Thermocouple Cold Junction Compensator and Matched Amplifier

FEATURES

- 0.75°C Initial Accuracy (A Version)
- Extremely Low Warmup Drift
- Preset Outputs for Type E, J, K, R, S, T
- Single 5V to ±20V Operation
- 480μA Typical Supply Current
- Available in 8-Pin DIP Package

APPLICATIONS

- Thermocouple Cold Junction Compensation

DESCRIPTION

The LTK001 is a thermocouple amplifier supplied with a matched cold junction compensator. By separating the amplifier and compensator functions, the problem of compensator temperature rise is virtually eliminated. The compensator is a selected version of the LT®1025 cold junction compensator. The amplifier, which is also available separately as LTKA0x has been specially selected for thermocouple applications. It has low supply current to minimize warmup drift, very low offset voltage (<35μV), high gain, and extremely low input bias currents (<600pA) to allow high impedance input filters to be used without degrading offset voltage or drift.

Matching of the kits is accomplished by separating the compensators and amplifiers according to the polarity of their initial (room temperature) errors. This eliminates the need to sum the errors of the two components to find the worst-case error.

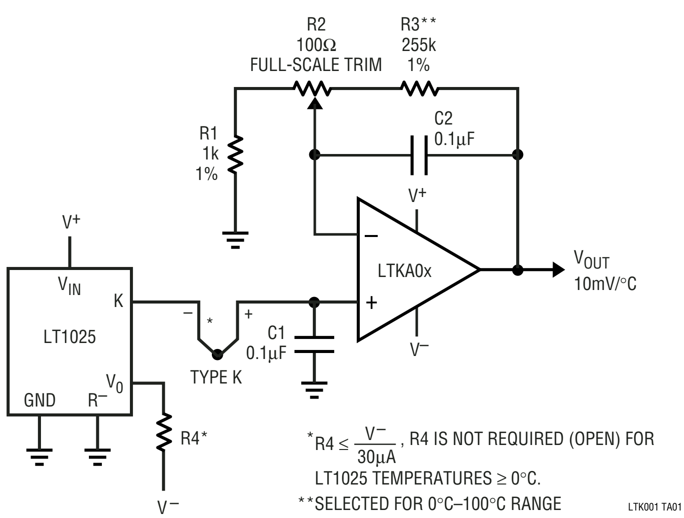
The LTK001 has direct thermocouple outputs of 60.9μV/°C (E), 51.7μV/°C (J), 40.6μV/°C (K, T), and 5.95μV/°C (R, S). It also has a 10mV/°C output which can be scaled to match any arbitrary thermocouple.

For multiple thermocouple applications using one compensator, amplifiers may be ordered separately (LTKA0x), still matched to the compensator.

 For typical performance curves and applications circuits consult the LT1025 data sheet.

TYPICAL APPLICATION

Type K 10mV/°C Thermometer



ABSOLUTE MAXIMUM RATINGS (Note 1)

Amplifier (LTKA0x)

Supply Voltage (Total V^+ to V^-) 40V
Differential Input Current (Note 2) .... ±10mA
Common Mode Input Voltage .... Equal to Supplies
Output Short-Circuit Duration .... Indefinite

Compensator (LT1025)

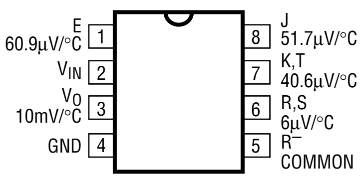
Supply Voltage (V_{IN} to Ground Pin) 36V
Output Voltage (Forced) 5V
Output Short-Circuit Duration .... Indefinite

Both Devices

Operating Temperature Range
LTK001AMJ8, LTK001MJ8 **(OBSOLETE)** .... –55°C to 125°C
LTK001ACN8, LTK001CN8 .... 0°C to 70°C
Storage Temperature Range .... –65°C to 150°C
Lead Temperature Range (Soldering, 10 sec.)...... 300°C

PACKAGE/ORDER INFORMATION

TOP VIEW



N8 PACKAGE
8-LEAD PDIP
COMPENSATOR
(LT1025)

T_{JMAX} = 100°C, θ_{JA} = 130°C/W (N8)

ORDER PART NUMBER

KIT
LTK001CN8
LTK001ACN8

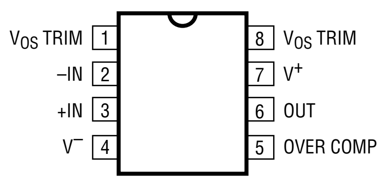
J8 PACKAGE
8-LEAD CERDIP
COMPENSATOR
(LT1025)

T_{JMAX} = 150°C, θ_{JA} = 100°C/W (J8)

LTK001MJ8
LTK001AMJ8

OBSOLETE PACKAGE
Consider the N8 Package for Alternate Source

TOP VIEW



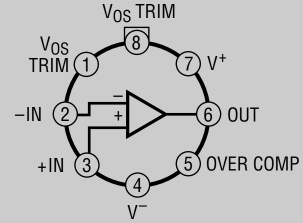
N8 PACKAGE
8-LEAD PDIP AMPLIFIER
(LTKA0x)

T_{JMAX} = 100°C, θ_{JA} = 130°C/W

ORDER PART NUMBER

AMPLIFIER ONLY
(Note A)
LTKA00CN8
LTKA01CN8

TOP VIEW



H PACKAGE
8-LEAD TO-5 METAL CAN
AMPLIFIER (LTKA0x)

T_{JMAX} = 150°C, θ_{JA} = 150°C/W, θ_{JC} = 45°C/W

ORDER PART NUMBER

AMPLIFIER ONLY
(Note A)
LTKA00MH
LTKA01MH

OBSOLETE PACKAGE

Note A: The polarity of the amplifier is indicated by the 0 or 1 in the part number. An LT1025 with a 0 identifier is properly matched with an LTKA00, while an LT1025 with a 1 identifier should be used with an LTKA01.

Consult factory for parts specified with wider operating temperature ranges.

ELECTRICAL CHARACTERISTICS (Matched Amplifier and Compensator)

T_A = 25°C, V_S = ±15V (Amplifier), V_S = 5V (Compensator)

PARAMETER	CONDITIONS		LTK001A MIN	LTK001A TYP	LTK001A MAX	LTK001 MIN	LTK001 TYP	LTK001 MAX	UNITS
Total Temperature Error at 25°C (Note 3)		Type E			0.75			2.5	°C
		Type J			0.75			2.5	°C
		Type K, T			0.86			2.5	°C
		Type R, S	(Note 12)		5.0			5.0	°C
Slope Error (Notes 4 and 9)	0°C ≤ T_J ≤ 70°C	Type E			0.05			0.09	°C/°C
		Type J			0.06			0.09	°C/°C
		Type K, T			0.07			0.10	°C/°C
		Type R, S			0.28			0.32	°C/°C
Total Temperature Error at Temperature Extremes (Note 9)	0°C ≤ T_J ≤ 70°C	Type E			2.0			5	°C
		Type J			2.1			5	°C
		Type K, T			2.6			5.2	°C
		Type R, S	(Note 12)		16			16	°C
	–55°C ≤ T_J ≤ 125°C	Type E			6			8.5	°C
		Type J			6			8.5	°C
		Type K, T			6.3			9	°C
		Type R, S	(Note 12)		30			30	°C
Temperature Error Change with Supply Voltage (Note 5)					0.1			0.1	°C/V
Supply Current				480	900		480	900	μA

ELECTRICAL CHARACTERISTICS (Compensator LT1025)

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_S = 5V unless otherwise noted.

PARAMETER	CONDITIONS		COMPENSATOR (LT1025) MIN	TYP	MAX	UNITS
Temperature Error at 10mV/°C Output (Note 9)	T_J = 25°C, LTK001A T_J = 25°C, LTK001			0.3 0.5	0.5 2.0	°C °C
	Full Temperature Span	●	See Curve on LT1025 Data Sheet			
Temperature Error at Individual Outputs (Note 10)	LTK001A: E, J, K, T LTK001A: R, S			0.4 0.4	0.75 1.5	°C °C
	LTK001: E, J, K, T LTK001: R, S			0.8 1.2	2.4 3.5	°C °C
	Full Temperature Span	●	See Curve on LT1025 Data Sheet			
Supply Current	4V ≤ V_{IN} ≤ 36V			80	100	μA
	0°C ≤ T_J ≤ 70°C	●			150	μA
	–55°C ≤ T_J ≤ 125°C	●			200	μA
Change in Supply Current	4V ≤ V_{IN} ≤ 36V			0.01	0.05	μA/V
Line Regulation (Note 11)	4V ≤ V_{IN} ≤ 36V 10mV/°C Output	●		0.003	0.02	°C/V
Load Regulation (Note 11)	0 ≤ I_O ≤ 1mA 10mV/°C Output	●		0.04	0.2	°C
Divider Impedance	E J K, T R, S			2.5 2.1 4.4 3.8		kΩ kΩ kΩ kΩ

ELECTRICAL CHARACTERISTICS (Amplifier LTKA0x)

The ● denotes the specifications which apply over the full operating temperature range, otherwise specifications are at $T_A = 25°C$. $V_S = ±15V$, $V_{CM} = 0V$, $T_J = 25°C$ unless otherwise noted.

PARAMETER	CONDITIONS			AMPLIFIER (LTKA0x) MIN	TYP	MAX	UNITS
Input Offset Voltage					10	35	μV
Input Offset Voltage Drift with Temperature	(Note 6)		●		0.3	1.5	μV/°C
Input Bias Current	$0°C ≤ T_A ≤ 70°C$		●		±200	±600	pA
	$–55°C ≤ T_A ≤ 125°C$		●		±300	±1500	pA
Input Bias Current Drift with Temperature	(Note 6)				1	5	pA/°C
Input Offset Current	$0°C ≤ T_A ≤ 70°C$		●		±100	±500	pA
	$–55°C ≤ T_A ≤ 125°C$		●		±200	±700	pA
Input Offset Current Drift with Temperature	(Note 6)		●		0.6	4	pA/°C
Large Signal Voltage Gain	$R_L = 10kΩ$		●	400	2000		V/mV
Common Mode Rejection Ratio	$V_{CM} = ±13.5V$		●	106	130		dB
Power Supply Rejection Ratio	$±2.5V ≤ V_S ≤ ±20V$ (Note 5)		●	106	125		dB
Common Mode Input Voltage Range	Notes 6, 7	Above $V^–$		0.75			V
		Below V^+				1.0	V
Output Voltage Swing (Notes 6, 8)	Referred to Supplies	$I_{OUT} = 0.1mA$			0.8		V
		$I_{OUT} = 1mA$			1.1		V
Supply Current			●		400	800	μA
Supply Voltage Range	Total V^+ to $V^–$ Voltage		●	4.5		40	V

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

Note 2: The inputs of the LTKA0x amplifier are clamped with diodes, so a differential voltage rating does not apply.

Note 3: Total temperature error is the overall error at 25°C taking into account the offset of the amplifier, the offset at the compensator 10mV/°C output, and the error in the compensator divider network. Warmup drift is not included.

Note 4: Slope error is the increase in total temperature error as ambient temperature is increased. It is guaranteed by design and by other tests, but is not tested directly.

Note 5: This is a worst-case limit assuming that any or all supply voltages change.

Note 6: Guaranteed, but not tested.

Note 7: By referring common mode range to the supplies, the range referred to ground can be quickly calculated for any given supply voltage. With a single 5V supply, for instance, which has a worst-case low value of 4.7V, the upper common mode limit is 4.7V – 1V = 3.7V. The lower common mode limit is 0V + 0.75V = 0.75V. With ±15V supplies, the limits would be 14V and –14.25V, respectively. Common mode range has a temperature sensitivity of ≈2mV/°C.

Note 8: Absolute output voltage swing is calculated by subtracting the given limits from actual supply voltage. These limits indicate the point where offset voltage has changed suddenly by 5μV.

Note 9: Temperature error is defined as the deviation from the following formula:

$V_{OUT} = \alpha(T) + \alpha\beta(T - 25°C)^2$

α = Typical thermocouple Seebeck coefficient as follows,
E = 60.9μV/°C, J = 51.7μV/°C, K, T = 40.6μV/°C, R, S = 5.95μV/°C.
α = 10mV/°C at the 10mV output.

β = Nonlinearity coefficient built into the LT1025 to help compensate for the nonlinearities of thermocouples. $\beta = 5.5 \times 10^{-4}$, generating 0.34°C bow for 25°C temperature change, and 1.36°C bow for 50°C change.

Note 10: Temperature error at the individual outputs is the sum of the 10mV/°C output error plus the resistor divider error.

Note 11: Line and load regulation do not take into account the effects of self-heating. Output changes due to self-heating can be calculated as follows:

$\Delta V_{OUT}(\text{Line}) = \Delta V_{IN}(I_q + I_{load})(150°C/W)$

$\Delta V_{OUT}(\text{Load}) = (\Delta I_{load})(V_{IN})(150°C/W)$

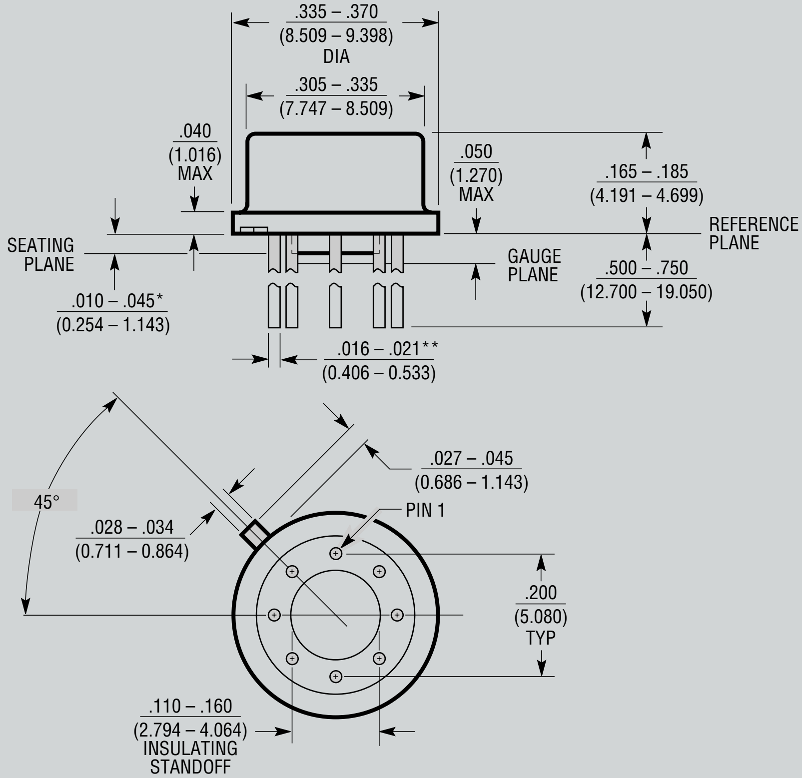
= LT1025 supply current

Load regulation is $30\mu A ≤ I_Q ≤ 1mA$ for $T_A ≤ 0°C$.

Note 12: Larger errors with type R and S thermocouples are due mostly to 35μV offset of the amplifier. This error can be reduced to 5μV max with the LTC®1050 or LTC1052 operational amplifiers.

PACKAGE DESCRIPTION

H Package
8-Lead TO-5 Metal Can (.200 Inch PCD)
(Reference LTC DWG # 05-08-1320)



*LEAD DIAMETER IS UNCONTROLLED BETWEEN THE REFERENCE PLANE AND THE SEATING PLANE

**FOR SOLDER DIP LEAD FINISH, LEAD DIAMETER IS .016 – .024 (0.406 – 0.610)

H8(TO-5) 0.200 PCD 0204

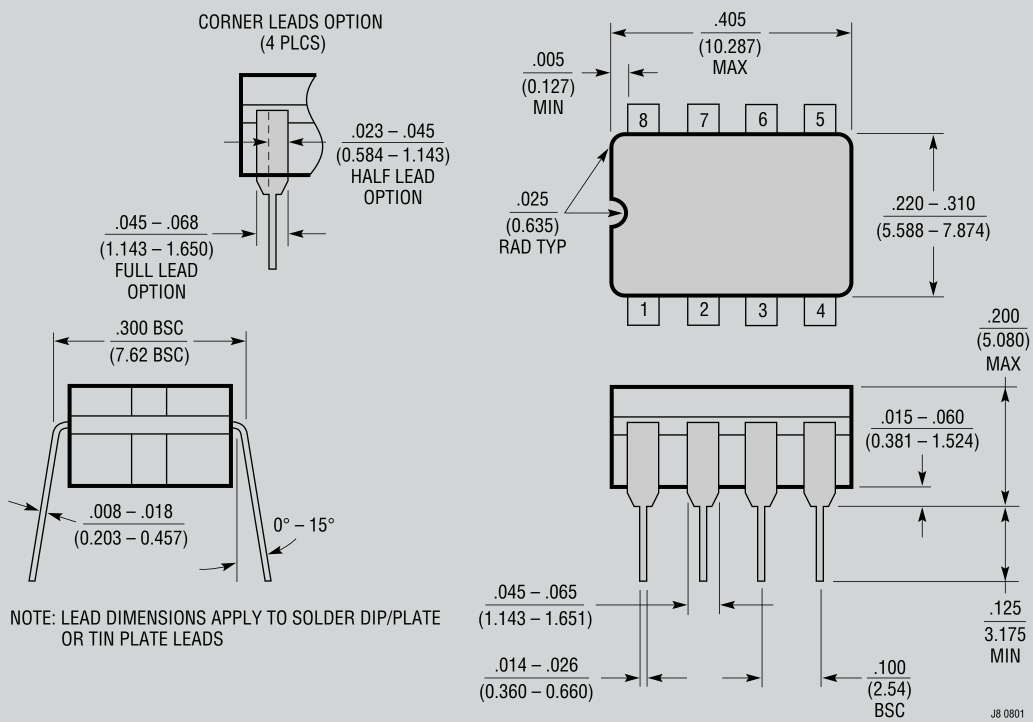
OBSOLETE PACKAGE

001fa

LINEAR TECHNOLOGY

PACKAGE DESCRIPTION

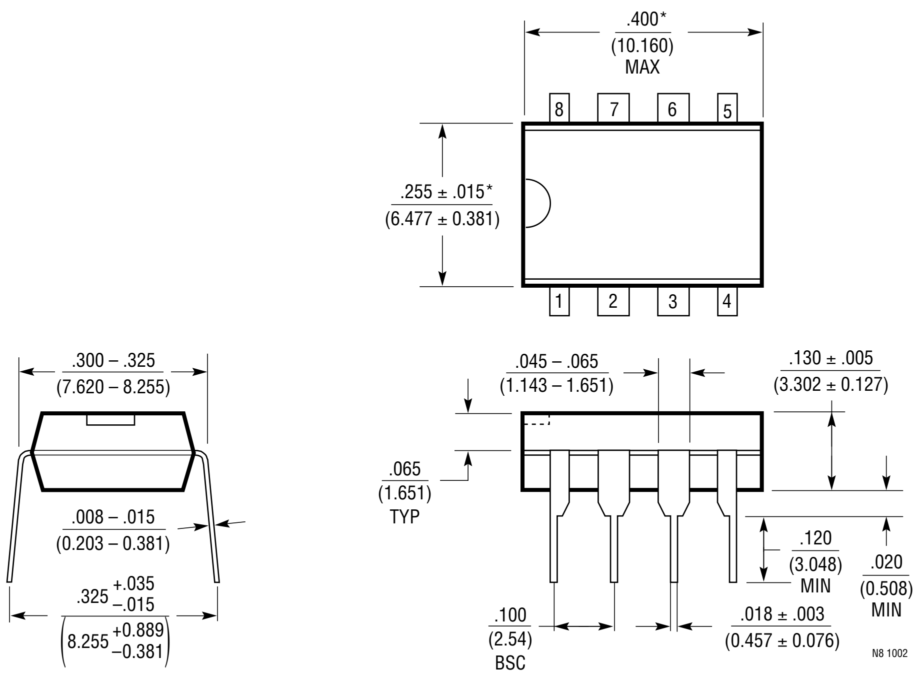
J8 Package
8-Lead CERDIP (Narrow .300 Inch, Hermetic)
(Reference LTC DWG # 05-08-1110)



OBSOLETE PACKAGE

PACKAGE DESCRIPTION

N8 Package
8-Lead PDIP (Narrow .300 Inch)
(Reference LTC DWG # 05-08-1510)



NOTE:
1. DIMENSIONS ARE INCHES / MILLIMETERS
*THESE DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
MOLD FLASH OR PROTRUSIONS SHALL NOT EXCEED .010 INCH (0.254mm)

RELATED PARTS

PART NUMBER	DESCRIPTION	COMMENTS
LT1012	Picoamp Input Current Amplifier	V_{OS} = 120µV MAX, I_{OS} = 280pA MAX
LT1025	Thermocouple Cold Junction Comparator	Micropower, 0.5°C Initial Accuracy
LTC1050	Zero Drift Amplifier	V_{OS} = 5µV MAX, A_{VOL} = 1V/µV MAX
LTC2050	SOT-23 Zero Drift Amplifier	V_{OS} = 3µV MAX

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