Raytheon

Micro-Power Operational Amplifier

RC3078, RM3078A

Features

- Low standby power — as low as 700nW
- Wide supply voltage range — ±0.75V to ±15V
- High peak output current — 6.5mA minimum
- Adjustable quiescent current
- Output short circuit protection

Applications

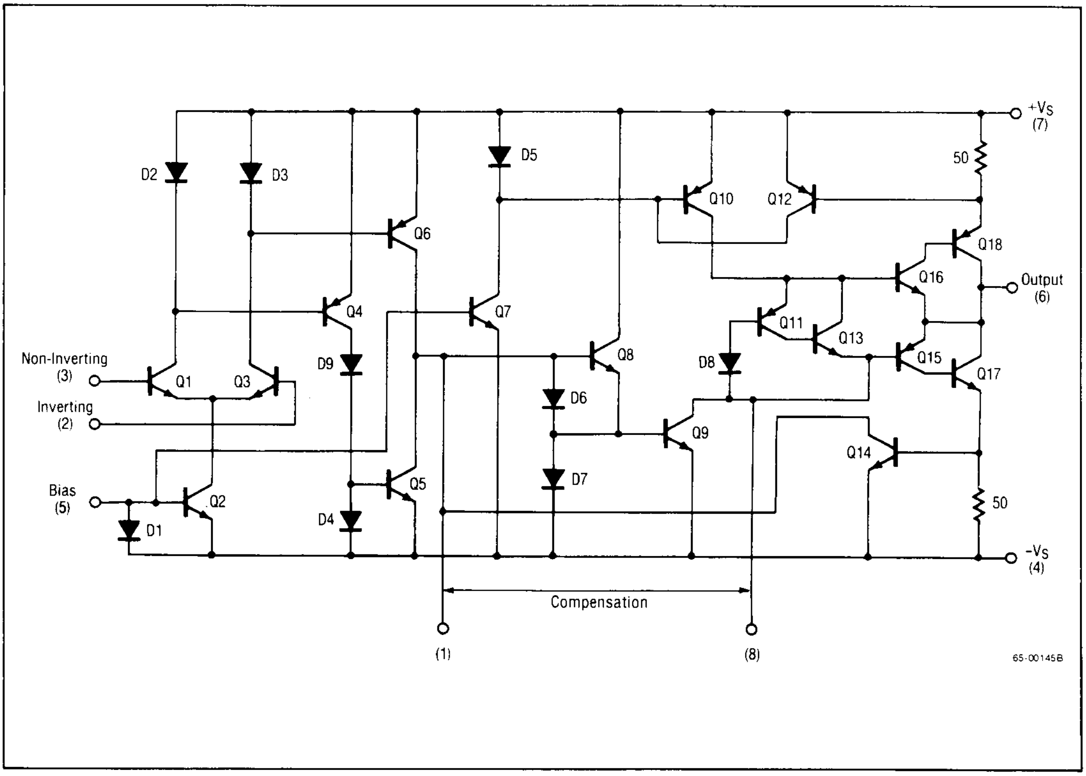
- Portable electronics
- Medical electronics
- Instrumentation
- Telemetry

Description

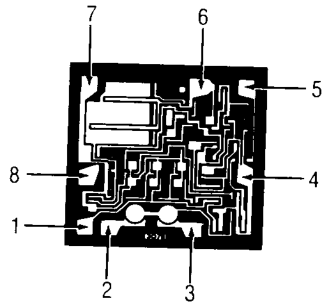
The 3078 and 3078A are high gain monolithic operational amplifiers which can deliver milliamperes of current yet only consume microwatts of standby power. Their operating points are externally adjustable and frequency compensation may be accomplished with one external capacitor. The 3078 and 3078A provide the designer with the opportunity to tailor the frequency response and improve the slew rate without sacrificing power. Operation with a single 1.5V battery is a practical reality with these devices.

The 3078A is a premium device having a supply voltage range of $V_S = \pm0.75V$ to $V_S = \pm15V$ and an operating temperature range of -55° C to +125° C. The 3078 has the same lower supply voltage limit but the upper limit is $+V_S = +6V$ and $-V_S = -6V$. The operating temperature range is from 0° C to +70° C

Schematic Diagram



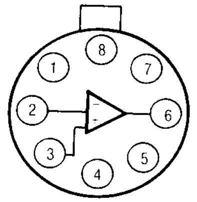
Mask Pattern



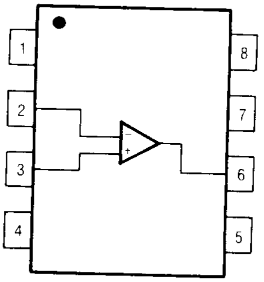
Die Size: 49 x 48 mils
Min. Pad Dimensions: 4 x 4 mils

Connection Information

8-Lead Metal Can TO-99
(Top View)



8-Lead Dual In-Line Package
(Top View)



65-00142A

Pin	Function
1	Compensation
2	Inverting Input
3	Non-Inverting Input
4	$-V_S$
5	Bias
6	Output
7	$+V_S$
8	Compensation

Absolute Maximum Ratings

Supply Voltage
- RC3078 .... ±7V
- RM3078A .... ±18V

Input Voltage .... $+V_S$ to $-V_S$
Differential Input Voltage 6V
Input Signal Current 0.1mA
Output Short Circuit Duration* .... No Limitation
Storage Temperature Range .... -65°C to +150°C
Operating Temperature Range
- RC3078 .... 0°C to +70°C
- RM3078A .... -55°C to +125°C

Lead Soldering Temperature (10 Sec) .... +300°C

*Short circuit may be applied to ground or to either supply.

Thermal Characteristics

	8-Lead Plastic DIP	8-Lead Ceramic DIP	8-Lead TO-99 Metal Can
Max. Junction Temp.	125°C	175°C	175°C
Max. P_D T_A < 50°C	468mW	833mW	658mW
Therm. Res. θ_{JC}	—	45°C/W	50°C/W
Therm. Res. θ_{JA}	160°C/W	150°C/W	190°C/W
For T_A > 50°C Derate at	6.25mW per °C	8.33mW per °C	5.26mW per °C

Ordering Information

Part Number	Package	Operating Temperature Range
RC3078DE	Ceramic	0°C to +70°C
RC3078NB	Plastic	0°C to +70°C
RC3078T	TO-99	0°C to +70°C
RM3078ADE	Ceramic	-55°C to +125°C
RM3078AT	TO-99	-55°C to +125°C
RM3078AT/883B*	TO-99	-55°C to +125°C

*MIL-STD-883, Level B Processing

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Electrical Characteristics ($V_S = \pm6V$)

Parameters	Test Conditions	RM3078A					RC3078					Units
		R_{SET} = 5.1MΩ, I_Q = 20μA					R_{SET} = 1MΩ, I_Q = 100μA					
		T_A = +25°C			T_A = -55°C to +125°C		T_A = +25°C			T_A = 0°C to +70°C		
		Min	Typ	Max	Min	Max	Min	Typ	Max	Min	Max	
Input Offset Voltage	$R_S \leq 10k\Omega$		0.70	3.5		4.5		1.3	4.5		5.0	mV
Input Offset Current			0.50	2.5		5.0		6.0	32		40	nA
Input Bias Current			7.0	12		50		60	170		200	nA
Large Signal Voltage Gain	$R_L \geq 10k\Omega$	39	100		31		25	39		20		V/mV
Supply Current			20	35		100		100	130		150	μA
Power Consumption			240	300		540		1200	1560		1800	μW
Output Voltage Swing	$R_L \geq 10k\Omega$	±5.1	±5.3		±5.0		±5.1	±5.3		±5.0		V
Input Voltage Range	$R_S \leq 10k\Omega$		-5.5 to +5.8		-5 to +5			-5.5 to +5.8		-5 to +5		V
Common Mode Rejection Ratio	$R_S \leq 10k\Omega$	80	115				80	110				dB
Output Current			12		5.0	30		12		5.0	30	mA
Power Supply Rejection Ratio Positive Supply	$R_S \leq 10k\Omega$	76	104				76	93				dB
NegativeSupply		76	104				76	93				dB

(R_{SET} = 13MΩ, I_Q = 20μA, $V_S = \pm15V$)

Parameters	Test Conditions	Min	Typ	Max	Min	Max	Min	Typ	Max	Min	Max	Units
Input Offset Voltage	$R_S \leq 10k\Omega$		1.4	3.5		4.5						mV
Large Signal Voltage Gain	$R_L \geq 10k\Omega$	32	100		25							V/mV
Supply Current			20	35		100						μA
Power Dissipation			600	750		1350						μW
Output Voltage Swing	$R_L \geq 10k\Omega$	13.7	14.1		13.5							V
Common Mode Rejection Ratio	$R_S \leq 10k\Omega$	80	106									dB
Input Bias Current			7.0	14		55						nA
Input Offset Current			0.50	2.7		5.5						nA

Electrical Characteristics (At $T_A = +25°C$)

Parameters	Typical Values: RM3078A, $V_S = \pm1.3V$, $R_{SET} = 2M\Omega$	RM3078A, $V_S = \pm0.75V$, $R_{SET} = 10M\Omega$	RC3078, $V_S = \pm1.3V$, $R_{SET} = 2M\Omega$	RC3078, $V_S = \pm0.75V$, $R_{SET} = 10M\Omega$	Units
Input Offset Voltage	0.7	0.9	1.3	1.5	mV
Input Offset Current	0.3	0.054	1.7	0.5	nA
Input Bias Current	3.7	0.45	9.0	1.3	nA
Large Signal Voltage Gain	16	1.8	10	1.0	V/mV
Supply Current	10	1.0	10	1.0	µA
Power Consumption	26	1.5	26	1.5	µW
Output Voltage Swing	1.4	0.3	1.4	0.3	V
Input Voltage Range	-0.8 to +1.1	-0.2 to +0.5	-0.8 to +1.1	-0.2 to +0.5	V
Common Mode Rejection Ratio	100	90	100	90	dB
Output Current	12	0.5	12	0.5	mA
Power Supply Rejection Ratio	94	86	94	86	dB

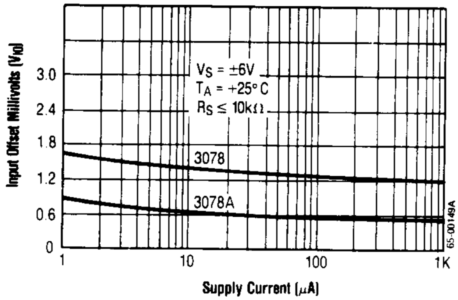
Electrical Characteristics

(Typical values intended only for design guidance at $T_A = +25°C$ and $V_S = \pm6V$)

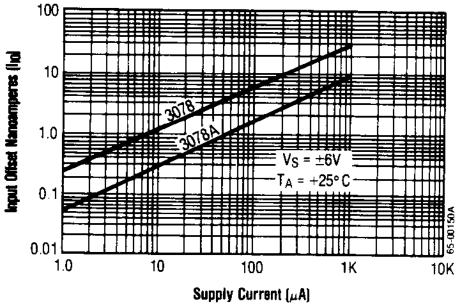
Parameters	Test Conditions	RM3078A: $R_{SET} = 5.1M\Omega$, $I_Q = 20\mu A$	RM3078A: $R_{SET} = 1M\Omega$, $I_Q = 100\mu A$	RC3078: $R_{SET} = 5.1M\Omega$, $I_Q = 100\mu A$	Units
Input Offset Voltage Drift	$R_S \le 10k\Omega$	5.0	6.0	6.0	µV/°C
Input Offset Current Drift	$R_S \le 10k\Omega$	6.3	70	70	pA/°C
Unity Gain Bandwidth	$A_V = -3dB$	0.3	2.0	2.0	kHz
Slew Rate: Unity Gain		0.027	0.04	0.04	V/µS
Slew Rate: Comparator	10% to 90%	0.5	1.5	1.5	V/µS
Rise Time		3.0	2.5	2.5	µS
Input Resistance (Differential Mode)		7.4	1.7	0.87	MΩ
Open Loop Output Resistance		1.0	0.8	0.8	kΩ
Input Noise Voltage Density	$R_S = 0$	36		19	$nV/\sqrt{Hz}$
Input Noise Current Density	$R_S = 1M\Omega$	0.4		1.0	$pA/\sqrt{Hz}$

Typical Performance Characteristics

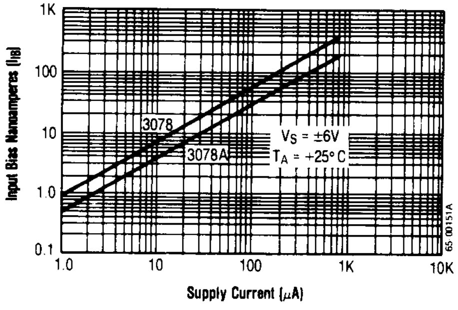
Input Offset Voltage vs. Total Quiescent Current



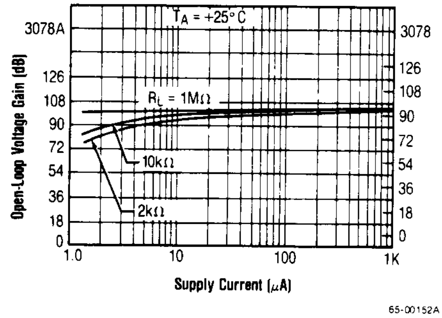
Input Offset Current vs. Total Quiescent Current



Input Bias Current vs. Total Quiescent Current

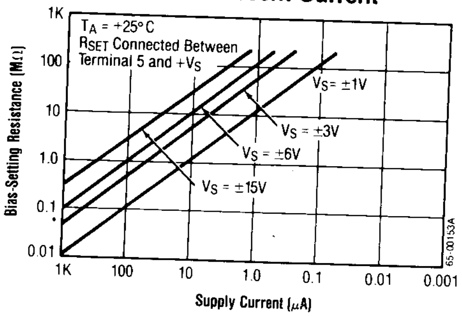


Open Loop Voltage Gain vs. Total Quiescent Current

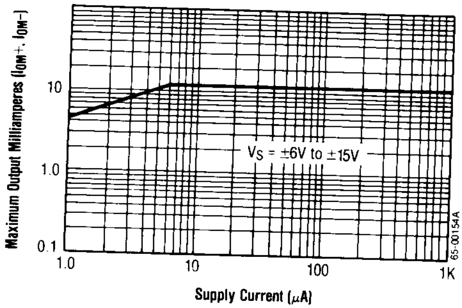


Typical Performance Characteristics (Continued)

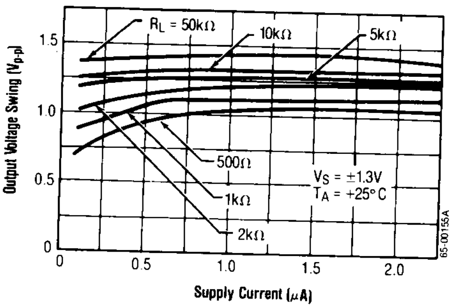
Bias-Setting Resistance vs. Total Quiescent Current



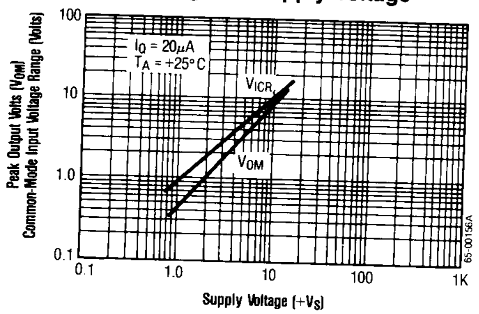
Maximum Output Current vs. Total Quiescent Current



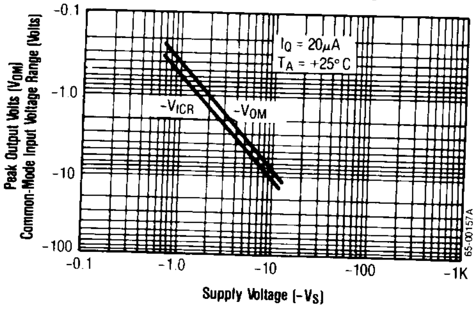
Output Voltage Swing vs. Total Quiescent Current



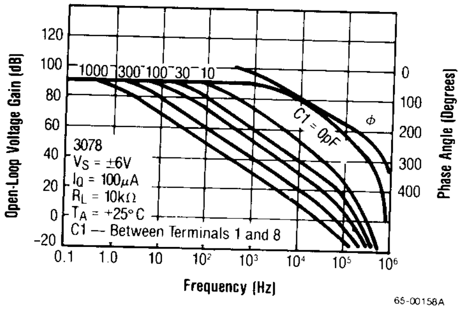
Positive Output and Common Mode Voltage vs. Supply Voltage



Negative Output and Common Mode Voltage vs. Supply Voltage

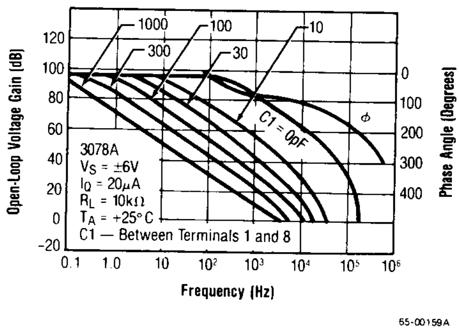


Open Loop Voltage Gain vs. Frequency — 3078

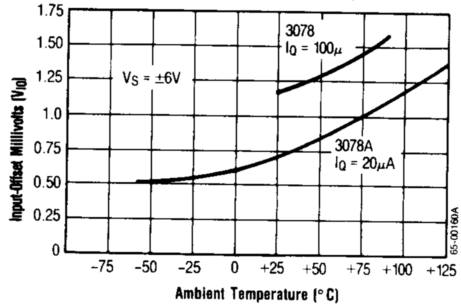


Typical Performance Characteristics (Continued)

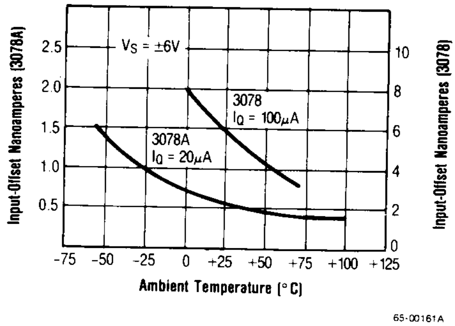
Open Loop Voltage Gain vs. Frequency — 3078A



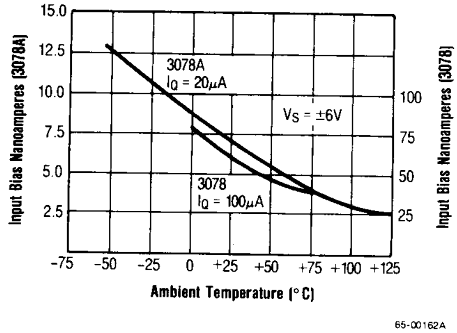
Input Offset Voltage vs. Temperature



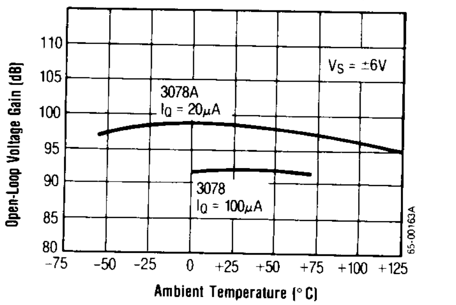
Input Offset Current vs. Temperature



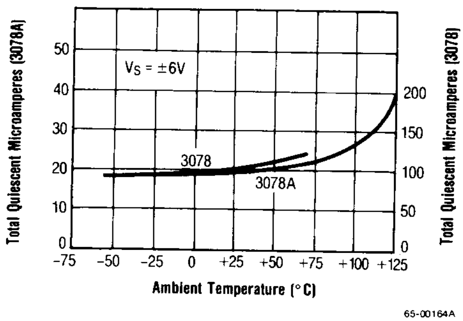
Input Bias Current vs. Temperature



Open Loop Voltage Gain vs. Temperature

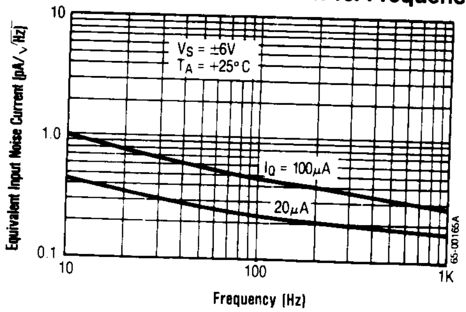


Total Quiescent Current vs. Temperature

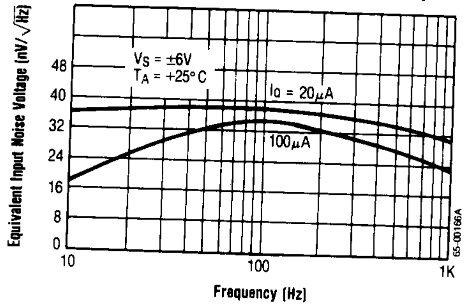


Typical Performance Characteristics (Continued)

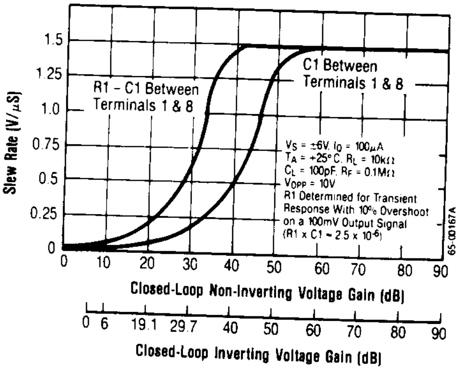
Equivalent Input Noise Current vs. Frequency



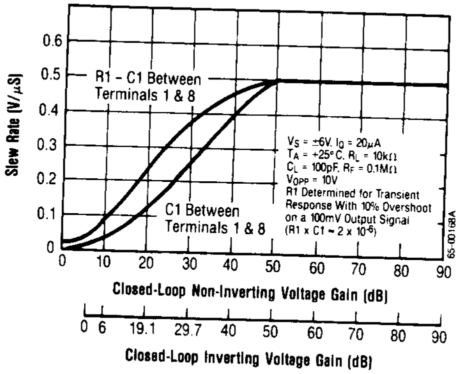
Equivalent Input Noise Voltage vs. Frequency



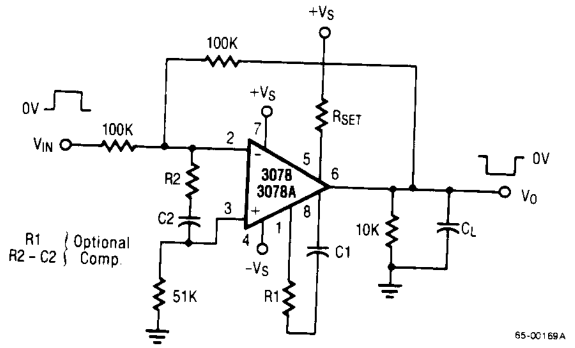
Slew Rate vs. Closed Loop Gain — 3078



Slew Rate vs. Closed Loop Gain — 3078A

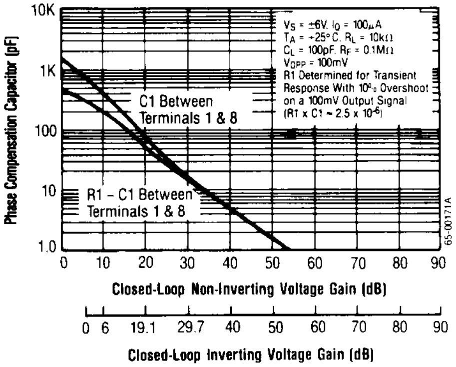


Transient Response and Slew Rate Unity Gain (Inverting) Test Circuit

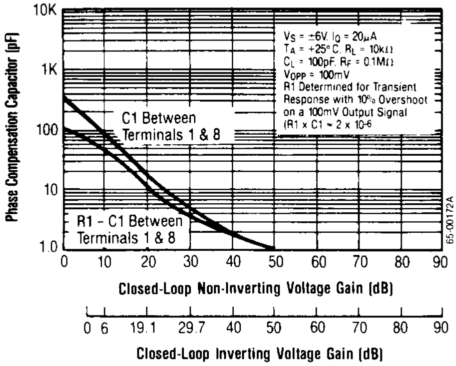


Typical Performance Characteristics (Continued)

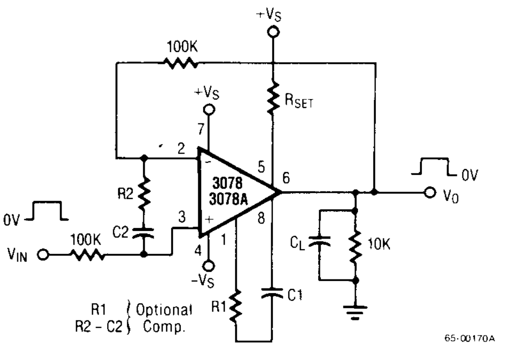
Phase Compensation Capacitance vs. Closed Loop Gain — 3078



Phase Compensation Capacitance vs. Closed Loop Gain — 3078A



Slew Rate, Unity Gain (Non-Inverting) Test Circuit



Operating Considerations

The 3078 and 3078A can be phase-compensated with one or two external components depending upon the closed-loop gain, power consumption, and speed desired. The recommended compensation is a resistor in series with a capacitor connected from terminal 1 to terminal 8. Values of the resistor and capacitor as required for compensation are a function of closed-loop gain. These curves represent the compensation necessary at quiescent currents of 20µA and 100µA, respectively, for a transient with 10% overshoot. The slew rates curves show what can be obtained with the two different compensation techniques. Higher speeds can be achieved with input compensation, but this increases noise output. Compensation can also be accomplished with a single capacitor connected from terminal 1 to terminal 8, with speed being sacrificed for simplicity. Table 1 gives an indication of slew rates that can be obtained with various compensation techniques at quiescent currents of 20µA and 100µA.

Single Supply Operation

The 3078 and 3078A can operate from a single supply with a minimum total supply voltage of 1.5V. Figures 2 and 3 show the 3078 and 3078A in inverting and non-inverting 20dB amplifier configurations utilizing a 1.5V type "A" cell for a supply. The total power consumption for either circuit is approximately 675 nanowatts. The output voltage swing in this configuration is $300mV_{p-p}$ with a 20kΩ load.

Table 1. Unity Gain Slew Rate Versus Compensation — 3078 and 3078A

$V_S = \pm 6V$, $R_L = 10k\Omega$	Transient Response: 10% Overshoot for an Output Voltage of 100mV, $T_A = +25°C$									
	Unity Gain (Inverting)					Unity Gain (Non-Inverting)				
Compensation Technique	R1	C1	R2	C2	Slew Rate	R1	C1	R2	C2	Slew Rate
3078 — $I_Q = 100\mu A$	kΩ	pF	kΩ	μF	V/μS	kΩ	pF	kΩ	μF	V/μS
Single Capacitor	0	750	∞	0	0.0085	0	1500	∞	0	0.0095
Resistor and Capacitor	3.5	350	∞	0	0.04	5.3	500	∞	0	0.024
Input	∞	0	0.25	0.306	0.67	∞	0	0.311	0.45	0.67
3078A — $I_Q = 20\mu A$										
Single Capacitor	0	300	∞	0	0.0095	0	800	∞	0	0.003
Resistor and Capacitor	14	100	∞	0	0.027	34	125	∞	0	0.02
Input	∞	0	0.644	0.156	0.29	∞	0	0.77	0.4	-0.4

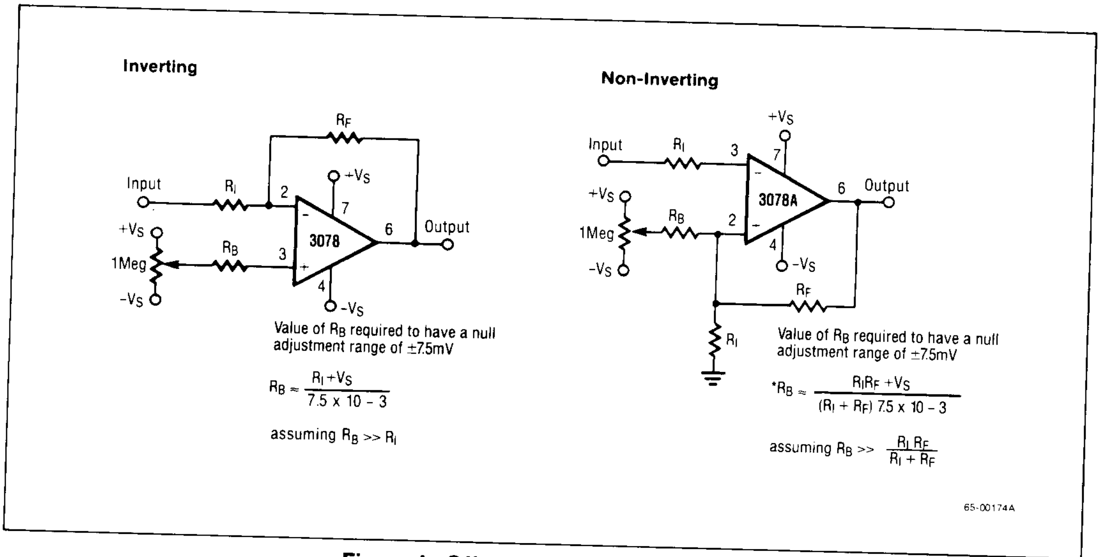


Figure 1. Offset Voltage Null Circuit

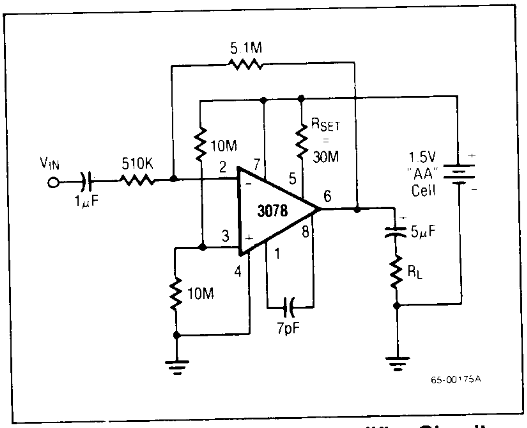


Figure 2. Inverting 20dB Amplifier Circuit

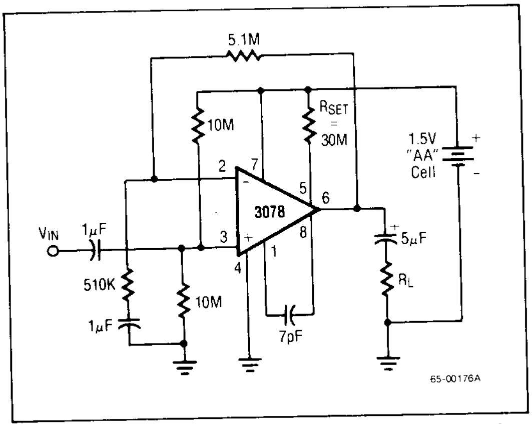


Figure 3. Non-Inverting 20dB Amplifier Circuit