National Semiconductor

LM78G/LM79G
4-Terminal Adjustable Voltage Regulators

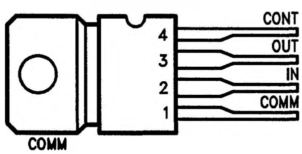
General Description

The LM78G and LM79G are 4-terminal adjustable voltage regulators. They are designed to deliver continuous load currents of up to 1.0A with a maximum input voltage of +40V for the positive regulator LM78G and −40V for the negative regulator LM79G. Output current capability can be increased to greater than 1.0A through use of one or more external transistors. The output voltage range of the LM78G positive voltage regulator is +5V to +30V and the output voltage range of the negative LM79G is −30V to −2.55V. For systems requiring both a positive and negative, the LM78G and LM79G are excellent for use as a dual tracking regulator with appropriate external circuitry.

Features

- Output current in excess of 1A
- LM78G positive output +5V to +30V
- LM79G negative output −30V to −2.55V
- Internal thermal overload protection
- Internal short circuit protection
- Output transistor safe-area protection

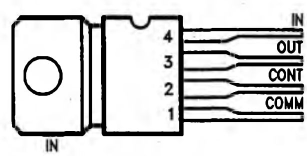
Connection Diagrams



TL/H/10054-1

Top View

Heat sink tabs connected to common through device substrate.



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Top View

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

Order Number LM78GCP or LM79GCP
See NS Package Number P04A

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
Power Dissipation	Internally Limited
Input Voltage	
LM78G	+40V
LM79G	−40V
Control Lead Voltage	
LM78G	$0V \le V^+ \le V_O$
LM79G	$V_O^- \le V^- \le 0V$

LM78G Electrical Characteristics

$0°C \le T_A \le 125°C$, $C_I = 0.33\ \mu F$, $C_O = 0.1\ \mu F$, $V_I = 10V$, $I_O = 500$ mA, 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	$(V_O + 3.0V) \le V_I \le (V_O + 15V)$, $5.0\ mA \le I_O \le 1.0A$, $P_D \le 15W$, $V_{I\ Max} = 38V$; $T_J = 25°C$			4.0	% V_O
		$(V_O + 3.0V) \le V_I \le (V_O + 15V)$, $5.0\ mA \le I_O \le 1.0A$, $P_D \le 15W$, $V_{I\ Max} = 38V$			5.0	% V_O
$V_{O\ LINE}$	Line Regulation	$T_J = 25°C$, $V_O \le 10V$, $(V_O + 2.5V) \le V_I \le (V_O + 20V)$			1.0	% V_O
$V_{O\ LOAD}$	Load Regulation	$T_J = 25°C$, $V_I \le V_O + 5.0V$; $250\ mA \le I_O \le 750\ mA$			1.0	% V_O
		$T_J = 25°C$, $V_I \le V_O + 5.0V$; $5.0\ mA \le I_O \le 1.5A$			2.0	% V_O
I_C	Control Lead Current	$T_J = 25°C$		1.0	5.0	μA
					8.0	μA
I_Q	Quiescent Current	$T_J = 25°C$		3.2	6.0	mA
					7.0	mA
$\Delta V_I/\Delta V_O$	Ripple Rejection	$8.0V \le V_I \le 18V$, $f = 2400$ Hz, $V_O = 5.0V$, $I_C = 350$ mA	68	78		dB
N_O	Noise	$T_J = 25°C$, $10\ Hz < f < 100\ kHz$, $V_O = 5.0V$, $I_O = 5.0$ mA		8.0	40	$\mu V/V_O$
V_{DO}	Dropout Voltage (Note 2)			2.0	2.5	V
I_{OS}	Output Short Circuit Current	$T_J = 25°C$, $V_I = 30V$		0.750	1.2	A
I_{pk}	Peak Output Current	$T_J = 25°C$	1.3	2.2	3.3	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	$mV/°C/V_O$
		$V_O = 5.0V$, $I_O = 5.0$ mA; $T_A = 25°C$ to $+125°C$			0.3	$mV/°C/V_O$
V_C	Control Lead Voltage (Reference)	$T_J = 25°C$	4.8	5.0	5.2	V
			4.75		5.25	V

Note 1: V_O is defined for the LM78G as $V_O = \frac{R1 + R2}{R2}(5.0)$;

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.

LM79G

Electrical Characteristics

$0°C \le T_A \le 125°C$ for LM79G, $V_I = -10V$, $I_O = 500$ mA, $C_I = 2.0$ μF, $C_O = 0.1$ μF, Test Circuit 2 and Note 3, unless otherwise specified

Symbol	Parameter	Conditions (Note 1)		Min	Typ	Max	Units
V_{IR}	Input Voltage Range	$T_J = 25°C$		−40		−7.0	V
V_{OR}	Nominal Output Voltage Range	$V_I = V_O - 5.0V$		−30		−2.55	V
V_O	Output Voltage Tolerance	$(V_O - 15V) \le V_I \le (V_O - 3.0V)$, $5.0\ mA \le I_O \le 1.0A$, $P_D \le 15W$, $V_{I\ Max} = -3.8V$	$T_J = 25°C$			4.0	% V_O
						5.0	
$V_{O\ LINE}$	Line Regulation	$T_J = 25°C$, $V_O \ge -10V$, $(V_O - 20V) \le V_I \le (V_O - 2.5V)$				1.0	% V_O
$V_{O\ LOAD}$	Load Regulation	$T_J = 25°C$, $V_I = V_O = -5.0V$	$250\ mA \le I_O \le 750\ mA$			1.0	% V_O
			$5.0\ mA \le I_O \le 1.5A$			2.0	
I_C	Control Lead Current	$T_J = 25°C$			0.4	2.0	μA
						3.0	
I_Q	Quiescent Current	$T_J = 25°C$			2.5	2.0	mA
						8.0	
$\Delta V_I/\Delta V_O$	Ripple Rejection	$V_O = -8.0V$, $V_I = -13V$, f = 2400 Hz, $I_C = 350$ mA		50	60		dB
N_O	Noise	$T_J = 25°C$, 10 Hz ≤ f ≤ 100 kHz, $V_O = -8.0V$, $I_O = 5.0$ mA			25	80	μV/V_O
V_{DO}	Dropout Voltage (Note 2)				1.1	2.3	V
I_{OS}	Output Short Circuit Current	$T_J = 25°C$, $V_I = -30V$			0.25	1.2	A
I_{pk}	Peak Output Current	$T_J = 25°C$		1.3	2.1	3.3	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	

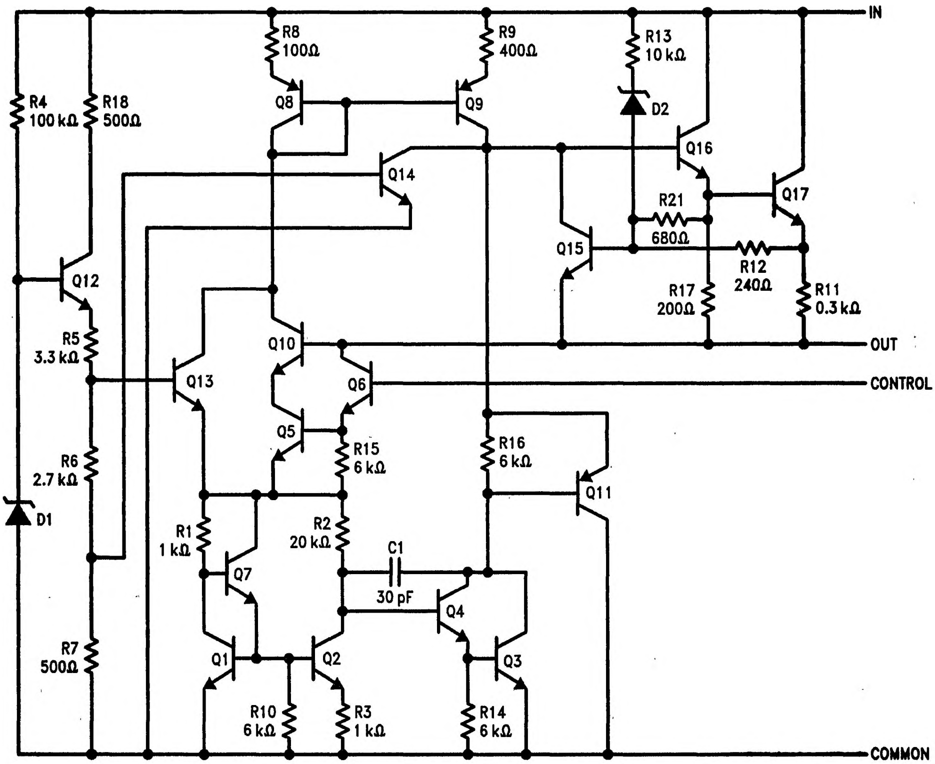
Note 1: V_O is defined for the LM79G as $V_O = \frac{R1 + R2}{R2}(-2.55)$.

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: The convention for negative regulators is the algebraic value, thus −15V is less than −10V.

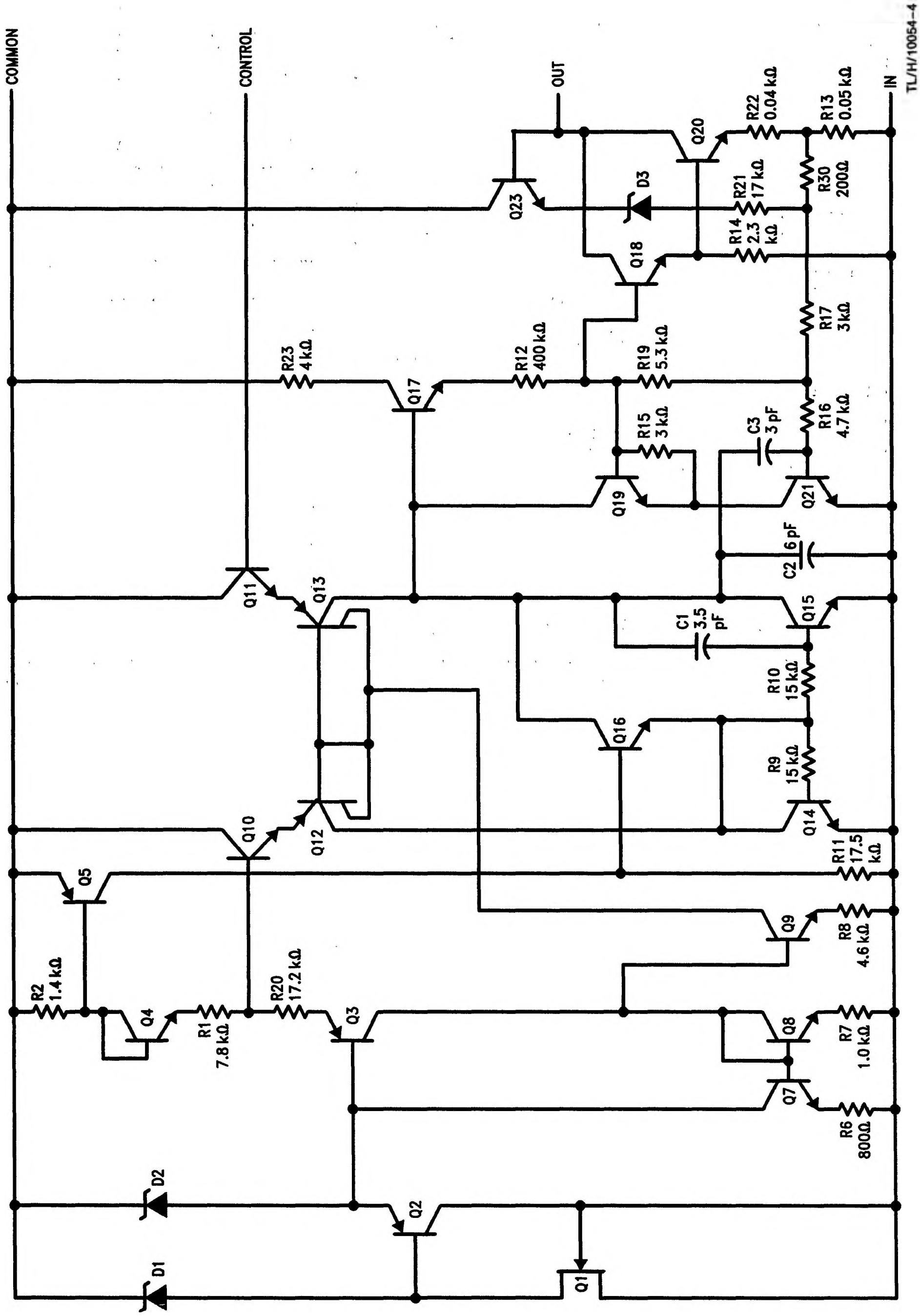
Note 4: All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ($t_w \le 10$ ms, duty cycle ≤ 5%). Output voltage changes due to changes in internal temperature must be taken into account separately.

LM78G Equivalent Circuit



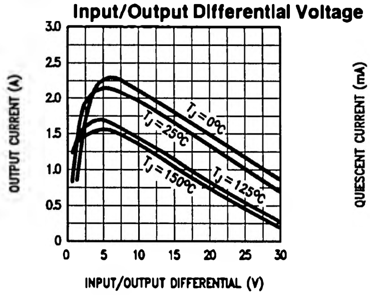
TL/H/10054-3

LM79G Equivalent Circuit

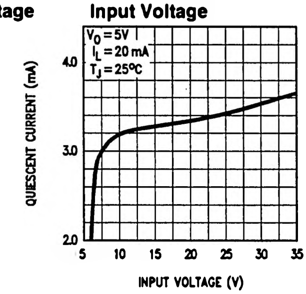


Typical Performance Curves for LM78G

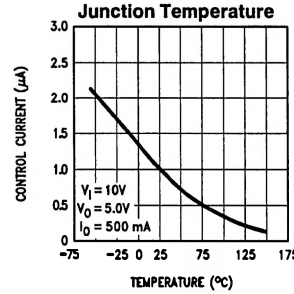
Peak Output Current vs Input/Output Differential Voltage



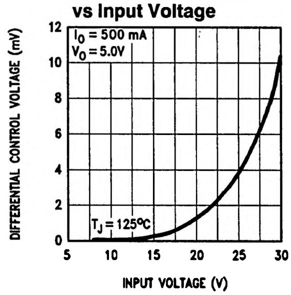
Quiescent Current vs Input Voltage



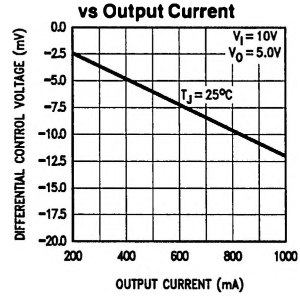
Control Current vs Junction Temperature



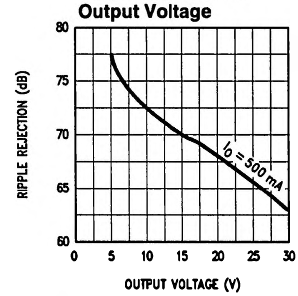
Differential Control Voltage vs Input Voltage



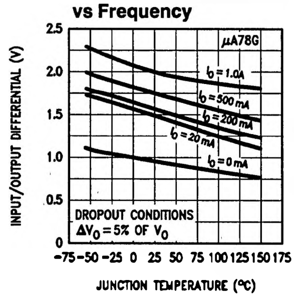
Differential Control Voltage vs Output Current



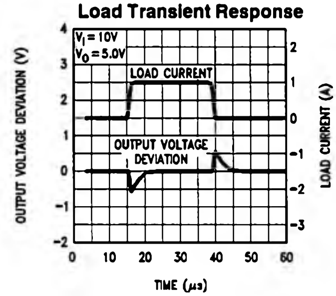
Ripple Rejection vs Output Voltage



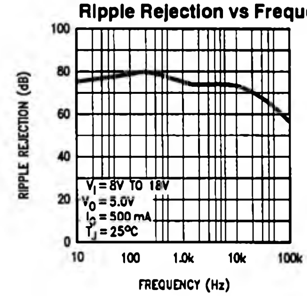
Dropout Voltage vs Junction Temperature vs Frequency



Load Transient Response



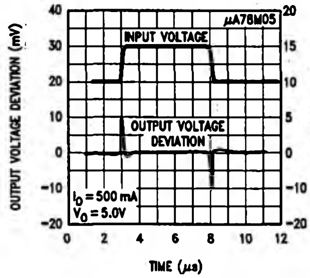
Ripple Rejection vs Frequency



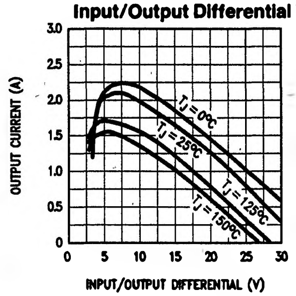
TL/H/10054-5

Typical Performance Curves for LM79G

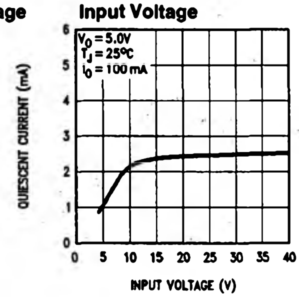
Line Transient Response for LM78G



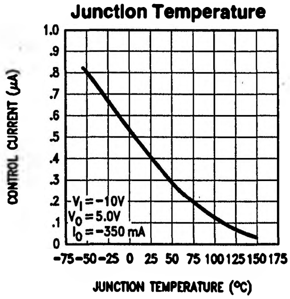
Peak Output Current vs Input/Output Differential Voltage



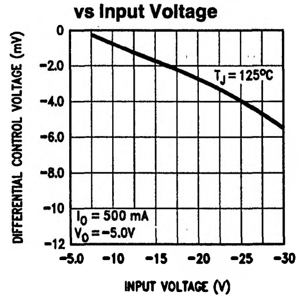
Quiescent Current vs Input Voltage



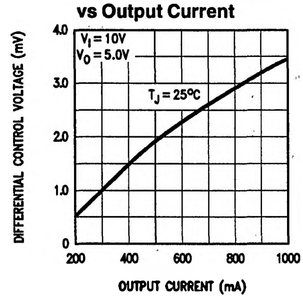
Control Current vs Junction Temperature



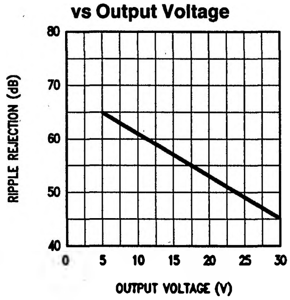
Differential Control Voltage vs Input Voltage



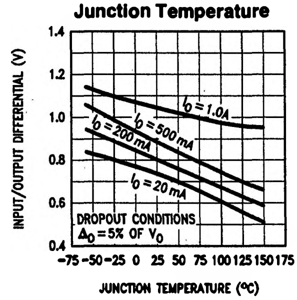
Differential Control Voltage vs Output Current



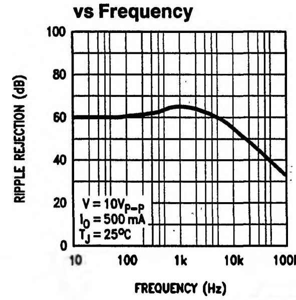
Ripple Rejection vs Output Voltage



Dropout Voltage vs Junction Temperature

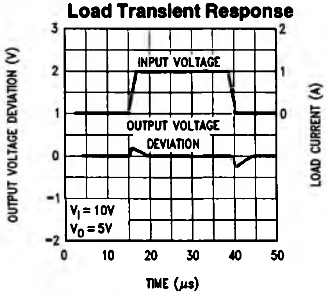


Ripple Rejection vs Frequency



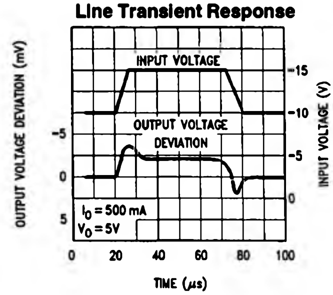
TL/H/10054–6

Load Transient Response



TL/H/10054–7

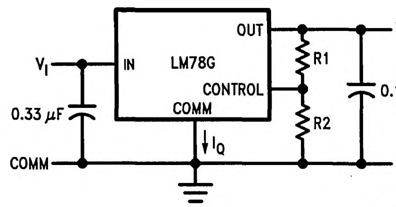
Line Transient Response



TL/H/10054–10

Test Circuits

LM78G Test Circuit 1

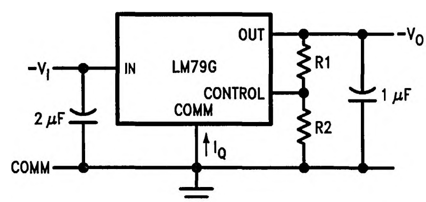


TL/H/10054-8

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

V_{CONT} Nominal = 5.0V

LM79G Test Circuit 2



TL/H/10054-9

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

V_{CONT} Nominal = −2.55V

Recommended R2 current ≈ 1.0 mA

∴ R2 = 5.0 kΩ (LM78G)

R2 = 2.55 kΩ (LM79G)

Design Considerations

The LM78G and LM79G Adjustable 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 LM78G is 5.0V and LM79G is −2.55V. If we allow 1.0 mA to flow in the control string to eliminate bias current effects, we can make R2 = 5.0 kΩ in the LM78G. Then, the output voltage is; V_O = (R1 + R2)V, where R1 and R2 are in kΩs.

Example: If R2 = 5.0 kΩ and R1 = 10 kΩ then
V_O = 15V nominal, for the LM78G
R2 = 2.55 kΩ and R1 = 12.8 kΩ then
V_O = −15.35 nominal, for the LM79G

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

Both LM78G and LM79G 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:

	Typ °C/W	Max °C/W	Typ °C/W	Max °C/W
Package	θ_{JC}	θ_{JC}	θ_{JA}	θ_{JA}
Power Watt	7.5	11	75	80

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

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

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

Solving for T_J:

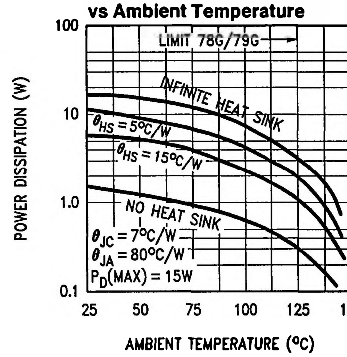
$$T_J = T_A + P_D(\theta_{JC} + \theta_{CA}) \text{ or}$$

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

Where:

T_J = Junction Temperature
T_A = Ambient Temperature
P_D = Power Dissipation
θ_{JA} = Junctiuon to Ambient Thermal Resistance
θ_{JC} = Junction to Case Thermal Resistance
θ_{CA} = Case to Ambient Thermal Resistance
θ_{CS} = Case to Heat Sink Resistance
θ_{SA} = Heat Sink to Ambient Thermal Resistance

LM78G and LM79G Power Tab (U1) Package Worst Case Power Dissipation vs Ambient Temperature



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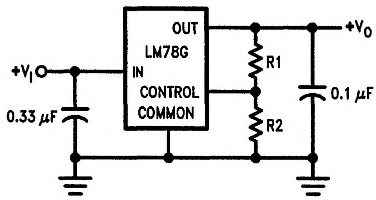
Typical Applications for LM78G

Bypassing of the input and output (0.33 μF and 0.1 μF, respectively) is necessary.

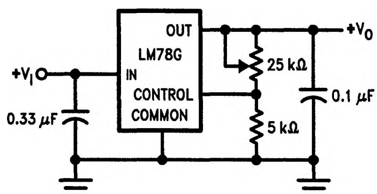
Basic Positive Regulator



TL/H/10054-12

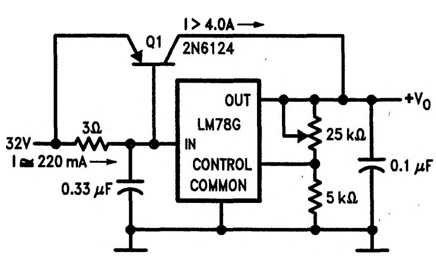
$$V_O = V_{CONT}\left(\frac{R1 + R2}{R2}\right)$$

Positive 5.0V to 30V Adjustable Regulator



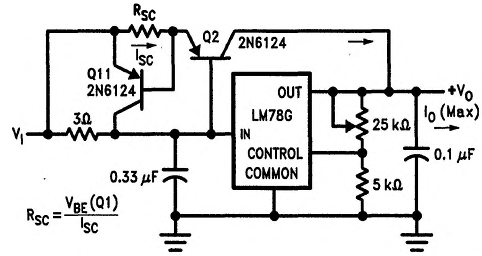
TL/H/10054-13

Positive 5.0V to 30V Adjustable Regulator
(I_O > 5.0A) (Note 1)



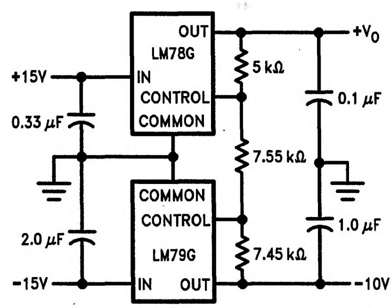
TL/H/10054-14

Positive High Current Short Circuit, Protected Regulator



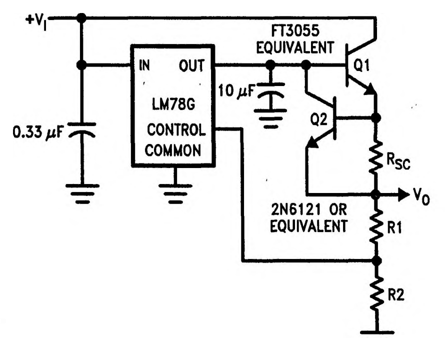
TL/H/10054-15

± 10V, 1.0A, Dual Tracking Regulator (Note 2)



TL/H/10054-16

Positive High Current, Short Circuit Protected Regulator



TL/H/10054-17

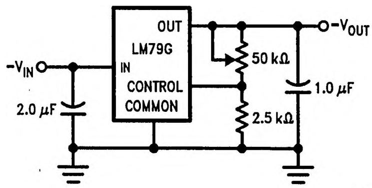
Note 1: External series pass device is not short circuit protected.

Note 2: If load is not ground referenced, connect reverse biased diodes from outputs to ground.

Typical Applications for LM79G

All LM78G applications apply to the LM79G under the following conditions: R2 values are 2.5 kΩ, all external transistors and diodes reverse polarity.

−30V to −2.5V Adjustable Regulator



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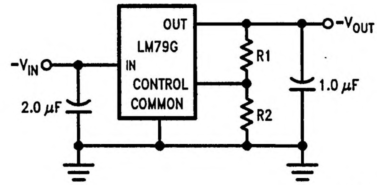
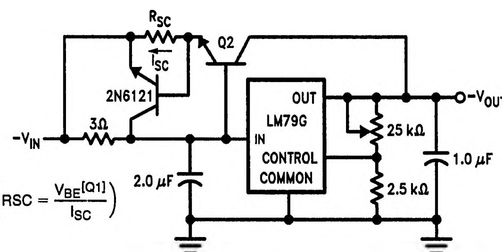
Basic Negative Regulator



TL/H/10054–19

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

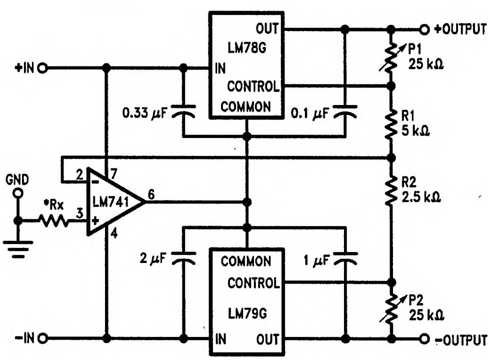
Negative High Current Short Circuit Protected Regulator



$$\left(RSC = \frac{V_{BE}[Q1]}{I_{SC}}\right)$$

TL/H/10054–20

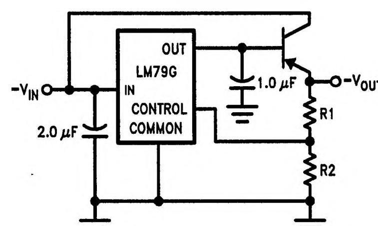
Adjustable Dual Tracking Regulator



TL/H/10054–21

*Rx = Parallel combination of (R1 + P1) and (R2 + P2).

Negative High Current Voltage Regulator External Series Pass



TL/H/10054–22

Applications Hints

Bypass capacitors are recommended for stable operation of the LM79G series of regulators over the input voltage and output current ranges. Output bypass capacitors will improve the transient response of the regulator.

The bypass capacitors (2 µF on the input, 1 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.