

**15MHz, BiMOS Operational Amplifier with MOSFET Input/CMOS Output**

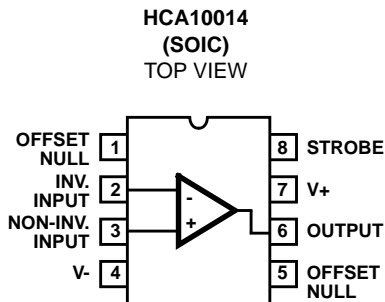
HCA10014 op amp combines the advantage of both CMOS and bipolar transistors.

Gate protected P-Channel MOSFET (PMOS) transistors are used in the input circuit to provide very high input impedance, very low input current, and exceptional speed performance. The use of PMOS transistors in the input stage results in common mode input voltage capability down to 0.5V below the negative supply terminal, an important attribute in single supply applications.

A CMOS transistor pair, capable of swinging the output voltage to within 10mV of either supply voltage terminal (at very high values of load impedance), is employed as the output circuit.

The HCA10014 operates at supply voltages ranging from 5V to 16V, ( $\pm 2.5V$  to  $\pm 8V$ ). It can be phase compensated with a single external capacitor, and have terminals for adjustment of offset voltage for applications requiring offset null capability. Terminal provisions are also made to permit strobing of the output stage.

**Pinout**



**Features**

- MOSFET Input Stage Provides:
  - Very High  $Z_i = 1.5T\Omega$  ( $1.5 \times 10^{12}\Omega$ ) (Typ)
  - Very Low  $I_i$ 
    - 15V Operation. . . . . 5pA (Typ)
    - 5V Operation. . . . . 2pA (Typ)
- Ideal for Single Supply Applications
- Common Mode Input Voltage Range Includes Negative Supply Rail; Input Terminals can be Swung 0.5V Below Negative Supply Rail
- CMOS Output Stage Permits Signal Swing to Either (or both) Supply Rails

**Applications**

- Ground Referenced Single Supply Amplifiers
- Fast Sample and Hold Amplifiers
- Long Duration Timers/Monostables
- High Input Impedance Comparators (Ideal Interface with Digital CMOS)
- High Input Impedance Wideband Amplifiers
- Voltage Followers (e.g., Follower for Single Supply D/A Converter)
- Voltage Regulators (Permits Control of Output Voltage Down to 0V)
- Peak Detectors
- Single Supply Full Wave Precision Rectifiers
- Photo Diode Sensor Amplifiers

**Ordering Information**

PART NO. (BRAND)	TEMP. RANGE (°C)	PACKAGE	PKG. NO.
HCA10014	-55 to 125	8 Ld SOIC Tape and Reel	M8.15

**Absolute Maximum Ratings**

DC Supply Voltage (Between V+ and V- Terminals) .....16V  
 Differential Input Voltage .....8V  
 DC Input Voltage ..... (V+ +8V) to (V- -0.5V)  
 Input Terminal Current ..... 1mA  
 Output Short Circuit Duration (Note 1)..... Indefinite

**Operating Conditions**

Temperature Range ..... -50°C to 125°C

**Thermal Information**

Thermal Resistance (Typical, Note 2)  $\theta_{JA}$  (°C/W)  
 SOIC Package ..... 160  
 Maximum Junction Temperature (Metal Can Package) .....175°C  
 Maximum Junction Temperature (Plastic Package) .....150°C  
 Maximum Storage Temperature Range ..... -65°C to 150°C  
 Maximum Lead Temperature (Soldering 10s) .....300°C  
 (SOIC - Lead Tips Only)

*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.*

**NOTES:**

1. Short circuit may be applied to ground or to either supply.
2.  $\theta_{JA}$  is measured with the component mounted on an evaluation PC board in free air.

**Electrical Specifications**  $T_A = 25^\circ\text{C}$ , V+ = 15V, V- = 0V, Unless Otherwise Specified

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	$ V_{IO} $	$V_S = \pm 7.5V$	-	8	15	mV
Input Offset Voltage Temperature Drift	$\Delta V_{IO}/\Delta T$		-	10	-	$\mu\text{V}/^\circ\text{C}$
Input Offset Current	$ I_{IO} $	$V_S = \pm 7.5V$	-	0.5	30	pA
Input Current	$I_I$	$V_S = \pm 7.5V$	-	5	50	pA
Large Signal Voltage Gain	$A_{OL}$	$V_O = 10V_{P-P}$ , $R_L = 2k\Omega$	50	320	-	kV/V
			94	110	-	dB
Common Mode Rejection Ratio	CMRR		70	90	-	dB
Common Mode Input Voltage Range	$V_{ICR}$		0	-0.5 to 12	10	V
Power Supply Rejection Ratio	$\Delta V_{IO}/\Delta V_S$	$V_S = \pm 7.5V$	-	32	320	$\mu\text{V}/\text{V}$
Maximum Output Voltage	$V_{OM+}$	$R_L = 2k\Omega$	12	13.3	-	V
	$V_{OM-}$	$R_L = 2k\Omega$	-	0.002	0.01	V
	$V_{OM+}$	$R_L = \infty$	14.99	15	-	V
	$V_{OM-}$	$R_L = \infty$	-	0	0.01	V
Maximum Output Current	$I_{OM+}$ (Source) at $V_O = 0V$		12	22	45	mA
	$I_{OM-}$ (Sink) at $V_O = 15V$		12	20	45	mA
Supply Current	I+	$V_O = 7.5V$ , $R_L = \infty$	-	10	15	mA
	I+	$V_O = 0V$ , $R_L = \infty$	-	2	3	mA

## HCA10014

**Electrical Specifications** Typical Values Intended Only for Design Guidance,  $V_{SUPPLY} = \pm 7.5V$ ,  $T_A = 25^\circ C$   
Unless Otherwise Specified

PARAMETER	SYMBOL	TEST CONDITIONS	TYP	UNITS		
Input Offset Voltage Adjustment Range		10k $\Omega$ Across Terminals 4 and 5 or 4 and 1	$\pm 22$	mV		
Input Resistance	$R_I$		1.5	T $\Omega$		
Input Capacitance	$C_I$	f = 1MHz	4.3	pF		
Equivalent Input Noise Voltage	$e_N$	BW = 0.2MHz, $R_S = 1M\Omega$ (Note 3)	23	$\mu V$		
Open Loop Unity Gain Crossover Frequency (for Unity Gain Stability $\geq 47pF$ Required)	$f_T$	$C_C = 0$	15	MHz		
		$C_C = 47pF$	4	MHz		
Slew Rate: Open Loop	SR	$C_C = 0$	30	V/ $\mu s$		
		Closed Loop	$C_C = 56pF$	10	V/ $\mu s$	
Transient Response: Rise Time	$t_r$	$C_C = 56pF$ , $C_L = 25pF$ , $R_L = 2k\Omega$ (Voltage Follower)	0.09	$\mu s$		
			Overshoot	OS	10	%
			Settling Time ( $T_o < 0.1\%$ , $V_{IN} = 4V_{P-P}$ )	$t_s$	1.2	$\mu s$

**NOTE:**

3. Although a 1M $\Omega$  source is used for this test, the equivalent input noise remains constant for values of  $R_S$  up to 10M $\Omega$ .

Typical Performance Curves

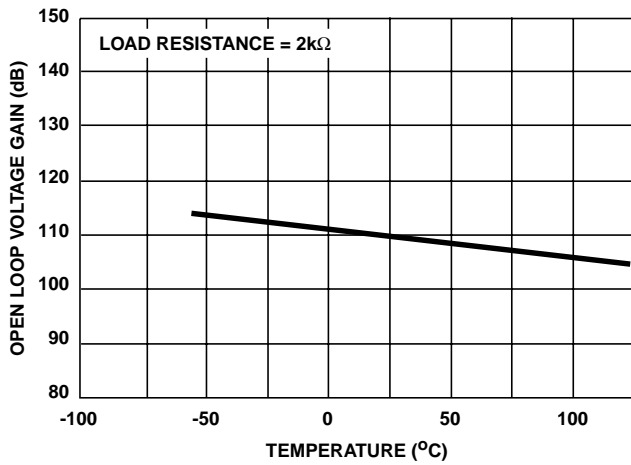
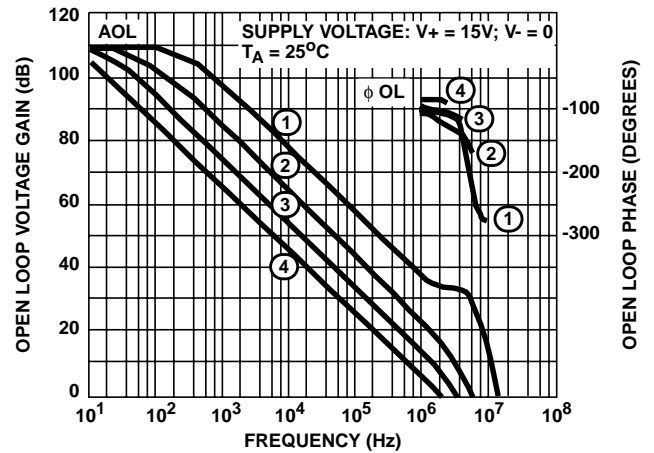


FIGURE 1. OPEN LOOP GAIN vs TEMPERATURE



1 -  $C_L = 9\text{pF}$ ,  $C_C = 0\text{pF}$ ,  $R_L = \infty$       3 -  $C_L = 30\text{pF}$ ,  $C_C = 47\text{pF}$ ,  $R_L = 2\text{k}\Omega$   
 2 -  $C_L = 30\text{pF}$ ,  $C_C = 15\text{pF}$ ,  $R_L = 2\text{k}\Omega$       4 -  $C_L = 30\text{pF}$ ,  $C_C = 150\text{pF}$ ,  $R_L = 2\text{k}\Omega$

FIGURE 2. OPEN LOOP RESPONSE

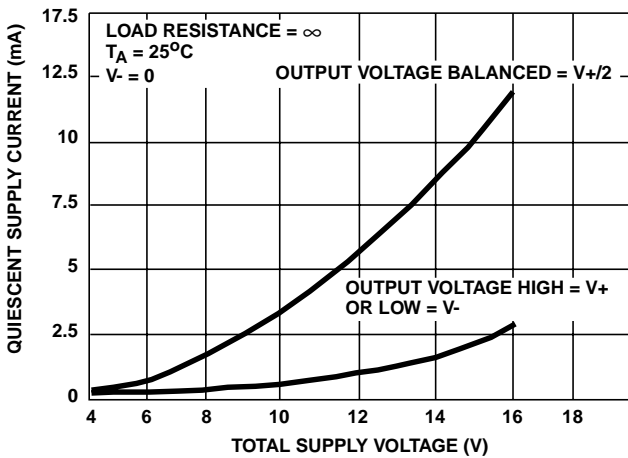


FIGURE 3. QUIESCENT SUPPLY CURRENT vs SUPPLY VOLTAGE

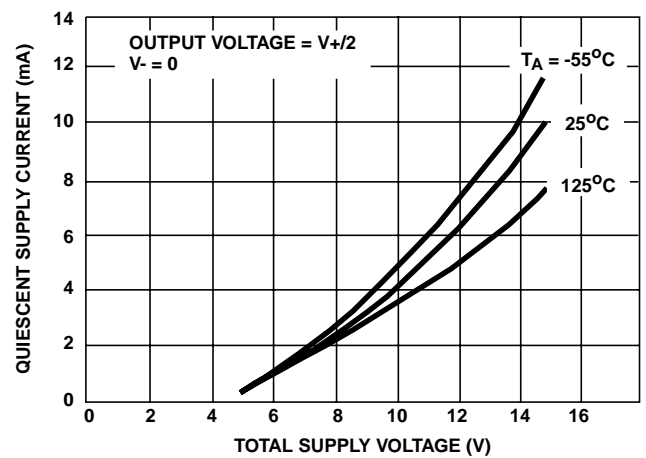


FIGURE 4. QUIESCENT SUPPLY CURRENT vs SUPPLY VOLTAGE

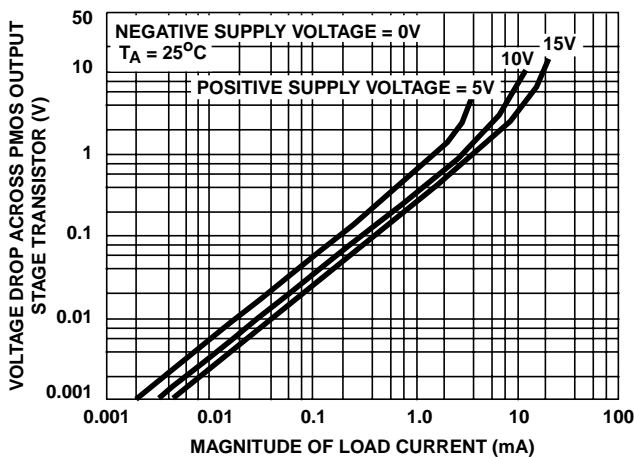


FIGURE 5. VOLTAGE ACROSS PMOS OUTPUT TRANSISTOR ( $Q_8$ ) vs LOAD CURRENT

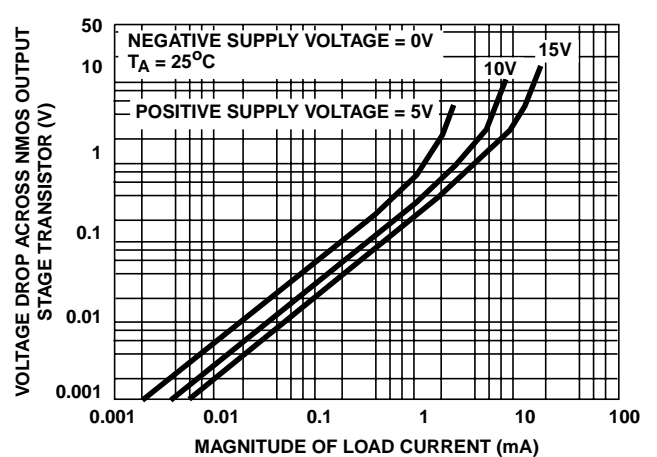
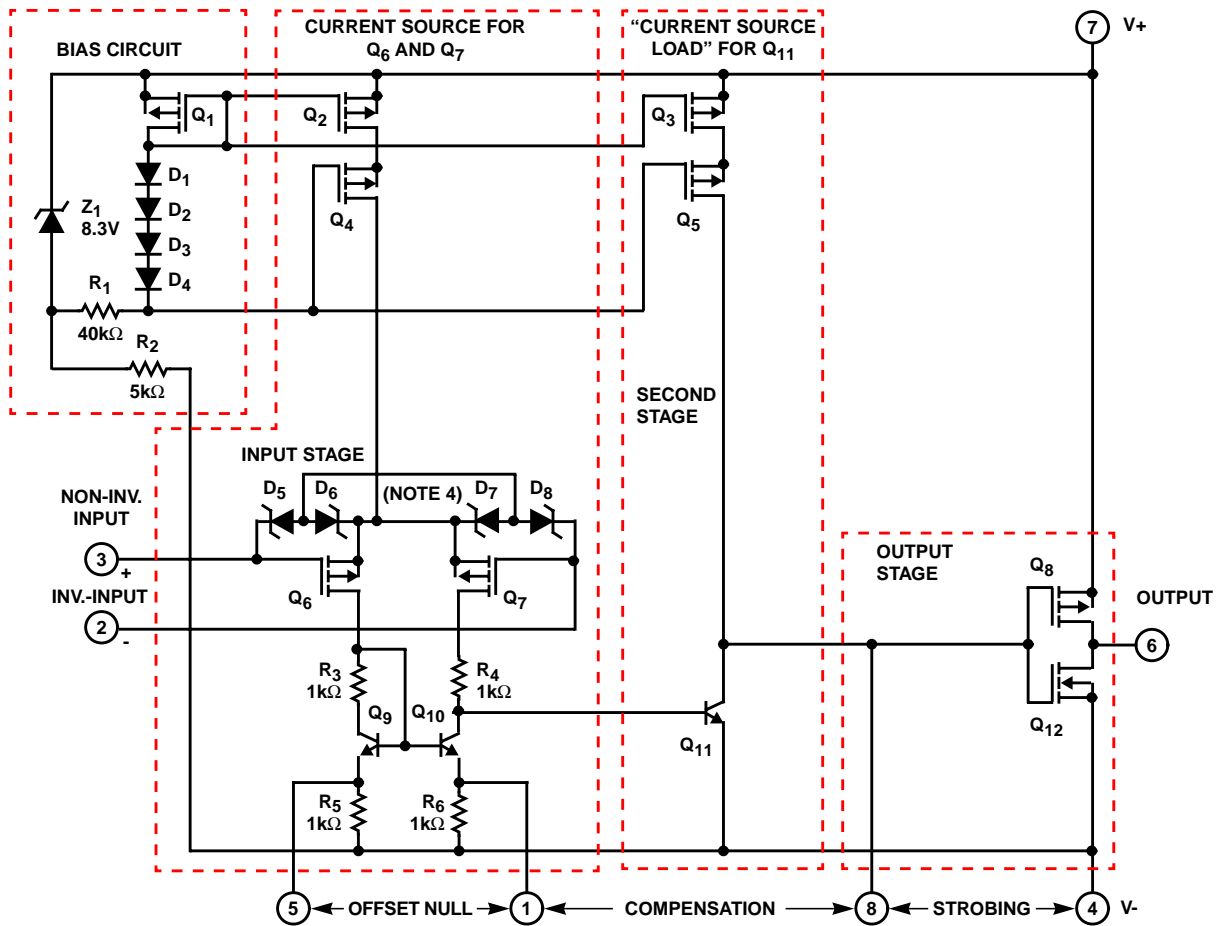


FIGURE 6. VOLTAGE ACROSS NMOS OUTPUT TRANSISTOR ( $Q_{12}$ ) vs LOAD CURRENT

**Schematic Diagram**



NOTE:

- 4. Diodes D<sub>5</sub> through D<sub>8</sub> provide gate-oxide protection for MOSFET input stage.

**Application Information**

**Circuit Description**

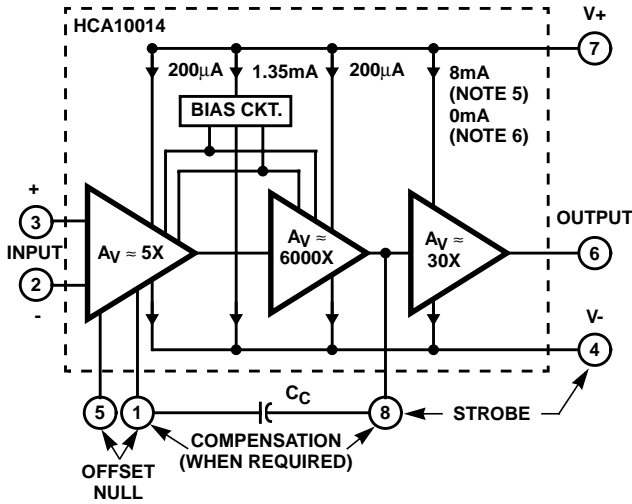
Figure 7 is a block diagram of the HCA10014. The input terminals may be operated down to 0.5V below the negative supply rail, and the output can be swung very close to either supply rail in many applications. Consequently, the HCA10014 is ideal for single supply operation. Three Class A amplifier stages, having the individual gain capability and current consumption shown in Figure 7, provide the total gain of the HCA10014. A biasing circuit provides two potentials for common use in the first and second stages. Terminal 8 can be used both for phase compensation and to strobe the output stage into quiescence. When Terminal 8 is tied to the negative supply rail (Terminal 4) by mechanical or electrical means, the output potential at Terminal 6 essentially rises to the positive supply rail potential at Terminal 7. This condition of essentially zero current drain in the output stage under the strobed "OFF" condition can only be achieved when the

ohmic load resistance presented to the amplifier is very high (e.g., when the amplifier output is used to drive CMOS digital circuits in Comparator applications).

**Input Stage**

The circuit is shown in the schematic diagram. It consists of a differential input stage using PMOS field effect transistors (Q<sub>6</sub>, Q<sub>7</sub>) working into a mirror pair of bipolar transistors (Q<sub>9</sub>, Q<sub>10</sub>) functioning as load resistors together with resistors R<sub>3</sub> through R<sub>6</sub>. The mirror pair transistors also function as a differential to single ended converter to provide base drive to the second stage bipolar transistor (Q<sub>11</sub>). Offset nulling, when desired, can be effected by connecting a 100,000Ω potentiometer across Terminals 1 and 5 and the potentiometer slider arm to Terminal 4. Cascade connected PMOS transistors Q<sub>2</sub>, Q<sub>4</sub> are the constant current source for the input stage. The biasing circuit for the constant current source is subsequently described. The small diodes D<sub>5</sub>

through D<sub>8</sub> provide gate oxide protection against high voltage transients, including static electricity during handling for Q<sub>6</sub> and Q<sub>7</sub>.



NOTES:

5. Total supply voltage (for indicated voltage gains) = 15V with input terminals biased so that Terminal 6 potential is +7.5V above Terminal 4.
6. Total supply voltage (for indicated voltage gains) = 15V with output terminal driven to either supply rail.

FIGURE 7. BLOCK DIAGRAM OF THE HCA10014

**Second Stage**

Most of the voltage gain is provided by the second amplifier stage, consisting of bipolar transistor Q<sub>11</sub> and its cascade connected load resistance provided by PMOS transistors Q<sub>3</sub> and Q<sub>5</sub>. The source of bias potentials for these PMOS transistors is subsequently described. Miller Effect compensation (roll off) is accomplished by simply connecting a small capacitor between Terminals 1 and 8. A 47pF capacitor provides sufficient compensation for stable unity gain operation in most applications.

**Bias Source Circuit**

At total supply voltages, somewhat above 8.3V, resistor R<sub>2</sub> and zener diode Z<sub>1</sub> serve to establish a voltage of 8.3V across the series connected circuit, consisting of resistor R<sub>1</sub>, diodes D<sub>1</sub> through D<sub>4</sub>, and PMOS transistor Q<sub>1</sub>. A tap at the junction of resistor R<sub>1</sub> and diode D<sub>4</sub> provides a gate bias potential of about 4.5V for PMOS transistors Q<sub>4</sub> and Q<sub>5</sub> with respect to Terminal 7. A potential of about 2.2V is developed across diode connected PMOS transistor Q<sub>1</sub> with respect to Terminal 7 to provide gate bias for PMOS transistors Q<sub>2</sub> and Q<sub>3</sub>. It should be noted that Q<sub>1</sub> is "mirror connected (see Note 7)" to both Q<sub>2</sub> and Q<sub>3</sub>. Since transistors Q<sub>1</sub>, Q<sub>2</sub>, Q<sub>3</sub> are designed to be identical, the approximately 200µA current in Q<sub>1</sub> establishes a similar current in Q<sub>2</sub> and Q<sub>3</sub> as constant current sources for both the first and second amplifier stages, respectively.

At total supply voltages somewhat less than 8.3V, zener diode Z<sub>1</sub> becomes nonconductive and the potential, developed across series connected R<sub>1</sub>, D<sub>1</sub>-D<sub>4</sub>, and Q<sub>1</sub>, varies directly with variations in supply voltage. Consequently, the gate bias for Q<sub>4</sub>, Q<sub>5</sub> and Q<sub>2</sub>, Q<sub>3</sub> varies in accordance with supply voltage variations. This variation results in deterioration of the power supply rejection ratio (PSRR) at total supply voltages below 8.3V. Operation at total supply voltages below about 4.5V results in seriously degraded performance.

**Output Stage**

The output stage consists of a drain loaded inverting amplifier using CMOS transistors operating in the Class A mode. When operating into very high resistance loads, the output can be swung within millivolts of either supply rail. Because the output stage is a drain loaded amplifier, its gain is dependent upon the load impedance. The transfer characteristics of the output stage for a load returned to the negative supply rail are shown in Figure 8. Typical op amp loads are readily driven by the output stage. Because large signal excursions are nonlinear, requiring feedback for good waveform reproduction, transient delays may be encountered. As a voltage follower, the amplifier can achieve 0.01% accuracy levels, including the negative supply rail.

NOTE:

7. For general information on the characteristics of CMOS transistor pairs in linear circuit applications, see Document # 619, data sheet on CA3600E "CMOS Transistor Array".

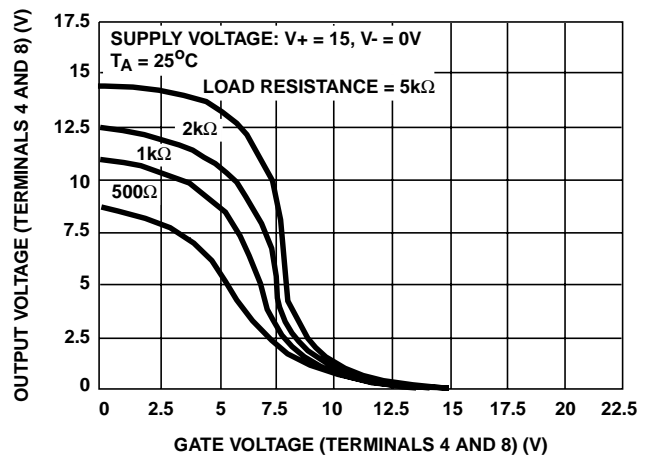


FIGURE 8. VOLTAGE TRANSFER CHARACTERISTICS OF CMOS OUTPUT STAGE

**Input Current Variation with Common Mode Input Voltage**

As shown in the Table of Electrical Specifications, the input current for the HCA10014 is typically 5pA at T<sub>A</sub> = 25°C when Terminals 2 and 3 are at a common mode potential of +7.5V with respect to negative supply Terminal 4. Figure 9 contains data showing the variation of input current as a function of

common mode input voltage at  $T_A = 25^\circ\text{C}$ . These data show that circuit designers can advantageously exploit these characteristics to design circuits which typically require an input current of less than 1pA, provided the common mode input voltage does not exceed 2V. As previously noted, the input current is essentially the result of the leakage current through the gate protection diodes in the input circuit and, therefore, a function of the applied voltage. Although the finite resistance of the glass terminal-to-case insulator of the metal can package also contributes an increment of leakage current, there are useful compensating factors.

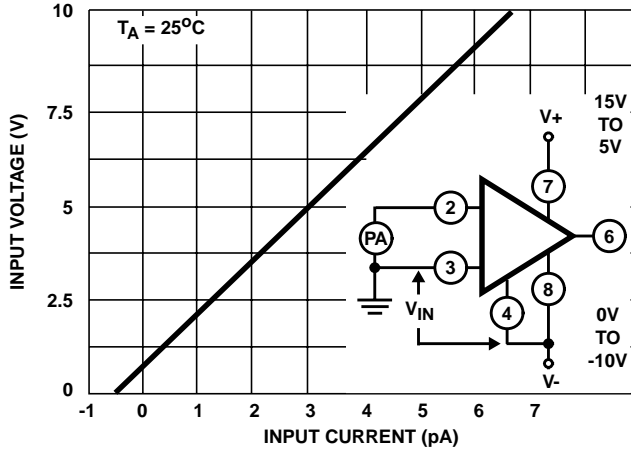


FIGURE 9. INPUT CURRENT vs COMMON-MODE VOLTAGE

**Offset Nulling**

Offset voltage nulling is usually accomplished with a 100,000Ω potentiometer connected across Terminals 1 and 5 and with the potentiometer slider arm connected to Terminal 4. A fine offset null adjustment usually can be effected with the slider arm positioned in the midpoint of the potentiometer's total range.

**Input Current Variation with Temperature**

The input current of the HCA10014 circuit is typically 5pA at 25°C. The major portion of this input current is due to leakage current through the gate protective diodes in the input circuit. As with any semiconductor junction device, including op amps with a junction FET input stage, the leakage current approximately doubles for every 10°C increase in temperature. Figure 10 provides data on the typical variation of input bias current as a function of temperature.

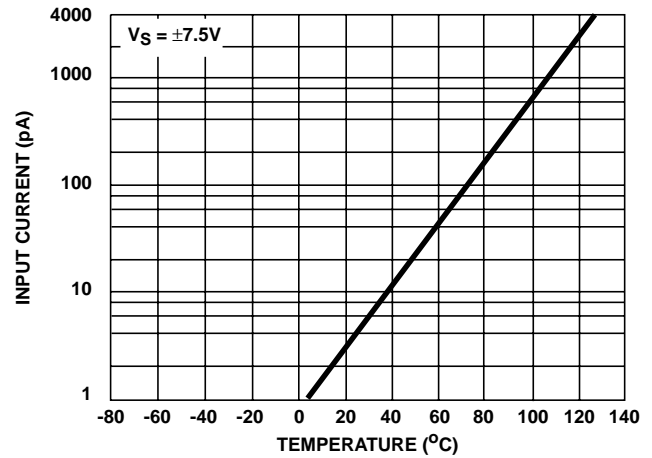


FIGURE 10. INPUT CURRENT vs TEMPERATURE

**Input Offset Voltage (VIO) Variation with DC Bias and Device Operating Life**

It is well known that the characteristics of a MOSFET device can change slightly when a DC gate source bias potential is applied to the device for extended time periods. The magnitude of the change is increased at high temperatures. Users should be alert to the possible impacts of this effect if the application of the device involves extended operation at high temperatures with a significant differential DC bias voltage applied across Terminals 2 and 3. Figure 11 shows typical data pertinent to shifts in offset voltage encountered with devices during life testing. At lower temperatures (metal can and plastic), for example at 85°C, this change in voltage is considerably less. In typical linear applications where the differential voltage is small and symmetrical, these incremental changes are of about the same magnitude as those encountered in an operational amplifier employing a bipolar transistor input stage. The 2V<sub>DC</sub> differential voltage example represents conditions when the amplifier output stage is "toggled", e.g., as in comparator applications.

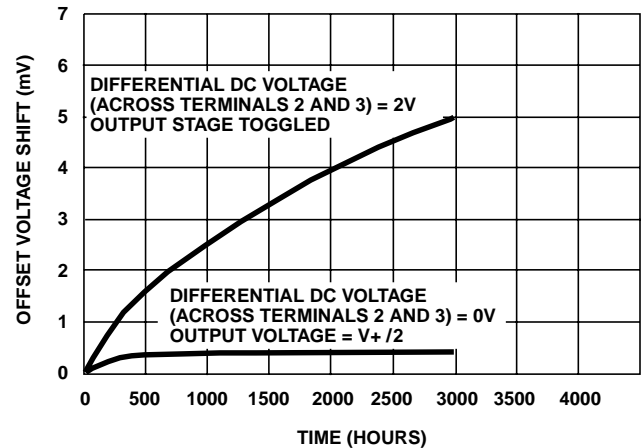


FIGURE 11. TYPICAL INCREMENTAL OFFSET VOLTAGE SHIFT vs OPERATING LIFE



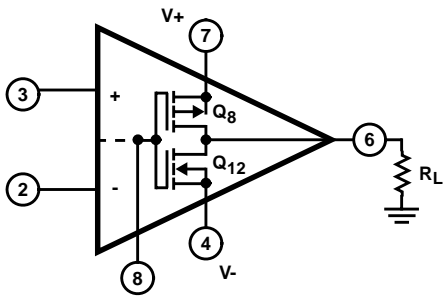


FIGURE 12A. DUAL POWER SUPPLY OPERATION

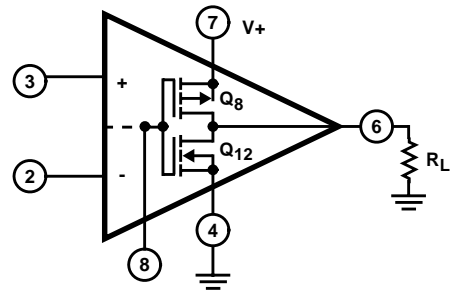


FIGURE 12B. SINGLE POWER SUPPLY OPERATION

FIGURE 12. OUTPUT STAGE IN DUAL AND SINGLE POWER SUPPLY OPERATION

### Power Supply Considerations

Because the HCA10014 is very useful in single supply applications, it is pertinent to review some considerations relating to power supply current consumption under both single and dual supply service. Figures 12A and 12B show connections for both dual and single supply operation.

**Dual Supply Operation** - When the output voltage at Terminal 6 is 0V, the currents supplied by the two power supplies are equal. When the gate terminals of  $Q_8$  and  $Q_{12}$  are driven increasingly positive with respect to ground, current flow through  $Q_{12}$  (from the negative supply) to the load is increased and current flow through  $Q_8$  (from the positive supply) decreases correspondingly. When the gate terminals of  $Q_8$  and  $Q_{12}$  are driven increasingly negative with respect to ground, current flow through  $Q_8$  is increased and current flow through  $Q_{12}$  is decreased accordingly.

**Single Supply Operation** - Initially, let it be assumed that the value of  $R_L$  is very high (or disconnected), and that the input terminal bias (Terminals 2 and 3) is such that the output terminal (No. 6) voltage is at  $V+/2$ , i.e., the voltage drops across  $Q_8$  and  $Q_{12}$  are of equal magnitude. Figure 4 shows typical quiescent supply current vs supply voltage for the HCA10014 operated under these conditions. Since the output stage is operating as a Class A amplifier, the supply current will remain constant under dynamic operating conditions as long as the transistors are operated in the linear portion of their voltage transfer characteristics (see Figure 8). If either  $Q_8$  or  $Q_{12}$  are swung out of their linear regions toward cutoff (a nonlinear region), there will be a corresponding reduction in supply current. In the extreme case, e.g., with Terminal 8 swung down to ground potential (or tied to ground), NMOS transistor  $Q_{12}$  is completely cut off and the supply current to series connected transistors  $Q_8$ ,  $Q_{12}$  goes essentially to zero. The two preceding stages, however, continue to draw modest supply current (see the lower curve in Figure 4) even though the output stage is strobed off. Figure 12A shows a dual supply arrangement for the output stage that can also be strobed off, assuming

$R_L = \infty$  by pulling the potential of Terminal 8 down to that of Terminal 4.

Let it now be assumed that a load resistance of nominal value (e.g.,  $2k\Omega$ ) is connected between Terminal 6 and ground in the circuit of Figure 12B. Let it be assumed again that the input terminal bias (Terminals 2 and 3) is such that the output terminal (No. 6) voltage is at  $V+/2$ . Since PMOS transistor  $Q_8$  must now supply quiescent current to both  $R_L$  and transistor  $Q_{12}$ , it should be apparent that under these conditions the supply current must increase as an inverse function of the  $R_L$  magnitude. Figure 5 shows the voltage drop across PMOS transistor  $Q_8$  as a function of load current at several supply voltages. Figure 8 shows the voltage transfer characteristics of the output stage for several values of load resistance.

### Wideband Noise

From the standpoint of low noise performance considerations, the use of the HCA10014 is most advantageous in applications where the source resistance of the input signal is on the order of  $1M\Omega$  or more. In this case, the total input referred noise voltage is typically only  $23\mu V$  when the test circuit amplifier of Figure 13 is operated at a total supply voltage of 15V. This value of total input referred noise remains essentially constant, even though the value of source resistance is raised by an order of magnitude. This characteristic is due to the fact that reactance of the input capacitance becomes a significant factor in shunting the source resistance. It should be noted, however, that for values of source resistance very much greater than  $1M\Omega$ , the total noise voltage generated can be dominated by the thermal noise contributions of both the feedback and source resistors.



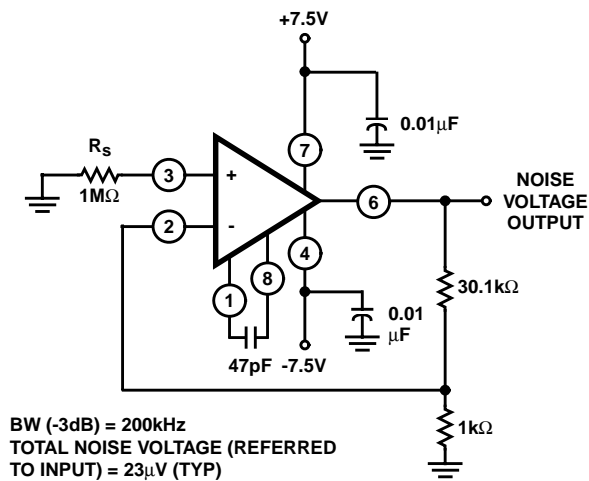


FIGURE 13. TEST CIRCUIT AMPLIFIER (30dB GAIN) USED FOR WIDEBAND NOISE MEASUREMENTS

## Typical Applications

### Voltage Followers

Operational amplifiers with very high input resistances are particularly suited to service as voltage followers. Figure 14 shows the circuit of a classical voltage follower, together with pertinent waveforms in a split supply configuration.

A voltage follower, operated from a single supply, is shown in Figure 15, together with related waveforms. This follower circuit is linear over a wide dynamic range, as illustrated by the reproduction of the output waveform in Figure 15A with input signal ramping. The waveforms in Figure 15B show that the follower does not lose its input to output phase sense, even though the input is being swung 7.5V below ground potential. This unique characteristic is an important attribute in both operational amplifier and comparator applications. Figure 15B also shows the manner in which the CMOS output stage permits the output signal to swing down to the negative supply rail potential (i.e., ground in the case shown). The digital-to-analog converter (DAC) circuit, described later, illustrates the practical use of the HCA10014 in a single supply voltage follower application.

### 9-Bit CMOS DAC

A typical circuit of a 9-bit Digital-to-Analog Converter (DAC) is shown in Figure 16. This system combines the concepts of multiple switch CMOS ICs, a low cost ladder network of discrete metal oxide film resistors, a HCA10014 op amp connected as a follower, and an inexpensive monolithic regulator in a simple single power supply arrangement. An additional feature of the DAC is that it is readily interfaced with CMOS input logic, e.g., 10V logic levels are used in the circuit of Figure 16.

The circuit uses an R/2R voltage ladder network, with the output potential obtained directly by terminating the ladder arms at either the positive or the negative power supply terminal. Each CD4007A contains three “inverters”, each “inverter” functioning as a single pole double throw switch to terminate an arm of the R/2R network at either the positive or negative power supply terminal. The resistor ladder is an assembly of 1% tolerance metal oxide film resistors. The five arms requiring the highest accuracy are assembled with series and parallel combinations of 806,000Ω resistors from the same manufacturing lot.

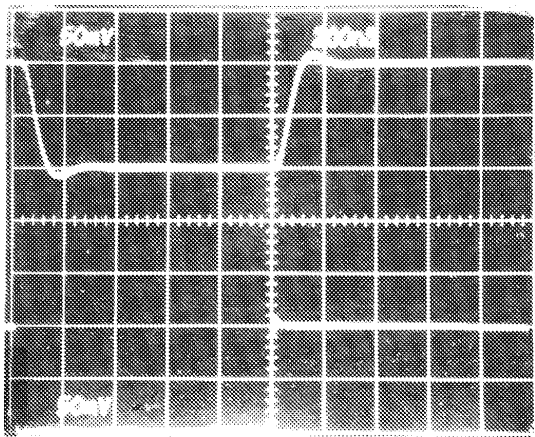
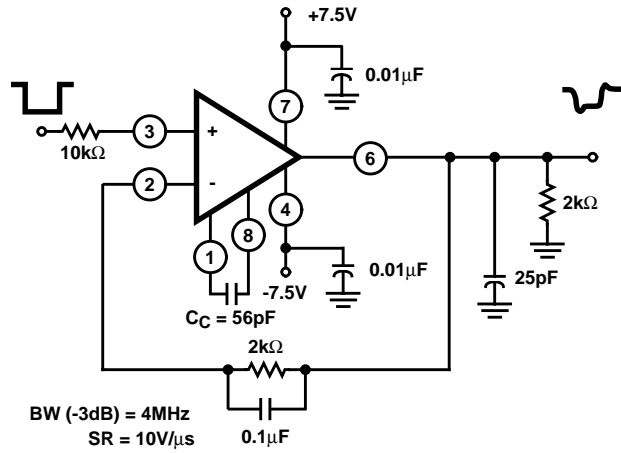
A single 15V supply provides a positive bus for the follower amplifier and feeds the CA3085 voltage regulator. A “scale-adjust” function is provided by the regulator output control, set to a nominal 10V level in this system. The line voltage regulation (approximately 0.2%) permits a 9-bit accuracy to be maintained with variations of several volts in the supply. The flexibility afforded by the CMOS building blocks simplifies the design of DAC systems tailored to particular needs.

### Single Supply, Absolute Value, Ideal Full Wave Rectifier

An absolute value circuit is shown in Figure 17. During positive excursions, the input signal is fed through the feedback network directly to the output. Simultaneously, the positive excursion of the input signal also drives the output terminal (No. 6) of the inverting amplifier in a negative going excursion such that the 1N914 diode effectively disconnects the amplifier from the signal path. During a negative going excursion of the input signal, the HCA10014 functions as a normal inverting amplifier with a gain equal to  $-R_2/R_1$ . When the equality of the two equations shown in Figure 17 is satisfied, the full wave output is symmetrical.

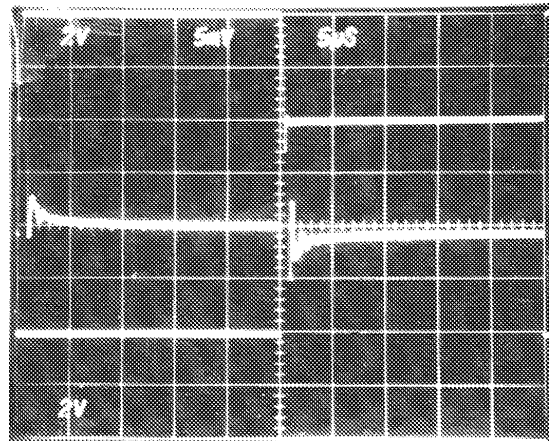
### Peak Detectors

Peak detector circuits are easily implemented, as illustrated in Figure 18 for both the peak positive and the peak negative circuit. It should be noted that with large signal inputs, the bandwidth of the peak negative circuit is much less than that of the peak positive circuit. The second stage of the HCA10014 limits the bandwidth in this case. Negative going output signal excursion requires a positive going signal excursion at the collector of transistor  $Q_{11}$ , which is loaded by the intrinsic capacitance of the associated circuitry in this mode. On the other hand, during a negative going signal excursion at the collector of  $Q_{11}$ , the transistor functions in an active “pull down” mode so that the intrinsic capacitance can be discharged more expeditiously.



Top Trace: Output  
Center Trace: Input

FIGURE 14A. SMALL SIGNAL RESPONSE (50mV/DIV., 200ns/DIV.)



Top Trace: Output Signal; 2V/Div., 5μs/Div.  
Center Trace: Difference Signal; 5mV/Div., 5μs/Div.  
Bottom Trace: Input Signal; 2V/Div., 5μs/Div.

FIGURE 14B. INPUT OUTPUT DIFFERENCE SIGNAL SHOWING SETTLING TIME (MEASUREMENT MADE WITH TEKTRONIX 7A13 DIFFERENTIAL AMPLIFIER)

FIGURE 14. SPLIT SUPPLY VOLTAGE FOLLOWER WITH ASSOCIATED WAVEFORMS

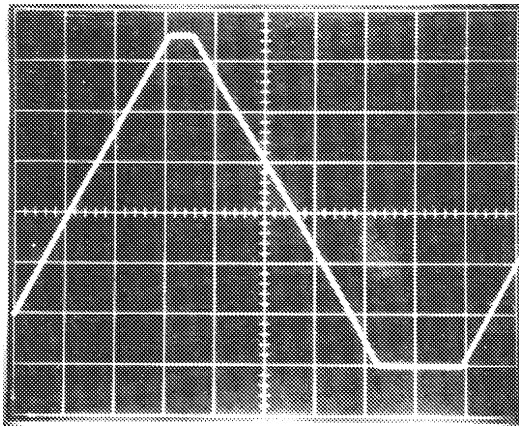
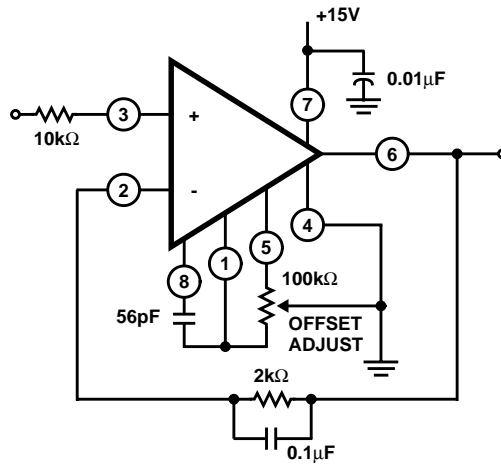
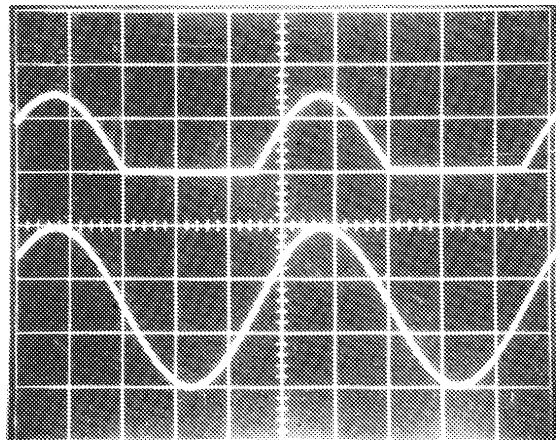


FIGURE 15A. OUTPUT WAVEFORM WITH INPUT SIGNAL RAMPING (2V/DIV., 500µs/DIV.)



Top Trace: Output; 5V/Div., 200µs/Div.  
Bottom Trace: Input Signal; 5V/Div., 200µs/Div.

FIGURE 15B. OUTPUT WAVEFORM WITH GROUND REFERENCE SINEWAVE INPUT

FIGURE 15. SINGLE SUPPLY VOLTAGE FOLLOWER WITH ASSOCIATED WAVEFORMS. (e.g., FOR USE IN SINGLE SUPPLY D/A CONVERTER; SEE FIGURE 9 IN AN6080)

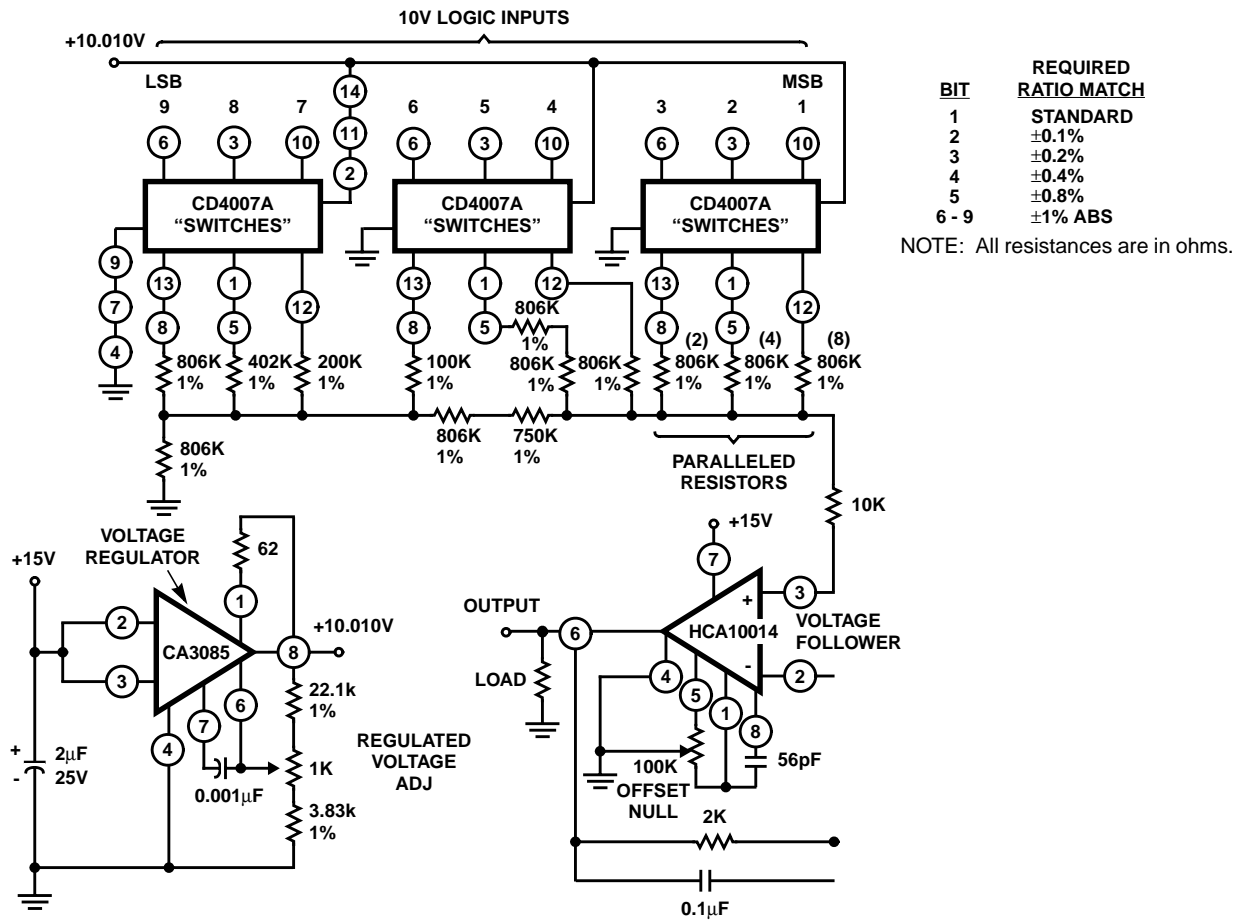


FIGURE 16. 9-BIT DAC USING CMOS DIGITAL SWITCHES AND HCA10014

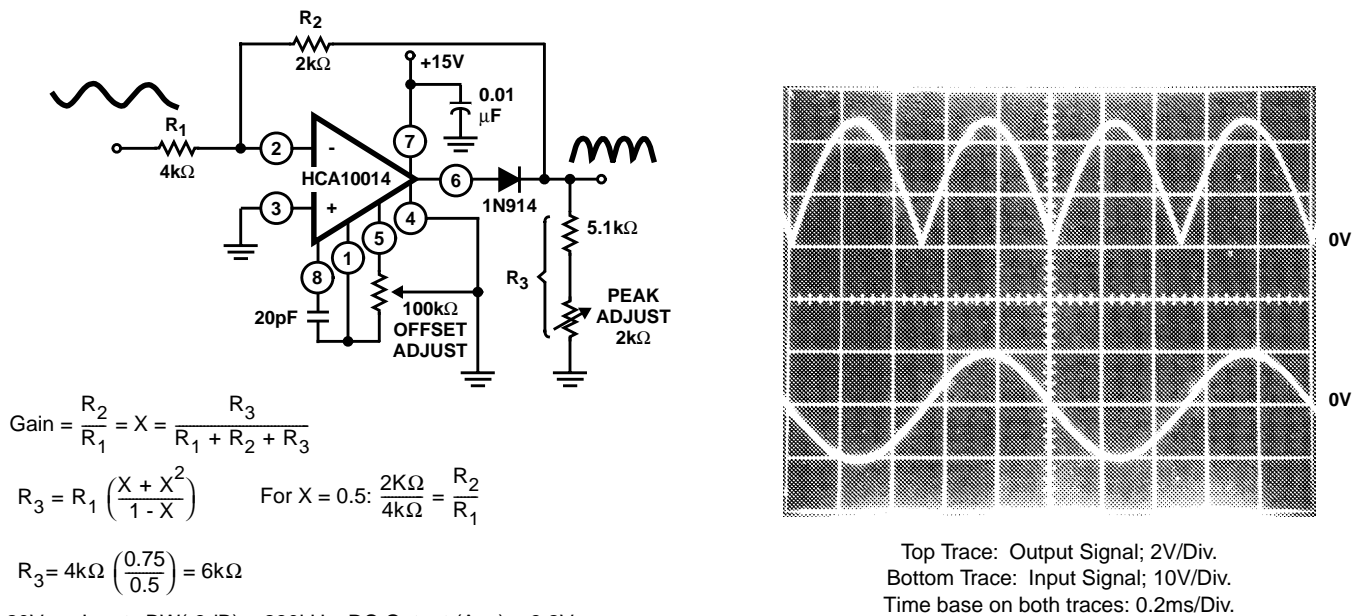


FIGURE 17. SINGLE SUPPLY, ABSOLUTE VALUE, IDEAL FULL WAVE RECTIFIER WITH ASSOCIATED WAVEFORMS

# HCA10014

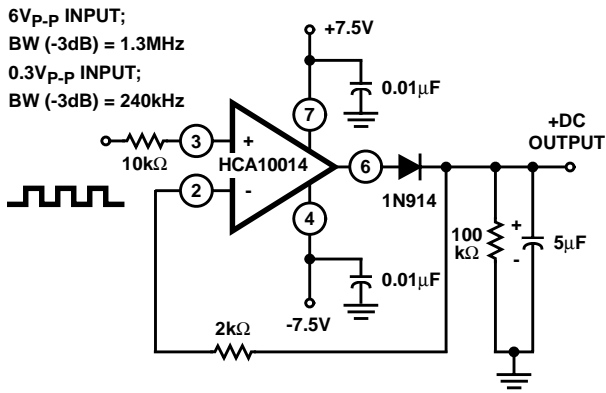


FIGURE 18A. PEAK POSITIVE DETECTOR CIRCUIT

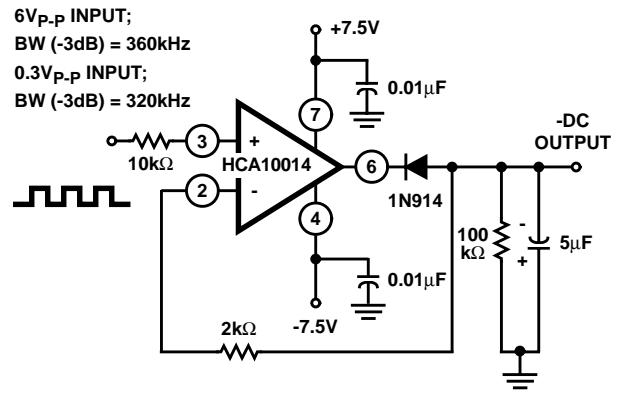


FIGURE 18B. PEAK NEGATIVE DETECTOR CIRCUIT

FIGURE 18. PEAK DETECTOR CIRCUITS

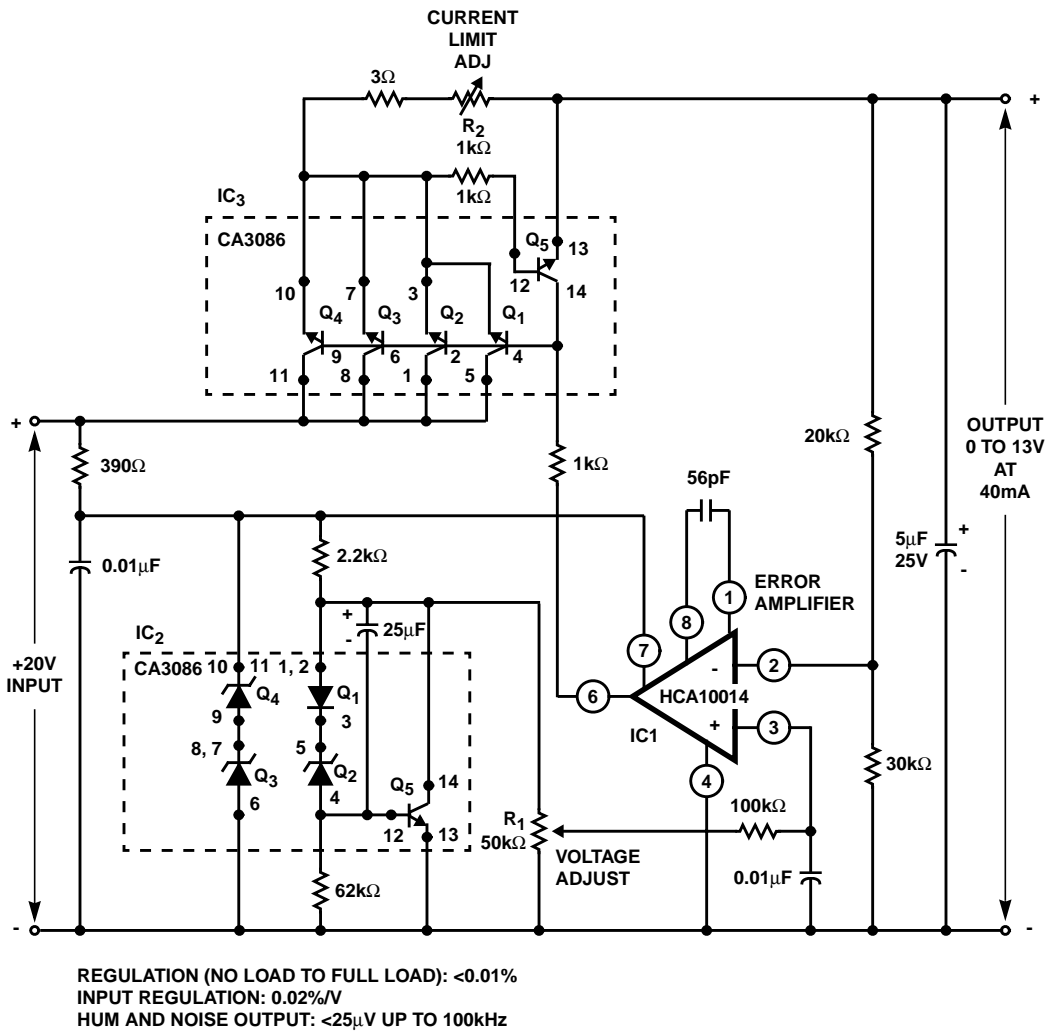


FIGURE 19. VOLTAGE REGULATOR CIRCUIT (0V TO 13V AT 40mA)



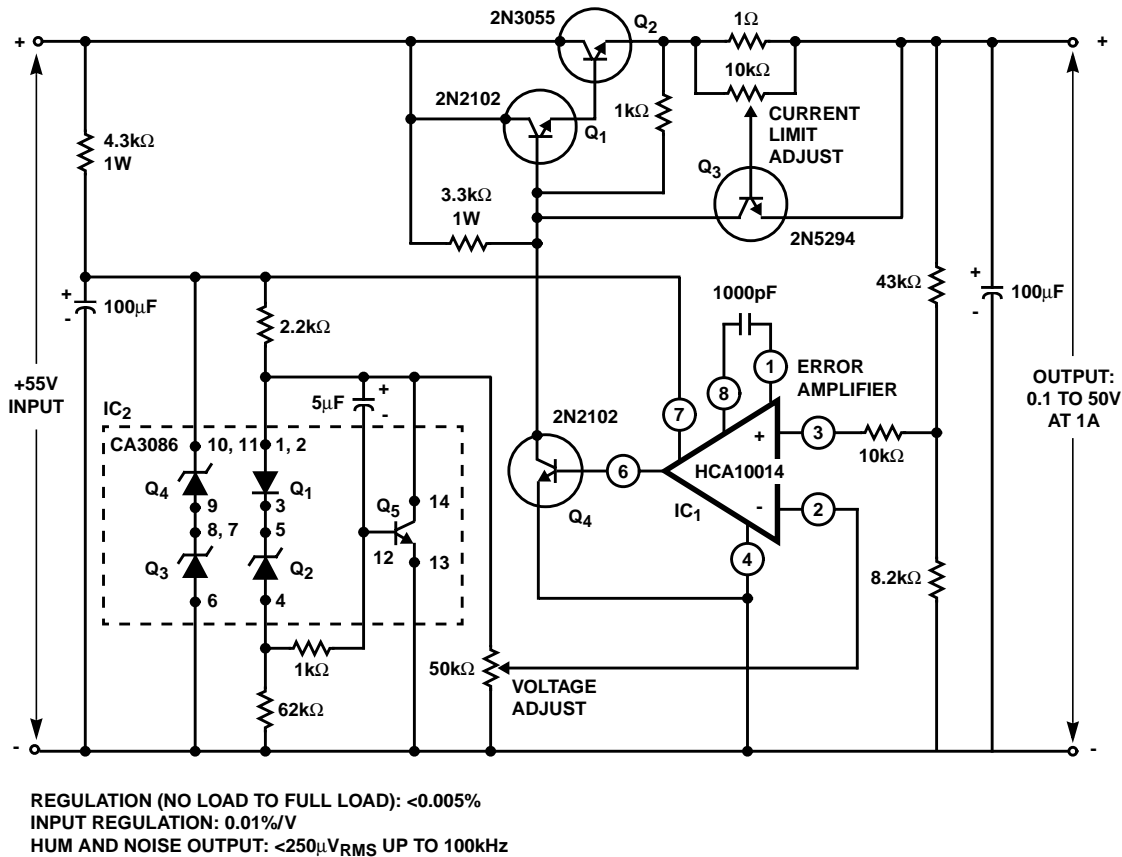


FIGURE 20. VOLTAGE REGULATOR CIRCUIT (0.1V TO 50V AT 1A)

**Error Amplifier in Regulated Power Supplies**

The HCA10014 is an ideal choice for error amplifier service in regulated power supplies since it can function as an error amplifier when the regulated output voltage is required to approach zero. Figure 19 shows the schematic diagram of a 40mA power supply capable of providing regulated output voltage by continuous adjustment over the range from 0V to 13V. Q<sub>3</sub> and Q<sub>4</sub> in IC<sub>2</sub> (a CA3086 transistor array IC) function as zeners to provide the supply voltage for comparator IC<sub>1</sub>. Q<sub>1</sub>, Q<sub>2</sub>, and Q<sub>5</sub> in IC<sub>2</sub> are configured as a low impedance, temperature compensated source of adjustable reference voltage for the error amplifier. Transistors Q<sub>1</sub>, Q<sub>2</sub>, Q<sub>3</sub>, and Q<sub>4</sub> in IC<sub>3</sub> (another CA3086 transistor array IC) are connected in parallel as the series pass element. Transistor Q<sub>5</sub> in IC<sub>3</sub> functions as a current limiting device by diverting base drive from the series pass transistors, in accordance with the adjustment of resistor R<sub>2</sub>.

Figure 20 contains the schematic diagram of a regulated power supply capable of providing regulated output voltage by continuous adjustment over the range from 0.1V to 50V and currents up to 1A. The error amplifier (IC<sub>1</sub>) and circuitry associated with IC<sub>2</sub> function as previously described, although the output of IC<sub>1</sub> is boosted by a discrete transistor (Q<sub>4</sub>) to provide adequate base drive for the Darlington

connected series pass transistors Q<sub>1</sub>, Q<sub>2</sub>. Transistor Q<sub>3</sub> functions in the previously described current limiting circuit.

**Multivibrators**

The exceptionally high input resistance presented by the HCA10014 is an attractive feature for multivibrator circuit design because it permits the use of timing circuits with high R/C ratios. The circuit diagram of a pulse generator (astable multivibrator), with provisions for independent control of the “on” and “off” periods, is shown in Figure 21. Resistors R<sub>1</sub> and R<sub>2</sub> are used to bias the HCA10014 to the midpoint of the supply voltage and R<sub>3</sub> is the feedback resistor. The pulse repetition rate is selected by positioning S<sub>1</sub> to the desired position and the rate remains essentially constant when the resistors which determine “on-period” and “off-period” are adjusted.

**Function Generator**

Figure 22 contains a schematic diagram of a function generator using the HCA10014 in the integrator and threshold detector functions. This circuit generates a triangular or square wave output that can be swept over a 1,000,000:1 range (0.1Hz to 100kHz) by means of a single control, R<sub>1</sub>. A voltage control input is also available for remote sweep control.

The heart of the frequency determining system is an operational transconductance amplifier (OTA) (see Note 9), IC<sub>1</sub>, operated as a voltage controlled current source. The output, I<sub>O</sub>, is a current applied directly to the integrating capacitor, C<sub>1</sub>, in the feedback loop of the integrator IC<sub>2</sub>, using a HCA10014, to provide the triangular wave output. Potentiometer R<sub>2</sub> is used to adjust the circuit for slope symmetry of positive going and negative going signal excursions.

Another HCA10014, IC<sub>3</sub>, is used as a controlled switch to set the excursion limits of the triangular output from the integrator circuit. Capacitor C<sub>2</sub> is a "peaking adjustment" to optimize the high frequency square wave performance of the circuit.

Potentiometer R<sub>3</sub> is adjustable to perfect the "amplitude symmetry" of the square wave output signals. Output from the threshold detector is fed back via resistor R<sub>4</sub> to the input of IC<sub>1</sub> so as to toggle the current source from plus to minus in generating the linear triangular wave.

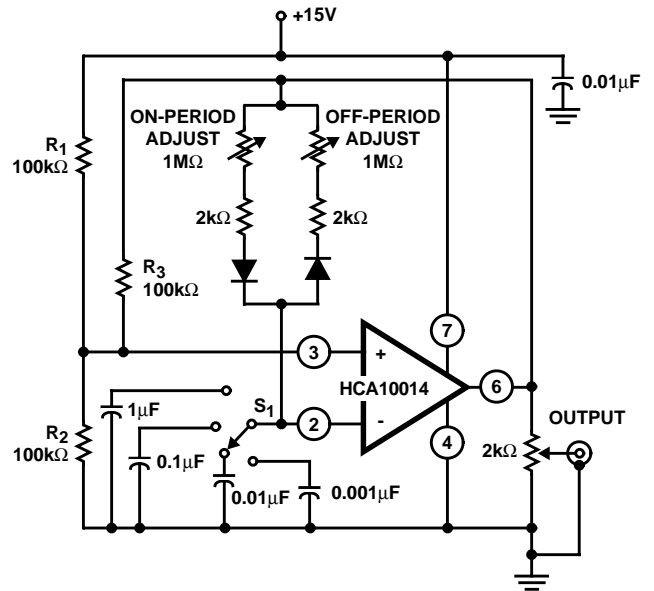
**Operation with Output Stage Power Booster**

The current sourcing and sinking capability of the HCA10014 output stage is easily supplemented to provide power boost capability. In the circuit of Figure 23, three CMOS transistor pairs in a single CA3600E (see Note 11) IC array are shown parallel connected with the output stage in the HCA10014. In the Class A mode of CA3600E shown, a typical device consumes 20mA of supply current at 15V operation. This arrangement boosts the current handling capability of the output stage by about 2.5X.

The amplifier circuit in Figure 23 employs feedback to establish a closed loop gain of 48dB. The typical large signal bandwidth (-3dB) is 50kHz.

**NOTE:**

- 8. See Document # 619 (CA3600E) for technical information.

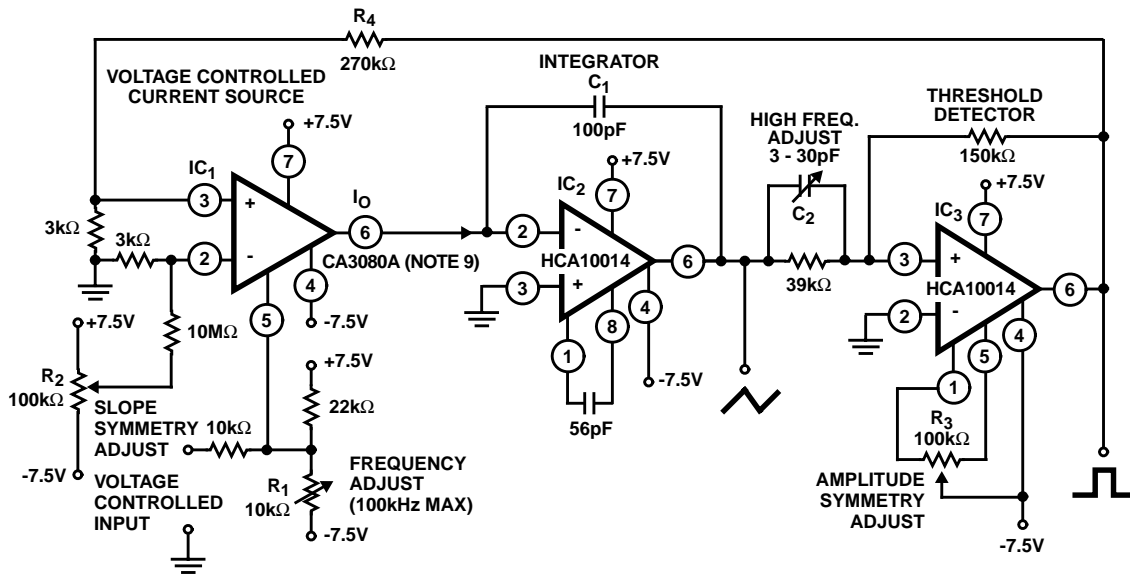


Frequency Range:

Position of S <sub>1</sub>	Pulse Period
0.001μF	4μs to 1ms
0.01μF	40μs to 10ms
0.1μF	0.4ms to 100ms
1μF	4ms to 1s

**FIGURE 21. PULSE GENERATOR (ASTABLE MULTIVIBRATOR) WITH PROVISIONS FOR INDEPENDENT CONTROL OF "ON" AND "OFF" PERIODS**

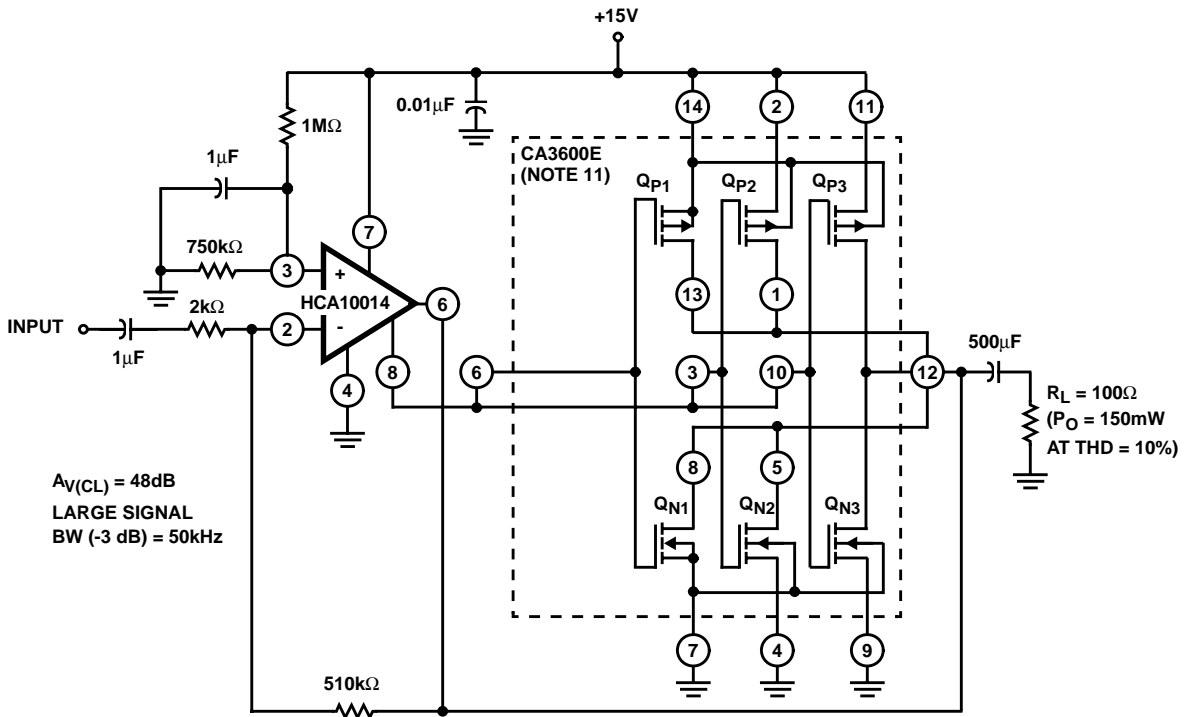




NOTE:

9. See Document # 475 (CA3080/CA3080A) and AN6668 for technical information.

FIGURE 22. FUNCTION GENERATOR (FREQUENCY CAN BE VARIED 1,000,000/1 WITH A SINGLE CONTROL)



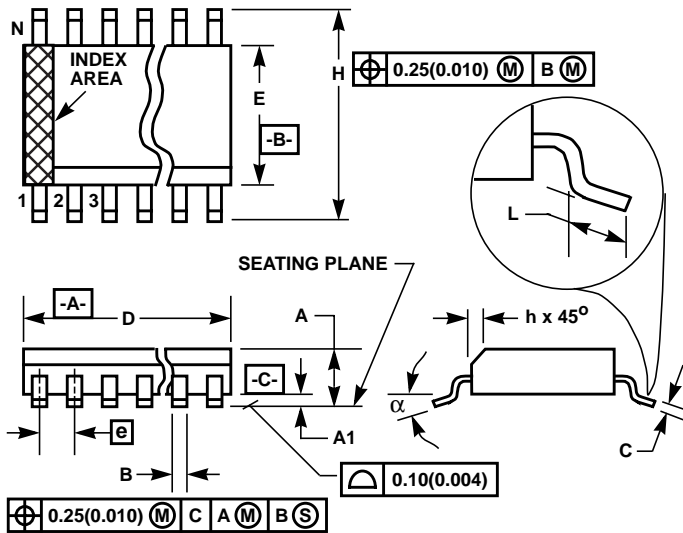
NOTES:

10. Transistors QP<sub>1</sub>, QP<sub>2</sub>, QP<sub>3</sub> and QN<sub>1</sub>, QN<sub>2</sub>, QN<sub>3</sub> are parallel connected with Q<sub>8</sub> and Q<sub>12</sub>, respectively, of the HCA10014.

11. See Document # 619 (CA3600E).

FIGURE 23. CMOS TRANSISTOR ARRAY (CA3600E) CONNECTED AS POWER BOOSTER IN THE OUTPUT STAGE OF THE HCA10014

**Small Outline Plastic Packages (SOIC)**



**M8.15 (JEDEC MS-012-AA ISSUE C)  
8 LEAD NARROW BODY SMALL OUTLINE PLASTIC  
PACKAGE**

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.0532	0.0688	1.35	1.75	-
A1	0.0040	0.0098	0.10	0.25	-
B	0.013	0.020	0.33	0.51	9
C	0.0075	0.0098	0.19	0.25	-
D	0.1890	0.1968	4.80	5.00	3
E	0.1497	0.1574	3.80	4.00	4
e	0.050 BSC		1.27 BSC		-
H	0.2284	0.2440	5.80	6.20	-
h	0.0099	0.0196	0.25	0.50	5
L	0.016	0.050	0.40	1.27	6
N	8		8		7
α	0°	8°	0°	8°	-

**NOTES:**

1. Symbols are defined in the "MO Series Symbol List" in Section 2.2 of Publication Number 95.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion and gate burrs shall not exceed 0.15mm (0.006 inch) per side.
4. Dimension "E" does not include interlead flash or protrusions. Interlead flash and protrusions shall not exceed 0.25mm (0.010 inch) per side.
5. The chamfer on the body is optional. If it is not present, a visual index feature must be located within the crosshatched area.
6. "L" is the length of terminal for soldering to a substrate.
7. "N" is the number of terminal positions.
8. Terminal numbers are shown for reference only.
9. The lead width "B", as measured 0.36mm (0.014 inch) or greater above the seating plane, shall not exceed a maximum value of 0.61mm (0.024 inch).
10. Controlling dimension: MILLIMETER. Converted inch dimensions are not necessarily exact.

Rev. 0 12/93

All Intersil semiconductor products are manufactured, assembled and tested under **ISO9000** quality systems certification.

*Intersil semiconductor products are sold by description only. Intersil Corporation reserves the right to make changes in circuit design and/or specifications at any time without notice. Accordingly, the reader is cautioned to verify that data sheets are current before placing orders. Information furnished by Intersil is believed to be accurate and reliable. However, no responsibility is assumed by Intersil or its subsidiaries for its use; nor for any infringements of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of Intersil or its subsidiaries.*

For information regarding Intersil Corporation and its products, see web site <http://www.intersil.com>

**Sales Office Headquarters**

**NORTH AMERICA**

Intersil Corporation  
P. O. Box 883, Mail Stop 53-204  
Melbourne, FL 32902  
TEL: (407) 724-7000  
FAX: (407) 724-7240

**EUROPE**

Intersil SA  
Mercure Center  
100, Rue de la Fusee  
1130 Brussels, Belgium  
TEL: (32) 2.724.2111  
FAX: (32) 2.724.22.05

**ASIA**

Intersil (Taiwan) Ltd.  
7F-6, No. 101 Fu Hsing North Road  
Taipei, Taiwan  
Republic of China  
TEL: (886) 2 2716 9310  
FAX: (886) 2 2715 3029