



March 1989

## 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:

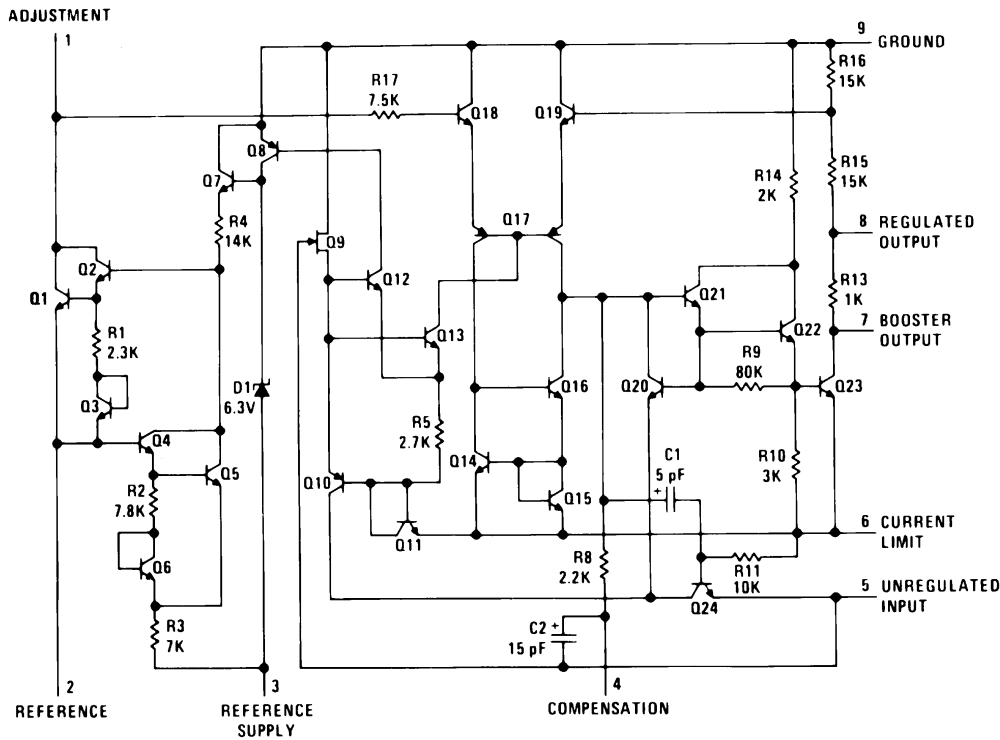
- Subsurface zener reference
- 1 mV regulation no load to full load
- 0.01%/V line regulation
- 0.2 mV/V ripple rejection
- 0.3% temperature stability over military temperature range

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  $+70^{\circ}\text{C}$ .

LM104/LM204/LM304 Negative Regulator

### Schematic Diagram



TL/H/7754-1

## Absolute Maximum Ratings

If Military/Aerospace specified devices are required, please 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	
LM204	-25°C to +85°C	
LM304		0°C to +70°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	$C_{19} = 10 \mu\text{F}$ , $f = 120 \text{ Hz}$ $V_{IN} < -15V$ $-7V \geq V_{IN} \geq -15V$		0.2	0.5		0.2	0.5	mV/V
			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			0.007		%
				15			15	
Standby Current Drain	$I_L = 5 \text{ mA}$ , $V_O = 0$ $V_O = -30V$ $V_O = -40V$		1.7	2.5		1.7	2.5	mA
						3.6	5.0	mA
			3.6	5.0				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 H10C 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.

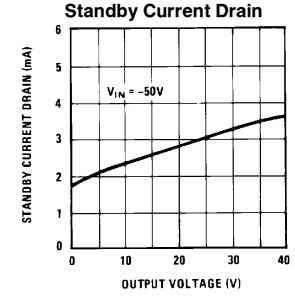
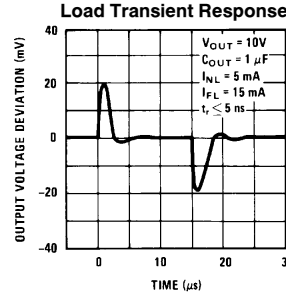
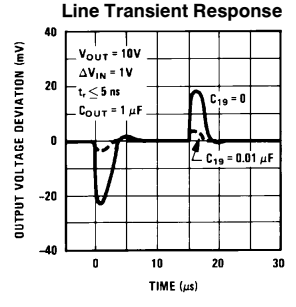
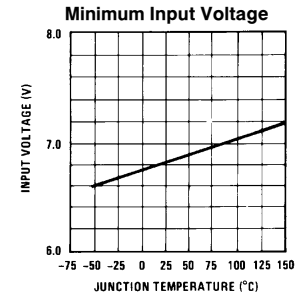
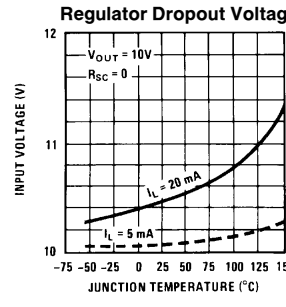
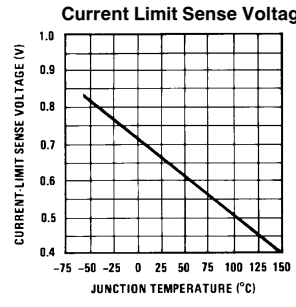
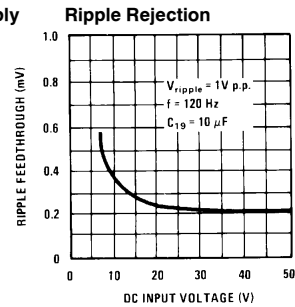
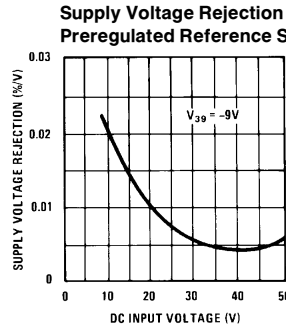
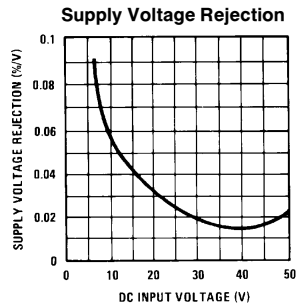
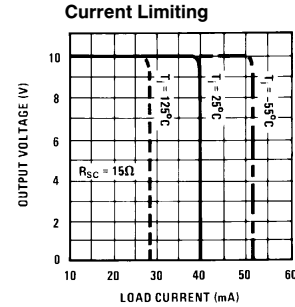
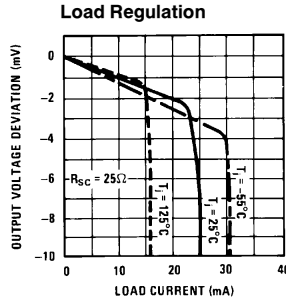
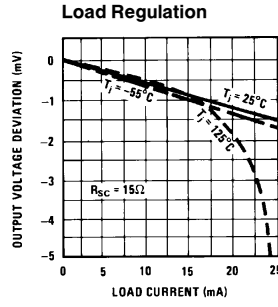
**Note 3:** When external booster transistors are used, the minimum output-input voltage differential is increased, in the worst case, by approximately 1V.

**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.

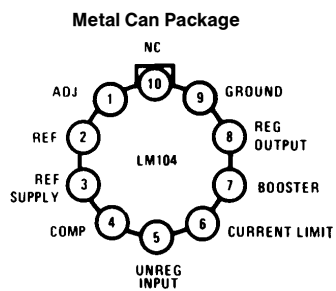
**Note 6:** Refer to RETS104X drawing for military specifications for the LM104.

# Typical Performance Characteristics



TL/H/7754-7

## Connection Diagram



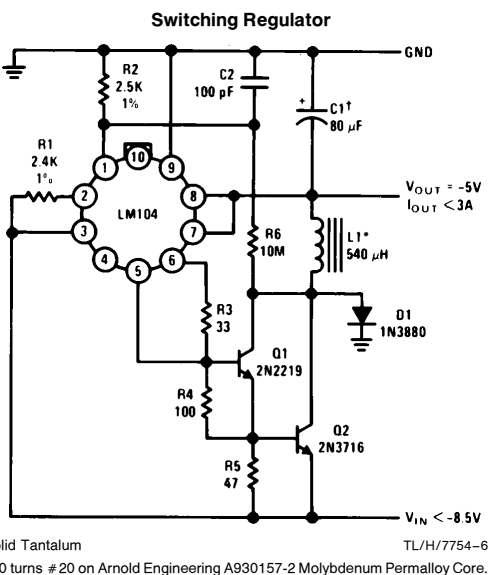
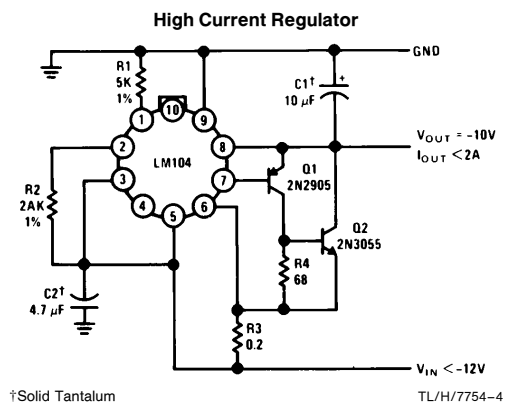
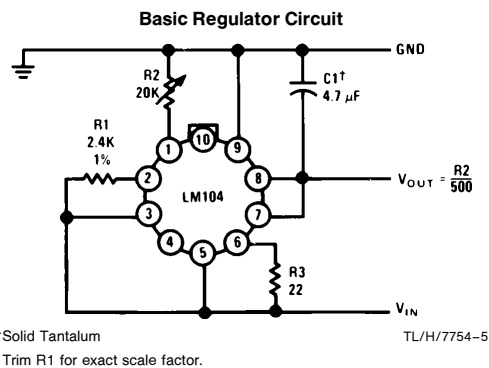
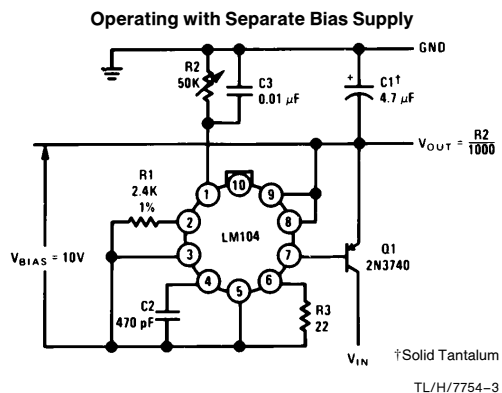
Note: Pin 5 connected to case.

TL/H/7754-2

Top View

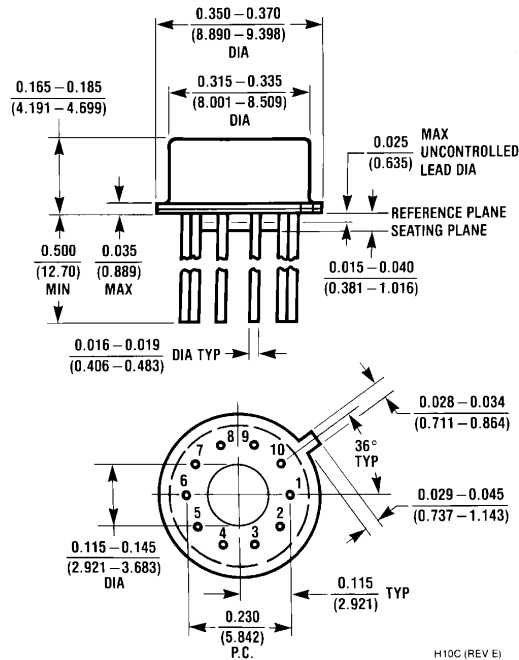
Order Number LM104H, LM204H or LM304H  
See NS Package H10C

## Typical Applications





**Physical Dimensions** inches (millimeters)



**Metal Can Package (H)**  
**Order Number LM104H, LM204H or LM304H**  
**NS Package Number H10C**

H10C (REV E)

**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**  
 1111 West Bardin Road  
 Arlington, TX 76017  
 Tel: 1(800) 272-9959  
 Fax: 1(800) 737-7018

**National Semiconductor Europe**  
 Fax: (+49) 0-180-530 85 86  
 Email: cnjwge@tevm2.nsc.com  
 Deutsch Tel: (+49) 0-180-530 85 85  
 English Tel: (+49) 0-180-532 78 32  
 Français Tel: (+49) 0-180-532 93 58  
 Italiano Tel: (+49) 0-180-534 16 80

**National Semiconductor Hong Kong Ltd.**  
 19th Floor, Straight Block,  
 Ocean Centre, 5 Canton Rd.  
 Tsimshatsui, Kowloon  
 Hong Kong  
 Tel: (852) 2737-1600  
 Fax: (852) 2736-9960

**National Semiconductor Japan Ltd.**  
 Tel: 81-043-299-2309  
 Fax: 81-043-299-2408

National does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and National reserves the right at any time without notice to change said circuitry and specifications.