

# MC1776C

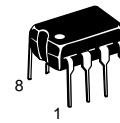
## Micropower Programmable Operational Amplifier

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

### PROGRAMMABLE OPERATIONAL AMPLIFIER

#### SEMICONDUCTOR TECHNICAL DATA



**P1 SUFFIX**  
PLASTIC PACKAGE  
CASE 626

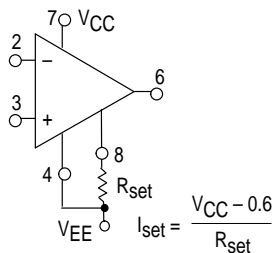


**D SUFFIX**  
PLASTIC PACKAGE  
CASE 751  
(SO-8)

#### Resistive Programming

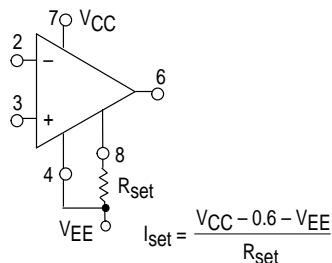
(See Figure 1)

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



##### $R_{set}$ to Negative Supply

(Recommended for supply voltage less than  $\pm 6.0$  V)



##### Typical $R_{set}$ Values

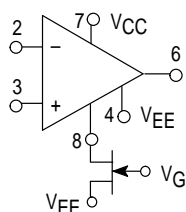
$V_{CC}, V_{EE}$	$I_{set} = 1.5 \mu A$	$I_{set} = 15 \mu A$
$\pm 6.0$ V	3.6 M $\Omega$	360 k $\Omega$
$\pm 10$ V	6.2 M $\Omega$	620 k $\Omega$
$\pm 12$ V	7.5 M $\Omega$	750 k $\Omega$
$\pm 15$ V	10 M $\Omega$	1.0 M $\Omega$

##### Typical $R_{set}$ Values

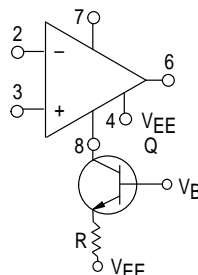
$V_{CC}, V_{EE}$	$I_{set} = 1.5 \mu A$	$I_{set} = 15 \mu A$
$\pm 1.5$ V	1.6 M $\Omega$	160 k $\Omega$
$\pm 3.0$ V	3.6 M $\Omega$	360 k $\Omega$
$\pm 6.0$ V	7.5 M $\Omega$	750 k $\Omega$
$\pm 15$ V	20 M $\Omega$	2.0 M $\Omega$

#### Active Programming

##### FET Current Source

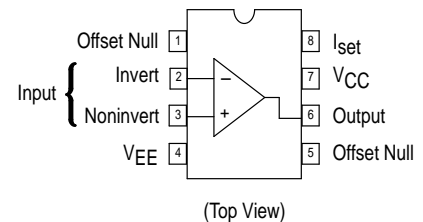


##### Bipolar Current Source



Pins not shown are not connected.

#### PIN CONNECTIONS



#### ORDERING INFORMATION

Device	Operating Temperature Range	Package
MC1776CD	$T_A = 0^\circ$ to $+70^\circ C$	SO-8
MC1776CP1		Plastic DIP

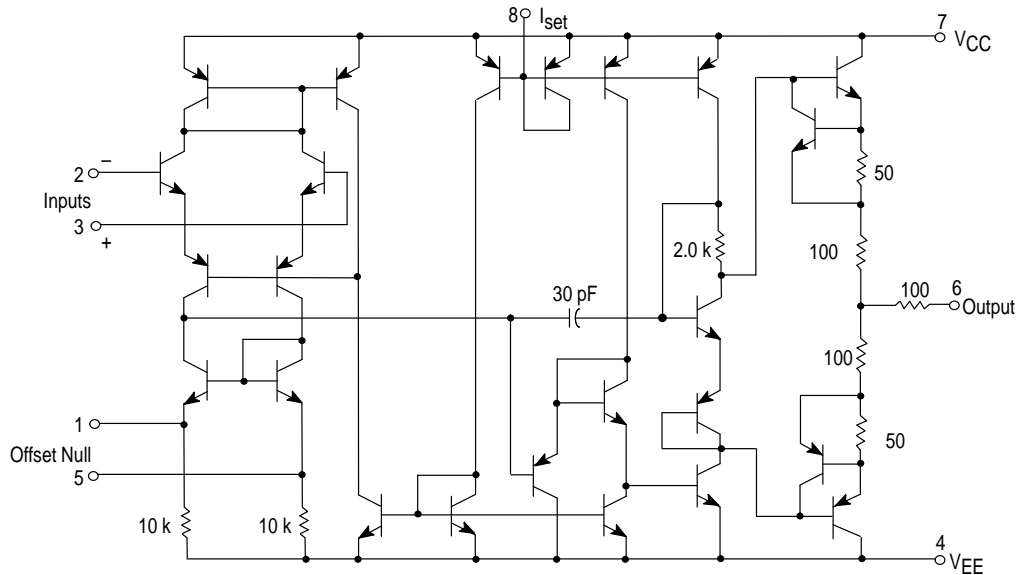
# MC1776C

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

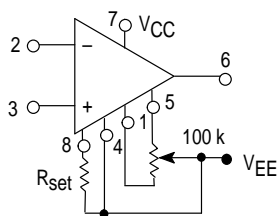
Rating	Symbol	Value	Unit
Power Supply Voltages	$V_{CC}, V_{EE}$	$\pm 18$	Vdc
Differential Input Voltage	$V_{ID}$	$\pm 30$	Vdc
Common Mode Input Voltage $V_{CC}$ and $ V_{EE}  < 15\text{ V}$ $V_{CC}$ and $ V_{EE}  \geq 15\text{ V}$	$V_{ICM}$	$V_{CC}, V_{EE}$ $\pm 15$	Vdc
Offset Null to $V_{EE}$ Voltage	$V_{off-V_{EE}}$	$\pm 0.5$	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	$T_A$	0 to $+70$	$^\circ\text{C}$
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  $+70^\circ\text{C}$  and  $I_{set} \leq 30\ \mu\text{A}$ .

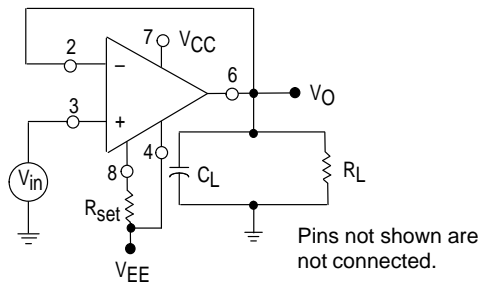
## Representative Schematic Diagram



## Voltage Offset Null Circuit



## Transient Response Test Circuit



# MC1776C

## 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
		–	–	7.5	
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
		–	–	6.0	
		–	–	10	
Input Bias Current $T_A = +25^\circ\text{C}$ $T_A = T_{high}$ $T_A = T_{low}$	$I_{IB}$	–	2.0	10	nA
		–	–	10	
		–	–	20	
Input Resistance	$r_i$	–	50	–	M $\Omega$
Input Capacitance	$c_i$	–	2.0	–	pF
Input Voltage Range $T_{low} \leq T_A \leq T_{high}$	$V_{ID}$	+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	–	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	$\mu\text{A}$
		–	–	25	
Power Dissipation $T_A = +25^\circ\text{C}$ $T_{low} \leq T_A \leq T_{high}$	$P_D$	–	78	120	$\mu\text{W}$
		–	–	150	
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 ( $R_L \geq 5.0\text{ k}\Omega$ )	$S_R$	–	0.03	–	V/ $\mu\text{s}$

\* $T_{low} = 0^\circ\text{C}$      $T_{high} = +70^\circ\text{C}$

# MC1776C

## ELECTRICAL CHARACTERISTICS ( $V_{CC} = +3.0\text{ V}$ , $V_{EE} = -3.0\text{ V}$ , $I_{set} = 15\ \mu\text{A}$ , $T_A = +25^\circ\text{C}$ , 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
		–	–	7.5	
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
		–	–	25	
		–	–	40	
Input Bias Current $T_A = +25^\circ\text{C}$ $T_A = T_{high}$ $T_A = T_{low}$	$I_{IB}$	–	15	50	nA
		–	–	50	
		–	–	100	
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	$\mu\text{A}$
		–	–	180	
Power Dissipation $T_A = +25^\circ\text{C}$ $T_{low} \leq T_A \leq T_{high}$	$P_D$	–	780	1020	$\mu\text{W}$
		–	–	1080	
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	$t_{TLH}$ $os$	–	0.6 5.0	– –	$\mu\text{s}$ %
Slew Rate ( $R_L \geq 5.0\ \text{k}\Omega$ )	$S_R$	–	0.35	–	V/ $\mu\text{s}$

\* $T_{low} = 0^\circ\text{C}$      $T_{high} = +70^\circ\text{C}$

# MC1776C

## 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
		–	–	7.5	
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
		–	–	6.0	
		–	–	10	
Input Bias Current $T_A = +25^\circ\text{C}$ $T_A = T_{high}$ $T_A = T_{low}$	$I_{IB}$	–	2.0	10	nA
		–	–	10	
		–	–	20	
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	$\mu\text{A}$
		–	–	35	
Power Dissipation $T_A = +25^\circ\text{C}$ $T_{low} \leq T_A \leq T_{high}$	$P_D$	–	780	0.9	mW
		–	–	1.05	
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	$t_{TLH}$ $t_{os}$	–	1.6 0	– –	$\mu\text{s}$ %
Slew Rate ( $R_L \geq 5.0\text{ k}\Omega$ )	$S_R$	–	0.1	–	$\text{V}/\mu\text{s}$

\* $T_{low} = 0^\circ\text{C}$      $T_{high} = +70^\circ\text{C}$

# MC1776C

## 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	mV
		–	–	7.5	
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
		–	–	25	
		–	–	40	
Input Bias Current $T_A = +25^\circ\text{C}$ $T_A = T_{high}$ $T_A = T_{low}$	$I_{IB}$	–	15	50	nA
		–	–	50	
		–	–	100	
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	$\mu\text{A}$
		–	–	200	
Power Dissipation $T_A = +25^\circ\text{C}$ $T_{low} \leq T_A \leq T_{high}$	$P_D$	–	–	5.7	$\mu\text{W}$
		–	–	6.0	
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	$t_{TLH}$ $t_{os}$	–	0.35 10	–	$\mu\text{s}$ %
Slew Rate ( $R_L \geq 5.0\text{ k}\Omega$ )	$S_R$	–	0.8	–	$\text{V}/\mu\text{s}$

\* $T_{low} = 0^\circ\text{C}$      $T_{high} = +70^\circ\text{C}$

Figure 1. Set Current versus Set Resistor

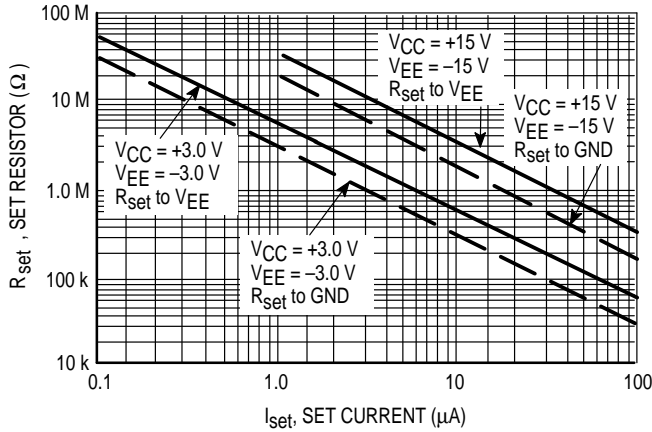


Figure 2. Positive Standby Supply Current versus Set Current

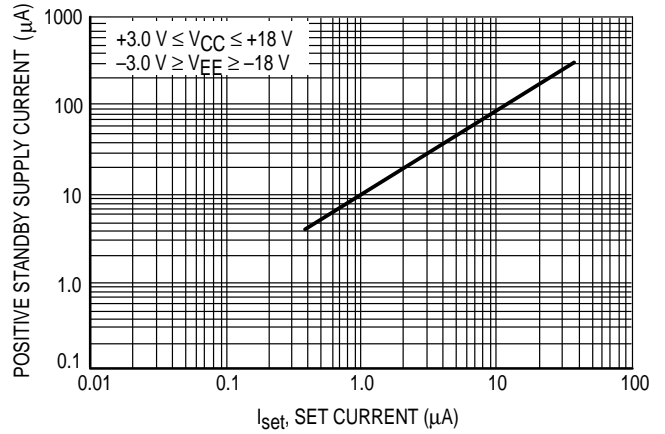


Figure 3. Open Loop Gain versus Set Current

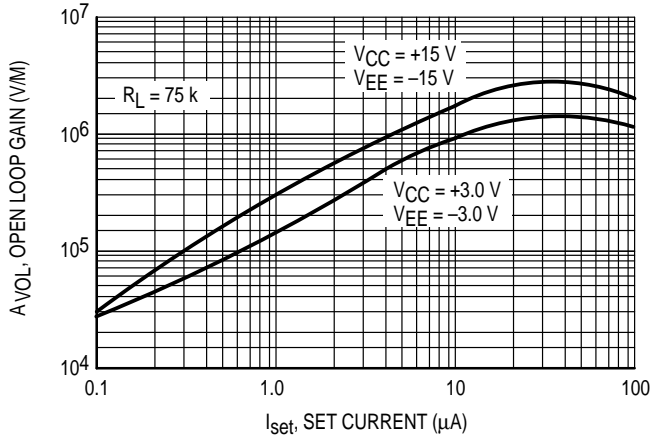


Figure 4. Input Bias Current versus Set Current

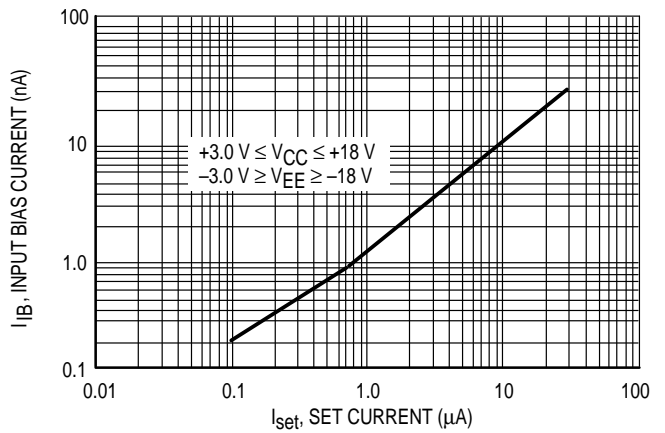


Figure 5. Input Bias Current versus Ambient Temperature

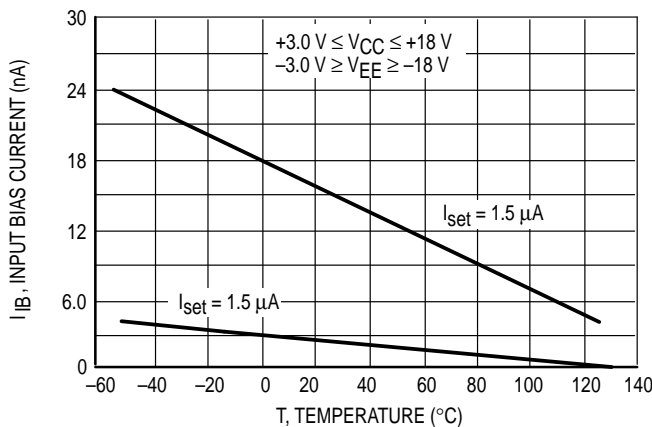


Figure 6. Gain Bandwidth Product versus Set Current

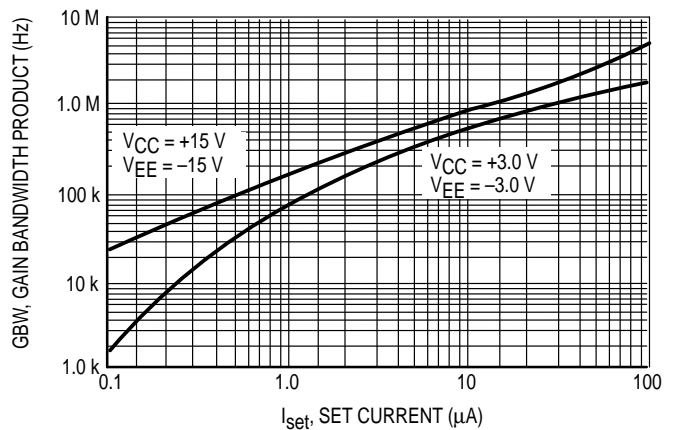


Figure 7. Output Voltage Swing versus Load Resistance

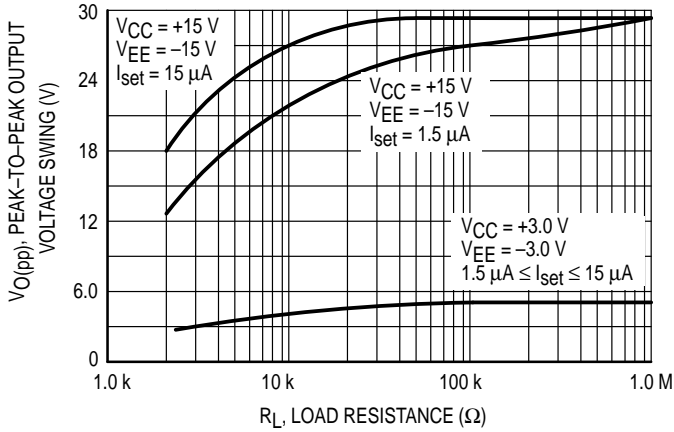


Figure 8. Supply Current versus Ambient Temperature

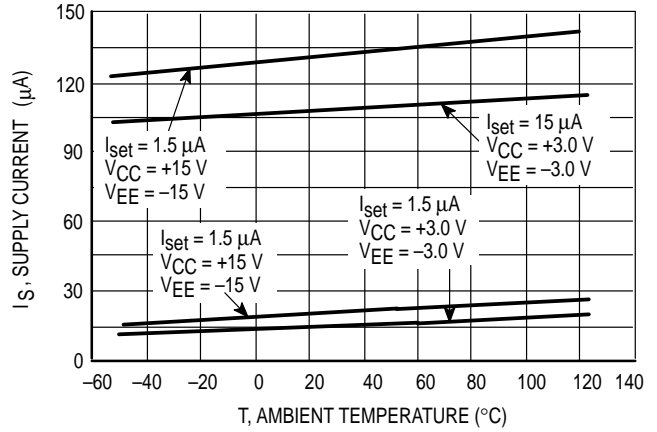


Figure 9. Output Voltage Swing versus Supply Voltage

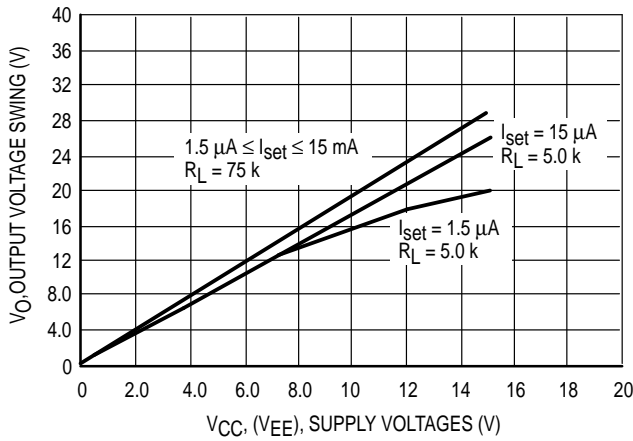


Figure 10. Slew Rate versus Set Current

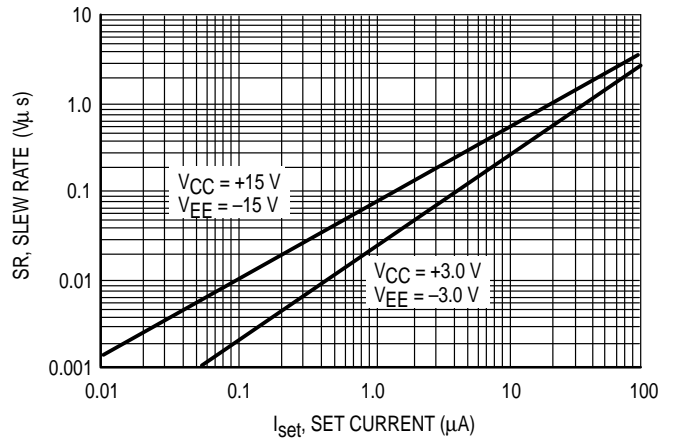


Figure 11. Input Noise Voltage versus Set Current

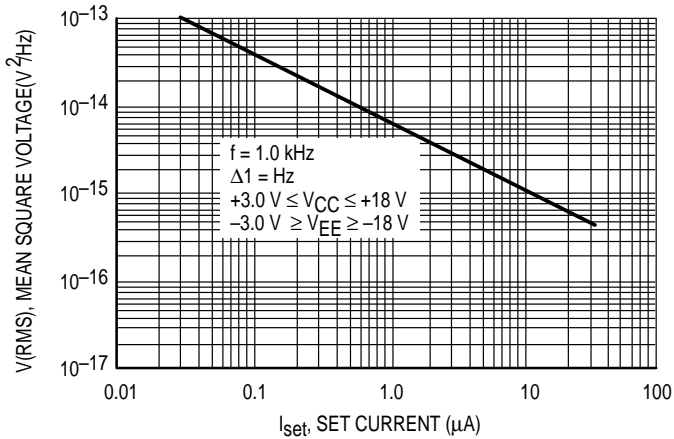


Figure 12. Optimum Source Resistance for Minimum Noise versus Set Current

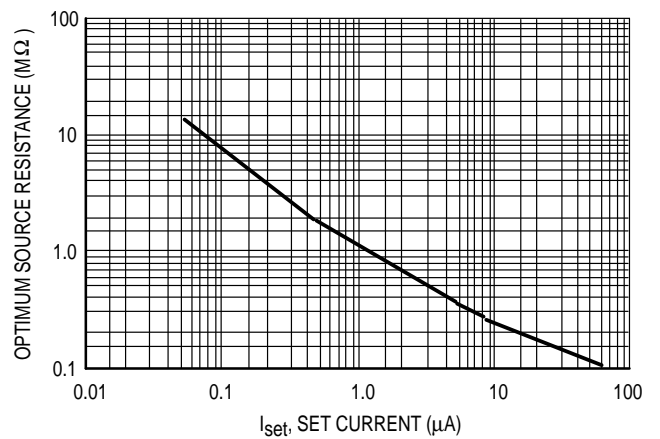
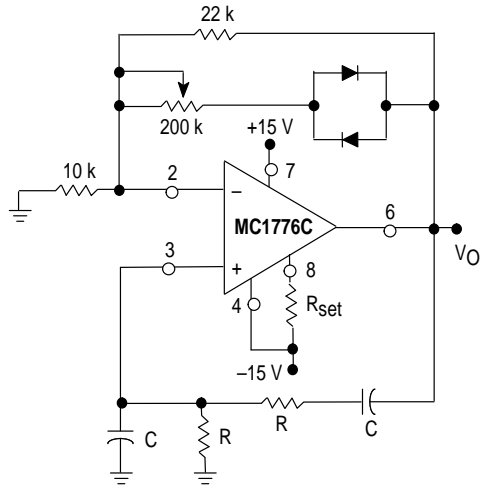




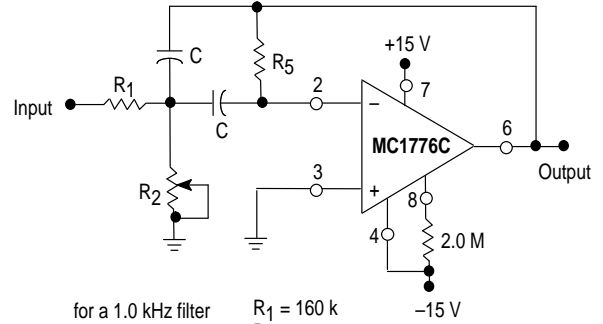
Figure 13. Wien Bridge Oscillator



$$f_0 = \frac{1}{2\pi RC} \quad (\text{for } f_0 = 1.0 \text{ kHz})$$

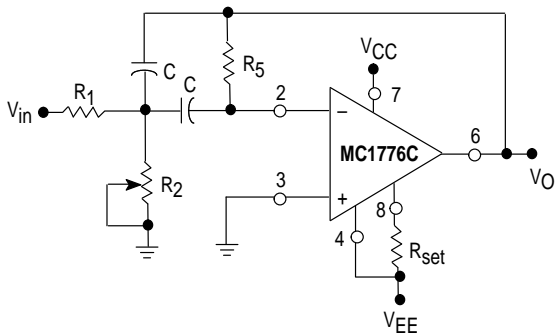
R = 16 kΩ  
C = 0.01 μF

Figure 15. Multiple Feedback Bandpass Filter (1.0 kHz)



for a 1.0 kHz filter with Q = 10 and A (f<sub>0</sub>) = 1  
R<sub>1</sub> = 160 k  
R<sub>2</sub> = 820  
R<sub>5</sub> = 300 k  
C = 0.01 μF

Figure 14. Multiple Feedback Bandpass Filter



For a given:

f<sub>0</sub> = center frequency  
A (f<sub>0</sub>) = Gain at center frequency  
Q = quality factor

Choose a value for C, then

$$R_5 = \frac{Q}{\pi f_0 C}$$

$$R_1 = \frac{R_5}{2A(f_0)}$$

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

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

$$\frac{Q_0 f_0}{\text{GBW}} \leq 0.1$$

where f<sub>0</sub> and GBW are expressed in Hz. GBW is available from Figure 6 as a function of Set Current, I<sub>set</sub>.

Figure 16. Gated Amplifier

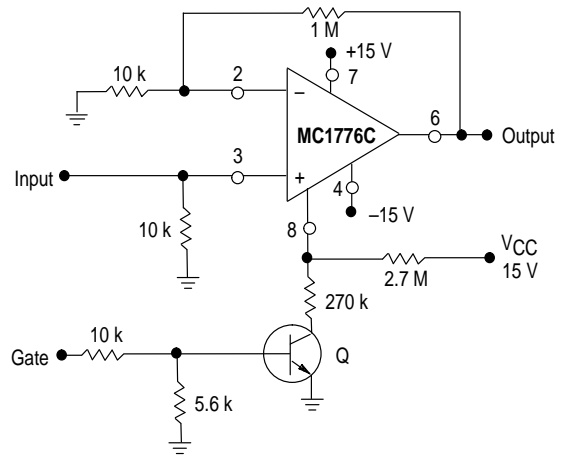
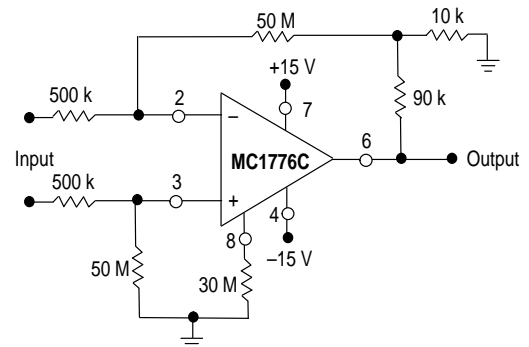


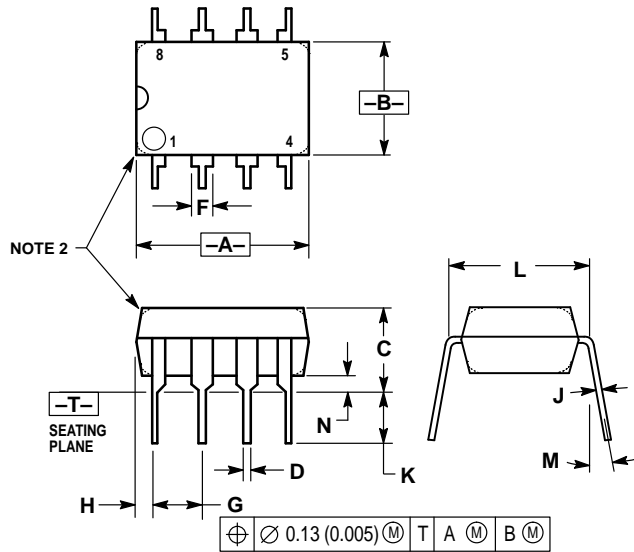
Figure 17. High Input Impedance Amplifier



# MC1776C

## OUTLINE DIMENSIONS

### P1 SUFFIX PLASTIC PACKAGE CASE 626-05 ISSUE K

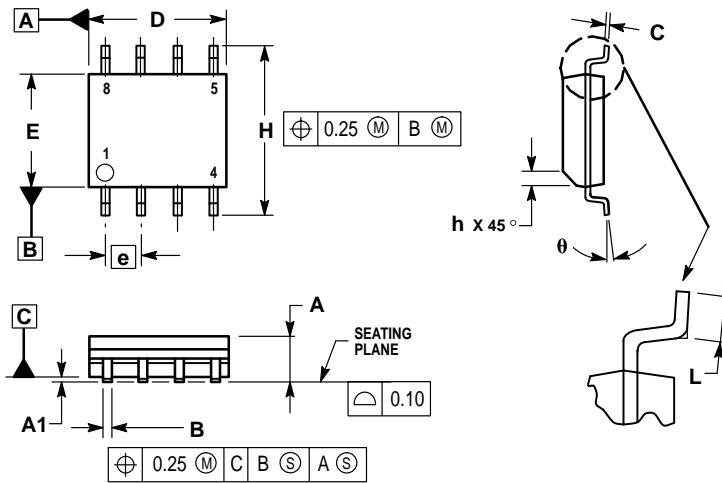


NOTES:

1. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.
2. PACKAGE CONTOUR OPTIONAL (ROUND OR SQUARE CORNERS).
3. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.40	10.16	0.370	0.400
B	6.10	6.60	0.240	0.260
C	3.94	4.45	0.155	0.175
D	0.38	0.51	0.015	0.020
F	1.02	1.78	0.040	0.070
G	2.54 BSC		0.100 BSC	
H	0.76	1.27	0.030	0.050
J	0.20	0.30	0.008	0.012
K	2.92	3.43	0.115	0.135
L	7.62 BSC		0.300 BSC	
M	10°		10°	
N	0.76	1.01	0.030	0.040


### D SUFFIX PLASTIC PACKAGE CASE 751-05 (SO-8) ISSUE R



NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. DIMENSIONS ARE IN MILLIMETERS.
3. DIMENSION D AND E DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 PER SIDE.
5. DIMENSION B DOES NOT INCLUDE MOLD PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 TOTAL IN EXCESS OF THE B DIMENSION AT MAXIMUM MATERIAL CONDITION.

DIM	MILLIMETERS	
	MIN	MAX
A	1.35	1.75
A1	0.10	0.25
B	0.35	0.49
C	0.18	0.25
D	4.80	5.00
E	3.80	4.00
e	1.27 BSC	
H	5.80	6.20
h	0.25	0.50
L	0.40	1.25
θ	0°	7°

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