HARRIS SEMICONDUCTOR

HA-5004

March 1993

100MHz Current Feedback Amplifier

Features

- Slew Rate 1200V/µs
- Output Current .... ±100mA
- Drives .... ±9V into 100Ω
- V_{SUPPLY} .... ±5V to ±18V
- Thermal Overload Protection and Output Flag
- Bandwidth Nearly Independent of Gain
- Output Enable/Disable

Applications

- Unity Gain Video/Wideband Buffer
- Video Gain Block
- High Speed Peak Detector
- Fiber Optic Transmitters
- Zero Insertion Loss Transmission Line Drivers
- Current to Voltage Converter
- Radar Systems

Ordering Information

PART NUMBER	TEMP. RANGE	PACKAGE
HA1-5004-5	-40°C to +85°C	14 Lead Ceramic DIP
HA1-5004-9	-40°C to +85°C	14 Lead Ceramic DIP
HA3-5004-5	0°C to +75°C	14 Lead Plastic DIP
HA9P5004-5	0°C to +75°C	14 Lead SOIC

Description

The HA-5004 current feedback amplifier is a video/wideband amplifier optimized for low gain applications. The design is based on current-mode feedback which allows the amplifier to achieve higher closed loop bandwidth than voltage-mode feedback operational amplifiers. Since feedback is employed, the HA-5004 can offer better gain accuracy and lower distortion than open loop buffers. Unlike conventional op amps, the bandwidth and rise time of the HA-5004 are nearly independent of closed loop gain. The 100MHz bandwidth at unity gain reduces to only 65MHz at a gain of 10. The HA-5004 may be used in place of a conventional op amp with a significant improvement in speed power product.

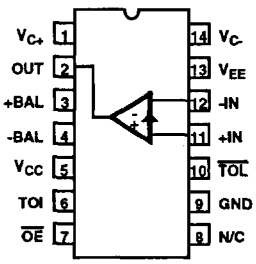
Several features have been designed in for added value. A thermal overload feature protects the part against excessive junction temperature by shutting down the output. If this feature is not needed, it can be inhibited via a TTL input (TOI). A TTL chip enable/disable ($\overline{OE}$) is also provided; when the chip is disabled its output is high impedance. Finally, an open collector output flag ($\overline{TOL}$) is provided to indicate the status of the chip. The status flag goes low to indicate when the chip is disabled due to either the internal Thermal Overload shutdown or the external disable.

In order to maximize bandwidth and output drive capacity, internal current limiting is not provided. However, current limiting may be applied via the V_C+ and V_C- pins which provide power separately to the output stage.

For Military grade product refer to the HA-5004/883 data sheet.

Pinout

HA-5004
(PDIP, CDIP, SOIC)
TOP VIEW



INPUTS		TEMP	$\overline{TOL}$ OUTPUT (OPEN COLLECTOR)	OPERATION
$\overline{OE}$	TOI	T_J		
0	0	Normal	1	Normal
0	0	High*	0	Auto Shutdown, Hi-Z OUT
0	1	X	1	Normal
1	X	X	0	Manual Shutdown, Hi-Z OUT

* > 180°C Typical

File Number 2923.1

Absolute Maximum Ratings (Note 1)

Supply Voltage (Between V+ and V- Terminals) 40V
Differential Input Voltage 5V
DC Input Voltage . . . . $\pm V_{SUPPLY}$
Output Current . . . . ±120mA Max (≤25% Duty Cycle)
Junction Temperature (Note 10) . . . . +175°C
Junction Temperature (Plastic Package) . . . . +150°C
Lead Temperature (Soldering 10 Sec.) . . . . +300°C

Operating Conditions

Operating Temperature Range
HA-5004-9 . . . . $-40°C \le T_A \le +85°C$
HA-5004-5 . . . . $0°C \le T_A \le +75°C$
Storage Temperature Range . . . . $-65°C \le T_A \le +150°C$

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

Electrical Specifications

$V_{CC} = V_{C+} = +15V$, $V_{EE} = V_{C-} = -15V$, $R_S = 50\Omega$, $R_L = 100\Omega$, $A_V = +1$, $R_F = 250\Omega$, $\overline{OE} = 0.8V$, TOI = 0.8V or 2.0V, Unless Otherwise Specified

PARAMETER		TEMP	HA-5004-5, -9 LIMITS			UNITS
			MIN	TYP	MAX	
INPUT CHARACTERISTICS						
Offset Voltage		+25°C	-	1	5	mV
		Full	-	-	20	mV
Average Offset Voltage Drift		Full	-	10	-	µV/°C
Bias Current (+Input Only) (Note 2)		+25°C	-	2	5	µA
		Full	-	-	20	µA
Input Resistance (-Input)		+25°C	-	6.5	-	Ω
Input Resistance (+Input)		+25°C	-	3	-	MΩ
Input Capacitance		+25°C	-	3	-	pF
Common Mode Range		Full	±10	-	-	V
DISTORTION AND NOISE						
Total Harmonic Distortion $2V_{P-P}$, 200kHz	$A_{VCL} = +1$	+25°C	-	-72	-	dBc
	$A_{VCL} = +2$	+25°C	-	-70	-	dBc
	$A_{VCL} = +5$	+25°C	-	-68	-	dBc
Input Noise Voltage 10Hz to 1MHz		+25°C	-	15	-	μV_{P-P}
Input Noise Voltage Density (Note 3)	f_O = 10kHz	+25°C	-	2.2	-	$nV/\sqrt{Hz}$
	f_O = 100kHz	+25°C	-	2.2	-	$nV/\sqrt{Hz}$
Input Noise Current Density (Note 3)	f_O = 10kHz	+25°C	-	6	-	$pA/\sqrt{Hz}$
	f_O = 100kHz	+25°C	-	4	-	$pA/\sqrt{Hz}$
DIGITAL I/O CHARACTERISTICS						
Logic Inputs (OE and TO)	V_{IH}	Full	2.0	-	-	V
	V_{IL}	Full	-	-	0.8	V
	I_{IH} at V_I = 2.4V	Full	-	-	1	µA
	I_{IH} at V_I = 0.4V	Full	-	-	10	µA
Logic Output (TOL) (Open Collector)	V_{OL} at 800µA	Full	-	0.05	0.4	V

Electrical Specifications $V_{CC} = V_{C+} = +15V$, $V_{EE} = V_{C-} = -15V$, $R_S = 50\Omega$, $R_L = 100\Omega$, $A_V = +1$, $R_F = 250\Omega$, $\overline{OE} = 0.8V$, TOI = 0.8V or 2.0V, Unless Otherwise Specified **(Continued)**

PARAMETER		TEMP	HA-5004-5, -9 LIMITS			UNITS
			MIN	TYP	MAX	
TRANSFER CHARACTERISTICS						
DC Gain Error (Note 4)	Small Signal (±100mV)	+25°C	-	0.25	0.43	%
		Full	-	0.25	0.75	%
	Large Signal (±10V) (R_L = 1K)	+25°C	-	0.25	0.43	%
		Full	-	0.25	0.75	%
DC Voltage Gain (Small and Large Signal)		+25°C	233	400	-	V/V
		Full	133	400	-	V/V
DC Transimpedance (Note 5)		+25°C	-	100	-	V/mA
		Full	33	100	-	V/mA
-3dB Bandwidth A_V = +1 (Note 6)		+25°C	-	100	-	MHz
Gain Flatness	DC to 5MHz	+25°C	-	0.03	-	dB
	DC to 10MHz	+25°C	-	0.05	-	dB
Differential Gain (Notes 6, 7, 8) 3.58MHz	A_{VCL} = +1	+25°C	-	0.035	-	%
	A_{VCL} = +2	+25°C	-	0.058	-	%
Differential Gain (Notes 6, 7, 8) 4.43MHz	A_{VCL} = +1	+25°C	-	0.035	-	%
	A_{VCL} = +2	+25°C	-	0.058	-	%
Differential Phase (Notes 6, 7) 3.58MHz	A_{VCL} = +1	+25°C	-	0.15	-	Degrees
	A_{VCL} = +2	+25°C	-	0.23	-	Degrees
Differential Phase (Notes 6, 7) 4.43MHz	A_{VCL} = +1	+25°C	-	0.17	-	Degrees
	A_{VCL} = +2	+25°C	-	0.24	-	Degrees
Common Mode Rejection Ratio (Note 9)		Full	-	58	-	dB
Minimum Stable Gain		Full	1	-	-	V/V
OUTPUT CHARACTERISTICS						
Output Voltage Swing	R_L = 100Ω	+25°C	±9.0	±9.5	-	V
	R_L = 1kΩ	+25°C	±11.5	±11.8	-	V
	R_L = 100Ω	Full	±8.0	±9.5	-	V
	R_L = 1kΩ	Full	±10.5	±11.8	-	V
Full Power Bandwidth (A_V = +1) (V_{OUT} = $4V_{P-P}$)		+25°C	-	50	-	MHz
Output Resistance, Open Loop		+25°C	-	5	-	Ω
Output Current		+25°C	±90	±100	-	mA
		Full	±80	±100	-	mA
Output Enable Time (Hi Z to ±2V)		Full	-	100	-	ns
Output Disable Time (±2V to Hi Z)		Full	-	3	-	µs
Output Leakage (Disabled)		Full	-	-	1	µA

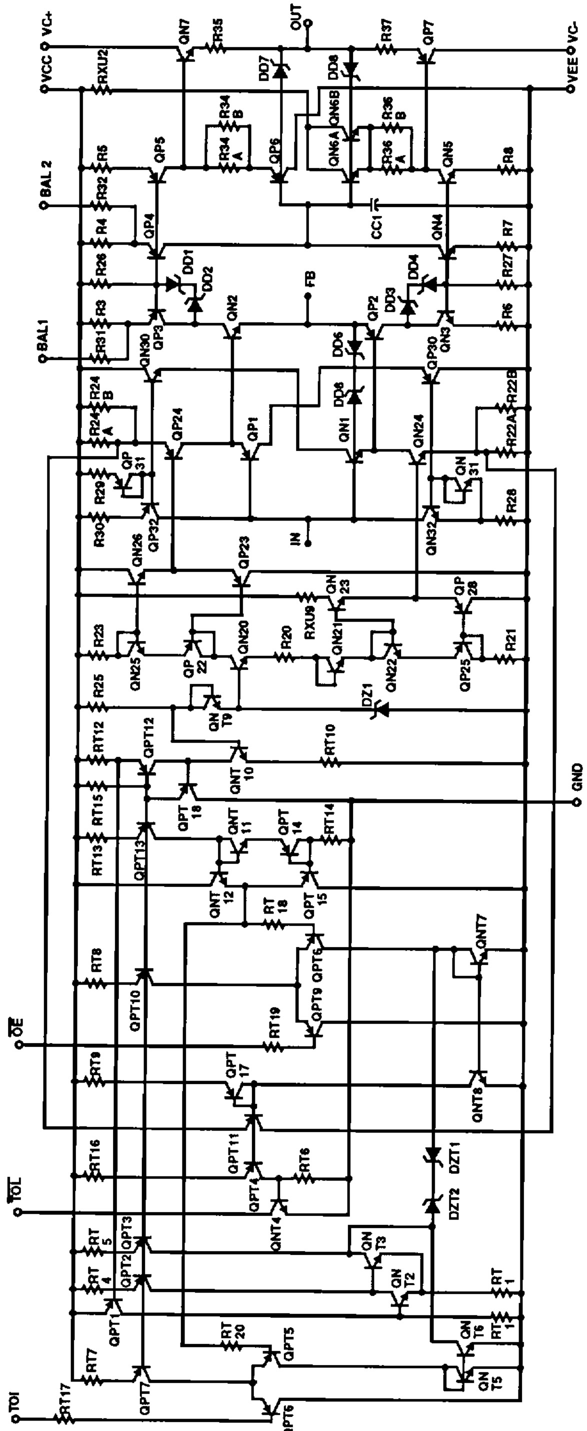
Electrical Specifications $V_{CC} = V_{C+} = +15V$, $V_{EE} = V_{C-} = -15V$, $R_S = 50\Omega$, $R_L = 100\Omega$, $A_V = +1$, $R_F = 250\Omega$, $\overline{OE} = 0.8V$, TOI = 0.8V or 2.0V, Unless Otherwise Specified **(Continued)**

PARAMETER		TEMP	HA-5004-5, -9 LIMITS			UNITS
			MIN	TYP	MAX	
TRANSIENT RESPONSE						
Rise Time/Fall Time (200mV Step)		+25°C	-	6.3	-	ns
Propagation Delay (10V Step)		+25°C	-	7	-	ns
Slew Rate (10V Step)		+25°C	-	1200	-	V/µs
Settling Time (0.1%, 10V Step)		+25°C	-	50	-	ns
Overshoot		+25°C	-	10	-	%
POWER SUPPLY CHARACTERISTICS						
Supply Current	(Enabled)	+25°C	-	12	16	mA
		Full	-	-	22	mA
	(Disabled)	+25°C	-	7	-	mA
Power Supply Rejection Ratio		Full	50	60	-	dB

NOTES:

1. Absolute maximum ratings are limiting values, applied individually, beyond which the serviceability of the circuit may be imparied. Functional operation under any of these conditions is not necessarily implied.
2. The inverting input is a low impedance point; Bias Current and Offset Current, are not specified for this terminal.
3. See typical performance curves.
4. $\text{Gain Error} = \frac{1}{\text{DC Voltage Gain}} \times 100\%$
5. $\text{DC Transimpedance} = \frac{R_F}{\text{Gain Error}}, R_F = 250\Omega$
6. $V_{IN} = 300mV_{P-P}$
7. $V_{OFFSET} = 1.0V$
8. Differential Gain (dB) = 0.0869 Differential Gain (%)
9. $V_{CM} = \pm10V$
10. Maximum power dissipation, including load condition, must be designed to maintain the junction temperature below +175°C for the ceramic DIP, and below +150°C for the plastic packages. See Thermal Resistances in the "Die Characteristics" section.

Schematic Diagram



Die Characteristics

Transistor Count 64
Die Dimensions . . . . 93 x 63 x 19mils (2370 x 1600 x 480μm)
Substrate Potential . . . . V_{EE}
Process. . . . . Bipolar DI

Thermal Constants (°C/W)	θ_{JA}	θ_{JC}
Ceramic DIP	71	14
Plastic DIP	107	38
SOIC	118	36

Typical Performance Curves

V_{SUPPLY} = ±15V, T_A = +25°C, Unless Otherwise Specified.

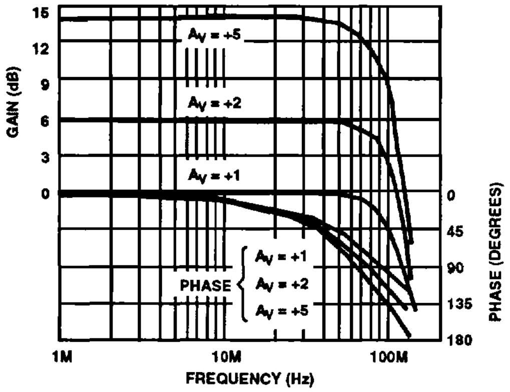


FIGURE 1. GAIN AND PHASE vs FREQUENCY

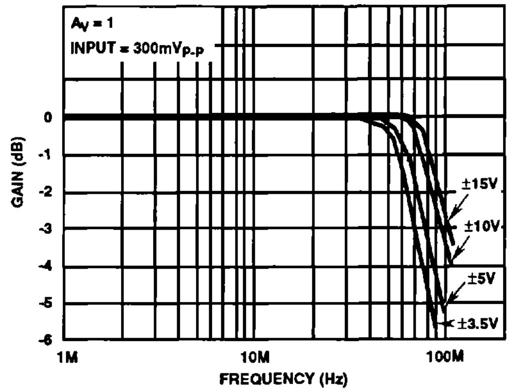


FIGURE 2. FREQUENCY RESPONSE vs SUPPLY VOLTAGE

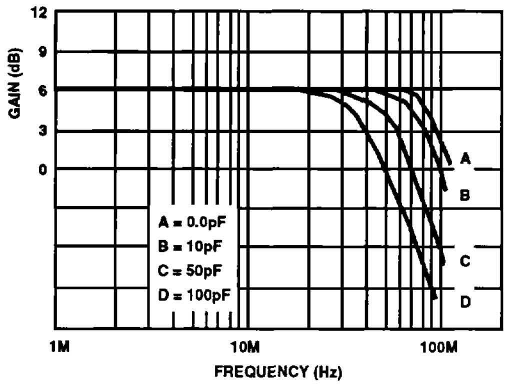


FIGURE 3. FREQUENCY RESPONSE vs C_L

V_{CC} = ±15V, A_V = +2, R_L = 1kΩ, Input = 10mV

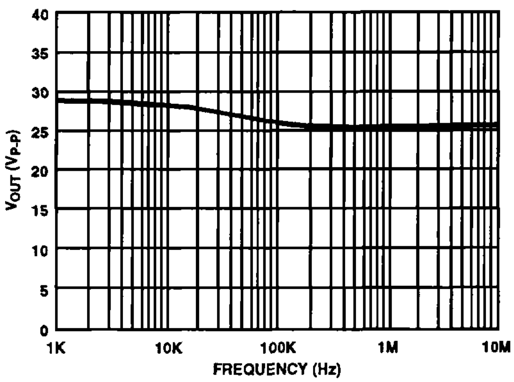


FIGURE 4. MAXIMUM UNDISTORTED SINEWAVE OUTPUT vs FREQUENCY

V_{CC} = ±15V, A_V = +1, Sinewave Input

Typical Performance Curves V_{SUPPLY} = ±15V, T_A = +25°C, Unless Otherwise Specified. **(Continued)**

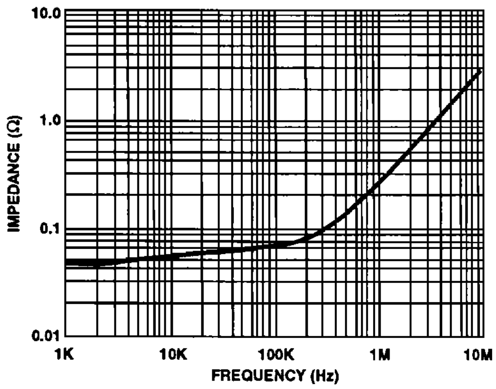


FIGURE 5. CLOSED LOOP OUTPUT IMPEDANCE vs FREQUENCY

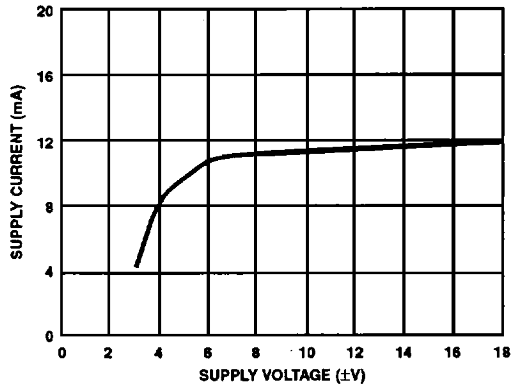


FIGURE 6. SUPPLY CURRENT vs SUPPLY VOLTAGE

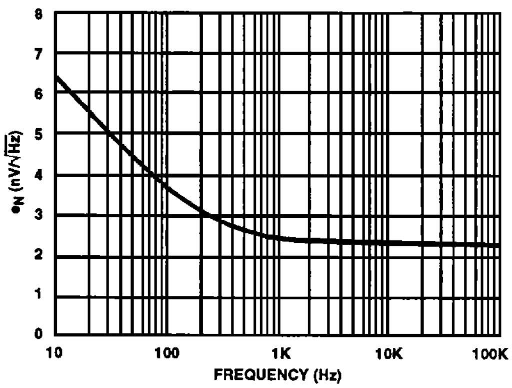


FIGURE 7. NOISE VOLTAGE vs FREQUENCY

V_{CC} = ±15V

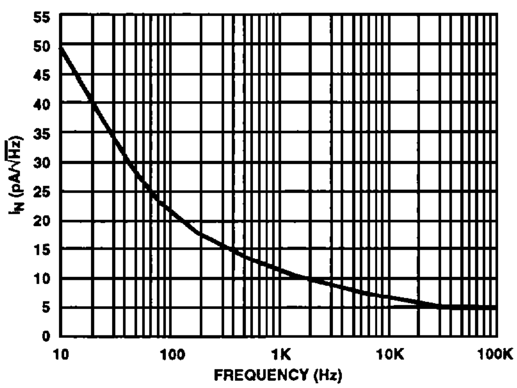
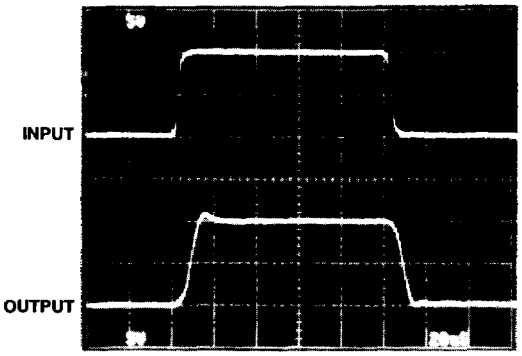


FIGURE 8. NOISE CURRENT vs FREQUENCY

V_{CC} = ±15V

Switching Waveforms

LARGE SIGNAL RESPONSE, $A_V = +1$
Vertical Scale: 5V/Div.
Horizontal Scale: 20ns/Div.



$A_V = +1$, $V_{SUPPLY} = \pm15V$

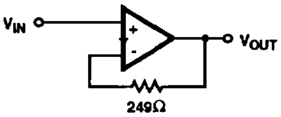
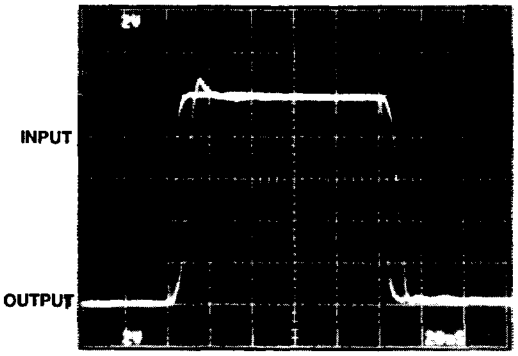


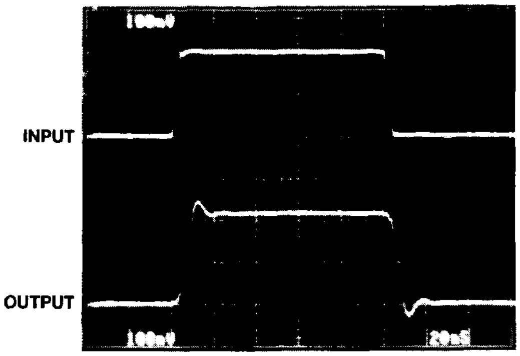
FIGURE 9. TEST CIRCUIT

PROPAGATION DELAY
Vertical Scale: 2V/Div.
Horizontal Scale: 20ns/Div.



$A_V = +1$, $V_{SUPPLY} = \pm15V$

SMALL SIGNAL RESPONSE
Vertical Scale: 100mV/Div.
Horizontal Scale: 20ns/Div.



$A_V = +1$, $V_{SUPPLY} = \pm15V$

Applications Information

Theory of Operation

The HA-5004 is a high performance amplifier that uses current feedback to achieve its outstanding performance. Although it is externally configured like an ordinary op amp in most applications, its internal operation is significantly different.

Inside the HA-5004, there is a unity gain buffer from the non-inverting (+) input to the inverting-input (as suggested by the circuit symbol), and the inverting terminal is a low impedance point. Error currents are sensed at the inverting input and amplified; a small change in input current produces a large change in output voltage. The ratio of output voltage delta due to input current delta is the transimpedance of the device.

Steady state current at the inverting input is very small because the transimpedance is large. The voltage across the input terminals is nearly zero due to the buffer amplifier. These two properties are similar to standard op amps and likewise simplify circuit analysis.

Resistor Selection

The HA-5004 is optimized for a feedback resistor of 250Ω, regardless of gain configuration. It is important to note that this resistor is required even for unity gain applications; higher gain settings use a second resistor like regular op amp circuits as shown in Figure 10 below.

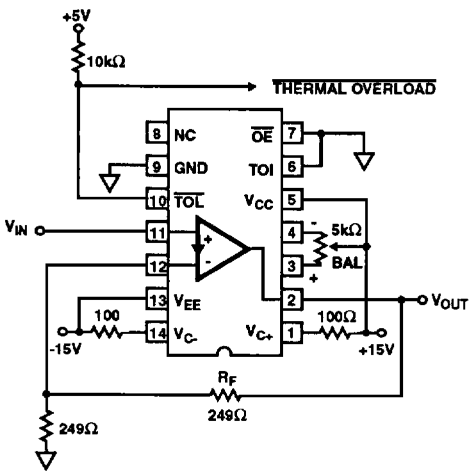


FIGURE 10. TYPICAL APPLICATION CIRCUIT, $A_V = +2$

Power Supplies

The HA-5004 will operate over a wide range of supply voltages with excellent performance. Supplies may be either single-ended or split, ranging from 6V (±3V) to 36V (±18V). Appropriate reduction in input and output signal excursion is necessary for operation at lower supply voltages. Bypass capacitors from each supply to ground are recommended, typically a 0.01μF ceramic in parallel with a 4.7μF electrolytic.

Current Limit

No internal current limiting is provided for the HA-5004 in order to maximize bandwidth and slew rate. However, power is supplied separately to the output stage via pins 1 (V_C+) and 14 (V_C-) so that external current limiting resistors may be used. If required, 100Ω resistors to each supply rail are recommended.

Enable/Disable and Thermal Overload Operation

The HA-5004 operates normally with a TTL low state on pin 7 ($\overline{OE}$) but it may be disabled manually by a TTL high state at this input. When disabled, the output and inverting-input go to a high impedance state and the circuit is electrically debiased, reducing supply current by about 5mA. It is important to keep the differential input voltage below the absolute maximum rating of 5V when the device is disabled.

If the power dissipation becomes excessive and chip temperature exceeds approximately 180°C, the HA-5004 will automatically disable itself. The thermal overload condition will be indicated by a low state at the $\overline{TOL}$ output on pin 10. ($\overline{TOL}$ is also low for manual shutdown via pin 7). Automatic thermal shutdown can be bypassed by a TTL high state on Thermal Overload Inhibit (TOI) pin 6. See the truth table for a summary of operation.

Offset Adjustment

Offset voltage may be nulled with a 5kΩ potentiometer between pins 3 and 4, center tapped to the positive supply. Setting the slider towards pin 3 (+BAL) increases output voltage; towards pin 4 (-BAL) decreases output voltage. Offset can be adjusted by about ±10mV with a 5K pot; this range is extended with a lower resistance potentiometer.