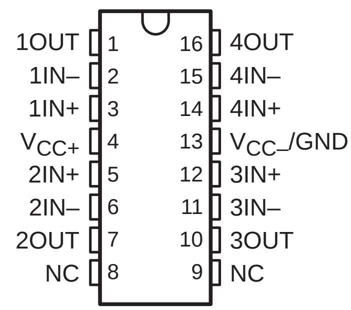
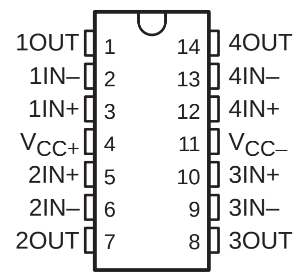
- **Single-Supply Operation: Input Voltage Range Extends to Ground, and Output Swings to Ground While Sinking Current**
- **Input Offset Voltage 300 μV Max at 25°C for LT1014**
- **Offset Voltage Temperature Coefficient 2.5 μV/°C Max for LT1014**
- **Input Offset Current 1.5 nA Max at 25°C for LT1014**
- **High Gain 1.2 V/μV Min (R_L = 2 kΩ), 0.5 V/μV Min (R_L = 600 Ω) for LT1014**
- **Low Supply Current 2.2 mA Max at 25°C for LT 1014**
- **Low Peak-to-Peak Noise Voltage 0.55 μV Typ**
- **Low Current Noise 0.07 pA/√Hz Typ**

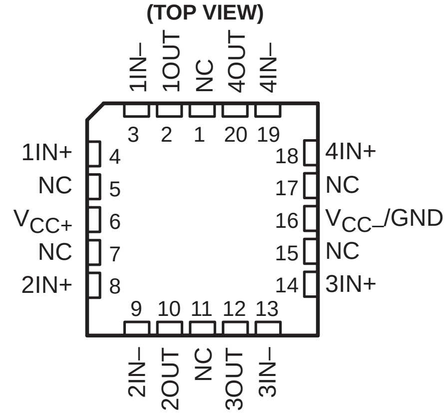
DW PACKAGE
(TOP VIEW)



J OR N PACKAGE
(TOP VIEW)



FK PACKAGE
(TOP VIEW)



NC – No internal connection

description

The LT1014, LT1014A, and LT1014D are quad precision operational amplifiers with 14-pin industry-standard configuration. They feature low offset-voltage temperature coefficient, high gain, low supply current, and low noise.

The LT1014, LT1014A, and LT1014D can be operated with both dual ±15-V and single 5-V power supplies. The common-mode input voltage range includes ground, and the output voltage can also swing to within a few milivolts of ground. Crossover distortion is eliminated.

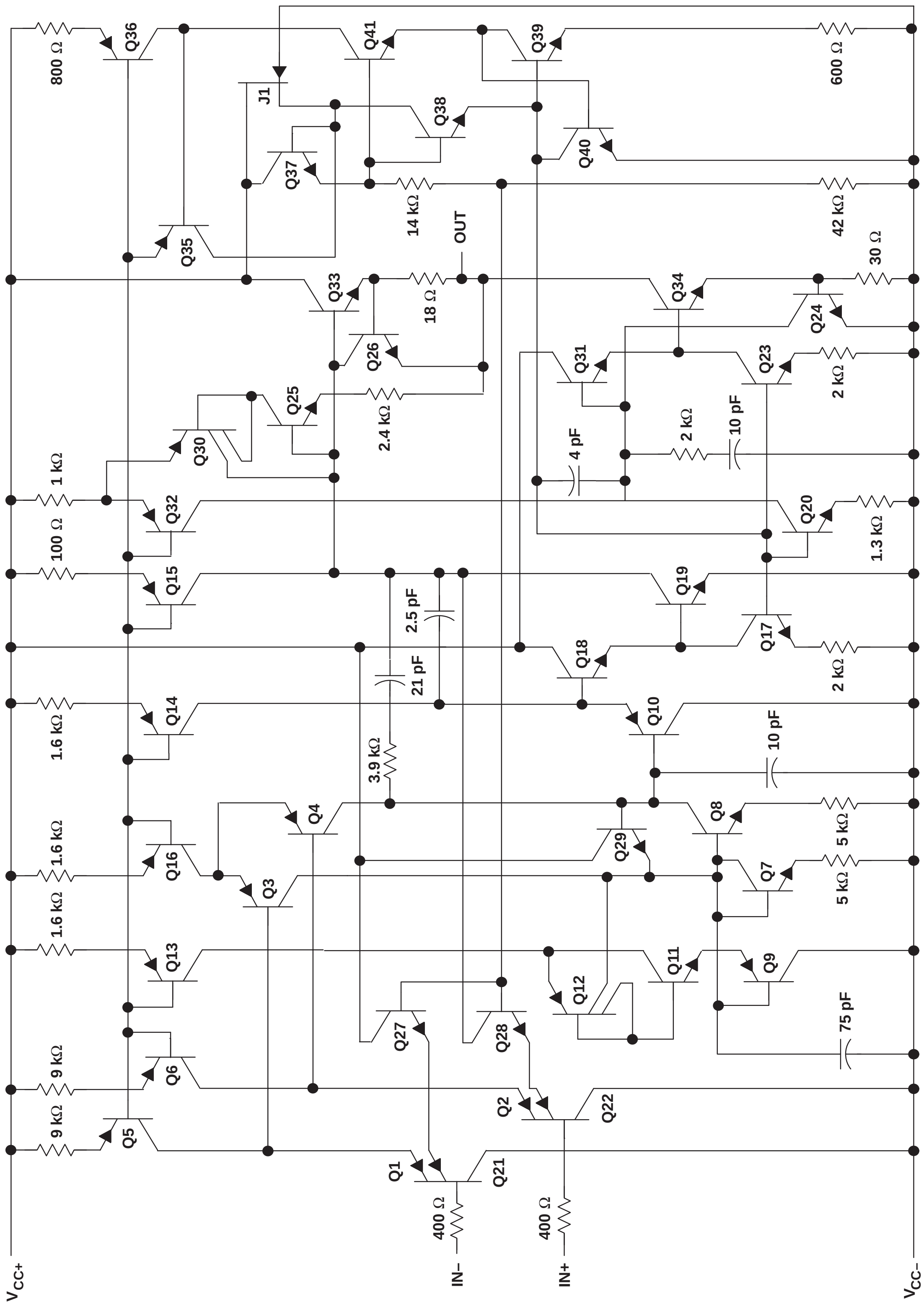
The LT1014C and LT1014 AC are characterized for operation from 0°C to 70°C. The LT1014I and LT1014DI are characterized for operation from –40°C to 105°C. The LT1014M, LT1014AM and LT1014DM are characterized for operation over the full military temperature range of –55°C to 125°C.

AVAILABLE OPTIONS

T_A	V_{IO} max AT 25°C	PACKAGED DEVICES			
		SMALL OUTLINE (DW)	CHIP CARRIER (FK)	CERAMIC DIP (J)	PLASTIC DIP (N)
0°C to 70°C	300 µV 800 µV	— LT1014DDW	— —	— —	LT1014CN LT1014DN
–40°C to 105°C	300 µV 800 µV	— LT1014DIDW	— —	— —	LT1014IN LT1014DIN
–55°C to 125°C	180 µV 300 µV 800 µV	— — LT1014DMDW	LT1014AMFK LT1014MFK —	LT1014AMJ LT1014MJ —	— LT1014MN LT1014DMN

The DW package is available taped and reeled. Add the suffix R to the device type (e.g., LT1014DDWR).

schematic (each amplifier)



Component values are nominal.

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage (see Note 1): V_{CC+} . . . . . 22 V
V_{CC-} . . . . . –22 V
Differential input voltage (see Note 2) . . . . . ±30 V
Input voltage range, V_I (any input) (see Note 1) . . . . . V_{CC-} – 5 V to V_{CC+}
Duration of short-circuit current at (or below) T_A = 25°C (see Note 3) . . . . . Unlimited
Continuous total power dissipation . . . . . See Dissipation Rating Table
Operating free-air temperature range, T_A: LT1014C, LT1014DC . . . . . –0°C to 70°C
LT1014I, LT1014DI . . . . . –40°C to 105°C
LT1014M, LT1014AM, LT1014DM . . . . . –55°C to 125°C
Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds: J package . . . . . 300°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: DW or N package . . . . . 260°C
Case temperature for 60 seconds: FK package . . . . . 260°C
Storage temperature range, T_{stg} . . . . . –65°C to 150°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTES: 1. All voltage values, except differential voltages, are with respect to the midpoint between V_{CC+} and V_{CC-}.
2. Differential voltages are at the noninverting input with respect to the inverting input.
3. The output may be shorted to either supply.

DISSIPATION RATING TABLE

PACKAGE	$T_A \leq 25°C$ POWER RATING	DERATING FACTOR ABOVE T_A = 25°C	T_A = 70°C POWER RATING	T_A = 105°C POWER RATING	T_A = 125°C POWER RATING
DW	1025 mV	8.2 mW/°C	656 mW	369 mW	205 mW
FK	1375 mV	11.0 mW/°C	880 mW	495 mW	275 mW
J	1375 mV	11.0 mW/°C	880 mW	495 mW	275 mW
N	1150 mV	9.2 mW/°C	736 mW	414 mW	230 mW

electrical characteristics at specified free-air temperature, $V_{CC\pm}$ = ±15 V, V_{IC} = 0 (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A†	LT1014C MIN	LT1014C TYP‡	LT1014C MAX	LT1014DC MIN	LT1014DC TYP‡	LT1014DC MAX	UNIT
V_{IO}	Input offset voltage	R_S = 50 Ω	25°C		60	300		200	800	µV
			Full range			550			1000	
α_{VIO}	Temperature coeficient of input offset voltage		Full range		0.4	2.5		0.7	5	µV/°C
	Long-term drift of input offset voltage		25°C		0.5			0.5		µV/mo
I_{IO}	Input offset current		25°C		0.15	1.5		0.15	1.5	nA
			Full range			2.8			2.8	
I_{IB}	Input bias current		25°C		–12	–30		–12	–30	nA
			Full range			–38			–38	
V_{ICR}	Common-mode input voltage range		25°C	–15 to 13.5	–15.3 to 13.8		–15 to 13.5	–15.3 to 13.8		V
			Full range	–15 to 13			–15 to 13			
V_{OM}	Maximum peak output voltage swing	R_L = 2 kΩ	25°C	±12.5	±14		±12.5	±14		V
			Full range	±12			±12			
A_{VD}	Large-signal differential voltage amplification	V_O = ±10 V, R_L = 600 Ω	25°C	0.5	2		0.5	2		V/µV
		V_O = ±10 V, R_L = 2 kΩ	25°C	1.2	8		1.2	8		
			Full range	0.7			0.7			
CMRR	Common-mode rejection ratio	V_{IC} = –15 V to 13.5 V	25°C	97	117		97	117		dB
		V_{IC} = –15 V to 13 V	Full range	94			94			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$)	$V_{CC\pm}$ = ±2 V to ±18 V	25°C	100	117		100	117		dB
			Full range	97			97			
	Channel separation	V_O = ±10 V, R_L = 2 kΩ	25°C	120	137		120	137		dB
r_{id}	Differential input resistance		25°C	70	300		70	300		MΩ
r_{ic}	Common-mode input resistance		25°C		4			4		GΩ
I_{CC}	Supply current per amplifier		25°C		0.35	0.55		0.35	0.55	mA
			Full range			0.6			0.6	

† Full range is 0°C to 70°C.
‡ All typical values are at T_A = 25°C.

electrical characteristics at specified free-air temperature, $V_{CC\pm}$ = 5 V, V_{CC-} = 0, V_O = 1.4 V, V_{IC} = 0 (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A†	LT1014C MIN	LT1014C TYP	LT1014C MAX	LT1014DC MIN	LT1014DC TYP	LT1014DC MAX	UNIT
V_{IO}	Input offset voltage	R_S = 50 Ω	25°C		90	450		250	950	µV
			Full range			570			1200	
I_{IO}	Input offset current		25°C		0.2	2		0.2	2	nA
			Full range			6			6	
I_{IB}	Input bias current		25°C		–15	–50		–15	–50	nA
			Full range			–90			–90	
V_{ICR}	Common-mode input voltage range		25°C	0 to 3.5	–0.3 to 3.8		0 to 3.5	–0.3 to 3.8		V
			Full range	0 to 3			0 to 3			
V_{OM}	Maximum peak output voltage swing	Output low, No load	25°C		15	25		15	25	mV
		Output low, R_L = 600 Ω to GND	25°C		5	10		5	10	
			Full range			13			13	
		Output low, I_{sink} = 1 mA	25°C		220	350		220	350	
		Output high, No load	25°C	4	4.4		4	4.4		V
		Output high, R_L = 600 Ω to GND	25°C	3.4	4		3.4	4		
			Full range	3.2			3.2			
A_{VD}	Large-signal differential voltage amplification	V_O = 5 mV to 4 V, R_L = 500 Ω	25°C		1			1		V/µV
I_{CC}	Supply current per amplifier		25°C		0.3	0.5		0.3	0.5	mA
			Full range			0.55			0.55	

† Full range is 0°C to 70°C.

operating characteristics, $V_{CC\pm}$ = ±15 V, V_{IC} = 0, T_A = 25°C

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
SR	Slew rate		0.2	0.4		V/µs
V_n	Equivalent input noise voltage	f = 10 Hz		24		nV/√Hz
		f = 1 kHz		22		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 10 Hz		0.55		µV
I_n	Equivalent input noise current	f = 10 Hz		0.07		pA/√Hz

electrical characteristics at specified free-air temperature, $V_{CC\pm} = \pm15$ V, $V_{IC} = 0$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A†	LT1014I MIN	LT1014I TYP‡	LT1014I MAX	LT1014DI MIN	LT1014DI TYP‡	LT1014DI MAX	UNIT
V_{IO}	Input offset voltage	R_S = 50 Ω	25°C		60	300		200	800	μV
			Full range			550			1000	
$\alpha_{V_{IO}}$	Temperature coeficient of input offset voltage		Full range		0.4	2.5		0.7	5	μV/°C
	Long-term drift of input offset voltage		25°C		0.5			0.5		μV/mo
I_{IO}	Input offset current		25°C		0.15	1.5		0.15	1.5	nA
			Full range			2.8			2.8	
I_{IB}	Input bias current		25°C		–12	–30		–12	–30	nA
			Full range			–38			–38	
V_{ICR}	Common-mode input voltage range		25°C	–15 to 13.5	–15.3 to 13.8		–15 to 13.5	–15.3 to 13.8		V
			Full range	–15 to 13			–15 to 13			
V_{OM}	Maximum peak output voltage swing	R_L = 2 kΩ	25°C	±12.5	±14		±12.5	±14		V
			Full range	±12			±12			
A_{VD}	Large-signal differential voltage amplification	V_O = ±10 V, R_L = 600 Ω	25°C	0.5	2		0.5	2		V/μV
		V_O = ±10 V, R_L = 2 kΩ	25°C	1.2	8		1.2	8		
			Full range	0.7			0.7			
CMRR	Common-mode rejection ratio	V_{IC} = –15 V to 13.5 V	25°C	97	117		97	117		dB
			Full range	94			94			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$)	$V_{CC\pm}$ = ±2 V to ±18 V	25°C	100	117		100	117		dB
			Full range	97			97			
	Channel separation	V_O = ±10 V, R_L = 2 kΩ	25°C	120	137		120	137		dB
r_{id}	Differential input resistance		25°C	70	300		70	300		MΩ
r_{ic}	Common-mode input resistance		25°C		4			4		GΩ
I_{CC}	Supply current per amplifier		25°C		0.35	0.55		0.35	0.55	mA
			Full range			0.6			0.6	

† Full range is –40°C to 105°C.
‡ All typical values are at T_A = 25°C.

electrical characteristics at specified free-air temperature, V_{CC+} = 5 V, V_{CC-} = 0, V_O = 1.4 V, V_{IC} = 0 (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A†	LT1014I			LT1014DI			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO}	Input offset voltage	R_S = 50 Ω	25°C		90	450		250	950	μV
			Full range			570			1200	
I_{IO}	Input offset current		25°C		0.2	2		0.2	2	nA
			Full range			6			6	
I_{IB}	Input bias current		25°C		–15	–50		–15	–50	nA
			Full range			–90			–90	
V_{ICR}	Common-mode input voltage range		25°C	0 to 3.5	–0.3 to 3.8		0 to 3.5	–0.3 to 3.8		V
			Full range	0 to 3			0 to 3			
V_{OM}	Maximum peak output voltage swing	Output low, No load	25°C		15	25		15	25	mV
		Output low, R_L = 600 Ω to GND	25°C		5	10		5	10	
			Full range			13			13	
		Output low, I_{sink} = 1 mA	25°C		220	350		220	350	
		Output high, No load	25°C	4	4.4		4	4.4		V
		Output high, R_L = 600 Ω to GND	25°C	3.4	4		3.4	4		
			Full range	3.2			3.2			
A_{VD}	Large-signal differential voltage amplification	V_O = 5 mV to 4 V, R_L = 500 Ω	25°C		1			1		V/μV
I_{CC}	Supply current per amplifier		25°C		0.3	0.5		0.3	0.5	mA
			Full range			0.55			0.55	

† Full range is –40°C to 105°C.

operating characteristics, $V_{CC±}$ = ±15 V, V_{IC} = 0, T_A = 25°C

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
SR	Slew rate		0.2	0.4		V/μs
V_n	Equivalent input noise voltage	f = 10 Hz		24		nV/√Hz
		f = 1 kHz		22		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 10 Hz		0.55		μV
I_n	Equivalent input noise current	f = 10 Hz		0.07		pA/√Hz

electrical characteristics at specified free-air temperature, $V_{CC\pm} = \pm15$ V, $V_{IC} = 0$ (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A†	LT1014M MIN	LT1014M TYP‡	LT1014M MAX	LT1014AM MIN	LT1014AM TYP‡	LT1014AM MAX	LT1014DM MIN	LT1014DM TYP‡	LT1014DM MAX	UNIT
V_{IO}	Input offset voltage	R_S = 50 Ω	25°C		60	300		60	180		200	800	µV
			Full range			550			350			1000	
$\alpha_{V_{IO}}$	Temperature coefficient of input offset voltage		Full range		0.5	2.5		0.5	2		0.5	2.5	µV/°C
	Long-term drift of input offset voltage		25°C		0.5			0.5			0.5		µV/mo
I_{IO}	Input offset current		25°C		0.15	1.5		0.15	0.8		0.15	1.5	nA
			Full range			5			2.8			5	
I_{IB}	Input bias current		25°C		–12	–30		–12	–20		–12	–30	nA
			Full range			–45			–30			–45	
V_{ICR}	Common-mode input voltage range		25°C	–15 to 13.5	–15.3 to 13.8		–15 to 13.5	–15.3 to 13.8		–15 to 13.5	–15.3 to 13.8		V
			Full range	–14.9 to 13			–14.9 to 13			–14.9 to 13			
V_{OM}	Maximum peak output voltage swing	R_L = 2 kΩ	25°C	±12.5	±14		±13	±14		±12.5	±14		V
			Full range	±11.5			±12			±11.5			
A_{VD}	Large-signal differential voltage amplification	V_O = ±10 V, R_L = 600 Ω	25°C	0.5	2		0.8	2.2		0.5	2		V/µV
		V_O = ±10 V, R_L = 2 kΩ	25°C	1.2	8		1.5	8		1.2	8		
			Full range	0.25			0.4			0.25			
CMRR	Common-mode rejection ratio	V_{IC} = –15 V to 13.5 V	25°C	97	117		100	117		97	117		dB
		V_{IC} = –14.9 V to 13 V	Full range	94			96			94			
k_{SVR}	Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$)	$V_{CC\pm}$ = ±2 V to ±18 V	25°C	100	117		103	117		100	117		dB
			Full range	97			100			97			
	Channel separation	V_O = ±10 V, R_L = 2 kΩ	25°C	120	137		123	137		120	137		dB
r_{id}	Differential input resistance		25°C	70	300		100	300		70	300		MΩ
r_{ic}	Common-mode input resistance		25°C		4			4			4		GΩ
I_{CC}	Supply current per amplifier		25°C		0.35	0.55		0.35	0.50		0.35	0.55	mA
			Full range			0.7			0.6			0.7	

† Full range is –55°C to 125°C.
‡ All typical values are at T_A = 25°C.

electrical characteristics at specified free-air temperature, V_{CC+} = 5 V, V_{CC-} = 0, V_O = 1.4 V, V_{IC} = 0 (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T_A†	LT1014M			LT1014AM			LT1014DM			UNIT
				MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO}	Input offset voltage	R_S = 50Ω	25°C		90	450		90	280		250	950	μV
			Full range		400	1500		400	960		800	2000	
		R_S = 50Ω, V_{IC} = 0.1 V	125°C		200	750		200	480		560	1200	
I_{IO}	Input offset current		25°C		0.2	2		0.2	1.3		0.2	2	nA
			Full range			10			7			10	
I_{IB}	Input bias current		25°C		–15	–50		–15	–35		–15	–50	
			Full range			–120			–90			–120	
V_{ICR}	Common-mode input voltage range		25°C	0 to 3.5	–0.3 to 3.8		0 to 3.5	–0.3 to 3.8		0 to 3.5	–0.3 to 3.8		V
			Full range	0.1 to 3			0.1 to 3			0.1 to 3			
V_{OM}	Maximum peak output voltage swing	Output low, No load	25°C		15	25		15	25		15	25	mV
		Output low, R_L = 600Ω to GND	25°C		5	10		5	10		5	10	
			Full range			18			15			18	
		Output low, I_{sink} = 1 mA	25°C		220	350		220	350		220	350	
		Output high, No load	25°C	4	4.4		4	4.4		4	4.4		V
		Output high,	25°C	3.4	4		3.4	4		3.4	4		
		R_L = 600Ω to GND	Full range	3.1			3.2			3.1			
A_{VD}	Large-signal differential voltage amplification	V_O = 5 mV to 4 V, R_L = 500Ω	25°C		1			1			1		V/μV
I_{CC}	Supply current per amplifier		25°C		0.3	0.5		0.3	0.45		0.3	0.5	mA
			Full range			0.65			0.55			0.65	

† Full range is –55°C to 125°C.

operating characteristics, $V_{CC\pm}$ = ±15 V, V_{IC} = 0, T_A = 25°C

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
SR	Slew rate		0.2	0.4		V/μs
V_n	Equivalent input noise voltage	f = 10 Hz		24		nV/√Hz
		f = 1 kHz		22		
$V_{N(PP)}$	Peak-to-peak equivalent input noise voltage	f = 0.1 Hz to 10 Hz		0.55		μV
I_n	Equivalent input noise current	f = 10 Hz		0.07		pA/√Hz

TYPICAL CHARACTERISTICS

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	Pulse response (large signal) vs Time		20, 22, 23
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TYPICAL CHARACTERISTICS†

**LT1014
INPUT OFFSET VOLTAGE
vs
BALANCED SOURCE RESISTANCE**

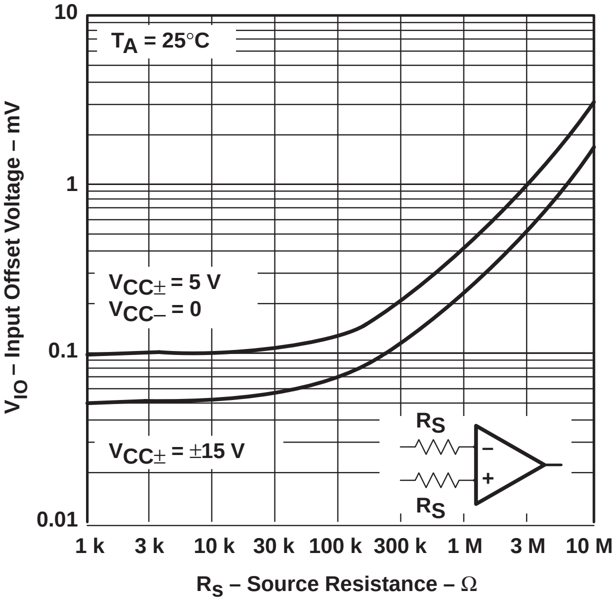


Figure 1

**INPUT OFFSET VOLTAGE
OF REPRESENTATIVE UNITS
vs
FREE-AIR TEMPERATURE**

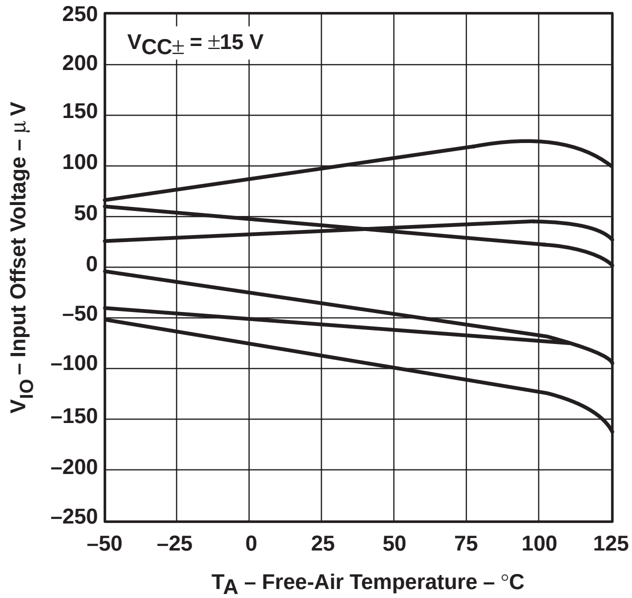


Figure 2

**WARM-UP CHANGE IN INPUT OFFSET VOLTAGE
vs
ELAPSED TIME**

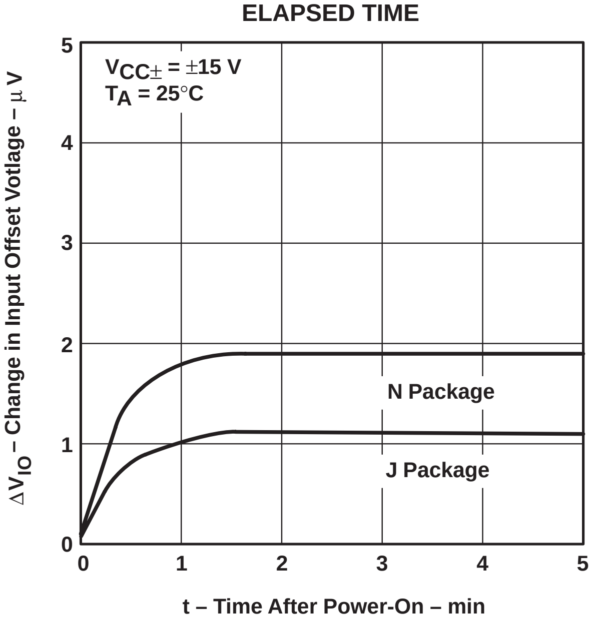


Figure 3

**INPUT OFFSET CURRENT
vs
FREE-AIR TEMPERATURE**

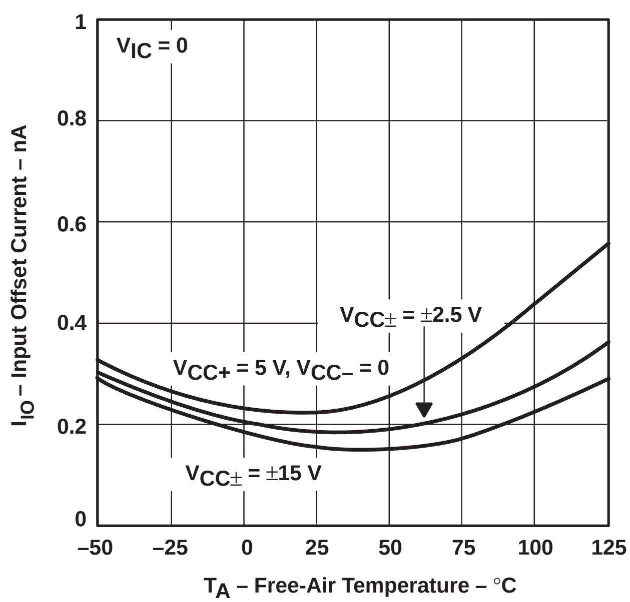


Figure 4

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

TYPICAL CHARACTERISTICS†

INPUT BIAS CURRENT vs FREE-AIR TEMPERATURE

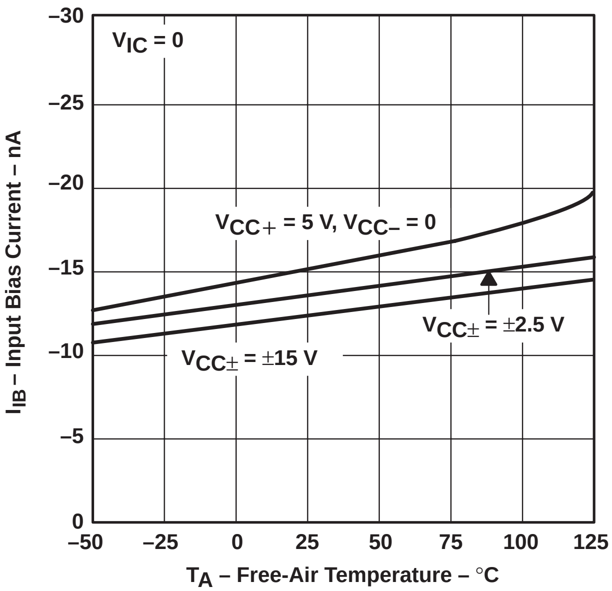


Figure 5

COMMON-MODE INPUT VOLTAGE vs INPUT BIAS CURRENT

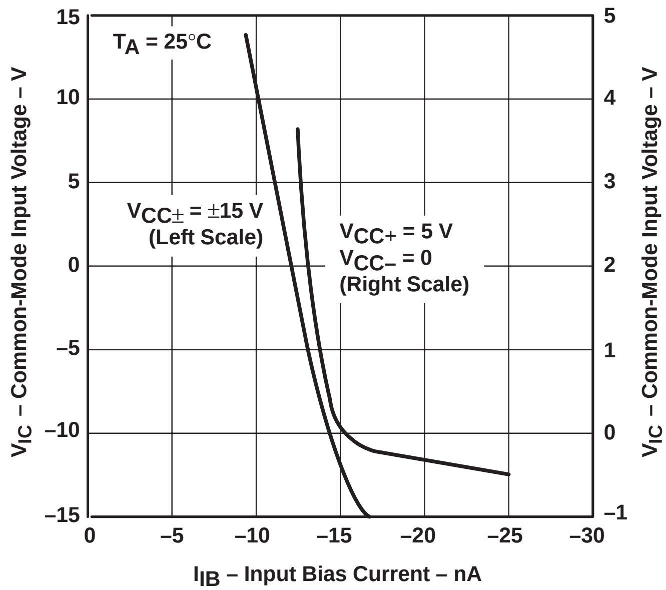


Figure 6

DIFFERENTIAL VOLTAGE AMPLIFICATION vs LOAD RESISTANCE

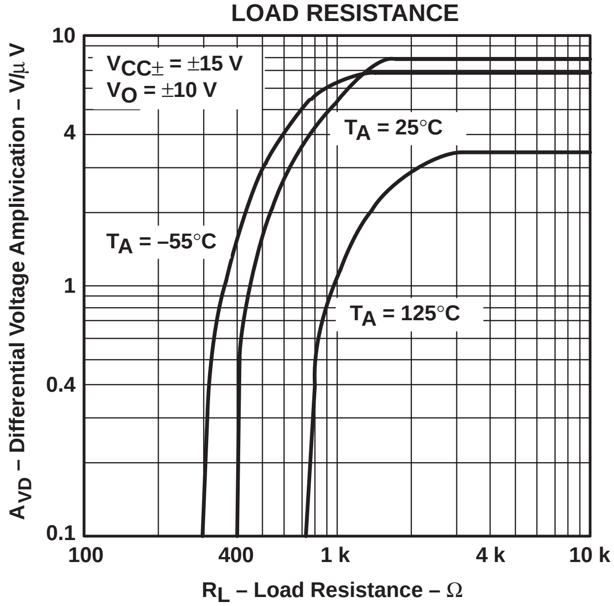


Figure 7

DIFFERENTIAL VOLTAGE AMPLIFICATION vs LOAD RESISTANCE

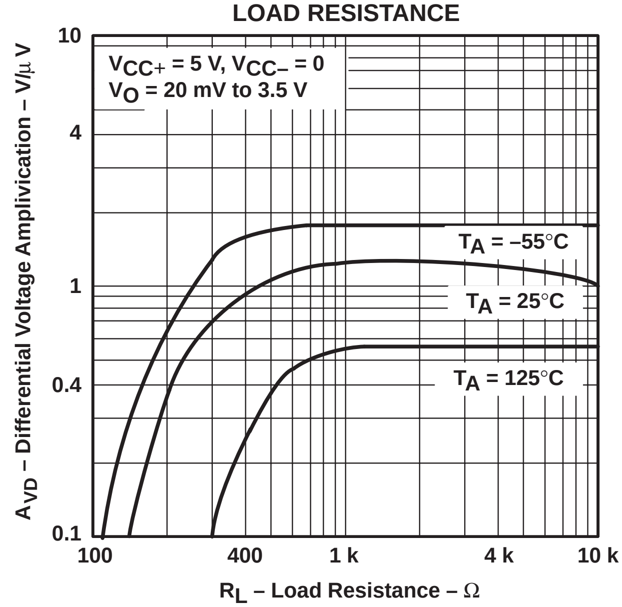


Figure 8

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

TYPICAL CHARACTERISTICS†

DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE SHIFT vs FREQUENCY

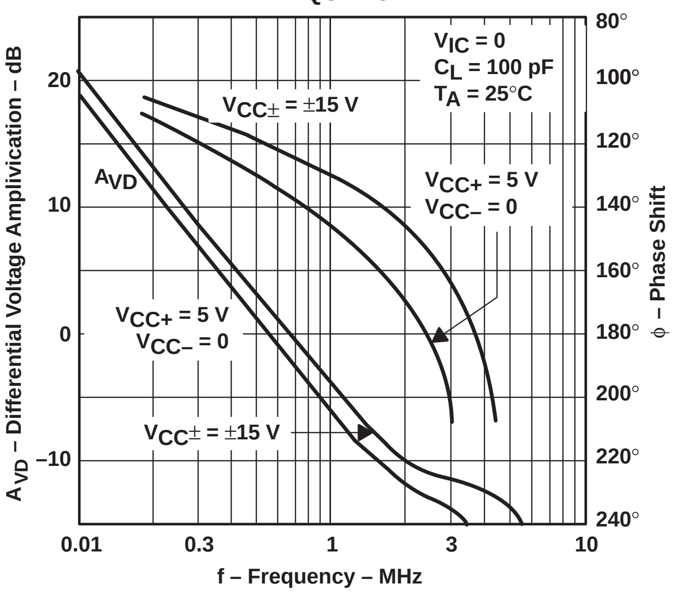


Figure 9

DIFFERENTIAL VOLTAGE AMPLIFICATION vs FREQUENCY

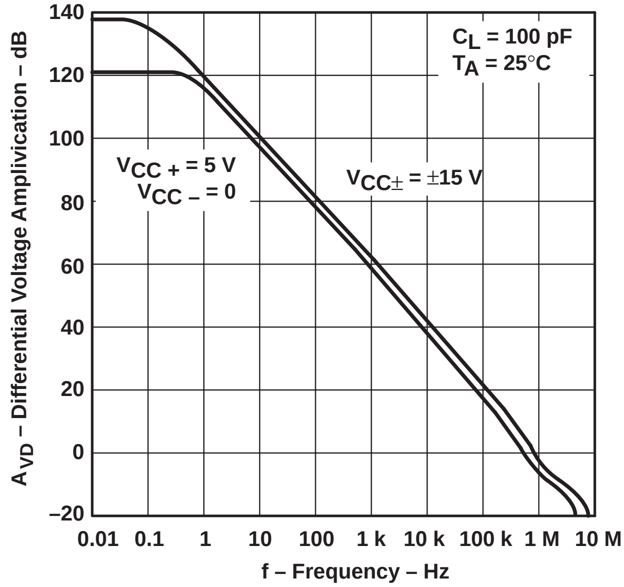


Figure 10

CHANNEL SEPARATION vs FREQUENCY

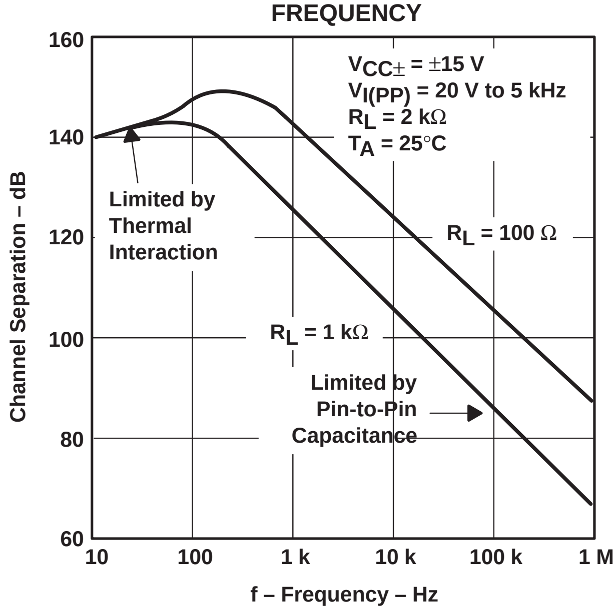


Figure 11

OUTPUT SATURATION VOLTAGE vs FREE-AIR TEMPERATURE

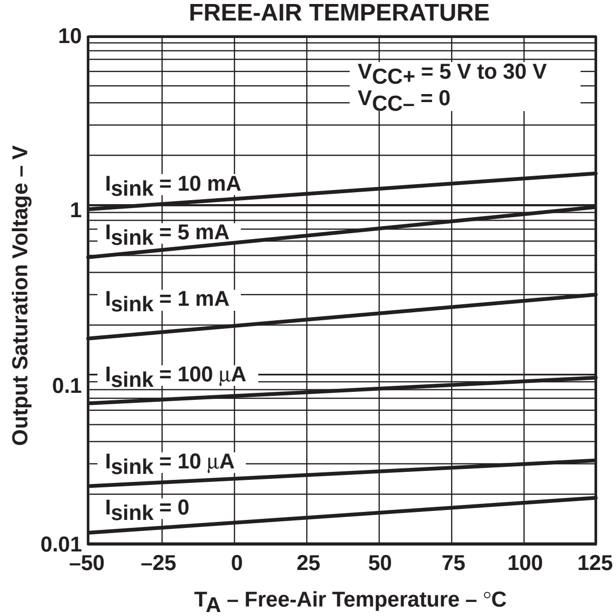


Figure 12

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

TYPICAL CHARACTERISTICS†

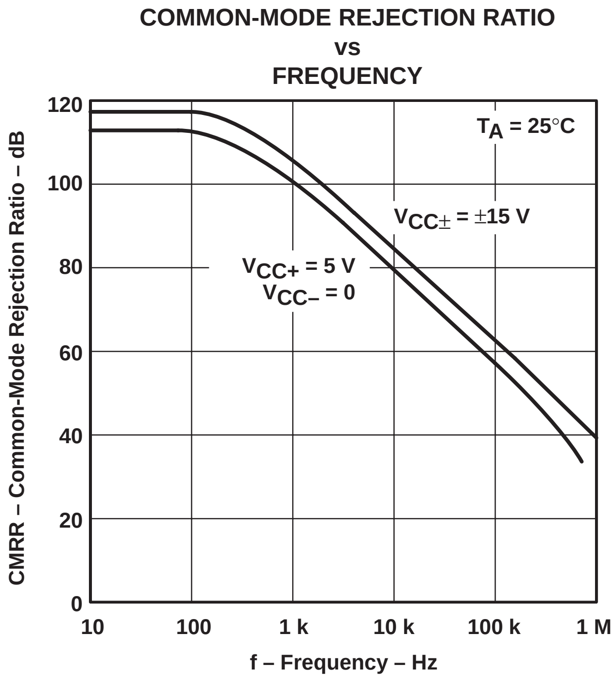


Figure 13

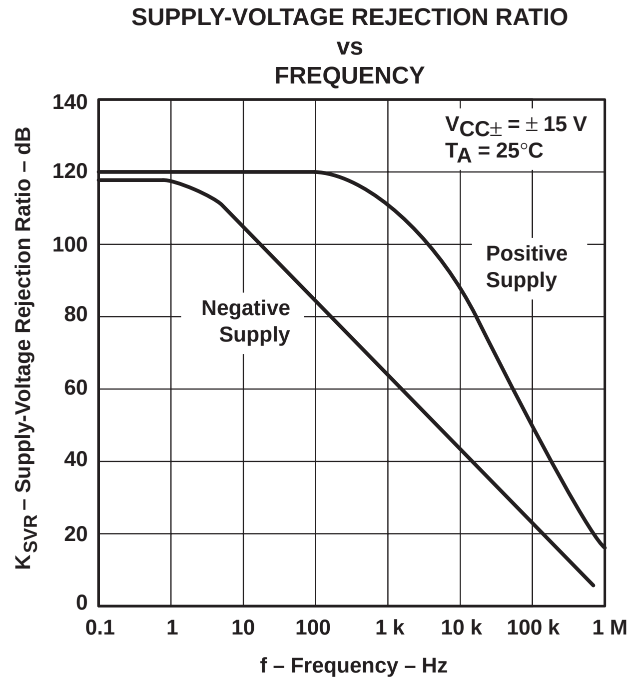


Figure 14

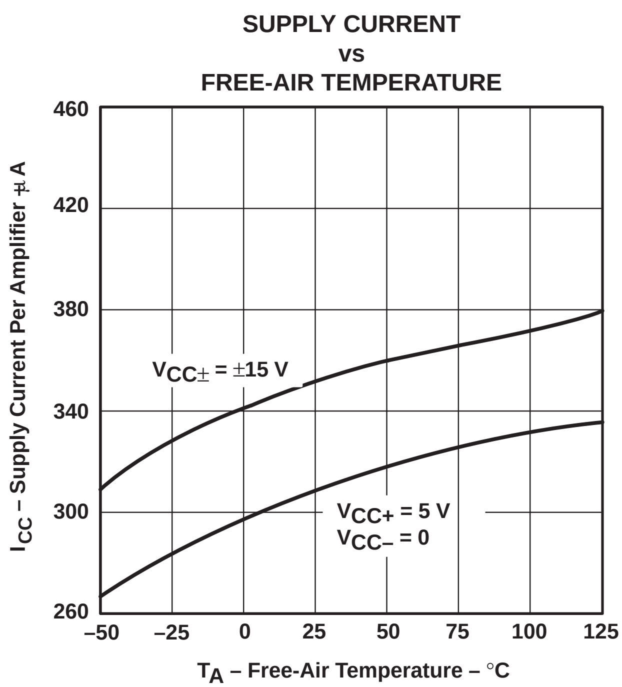


Figure 15

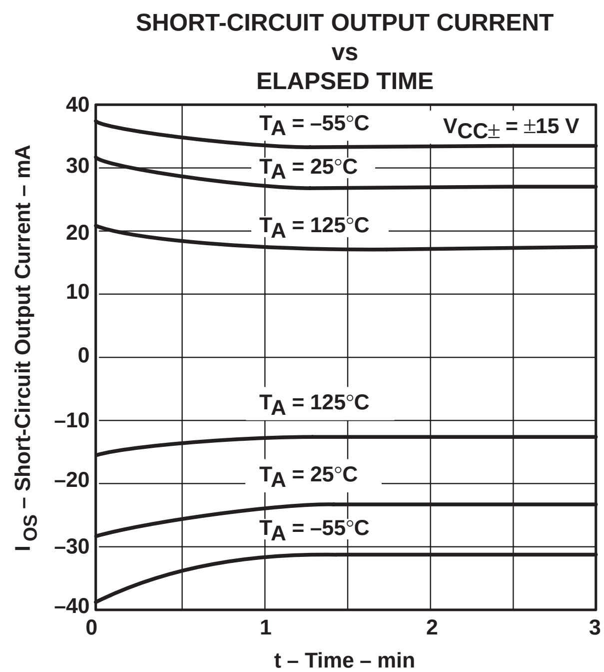


Figure 16

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

TYPICAL CHARACTERISTICS

EQUIVALENT INPUT NOISE VOLTAGE
AND EQUIVALENT INPUT NOISE CURRENT
vs
FREQUENCY

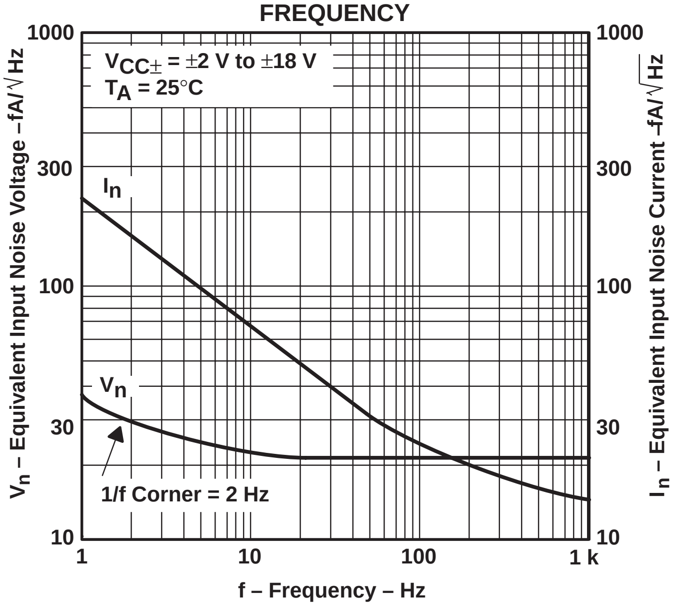


Figure 17

PEAK-TO-PEAK INPUT NOISE VOLTAGE
OVER A 10-SECOND PERIOD
vs
TIME

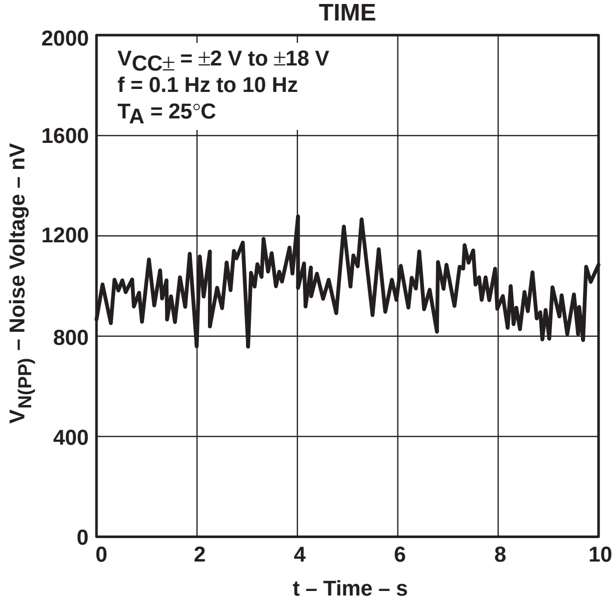


Figure 18

VOLTAGE-FOLLOWER SMALL-SIGNAL
PULSE RESPONSE
vs
TIME

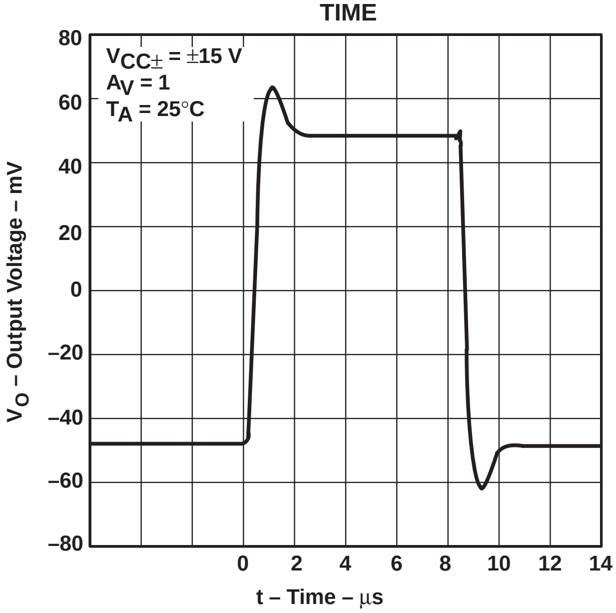


Figure 19

VOLTAGE-FOLLOWER LARGE-SIGNAL
PULSE RESPONSE
vs
TIME

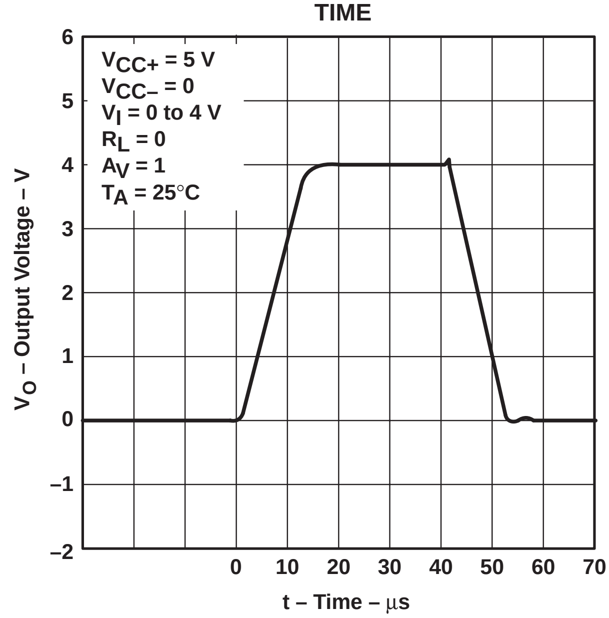


Figure 20

TYPICAL CHARACTERISTICS

VOLTAGE-FOLLOWER SMALL-SIGNAL PULSE RESPONSE vs TIME

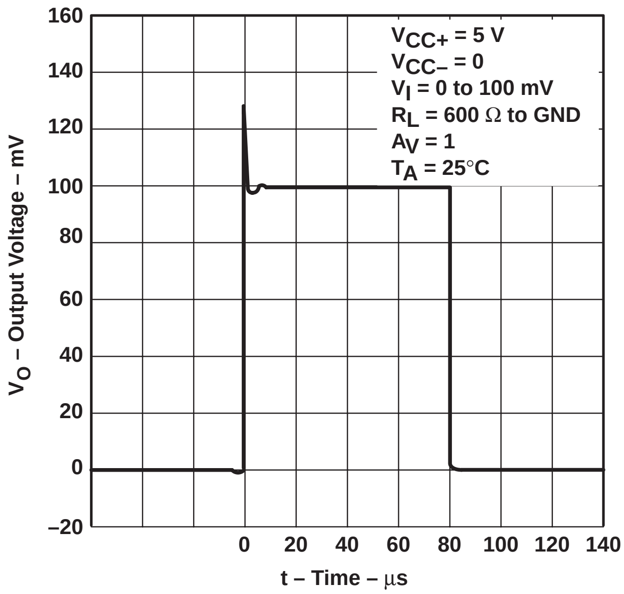


Figure 21

VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE vs TIME

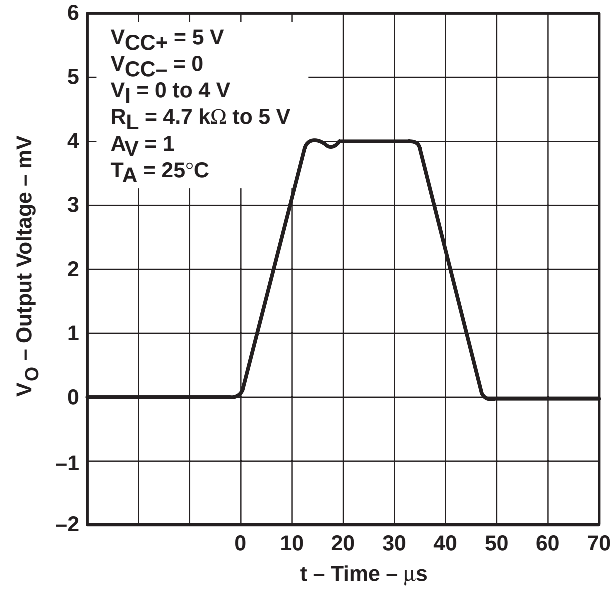


Figure 22

VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE vs TIME

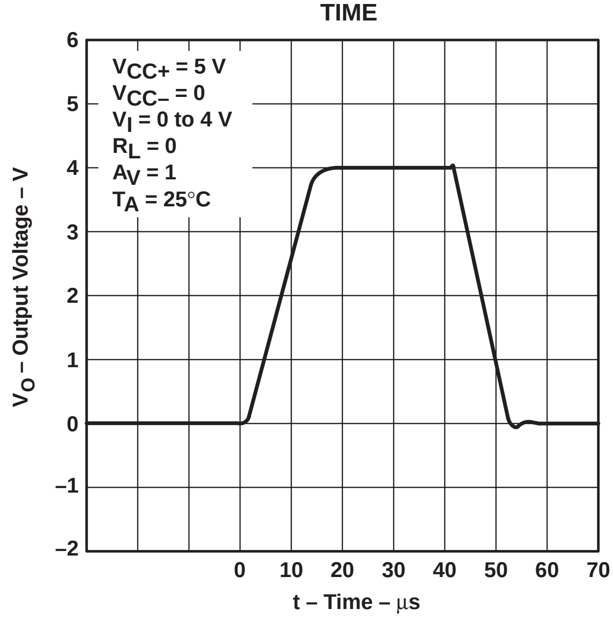


Figure 23

APPLICATION INFORMATION

single-supply operation

The LT1014 is fully specified for single-supply operation (V_{CC-} = 0). The common-mode input voltage range includes ground, and the output swings within a few millivolts of ground.

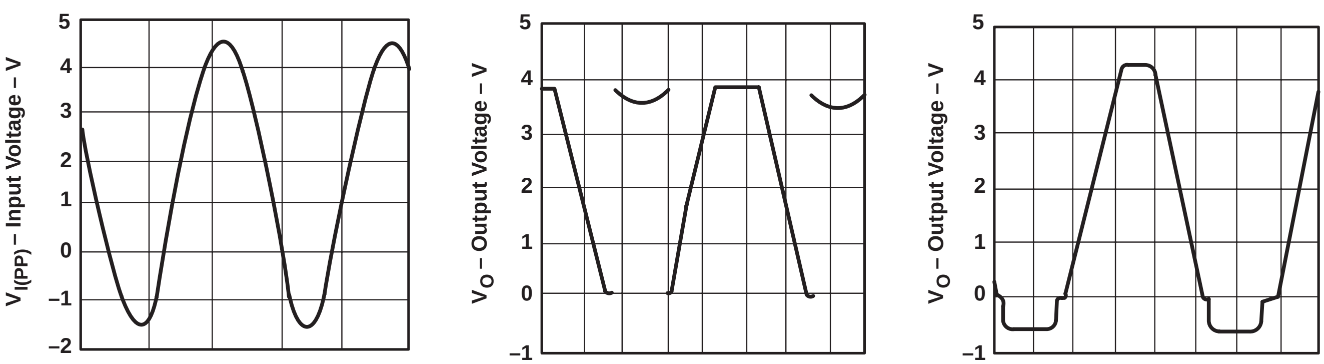
Furthermore, the LT1014 has specific circuitry that addresses the difficulties of single-supply operation, both at the input and at the output. At the input, the driving signal can fall below 0 V, either inadvertently or on a transient basis. If the input is more than a few hundred millivolts below ground, the LT1014 is designed to deal with the following two problems that can occur:

1. On many other operational amplifiers, when the input is more than a diode drop below ground, unlimited current flows from the substrate (V_{CC-} terminal) to the input, which can destroy the unit. On the LT1014, the 400-Ω resistors in series with the input (see schematic) protect the device even when the input is 5 V below ground.
2. When the input is more than 400 mV below ground (at T_A = 25°C), the input stage of similar type operational amplifiers saturates, and phase reversal occurs at the output. This can cause lockup in servo systems. Because of unique phase-reversal protection circuitry (Q21, Q22, Q27, and Q28), the LT1014 outputs do not reverse, even when the inputs are at –1.5 V (see Figure 24).

However, this phase-reversal protection circuitry does not function when the other operational amplifier on the LT1014 is driven hard into negative saturation at the output. Phase-reversal protection does not work on an amplifier:

- When 4's output is in negative saturation (the outputs of 2 and 3 have no effect)
- When 3's output is in negative saturation (the outputs of 1 and 4 have no effect)
- When 2's output is in negative saturation (the outputs of 1 and 4 have no effect)
- When 1's output is in negative saturation (the outputs of 2 and 3 have no effect)

At the output, other single-supply designs either cannot swing to within 600 mV of ground or cannot sink more than a few microproamperes while swinging to ground. The all-npn output stage of the LT1014 maintains its low output resistance and high gain characteristics until the output is saturated. In dual-supply operations, the output stage is free of crossover distortion.



(a) $V_{I(PP)}$ = –1.5 V to 4.5 V

(b) Output Phase Reversal Exhibited by LM358

(c) No Phase Reversal Exhibited by LT1014

Figure 24. Voltage-Follower Response With Input Exceeding the Negative Common-Mode Input Voltage Range

APPLICATION INFORMATION

comparator applications

The single-supply operation of the LT1014 can be used as a precision comparator with TTL-compatible output. In systems using both operational amplifiers and comparators, the LT1014 can perform multiple duties (see Figures 25 and 26).

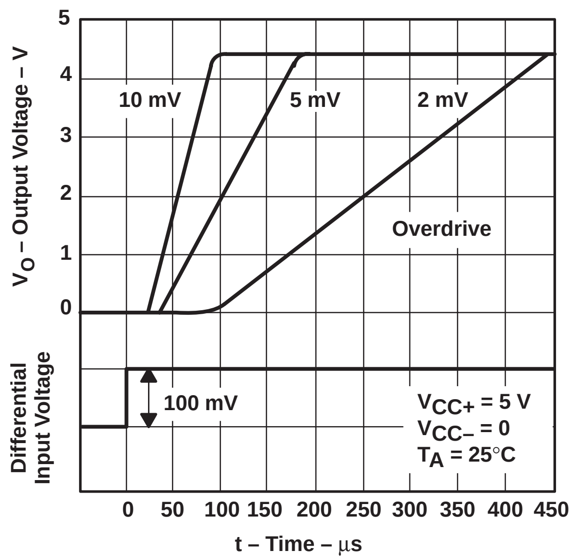


Figure 25. Low-to-High-Level Output Response for Various Input Overdrives

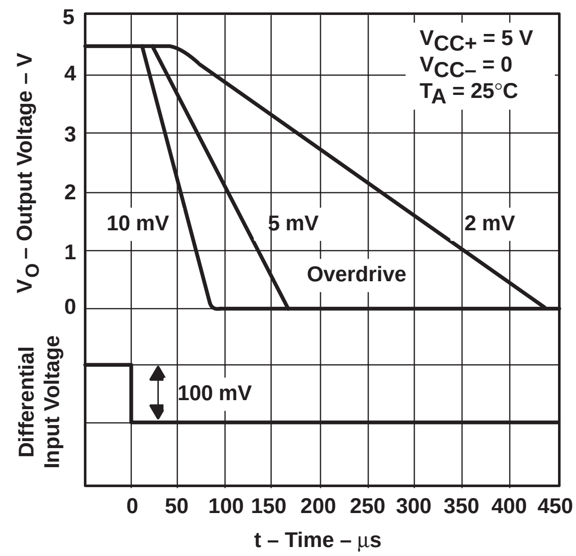


Figure 26. High-to-Low-Level Output Response for Various Input Overdrives

low-supply operation

The minimum supply voltage for proper operation of the LT1014 is 3.4 V (three Ni-Cad batteries). Typical supply current at this voltage is 290 µA; therefore, power dissipation is only 1 mW per amplifier.

offset voltage and noise testing

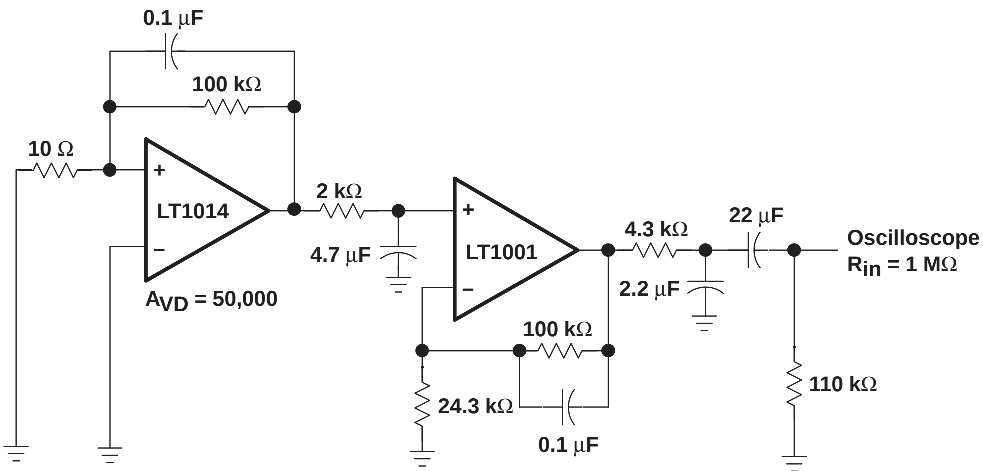
Figure 30 shows the test circuit for measuring input offset voltage and its temperature coefficient. This circuit with supply voltages increased to ±20 V is also used as the burn-in configuration.

The peak-to-peak equivalent input noise voltage of the LT1014 is measured using the test circuit shown in Figure 27. The frequency response of the noise tester indicates that the 0.1-Hz corner is defined by only one zero. The test time to measure 0.1-Hz to 10-Hz noise should not exceed 10 seconds, as this time limit acts as an additional zero to eliminate noise contribution from the frequency band below 0.1 Hz.

An input noise-voltage test is recommended when measuring the noise of a large number of units. A 10-Hz input noise-voltage measurement correlates well with a 0.1-Hz peak-to-peak noise reading because both results are determined by the white noise and the location of the 1/f corner frequency.

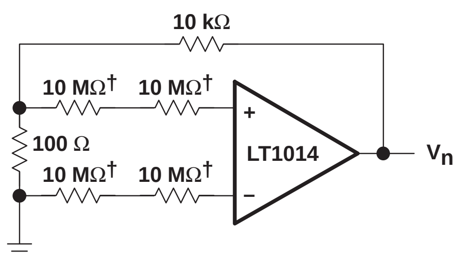
Noise current is measured by the circuit and formula shown in Figure 28. The noise of the source resistors is subtracted.

APPLICATION INFORMATION



NOTE A: All capacitor values are for nonpolarized capacitors only.

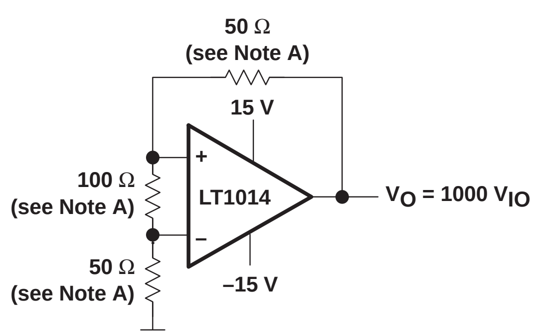
Figure 27. 0.1-Hz to 10-Hz Peak-to-Peak Noise Test Circuit



$$I_n = \frac{\left[V_{no}^2 - (820\ \text{nV})^2\right]^{1/2}}{40\ \text{M}\Omega \times 100}$$

† Metal-film resistor

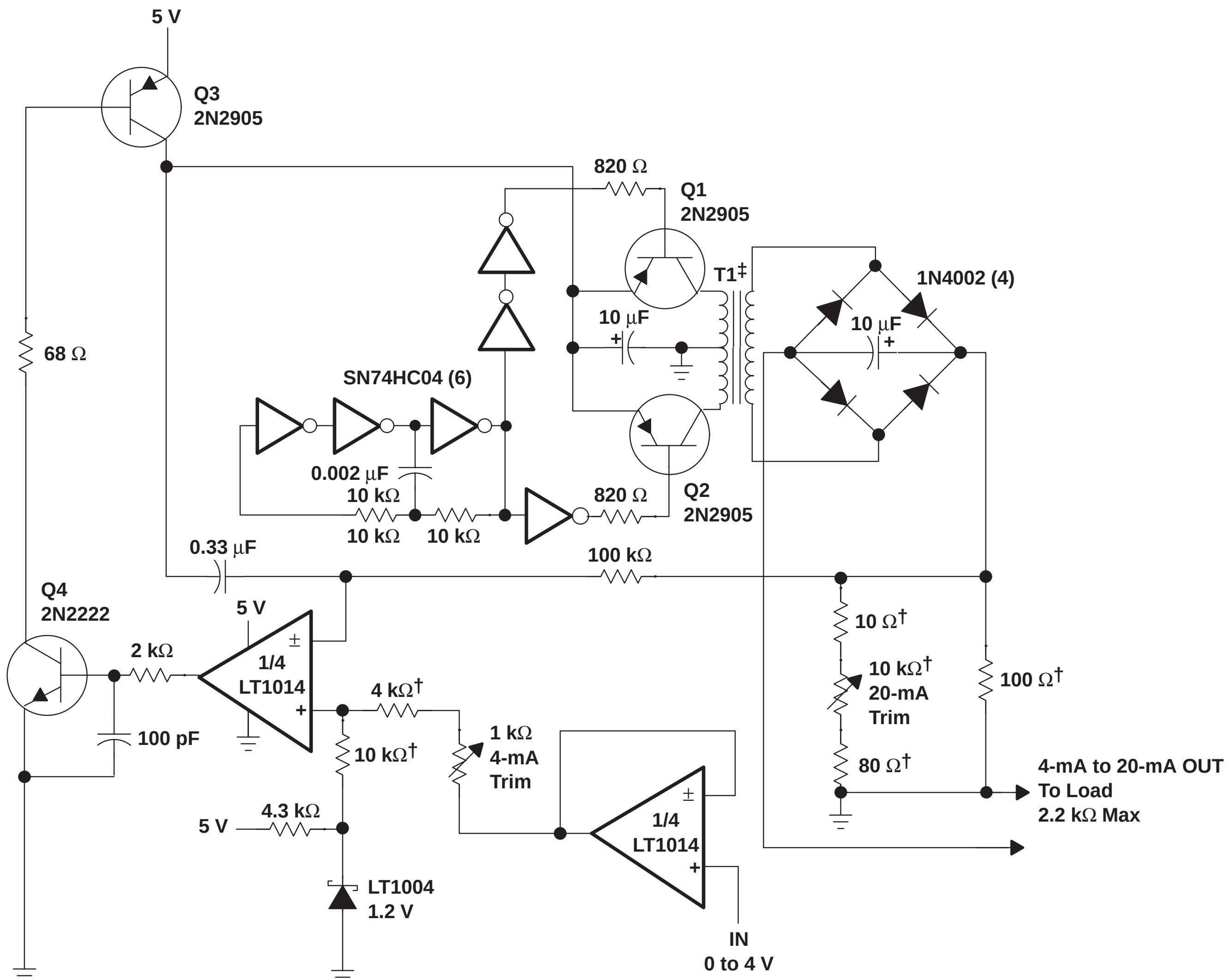
Figure 28. Noise-Current Test Circuit and Formula



NOTE A: Resistors must have low thermoelectric potential.

Figure 29. Test Circuit for V_{IO} and αV_{IO}

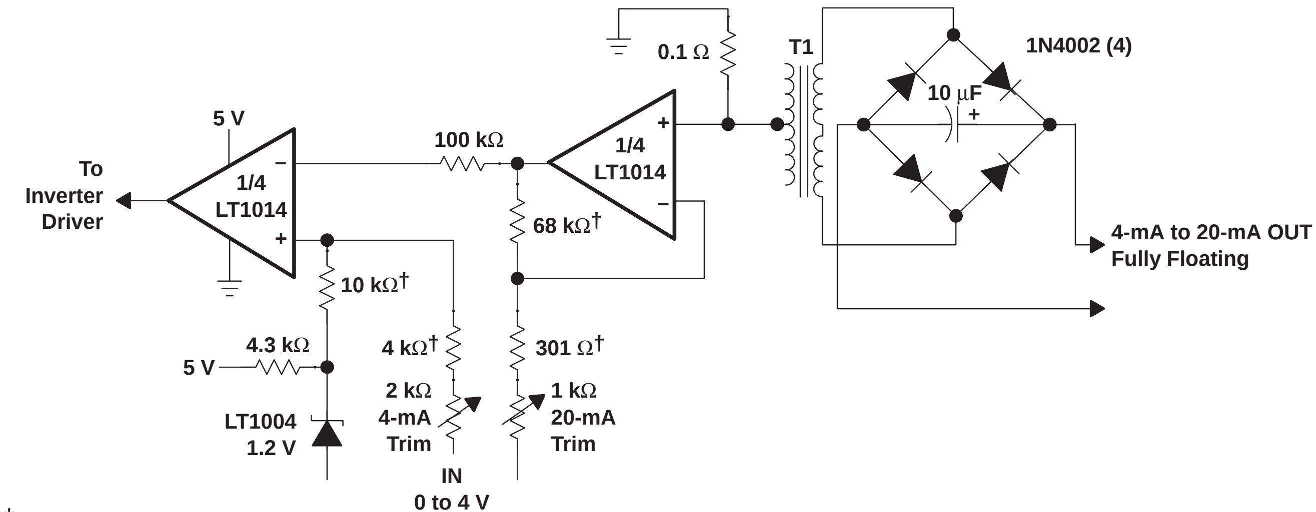
APPLICATION INFORMATION



† 1% film resistor. Match 10-kΩ resistors 0.05%.
‡ T1 = PICO-31080

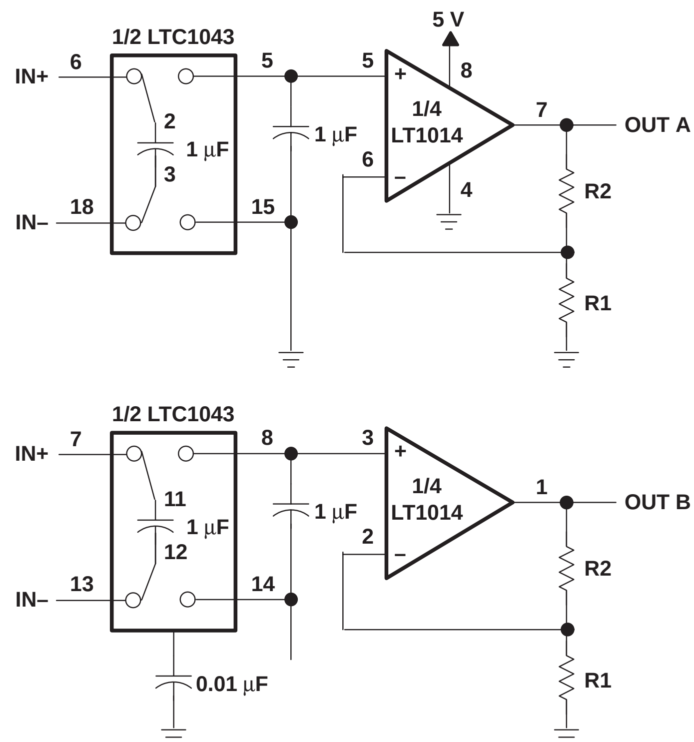
Figure 30. 5-V Powered, 4-mA to 20-mA Current-Loop Transmitter With 12-Bit Accuracy

APPLICATION INFORMATION



† 1% film resistor

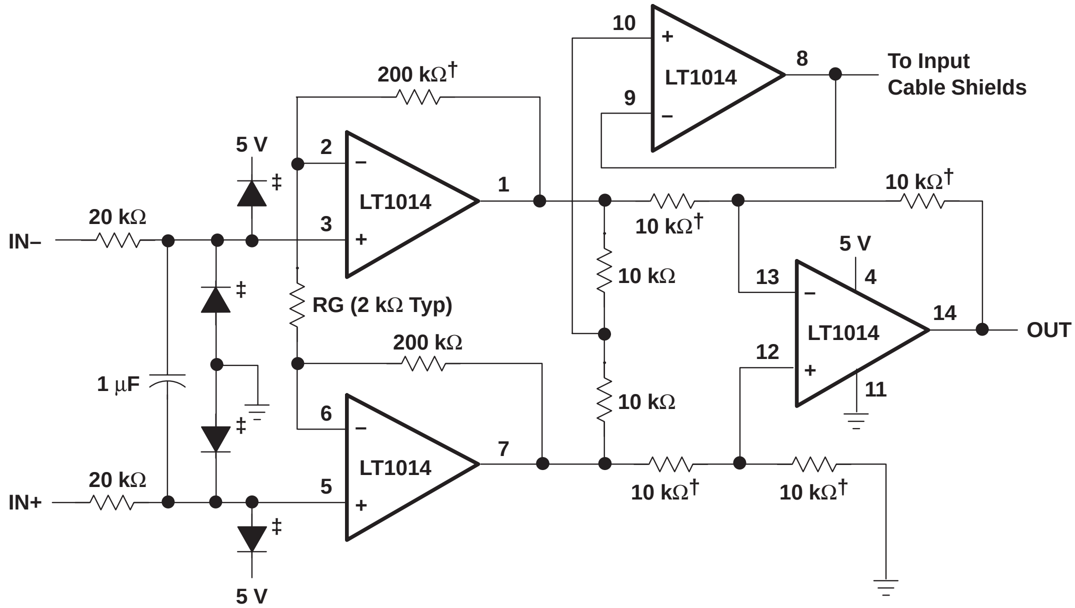
Figure 31. Fully Floating Modification to 4-mA to 20-mA Current-Loop Transmitter With 8-Bit Accuracy



NOTE A: V_{IO} = 150 μV, A_{VD} = (R1/R2) + 1, CMRR = 120 dB, V_{ICR} = 0 to 5 V

Figure 32. 5-V Single-Supply Dual Instrumentation Amplifier

APPLICATION INFORMATION



† † 1% film resistor. Match 10-kΩ resistors 0.05%.
‡ For high source impedances, use 2N2222 as diodes (with collector connected to base).
NOTE A: A_{VD} = (400,000/RG) + 1

Figure 33. 5-V Powered Precision Instrumentation Amplifier

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
5962-89677012A	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
5962-8967701CA	ACTIVE	CDIP	J	14	1	TBD	A42 SNPB	N / A for Pkg Type
5962-89677022A	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
5962-8967702CA	ACTIVE	CDIP	J	14	1	TBD	A42 SNPB	N / A for Pkg Type
LT1014AMFKB	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
LT1014AMJ	ACTIVE	CDIP	J	14	1	TBD	A42 SNPB	N / A for Pkg Type
LT1014AMJB	ACTIVE	CDIP	J	14	1	TBD	A42 SNPB	N / A for Pkg Type
LT1014CN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LT1014CNE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LT1014DDW	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1014DDWE4	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1014DDWG4	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1014DDWR	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1014DDWRE4	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1014DDWRG4	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1014DIDW	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1014DIDWG4	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1014DIDWR	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LT1014DIN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LT1014DINE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LT1014DMDW	ACTIVE	SOIC	DW	16	40	TBD	CU NIPDAU	Level-1-220C-UNLIM
LT1014DN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LT1014DNE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LT1014IN	OBSOLETE	PDIP	N	14		TBD	Call TI	Call TI
LT1014MFKB	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
LT1014MJ	ACTIVE	CDIP	J	14	1	TBD	A42 SNPB	N / A for Pkg Type
LT1014MJB	ACTIVE	CDIP	J	14	1	TBD	A42 SNPB	N / A for Pkg Type

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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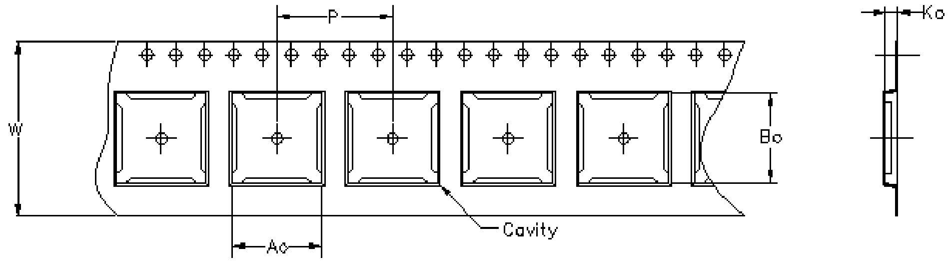
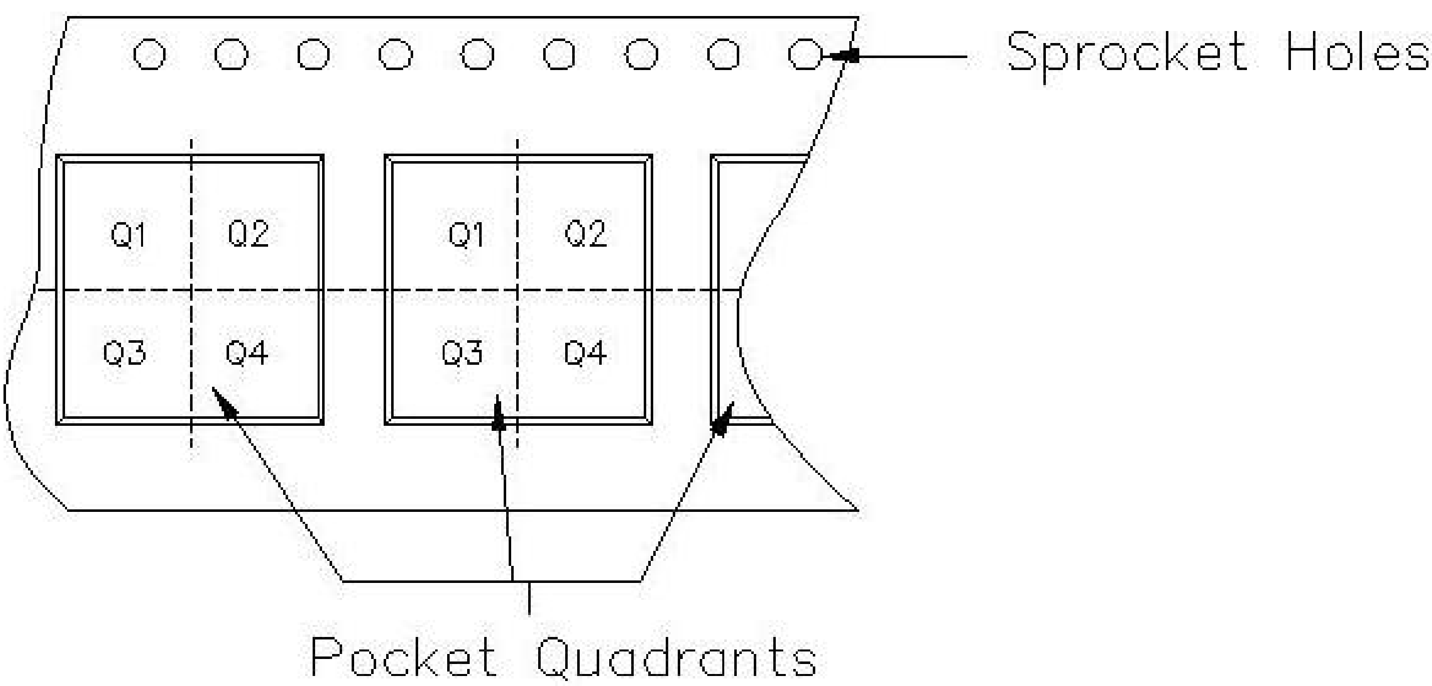


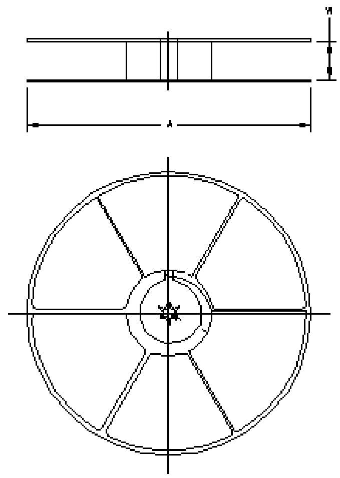
Carrier tape design is defined largely by the component lentgh, width, and thickness.

Ao = Dimension designed to accommodate the component width.	
Bo = Dimension designed to accommodate the component length.	
Ko = Dimension designed to accommodate the component thickness.	
W = Overall width of the carrier tape.	
P = Pitch between successive cavity centers.	



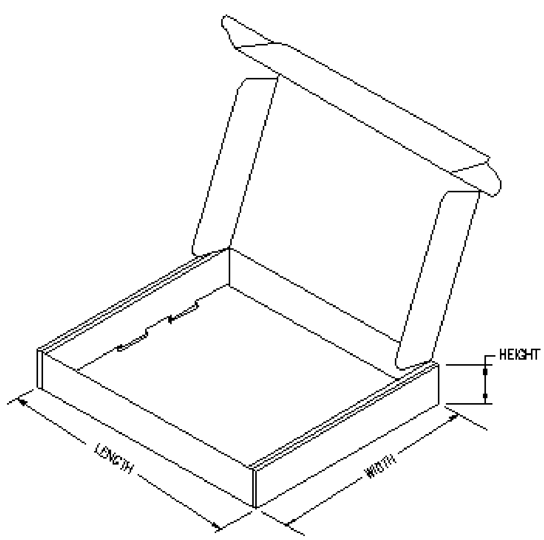
TAPE AND REEL INFORMATION

Device	Package	Pins	Site	Reel Diameter (mm)	Reel Width (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LT1014DDWR	DW	16	TAI	330	16	10.75	10.7	2.7	12	16	Q1
LT1014DIDWR	DW	16	TAI	330	16	10.75	10.7	2.7	12	16	Q1



TAPE AND REEL BOX INFORMATION

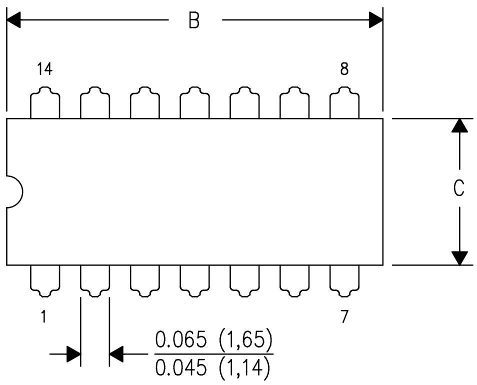
Device	Package	Pins	Site	Length (mm)	Width (mm)	Height (mm)
LT1014DDWR	DW	16	TAI	346.0	346.0	33.0
LT1014DIDWR	DW	16	TAI	346.0	346.0	33.0

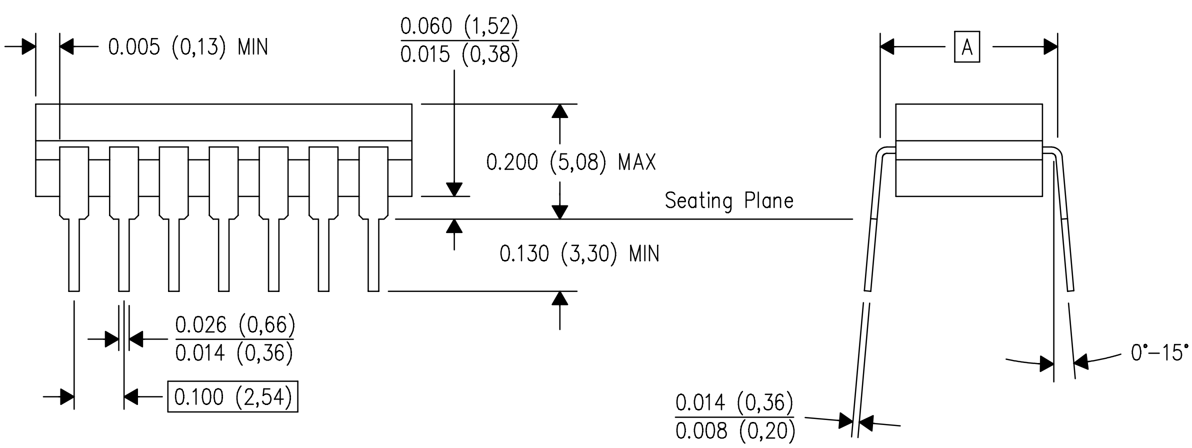


J (R–GDIP–T**) CERAMIC DUAL IN–LINE PACKAGE

14 LEADS SHOWN

DIM \ PINS **	14	16	18	20
A	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC
B MAX	0.785 (19,94)	.840 (21,34)	0.960 (24,38)	1.060 (26,92)
B MIN	—	—	—	—
C MAX	0.300 (7,62)	0.300 (7,62)	0.310 (7,87)	0.300 (7,62)
C MIN	0.245 (6,22)	0.245 (6,22)	0.220 (5,59)	0.245 (6,22)



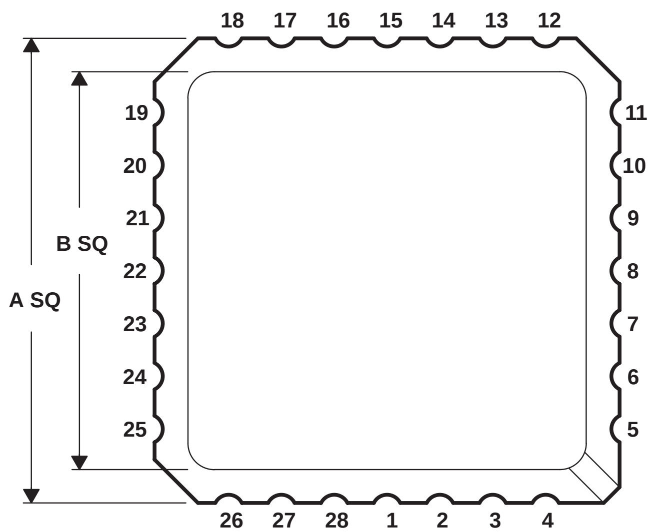


4040083/F 03/03

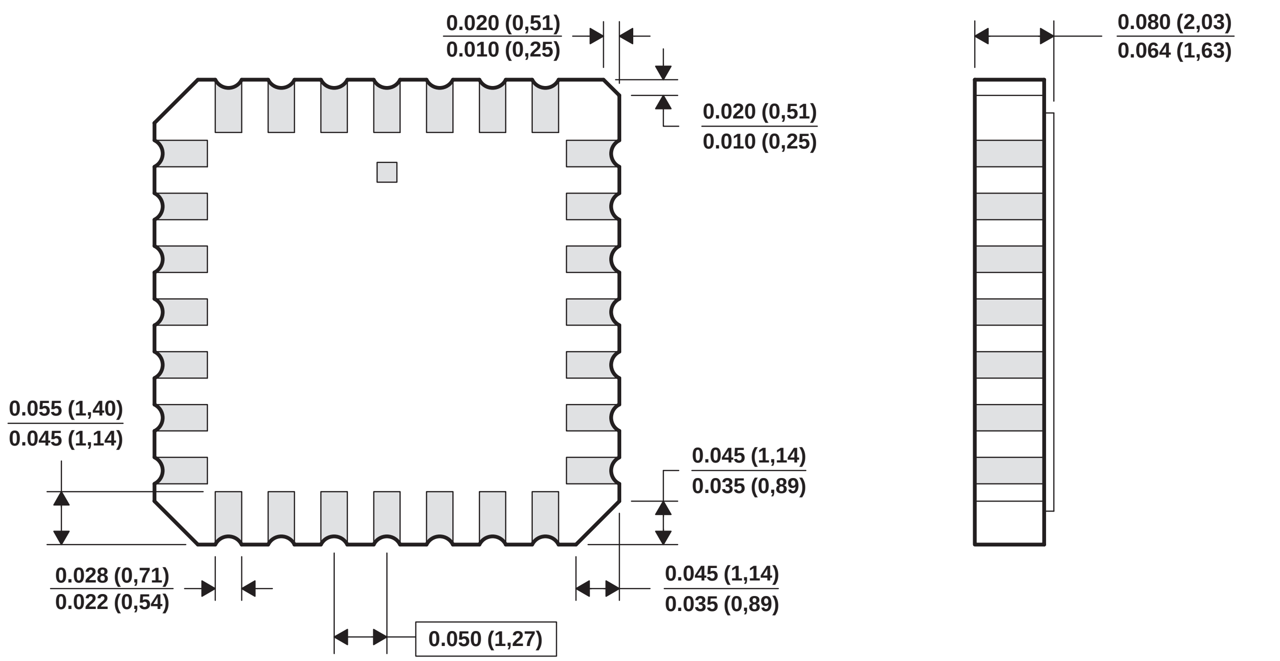
NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. This package is hermetically sealed with a ceramic lid using glass frit.
- D. Index point is provided on cap for terminal identification only on press ceramic glass frit seal only.
- E. Falls within MIL STD 1835 GDIP1–T14, GDIP1–T16, GDIP1–T18 and GDIP1–T20.

FK (S-CQCC-N)** **LEADLESS CERAMIC CHIP CARRIER**

28 TERMINAL SHOWN



NO. OF TERMINALS **	A		B	
	MIN	MAX	MIN	MAX
20	0.342 (8,69)	0.358 (9,09)	0.307 (7,80)	0.358 (9,09)
28	0.442 (11,23)	0.458 (11,63)	0.406 (10,31)	0.458 (11,63)
44	0.640 (16,26)	0.660 (16,76)	0.495 (12,58)	0.560 (14,22)
52	0.739 (18,78)	0.761 (19,32)	0.495 (12,58)	0.560 (14,22)
68	0.938 (23,83)	0.962 (24,43)	0.850 (21,6)	0.858 (21,8)
84	1.141 (28,99)	1.165 (29,59)	1.047 (26,6)	1.063 (27,0)

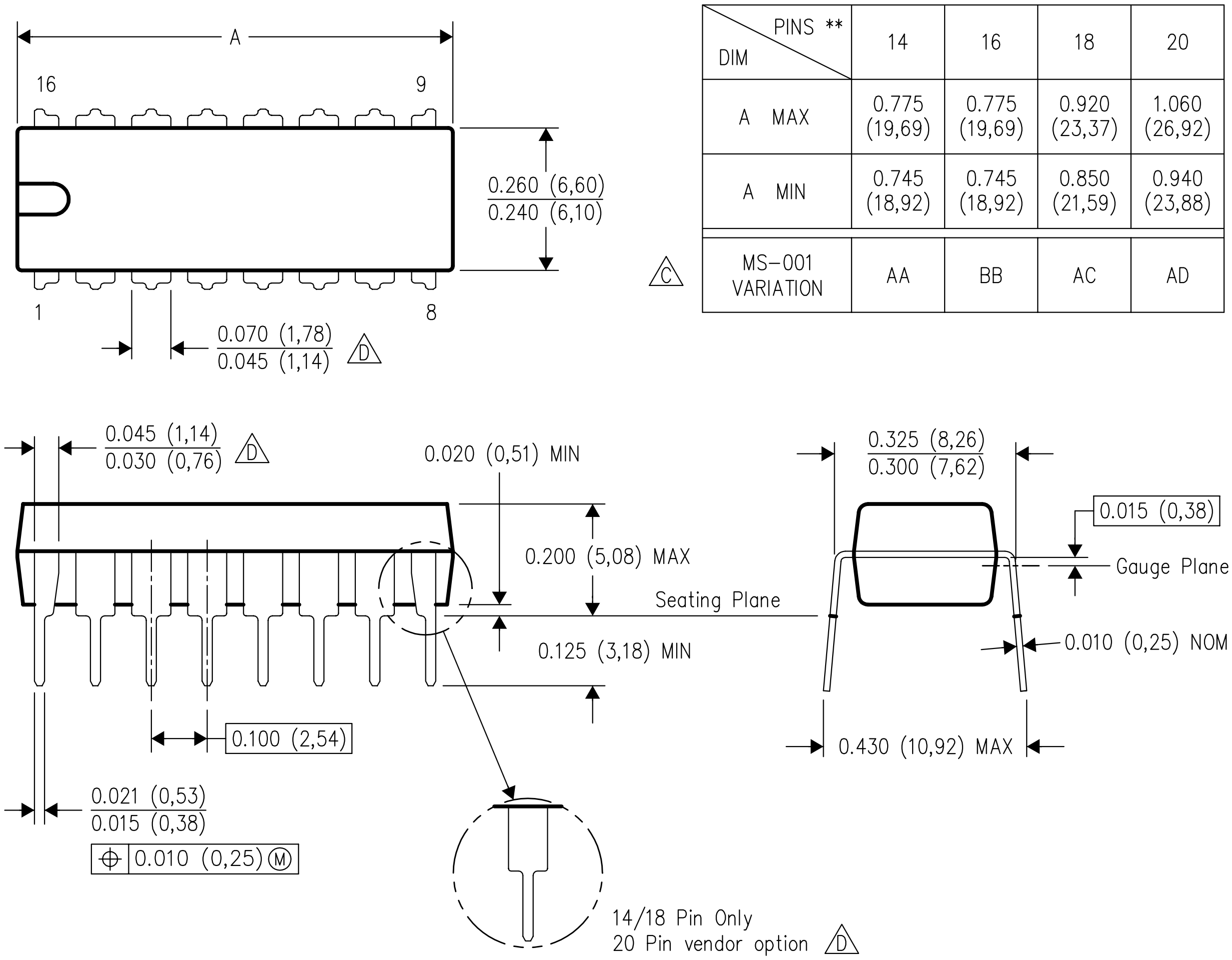


4040140 / D 10/96

NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. This package can be hermetically sealed with a metal lid.
D. The terminals are gold plated.
E. Falls within JEDEC MS-004

N (R–PDIP–T**) PLASTIC DUAL–IN–LINE PACKAGE

16 PINS SHOWN

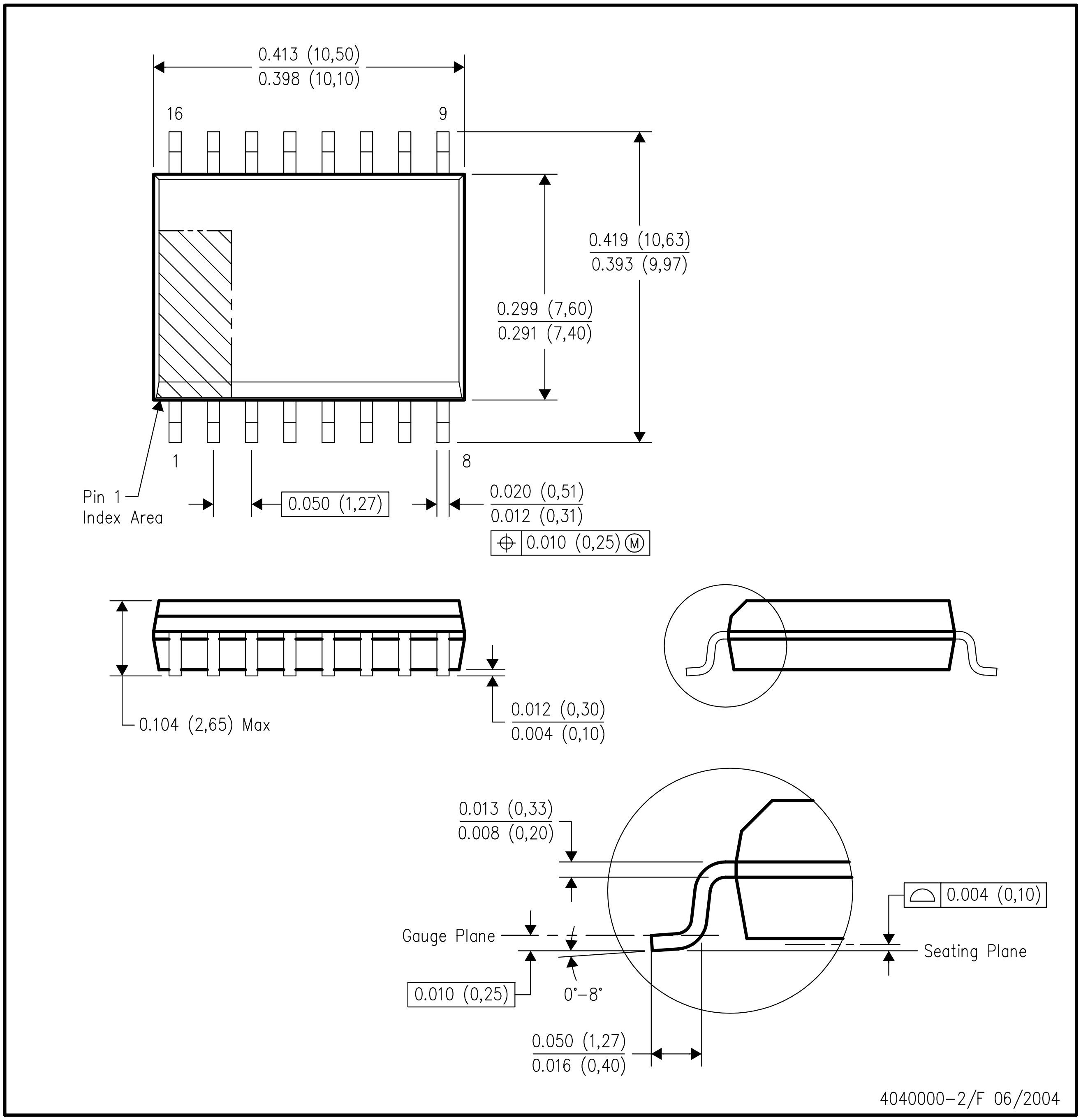


DIM \ PINS **	14	16	18	20
A MAX	0.775 (19,69)	0.775 (19,69)	0.920 (23,37)	1.060 (26,92)
A MIN	0.745 (18,92)	0.745 (18,92)	0.850 (21,59)	0.940 (23,88)
MS–001 VARIATION (C)	AA	BB	AC	AD

4040049/E 12/2002

NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS–001, except 18 and 20 pin minimum body length (Dim A).
D. The 20 pin end lead shoulder width is a vendor option, either half or full width.

DW (R-PDSO-G16) PLASTIC SMALL-OUTLINE PACKAGE



NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
- D. Falls within JEDEC MS-013 variation AA.