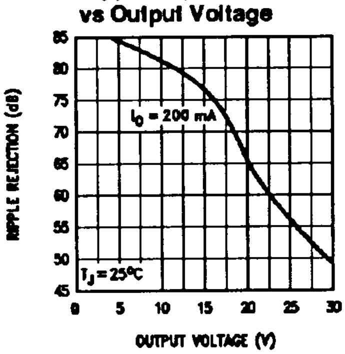
Differential Control Voltage vs Input Voltage



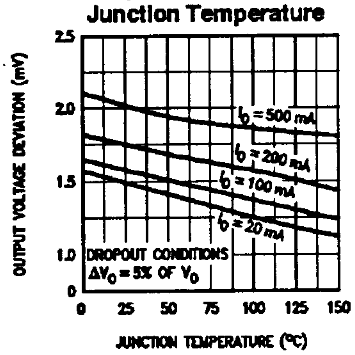
Differential Control Voltage vs Output Current



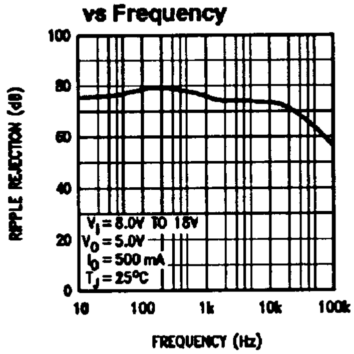
Ripple Rejection vs Output Voltage



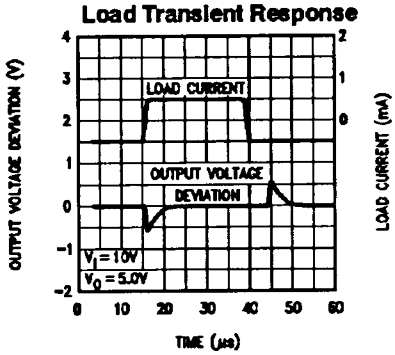
Dropout Voltage vs Junction Temperature



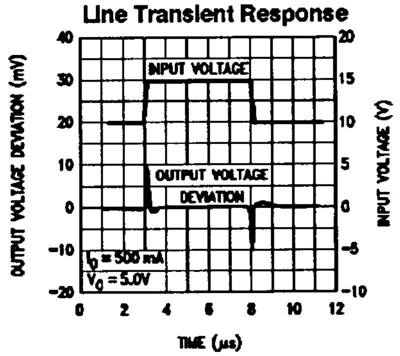
Ripple Rejection vs Frequency



Load Transient Response



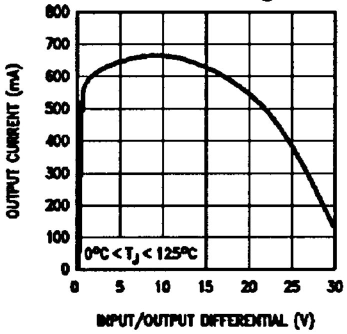
Line Transient Response



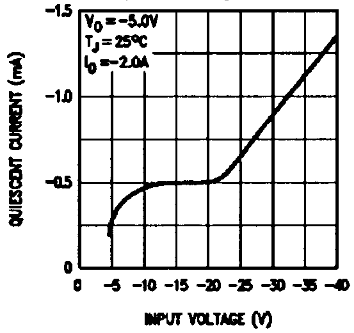
TL/H/10058–5

Typical Performance Characteristics for LM79MG

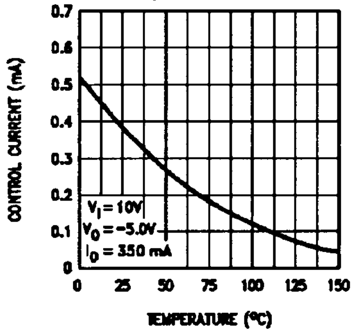
Peak Output Current vs Input/Output Differential Voltage



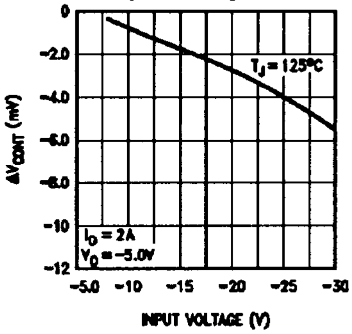
Quiescent Current vs Input Voltage



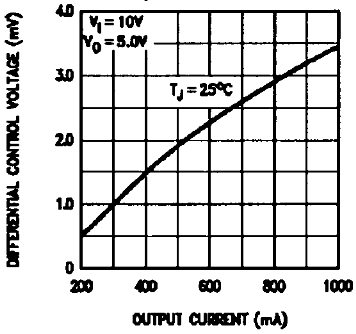
Control Current vs Temperature



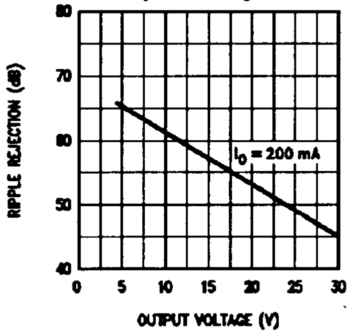
Differential Control Voltage vs Input Voltage



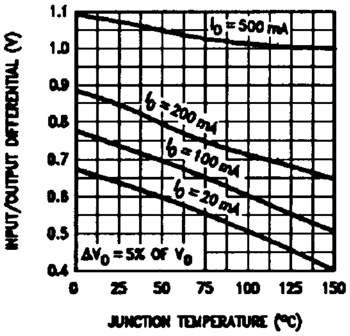
Differential Control Voltage vs Output Current



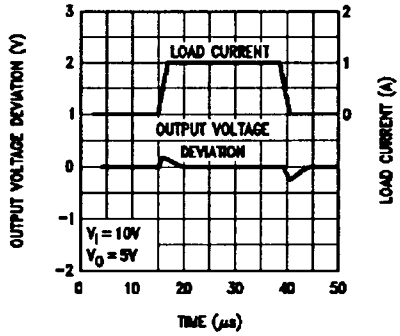
Ripple Rejection vs Output Voltage



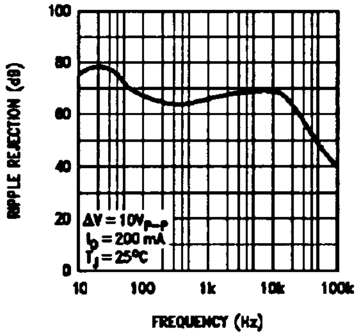
Dropout Voltage vs Junction Temperature



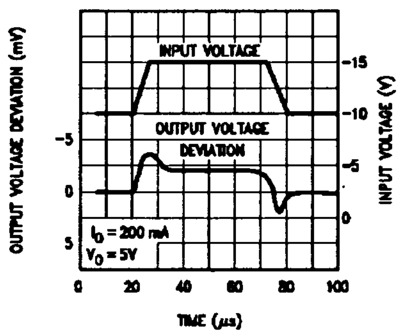
Load Transient Response



Ripple Rejection vs Frequency

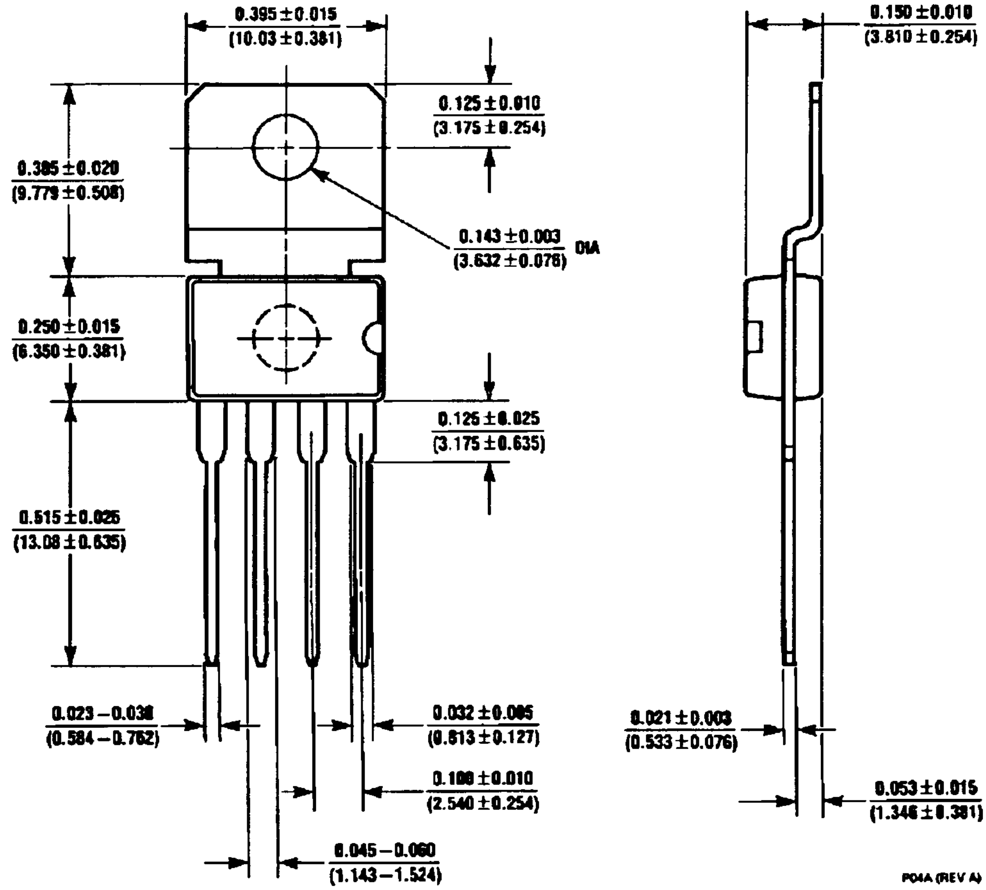


Line Transient Response



TL/H/10058–6

Physical Dimensions inches (millimeters)



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

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.

National Semiconductor Corporation
2900 Semiconductor Drive
P.O. Box 58090
Santa Clara, CA 95052-8090
Tel: 1(800) 272-9959
TWX: (910) 339-9240

National Semiconductor GmbH
Industriestrasse 10
D-8080 Furstenfeldbruck
West Germany
Tel: (0-81-41) 103-0
Telex: 527-649
Fax: (08141) 103554

National Semiconductor Japan Ltd.
Sanseido Bldg. 5F
4-15 Nishi Shinjuku
Shinjuku-Ku,
Tokyo 160, Japan
Tel: 3-299-7001
FAX: 3-299-7000

National Semiconductor Hong Kong Ltd.
Suite 513, 5th Floor
Chinachem Golden Plaza,
77 Mody Road, Tsimshatsui East,
Kowloon, Hong Kong
Tel: 3-7231290
Telex: 52996 NSSEA HX
Fax: 3-3112536

National Semicondutores Do Brasil Ltda.
Av. Brig. Faria Lima, 1383
6.0 Andor-Conj. 62
01451 Sao Paulo, SP, Brasil
Tel: (55/11) 212-5066
Fax: (55/11) 211-1181 NSBR BR

National Semiconductor (Australia) PTY, Ltd.
1st Floor, 441 St. Kilda Rd.
Melbourne, 3004
Victory, Australia
Tel: (03) 267-5000
Fax: 61-3-2677458