

# LINEAR INTEGRATED CIRCUITS

# TYPES LM104, LM204, LM304 NEGATIVE-VOLTAGE REGULATORS

BULLETIN NO. DL-S 12052, SEPTEMBER 1973—REVISED JUNE 1976

FORMERLY SN52104, SN72104

- Typical Load Regulation . . . 1 mV
- Typical Input Regulation . . . 0.06%
- Designed to be Interchangeable with National Semiconductor LM104, LM204, and LM304 Respectively

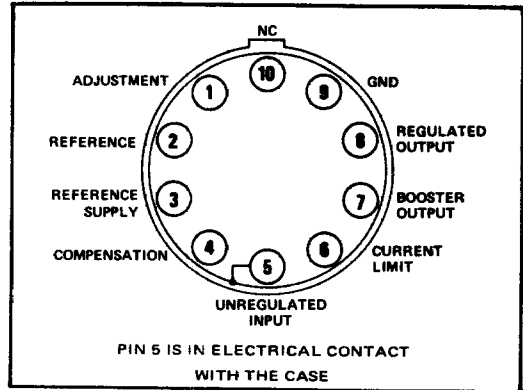
## description

The LM104, LM204, and LM304 are monolithic integrated circuit voltage regulators that can be programmed with a single external resistor to provide any voltage between -40 volts and approximately 0 volts while operating from a single unregulated negative supply. When used with a separate floating bias supply, these devices can provide regulation with the output voltage limited only by the breakdown characteristics of the external pass transistors.

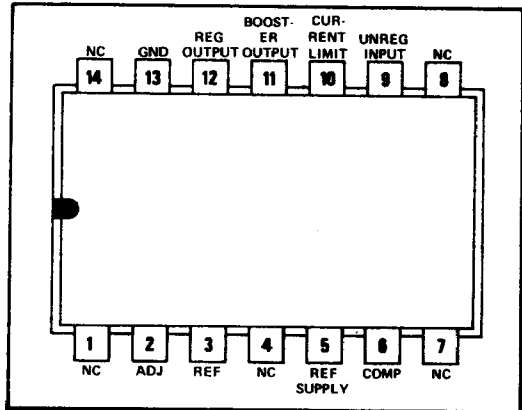
Although designed primarily for application as linear series regulators at output currents up to 25 milliamperes, the LM104, LM204, and LM304 can be used as current regulators, switching regulators, or control elements with the output current limited by the capability of the external pass transistors. The improvement factor for load regulation is approximately equal to the composite current gain of the added transistors. The devices can be used in either constant-current or fold-back current-limiting applications.

The LM104 is characterized for operation over the full military temperature range of -55°C to 125°C; the LM204 is characterized for operation from -25°C to 85°C; and the LM304 is characterized for operation from 0°C to 70°C.

LM104, LM204 . . . L  
PLUG-IN PACKAGE (TOP VIEW)

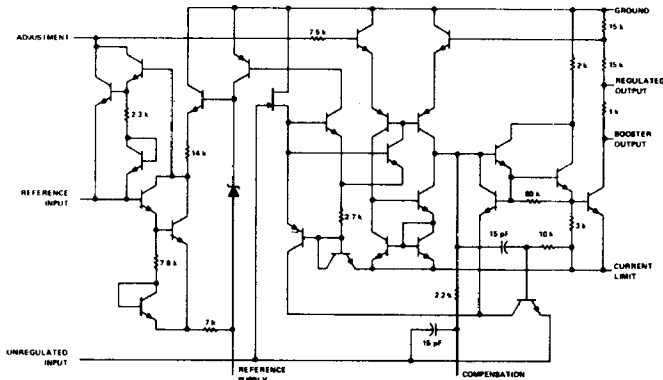


LM104 . . . J  
LM204, LM304 . . . J OR N  
DUAL-IN-LINE PACKAGE (TOP VIEW)



NC—No internal connection

## schematic



Component values shown are nominal.  
Resistor values are in ohms.

Copyright © 1976 by Texas Instruments Incorporated

**TEXAS INSTRUMENTS**  
INCORPORATED  
POST OFFICE BOX 5012 • DALLAS, TEXAS 75222

# TYPES LM104, LM204, LM304 NEGATIVE-VOLTAGE REGULATORS

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

		LM104	LM204	LM304	UNIT
Input voltage (see Note 1)		-50	-50	-40	V
Input-to-output voltage differential		-50	-50	-40	V
Continuous total dissipation at (or below) 25°C free-air temperature (see Note 2)	J or N package	1000	1000	1000	mW
	L package	800	800	800	
Operating free-air temperature range		-55 to 125	-25 to 85	0 to 70	°C
Storage temperature range		-65 to 150	-65 to 150	-65 to 150	°C
Lead temperature 1/16 inch from case for 60 seconds: J or L package		300	300	300	°C
Lead temperature 1/16 inch from case for 10 seconds: N package			260	260	°C

NOTES: 1. Voltage values, except input-to-output voltage differential, are with respect to network ground terminal.  
2. For operation above 25°C free-air temperature, refer to Dissipation Derating Table, Figures I, II, and III, page 90. This rating for the L package requires a heat sink that provides a thermal resistance from case to free-air,  $R_{\theta CA}$ , of not more than 105°C/W.

## recommended operating conditions

		LM104		LM204		LM304		UNIT
		MIN	MAX	MIN	MAX	MIN	MAX	
Input voltage, $V_I$		-8	-50	-8	-50	-8	-40	V
Output voltage, $V_O$		-0.015	-40	-0.015	-40	-0.035	-30	V
Input-to-output voltage differential, $V_I - V_O$	$I_O = 20$ mA	-2	-50	-2	-50	-2	-40	V
	$I_O \leq 5$ mA	-0.5	-50	-0.5	-50	-0.5	-40	
Output current, $I_O$			20		20		20	mA
Operating free-air temperature, $T_A$		-55	125	-25	85	0	70	°C

## electrical characteristics over recommended ranges of input and output voltage and operating free-air temperature (unless otherwise noted)

PARAMETER	TEST CONDITIONS†	LM104, LM204			LM304			UNIT	
		MIN	TYP	MAX	MIN	TYP	MAX		
Input regulation	$V_O = -5$ V to MAX, $\Delta V_I = 0.1 V_I$ , See Notes 3 and 4		0.06	0.1		0.06	0.1	%	
Ripple sensitivity	$C_1 = 10$ $\mu$ F, $f = 120$ Hz		$V_I = -15$ V to MAX	0.2	0.5		0.2	0.5	mV/V
			$V_I = -7$ V to -15 V	0.5	1		0.5	1	
Output regulation	$I_O = 0$ to 20 mA, $R_{SC} = 15$ $\Omega$ , See Note 3			1	5		1	5	mV
Output voltage scale factor	$R_1 = 2.4$ k $\Omega$ , See Figure 2	1.8	2	2.2	1.8	2	2.2	V/k $\Omega$	
Output voltage change with temperature	$T_A = \text{MIN}$ to $T_A = 25^\circ\text{C}$			1			1	%	
	$T_A = 25^\circ\text{C}$ to $T_A = \text{MAX}$			1			1		
Output noise voltage	$V_O = -5$ V to MAX, $f = 10$ Hz to 10 kHz		$C_1 = 0$	0.007		0.007		%	
			$C_1 = 10$ $\mu$ F	15		15			
Bias current	$I_O = 5$ mA		$V_O = 0$	1.7	2.5		1.7	2.5	mA
			$V_O = -30$ V				3.6	5	
			$V_O = -40$ V	3.6	5				

†For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

NOTES: 3. Input regulation and output regulation are measured using pulse techniques ( $t_W \leq 10$   $\mu$ s, duty cycle  $\leq 5\%$ ) to limit changes in average internal dissipation. Output voltages due to large changes in internal dissipation must be taken into account separately.

4. At zero output voltage, the output variation can be determined using the ripple sensitivity. At low voltages (i.e., 0 to -5 V), the output variation determined from the ripple sensitivity must be added to the variation determined from the input regulation to determine the overall line regulation.

# TYPES LM104, LM204, LM304 NEGATIVE-VOLTAGE REGULATORS

## TYPICAL APPLICATION DATA

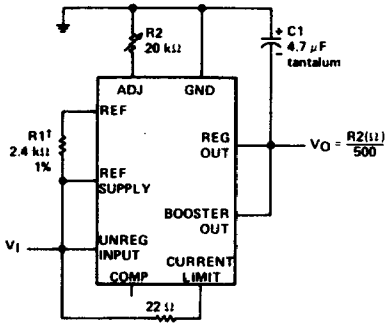


FIGURE 1—BASIC REGULATOR CIRCUIT

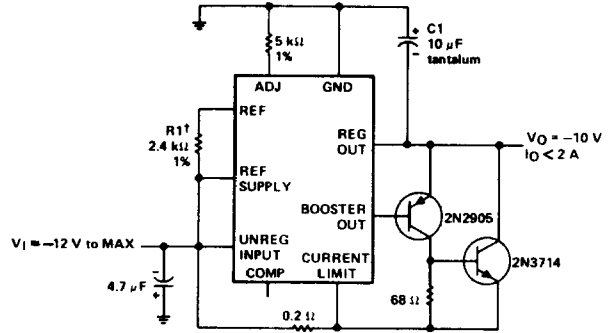
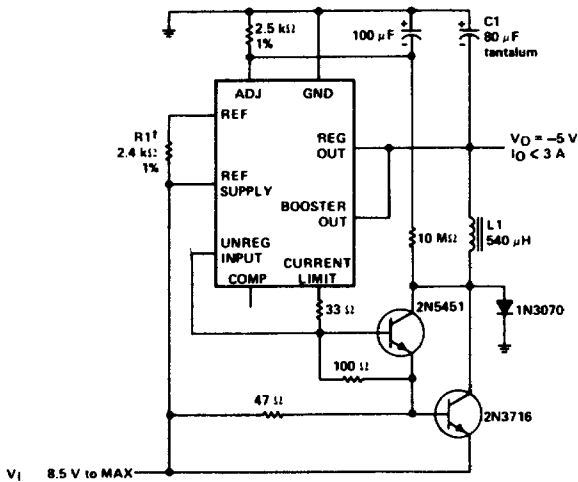


FIGURE 2—HIGH-CURRENT REGULATOR



L1: 60 turns #20 on Arnold Engineering A930157-2 molybdenum permalloy core, or equivalent

FIGURE 3—SWITCHING REGULATOR

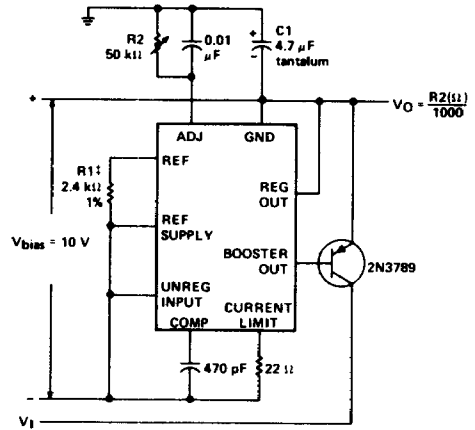


FIGURE 4—OPERATING WITH SEPARATE BIAS SUPPLY

† Trim R1 for exact scale factor.

# VOLTAGE REGULATORS

## THERMAL INFORMATION

These curves are for use with the continuous dissipation ratings specified on the individual data sheets. Those ratings apply up to the temperature at which the rated level intersects the appropriate derating curve or the maximum operating free-air temperature.

J AND JG PACKAGE FREE-AIR TEMPERATURE DISSIPATION DERATING CURVES

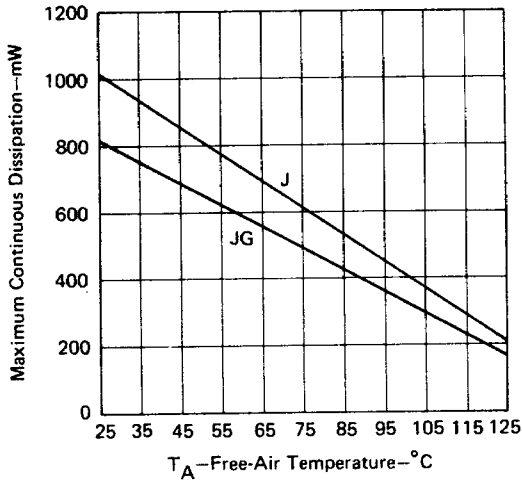


FIGURE I

L PACKAGE FREE-AIR TEMPERATURE DISSIPATION DERATING CURVES

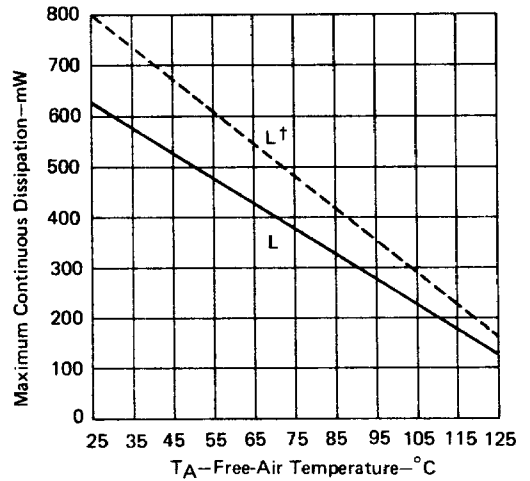


FIGURE II

N PACKAGE FREE-AIR TEMPERATURE DISSIPATION DERATING CURVES

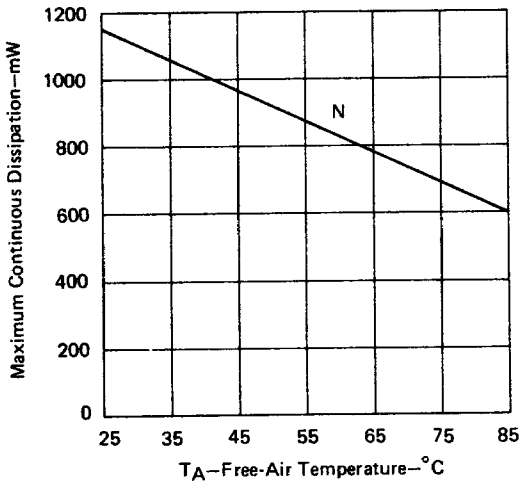


FIGURE III

P PACKAGE FREE-AIR TEMPERATURE DISSIPATION DERATING CURVES

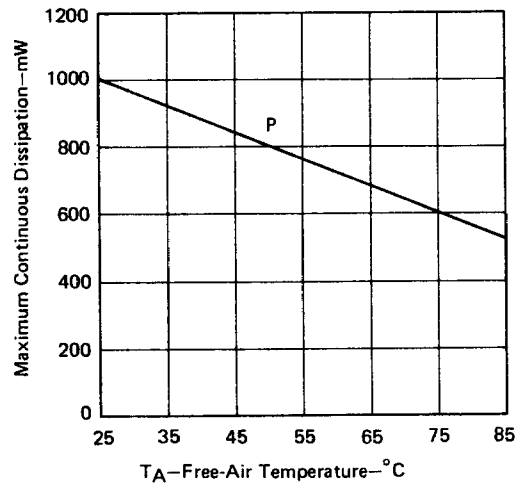


FIGURE IV

† This rating for the L package requires a heat sink that provides a thermal resistance from case to free-air,  $R_{\theta CA}$ , of not more than  $105^{\circ}\text{C}/\text{W}$ .