

LM725 Operational Amplifier

General Description

The LM725/LM725A/LM725C are operational amplifiers featuring superior performance in applications where low noise, low drift, and accurate closed-loop gain are required. With high common mode rejection and offset null capability, it is especially suited for low level instrumentation applications over a wide supply voltage range.

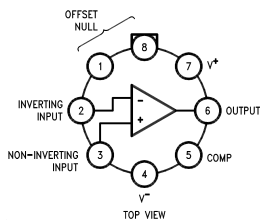
The LM725A has tightened electrical performance with higher input accuracy and like the LM725, is guaranteed over a -55°C to $+125^{\circ}\text{C}$ temperature range. The LM725C has slightly relaxed specifications and has its performance guaranteed over a 0°C to 70°C temperature range.

Features

- High open loop gain 3,000,000
- Low input voltage drift $0.6 \mu\text{V}/^{\circ}\text{C}$
- High common mode rejection 120 dB
- Low input noise current $0.15 \text{ pA}/\sqrt{\text{Hz}}$
- Low input offset current 2 nA
- High input voltage range $\pm 14\text{V}$
- Wide power supply range $\pm 3\text{V}$ to $\pm 22\text{V}$
- Offset null capability
- Output short circuit protection

Connection Diagrams

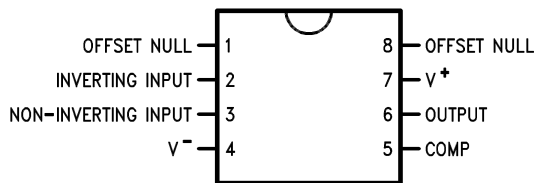
Metal Can Package



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Order Number LM725H/883, LM725CH or LM725AH/883
See NS Package Number H08C

Dual-In-Line Package

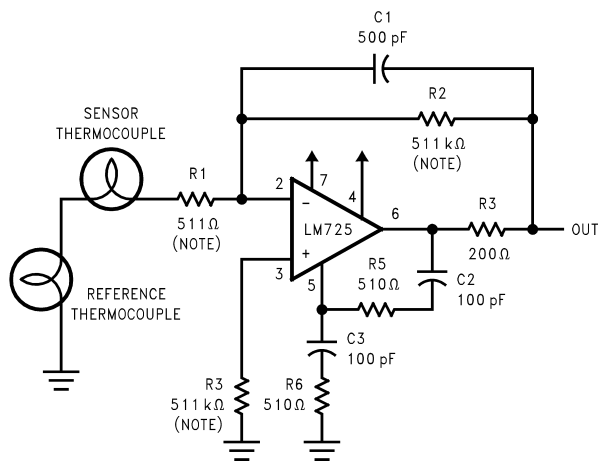


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Order Number LM725CN
See NS Package Number N08E

Typical Applications

Thermocouple Amplifier



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Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

| | |
|-------------------------------------|-----------------|
| Supply Voltage | ±22V |
| Internal Power Dissipation (Note 2) | 500 mW |
| Differential Input Voltage | ±5V |
| Input Voltage (Note 3) | ±22V |
| Storage Temperature Range | -65°C to +150°C |

Lead Temperature

(Soldering, 10 Sec.)

260°C

Maximum Junction Temperature

150°C

Operating Temperature Range

 $T_{A(MIN)}$ $T_{A(MAX)}$

LM725 -55°C to +125°C

LM725A -55°C to +125°C

LM725C 0°C to +70°C

Electrical Characteristics (Note 4)

| Parameter | Conditions | LM725A | | | LM725 | | | LM725C | | | Units |
|---|---|--------|-------|-----|-------|-------|-----|--------|-------|-----|--|
| | | Min | Typ | Max | Min | Typ | Max | Min | Typ | Max | |
| Input Offset Voltage (Without External Trim) | $T_A = 25^\circ\text{C}$, $R_S \leq 10\text{ k}\Omega$ | | | 0.5 | | 0.5 | 1.0 | | 0.5 | 2.5 | mV |
| Input Offset Current | $T_A = 25^\circ\text{C}$ | | 2.0 | 5.0 | | 2.0 | 20 | | 2.0 | 35 | nA |
| Input Bias Current | $T_A = 25^\circ\text{C}$ | | 42 | 80 | | 42 | 100 | | 42 | 125 | nA |
| Input Noise Voltage | $T_A = 25^\circ\text{C}$ $f_o = 10\text{ Hz}$ $f_o = 100\text{ Hz}$ $f_o = 1\text{ kHz}$ | | | | | 15 | | | 15 | | $\text{nV}/\sqrt{\text{Hz}}$ $\text{nV}/\sqrt{\text{Hz}}$ $\text{nV}/\sqrt{\text{Hz}}$ |
| Input Noise Current | $T_A = 25^\circ\text{C}$ $f_o = 10\text{ Hz}$ $f_o = 100\text{ Hz}$ $f_o = 1\text{ kHz}$ | | | | | 1.0 | | | 1.0 | | $\text{pA}/\sqrt{\text{Hz}}$ $\text{pA}/\sqrt{\text{Hz}}$ $\text{pA}/\sqrt{\text{Hz}}$ |
| Input Resistance | $T_A = 25^\circ\text{C}$ | | | 1.5 | | 1.5 | | | 1.5 | | M Ω |
| Input Voltage Range | $T_A = 25^\circ\text{C}$ | ±13.5 | ±14 | | ±13.5 | ±14 | | ±13.5 | ±14 | | V |
| Large Signal Voltage Gain | $T_A = 25^\circ\text{C}$, $R_L \geq 2\text{ k}\Omega$, $V_{OUT} = \pm 10\text{V}$ | 1000 | 3000 | | 1000 | 3000 | | 250 | 3000 | | V/mV |
| Common-Mode Rejection Ratio | $T_A = 25^\circ\text{C}$, $R_S \leq 10\text{ k}\Omega$ | 120 | | | 110 | 120 | | 94 | 120 | | dB |
| Power Supply Rejection Ratio | $T_A = 25^\circ\text{C}$, $R_S \leq 10\text{ k}\Omega$ | | 2.0 | 5.0 | | 2.0 | 10 | | 2.0 | 35 | $\mu\text{V}/\text{V}$ |
| Output Voltage Swing | $T_A = 25^\circ\text{C}$, $R_L \geq 10\text{ k}\Omega$ $R_L \geq 2\text{ k}\Omega$ | ±12.5 | ±13.5 | | ±12 | ±13.5 | | ±12 | ±13.5 | | V V |
| Power Consumption | $T_A = 25^\circ\text{C}$ | | 80 | 105 | | 80 | 105 | | 80 | 150 | mW |
| Input Offset Voltage (Without External Trim) | $R_S \leq 10\text{ k}\Omega$ | | | 0.7 | | | 1.5 | | | 3.5 | mV |
| Average Input Offset Voltage Drift (Without External Trim) | $R_S = 50\Omega$ | | | 2.0 | | 2.0 | 5.0 | | 2.0 | | $\mu\text{V}/^\circ\text{C}$ |
| Average Input Offset Voltage Drift (With External Trim) | $R_S = 50\Omega$ | | 0.6 | 1.0 | | 0.6 | | | 0.6 | | $\mu\text{V}/^\circ\text{C}$ |
| Input Offset Current | $T_A = T_{MAX}$ $T_A = T_{MIN}$ | | 1.2 | 4.0 | | 1.2 | 20 | | 1.2 | 35 | nA nA |
| Average Input Offset Current Drift | | | 35 | 90 | | 35 | 150 | | 10 | | $\text{pA}/^\circ\text{C}$ |
| Input Bias Current | $T_A = T_{MAX}$ $T_A = T_{MIN}$ | | 20 | 70 | | 20 | 100 | | | 125 | nA nA |
| | | | 80 | 180 | | 80 | 200 | | | 250 | |

Electrical Characteristics (Note 4) (Continued)

| Parameter | Conditions | LM725A | | | LM725 | | | LM725C | | | Units |
|------------------------------|---|-----------|-----|-----|-----------|-----|-----|----------|-----|-----|-----------------|
| | | Min | Typ | Max | Min | Typ | Max | Min | Typ | Max | |
| Large Signal Voltage Gain | $R_L \geq 2\text{ k}\Omega$ $T_A = T_{MAX}$ $R_L \geq 2\text{ k}\Omega$ | 1,000,000 | | | 1,000,000 | | | 125,000 | | | V/V |
| | $T_A = T_{MIN}$ | 500,000 | | | 250,000 | | | 125,000 | | | V/V |
| Common-Mode Rejection Ratio | $R_S \leq 10\text{ k}\Omega$ | 110 | | | 100 | | | 115 | | | dB |
| Power Supply Rejection Ratio | $R_S \leq 10\text{ k}\Omega$ | 8.0 | | | 20 | | | 20 | | | $\mu\text{V/V}$ |
| Output Voltage Swing | $R_L \geq 2\text{ k}\Omega$ | ± 12 | | | ± 10 | | | ± 10 | | | V |

Note 1: "Absolute Maximum Ratings" indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits.

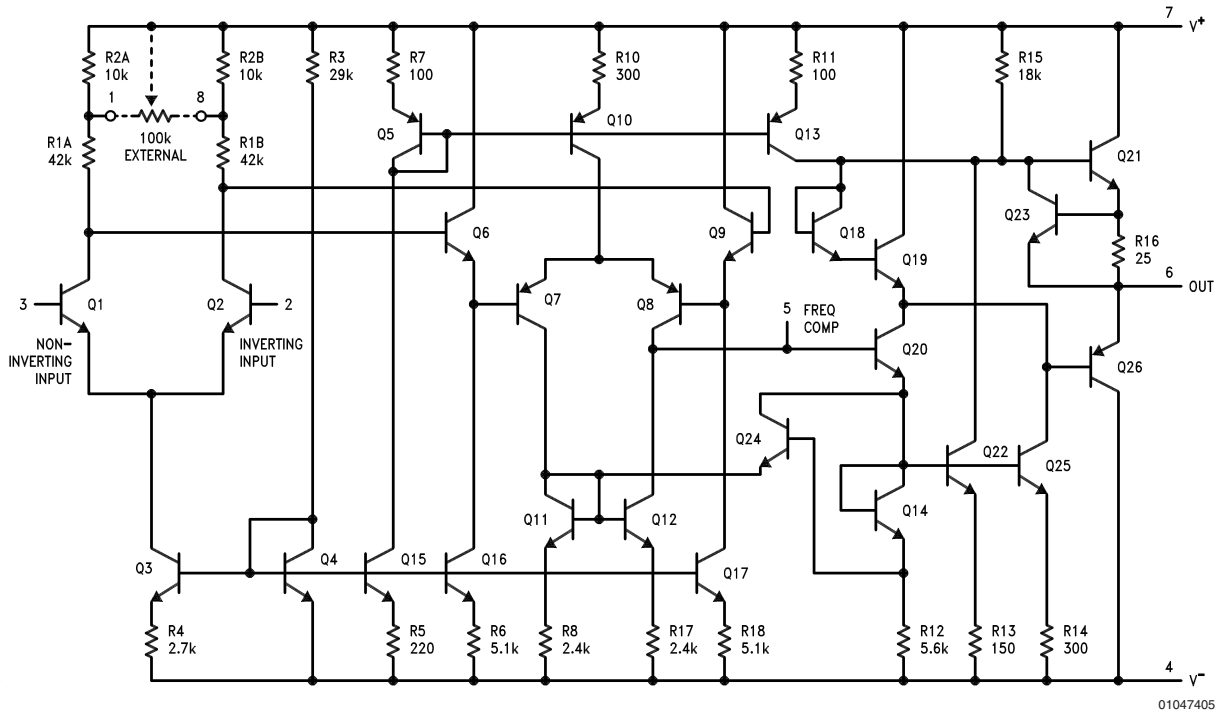
Note 2: Derate at 150°C/W for operation at ambient temperatures above 75°C.

Note 3: For supply voltages less than $\pm 22\text{V}$, the absolute maximum input voltage is equal to the supply voltage.

Note 4: These specifications apply for $V_S = \pm 15\text{V}$ unless otherwise specified.

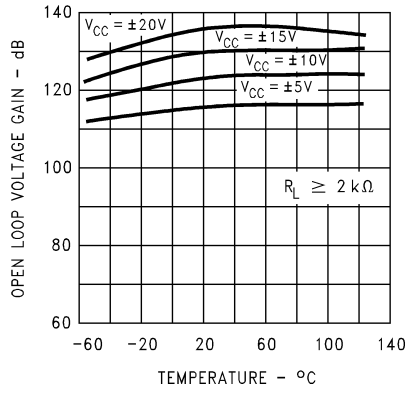
Note 5: For Military electrical specifications RETS725AX are available for LM725AH and RETS725X are available for LM725H.

Schematic Diagram



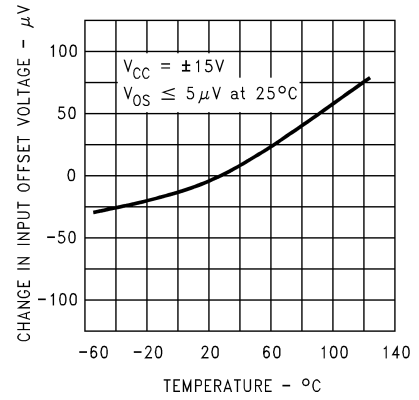
Typical Performance Characteristics

Voltage Gain vs Temperature for Supply Voltages



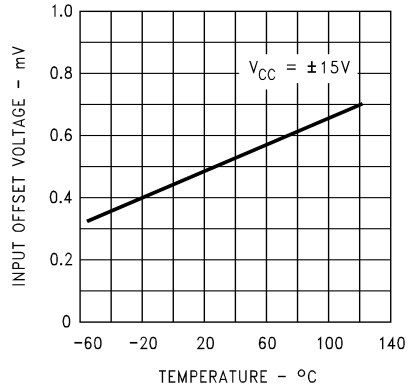
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Change in Trimmed Input Offset Voltage vs Temperature



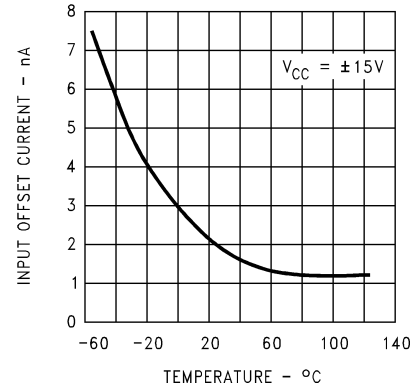
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Untrimmed Input Offset Voltage vs Temperature



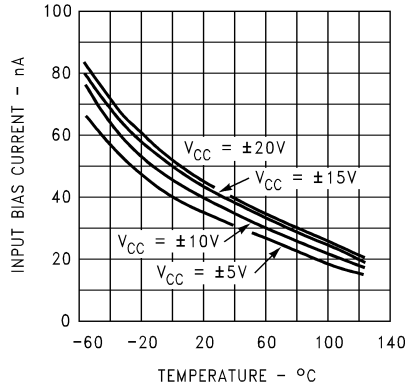
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Input Offset Current vs Temperature



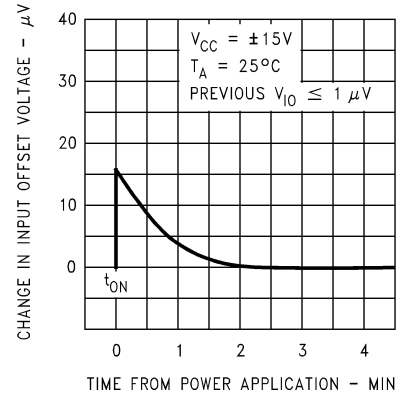
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Input Bias Current vs Temperature



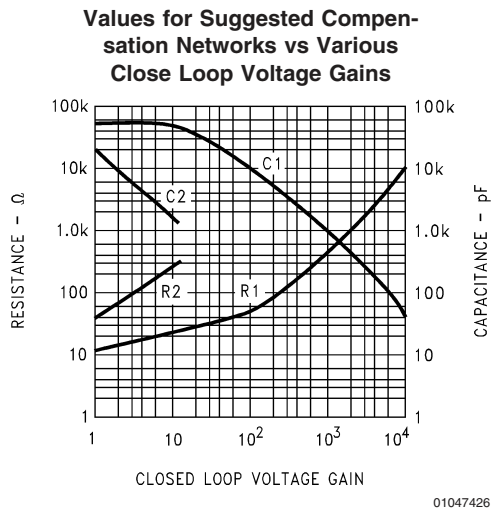
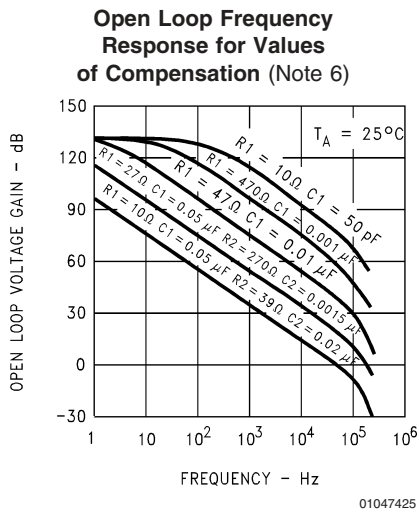
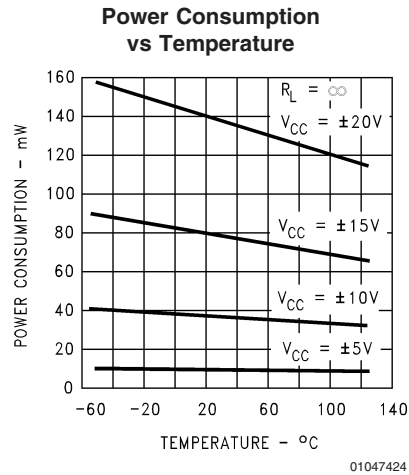
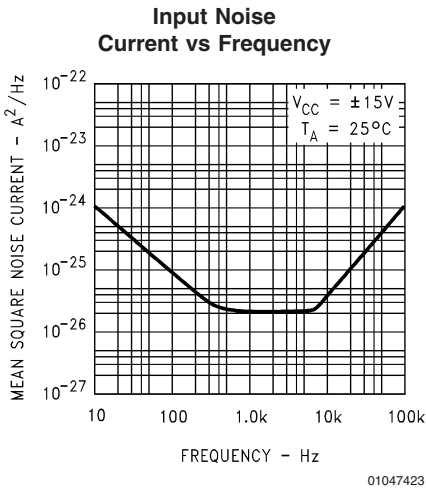
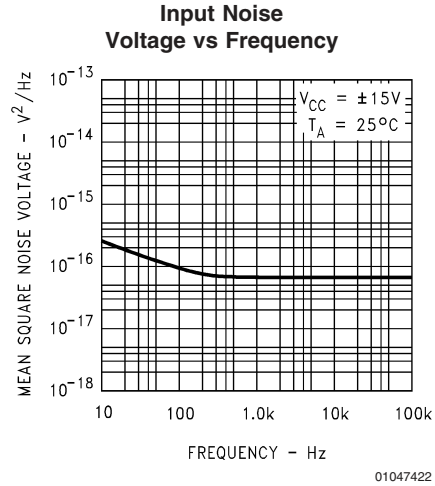
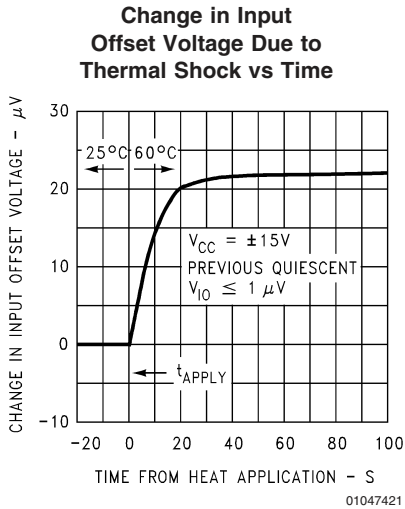
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Stabilization Time of Input Offset Voltage from Power Turn-On



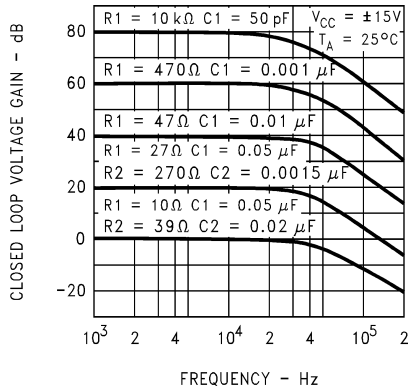
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Typical Performance Characteristics (Continued)



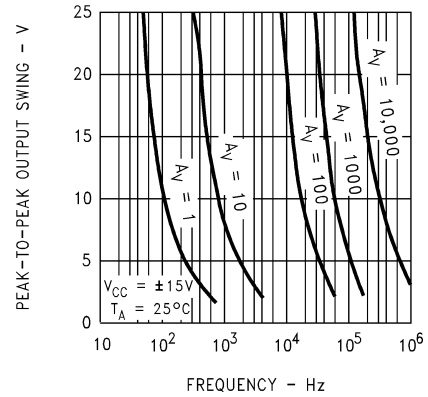
Typical Performance Characteristics (Continued)

Frequency Response for Various Close Loop Gain (Note 6)



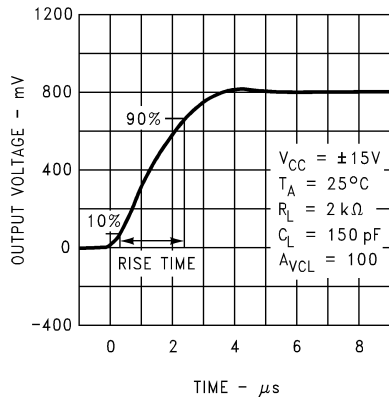
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Output Voltage Swing vs Frequency (Note 6)



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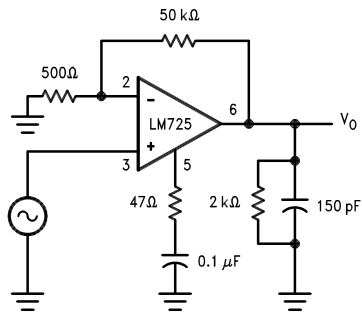
Transient Response



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Note 6: Performance is shown using recommended compensation networks.

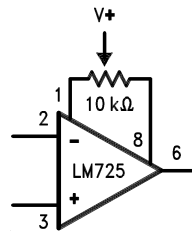
Transient Response Test Circuit



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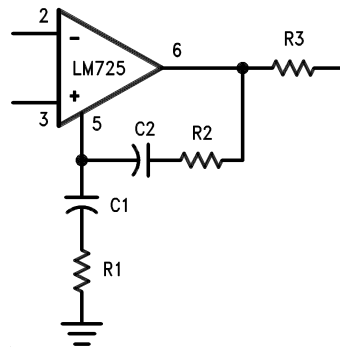
Auxiliary Circuits

Voltage Offset
Null Circuit



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Frequency Compensation
Circuit



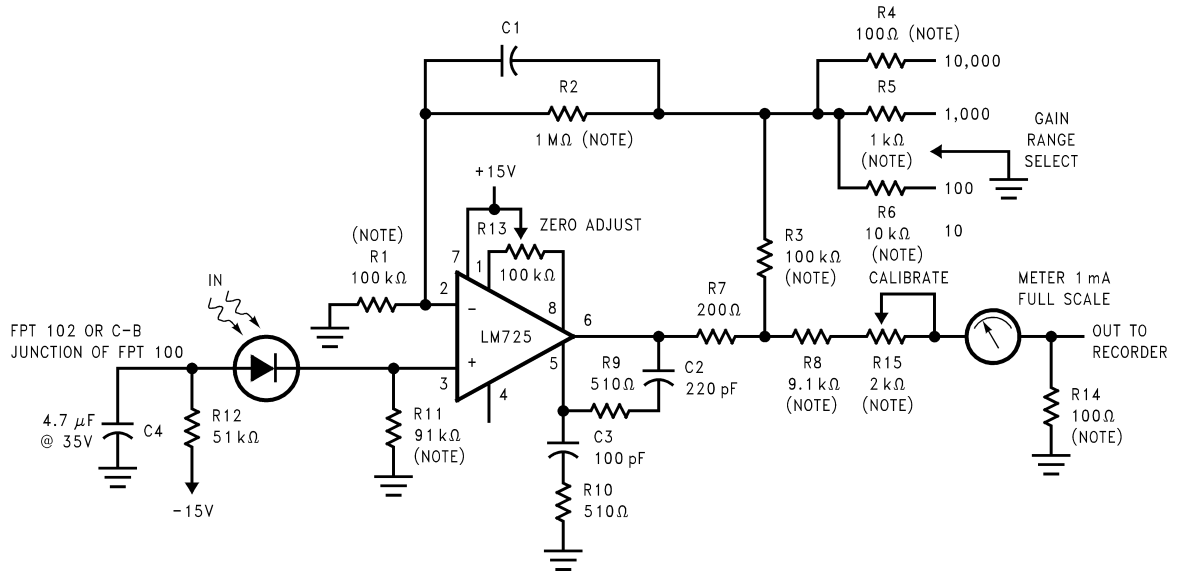
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Compensation Component Values

| A_v | R_1 (Ω) | C_1 (μF) | R_2 (Ω) | C_2 (μF) |
|--------|-----------------------|----------------------------|-----------------------|----------------------------|
| 10,000 | 10k | 50 pF | | |
| 1,000 | 470 | 0.001 | | |
| 100 | 47 | 0.01 | | |
| 10 | 27 | 0.05 | 270 | 0.0015 |
| 1 | 10 | 0.05 | 39 | 0.02 |

Typical Applications

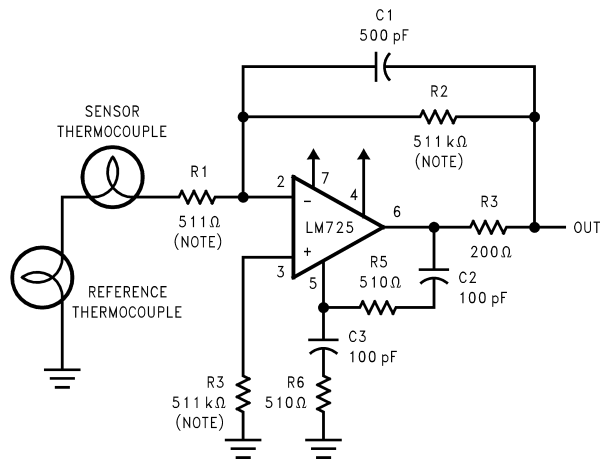
Photodiode Amplifier



DC Gains = 10,000; 1,000; 100; and 10
Bandwidth = Determined by value of C1

01047409

Thermocouple Amplifier



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$$\frac{R2}{R5} = \frac{R6}{R7} \text{ for best CMR}$$

$$R1 = R4$$

$$R2 = R5$$

$$\text{Gain} = \frac{R6}{R2} + \left(\frac{2R1}{R3} \right)$$

$$\text{DC Gain} = 1000$$

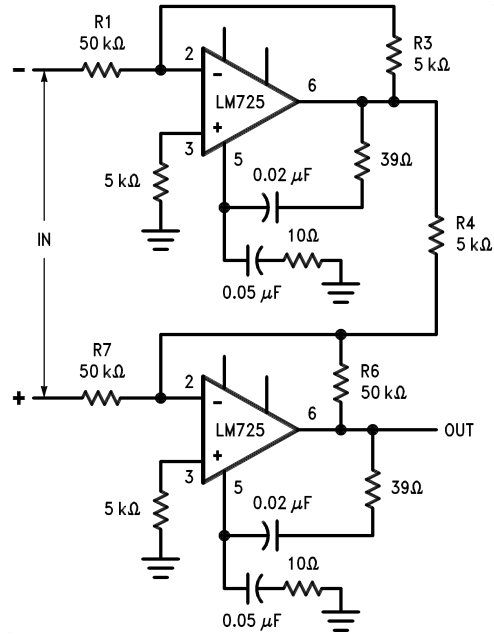
$$\text{Bandwidth} = \text{DC to } 540 \text{ Hz}$$

$$\text{Equivalent Input Noise} = 0.24 \mu\text{V}_{\text{rms}}$$

Note: Indicates ±1% metal film resistors recommended for temperature stability.

Typical Applications (Continued)

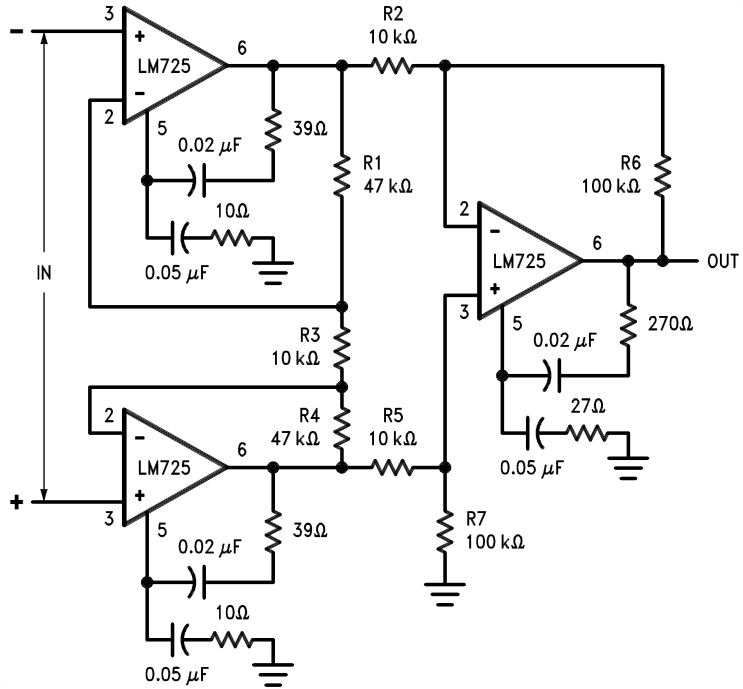
$\pm 100\text{V}$ Common Mode Range Differential Amplifier



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Typical Applications (Continued)

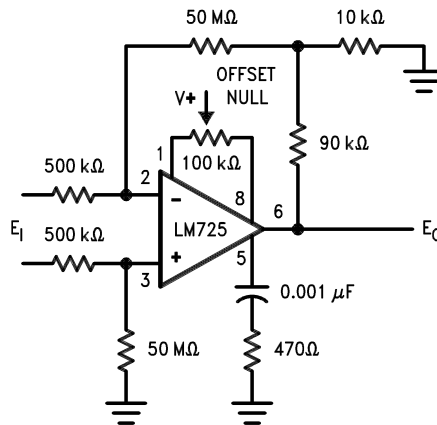
Instrumentation Amplifier with High Common Mode Rejection



01047412

$$\begin{aligned} \frac{R1}{R6} &= \frac{R3}{R4} \text{ for best CMRR} \\ R3 &= R4 \\ R1 = R6 &= 10 R3 \\ \text{Gain} &= \frac{R6}{R7} \end{aligned}$$

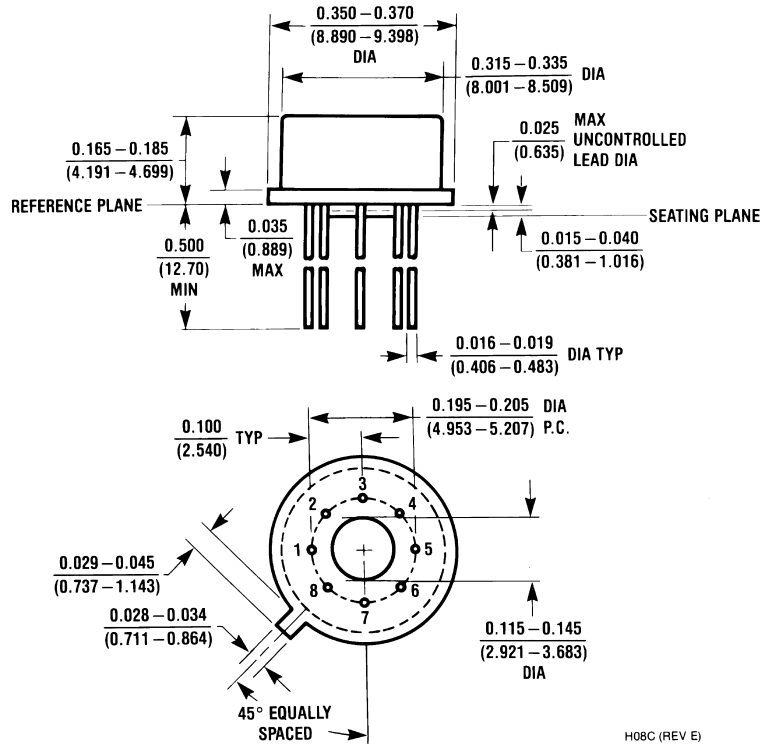
Precision Amplifier $A_{VCL} = 1000$



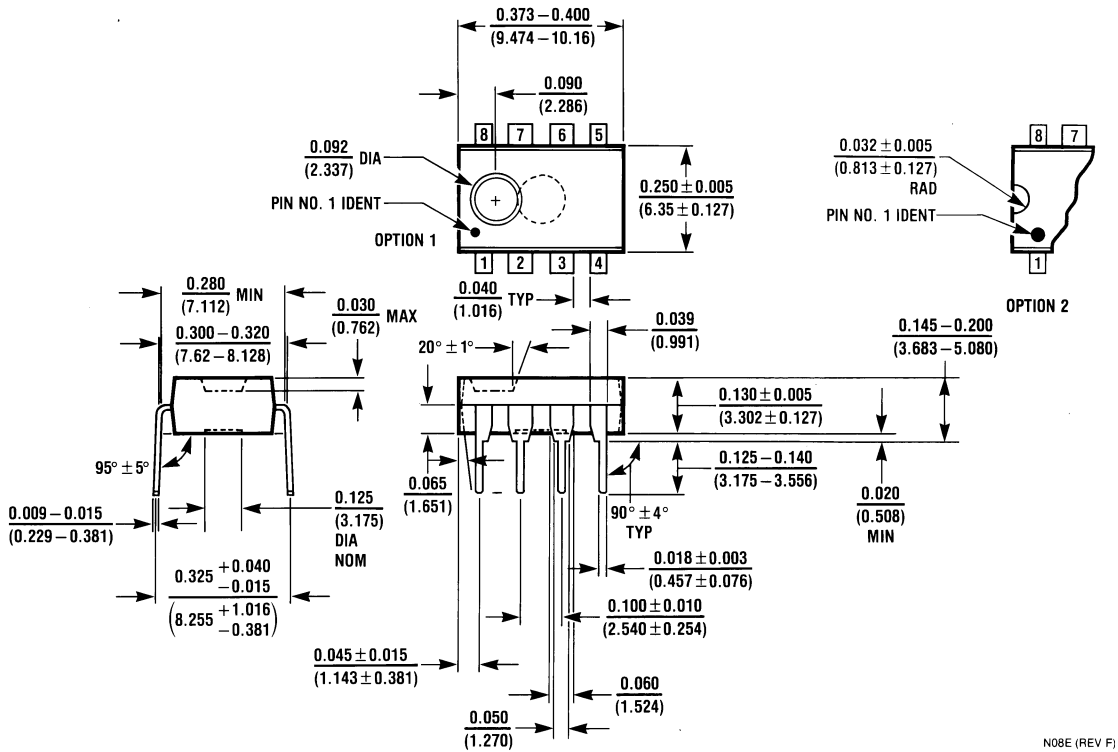
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Physical Dimensions inches (millimeters)

unless otherwise noted



Order Number LM725H/883, LM725CH or LM725AH/883
 NS Package Number H08C



Order Number LM725CN
 NS Package Number N08E

Notes

National does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and National reserves the right at any time without notice to change said circuitry and specifications.

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