

## Micropower Programmable Operator Amplifier

(compatible to TLC251&TLC271 (TI USA))

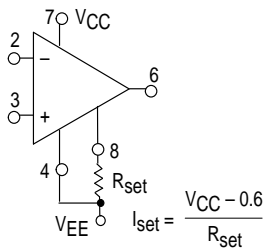
This extremely versatile operational amplifier features low power consumption and high input impedance. In addition, the quiescent currents within the device may be programmed by the choice of an external resistor value or current source applied to the  $I_{set}$  input. This allows the amplifier's characteristics to be optimized for input current and power consumption despite wide variations in operating power supply voltages.

- $\pm 1.2$  V to  $\pm 18$  V Operation
- Wide Programming Range
- Offset Null Capability
- No Frequency Compensation Required
- Low Input Bias Currents
- Short Circuit Protection

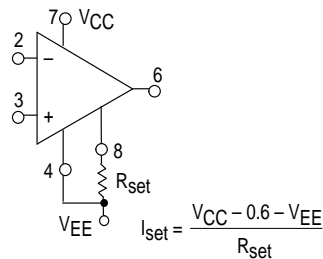
### Resistive Programming

(See Figure 1)

#### $R_{set}$ to Ground



#### $R_{set}$ to Negative Supply (Recommended for supply voltage less than $\pm 6.0$ V)

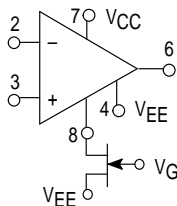


Typical $R_{set}$ Values		
$V_{CC}, V_{EE}$	$I_{set} = 1.5 \mu A$	$I_{set} = 15 \mu A$
$\pm 6.0$ V	3.6 M $\Omega$	360 k $\Omega$
$\pm 10$ V	6.2 M $\Omega$	620 k $\Omega$
$\pm 12$ V	7.5 M $\Omega$	750 k $\Omega$
$\pm 15$ V	10 M $\Omega$	1.0 M $\Omega$

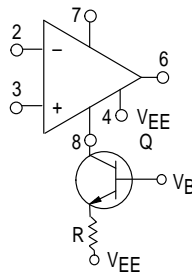
Typical $R_{set}$ Values		
$V_{CC}, V_{EE}$	$I_{set} = 1.5 \mu A$	$I_{set} = 15 \mu A$
$\pm 1.5$ V	1.6 M $\Omega$	160 k $\Omega$
$\pm 3.0$ V	3.6 M $\Omega$	360 k $\Omega$
$\pm 6.0$ V	7.5 M $\Omega$	750 k $\Omega$
$\pm 15$ V	20 M $\Omega$	2.0 M $\Omega$

### Active Programming

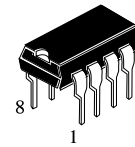
#### FET Current Source



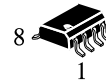
#### Bipolar Current Source



Pins not shown are not connected.



**DIP8-8 N SUFFIX**  
**HT8776ANZ**



**SOP-8 R SUFFIX**  
**HT8776ARZ**

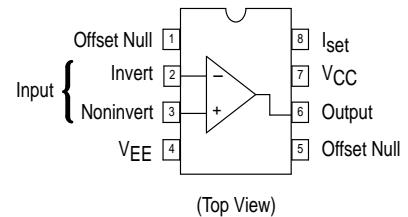


**MSOP-8 M SUFFIX**  
**HT8776ARMZ**

$T_A = -40^\circ$  to  $85^\circ$ C for all packages.

**NOTE:** suffix A is version, suffix R is roll tape, suffix Z environmental protection.

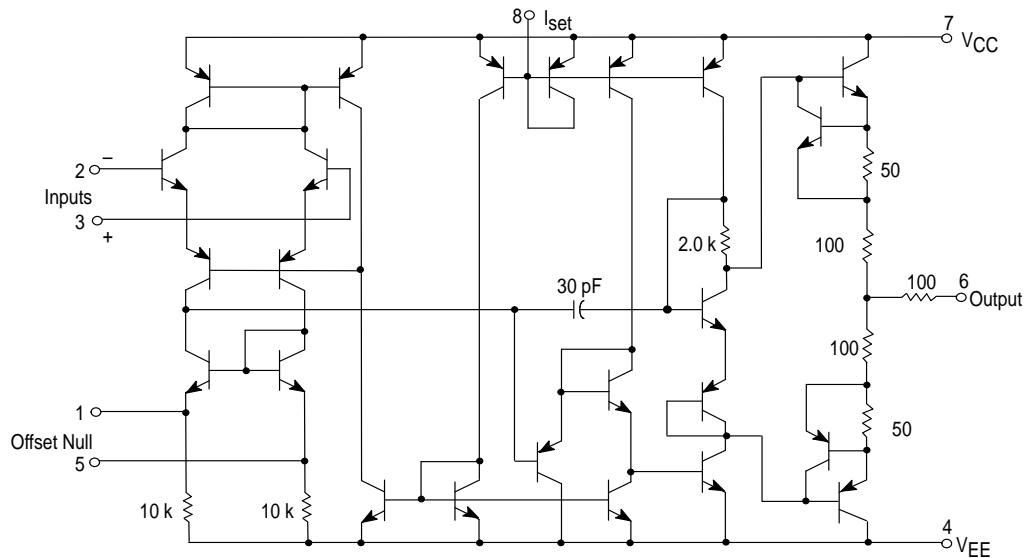
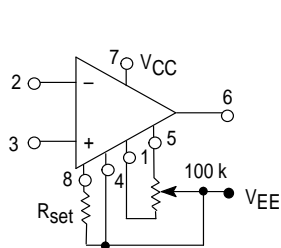
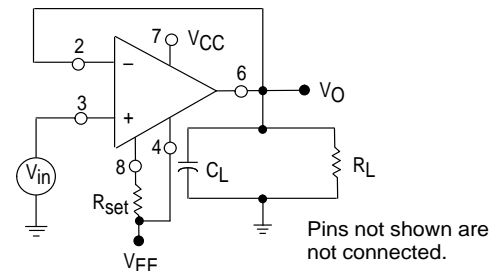
### PIN CONNECTIONS



**MAXIMUM RATINGS** ( $T_A = +25^\circ\text{C}$ , unless otherwise noted.)

Rating	Symbol	Value	Unit
Power Supply Voltages	$V_{CC}, V_{EE}$	$\pm 18$	Vdc
Differential Input Voltage	$V_{ID}$	$\pm 30$	Vdc
Common Mode Input Voltage $V_{CC}$ and $ V_{EE}  < 15\text{ V}$ $V_{CC}$ and $ V_{EE}  \geq 15\text{ V}$	$V_{ICM}$	$V_{CC}, V_{EE}$ $\pm 15$	Vdc
Offset Null to $V_{EE}$ Voltage	$V_{off-V_{EE}}$	$\pm 0.5$	Vdc
Programming Current	$I_{set}$	500	$\mu\text{A}$
Programming Voltage (Voltage from $I_{set}$ Terminal to Ground)	$V_{set}$	$(V_{CC} - 2.0\text{ V})$ to $V_{CC}$	Vdc
Output Short Circuit Duration (Note 1)	$t_{SC}$	Indefinite	sec
Operating Temperature Range	$T_A$	-40 to +85	$^\circ\text{C}$
Storage Temperature Range	$T_{stg}$	-65 to +150	$^\circ\text{C}$
Junction Temperature	$T_J$	150	$^\circ\text{C}$

NOTE 1. May be to ground or either supply voltage. Rating applies up to a case temperature of  $+125^\circ\text{C}$  or ambient temperature of  $+85^\circ\text{C}$  and  $I_{set} \leq 30\ \mu\text{A}$ .

**Representative Schematic Diagram**

**Voltage Offset Null Circuit**

**Transient Response Test Circuit**


**ELECTRICAL CHARACTERISTICS** ( $V_{CC} = +3.0\text{ V}$ ,  $V_{EE} = -3.0\text{ V}$ ,  $I_{set} = 1.5\ \mu\text{A}$ ,  $T_A = +25^\circ\text{C}$ , unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Input Offset Voltage ( $R_S \leq 10\ \text{k}\Omega$ ) $T_A = +25^\circ\text{C}$ $T_{low}^* \leq T_A \leq T_{high}^*$	$V_{IO}$	–	2.0	6.0	mV
Offset Voltage Adjustment Range	$V_{IOR}$	–	9.0	–	mV
Input Offset Current $T_A = +25^\circ\text{C}$ $T_A = T_{high}$ $T_A = T_{low}$	$I_{IO}$	–	0.7	6.0	nA
Input Bias Current $T_A = +25^\circ\text{C}$ $T_A = T_{high}$ $T_A = T_{low}$	$I_{IB}$	–	2.0	10	nA
Input Resistance	$r_i$	–	50	–	$\text{M}\Omega$
Input Capacitance	$c_i$	–	2.0	–	pF
Input Voltage Range $T_{low} \leq T_A \leq T_{high}$	$V_{ID}$	+1.0	–	–	V
Large Signal Voltage Gain $R_L \geq 75\ \text{k}\Omega$ , $V_O = \pm 1.0\ \text{V}$ , $T_A = +25^\circ\text{C}$ $R_L \geq 75\ \text{k}\Omega$ , $V_O = \pm 1.0\ \text{V}$ , $T_{low} \leq T_A \leq T_{high}$	$A_{VOL}$	25 k 25 k	200 k –	– –	V/V
Output Voltage Swing $R_L \geq 75\ \text{k}\Omega$ , $T_{low} \leq T_A \leq T_{high}$	$V_O$	$\pm 2.0$	$\pm 2.4$	–	V
Output Resistance	$r_o$	–	5.0	–	$\text{k}\Omega$
Output Short Circuit Current	$I_{SC}$	–	3.0	–	mA
Common Mode Rejection $R_S \leq 10\ \text{k}\Omega$ , $T_{low} \leq T_A \leq T_{high}$	CMR	70	86	–	dB
Supply Voltage Rejection Ratio $R_S \leq 10\ \text{k}\Omega$ , $T_{low} \leq T_A \leq T_{high}$	PSRR	–	25	200	$\mu\text{V/V}$
Supply Current $T_A = +25^\circ\text{C}$ $T_{low} \leq T_A \leq T_{high}$	$I_{CC}$ , $I_{EE}$	– –	13 –	20 25	$\mu\text{A}$
Power Dissipation $T_A = +25^\circ\text{C}$ $T_{low} \leq T_A \leq T_{high}$	$P_D$	– –	78 –	120 150	$\mu\text{W}$
Transient Response (Unity Gain) $V_{in} = 20\ \text{mV}$ , $R_L \geq 5.0\ \text{k}\Omega$ , $C_L = 100\ \text{pF}$ Rise Time Overshoot	$t_{TLH}$ $t_{os}$	– –	3.0 0	– –	$\mu\text{s}$ %
Slew Rate ( $R_L \geq 5.0\ \text{k}\Omega$ )	SR	–	0.03	–	$\text{V}/\mu\text{s}$

**ELECTRICAL CHARACTERISTICS** ( $V_{CC} = +3.0\text{ V}$ ,  $V_{EE} = -3.0\text{ V}$ ,  $I_{set} = 15\text{ }\mu\text{A}$ ,  $T_A = +25^\circ\text{C}$ , unless otherwise noted.)

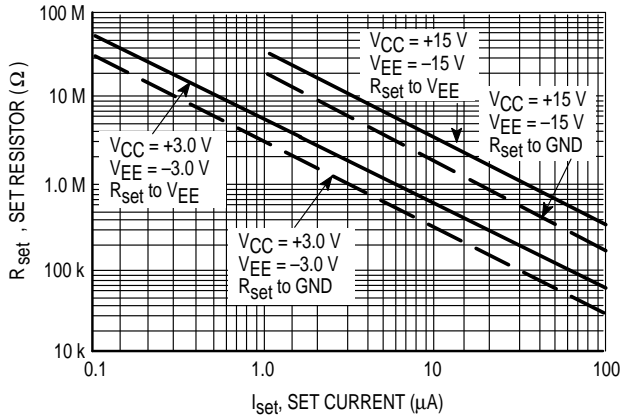
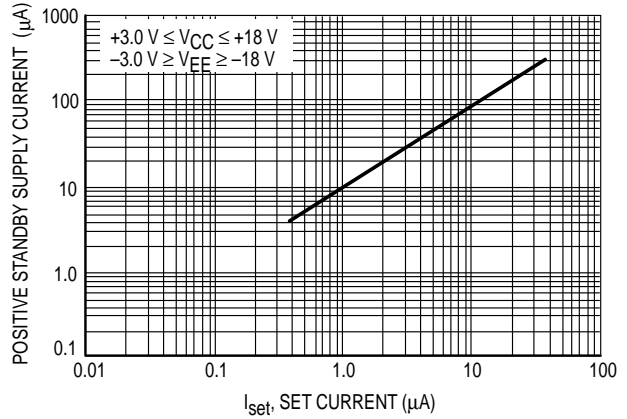
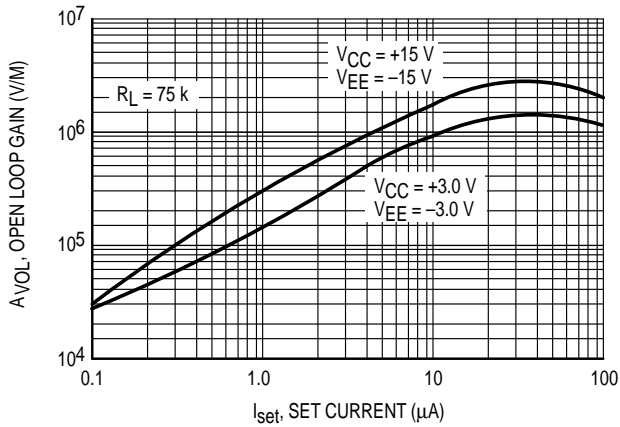
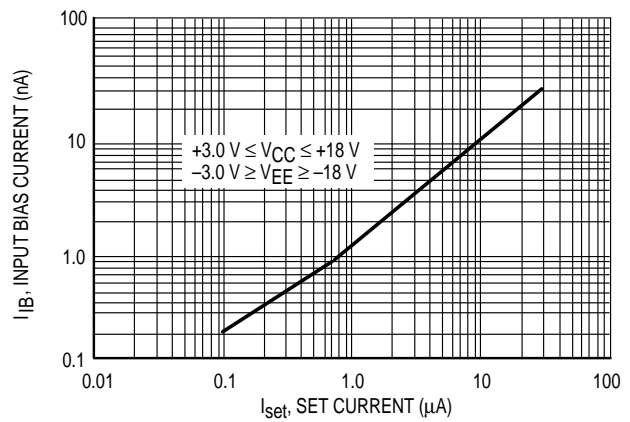
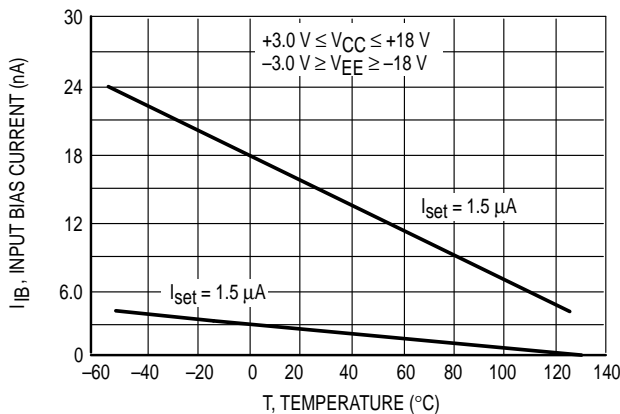
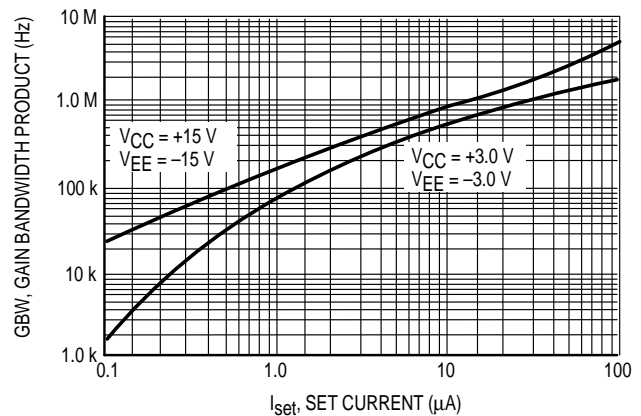
Characteristic	Symbol	Min	Typ	Max	Unit
Input Offset Voltage ( $R_S \leq 10\text{ k}\Omega$ ) $T_A = +25^\circ\text{C}$ $T_{low}^* \leq T_A \leq T_{high}^*$	$V_{IO}$	–	2.0	6.0	mV
Offset Voltage Adjustment Range	$V_{IOR}$	–	18	–	mV
Input Offset Current $T_A = +25^\circ\text{C}$ $T_A = T_{high}$ $T_A = T_{low}$	$I_{IO}$	–	2.0	25	nA
Input Bias Current $T_A = +25^\circ\text{C}$ $T_A = T_{high}$ $T_A = T_{low}$	$I_{IB}$	–	15	50	nA
Input Resistance	$r_i$	–	5.0	–	$M\Omega$
Input Capacitance	$c_i$	–	2.0	–	pF
Input Voltage Range $T_{low} \leq T_A \leq T_{high}$	$V_{ID}$	$\pm 1.0$	–	–	V
Large Signal Voltage Gain $R_L \geq 5.0\text{ k}\Omega$ , $V_O = \pm 1.0\text{ V}$ , $T_A = +25^\circ\text{C}$ $R_L \geq 5.0\text{ k}\Omega$ , $V_O = \pm 1.0\text{ V}$ , $T_{low} \leq T_A \leq T_{high}$	$A_{VOL}$	25 k 25 k	200 k –	– –	V/V
Output Voltage Swing $R_L \geq 5.0\text{ k}\Omega$ , $T_{low} \leq T_A \leq T_{high}$	$V_O$	$\pm 2.0$	$\pm 2.1$	–	V
Output Resistance	$r_o$	–	1.0	–	$k\Omega$
Output Short Circuit Current	$I_{SC}$	–	5.0	–	mA
Common Mode Rejection $R_S \leq 10\text{ k}\Omega$ , $T_{low} \leq T_A \leq T_{high}$	CMR	70	86	–	dB
Supply Voltage Rejection Ratio $R_S \leq 10\text{ k}\Omega$ , $T_{low} \leq T_A \leq T_{high}$	PSRR	–	25	200	$\mu\text{V/V}$
Supply Current $T_A = +25^\circ\text{C}$ $T_{low} \leq T_A \leq T_{high}$	$I_{CC}$ , $I_{EE}$	–	130	170	$\mu\text{A}$
Power Dissipation $T_A = +25^\circ\text{C}$ $T_{low} \leq T_A \leq T_{high}$	$P_D$	–	780	1020	$\mu\text{W}$
Transient Response (Unity Gain) $V_{in} = 20\text{ mV}$ , $R_L \geq 5.0\text{ k}\Omega$ , $C_L = 100\text{ pF}$ Rise Time Overshoot	$t_{TLH}$ $t_{os}$	–	0.6	–	$\mu\text{s}$ %
Slew Rate ( $R_L \geq 5.0\text{ k}\Omega$ )	$S_R$	–	0.35	–	$\text{V}/\mu\text{s}$

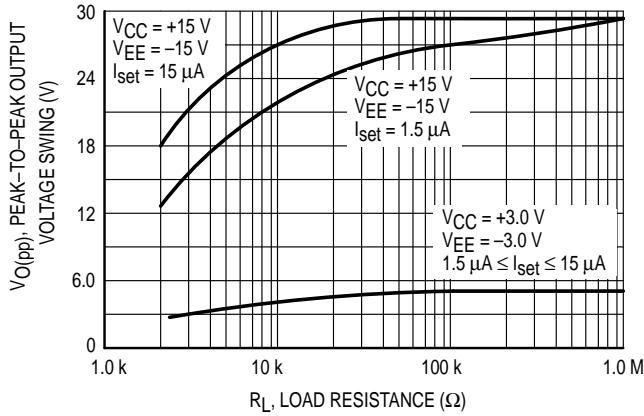
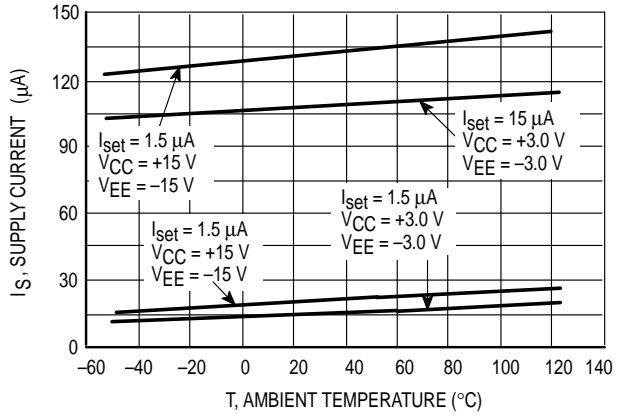
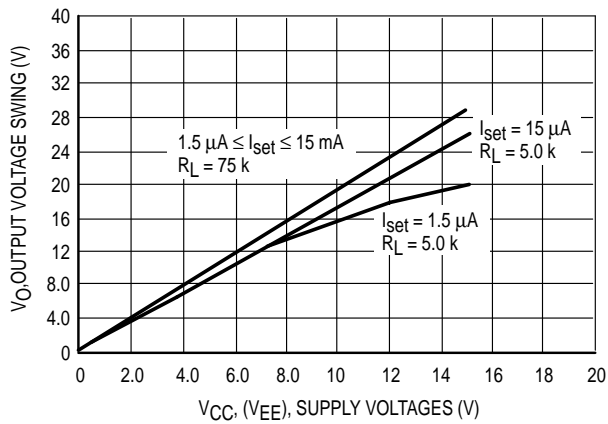
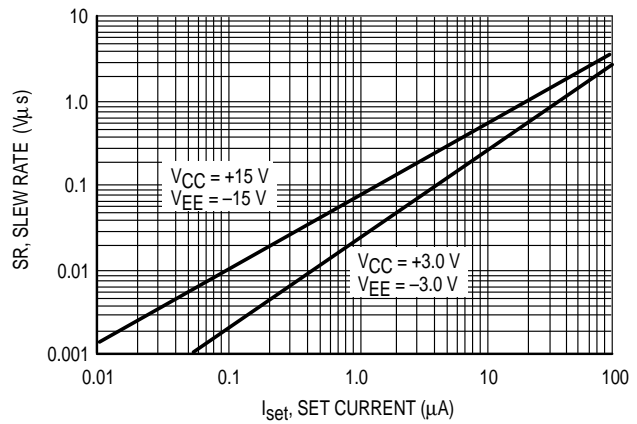
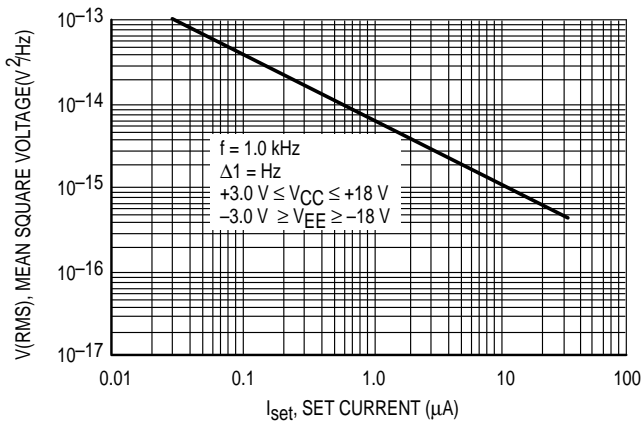
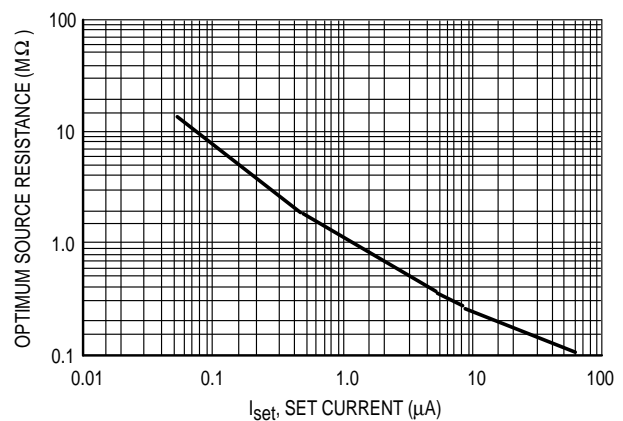
**ELECTRICAL CHARACTERISTICS** ( $V_{CC} = +15\text{ V}$ ,  $V_{EE} = -15\text{ V}$ ,  $I_{set} = 1.5\ \mu\text{A}$ ,  $T_A = +25^\circ\text{C}$ , unless otherwise noted.\*)

Characteristic	Symbol	Min	Typ	Max	Unit
Input Offset Voltage ( $R_S \leq 10\ \text{k}\Omega$ ) $T_A = +25^\circ\text{C}$ $T_{low}^* \leq T_A \leq T_{high}^*$	$V_{IO}$	–	2.0	6.0	mV
Offset Voltage Adjustment Range	$V_{IOR}$	–	9.0	–	mV
Input Offset Current $T_A = +25^\circ\text{C}$ $T_A = T_{high}$ $T_A = T_{low}$	$I_{IO}$	–	0.7	6.0	nA
Input Bias Current $T_A = +25^\circ\text{C}$ $T_A = T_{high}$ $T_A = T_{low}$	$I_{IB}$	–	2.0	10	nA
Input Resistance	$r_i$	–	50	–	M $\Omega$
Input Capacitance	$c_i$	–	2.0	–	pF
Input Voltage Range $T_{low} \leq T_A \leq T_{high}$	$V_{ID}$	$\pm 10$	–	–	V
Large Signal Voltage Gain $R_L \geq 75\ \text{k}\Omega$ , $V_O = \pm 10\ \text{V}$ , $T_A = +25^\circ\text{C}$ $R_L \geq 75\ \text{k}\Omega$ , $V_O = \pm 10\ \text{V}$ , $T_{low} \leq T_A \leq T_{high}$	$A_{VOL}$	50 k 50 k	400 k –	– –	V/V
Output Voltage Swing $R_L \geq 75\ \text{k}\Omega$ , $T_A = +25^\circ\text{C}$ $R_L \geq 75\ \text{k}\Omega$ , $T_{low} \leq T_A \leq T_{high}$	$V_O$	$\pm 12$ $\pm 10$	$\pm 14$ –	– –	V
Output Resistance	$r_o$	–	5.0	–	k $\Omega$
Output Short Circuit Current	$I_{SC}$	–	3.0	–	mA
Common Mode Rejection $R_S \leq 10\ \text{k}\Omega$ , $T_{low} \leq T_A \leq T_{high}$	CMR	70	90	–	dB
Supply Voltage Rejection Ratio $R_S \leq 10\ \text{k}\Omega$ , $T_{low} \leq T_A \leq T_{high}$	PSRR	–	25	200	$\mu\text{V/V}$
Supply Current $T_A = +25^\circ\text{C}$ $T_{low} \leq T_A \leq T_{high}$	$I_{CC}$ , $I_{EE}$	–	20	30	$\mu\text{A}$
Power Dissipation $T_A = +25^\circ\text{C}$ $T_{low} \leq T_A \leq T_{high}$	$P_D$	–	780	0.9	mW
Transient Response (Unity Gain) $V_{in} = 20\ \text{mV}$ , $R_L \geq 5.0\ \text{k}\Omega$ , $C_L = 100\ \text{pF}$ Rise Time Overshoot	$t_{TLH}$ $os$	–	1.6 0	–	$\mu\text{s}$ %
Slew Rate ( $R_L \geq 5.0\ \text{k}\Omega$ )	$S_R$	–	0.1	–	V/ $\mu\text{s}$

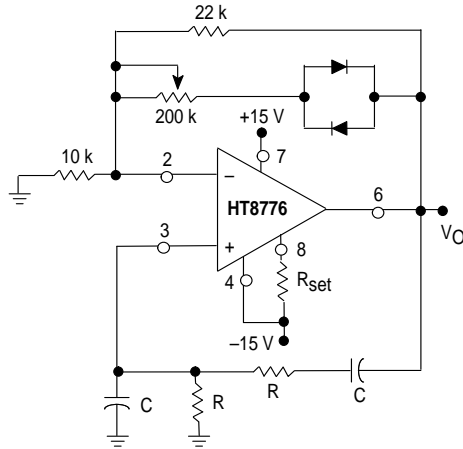
**ELECTRICAL CHARACTERISTICS** ( $V_{CC} = +15\text{ V}$ ,  $V_{EE} = -15\text{ V}$ ,  $I_{set} = 15\text{ }\mu\text{A}$ ,  $T_A = +25^\circ\text{C}$ , unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Input Offset Voltage ( $R_S \leq 10\text{ k}\Omega$ ) $T_A = +25^\circ\text{C}$ $T_{low}^* \leq T_A \leq T_{high}^*$	$V_{IO}$	– –	2.0 –	6.0 7.5	mV
Offset Voltage Adjustment Range	$V_{IOR}$	–	18	–	mV
Input Offset Current $T_A = +25^\circ\text{C}$ $T_A = T_{high}$ $T_A = T_{low}$	$I_{IO}$	– – –	2.0 – –	25 25 40	nA
Input Bias Current $T_A = +25^\circ\text{C}$ $T_A = T_{high}$ $T_A = T_{low}$	$I_{IB}$	– – –	15 – –	50 50 100	nA
Input Resistance	$r_i$	–	5.0	–	M $\Omega$
Input Capacitance	$c_i$	–	2.0	–	pF
Input Voltage Range $T_{low} \leq T_A \leq T_{high}$	$V_{ID}$	$\pm 10$	–	–	V
Large Signal Voltage Gain $R_L \geq 5.0\text{ k}\Omega$ , $V_O = \pm 10\text{ V}$ , $T_A = +25^\circ\text{C}$ $R_L \geq 75\text{ k}\Omega$ , $V_O = \pm 10\text{ V}$ , $T_{low} \leq T_A \leq T_{high}$	$A_{VOL}$	50 k 50 k	400 k –	– –	V/V
Output Voltage Swing $R_L \geq 5.0\text{ k}\Omega$ , $T_A = +25^\circ\text{C}$ $R_L \geq 75\text{ k}\Omega$ , $T_{low} \leq T_A \leq T_{high}$	$V_O$	$\pm 10$ $\pm 10$	$\pm 13$ –	– –	V
Output Resistance	$r_o$	–	1.0	–	k $\Omega$
Output Short Circuit Current	$I_{SC}$	–	12	–	mA
Common Mode Rejection $R_S \leq 10\text{ k}\Omega$ , $T_{low} \leq T_A \leq T_{high}$	CMR	70	90	–	dB
Supply Voltage Rejection Ratio $R_S \leq 10\text{ k}\Omega$ , $T_{low} \leq T_A \leq T_{high}$	PSRR	–	25	200	$\mu\text{V/V}$
Supply Current $T_A = +25^\circ\text{C}$ $T_{low} \leq T_A \leq T_{high}$	$I_{CC}$ , $I_{EE}$	– –	160 –	190 200	$\mu\text{A}$
Power Dissipation $T_A = +25^\circ\text{C}$ $T_{low} \leq T_A \leq T_{high}$	$P_D$	– –	– –	5.7 6.0	$\mu\text{W}$
Transient Response (Unity Gain) $V_{in} = 20\text{ mV}$ , $R_L \geq 5.0\text{ k}\Omega$ , $C_L = 100\text{ pF}$ Rise Time Overshoot	$t_{TLH}$ $os$	– –	0.35 10	– –	$\mu\text{s}$ %
Slew Rate ( $R_L \geq 5.0\text{ k}\Omega$ )	$S_R$	–	0.8	–	V/ $\mu\text{s}$

**Figure 1. Set Current versus Set Resistor**

**Figure 2. Positive Standby Supply Current versus Set Current**

**Figure 3. Open Loop Gain versus Set Current**

**Figure 4. Input Bias Current versus Set Current**

**Figure 5. Input Bias Current versus Ambient Temperature**

**Figure 6. Gain Bandwidth Product versus Set Current**


**Figure 7. Output Voltage Swing versus Load Resistance**

**Figure 8. Supply Current versus Ambient Temperature**

**Figure 9. Output Voltage Swing versus Supply Voltage**

**Figure 10. Slew Rate versus Set Current**

**Figure 11. Input Noise Voltage versus Set Current**

**Figure 12. Optimum Source Resistance for Minimum Noise versus Set Current**


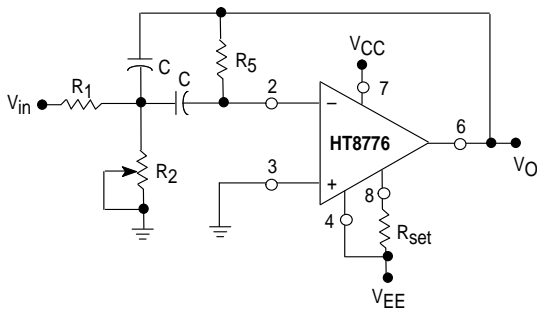


**Figure 13. Wien Bridge Oscillator**


$$f_o = \frac{1}{2\pi RC} \quad (\text{for } f_o = 1.0 \text{ kHz})$$

$$R = 16 \text{ k}\Omega$$

$$C = 0.01 \mu\text{F}$$

**Figure 14. Multiple Feedback Bandpass Filter**


For a given:

 $f_o$  = center frequency  
 $A(f_o)$  = Gain at center frequency  
 $Q$  = quality factor

Choose a value for C, then

$$R_5 = \frac{Q}{\pi f_o C}$$

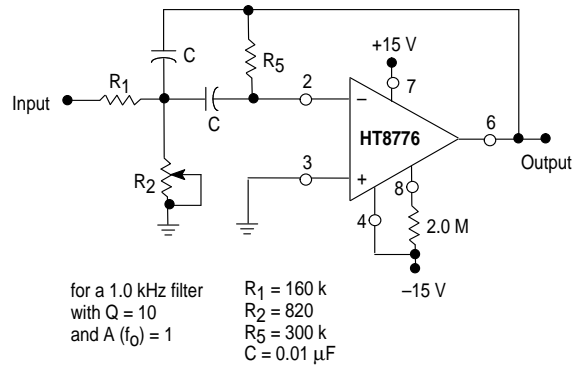
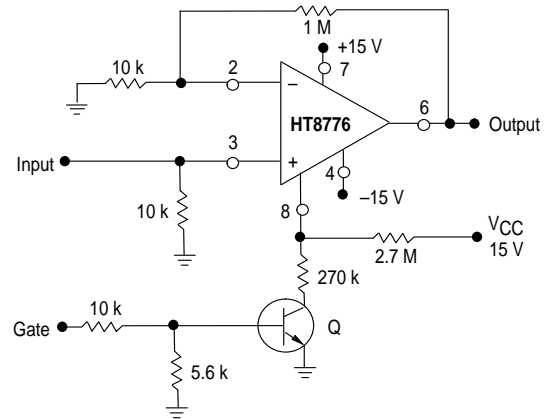
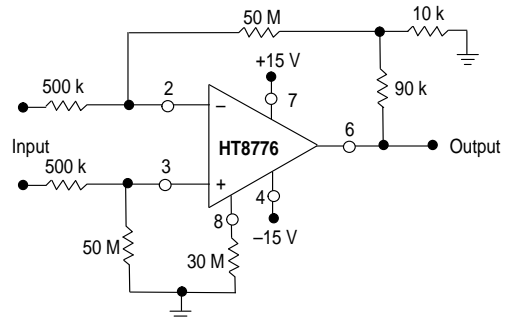
$$R_1 = \frac{R_5}{2A(f_o)}$$

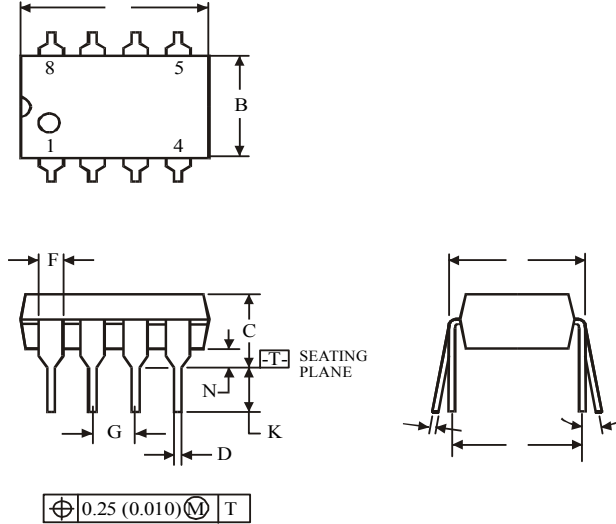
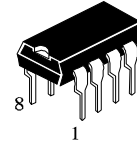
$$R_2 = \frac{R_1 R_5}{4Q^2 R_1 - R_5}$$

To obtain less than 10% error from the operational amplifier:

$$\frac{QO f_o}{\text{GBW}} \leq 0.1$$

 where  $f_o$  and GBW are expressed in Hz. GBW is available from Figure 6 as a function of Set Current,  $I_{\text{set}}$ .

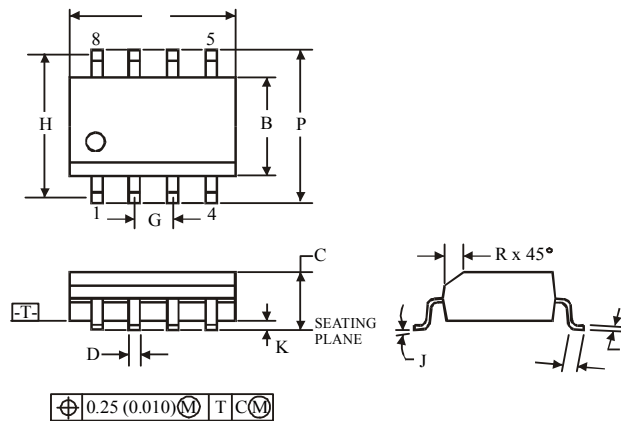
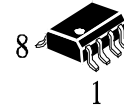
**Figure 15. Multiple Feedback Bandpass Filter (1.0 kHz)**

**Figure 16. Gated Amplifier**

**Figure 17. High Input Impedance Amplifier**


**(DIP8)**


Symbol	Dimension, mm	
	MIN	MAX
A	8.51	10.16
B	6.1	7.11
C		5.33
D	0.36	0.56
F	1.14	1.78
G	2.54	
H	7.62	
J	0°	10°
K	2.92	3.81
L	7.62	8.26
M	0.2	0.36
N	0.38	

**NOTES:**

- Dimensions "A", "B" do not include mold flash or protrusions.  
Maximum mold flash or protrusions 0.25 mm (0.010) per side.

**(SOP8)**


Symbol	Dimension, mm	
	MIN	MAX
A	4.8	5
B	3.8	4
C	1.35	1.75
D	0.33	0.51
F	0.4	1.27
G	1.27	
H	5.72	
J	0°	8°
K	0.1	0.25
M	0.19	0.25
P	5.8	6.2
R	0.25	0.5

**NOTES:**

- Dimensions A and B do not include mold flash or protrusion.
- Maximum mold flash or protrusion 0.15 mm (0.006) per side for A; for B - 0.25 mm (0.010) per side.

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