MC1776

LINEAR INTEGRATED CIRCUITS

PROGRAMMABLE OPERATIONAL AMPLIFIERS

- MICROPOWER CONSUMPTION
- INTERNALLY FREQUENCY COMPENSATION
- OFFSET NULL CAPABILITY
- SHORT CIRCUIT PROTECTION
- LOW INPUT BIAS CURRENTS
- LOW NOISE

The MC1776 is a programmable operational amplifier available in four different packages (plastic and ceramic Minidip, TO-99 and SO-8 micropackage). High input impedance, low supply currents and low input noise over a wide range of operating supply voltages coupled with programmable electrical characteristics, make it an extremely versatile amplifier for use in high accuracy, low power consumption analog applications.

Input noise voltage and current, power consumption and input current can be optimized by a single resistor of current source that sets the quiescent current for nanowatt power consumption or for characteristics similar to the LM741. Internal frequency compensation absence of "latch-up" high slew rate and short circuit current protection assure ease of use in long interval integrators, active filters and sample and hold circuits.

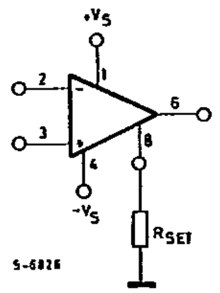
ABSOLUTE MAXIMUM RATINGS

V_s	Supply voltage	± 18	V
$V_{I(1)}$	Input voltage	± 15	V
ΔV_I	Differential input voltage	± 30	V
V_{SET}	Maximum voltage to ground at I_{SET}	V_s -2V to V_s	V
I_{SET}	Minimum current at I_{SET}	500	μA
T_{op}	Operating temperature for MC1776	-55 to 125	°C
	for MC1776I	-25 to 85	°C
	for MC1776C	0 to 70	°C
	Output short circuit duration (2)	indefinite	
T_{stg}	Storage temperature	-65 to 150	°C
T_j	Junction temperature	150	°C

1) For supply voltage less than ± 1.5V, input voltage is equal to the supply voltage
2) The short circuit duration is limited by thermal dissipation

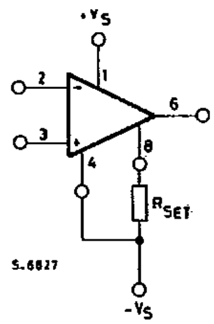
PROGRAMMING

R_{set} to GROUND



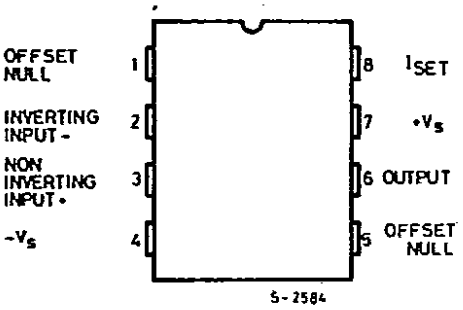
Typical R_{SET} values		
V_s	I_{SET} = 1.5μA	I_{SET} = 15μA
± 6V	3.6 MΩ	360 kΩ
± 10V	6.2 MΩ	620 kΩ
± 12V	7.5 MΩ	750 kΩ
± 15V	10 MΩ	1 MΩ

R_{set} to NEGATIVE SUPPLY (Recommended for supply voltage less than ± 6V)



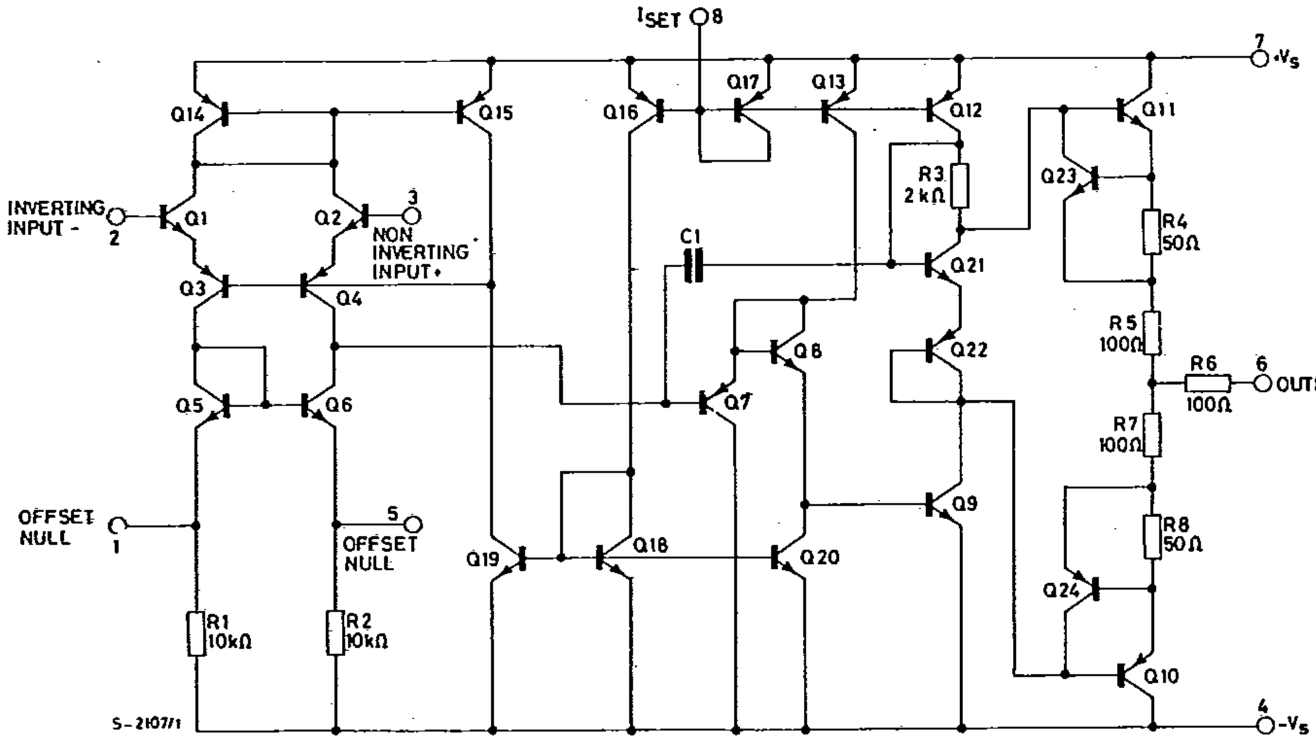
Typical R_{SET} values		
V_s	I_{SET} = 1.5μA	I_{SET} = 15μA
± 1.5V	1.6 MΩ	160 kΩ
± 3V	3.6 MΩ	360 kΩ
± 6V	7.5 MΩ	750 kΩ
± 15V	20 MΩ	2 MΩ

CONNECTION DIAGRAM AND ORDERING NUMBERS
(top views)



Temperature range	Ceramic Minidip	Plastic Minidip	SO-8 Micropackage	TO-99
Commercial 0 to 70°C	MC1776CU	MC1776CP1	MC1776CD	MC1776CG
Industrial -25 to 85°C	–	–	MC1776ID	–
Military -55 to 125°C	MC1776U	–	–	MC1776G

SCHEMATIC DIAGRAM



THERMAL DATA

			Plastic Minidip	Ceramic Minidip	TO-99	SO-8
$R_{th\ j\text{-}amb}$	Thermal resistance junction-ambient	max	120°C/W	150°C/W	155°C/W	200°C/W

ELECTRICAL CHARACTERISTICS for MC1776/I

($V_s = \pm 15V$, $T_{amb} = 25°C$ unless otherwise specified)

Symbol	Parameter	Test conditions	$I_{SET} = 1.5\ \mu A$ Min.	Typ.	Max.	$I_{SET} = 15\ \mu A$ Min.	Typ.	Max.	Unit
V_{OS}	Input offset voltage	$R_g \leq 10\ k\Omega$		2	5		2	5	mV
I_{OS}	Input offset current	$R_g \leq 10\ k\Omega$		0.7	3		2	15	nA
I_b	Input bias current			2	7.5		15	50	nA
R_i	Input resistance			50			5		MΩ
C_i	Input capacitance			2			2		pF
ΔV_{OS}	Input offset voltage adjustment range			9			18		mV
G_v	Large signal voltage gain	$R_L \geq 75\ k\Omega$ $V_o = \pm 10\ V$	106	112					dB
		$R_L \geq 5\ k\Omega$ $V_o = \pm 10\ V$				100	112		dB
R_o	Output resistance			5			1		kΩ
I_{sc}	Output short–circuit current			3			12		mA
I_s	Supply current			20	25		160	180	µA
P_S	Power consumption				0.75			5.4	mW
	Transient response (unity gain)	$V_I = 20\ mV$ $R_L \geq 5\ k\Omega$ $C_L = 100\ pF$							
	Rise time t_r			1.6			0.35		µs
	Overshoot ΔV_o			0			10		%
SR	Slew rate	$R_L \geq 5\ k\Omega$		0.1			0.8		V/µs
V_o	Output voltage swing	$R_L \geq 75\ k\Omega$	± 12	± 14					V
		$R_L \geq 5\ k\Omega$				± 10	± 13		V
The following specifications apply for T_{amb} = -55 to 125°C (MC1776), -25 to + 85°C (MC1776I)									
V_{OS}	Input offset voltage	$R_g \leq 10\ k\Omega$			6			6	mV
I_{OS}	Input offset current	T_{amb} = Max			5			15	nA
		T_{amb} = Min			10			40	nA
I_b	Input bias current	T_{amb} = Max			7.5			50	nA
		T_{amb} = Min			20			120	nA
V_i	Input voltage range		± 10			± 10			V
CMR	Common mode rejection	$R_g \leq 10\ k\Omega$	70	90		70	90		dB
SVR	Supply voltage rejection	$R_g \leq 10\ k\Omega$	76	92		76	92		dB
G_v	Large signal voltage gain	$R_L \geq 75\ k\Omega$ $V_o = \pm 10V$	100			98			dB
V_o	Output voltage swing	$R_L \geq 75\ k\Omega$	± 10			± 10			V
I_s	Supply current				30			200	µA
P_S	Power consumption				0.9			6	mW

ELECTRICAL CHARACTERISTICS for MC1776/I

($V_s = \pm 3V$, $T_{amb} = 25°C$ unless otherwise specified)

	Parameter	Test conditions	$I_{SET} = 1.5\ \mu A$			$I_{SET} = 15\ \mu A$			Unit
			Min.	Typ.	Max.	Min.	Typ.	Max.	
V_{OS}	Input offset voltage	$R_g \leq 10\ k\Omega$		2	5		2	5	mV
I_{OS}	Input offset current			0.7	3		2	15	nA
I_b	Input bias current			2	7.5		15	50	nA
R_i	Input resistance			50			5		MΩ
C_i	Input capacitance			2			2		pF
ΔV_{OS}	Input offset voltage adjustment range			9			18		mV
G_v	Large signal voltage gain	$R_L \geq 75\ k\Omega$ $V_o = \pm 1V$	94	106					dB
		$R_L \geq 5\ k\Omega$ $V_o = \pm 1V$				94	106		dB
R_o	Output resistance			5			1		kΩ
I_{sc}	Output short-circuit current			3			5		mA
I_s	Supply current			13	20		130	160	µA
P_S	Power consumption			78	120		780	960	µW
	Transient response (unity gain)	$V_i = 20\ mV$ $R_L \geq 5\ k\Omega$ $C_L \leq 100\ pF$							
	Rise time t_r			3			0.6		µs
	Overshoot ΔV_o			0			5		%
SR	Slew rate	$R_L \geq 5\ k\Omega$		0.03			0.35		V/µs
The following specifications apply for T_{amb} = -55 to 125°C (MC1776), -25 to + 85°C (MC1776I)									
V_{OS}	Input offset voltage	$R_g \leq 10\ k\Omega$			6			6	mV
I_{OS}	Input offset current	T_{amb} = Max			5			15	nA
		T_{amb} = Min			10			40	nA
I_b	Input bias current	T_{amb} = Max			7.5			50	nA
		T_{amb} = Min			20			120	nA
V_i	Input voltage range		± 1			± 1			V
CMR	Common mode rejection	$R_g \leq 10\ k\Omega$	70	86		70	86		dB
SVR	Supply voltage rejection	$R_g \leq 10\ k\Omega$	76	92		76	92		dB
G_v	Large signal voltage gain	$R_L \geq 75\ k\Omega$ $V_o = \pm 1V$	88						dB
		$R_L \geq 5\ k\Omega$ $V_o = \pm 1V$				88			dB
V_o	Output voltage swing	$R_L \geq 75\ k\Omega$	± 2	± 2.4					V
		$R_L \geq 5\ k\Omega$				± 1.9	± 2.1		V
I_s	Supply current				25			180	µA
P_S	Power consumption				150			1080	µW

ELECTRICAL CHARACTERISTICS for MC1776C

($V_s = \pm 15V$, $T_{amb} = 25°C$ unless otherwise specified)

Parameter		Test conditions	$I_{SET} = 1.5\ \mu A$ Min.	Typ.	Max.	$I_{SET} = 15\ \mu A$ Min.	Typ.	Max.	Unit
V_{OS}	Input offset voltage	$R_g \leq 10\ k\Omega$		2	6		2	6	mV
I_{OS}	Input offset current			0.7	6		2	25	nA
I_b	Input bias current			2	10		15	50	nA
R_i	Input resistance			50			5		MΩ
C_i	Input capacitance			2			2		pF
ΔV_{OS}	Input offset voltage adjustment range			9			18		mV
G_v	Large signal voltage gain	$R_L \geq 75\ k\Omega$ $V_o = \pm 10V$	94	112					dB
		$R_L \geq 5\ k\Omega$ $V_o = \pm 10V$				94	112		dB
R_o	Output resistance			5			1		kΩ
I_{sc}	Output short-circuit current			3			12		mA
I_s	Supply current			20	30		160	190	μA
P_S	Power consumption				0.9			5.7	mW
	Transient response (unity gain)	$V_i = 20\ mV$ $R_L \geq 5\ k\Omega$ $C_L \leq 100\ pF$							
	Rise time t_r			1.6			0.35		μs
	Overshoot ΔV_o			0			10		%
SR	Slew rate	$R_L \geq 5\ k\Omega$		0.1			0.8		V/μs
V_o	Output voltage swing	$R_L \geq 75\ k\Omega$	± 12	± 14					V
		$R_L \geq 5\ k\Omega$				± 10	± 13		V
The following specifications apply for $T_{amb} = 0$ to $70°C$									
V_{OS}	Input offset voltage	$R_g \leq 10\ k\Omega$			7.5			7.5	mV
I_{OS}	Input offset current	$T_{amb} = 70°C$			6			25	nA
		$T_{amb} = 0°C$			10			40	nA
I_b	Input bias current	$T_{amb} = 70°C$			10			50	nA
		$T_{amb} = 0°C$			20			100	nA
V_i	Input voltage range		± 10			± 10			V
CMR	Common mode rejection	$R_g \leq 10\ k\Omega$	70	90		70	90		dB
SVR	Supply voltage rejection	$R_g \leq 10\ k\Omega$	74	92		74	92		dB
G_v	Large signal voltage gain	$R_L \geq 75\ k\Omega$ $V_o = \pm 10V$	94			94			dB
V_o	Output voltage swing	$R_L \geq 75\ k\Omega$	± 10			± 10			V
I_s	Supply current				35			200	μA
P_S	Power consumption				1.05			6	mW

ELECTRICAL CHARACTERISTICS for MC1776C

($V_s = \pm 3V$, $T_{amb} = 25°C$ unless otherwise specified)

Symbol	Parameter	Test conditions	$I_{SET} = 1.5\ \mu A$ Min.	Typ.	Max.	$I_{SET} = 15\ \mu A$ Min.	Typ.	Max.	Unit
V_{OS}	Input offset voltage	$R_g \leq 10\ k\Omega$		2	6		2	6	mV
I_{OS}	Input offset current			0.7	6		2	25	nA
I_b	Input bias current			2	10		15	50	nA
R_i	Input resistance			50			5		MΩ
C_i	Input capacitance			2			2		pF
ΔV_{OS}	Input offset voltage adjustment range			9			18		mV
G_v	Large signal voltage gain	$R_L \geq 75\ k\Omega$ $V_o = \pm 1V$	88	106					dB
		$R_L \geq 5\ k\Omega$ $V_o = \pm 1V$				88	106		dB
R_o	Output resistance			5			1		kΩ
I_{sc}	Output short-circuit current			3			5		mA
I_s	Supply current			13	20		130	170	μA
P_S	Power consumption			78	120		780	1020	μW
	Transient response (unity gain)	$V_i = 20\ mV$ $R_L \geq 5\ k\Omega$ $C_L \leq 100\ pF$							
	Rise time t_r			3			0.6		μs
	Overshoot ΔV_o			0			5		%
SR	Slew rate	$R_L \geq 5\ k\Omega$		0.03			0.35		V/μs
The following specifications apply for $T_{amb} = 0$ to $70°C$									
V_{OS}	Input offset voltage	$R_g \leq 10\ k\Omega$			7.5			7.5	mV
I_{OS}	Input offset current	$T_{amb} = 70°C$			6			25	nA
		$T_{amb} = 0°C$			10			40	nA
I_b	Input bias current	$T_{amb} = 70°C$			10			50	nA
		$T_{amb} = 0°C$			20			100	nA
V_I	Input voltage range		± 1			± 1			V
CMR	Common mode rejection	$R_g \leq 10\ k\Omega$	70	86		70	86		dB
SVR	Supply voltage rejection	$R_g \leq 10\ k\Omega$	74	92		74	92		dB
G_v	Large signal voltage gain	$R_L \geq 75\ k\Omega$ $V_o = \pm 1V$	88						dB
		$R_L \geq 5\ k\Omega$ $V_o = \pm 1V$				88			dB
V_o	Output voltage swing	$R_L \geq 75\ k\Omega$	± 2	± 2.4					V
		$R_L \geq 5\ k\Omega$				± 2	± 2.1		V
I_s	Supply current				25			180	μA
P_S	Power consumption				150			1080	μW

Fig. 1 - Input bias current vs. set current

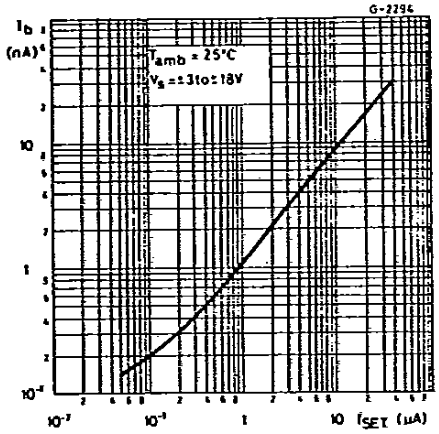


Fig. 2 - Input bias current vs. ambient temperature

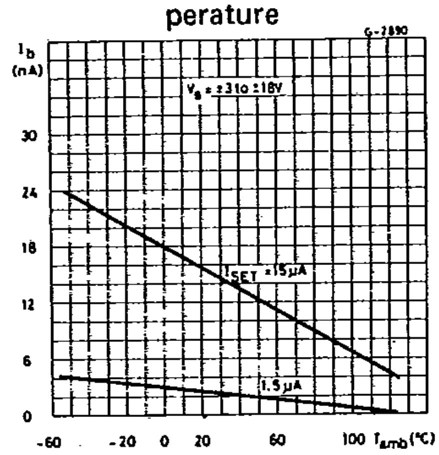


Fig. 3 - Input offset current vs. ambient temperature

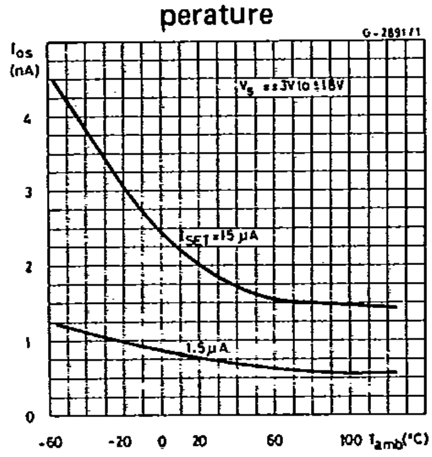


Fig. 4 - Change in input offset voltage vs. set current

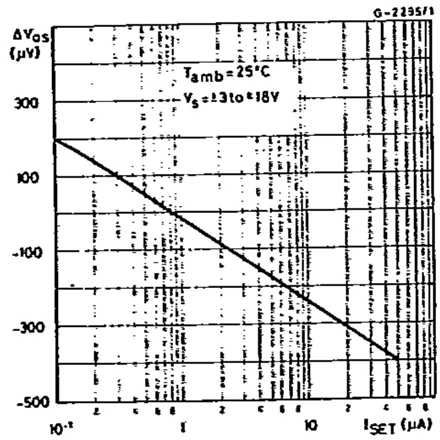


Fig. 5 - Change in input offset voltage vs. ambient temperature (unnulled)

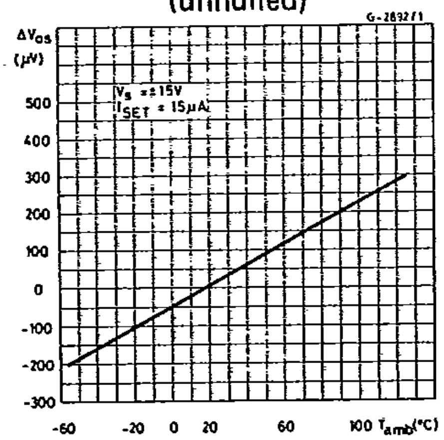


Fig. 6 - Input noise voltage vs. set current

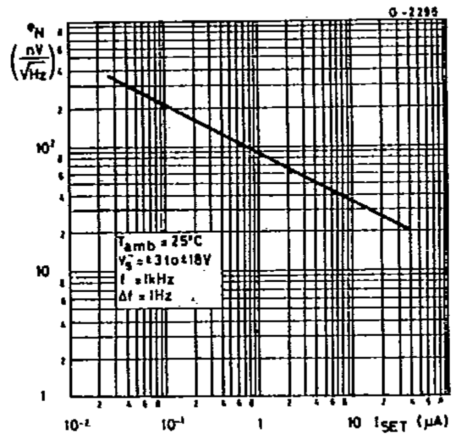


Fig. 7 - Input noise voltage and current vs. frequency

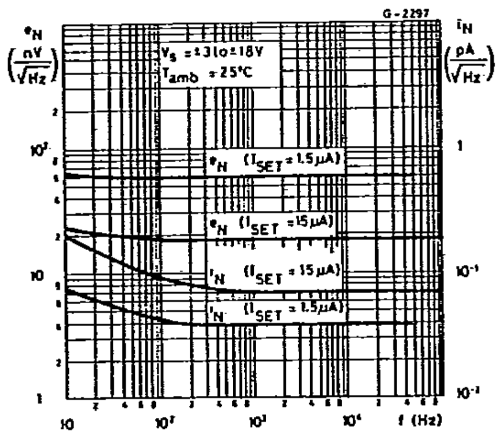


Fig. 8 - Input noise current vs. set current

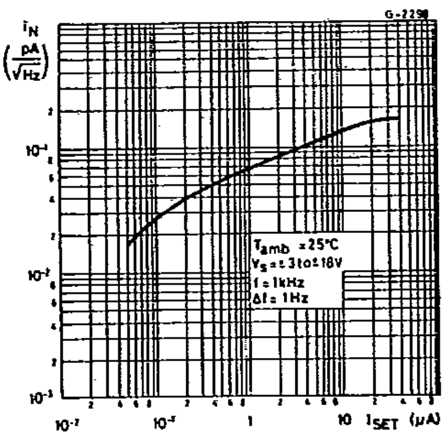


Fig. 9 - Optimum source resistance for minimum noise vs. set current.

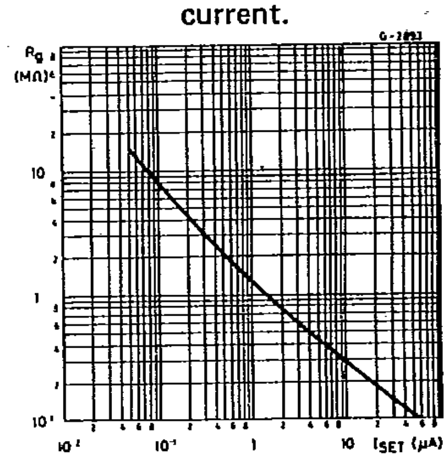


Fig. 10 - Output voltage swing vs. load resistance

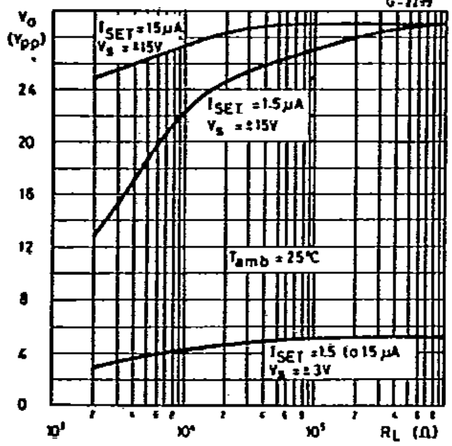


Fig. 11 - Output voltage swing vs. supply voltage

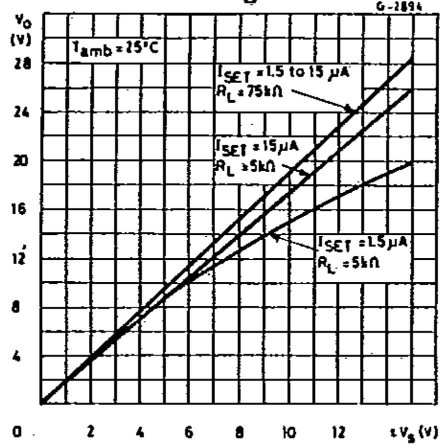


Fig. 12 - Gain bandwidth product vs. set current

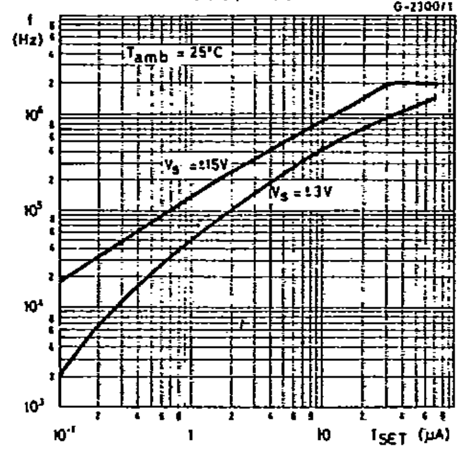


Fig. 13 - Open loop voltage gain vs. ambient temperature

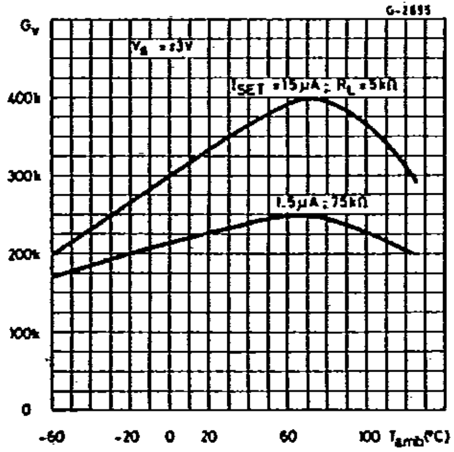


Fig. 14 - Open loop voltage gain vs. ambient temperature

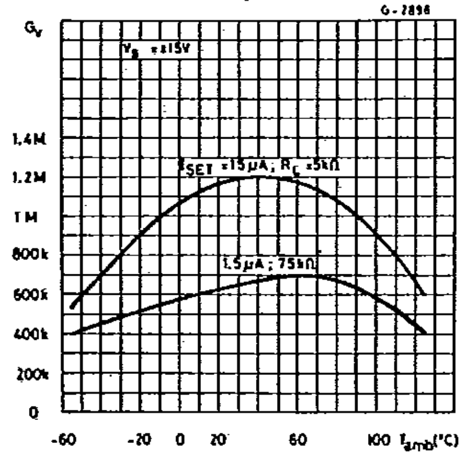


Fig. 15 - Open loop voltage gain vs. set current

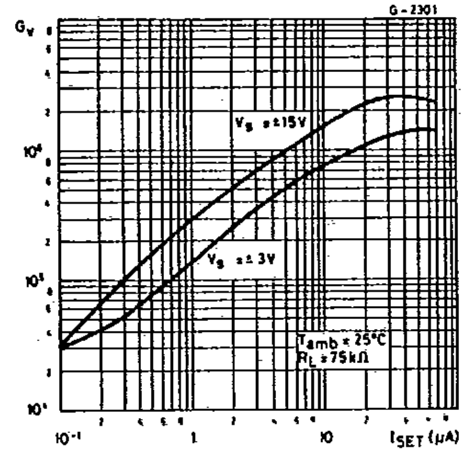


Fig. 16 - Common mode rejection vs. set current

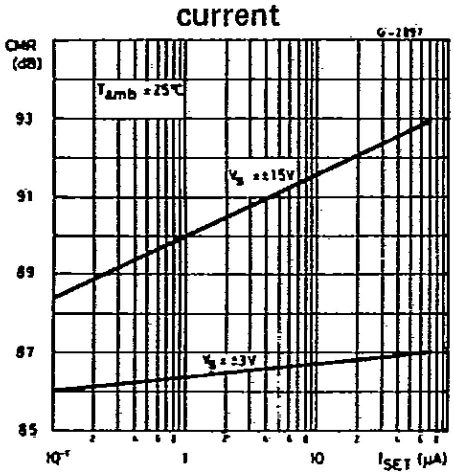


Fig. 17 - Supply voltage rejection vs. set current

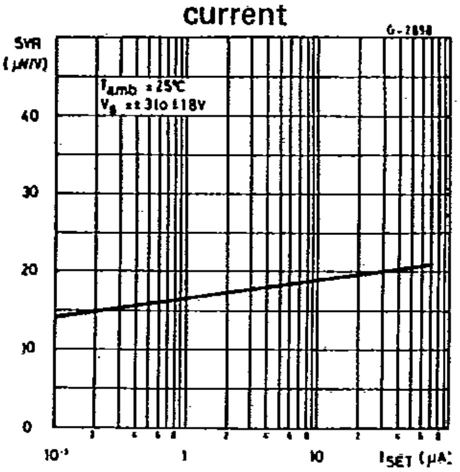


Fig. 18 - Supply current vs. ambient temperature

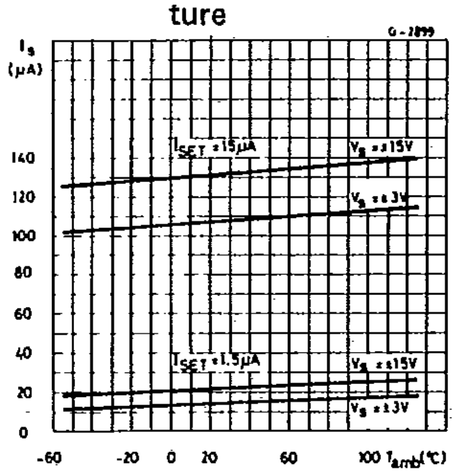


Fig. 19 – Standby supply current vs. set current

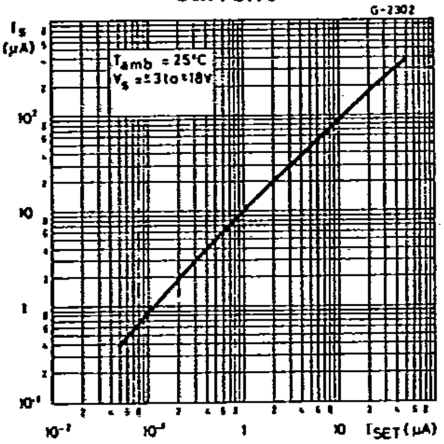


Fig. 20 – Slew rate vs. set current

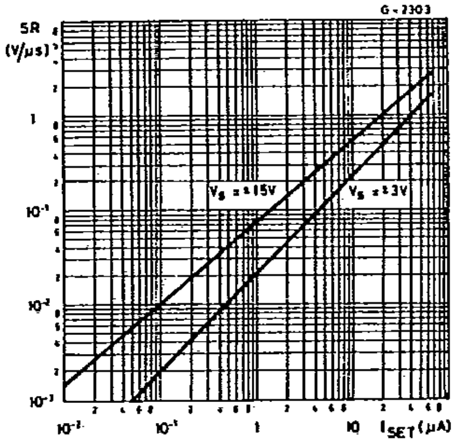
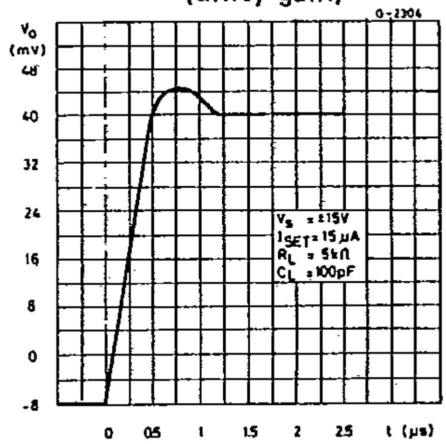


Fig. 21 – Voltage follower transient response (unity gain)



TYPICAL APPLICATIONS

Fig. 22 – High accuracy sample and hold

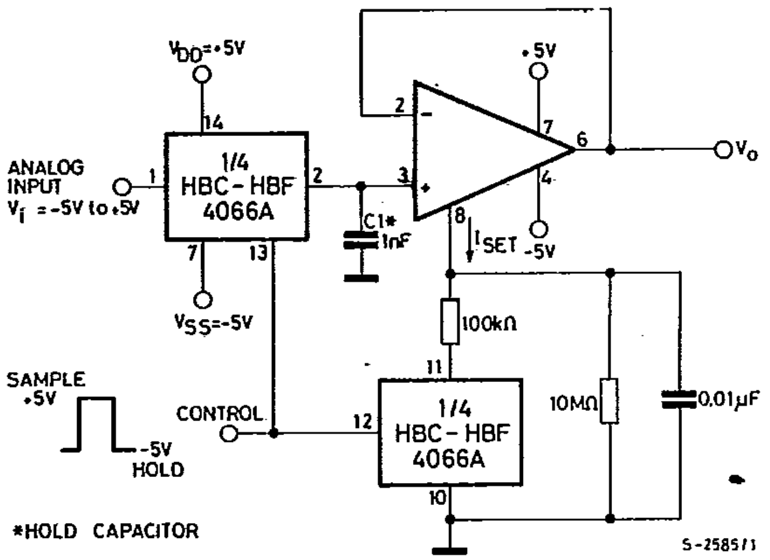


Fig. 23 – Nanowatt amplifier ($V_S = \pm 1.2V$)

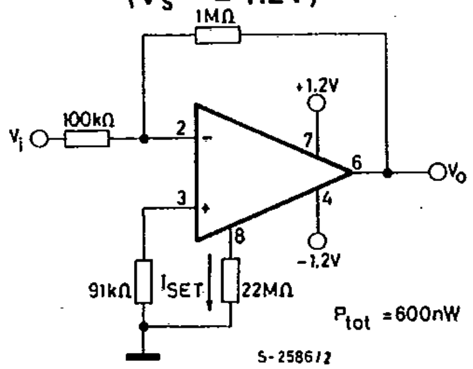
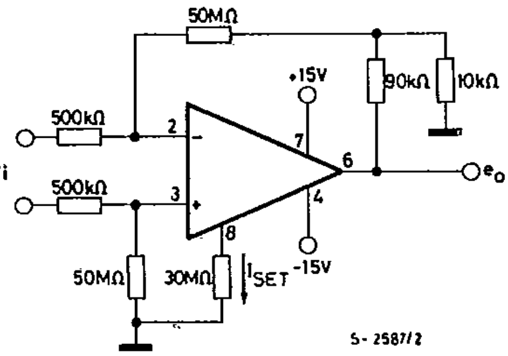


Fig. 24 – High input impedance amplifier



TYPICAL APPLICATIONS (continued)

Fig. 25 – Multiplexing and signal conditioning

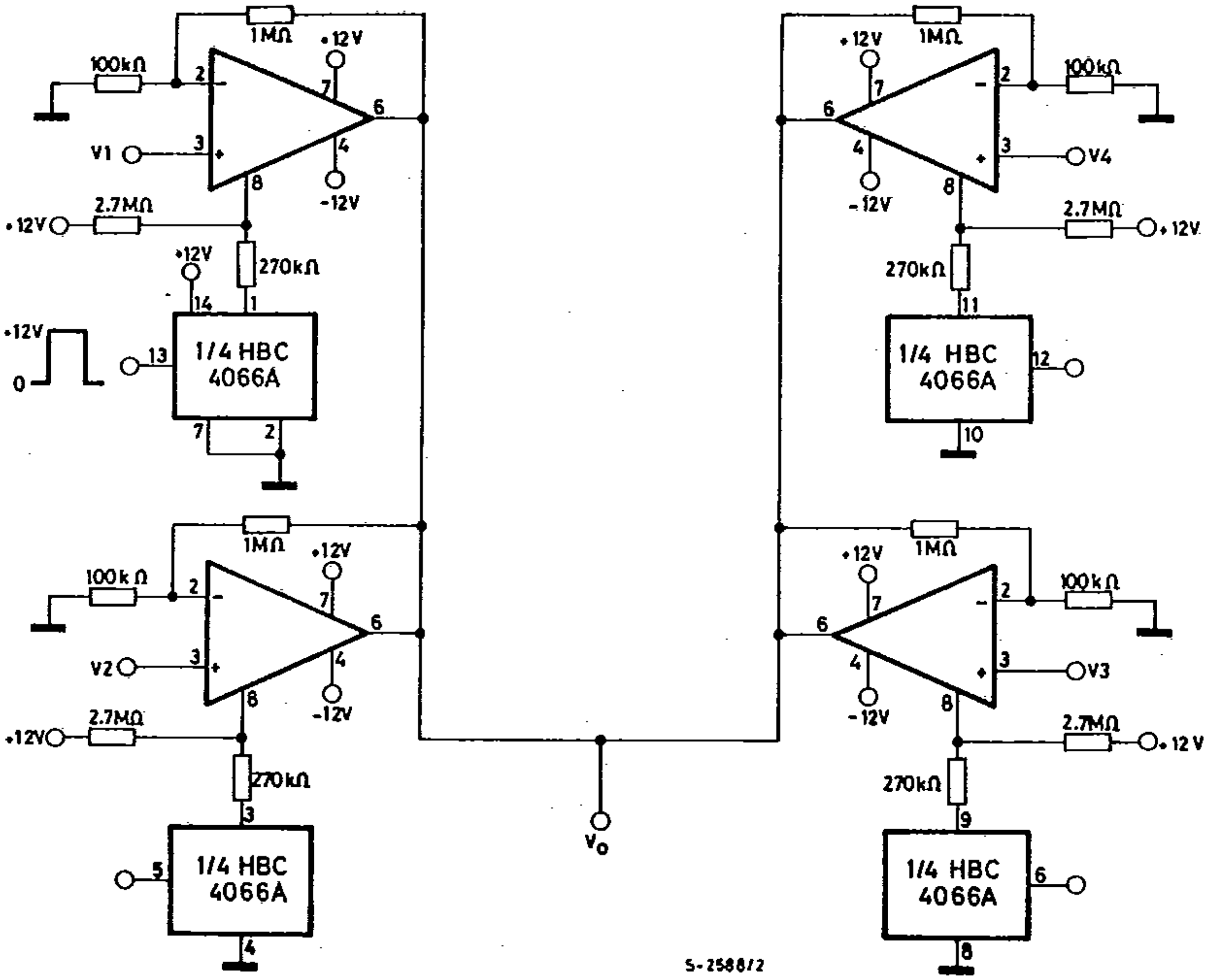


Fig. 26 – Multiple feedback bandpass filter

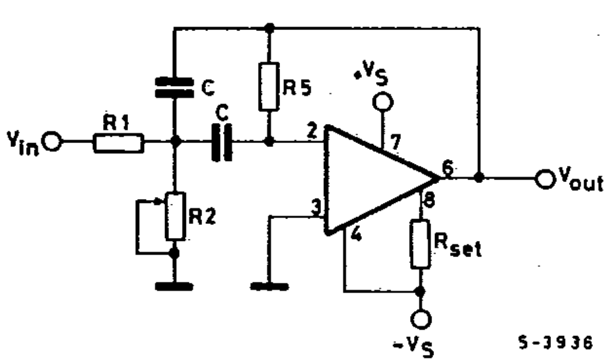
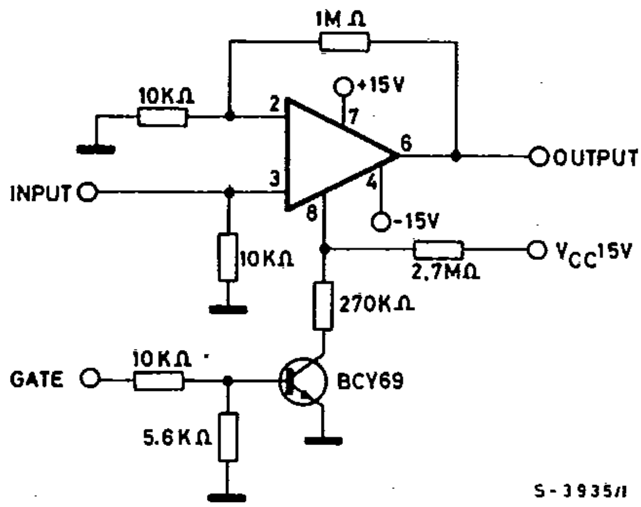
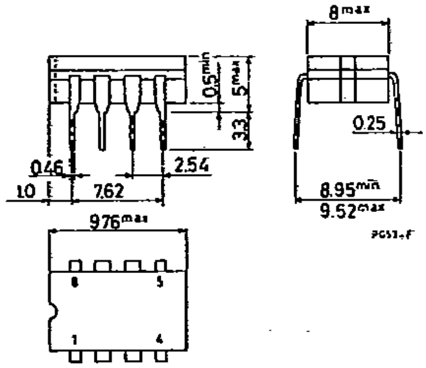


Fig. 27 – Gated amplifier

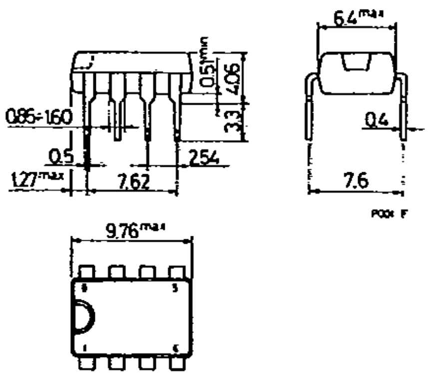


MECHANICAL DATA (Dimensions in mm)

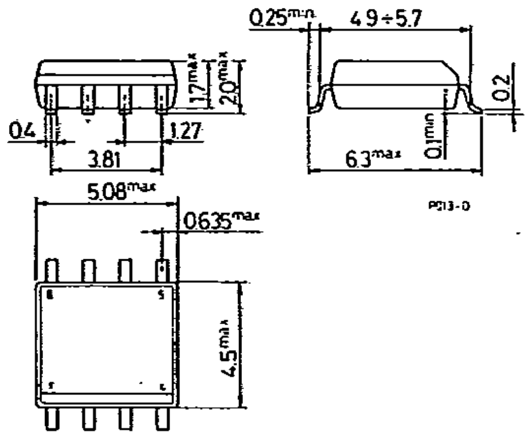
Minidip (Ceramic)



Minidip (Plastic)



SO-8 (Micropackage)



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