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

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 LT1025 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.

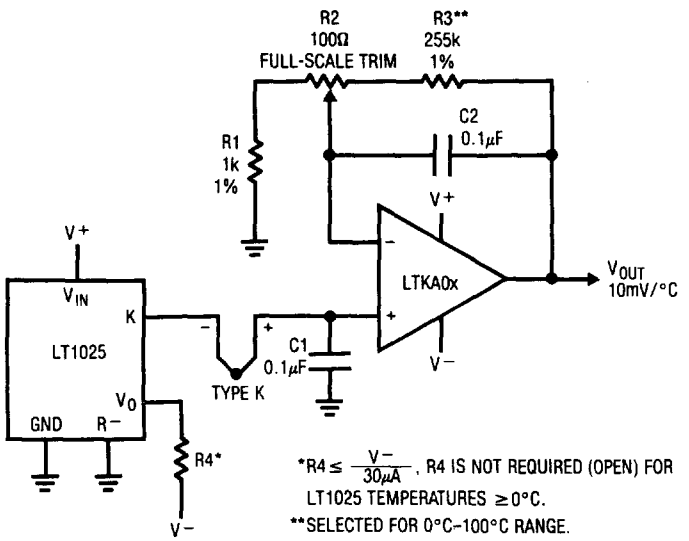
The LTK001 has direct thermocouple outputs of 60.9μV/°C (E), 51.7μV/°C (J), 40.6μV/°C (K, T), and 5.95μV/°C (R, S). It also has a 10mV/°C output which can be scaled to match any arbitrary thermocouple.

The amplifier in the LTK001 kit is available in an 8-pin plastic miniDIP for 0°C to 70°C operation and an 8-pin TO-39 metal can for −55°C to +125°C operation. The compensator is available in 8-pin plastic miniDIP for 0°C to 70°C operation and 8-pin ceramic miniDIP for −55°C to +125°C operation.

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.

Type K 10mV/°C Thermometer



11

ABSOLUTE MAXIMUM RATINGS

Amplifier (LTKA0x)

Supply Voltage (Total V^+ to V^-) 40V
Differential Input Current (Note 1)..... ±10mA
Common-Mode Input Voltage ..... Equal to Supplies
Output Short Circuit Duration ..... Indefinite

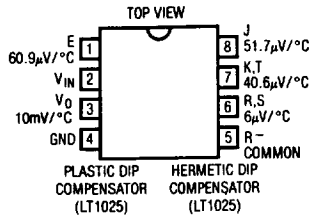
Compensator (LT1025)

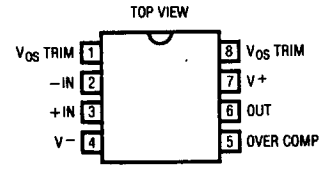
Supply Voltage (V_{IN} to Ground Pin)..... 36V
Output Voltage (Forced)..... 5V
Output Short Circuit Duration ..... Indefinite

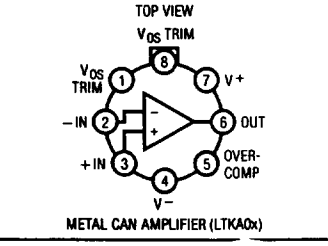
Both Devices

Operating Temperature Range
LTK001AMJ, LTK001MJ ..... −55°C to 125°C
LTK001ACN, LTK001CN ..... 0°C to 70°C
Storage Temperature Range..... −65°C to 150°C
Lead Temperature Range (Soldering, 10 sec.)..... 300°C

PACKAGE/ORDER INFORMATION







ORDER PART NUMBER
KIT
LTK001CN
LTK001ACN
LTK001MJ
LTK001AMJ
AMPLIFIER ONLY (Note A)
LTKA00CN8
LTKA01CN8
AMPLIFIER ONLY (Note A)
LTKA00MH
LTKA01MH

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.

ELECTRICAL CHARACTERISTICS — MATCHED AMPLIFIER AND COMPENSATOR $T_A = 25°C$, $V_S = \pm 15V$ (Amplifier), $V_S = 5V$ (Compensator)

PARAMETER	CONDITIONS		LTK001A MIN	LTK001A TYP	LTK001A MAX	LTK001 MIN	LTK001 TYP	LTK001 MAX	UNITS
Total Temperature Error @25°C (Note 2)		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 11)		5.0			5.0	°C
Slope Error (Notes 3 and 8)	$0°C \le T_j \le 70°C$	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 8)	$0°C \le T_j \le 70°C$	Type E			2.0			5	°C
		Type J			2.1			5	°C
		Type K, T			2.6			5.2	°C
		Type R, S	(Note 11)		16			16	°C
	$-55°C \le T_j \le 125°C$	Type E			6			8.5	°C
		Type J			6			8.5	°C
		Type K, T			6.3			9	°C
		Type R, S	(Note 11)		30			30	°C
Temperature Error Change with Supply Voltage (Note 4)					0.1			0.1	°C/V
Supply Current				480	900		480	900	μA

ELECTRICAL CHARACTERISTICS
COMPENSATOR (LT1025) V_S = 5V unless otherwise specified

PARAMETER	CONDITIONS			COMPENSATOR (LT1025) MIN	TYP	MAX	UNITS
Temperature Error at 10mV/°C Output (Note 8)	T_j = 25°C	LTK001A			0.3	0.5	°C
		LTK001			0.5	2.0	°C
	Full Temperature Span		●	See Curve on LT1025 Data Sheet			
Temperature Error at Individual Outputs (Note 9)	LTK001A	E, J, K, T			0.4	0.75	°C
		R, S			0.4	1.5	°C
	LTK001	E, J, K, T			0.8	2.4	°C
		R, S			1.2	3.5	°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 10)	4V ≤ V_{IN} ≤ 36V 10mV/°C Output		●		0.003	0.02	°C/V
Load Regulation (Note 10)	0 ≤ I_O ≤ 1mA 10mV/°C Output		●		0.04	0.2	°C
Divider Impedance		E			2.5		kΩ
		J			2.1		kΩ
		K, T			4.4		kΩ
		R, S			3.8		kΩ

ELECTRICAL CHARACTERISTICS
AMPLIFIER (LTKA0x) V_S = ±15V, V_{CM} = 0, T_j = 25°C, unless otherwise specified

PARAMETER	CONDITIONS			AMPLIFIER (LTKA0x) MIN	TYP	MAX	UNITS
Input Offset Voltage					10	35	µV
Input Offset Voltage Drift with Temperature	(Note 5)		●		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 5)		●		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 5)		●		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 4)		●	106	125		dB
Common-Mode Input Voltage Range	Notes 5 and 6	Above V^-		0.75			V
		Below V^+				1.0	V
Output Voltage Swing (Notes 5 and 7)	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

11

The ● denotes the specifications which apply over the full operating temperature range.

Note 1: The inputs of the LTKA0x amplifier are clamped with diodes, so a differential voltage rating does not apply.

Note 2: 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 3: 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 4: This is a worst-case limit assuming that any or all supply voltages change.

Note 5: Guaranteed, but not tested.

Note 6: 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 7: 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 8: Temperature error is defined as the deviation from the following formula:

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

α = Typical thermoucouple 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 9: Temperature error at the individual outputs is the sum of the 10mV/°C output error plus the resistor divider error.

Note 10: 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:

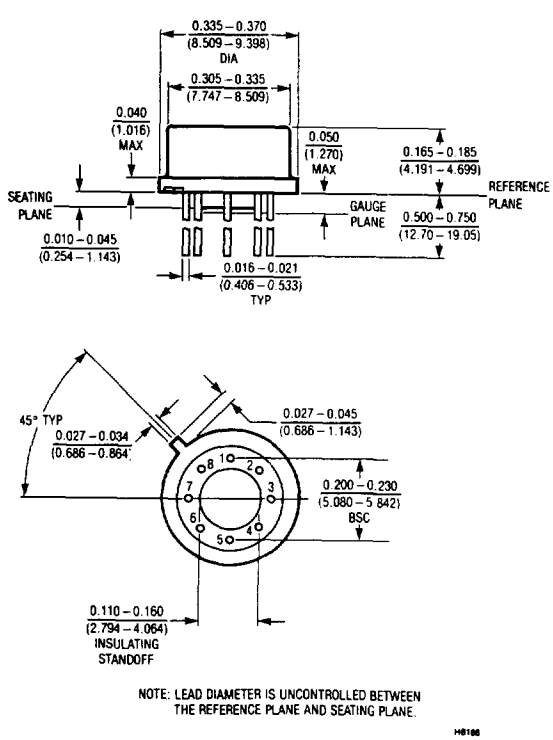
$$\Delta V_{OUT}(\text{Line}) = \Delta V_{IN}(I_q + I_{load})(150°C/W)$$
$$\Delta V_{OUT}(\text{Load}) = (\Delta I_{load})(V_{IN})(150°C/W)$$
$$I_q = \text{LT1025 supply current}$$

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

Note 11: Larger errors with type R and S thermoucouples are due mostly to 35μV offset of the amplifier. This error can be reduced to 5μV max with the LTC1050 or LTC1052 operational amplifiers.

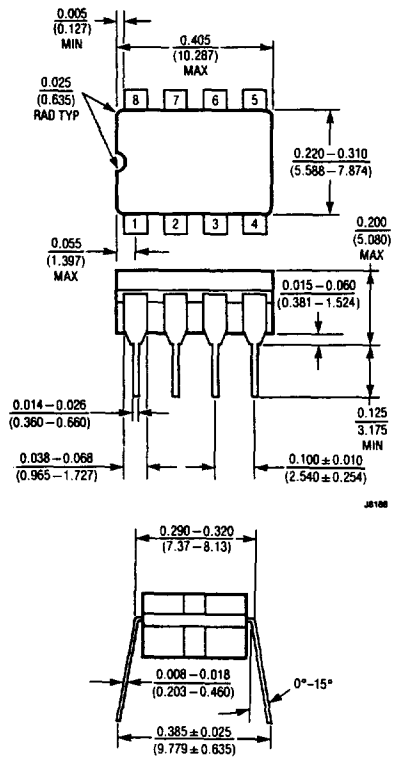
PACKAGE DESCRIPTION Dimensions in inches (millimeters) unless otherwise noted.

H Package
8 Lead TO-5 Metal Can



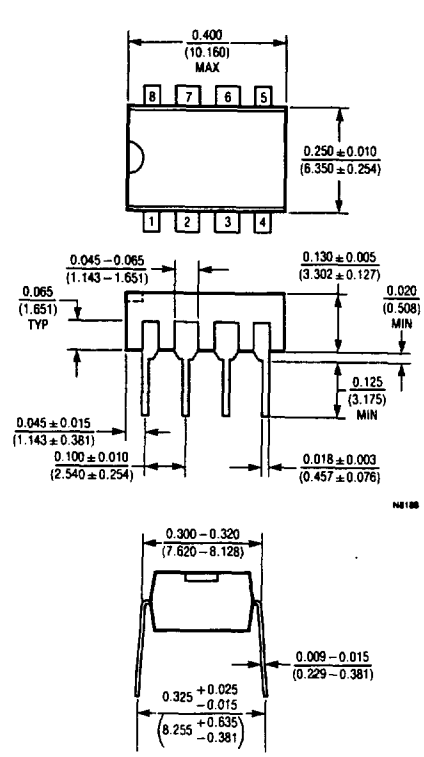
T_{JMAX}	θ_{JA}	θ_{JC}
150°C	150°C/W	45°C/W

J Package
8 Lead Hermetic DIP



T_{JMAX}	θ_{JA}
150°C	100°C/W

N Package
8 Lead Molded DIP



T_{JMAX}	θ_{JA}
100°C	130°C/W