National Semiconductor

LM776
Multi-Purpose Programmable Operational Amplifier

General Description

The LM776 Programmable Operational Amplifier is constructed using the Planar Epitaxial process. High input impedance, low supply currents, and low input noise over a wide range of operating supply voltages coupled with programmable electrical characteristics result in 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 or current source that sets the chip quiescent current for nano watt 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 time integrators, active filters, and sample and hold circuits.

Features

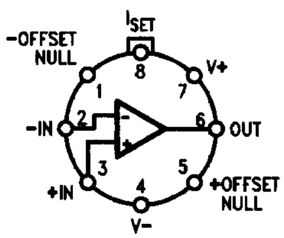
- Micropower consumption
- ±1.2V to ±18V operation
- No frequency compensation required
- Low input bias currents
- Wide programming range
- High slew rate
- Low noise
- Short circuit protection
- Offset null capability
- No latch up

Applications

- Battery-powered instrumentation
- High-gain amp
- Filters
- Sample-and-Hold

Connection Diagrams

8-Lead Metal Package



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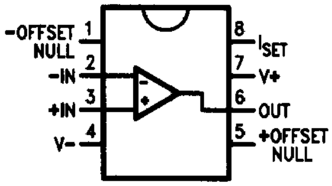
Top View

Lead 4 connected to case.

8-Lead DIP



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Top View

Ordering Information

Device Code	Package Code	Package Description
LM776H	H08A	Metal
LM776CH	H08A	Metal
LM776CN	N08E	Molded DIP

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Absolute Maximum Ratings

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Storage Temperature Range	
Metal Can	−65°C to +175°C
Molded DIP	−65°C to +150°C
Operating Temperature Range	
Extended (LM776M)	−55°C to +125°C
Commercial (LM776C)	0°C to +70°C
Lead Temperature	
Metal Can (Soldering, 60 sec.)	300°C
Molded DIP (Soldering, 10 sec.)	265°C
Internal Power Dissipation (Notes 1, 2)	
8L-Metal Can	1.00W
8L-Molded DIP	0.93W
Supply Voltage	±18V
Differential Input Voltage	±30V
Input Voltage (Note 3)	±15V
Voltage Between Offset Null and V^-	±0.5V
Output Short Circuit Duration (Note 4)	Indefinite
I_{SET} (Maximum Current at I_{SET})	500 µA
V_{SET} (Maximum Voltage to Ground at I_{SET})	$(V^+ - 2.0V) \le V_{SET} \le V^+$
ESD Tolerance	(to be determined)

LM776

Electrical Characteristics $T_A = 25°C$, $V_{CC} = \pm 15V$, unless otherwise specified

Symbol	Parameter	Conditions	I_{SET} = 1.5 µA			I_{SET} = 15 µA			Units
			Min	Typ	Max	Min	Typ	Max	
V_{IO}	Input Offset Voltage	$R_S \le 10\ k\Omega$		2.0	5.0		2.0	5.0	mV
$V_{IO\ adj}$	Input Offset Voltage Adjustment Range			9.0			18		mV
I_{IO}	Input Offset Current			0.7	3.0		2.0	15	nA
I_{IB}	Input Bias Current			2.0	7.5		15	50	nA
Z_I	Input Impedance			50			5.0		MΩ
I_{CC}	Supply Current			20	25		160	180	µA
P_c	Power Consumption				0.75			5.4	mW
I_{OS}	Output Short Circuit Current			3.0			12		mA
A_{VS}	Large Signal Voltage Gain	$V_O = \pm 10V$, $R_L \ge 75\ k\Omega$	200	400					V/mV
		$V_O = \pm 10V$, $R_L \ge 5.0\ k\Omega$				100	400		
V_{OP}	Output Voltage Swing	$R_L = 75\ k\Omega$	±12	±14					V
		$R_L = 5.0\ k\Omega$				±10	±13		
TR	Transient Response — Rise Time	$V_I = 20\ mV$, $R_L = 5.0\ k\Omega$, $C_L = 100\ pF$, $A_V = 1.0$		1.6			0.35		µs
	Transient Response — Overshoot			0			10		%
SR	Slew Rate	$R_L = 5.0\ k\Omega$, $A_V = 1.0$		0.1			0.8		V/µs
The following specifications apply $-55°C \le T_A \le +125°C$									
V_{IO}	Input Offset Voltage	$R_S \le 10\ k\Omega$			6.0			6.0	mV
I_{IO}	Input Offset Current	$T_A = +125°C$			5.0			15	nA
		$T_A = -55°C$			10			40	
I_{IB}	Input Bias Current	$T_A = +125°C$			7.5			50	nA
		$T_A = -55°C$			20			120	
I_{CC}	Supply Current				30			200	µA
P_c	Power Consumption				0.9			6.0	mW
CMR	Common Mode Rejection	$R_S \le 10\ k\Omega$	70	90		70	90		dB
V_{IR}	Input Voltage Range		±10			±10			V
PSRR	Power Supply Rejection Ratio	$R_S \le 10\ k\Omega$		25	150		25	150	µV/V
A_{VS}	Large Signal Voltage Gain	$V_O = +10V$, $R_L \ge 75\ k\Omega$	100			75			V/mV
V_{OP}	Output Voltage Swing	$R_L = 75\ k\Omega$	±10			±10			V

LM776

Electrical Characteristics $T_A = 25°C, V_{CC} = \pm 3.0V$, unless otherwise specified

Symbol	Parameter	Conditions	$I_{SET} = 1.5\ \mu A$			$I_{SET} = 15\ \mu A$			Units
			Min	Typ	Max	Min	Typ	Max	
V_{IO}	Input Offset Voltage	$R_S \le 10\ k\Omega$		2.0	5.0		2.0	5.0	mV
$V_{IO\ adj}$	Input Offset Voltage Adjustment Range			9.0			18		mV
I_{IO}	Input Offset Current			0.7	3.0		2.0	15	nA
I_{IB}	Input Bias Current			2.0	7.5		15	50	nA
Z_I	Input Impedance			50			5.0		MΩ
I_{CC}	Supply Current			13	20		130	160	μA
P_c	Power Consumption			78	120		780	960	μW
I_{OS}	Output Short Circuit Current			3.0			5.0		mA
A_{VS}	Large Signal Voltage Gain	$V_O = \pm 1.0V, R_L \ge 75\ k\Omega$	50	200					V/mV
		$V_O = \pm 1.0V, R_L \ge 5.0\ k\Omega$				50	200		
TR	Transient Response — Rise Time	$V_I = 20\ mV, R_L = 5.0\ k\Omega, C_L = 100\ pF, A_V = 1.0$		3.0			0.6		μs
	Transient Response — Overshoot			0			5		%
SR	Slew Rate	$R_L = 5.0\ k\Omega, A_V = 1.0$		0.03			0.35		V/μs
The following specifications apply $-55°C \le T_A \le +125°C$									
V_{IO}	Input Offset Voltage	$R_S \le 10\ k\Omega$			6.0			6.0	mV
I_{IO}	Input Offset Current	$T_A = +125°C$			5.0			15	nA
		$T_A = -55°C$			10			40	
I_{IB}	Input Bias Current	$T_A = +125°C$			7.5			50	nA
		$T_A = -55°C$			20			120	
I_{CC}	Supply Current				25			180	μA
P_c	Power Consumption				150			1080	μW
CMR	Common Mode Rejection	$R_S \le 10\ k\Omega$	70	86		70	86		dB
V_{IR}	Input Voltage Range		±1.0			±1.0			V
PSRR	Power Supply Rejection Ratio	$R_S \le 10\ k\Omega$		25	150		25	150	μV/V
A_{VS}	Large Signal Voltage Gain	$V_O = \pm 1.0V, R_L \ge 75\ k\Omega$	25						V/mV
		$V_O = \pm 1.0V, R_L \ge 5.0\ k\Omega$				25			
V_{OP}	Output Voltage Swing	$R_L = 75\ k\Omega$	±2.0	±2.4					V
		$R_L = 5.0\ k\Omega$				±1.9	±2.1		

Note 1: $T_{J\ Max} = 150°C$ for the Molded DIP, and 175°C for the Metal Can.

Note 2: Ratings apply to ambient temperature at 25°C. Above this temperature, derate the 8L-Metal Can at 6.7 mW/°C, and the 8L-Molded DIP at 7.5 mW/°C.

Note 3: For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.

Note 4: Short Circuit may be to ground or either supply. Rating applies to 125°C case temperature or 75°C ambient temperature for $I_{SET} \le 30\ \mu A$.

LM776C

Electrical Characteristics $T_A = 25°C$, $V_{CC} = \pm 15V$, unless otherwise specified

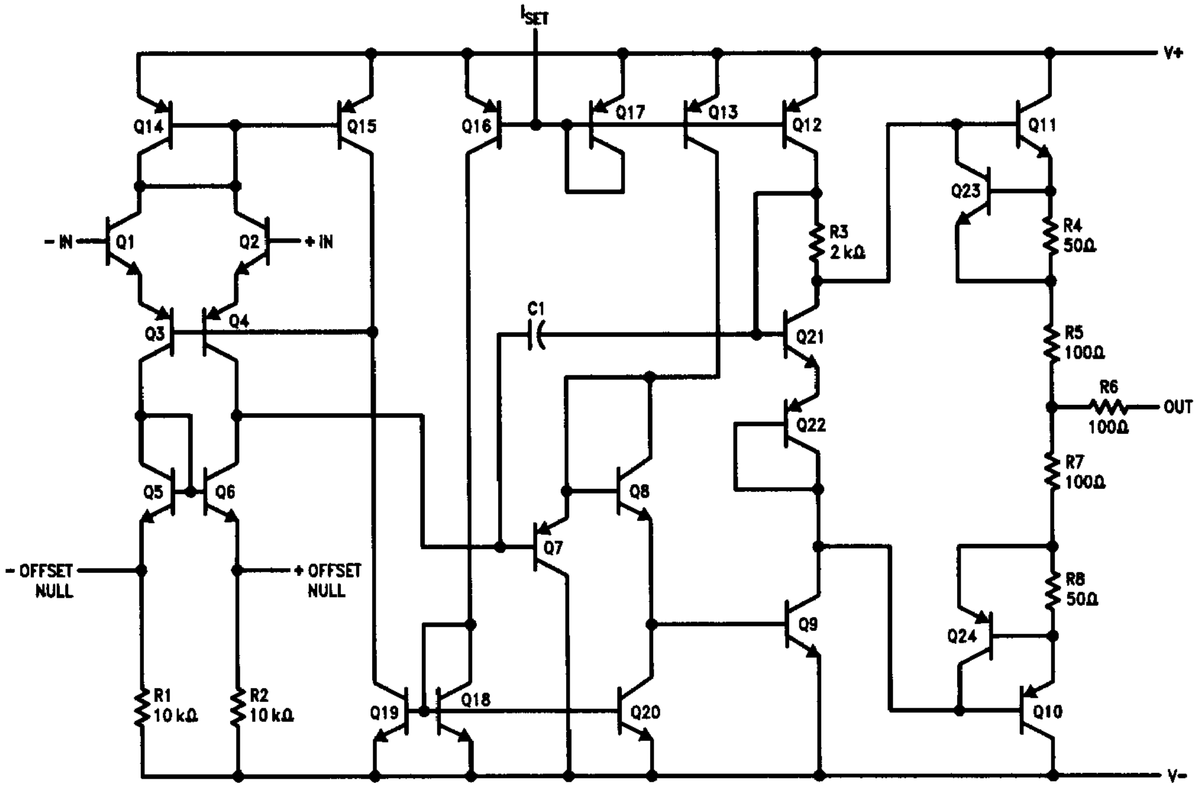
Symbol	Parameter	Conditions	$I_{SET} = 1.5\ \mu A$			$I_{SET} = 15\ \mu A$			Units
			Min	Typ	Max	Min	Typ	Max	
V_{IO}	Input Offset Voltage	$R_S \leq 10\ k\Omega$		2.0	6.0		2.0	6.0	mV
$V_{IO\ adj}$	Input Offset Voltage Adjustment Range			9.0			18		mV
I_{IO}	Input Offset Current			0.7	6.0		2.0	25	nA
I_{IB}	Input Bias Current			2.0	10		15	50	nA
Z_I	Input Impedance			50			5.0		MΩ
I_{CC}	Supply Current			20	30		160	190	μA
P_c	Power Consumption				0.9			5.7	mW
I_{OS}	Output Short Circuit Current			3.0			12		mA
A_{VS}	Large Signal Voltage Gain	$V_O = \pm 10V$, $R_L \geq 75\ k\Omega$	50	400					V/mV
		$V_O = \pm 10V$, $R_L \geq 5.0\ k\Omega$				50	400		
V_{OP}	Output Voltage Swing	$R_L = 75\ k\Omega$	±12	±14					V
		$R_L = 5.0\ k\Omega$				±10	±13		
TR	Transient Response: Rise Time	$V_I = 20\ mV$, $R_L \geq 5.0\ k\Omega$, $C_L = 100\ pF$, $A_V = 1.0$		1.6			0.35		μs
	Transient Response: Overshoot			0			10		%
SR	Slew Rate	$R_L = 5.0\ k\Omega$, $A_V = 1.0$		0.1			0.8		V/μs
The following specifications apply $0°C \leq T_A \leq +70°C$									
V_{IO}	Input Offset Voltage	$R_S \leq 10\ k\Omega$			7.5			7.5	mV
I_{IO}	Input Offset Current	$T_A = 70°C$			6.0			25	nA
		$T_A = 0°C$			10			40	
I_{IB}	Input Bias Current	$T_A = 70°C$			10			50	nA
		$T_A = 0°C$			20			100	
I_{CC}	Supply Current				35			200	μA
P_c	Power Consumption				1.05			6.0	mW
CMR	Common Mode Rejection	$R_S \leq 10\ k\Omega$	70	90		70	90		dB
V_{IR}	Input Voltage Range		±10			±10			V
PSRR	Power Supply Rejection Ratio	$R_S \leq 10\ k\Omega$		25	200		25	200	μV/V
A_{VS}	Large Signal Voltage Gain	$V_O = \pm 10V$, $R_L \geq 75\ k\Omega$	50			50			V/mV
V_{OP}	Output Voltage Swing	$R_L = 75\ k\Omega$	±10			±10			V

LM776C

Electrical Characteristics $T_A = 25°C$, $V_{CC} = \pm 3.0V$, unless otherwise specified

Symbol	Parameter	Conditions	$I_{SET} = 1.5\ \mu A$			$I_{SET} = 15\ \mu A$			Units
			Min	Typ	Max	Min	Typ	Max	
V_{IO}	Input Offset Voltage	$R_S \le 10\ k\Omega$		2.0	6.0		2.0	6.0	mV
$V_{IO\ adj}$	Input Offset Voltage Adjustment Range			9.0			18		mV
I_{IO}	Input Offset Current			0.7	6.0		2.0	25	nA
I_{IB}	Input Bias Current			2.0	10		15	50	nA
Z_I	Input Impedance			50			5.0		MΩ
I_{CC}	Supply Current			13	20		130	170	μA
P_c	Power Consumption			78	120		780	1020	μW
I_{OS}	Output Short Circuit Current			3.0			5.0		mA
A_{VS}	Large Signal Voltage Gain	$V_O = \pm 1.0V$, $R_L \ge 75\ k\Omega$	25	200					V/mV
		$V_O = \pm 1.0V$, $R_L \ge 5.0\ k\Omega$				25	200		
TR	Transient Response — Rise Time	$V_I = 20\ mV$, $R_L \ge 5.0\ k\Omega$, $C_L = 100\ pF$, $A_V = 1.0$		3.0			0.6		μs
	Transient Response — Overshoot			0			5		%
SR	Slew Rate	$R_L = 5.0\ k\Omega$, $A_V = 1.0$		0.03			0.35		V/μs
The following specifications apply $0°C \le T_A \le +70°C$									
V_{IO}	Input Offset Voltage	$R_S \le 10\ k\Omega$			7.5			7.5	mV
I_{IO}	Input Offset Current	$T_A = 70°C$			6.0			25	nA
		$T_A = 0°C$			10			40	
I_{IB}	Input Bias Current	$T_A = 70°C$			10			50	nA
		$T_A = 0°C$			20			100	
I_{CC}	Supply Current				25			180	μA
P_c	Power Consumption				150			1080	μW
CMR	Common Mode Rejection	$R_S \le 10\ k\Omega$	70	86		70	86		dB
V_{IR}	Input Voltage Range		±1.0			±1.0			V
PSRR	Power Supply Rejection Ratio	$R_S \le 10\ k\Omega$		25	200		25	200	μV/V
A_{VS}	Large Signal Voltage Gain	$V_O = \pm 1.0V$, $R_L \ge 75\ k\Omega$	25						V/mV
		$V_O = \pm 1.0V$, $R_L \ge 5.0\ k\Omega$				25			
V_{OP}	Output Voltage Swing	$R_L = 75\ k\Omega$	±2.0	±2.4					V
		$R_L = 5.0\ k\Omega$				±2.0	±2.1		

Equivalent Circuit



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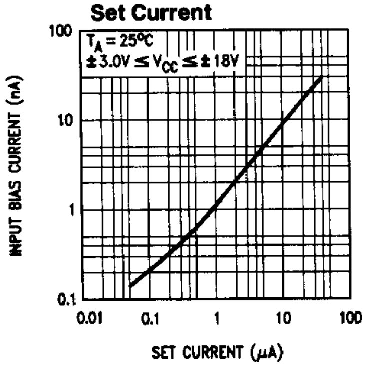
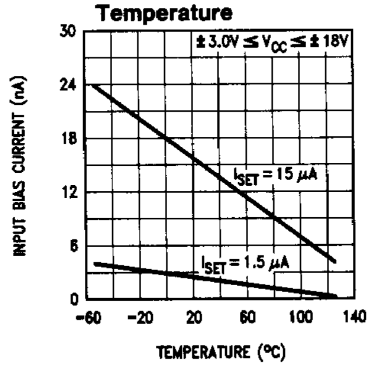
Typical Performance Characteristics for LM776 and LM776C

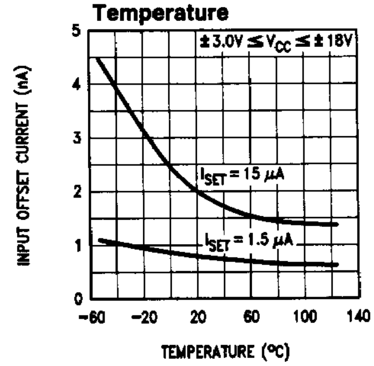
Input Bias Current vs Set Current



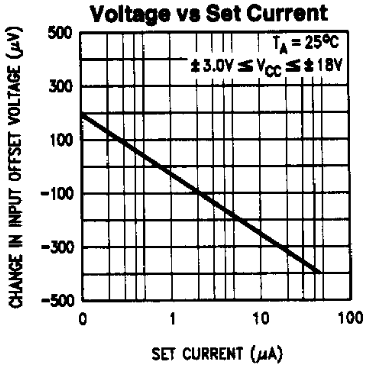
Input Bias Current vs Temperature



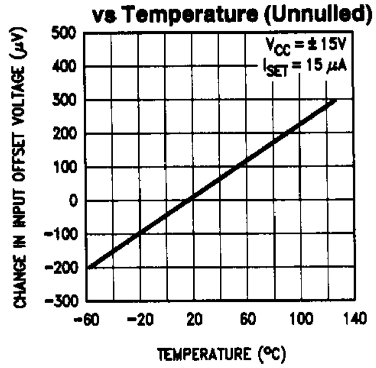
Input Offset Current vs Temperature



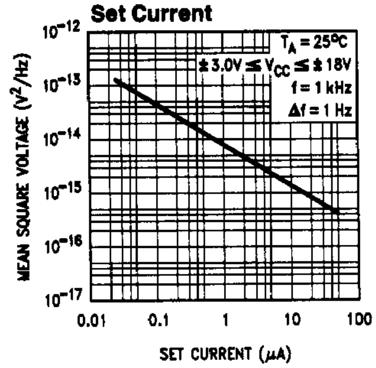
Change in Input Offset Voltage vs Set Current



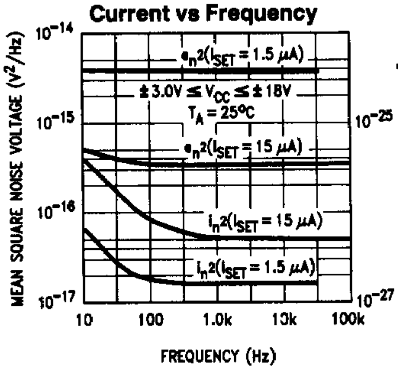
Change in Input Offset Voltage vs Temperature (Unnulled)



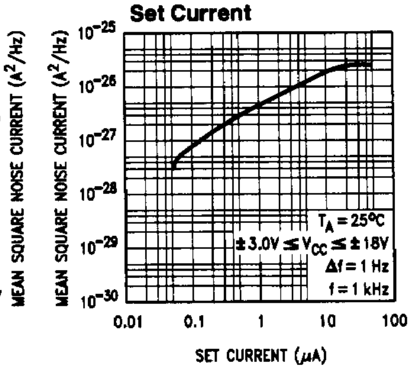
Input Noise Voltage vs Set Current



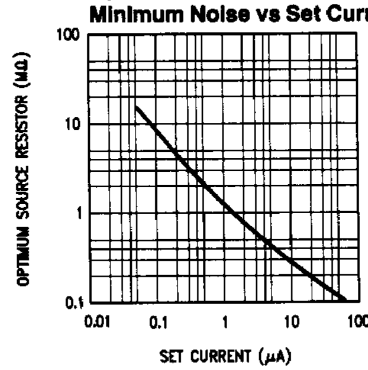
Input Noise Voltage and Current vs Frequency



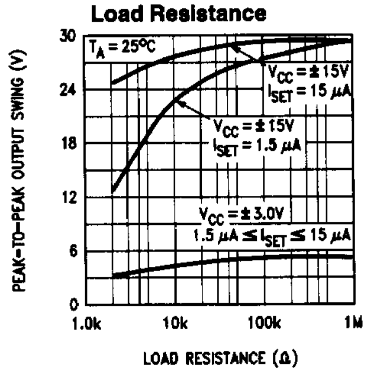
Input Noise Current vs Set Current



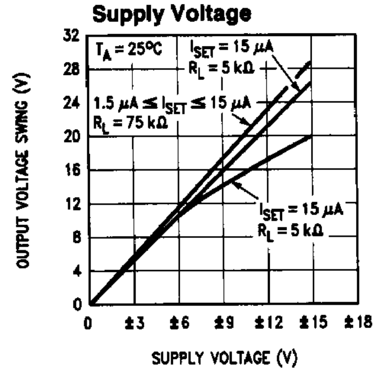
Optimum Source Resistor for Minimum Noise vs Set Current



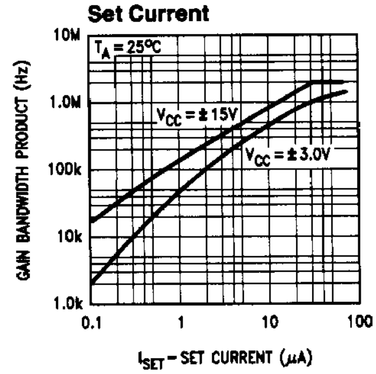
Output Voltage Swing vs Load Resistance



Output Voltage Swing vs Supply Voltage



Gain Bandwidth Product vs Set Current



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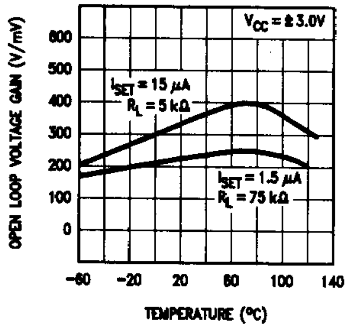
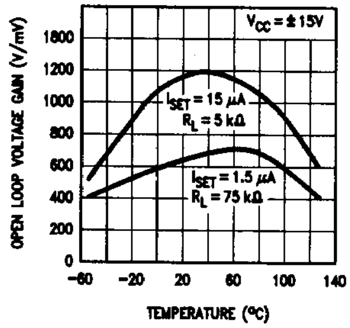
Typical Performance Characteristics for LM776 and LM776C (Continued)

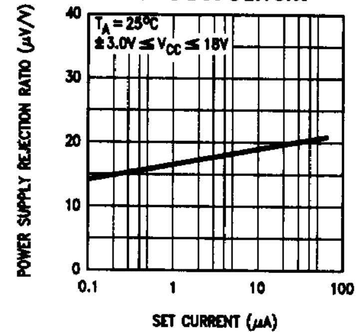
Voltage Gain vs Temperature



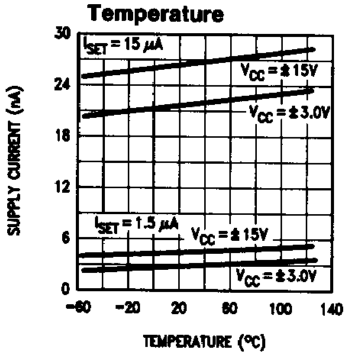
Voltage Gain vs Temperature



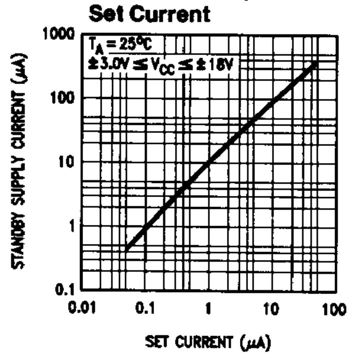
Power Supply Rejection Ratio vs Set Current



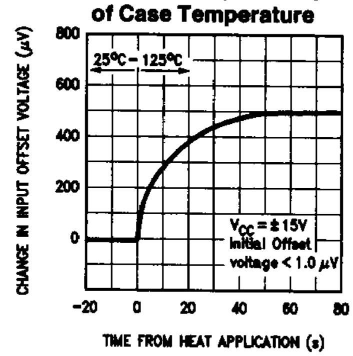
Supply Current vs Temperature



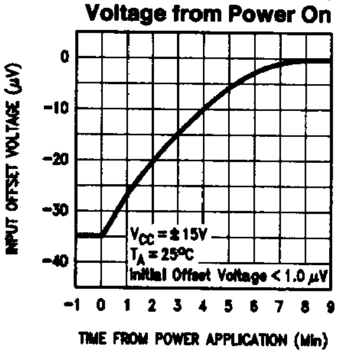
Standby Supply Current vs Set Current



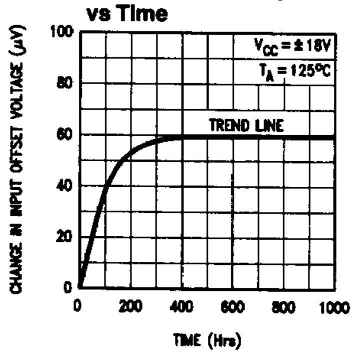
Thermal Response of Input Offset Voltage to Step Change of Case Temperature



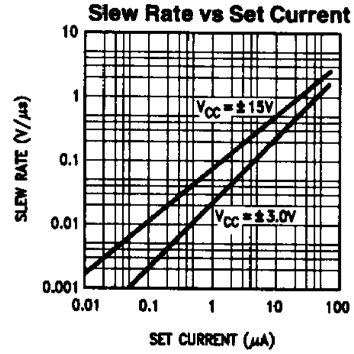
Stabilization Time of Input Offset Voltage from Power On



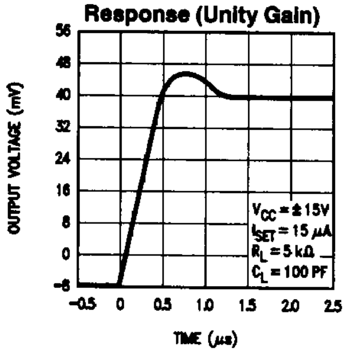
Input Offset Voltage Drift vs Time



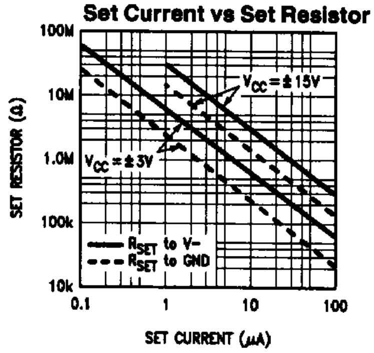
Slew Rate vs Set Current



Voltage Follower Transient Response (Unity Gain)



Set Current vs Set Resistor



TL/H/10073–5

Applications Information

Quiescent Current Setting Resistor (I_{SET} to V^-)

V_S	I_{SET}	
	1.5 µA	15 µA
±1.5V	1.7 MΩ	170 kΩ
±3.0V	3.6 MΩ	360 kΩ
±6.0V	7.5 MΩ	750 kΩ
±15V	20 MΩ	2.0 MΩ

Note: The LM776 may be operated with R_{SET} connected to ground or V.

I_{SET} Equations

$$I_{SET} = \frac{(V^+) - 0.7 - (V^-)}{R_{SET}}$$

where:

R_{SET} is connected to V^-

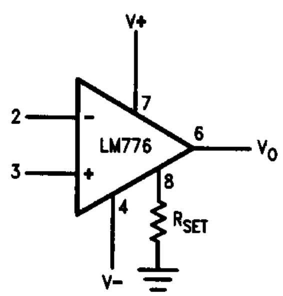
$$I_{SET} = \frac{(V^+) - 0.7}{R_{SET}}$$

where:

R_{SET} is connected to ground.

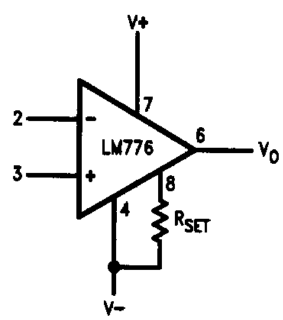
Biasing Circuits

Resistor Biasing



TL/H/10073-6

R_{SET} Connected to Ground

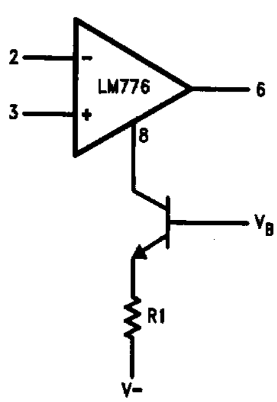


TL/H/10073-7

R_{SET} Connected to V^-

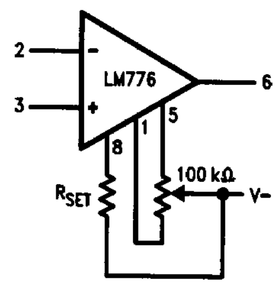
*Recommended for supply voltages less than ±6V.

Transistor Current Biasing



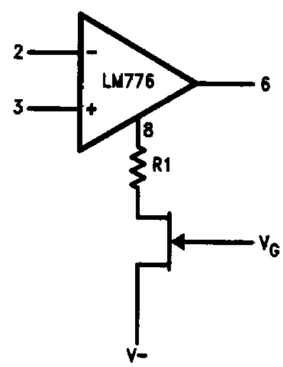
TL/H/10073-8

Voltage Offset Null Circuit



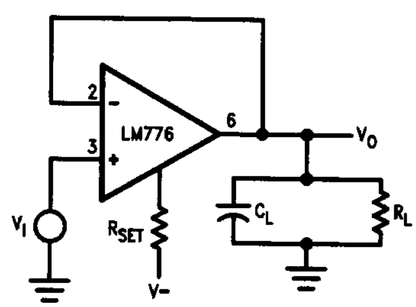
TL/H/10073-9

FET Current Source Biasing



TL/H/10073-10

Transient Response Test Circuit



TL/H/10073-11

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