Low Noise, Precision Instrumentation Amplifier

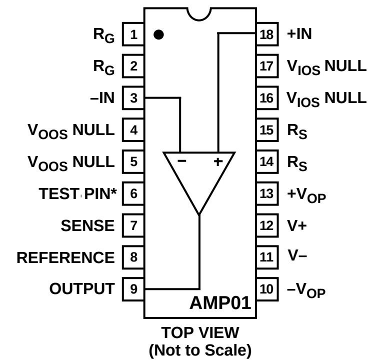
AMP01*

FEATURES

Low Offset Voltage: 50 μV Max
Very Low Offset Voltage Drift: 0.3 μV/°C Max
Low Noise: 0.12 μV p-p (0.1 Hz to 10 Hz)
Excellent Output Drive: ±10 V at ±50 mA
Capacitive Load Stability: to 1 μF
Gain Range: 0.1 to 10,000
Excellent Linearity: 16-Bit at G = 1000
High CMR: 125 dB min (G = 1000)
Low Bias Current: 4 nA Max
May Be Configured as a Precision Op Amp
Output-Stage Thermal Shutdown
Available in Die Form

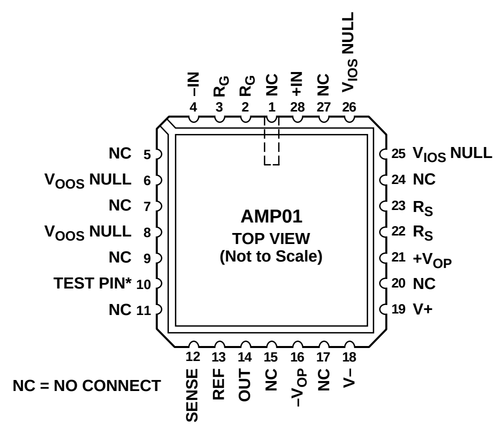
PIN CONFIGURATIONS

18-Lead Cerdip



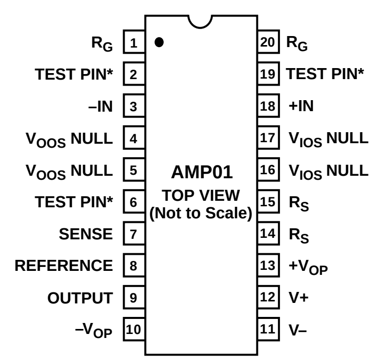
*MAKE NO ELECTRICAL CONNECTION

AMP01 BTC/883
28-Terminal LCC



*MAKE NO ELECTRICAL CONNECTION

20-Lead SOIC



*MAKE NO ELECTRICAL CONNECTION

GENERAL DESCRIPTION

The AMP01 is a monolithic instrumentation amplifier designed for high-precision data acquisition and instrumentation applications. The design combines the conventional features of an instrumentation amplifier with a high current output stage. The output remains stable with high capacitance loads (1 μF), a unique ability for an instrumentation amplifier. Consequently, the AMP01 can amplify low level signals for transmission through long cables without requiring an output buffer. The output stage may be configured as a voltage or current generator.

Input offset voltage is very low (20 μV), which generally eliminates the external null potentiometer. Temperature changes have minimal effect on offset; TCV_{IOS} is typically 0.15 μV/°C. Excellent low-frequency noise performance is achieved with a minimal compromise on input protection. Bias current is very low, less than 10 nA over the military temperature range. High common-mode rejection of 130 dB, 16-bit linearity at a gain of 1000, and 50 mA peak output current are achievable simultaneously. This combination takes the instrumentation amplifier one step further towards the ideal amplifier.

AC performance complements the superb dc specifications. The AMP01 slews at 4.5 V/μs into capacitive loads of up to 15 nF, settles in 50 μs to 0.01% at a gain of 1000, and boasts a healthy 26 MHz gain-bandwidth product. These features make the AMP01 ideal for high speed data acquisition systems.

Gain is set by the ratio of two external resistors over a range of 0.1 to 10,000. A very low gain temperature coefficient of 10 ppm/°C is achievable over the whole gain range. Output voltage swing is guaranteed with three load resistances; 50 Ω, 500 Ω, and 2 kΩ. Loaded with 500 Ω, the output delivers ±13.0 V minimum. A thermal shutdown circuit prevents destruction of the output transistors during overload conditions.

The AMP01 can also be configured as a high performance operational amplifier. In many applications, the AMP01 can be used in place of op amp/power-buffer combinations.

REV. D

*Protected under U.S. Patent Numbers 4,471,321 and 4,503,381.

AMP01–SPECIFICATIONS

ELECTRICAL CHARACTERISTICS (@ V_S = ±15 V, R_S = 10 kΩ, R_L = 2 kΩ, T_A = +25°C, unless otherwise noted)

Parameter	Symbol	Conditions	AMP01A Min	AMP01A Typ	AMP01A Max	AMP01B Min	AMP01B Typ	AMP01B Max	Units
OFFSET VOLTAGE									
Input Offset Voltage	V_{IOS}	T_A = +25°C		20	50		40	100	µV
		–55°C ≤ T_A ≤ +125°C		40	80		60	150	µV
Input Offset Voltage Drift	TCV_{IOS}	–55°C ≤ T_A ≤ +125°C		0.15	0.3		0.3	1.0	µV/°C
Output Offset Voltage	V_{OOS}	T_A = +25°C		1	3		2	6	mV
		–55°C ≤ T_A ≤ +125°C		3	6		6	10	mV
Output Offset Voltage Drift	TCV_{OOS}	R_G = ∞							
		–55°C ≤ T_A ≤ +125°C		20	50		50	120	µV/°C
Offset Referred to Input vs. Positive Supply V+ = +5 V to +15 V	PSR	G = 1000	120	130		110	120		dB
		G = 100	110	130		100	120		dB
		G = 10	95	110		90	100		dB
		G = 1	75	90		70	80		dB
		–55°C ≤ T_A ≤ +125°C							
		G = 1000	120	130		110	120		dB
		G = 100	110	130		100	120		dB
		G = 10	95	110		90	100		dB
		G = 1	75	90		70	80		dB
Offset Referred to Input vs. Negative Supply V– = –5 V to –15 V	PSR	G = 1000	105	125		105	115		dB
		G = 100	90	105		90	95		dB
		G = 10	70	85		70	75		dB
		G = 1	50	65		50	60		dB
		–55°C ≤ T_A ≤ +125°C							
		G = 1000	105	125		105	115		dB
		G = 100	90	105		90	95		dB
		G = 10	70	85		70	75		dB
		G = 1	50	85		50	60		dB
Input Offset Voltage Trim Range		V_S = ±4.5 V to ±18 V[1]		±6			±6		mV
Output Offset Voltage Trim Range		V_S = ±4.5 V to ±18 V[1]		±100			±100		mV
INPUT CURRENT									
Input Bias Current	I_B	T_A = +25°C		1	4		2	6	nA
		–55°C ≤ T_A ≤ +125°C		4	10		6	15	nA
Input Bias Current Drift	TCI_B	–55°C ≤ T_A ≤ +125°C		40			50		pA/°C
Input Offset Current	I_{OS}	T_A = +25°C		0.2	1.0		0.5	2.0	nA
		–55°C ≤ T_A ≤ +125°C		0.5	3.0		1.0	6.0	nA
Input Offset Current Drift	TCI_{OS}	–55°C ≤ T_A ≤ +125°C		3			5		pA/°C
INPUT									
Input Resistance	R_{IN}	Differential, G = 1000		1			1		GΩ
		Differential, G ≤ 100		10			10		GΩ
		Common Mode, G = 1000		20			20		GΩ
Input Voltage Range	IVR	T_A = +25°C[2]	±10.5			±10.5			V
		–55°C ≤ T_A ≤ +125°C	±10.0			±10.0			V
Common-Mode Rejection	CMR	V_{CM} = ±10 V, 1 kΩ Source Imbalance							
		G = 1000	125	130		115	125		dB
		G = 100	120	130		110	125		dB
		G = 10	100	120		95	110		dB
		G = 1	85	100		75	90		dB
		–55°C ≤ T_A ≤ +125°C							
		G = 1000	120	125		110	120		dB
		G = 100	115	125		105	120		dB
		G = 10	95	115		90	105		dB
		G = 1	80	95		75	90		dB

NOTES

[1] V_{IOS} and V_{OOS} nulling has minimal affect on TCV_{IOS} and TCV_{OOS} respectively.

[2] Refer to section on common-mode rejection.

Specifications subject to change without notice.

ELECTRICAL CHARACTERISTICS (@ V_S = ±15 V, R_S = 10 kΩ, R_L = 2 kΩ, T_A = +25°C, –25°C ≤ T_A ≤ +85°C for E, F grades, 0°C ≤ T_A ≤ +70°C for G grade, unless otherwise noted)

Parameter	Symbol	Conditions	AMP01E Min	AMP01E Typ	AMP01E Max	AMP01F/G Min	AMP01F/G Typ	AMP01F/G Max	Units
OFFSET VOLTAGE									
Input Offset Voltage	V_{IOS}	T_A = +25°C		20	50		40	100	μV
		$T_{MIN} \le T_A \le T_{MAX}$		40	80		60	150	μV
Input Offset Voltage Drift	TCV_{IOS}	$T_{MIN} \le T_A \le T_{MAX}$[1]		0.15	0.3		0.3	1.0	μV/°C
Output Offset Voltage	V_{OOS}	T_A = +25°C		1	3		2	6	mV
		$T_{MIN} \le T_A \le T_{MAX}$		3	6		6	10	mV
Output Offset Voltage Drift	TCV_{OOS}	$R_G = \infty$[1]							
		$T_{MIN} \le T_A \le T_{MAX}$		20	100		50	120	μV/°C
Offset Referred to Input vs. Positive Supply V+ = +5 V to +15 V	PSR	G = 1000	120	130		110	120		dB
		G = 100	110	130		100	120		dB
		G = 10	95	110		90	100		dB
		G = 1	75	90		70	80		dB
		$T_{MIN} \le T_A \le T_{MAX}$							
		G = 1000	120	130		110	120		dB
		G = 100	110	130		100	120		dB
		G = 10	95	110		90	100		dB
		G = 1	75	90		70	80		dB
Offset Referred to Input vs. Negative Supply V– = –5 V to –15 V	PSR	G = 1000	110	125		105	115		dB
		G = 100	95	105		90	95		dB
		G = 10	75	85		70	75		dB
		G = 1	55	65		50	60		dB
		$T_{MIN} \le T_A \le T_{MAX}$							
		G = 1000	110	125		105	115		dB
		G = 100	95	105		90	95		dB
		G = 10	75	85		70	75		dB
		G = 1	55	85		50	60		dB
Input Offset Voltage Trim Range		V_S = ±4.5 V to ±18 V[2]		±6			±6		mV
Output Offset Voltage Trim Range		V_S = ±4.5 V to ±18 V[2]		±100			±100		mV
INPUT CURRENT									
Input Bias Current	I_B	T_A = +25°C		1	4		2	6	mV
		$T_{MIN} \le T_A \le T_{MAX}$		4	10		6	15	mV
Input Bias Current Drift	TCI_B	$T_{MIN} \le T_A \le T_{MAX}$		40			50		pA/°C
Input Offset Current	I_{OS}	T_A = +25°C		0.2	1.0		0.5	2.0	mV
		$T_{MIN} \le T_A \le T_{MAX}$		0.5	3.0		1.0	6.0	mV
Input Offset Current Drift	TCI_{OS}	$T_{MIN} \le T_A \le T_{MAX}$		3			5		pA/°C
INPUT									
Input Resistance	R_{IN}	Differential, G = 1000		1			1		GΩ
		Differential, G ≤ 100		10			10		GΩ
		Common Mode, G = 1000		20			20		GΩ
Input Voltage Range	IVR	T_A = +25°C[3]	±10.5			±10.5			V
		$T_{MIN} \le T_A \le T_{MAX}$	±10.0			±10.0			V
Common-Mode Rejection	CMR	V_{CM} = ±10 V, 1 kΩ Source Imbalance							
		G = 1000	125	130		115	125		dB
		G = 100	120	130		110	125		dB
		G = 10	100	120		95	110		dB
		G = 1	85	100		75	90		dB
		$T_{MIN} \le T_A \le T_{MAX}$							
		G = 1000	120	125		110	120		dB
		G = 100	115	125		105	120		dB
		G = 10	95	115		90	105		dB
		G = 1	80	95		75	90		dB

NOTES
[1] Sample tested.
[2] V_{IOS} and V_{OOS} nulling has minimal affect on TCV_{IOS} and TCV_{OOS}, respectively.
[3] Refer to section on common-mode rejection.
Specifications subject to change without notice.

ELECTRICAL CHARACTERISTICS (@ V_S = ±15 V, R_S = 10 kΩ, R_L = 2 kΩ, T_A = +25°C, unless otherwise noted)

Parameter	Symbol	Conditions	AMP01A/E Min	AMP01A/E Typ	AMP01A/E Max	AMP01B/F/G Min	AMP01B/F/G Typ	AMP01B/F/G Max	Units
GAIN									
Gain Equation Accuracy		$G = \frac{20 \times R_S}{R_G}$		0.3	0.6		0.5	0.8	%
		Accuracy Measured from G = 1 to 1000							
Gain Range	G		0.1		10k	0.1		10k	V/V
Nonlinearity		G = 1000[1]		0.0007	0.005		0.0007	0.005	%
		G = 100[1]			0.005			0.005	%
		G = 10[1]			0.005			0.007	%
		G = 1[1]			0.010			0.015	%
Temperature Coefficient	G_{TC}	1 ≤ G ≤ 1000[1, 2]		5	10		5	15	ppm°C
OUTPUT RATING									
Output Voltage Swing	V_{OUT}	R_L = 2 kΩ	±13.0	±13.8		±13.0	±13.8		V
		R_L = 500 Ω	±13.0	±13.5		±13.0	±13.5		V
		R_L = 50 Ω	±2.5	±4.0		±2.5	±4.0		V
		R_L = 2 kΩ Over Temp.	±12.0	±13.8		±12.0	±13.8		V
		R_L = 500 Ω[3]	±12.0	±13.5		±12.0	±13.5		V
Positive Current Limit		Output-to-Ground Short	60	100	120	60	100	120	mA
Negative Current Limit		Output-to-Ground Short	60	90	120	60	90	120	mA
Capacitive Load Stability		1 ≤ G ≤ 1000							
		No Oscillations[1]	0.1	1		0.1	1		µF
Thermal Shutdown Temperature		Junction Temperature		165			165		°C
NOISE									
Voltage Density, RTI	e_n	f_O = 1 kHz							
	e_n	G = 1000		5			5		nV/√Hz
	e_n	G = 100		10			10		nV/√Hz
	e_n	G = 10		59			59		nV/√Hz
	e_n	G = 1		540			540		nV/√Hz
Noise Current Density, RTI	i_n	f_O = 1 kHz, G = 1000		0.15			0.15		pA/√Hz
Input Noise Voltage	e_n p-p	0.1 Hz to 10 Hz							
	e_n p-p	G = 1000		0.12			0.12		µV p-p
	e_n p-p	G = 100		0.16			0.16		µV p-p
	e_n p-p	G = 10		1.4			1.4		µV p-p
	e_n p-p	G = 1		13			13		µV p-p
Input Noise Current	i_n p-p	0.1 Hz to 10 Hz, G = 1000		2			2		pA p-p
DYNAMIC RESPONSE									
Small-Signal		G = 1		570			570		kHz
Bandwidth (–3 dB)	BW	G = 10		100			100		kHz
		G = 100		82			82		kHz
		G = 1000		26			26		kHz
Slew Rate	SR	G = 10	3.5	4.5		3.0	4.5		V/µs
Settling Time	t_S	To 0.01%, 20 V step							
		G = 1		12			12		µs
		G = 10		13			13		µs
		G = 100		15			15		µs
		G = 1000		50			50		µs

NOTES
[1]Guaranteed by design.
[2]Gain tempco does not include the effects of gain and scale resistor tempco match.
[3]–55°C ≤ T_A ≤ +125°C for A/B grades, –25°C ≤ T_A ≤ +85°C for E/F grades, 0°C ≤ T_A ≤ 70°C for G grades.
Specifications subject to change without notice.

ELECTRICAL CHARACTERISTICS (@ V_S = ±15 V, R_S = 10 kΩ, R_L = 2 kΩ, T_A = +25°C, unless otherwise noted)

Parameter	Symbol	Conditions	AMP01A/E Min	AMP01A/E Typ	AMP01A/E Max	AMP01B/F/G Min	AMP01B/F/G Typ	AMP01B/F/G Max	Units
SENSE INPUT									
Input Resistance	R_{IN}		35	50	65	35	50	65	kΩ
Input Current	I_{IN}	Referenced to V–		280			280		μA
Voltage Range		(Note 1)	–10.5		+15	–10.5		+15	V
REFERENCE INPUT									
Input Resistance	R_{IN}		35	50	65	35	50	65	kΩ
Input Current	I_{IN}	Referenced to V–		280			280		μA
Voltage Range		(Note 1)	–10.5		+15	–10.5		+15	V
Gain to Output				1			1		V/V
POWER SUPPLY –25°C ≤ T_A ≤ +85°C for E/F Grades, –55°C ≤ T_A ≤ +125°C for A/B Grades									
Supply Voltage Range	V_S	+V linked to $+V_{OP}$	±4.5		±18	±4.5		±18	V
	V_S	–V linked to $–V_{OP}$	±4.5		±18	±4.5		±18	V
Quiescent Current	I_Q	+V linked to $+V_{OP}$		3.0	4.8		3.0	4.8	mA
	I_Q	–V linked to $–V_{OP}$		3.4	4.8		3.4	4.8	mA

NOTE
[1]Guaranteed by design.
Specifications subject to change without notice.

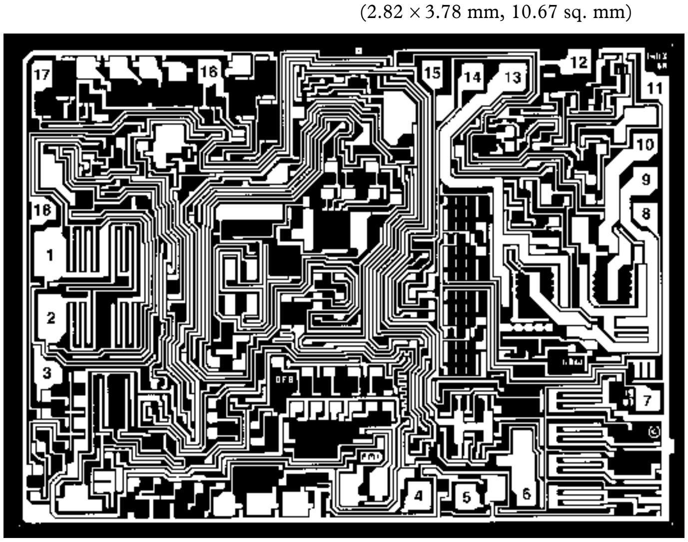
ORDERING GUIDE

Model	Temperature Range	Package Description	Package Option
AMP01AX	–55°C to +125°C	18-Lead Cerdip	Q-18
AMP01AX/883C	–55°C to +125°C	18-Lead Cerdip	Q-18
AMP01BTC/883C	–55°C to +125°C	28-Terminal LCC	E-28A
AMP01BX	–55°C to +125°C	18-Lead Cerdip	Q-18
AMP01BX/883C	–55°C to +125°C	18-Lead Cerdip	Q-18
AMP01EX	–25°C to +85°C	18-Lead Cerdip	Q-18
AMP01FX	–25°C to +85°C	18-Lead Cerdip	Q-18
AMP01GBC		Die	
AMP01GS	0°C to +70°C	20-Lead SOIC	R-20
AMP01GS-REEL	0°C to +70°C	13" Tape and Reel	R-20
AMP01NBC		Die	
5962-8863001VA*	–55°C to +125°C	18-Lead Cerdip	Q-18
5962-88630023A*	–55°C to +125°C	28-Terminal LCC	E-28A
5962-8863002VA*	–55°C to +125°C	18-Lead Cerdip	Q-18

*Standard military drawing available.

DICE CHARACTERISTICS

Die Size 0.111 × 0.149 inch, 16,539 sq. mils
(2.82 × 3.78 mm, 10.67 sq. mm)



1. R_G
2. R_G
3. –INPUT
4. V_{OOS} NULL
5. V_{OOS} NULL
6. TEST PIN*
7. SENSE
8. REFERENCE
9. OUTPUT
10. V– (OUTPUT)
11. V–
12. V+
13. V+ (OUTPUT)
14. R_S
15. R_S
16. V_{IOS} NULL
17. V_{IOS} NULL
18. +INPUT

*MAKE NO ELECTRICAL CONNECTION

WAFER TEST LIMITS (@ V_S = ±15 V, R_S = 10 kΩ, R_L = 2 kΩ, T_A = +25°C, unless otherwise noted)

Parameter	Symbol	Conditions	AMP01NBC Limit	AMP01GBC Limit	Units
Input Offset Voltage	V_{IOS}		60	120	µV max
Output Offset Voltage	V_{OOS}		4	8	mV max
Offset Referred to Input	PSR	V+ = +5 V to +15 V			dB min
vs. Positive Supply		G = 1000	120	110	dB min
		G = 100	110	100	dB min
		G = 10	95	90	dB min
		G = 1	75	70	dB min
Offset Referred to Input	PSR	V– = –5 V to –15 V			dB min
vs. Negative Supply		G = 1000	105	105	dB min
		G = 100	90	90	dB min
		G = 10	70	70	dB min
		G = 1	50	50	dB min
Input Bias Current	I_B		4	8	nA max
Input Offset Current	I_{OS}		1	3	nA max
Input Voltage Range	IVR	Guaranteed by CMR Tests	±10	±10	V min
Common Mode Rejection	CMR	V_{CM} = ±10 V			dB min
		G = 1000	125	115	dB min
		G = 100	120	110	dB min
		G = 10	100	95	dB min
		G = 1	85	75	dB min
Gain Equation Accuracy		$G = \frac{20 \times R_S}{R_G}$	0.6	0.8	% max
Output Voltage Swing	V_{OUT}	R_L = 2 kΩ	±13	±13	V min
	V_{OUT}	R_L = 500 Ω	±13	±13	V min
	V_{OUT}	R_L = 50 Ω	±2.5	±2.5	V min
Output Current Limit		Output to Ground Short	±60	±60	mA min
Output Current Limit		Output to Ground Short	±120	±120	mA max
Quiescent Current	I_Q	+V Linked to $+V_{OP}$	4.8	4.8	mA max
		–V Linked to $-V_{OP}$	4.8	4.8	mA max

NOTE
Electrical tests are performed at wafer probe to the limits shown. Due to variations in assembly methods and normal yield loss, yield after packaging is not guaranteed for standard product dice. Consult factory to negotiate specifications based on dice lot qualification through sample lot assembly and testing.

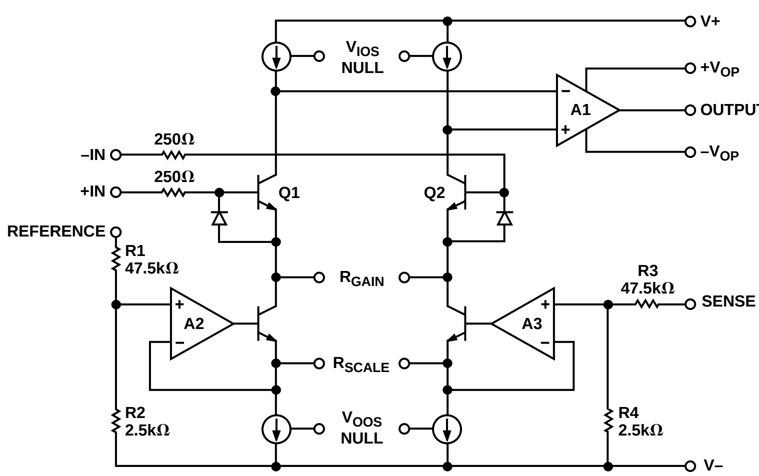


Figure 1. Simplified Schematic

CAUTION
ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although the AMP01 features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

ELECTRICAL CHARACTERISTICS (@ V_S = ±15 V, R_S = 10 kΩ, R_L = 2 kΩ, T_A = +25°C, unless otherwise noted)

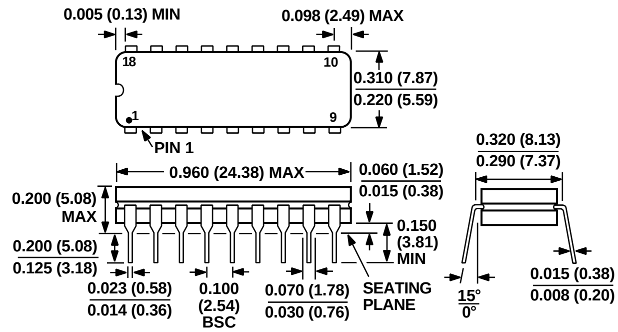
Parameter	Symbol	Conditions	AMP01NBC Typical	AMP01GBC Typical	Units
Input Offset Voltage Drift	TCV_{IOS}		0.15	0.30	µV/°C
Output Offset Voltage Drift	TCV_{OOS}	$R_G = \infty$	20	50	µV/°C
Input Bias Current Drift	TCI_B		40	50	pA/°C
Input Offset Current Drift	TCI_{OS}		3	5	pA/°C
Nonlinearity		G = 1000	0.0007	0.0007	%
Voltage Noise Density	e_n	G = 1000			
		f_O = 1 kHz	5	5	nV/$\sqrt{Hz}$
Current Noise Density	i_n	G = 1000			
		f_O = 1 kHz	0.15	0.15	pA/$\sqrt{Hz}$
Voltage Noise	e_n p-p	G = 1000			
		0.1 Hz to 10 Hz	0.12	0.12	µV p-p
Current Noise	i_n p-p	G = 1000	2	2	pA p-p
		0.1 Hz to 10 Hz			
Small-Signal Bandwidth (–3 dB)	BW	G = 1000	26	26	kHz
Slew Rate	SR	G = 10	4.5	4.5	V/µs
Settling Time	t_S	To 0.01%, 20 V Step			
		G = 1000	50	50	µs

NOTE
Electrical tests are performed at wafer probe to the limits shown. Due to variations in assembly methods and normal yield loss, yield after packaging is not guaranteed for standard product dice. Consult factory to negotiate specifications based on dice lot qualification through sample lot assembly and testing.

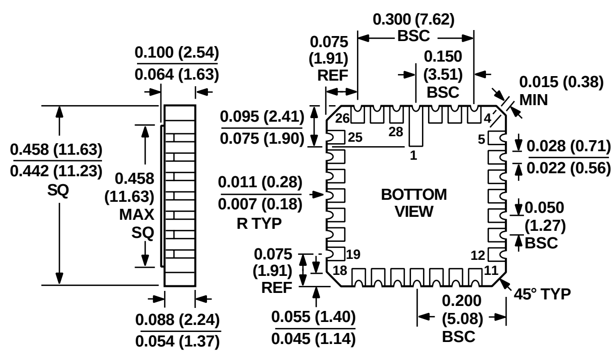
OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).

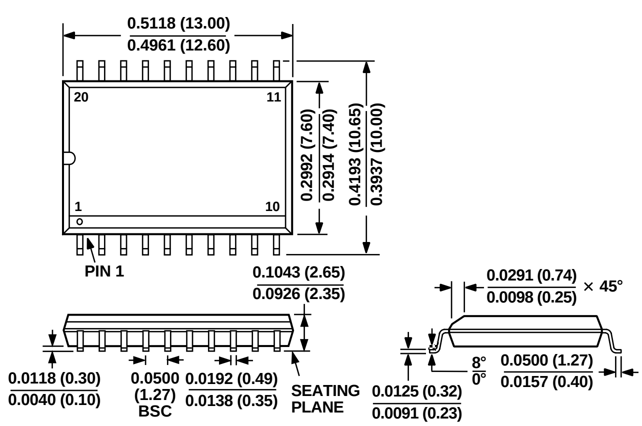
18-Lead Cerdip (Q-18)



28-Terminal Ceramic Leadless Chip Carrier (E-28A)



20-Lead SOIC (R-20)



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