National Semiconductor

LM78G
4-Terminal Adjustable Voltage Regulator

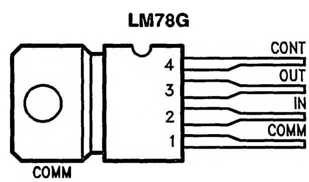
General Description

The LM78G is a 4-terminal adjustable voltage regulator designed to deliver continuous load currents of up to 1.0A with a maximum input voltage of +40V. Output current capability can be increased to greater than 1.0A through use of one or more external transistors. The output voltage range is +5V to +20V.

Features

- Output current in excess of 1A
- Output range of +5V to +30V
- Internal thermal overload protection
- Internal short circuit protection
- Output transistor safe-area protection

Connection Diagram and Ordering Information



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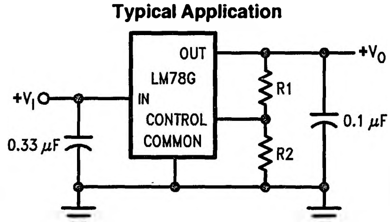
Top View

Heat sink tabs connected to common through device substrate.

4-Lead, TO-202
Order Number LM78GCP
See NS Package Number P04A

Typical Application



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

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	+40V
Control Lead Voltage	$0V \le V^+ \le V_O$

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

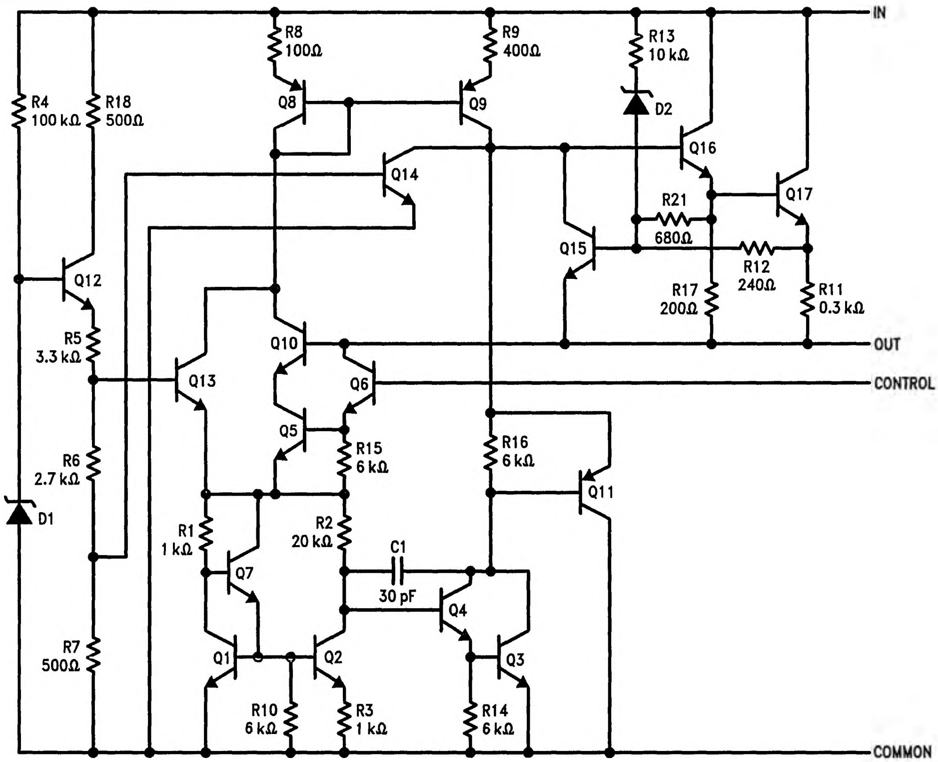
Symbol	Parameter	Conditions (Notes 1, 3)		Min	Typ	Max	Units
V_{IR}	Input Voltage Range	$T_J = 25°C$		7.5		40	V
V_{OR}	Output Voltage Range	$V_I = V_O + 5.0V$		5.0		30	V
V_O	Output Voltage Tolerance	$(V_O + 3.0V) \le V_I \le (V_O + 15V)$, $5.0\ mA \le I_O \le 1.0A$, $P_D \le 15W$, $V_{I\ Max} = 38V$	$T_J = 25°C$			4.0	% V_O
						5.0	
$V_{O\ LINE}$	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
			$5.0\ mA \le I_O \le 1.5A$			2.0	
I_C	Control Lead Current	$T_J = 25°C$			1.0	5.0	μA
						8.0	
I_Q	Quiescent Current	$T_J = 25°C$			3.2	6.0	mA
						7.0	
$\Delta V_I/\Delta V_O$	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	$mV/°C/V_O$
			$T_A = 25°C$ 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	

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.

Equivalent Circuit



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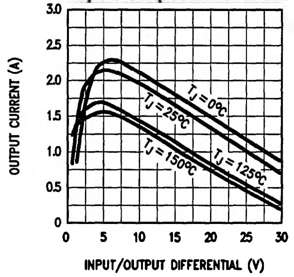
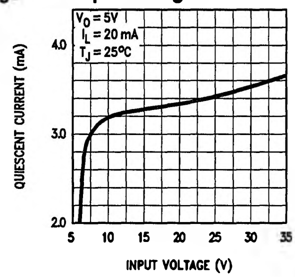
Typical Performance Curves

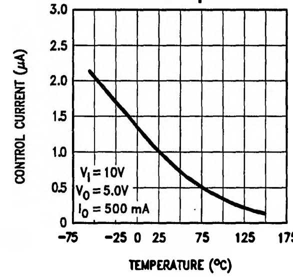
Peak Output Current vs Input/Output Differential Voltage



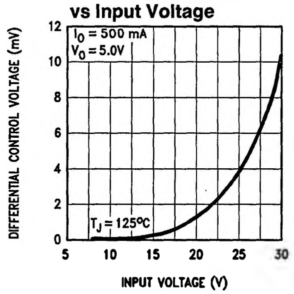
Quiescent Current vs Input Voltage



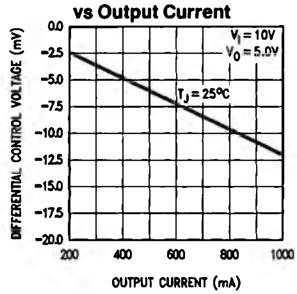
Control Current vs Junction Temperature



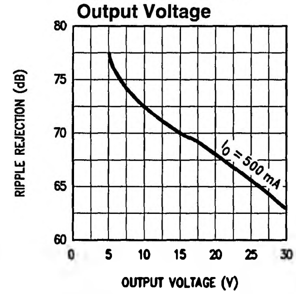
Differential Control Voltage vs Input Voltage



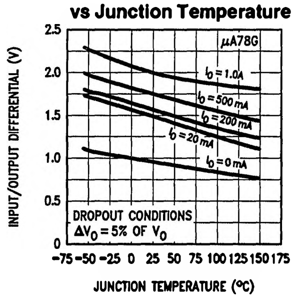
Differential Control Voltage vs Output Current



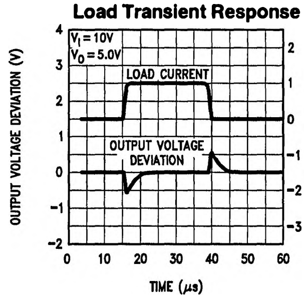
Ripple Rejection vs Output Voltage



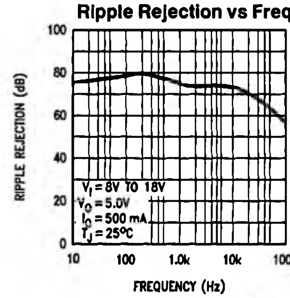
Dropout Voltage vs Junction Temperature



Load Transient Response



Ripple Rejection vs Frequency



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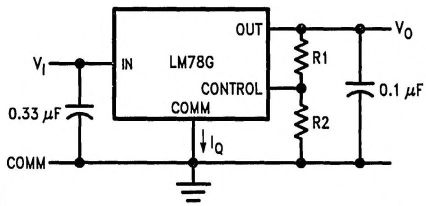
Test Circuit



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

V_{CONT} Nominal = 5.0V

Design Considerations

The LM78G Adjustable Voltage Regulator has an output voltage which varies from V_{CONT} to typically

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

V_{CONT} nominal in the LM78G is 5.0V. If we allow 1.0 mA to flow in the control string to eliminate bias current effects, we can make R2 = 5.0 kΩ. 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

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

The LM78G regulator has thermal overload protection from excessive power, internal short circuit protection which limits the maximum current, and output transistor safe-area protection for reducing the output current as the voltage across the pass transistor increases.

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:

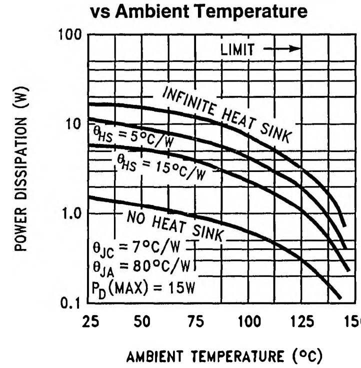
$$T_J = T_A + P_D(\theta_{JC} + \theta_{CA}) \text{ or}$$

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

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

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



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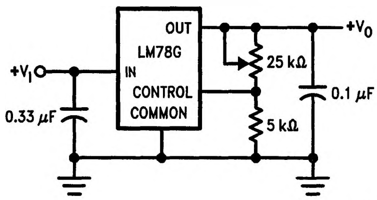
Typical Applications for LM78G

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

5.0V to 30V Adjustable Regulator



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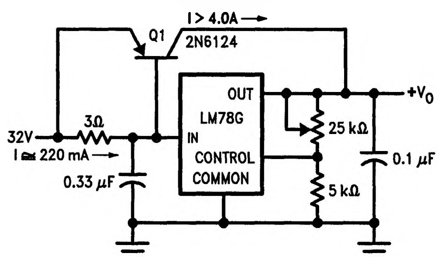
5.0V to 30V Adjustable Regulator ($I_O > 5.0A$) (Note 1)



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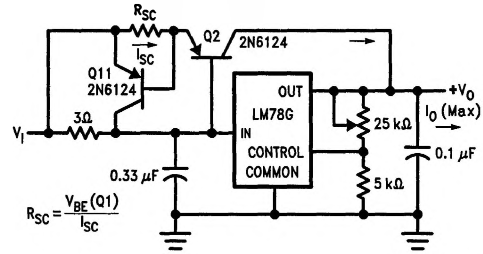
High Current Short Circuit, Protected Regulator



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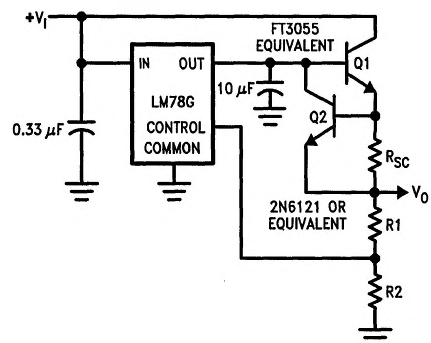
High Current, Short Circuit Protected Regulator



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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.