National Semiconductor

LH4009/LH4009C Fast Buffer

General Description

The LH4009 is a very high speed, FET input, voltage follower/buffer designed to provide high current drive at frequencies from DC to over 190 MHz. The LH4009/LH4009C will provide ±200 mA into 50Ω loads (±250 mA peak) at slew rates of 10000V/μs. In addition, it exhibits excellent phase linearity.

The LH4009 is intended to fulfill a wide range of buffer applications. Due to its high speed it does not degrade the system performance. Its high output current makes it adequate for most loads. Only a single +10V supply is needed for a 5 V_{PP} video signal. In addition, the LH4009 can continuously drive 50Ω coaxial cables.

These devices are constructed using specially selected junction FETs and active laser trimming to achieve guaranteed performance specifications. The LH4009K is specified for operation from −55°C to +125°C; whereas, the LH4009CK is specified from −25°C to +85°C. LH4009K and LH4009CK are available in an 8-pin TO-3 package. LH4009CT is available in an 11-pin TO-220 package and is specified from −25°C to +85°C.

Features

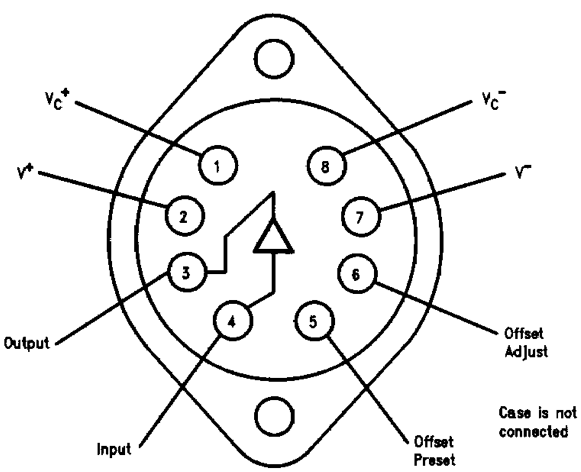
- Fast — 10000V/μs
- Wide range single or dual supply operation
- Wide power bandwidth — DC to 150 MHz
- High output drive — ±10V with 50Ω load
- Low phase non-linearity — 2 degrees
- Fast rise times — 2 ns
- High input resistance — $10^{10}\Omega$
- Pin compatible with LH0063
- Built in short circuit protection

Applications

- High speed line drivers
- Video impedance transformation
- Op amp isolation buffers
- Yoke driver for high resolution CRT
- High impedance input buffer

Connection Diagrams

Metal Can Package (TO-3), 8-Pin



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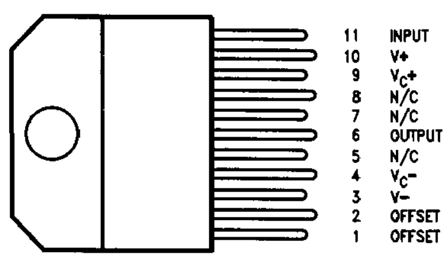
Top View

Order Number LH4009K or LH4009CK
See NS Package Number K08A

Plastic Package (TO-220), 11 Pin



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Top View

Metal Tab is Electrically Isolated

Order Number LH4009CT
See NS Package Number TA11B

Absolute Maximum Ratings

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

Supply Voltage ($V^+ - V^-$)	40V
Maximum Power Dissipation (see Curves)	3W
Maximum Junction Temperature	175°C
Input Voltage	Equal to Supplies
Continuous Output Current	±200 mA
Peak Output Current	±250 mA
Duration of Short Circuit Protection	30 sec
Operating Temperature Range	
LH4009	−55°C to +125°C
LH4009C	−25°C to +85°C
Storage Temperature Range	−65°C to +150°C
Lead Temperature (Soldering, 10 sec.)	300°C
ESD	TBD

DC Electrical Characteristics $V_S = \pm 15V$, $R_S = R_L = 50\Omega$, $T_A = 25°C$ unless otherwise specified

Symbol	Parameter	Conditions	LH4009			Units (Max unless otherwise noted)
			Typical	Tested Limit (Note 2)	Design Limit (Note 3)	
V_{OS}	Output Offset	(Note 4)	10	25 **150**		mV
I_B	Input Bias Current	(Note 4)	5	30 **100**		nA
Av	Voltage Gain	$V_{IN} = \pm 10V$, $R_L = 1\ k\Omega$	0.92	0.9 **0.85**		V/V (Min)
Av	Voltage Gain	$V_{IN} = \pm 10V$	0.87	0.85 **0.8**		V/V (Min)
C_{IN}	Input Capacitance		10			pF
R_{OUT}	Output Impedance	$V_{OUT} = \pm 10V$		**5**		Ω
V_O	Output Voltage Swing		±11	±10 **±8**		V (Min)
LSV_O	Low Supply Output Voltage Swing	$V_S = \pm 5.0V$		±2.5		V (Min)
I_S	Supply Current	$V_S = \pm 15V$, $R_L = \infty$,	47	60 **75**		mA
LVI_S	Low Voltage Supply Current	$V_S = \pm 5.0V$	45	60		mA
P_D	Power Consumption	$V_S = \pm 15V$, $R_L = \infty$	1.26	1.8		W
P_D	Power Consumption	$V_S = \pm 5.0V$, $R_L = \infty$		600		mW

DC Electrical Characteristics $V_S = \pm 15V$, $R_S = R_L = 50\Omega$, $T_A = 25°C$ unless otherwise specified

Symbol	Parameter	Conditions	LH4009C			Units (Max unless otherwise noted)
			Typical	Tested Limit (Note 2)	Design Limit (Note 3)	
V_{OS}	Output Offset	(Note 4)	10	50		mV
I_B	Input Bias Current	(Note 4)	5	30		nA
Av	Voltage Gain	$V_{IN} = \pm 10V$, $R_L = 1\ k\Omega$	0.92	0.9		V/V (Min)
Av	Voltage Gain	$V_{IN} = \pm 10V$	0.87	0.85		V/V (Min)
C_{IN}	Input Capacitance					pF
R_{OUT}	Output Impedance	$V_{OUT} = \pm 10V$		5		Ω
V_O	Output Voltage Swing		±11	±10		V (Min)
V_O	Output Voltage Swing	$V_S = \pm 5.0V$		±2.5		V (Min)
I_S	Supply Current	$V_S = \pm 15V$, $R_L = \infty$	42	60		mA
LVI_S	Low Voltage Supply Current	$V_S = \pm 5.0V$	45	60		mA
P_D	Power Consumption	$V_S = \pm 15V$, $R_L = \infty$	1.26	1.8		W
P_D	Power Consumption	$V_S = \pm 5.0V$, $R_L = \infty$		600		mW

AC Electrical Characteristics $T_J = 25°C, V_S = \pm 15V, R_S = 50\Omega, R_L = 50\Omega$

Symbol	Parameter	Conditions	LH4009			Units (Max unless otherwise noted)
			Typical	Tested Limit (Note 2)	Design Limit (Note 3)	
SR	Slew Rate Rising Edge	$V_{IN} = 20\ V_{PP}$ 20%–80%	11,000			V/μs (Min)
SR	Slew Rate Falling Edge	$V_{IN} = 20\ V_{PP}$ 20%–80%	8000			V/μs (Min)
BW	Bandwidth	$V_{IN} = 1.0$ Vrms	190	160		MHz (Min)
PBW	Power Bandwidth	$V_{IN} = 20\ V_{PP}$	150	130		MHz (Min)
	Rise Time	$\Delta V_{IN} = 20\ V_{PP}$	1.2			ns
	Propagation Delay	$\Delta V_{IN} = 20\ V_{PP}$	1.3			ns

Note 1: Boldface limits are guaranteed over full temperature range. Operating ambient temperature range of LH4009C is −25°C to +85°C, and LH4009 is −55°C to +125°C.

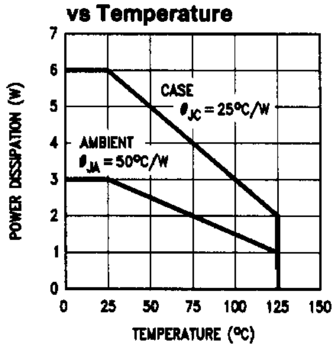
Note 2: Tested limits are guaranteed and 100% production tested.

Note 3: Design limits are guaranteed (but not production tested) over the indicated temperature or temperature range. These limits are not used to calculate outgoing quality level.

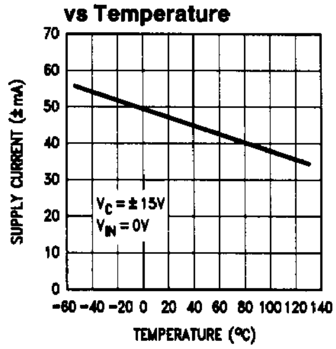
Note 4: Specifications are at 25°C junction temperature due to requirements of high speed automatic testing. Actual values at operating temperature will exceed value at $T_J = 25°C$.

Typical Performance Characteristics

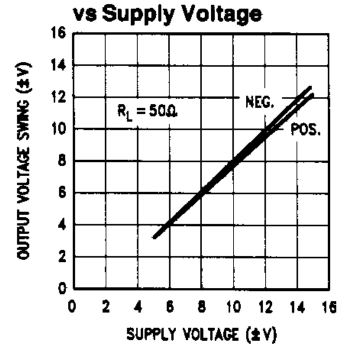
Maximum Power Dissipation vs Temperature



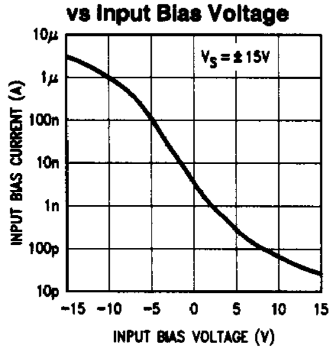
Supply Current vs Temperature



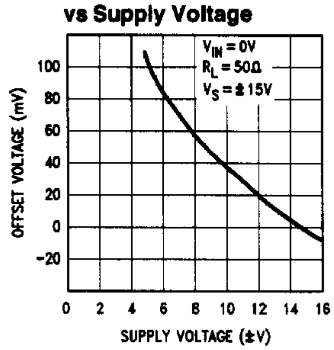
Output Voltage Swing vs Supply Voltage



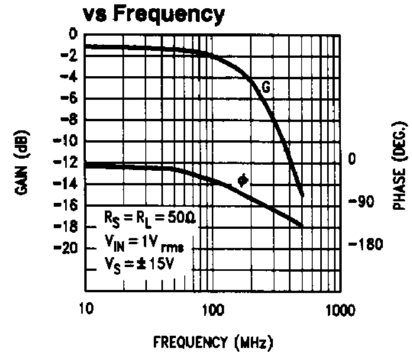
Input Bias Current vs Input Bias Voltage



Offset Voltage vs Supply Voltage



Gain and Phase vs Frequency



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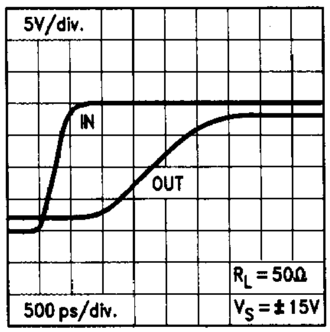
Typical Performance Characteristics (Continued)

Large Signal Rise Time



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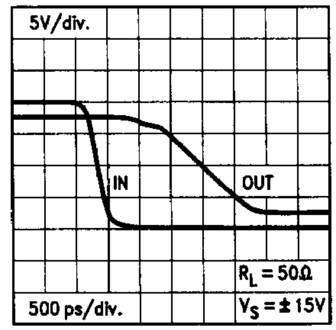
Large Signal Fall Time



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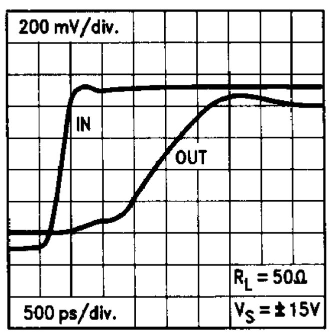
Small Signal Rise Time



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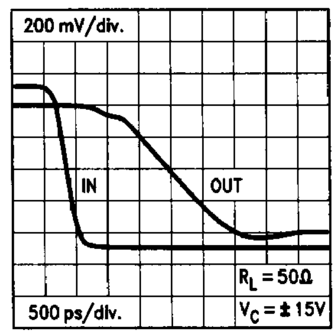
Small Signal Fall Time



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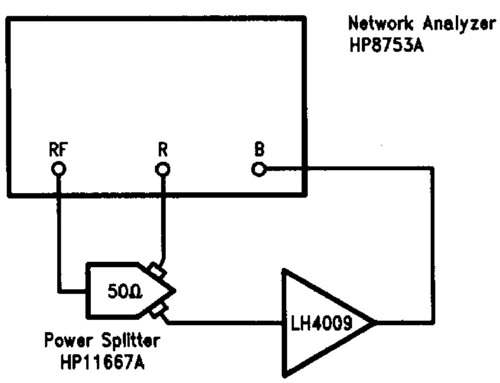
Bandwidth Test Circuit



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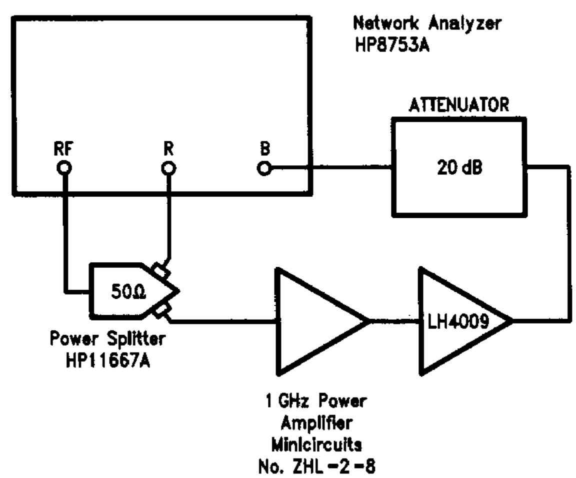
Power Bandwidth Test Circuit



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Application Hints

RECOMMENDED LAYOUT PRECAUTIONS: RF/video printed circuit board layout rules should be followed when using the LH4009 since it will provide power gain to frequencies over 200 MHz. Ground planes are recommended and power supplies should be decoupled at each device with low inductance capacitors. In addition, ground plane shielding may be extended to the metal case of the device since it is electrically isolated from internal circuitry. Alternatively, the case should be connected to the output to minimize input capacitance.

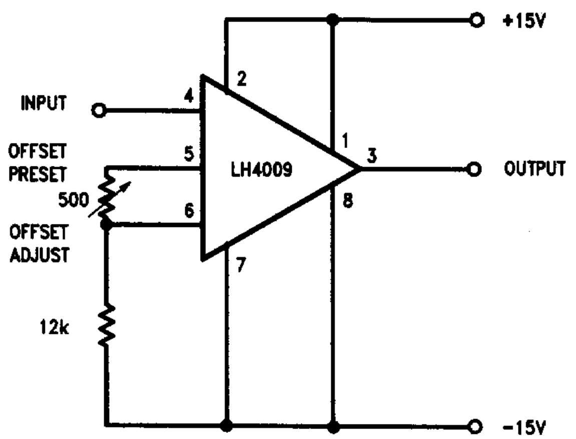

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FIGURE 1. Offset Zero Adjust

SHORT CIRCUIT PROTECTION: The LH4009 features built-in short circuit protection. It will protect the device against output shorts to ground for up to 30 seconds. Beyond that the device may get degraded.

CAPACITIVE LOADING: The LH4009 is designed to drive capacitive loads such as coaxial cables in excess of several thousand picofarads without susceptibility to oscillation. However, peak current resulting from ($C \times dV/dt$), should be limited below absolute maximum peak current ratings for the devices.

$$\left(\frac{\Delta V_{IN}}{\Delta t}\right) \times C_L \leq I_{OUT} \leq \pm 250\ \text{mA}$$

In addition, power dissipation resulting from driving capacitive loads plus standby power should be kept below package power rating:

$$P_{\underset{pkg.}{diss}} \geq P_{DC} + P_{AC}$$

$$P_{\underset{pkg.}{diss}} \geq (V^+ - V^-) \times I_S + P_{AC}$$

$$P_{AC} = (Vp\text{-}p)^2 \times f \times C_L$$

where $Vp\text{-}p$ = Peak-to-peak output voltage swing
f = frequency
C_L = Load Capacitance

OPERATION WITHIN AN OP AMP LOOP: The device may be used as a current booster or isolation buffer within a closed loop with op amps such as LH0032, LM6161, or LM118. An isolation resistor of 47Ω should be used between the op amp output and the input of LH4009. The wide bandwidth and high slew rate of the LH4009 assures that the loop has the characteristics of the op amp and that additional rolloff is not required.

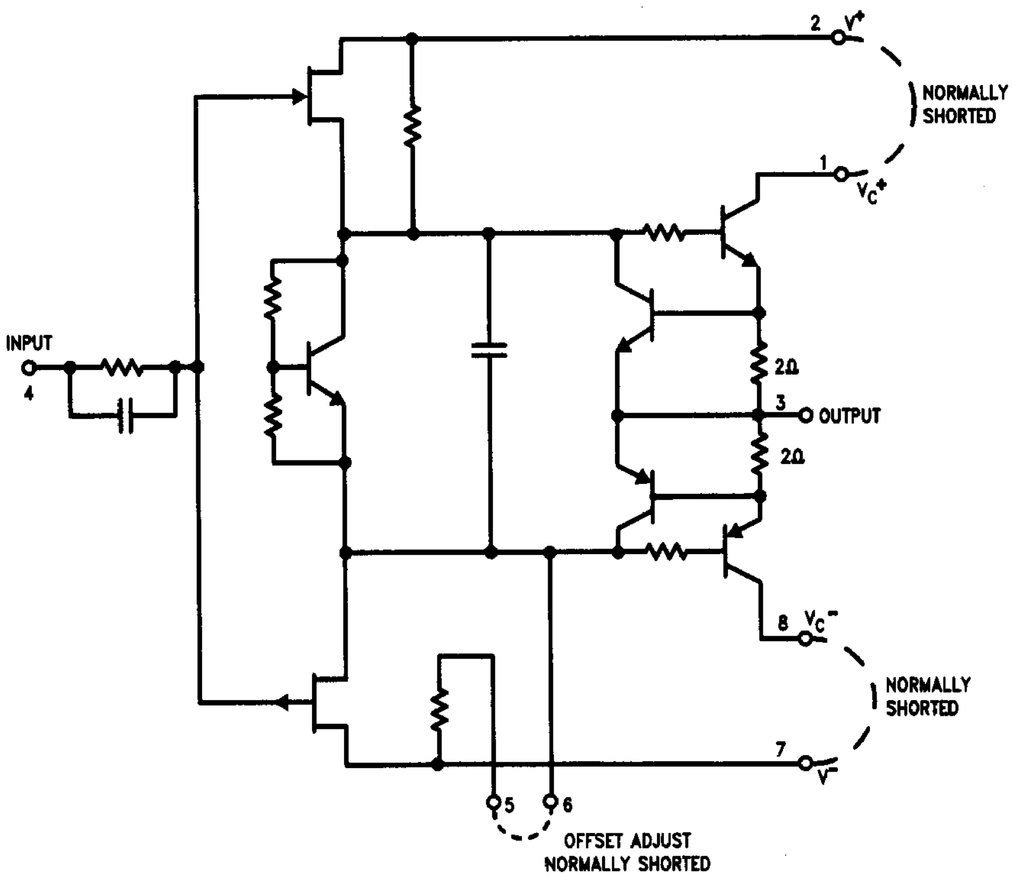
HARDWARE: In order to utilize the full drive capabilities of both devices, each should be mounted with a heat sink particularly for extended temperature operation. The cases of both are isolated from the circuit and may be connected to system chassis.

ATTENTION!

POWER SUPPLY BYPASSING is necessary to prevent oscillation in all circuits. Low inductance ceramic disc capacitance with the shortest practical lead lengths must be connected from each supply lead (within <¼ to ½″ of the device package) to a ground plane. Capacitors should be two 0.1 μF ceramic and one 4.7 μF solid tantalum capacitors in parallel on each supply lead.

Schematic Diagram

LH4009



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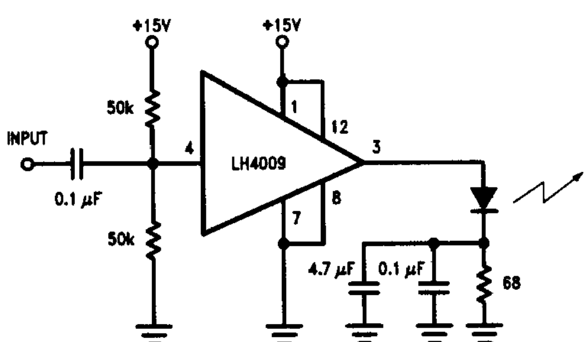
Typical Applications

Laser Diode Transmitter



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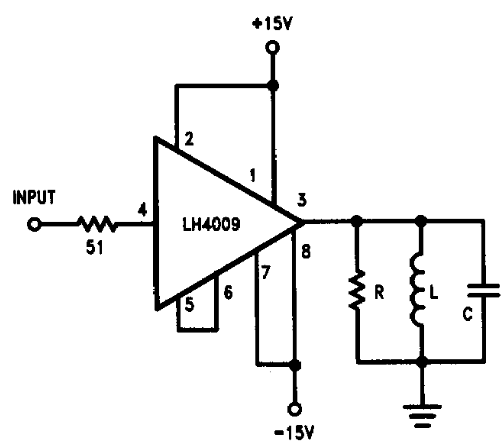
Isolation Buffer



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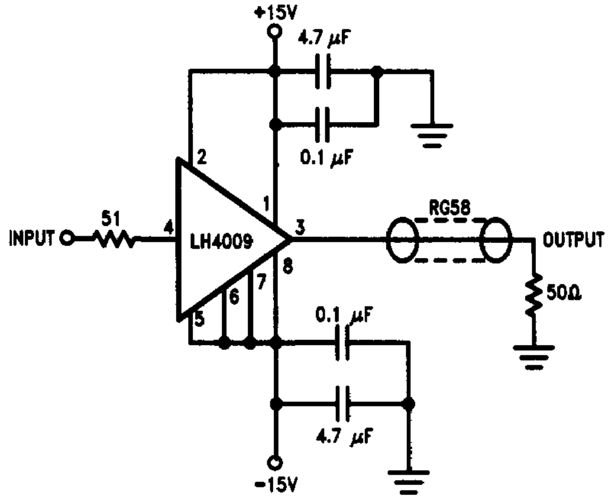
Typical Applications (Continued)

Coaxial Cable Driver



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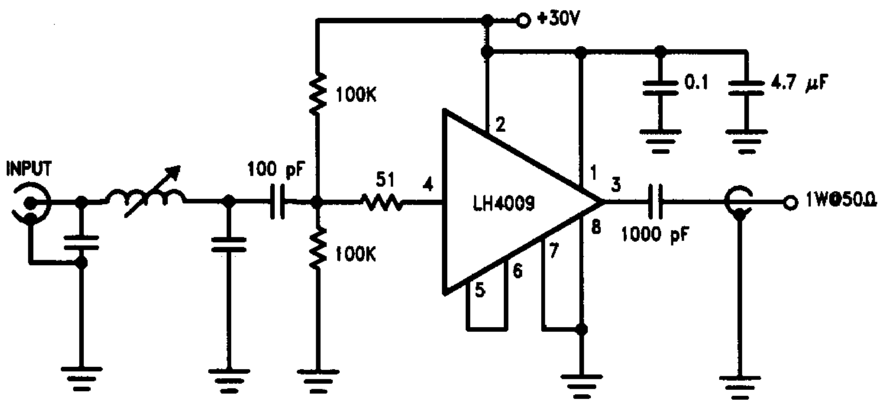
1W CW Final Amplifier



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