

# LM104/LM204/LM304 Negative Regulator

## General Description

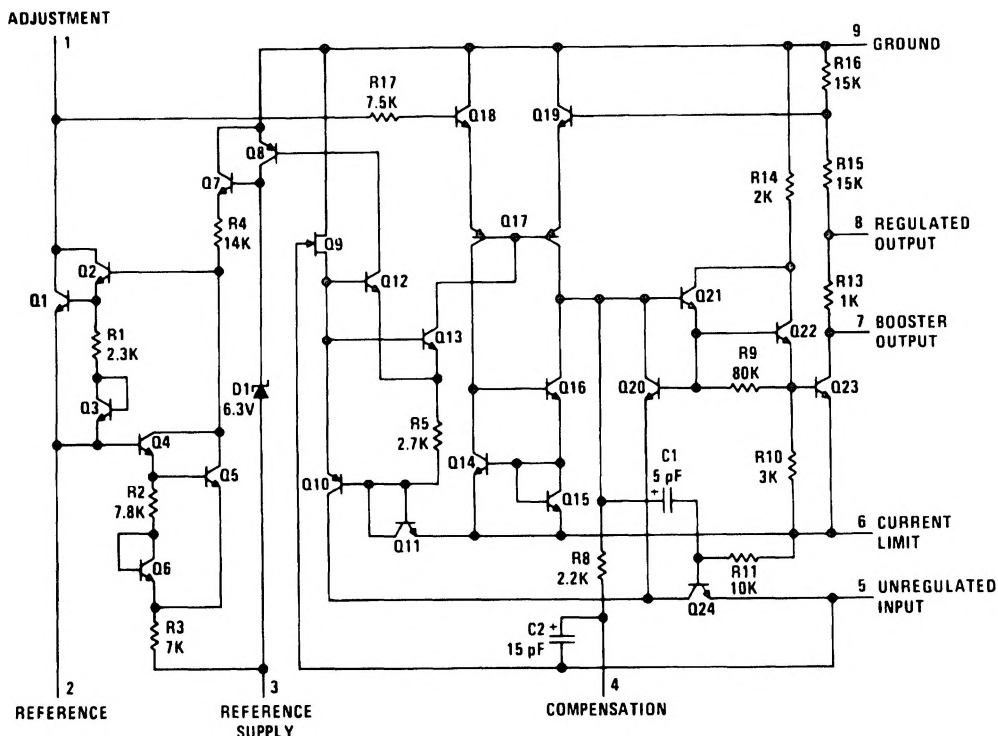
The LM104 series are precision voltage regulators which can be programmed by a single external resistor to supply any voltage from 40V down to zero while operating from a single unregulated supply. They can also provide 0.01-percent regulation in circuits using a separate, floating bias supply, where the output voltage is limited only by the breakdown of external pass transistors. Although designed primarily as linear, series regulators, the circuits can be used as switching regulators, current regulators or in a number of other control applications. Typical performance characteristics are:

- Subsurface zener reference
- 1 mV regulation no load to full load
- 0.01%/V line regulation
- 0.2 mV/V ripple rejection
- 0.3% temperature stability over military temperature range

The LM104 series is the complement of the LM105 positive regulator, intended for systems requiring regulated negative voltages which have a common ground with the unregulated supply. By themselves, they can deliver output currents to 25 mA, but external transistors can be added to get any desired current. The output voltage is set by external resistors, and either constant or foldback current limiting is made available.

The LM104 is specified for operation over the  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  military temperature range. The LM204 is specified for operation over the  $-25^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  temperature range. The LM304 is specified for operation from  $0^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$ .

## Schematic Diagram



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## Absolute Maximum Ratings

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

(Note 6)

	LM104/LM204	LM304
Input Voltage	50V	40V
Input-Output Voltage Differential	50V	40V
Power Dissipation (Note 1)	500 mW	500 mW
Operating Temperature Range		
LM104	–55°C to +125°C	0°C to +70°C
LM204	–25°C to +85°C	
LM304		–65°C to +150°C
Storage Temperature Range	–65°C to +150°C	–65°C to +150°C
Lead Temperature (Soldering, 10 sec.)	260°C for plastic	300°C for hermetic

## Electrical Characteristics

Parameter	Conditions	LM104/LM204			LM304			Units
		Min	Typ	Max	Min	Typ	Max	
Input Voltage Range		–50		–8	–40		–8	V
Output Voltage Range		–40		–0.015	–30		–0.035	V
Output-Input Voltage Differential (Note 3)	$I_O = 20 \text{ mA}$	2.0		50	2.0		40	V
	$I_O = 5 \text{ mA}$	0.5		50	0.5		40	V
Load Regulation (Note 4)	$0 \leq I_O \leq 20 \text{ mA}$ $R_{SC} = 15\Omega$		1	5		1	5	mV
Line Regulation (Note 5)	$V_{OUT} \leq -5V$ $\Delta V_{IN} = 0.1 V_{IN}$		0.056	0.1		0.056	0.1	%
Ripple Rejection	$C_{19} = 10 \mu\text{F}$ , $f = 120 \text{ Hz}$		0.2	0.5		0.2	0.5	mV/V
	$V_{IN} < -15V$ $-7V \geq V_{IN} \geq -15V$		0.5	1.0		0.5	1.0	mV/V
Output Voltage Scale Factor	$R_{2,3} = 2.4k$	1.8	2.0	2.2	1.8	2.0	2.2	V/k $\Omega$
Temperature Stability	$V_O \leq -1V$		0.3	1.0		0.3	1.0	%
Output Noise Voltage	$10 \text{ Hz} \leq f \leq 10 \text{ kHz}$							
	$V_O \leq -5V$ , $C_{1,9} = 0$ $C_{1,9} = 10 \mu\text{F}$		0.007 15			0.007 15		% $\mu\text{V}$
Standby Current Drain	$I_L = 5 \text{ mA}$ , $V_O = 0$		1.7	2.5		1.7	2.5	mA
	$V_O = -30V$ $V_O = -40V$		3.6 5.0			3.6 5.0		mA mA
Long Term Stability	$V_O \leq -1V$		0.01	1.0		0.01	1.0	%

**Note 1:** The maximum junction temperature of the LM104 is 150°C, while that of the LM204 is 125°C and LM304 is 100°C. For operating at elevated temperatures, devices in the TO-5 package must be derated based on a thermal resistance of 150°C/W, junction to ambient, or 45°C/W, junction to case.

**Note 2:** These specifications apply for junction temperatures between –55°C and 150°C (between –25°C and 100°C for the LM204 and 0°C to +85°C for the LM304) and for input and output voltages within the ranges given, unless otherwise specified. The load and line regulation specifications are for constant junction temperature. Temperature drift effects must be taken into account separately when the unit is operating under conditions of high dissipation.

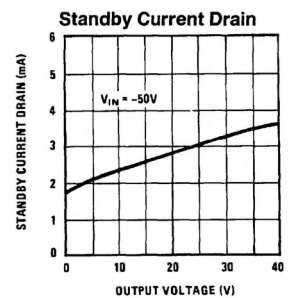
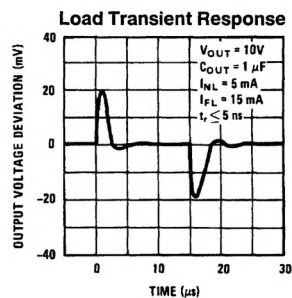
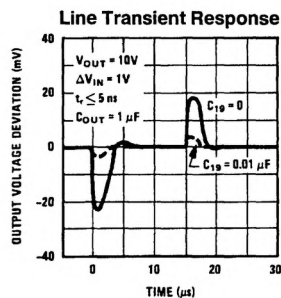
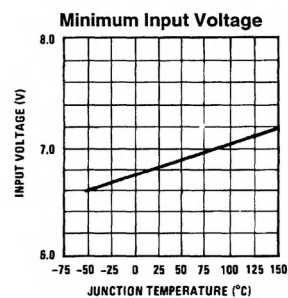
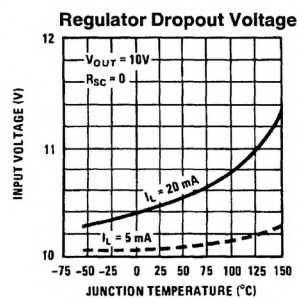
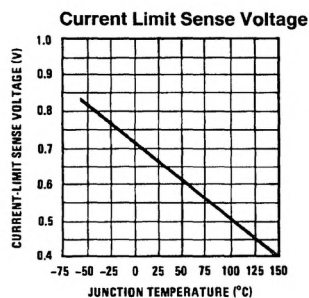
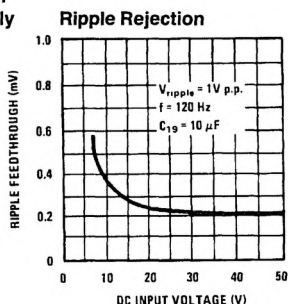
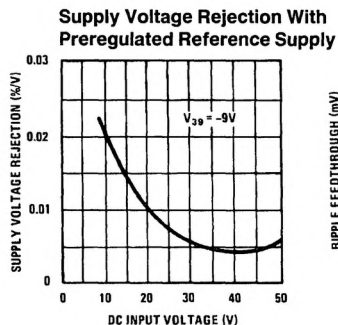
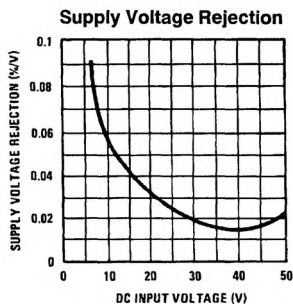
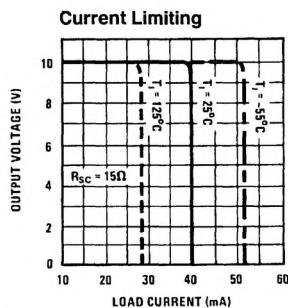
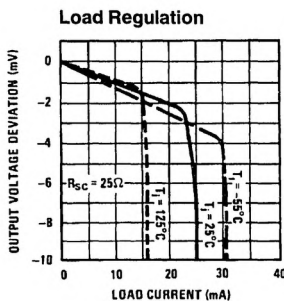
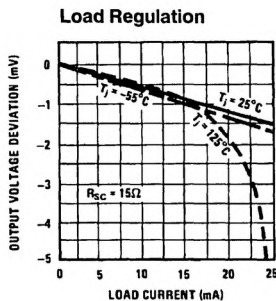
**Note 3:** When external booster transistors are used, the minimum output-input voltage differential is increased, in the worst case, by approximately 1V.

**Note 4:** The output currents given, as well as the load regulation, can be increased by the addition of external transistors. The improvement factor will be roughly equal to the composite current gain of the added transistors.

**Note 5:** With zero output, the dc line regulation is determined from the ripple rejection. Hence, with output voltages between 0V and –5V, a dc output variation, determined from the ripple rejection, must be added to find the worst-case line regulation.

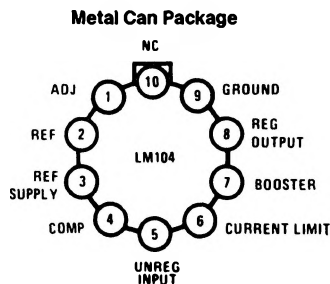
**Note 6:** Refer to RETS104X drawing for military specifications for the LM104.

# Typical Performance Characteristics



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## Connection Diagram



Note: Pin 5 connected to case.

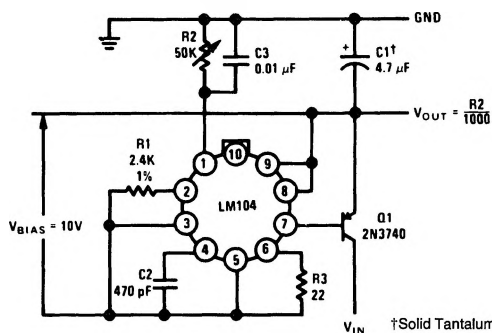
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### Top View

Order Number LM104H, LM204H or LM304H  
See NS Package H10C

## Typical Applications

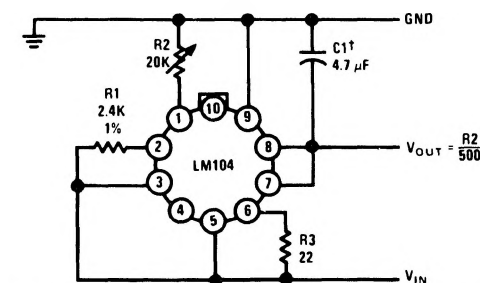
### Operating with Separate Bias Supply



†Solid Tantalum

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### Basic Regulator Circuit

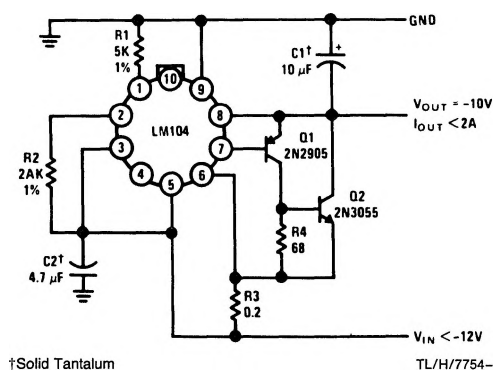


†Solid Tantalum

Trim R1 for exact scale factor.

TL/H/7754-5

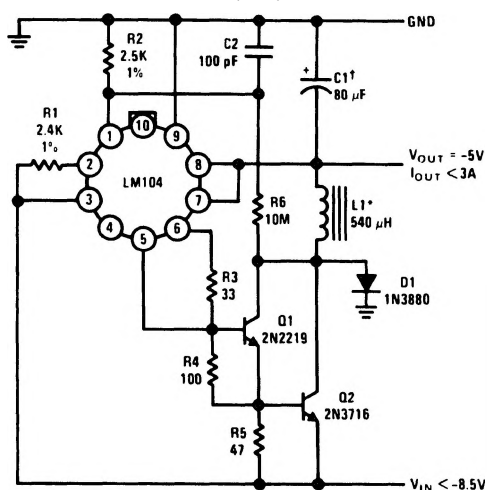
### High Current Regulator



†Solid Tantalum

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### Switching Regulator



†Solid Tantalum

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\*60 turns #20 on Arnold Engineering A930157-2 Molybdenum Permalloy Core.