



Micropower Thermocouple Cold Junction Compensator

AC1226

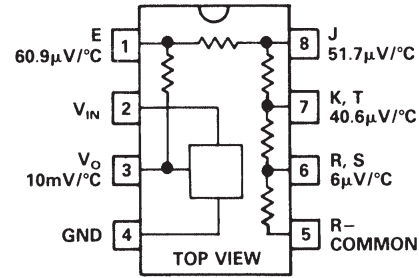
FEATURES

- 80 μ A Supply Current
- 4V to 36V Operation
- 0.5 $^{\circ}$ C Typical Initial Accuracy
- Compatible with Standard Thermocouples (E, J, K, R, S, T)
- Auxiliary 10mV/ $^{\circ}$ C Output
- Bow Corrected

APPLICATIONS

- Thermocouple Cold Junction Compensator
- Centigrade Thermometer
- Temperature Compensation Network

PIN CONFIGURATION



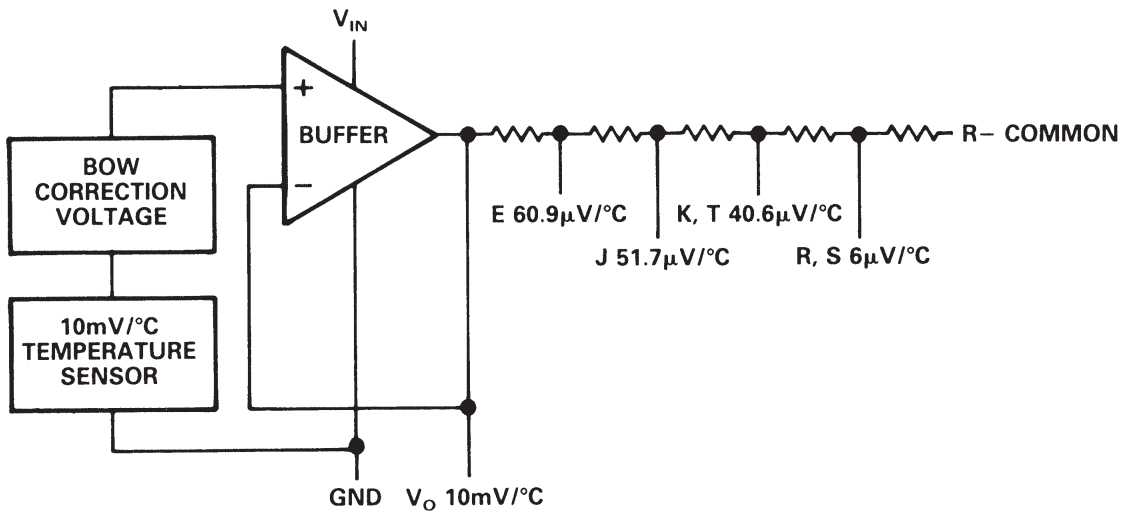
PRODUCT DESCRIPTION

The AC1226 is a micropower thermocouple cold junction compensator for use with type E, J, K, R, S and T thermocouples. It utilizes wafer level and post-package trimming to achieve typical 0.5 $^{\circ}$ C initial accuracy. Special curvature correction circuitry is used to match the "bow" found in all thermocouples so that accurate cold junction compensation is maintained over a wider temperature range.

The AC1226 will operate with a supply voltage from 4V to 36V.

Typical supply current is 80 μ A, resulting in less than 0.1 $^{\circ}$ C internal temperature rise for supply voltages under 10V. A 10mV/ $^{\circ}$ C output is available at low impedance in addition to the direct thermocouple voltages of 60.9 μ V/ $^{\circ}$ C (E), 51.7 μ V/ $^{\circ}$ C (J), 40.3 μ V/ $^{\circ}$ C (K, T) and 5.95 μ V/ $^{\circ}$ C (R, S). All outputs are essentially independent of power supply voltage.

The AC1226 is available in an 8-pin plastic mini-DIP for temperatures between 0 and +70 $^{\circ}$ C.



AC1226 Block Diagram

AC1226—SPECIFICATIONS

Electrical Characteristics ($V_s = 5V$, $T_A = +25^\circ C$, Pin 5 tied to Pin 4, unless otherwise noted.)

Parameter	Conditions	Min	Typ	Max	Units
TEMPERATURE ERROR AT 10mV/°C OUTPUT ^{1,2}	$T_J = +25^\circ C$ Full Temperature Span*		0.5 See Curve	2.0	°C
RESISTOR DIVIDER ACCURACY ^{1,3}	$V_{OUT} = 10mV/^\circ C$ E J K, T R, S	60.4 51.2 40.2 5.75	60.9 51.7 40.6 5.95	61.6 52.3 41.2 6.3	$\mu V/^\circ C$
SUPPLY CURRENT	$4V \leq V_{IN} \leq 36V$ *	50 50	80	100 150	μA
LINE REGULATION ⁴	$4V \leq V_{IN} \leq 36V^*$		0.003	0.02	°C/V
LOAD REGULATION ⁴	$0 \leq I_O \leq 1mA^*$		0.04	0.2	°C
DIVIDER IMPEDANCE	E J K, T R, S		2.5 2.1 4.4 3.8		k Ω
CHANGE IN SUPPLY CURRENT	$4V \leq V_{IN} \leq 36V$		0.01	0.05	$\mu A/V$
PACKAGE OPTION ⁵ Plastic DIP (N-8)					

NOTES

¹To calculate total temperature error at individual thermocouple outputs, add 10mV/°C output error to the resistor divider error. Total error for type K output at +25°C with an AC1226 is 2.0°C plus (0.6 $\mu V/^\circ C$) (25°C)/(40.6 $\mu V/^\circ C$)=2.0°C+0.37°C=2.37°C.

²Temperature error is defined as the deviation from the following formula: $V_{OUT} = 10mV(T) + (10mV)(5.5 \times 10^{-4})(T - 25^\circ C)^2$. The second term is a built-in nonlinearity designed to help compensate the nonlinearity of the cold junction. This "bow" is $\approx 0.34^\circ C$ for a 25°C temperature change.

³Divider accuracy is measured by applying a 10.000V signal to the output divider and measuring the individual outputs.

⁴Regulation does not include the effects of self-heating. See "Internal Temperature Rise" in Application Guide. Load regulation is $30\mu A \leq I_O \leq 1mA$ for $T_A \leq 0^\circ C$.

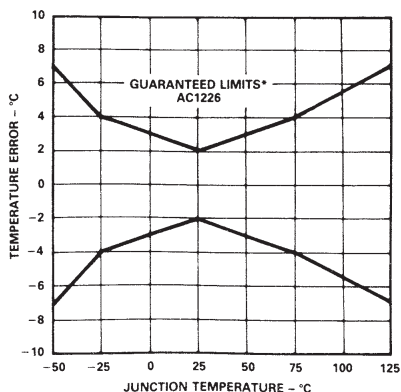
⁵For outline information see Package Information section.

*Denotes the specifications which apply over the full operating temperature range. Specifications subject to change without notice.

ABSOLUTE MAXIMUM RATINGS

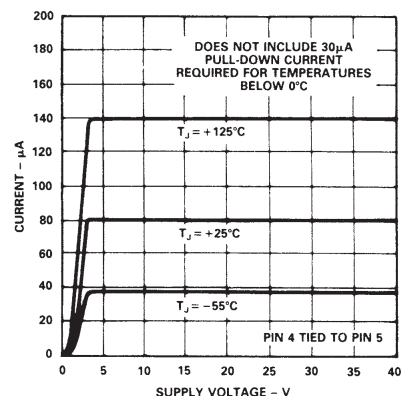
Input Supply Voltage36V
 Output Voltage (Forced)5V
 Output Short Circuit DurationIndefinite
 Operating Temperature Range0 to +70°C
 Storage Temperature Range-55°C to +150°C
 Lead Temperature (Soldering, 10sec)+300°C

Typical Performance Characteristics



*ERROR CURVE FACTORS IN THE NONLINEARITY TERM BUILT IN TO THE AC1226 SEE THEORY OF OPERATION IN APPLICATION GUIDE SECTION.

10mV/°C Output Temperature Error



Supply Current

APPLICATION GUIDE

The AC1226 was designed to be extremely easy to use, but the following ideas and suggestions should be helpful in obtaining the best possible performance and versatility from this new cold junction compensator.

THEORY OF OPERATION

A thermocouple consists of two dissimilar metals joined together. A voltage (Seebeck EMF) will be generated if the two ends of the thermocouple are at different temperatures. In Figure 1, iron and constantan are joined at the temperature measuring point T1. Two additional thermocouple junctions are formed where the iron and constantan connect to ordinary copper wire. For the purposes of this discussion it is assumed that these two junctions are at the same temperature, T2. The Seebeck voltage, V_S , is the product of the Seebeck coefficient α , and the temperature difference, $T_1 - T_2$; $V_S = \alpha (T_1 - T_2)$. The junctions at T2 are commonly called the cold junction because a common practice is to immerse the T2 junction in 0°C ice/water slurry to make T2 independent of room temperature variations. Thermocouple tables are based on a cold junction temperature of 0°C.

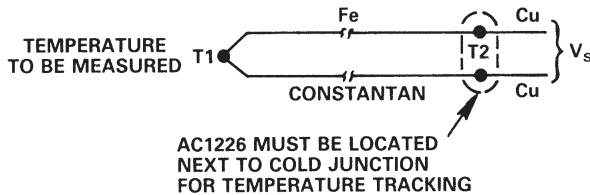


Figure 1.

For most applications an electronically simulated cold junction is required. The idea is basically to add a temperature dependent voltage to V_S such that the voltage sum is the same as if the T2 junction were at a constant 0°C instead of at room temperature. This voltage source is called a cold junction compensator. Its output is designed to be 0V at 0°C and have a slope equal to the Seebeck coefficient over the expected range of T2 temperatures.

To operate properly, a cold junction compensator must be at exactly the same temperature as the cold junction of the thermocouple (T2). Therefore, it is important to locate the AC1226 physically close to the cold junction with local temperature gradients minimized. If this is not possible, an extender made of matching thermocouple wire can be used. This shifts the cold junction from the user termination to the end of the extender so that the AC1226 can be located remotely from the user termination as shown in Figure 2.

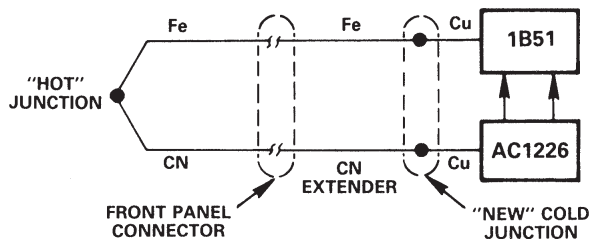


Figure 2.

The four thermocouple outputs on the AC1226 are 60.9 μ V/°C (E), 51.7 μ V/°C (J), 40.6 μ V/°C (K and T) and 6 μ V/°C (R and S). These particular coefficients are chosen to match the room temperature (+25°C) slope of the thermocouples. Over wide temperature ranges, however, the slope of thermocouples changes, yielding a quasi-parabolic error compared to a constant slope. The AC1226 outputs have a deliberate parabolic “bow” to help compensate for this effect. The outputs can be mathematically described as the sum of a linear term equal to room temperature slope plus a quadratic term proportional to temperature deviation from +25°C squared. The coefficient (β) of the quadratic term is a compromise value chosen to offer improvement in all the outputs.

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

$$\beta \approx 5.5 \times 10^{-4}$$

The actual β term which would be required to best compensate each thermocouple type in the temperature range of 0 to +50°C is: E, 6.6 $\times 10^{-4}$; J, 4.8 $\times 10^{-4}$; K, 4.3 $\times 10^{-4}$; R, 1.9 $\times 10^{-3}$; S, 1.9 $\times 10^{-3}$; T, 1 $\times 10^{-3}$.

The temperature error specification for the AC1226 (shown as a graph) assumes a β of 5.5 $\times 10^{-4}$. For example, an AC1226 is considered “perfect” if its 10mV/°C output fits the equation $V_O = 10mV(T) + 5.5 \times 10^{-4}(T - 25)^2$.

OPERATING AT NEGATIVE TEMPERATURES

The AC1226 is designed to operate with a single positive supply. It therefore cannot deliver proper outputs for temperatures below zero unless an external pull-down resistor is added to the V_O output. This resistor can be connected to any convenient negative supply. It should be selected to sink at least 30 μ A of current. Suggested value for a -5V supply is 150k Ω , and for a -15V supply, 470k Ω . Smaller resistors must be used if an external load is connected to the 10mV/°C output. The AC1226 can source up to 1mA of current, but there is a trade-off with internal temperature rise.

INTERNAL TEMPERATURE RISE

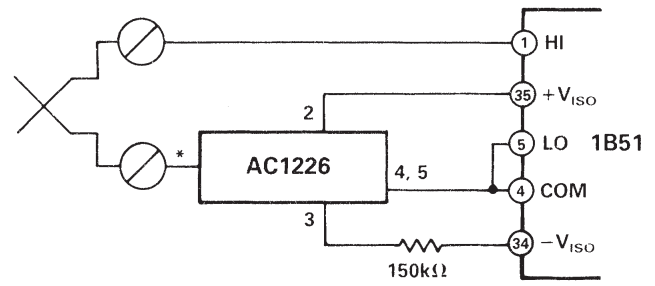
The AC1226 is specified for temperature accuracy assuming no internal temperature rise. At low supply voltages this rise is usually negligible ($\approx 0.05^\circ C$ @ 5V), but at higher supply voltages or with external loads or pull-down current, internal rise could become significant. This effect can be calculated from a simple thermal formula, $\Delta T = (\theta_{JA}) (V^+) (I_Q + I_L)$, where θ_{JA} is thermal resistance from junction to ambient ($\approx 130^\circ C/W$), V^+ is the AC1226 supply voltage, I_Q is the AC1226 supply current ($\approx 80\mu A$), and I_L is the total load current including actual load to ground and any pull-down current needed to generate negative outputs. A sample calculation with a 15V supply and 50 μA pull-down current would yield, $(130^\circ C/W) (15V) (80 + 50\mu A) = 0.32^\circ C$. This is a significant rise in some applications. It can be reduced by lowering supply voltage (a simple fix is to insert a 10V Zener in the V_{IN} lead) or the system can be calibrated and specified after an initial warm-up period of several minutes.

THERMOCOUPLE EFFECTS IN LEADS

Thermocouple voltages are generated whenever dissimilar materials are joined. *This includes the leads of IC packages*, which may be kovar in TO-5 cans, alloy 42 or copper in dual-in-line packages, and a variety of other materials in plating finishes and solders. The net effect of these thermocouples is “zero” if all are at exactly the same temperature, but temperature gradients exist within IC packages and across PC boards whenever power is dissipated. For this reason, extreme care must be used to ensure that no temperature gradients exist in the vicinity of thermocouple terminations, the AC1226, or the thermocouple amplifier. If a gradient cannot be eliminated, leads should be positioned isothermally, especially the AC1226 R⁻ and appropriate output pins, the amplifier input pins and the gain setting resistor leads. An effect to watch for is amplifier offset voltage warm-up drift caused by mismatched thermocouple materials in the wire bond/lead system of the package. This effect can be as high as tens of microvolts in TO-5 cans with kovar leads. It has nothing to do with the actual offset drift specification of the amplifier and can occur in amplifiers with measured “zero” drift. Warm-up drift is directly proportional to amplifier power dissipation. It can be minimized by avoiding TO-5 cans, using low supply current amplifiers and by using the lowest possible supply voltages. Finally, it can be accommodated by calibrating and specifying the system after a five minute warm-up period.

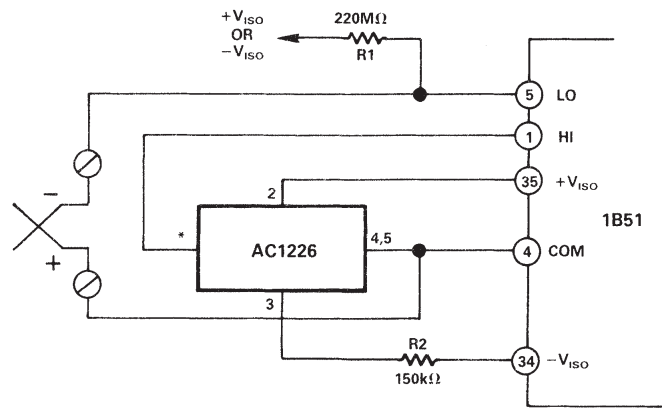
Figure 3 shows how to connect the AC1226 to the IB51 to compensate for the cold junction. This circuit is a conditioned and isolated channel for E, J, K, R, S or T thermocouples.

Figure 4 shows optional AC1226/IB51 connections with open input detection. This circuit minimizes input offset error generated by the pull up (or pull down) resistor, by eliminating the AC1226’s divider impedance as seen by the resistor R1.



*PIN NUMBER DEPENDS ON THERMOCOUPLE TYPE.

Figure 3. Using the AC1226 with the IB51, Isolated mV/Thermocouple Signal Conditioner



*PIN NUMBER DEPENDS ON THERMOCOUPLE TYPE.

Figure 4. Optional AC1226/IB51 Connections for Thermocouple Input with Open Detection Circuit

SUNSTAR商斯达实业集团是集研发、生产、工程、销售、代理经销、技术咨询、信息服务等为一体的高科技企业，是专业高科技电子产品生产厂家，是具有10多年历史的专业电子元器件供应商，是中国最早和最大的仓储式连锁规模经营大型综合电子零部件代理分销商之一，是一家专业代理和分销世界各大品牌IC芯片和电子元器件的连锁经营综合性国际公司。在香港、北京、深圳、上海、西安、成都等全国主要电子市场设有直属分公司和产品展示展销窗口门市部专卖店及代理分销商，已在全国范围内建成强大统一的供货和代理分销网络。我们专业代理经销、开发生产电子元器件、集成电路、传感器、微波光电元器件、工控机/DOC/DOM电子盘、专用电路、单片机开发、MCU/DSP/ARM/FPGA软件硬件、二极管、三极管、模块等，是您可靠的一站式现货配套供应商、方案提供商、部件功能模块开发配套商。专业以现代信息产业（计算机、通讯及传感器）三大支柱之一的传感器为主营业务，专业经营各类传感器的代理、销售生产、网络信息、科技图书资料及配套产品设计、工程开发。我们的专业网站——中国传感器科技信息网（全球传感器数据库）www.SENSOR-IC.COM 服务于全球高科技生产商及贸易商，为企业科技产品开发提供技术交流平台。欢迎各厂商互通有无、交换信息、交换链接、发布寻求代理信息。欢迎国外高科技传感器、变送器、执行器、自动控制产品厂商介绍产品到中国，共同开拓市场。本网站是关于各种传感器-变送器-仪器仪表及工业自动化大型专业网站，深入到工业控制、系统工程计 测量、自动化、安防报警、消费电子等众多领域，把最新的传感器-变送器-仪器仪表买卖信息，最新技术供求，最新采购商，行业动态，发展方向，最新的技术应用和市场资讯及时的传递给广大科技开发、科学研究、产品设计人员。本网站已成功为石油、化工、电力、医药、生物、航空、航天、国防、能源、冶金、电子、工业、农业、交通、汽车、矿山、煤炭、纺织、信息、通信、IT、安防、环保、印刷、科研、气象、仪器仪表等领域从事科学研究、产品设计、开发、生产制造的科技人员、管理人员、和采购人员提供满意服务。我们公司专业生产、代理、经销、销售各种传感器、变送器、敏感元器件、开关、执行器、仪器仪表、自动化控制系统：专业从事设计、生产、销售各种传感器、变送器、各种测控仪表、热工仪表、现场控制器、计算机控制系统、数据采集系统、各类环境监控系统、专用控制系统应用软件以及嵌入式系统开发及应用等工作。如热敏电阻、压敏电阻、温度传感器、温度变送器、湿度传感器、湿度变送器、气体传感器、气体变送器、压力传感器、压力变送、称重传感器、物（液）位传感器、物（液）位变送器、流量传感器、流量变送器、电流（压）传感器、溶氧传感器、霍尔传感器、图像传感器、超声波传感器、位移传感器、速度传感器、加速度传感器、扭距传感器、红外传感器、紫外传感器、火焰传感器、激光传感器、振动传感器、轴角传感器、光电传感器、接近传感器、干簧管传感器、继电器传感器、微型电泵、磁敏（阻）传感器、压力开关、接近开关、光电开关、色标传感器、光纤传感器、齿轮测速传感器、时间继电器、计数器、计米器、温控仪、固态继电器、调压模块、电磁铁、电压表、电流表等特殊传感器。同时承接传感器应用电路、产品设计和自动化工程项目。

更多产品请看本公司产品专用销售网站：

商斯达中国传感器科技信息网：<http://www.sensor-ic.com/>

商斯达工控安防网：<http://www.pc-ps.net/>

商斯达电子元器件网：<http://www.sunstare.com/>

商斯达微波光电产品网：[HTTP://www.rfoe.net/](http://www.rfoe.net/)

商斯达消费电子产品网：<http://www.icasic.com/>

商斯达军工产品网：<http://www.junpinic.com/>

商斯达实业科技产品网：<http://www.sunstars.cn/> 传感器销售热线：

地址：深圳市福田区福华路福庆街鸿图大厦1602室

电话：0755-83607652 83376489 83376549 83370250 83370251 82500323

传真：0755-83376182 (0) 13902971329 MSN: SUNS888@hotmail.com

邮编：518033 E-mail: szss20@163.com QQ: 195847376

深圳赛格展销部：深圳华强北路赛格电子市场2583号 电话：0755-83665529 25059422

技术支持：0755-83394033 13501568376

欢迎索取免费详细资料、设计指南和光盘；产品凡多，未能尽录，欢迎来电查询。

北京分公司：北京海淀区知春路132号中发电子大厦3097号

TEL: 010-81159046 82615020 13501189838 FAX: 010-62543996

上海分公司：上海市北京东路668号上海赛格电子市场D125号

TEL: 021-28311762 56703037 13701955389 FAX: 021-56703037

西安分公司：西安高新开发区20所(中国电子科技集团导航技术研究所)

西安劳动南路88号电子商城二楼D23号

TEL: 029-81022619 13072977981 FAX: 029-88789382