

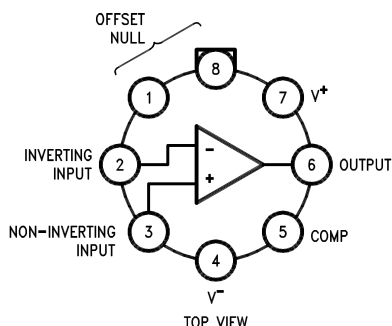
## LM725 Operational Amplifier

Check for Samples: [LM725](#)

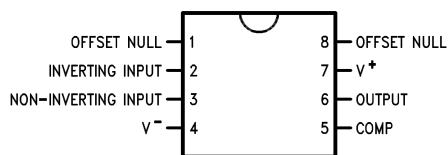
### FEATURES

- 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 DIAGRAM



**Metal Can Package**



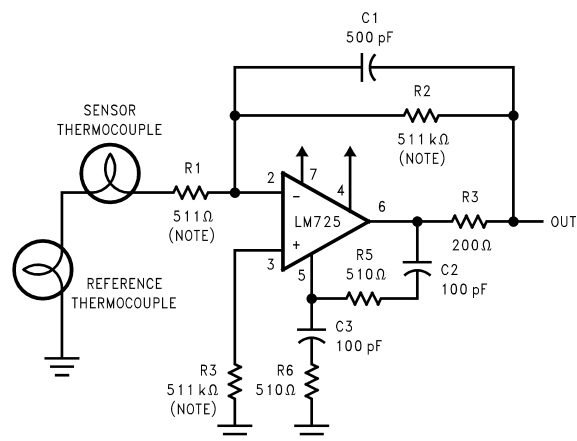
**Dual-In-Line Package**

### 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  $-55^\circ\text{C}$  to  $+125^\circ\text{C}$  temperature range. The LM725C has slightly relaxed specifications and has its performance guaranteed over a  $0^\circ\text{C}$  to  $70^\circ\text{C}$  temperature range.

### TYPICAL APPLICATIONS



**Figure 1. Thermocouple Amplifier**



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These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## ABSOLUTE MAXIMUM RATINGS <sup>(1)</sup>

If Military/Aerospace specified devices are required, contact the Texas Instruments Semiconductor Sales Office/  
Distributors for availability and specifications. <sup>(2)</sup>

|                                                                           |                 |
|---------------------------------------------------------------------------|-----------------|
| Supply Voltage                                                            | ±22V            |
| Internal Power Dissipation <sup>(3)</sup>                                 | 500 mW          |
| Differential Input Voltage                                                | ±5V             |
| Input Voltage <sup>(4)</sup>                                              | ±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 <sub>A(MIN)</sub> to T <sub>A(MAX)</sub> ) |                 |
| LM725                                                                     | –55°C to +125°C |
| LM725A                                                                    | –55°C to +125°C |
| LM725C                                                                    | 0°C to +70°C    |

(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.

(2) For Military electrical specifications RETS725AX are available for LM725AH and RETS725X are available for LM725H.

(3) Derate at 150°C/W for operation at ambient temperatures above 75°C.

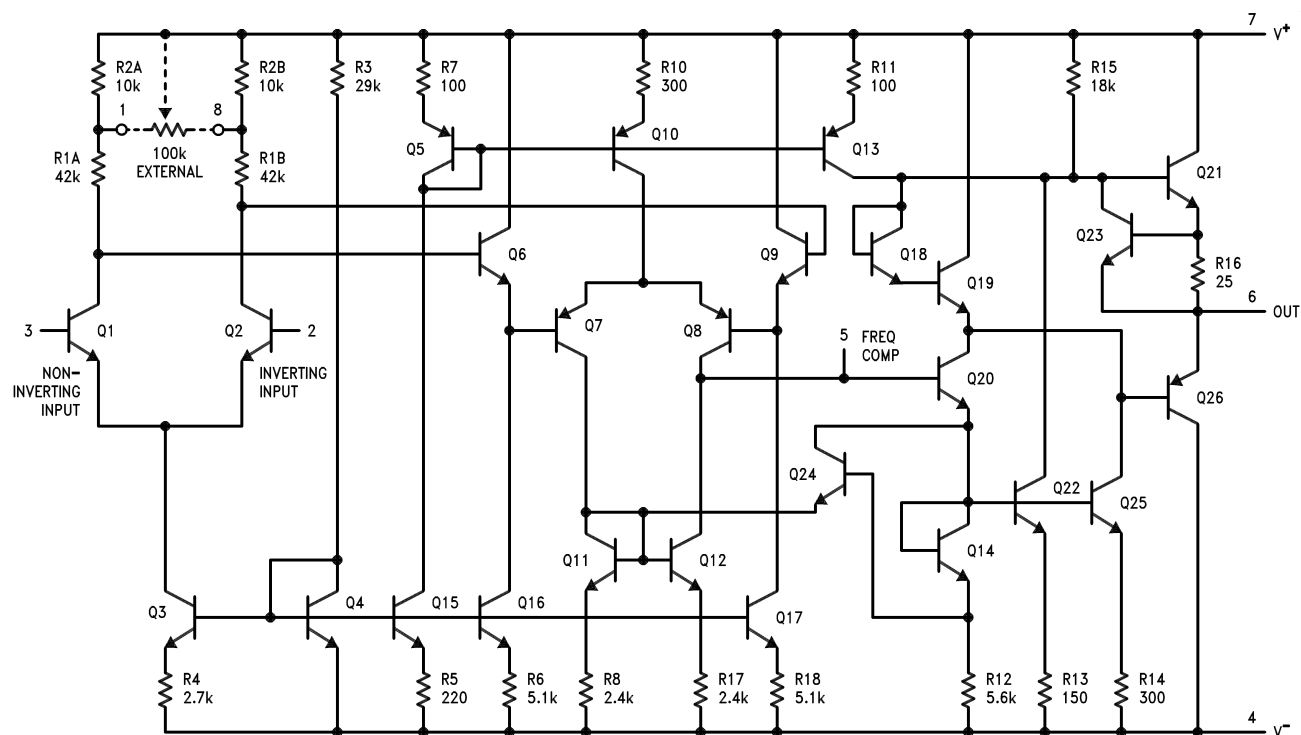
(4) For supply voltages less than ±22V, the absolute maximum input voltage is equal to the supply voltage.

**ELECTRICAL CHARACTERISTICS** <sup>(1)</sup>

| Parameter                                                     | Conditions                                                                                       | LM725A     |            |      | LM725      |            |     | LM725C     |            |     | Units                        |
|---------------------------------------------------------------|--------------------------------------------------------------------------------------------------|------------|------------|------|------------|------------|-----|------------|------------|-----|------------------------------|
|                                                               |                                                                                                  | Min        | Typ        | Max  | Min        | Typ        | Max | Min        | Typ        | Max |                              |
| Input Offset Voltage<br>(Without External Trim)               | $T_A = 25^\circ\text{C}$ ,<br>$R_S \leq 10\text{ k}\Omega$                                       |            |            | 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                                           | $T_A = 25^\circ\text{C}$                                                                         |            |            |      |            |            |     |            |            |     |                              |
|                                                               | $f_o = 10\text{ Hz}$                                                                             |            | 15         |      |            | 15         |     |            | 15         |     | $\text{nV}/\sqrt{\text{Hz}}$ |
|                                                               | $f_o = 100\text{ Hz}$                                                                            |            | 9.0        |      |            | 9.0        |     |            | 9.0        |     | $\text{nV}/\sqrt{\text{Hz}}$ |
|                                                               | $f_o = 1\text{ kHz}$                                                                             |            | 8.0        |      |            | 8.0        |     |            | 8.0        |     | $\text{nV}/\sqrt{\text{Hz}}$ |
| Input Noise Current                                           | $T_A = 25^\circ\text{C}$                                                                         |            |            |      |            |            |     |            |            |     |                              |
|                                                               | $f_o = 10\text{ Hz}$                                                                             |            | 1.0        |      |            | 1.0        |     |            | 1.0        |     | $\text{pA}/\sqrt{\text{Hz}}$ |
|                                                               | $f_o = 100\text{ Hz}$                                                                            |            | 0.3        |      |            | 0.3        |     |            | 0.3        |     | $\text{pA}/\sqrt{\text{Hz}}$ |
|                                                               | $f_o = 1\text{ kHz}$                                                                             |            | 0.15       |      |            | 0.15       |     |            | 0.15       |     | $\text{pA}/\sqrt{\text{Hz}}$ |
| Input Resistance                                              | $T_A = 25^\circ\text{C}$                                                                         |            | 1.5        |      |            | 1.5        |     |            | 1.5        |     | M $\Omega$                   |
| Input Voltage Range                                           | $T_A = 25^\circ\text{C}$                                                                         | $\pm 13.5$ | $\pm 14$   |      | $\pm 13.5$ | $\pm 14$   |     | $\pm 13.5$ | $\pm 14$   |     | V                            |
| Large Signal Voltage Gain                                     | $T_A = 25^\circ\text{C}$ ,<br>$R_L \geq 2\text{ k}\Omega$ ,<br>$V_{\text{OUT}} = \pm 10\text{V}$ | 1000       | 3000       |      | 1000       | 3000       |     | 250        | 3000       |     | V/mV                         |
| Common-Mode Rejection Ratio                                   | $T_A = 25^\circ\text{C}$ ,<br>$R_S \leq 10\text{ k}\Omega$                                       | 120        |            |      | 110        | 120        |     | 94         | 120        |     | dB                           |
| Power Supply Rejection Ratio                                  | $T_A = 25^\circ\text{C}$ ,<br>$R_S \leq 10\text{ k}\Omega$                                       |            | 2.0        | 5.0  |            | 2.0        | 10  |            | 2.0        | 35  | $\mu\text{V/V}$              |
| Output Voltage Swing                                          | $T_A = 25^\circ\text{C}$ ,<br>$R_L \geq 10\text{ k}\Omega$                                       | $\pm 12.5$ | $\pm 13.5$ |      | $\pm 12$   | $\pm 13.5$ |     | $\pm 12$   | $\pm 13.5$ |     | V                            |
|                                                               | $R_L \geq 2\text{ k}\Omega$                                                                      | $\pm 12.0$ | $\pm 13.5$ |      | $\pm 10$   | $\pm 13.5$ |     | $\pm 10$   | $\pm 13.5$ |     | V                            |
| Power Consumption                                             | $T_A = 25^\circ\text{C}$                                                                         |            | 80         | 105  |            | 80         | 105 |            | 80         | 150 | mW                           |
| Input Offset Voltage<br>(Without External Trim)               | $R_S \leq 10\text{ k}\Omega$                                                                     |            |            | 0.7  |            |            | 1.5 |            |            | 3.5 | mV                           |
| Average Input Offset Voltage Drift<br>(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<br>(With External Trim)    | $R_S = 50\Omega$                                                                                 |            | 0.6        | 1.0  |            | 0.6        |     |            | 0.6        |     | $\mu\text{V}/^\circ\text{C}$ |
| Input Offset Current                                          | $T_A = T_{\text{MAX}}$                                                                           |            | 1.2        | 4.0  |            | 1.2        | 20  |            | 1.2        | 35  | nA                           |
|                                                               | $T_A = T_{\text{MIN}}$                                                                           |            | 7.5        | 18.0 |            | 7.5        | 40  |            | 4.0        | 50  | nA                           |
| Average Input Offset Current Drift                            |                                                                                                  |            | 35         | 90   |            | 35         | 150 |            | 10         |     | $\text{pA}/^\circ\text{C}$   |
| Input Bias Current                                            | $T_A = T_{\text{MAX}}$                                                                           |            | 20         | 70   |            | 20         | 100 |            |            | 125 | nA                           |
|                                                               | $T_A = T_{\text{MIN}}$                                                                           |            | 80         | 180  |            | 80         | 200 |            |            | 250 | nA                           |
| Large Signal Voltage Gain                                     | $R_L \geq 2\text{ k}\Omega$                                                                      |            |            |      |            |            |     |            |            |     |                              |
|                                                               | $T_A = T_{\text{MAX}}$ ,<br>$R_L \geq 2\text{ k}\Omega$                                          | 1,000,000  |            |      | 1,000,000  |            |     | 125,000    |            |     | V/V                          |
|                                                               | $T_A = T_{\text{MIN}}$ ,<br>$R_L \geq 2\text{ k}\Omega$                                          | 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                                          | $R_L \geq 2\text{ k}\Omega$                                                                      | $\pm 12$   |            |      | $\pm 10$   |            |     | $\pm 10$   |            |     | V                            |

(1) These specifications apply for  $V_S = \pm 15\text{V}$  unless otherwise specified.

## SCHEMATIC DIAGRAM



## TYPICAL PERFORMANCE CHARACTERISTICS

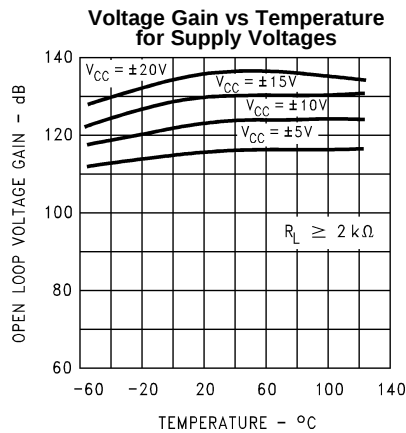


Figure 2.

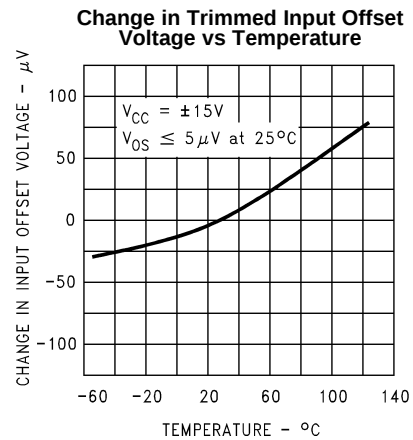


Figure 3.

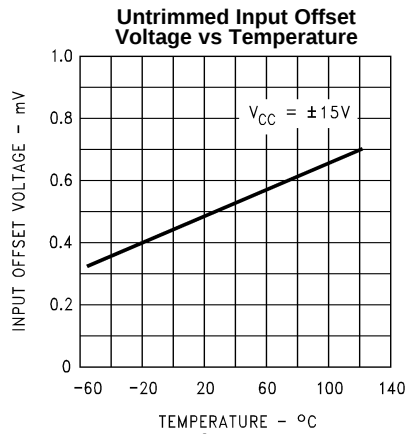


Figure 4.

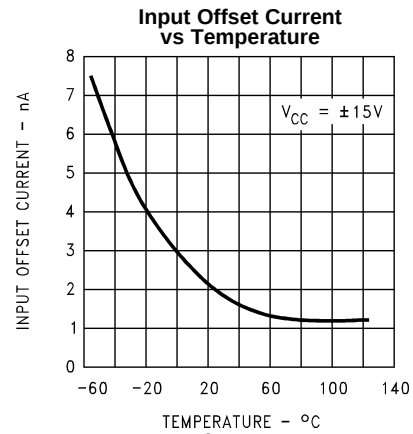


Figure 5.

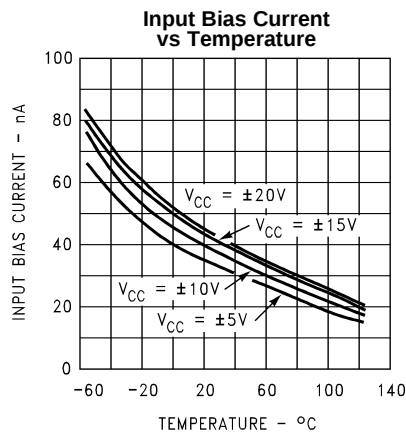


Figure 6.

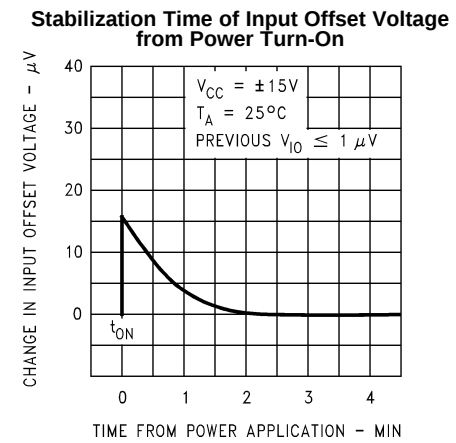


Figure 7.

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Change in Input Offset Voltage Due to Thermal Shock vs Time

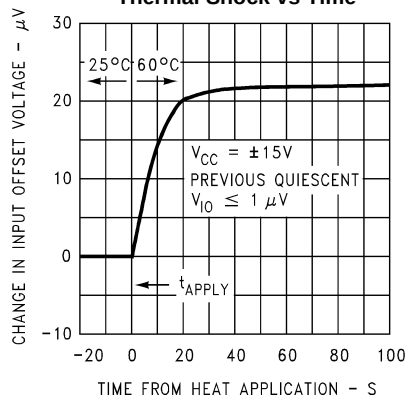


Figure 8.

Input Noise Voltage vs Frequency

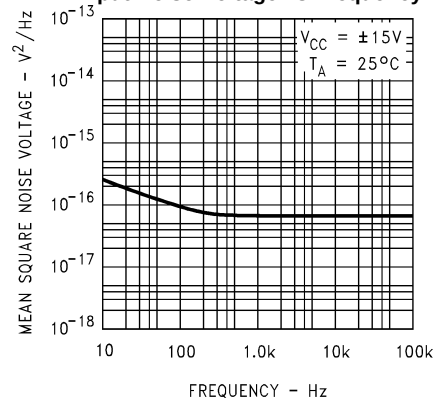


Figure 9.

Input Noise Current vs Frequency

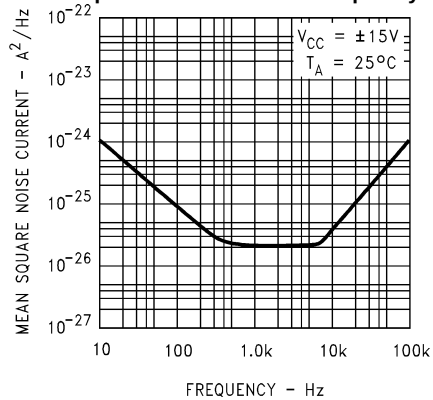


Figure 10.

Power Consumption vs Temperature

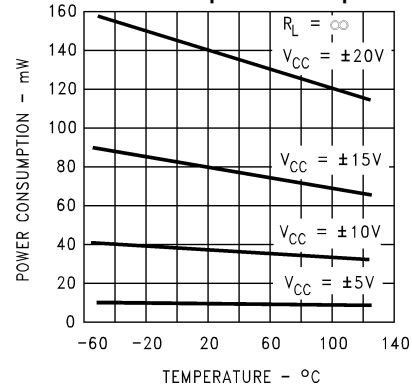


Figure 11.

Open Loop Frequency Response for Values of Compensation

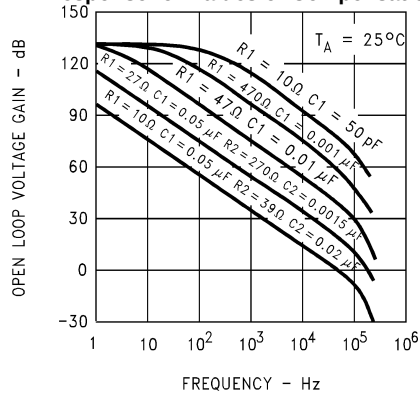


Figure 12.

Values for Suggested Compensation Networks vs Various Close Loop Voltage Gains

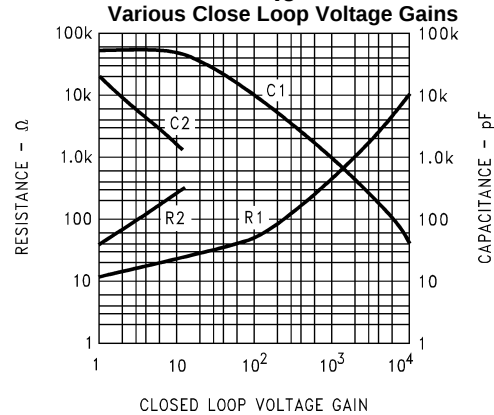
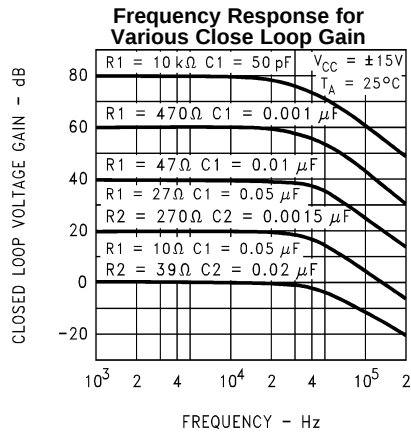


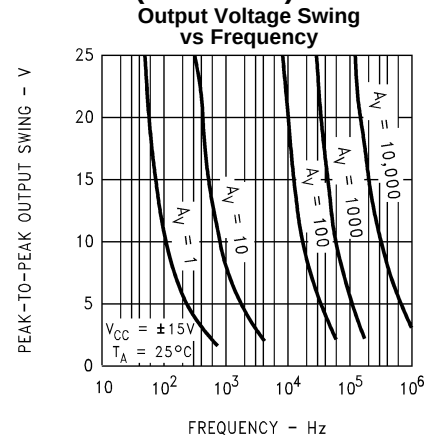
Figure 13.

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)



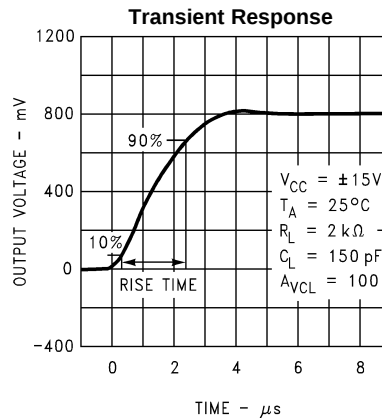
(1) Performance is shown using recommended compensation networks.

**Figure 14.**



(1) Performance is shown using recommended compensation networks.

**Figure 15.**



**Figure 16.**

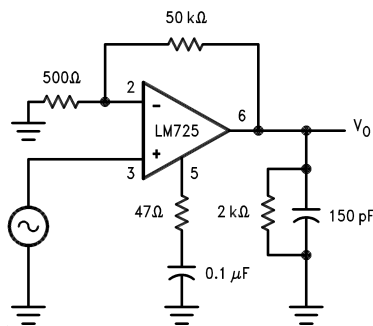


Figure 17. Transient Response Test Circuit

## AUXILIARY CIRCUITS

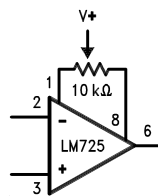


Figure 18. Voltage Offset Null Circuit

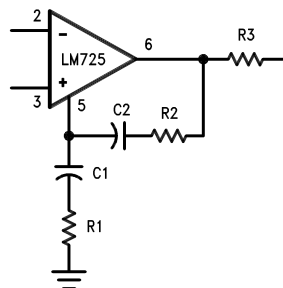
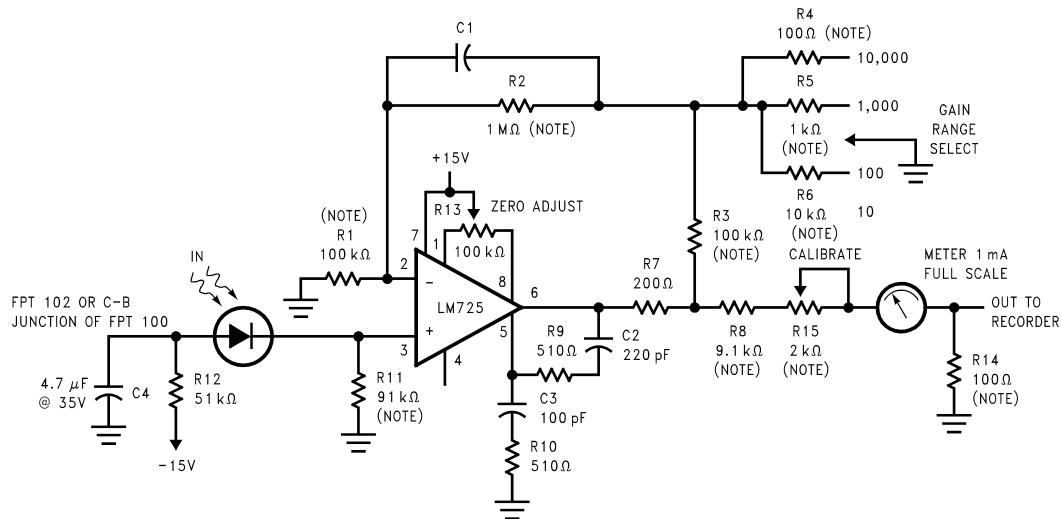


Figure 19. Frequency Compensation Circuit

Table 1. Compensation Component Values

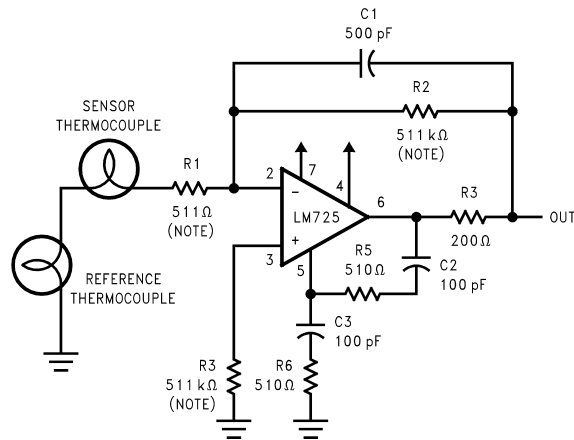
| $A_v$  | $R_1$<br>( $\Omega$ ) | $C_1$<br>( $\mu\text{F}$ ) | $R_2$<br>( $\Omega$ ) | $C_2$<br>( $\mu\text{F}$ ) |
|--------|-----------------------|----------------------------|-----------------------|----------------------------|
| 10,000 | 10k                   | 50 pF                      |                       |                            |
| 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



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

Figure 20. Photodiode Amplifier



$$\frac{R_2}{R_5} = \frac{R_6}{R_7} \text{ for best CMR}$$

$$R_1 = R_4$$

$$R_2 = R_5$$

$$\text{Gain} = \frac{R_6}{R_2} + \left( \frac{2R_1}{R_3} \right)$$

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

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

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

Indicates  $\pm 1\%$  metal film resistors recommended for temperature stability.

Figure 21. Thermocouple Amplifier

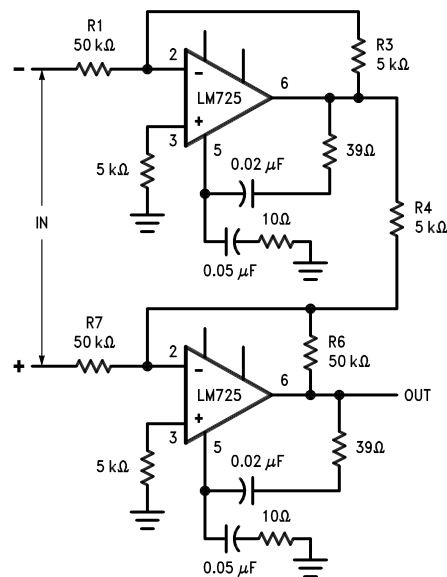
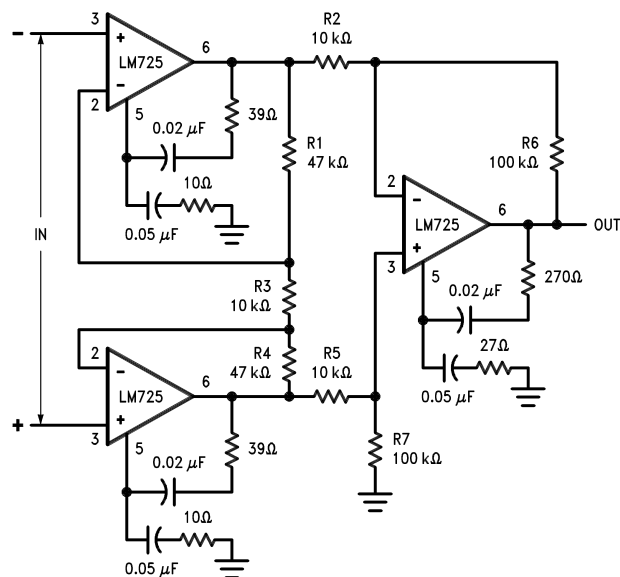


Figure 22. ±100V Common Mode Range Differential Amplifier



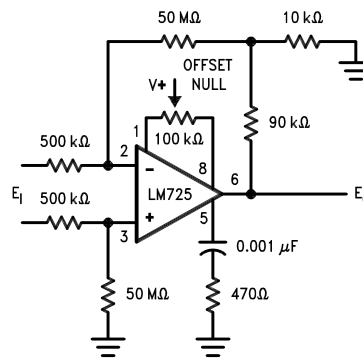
$$\frac{R1}{R6} = \frac{R3}{R4} \text{ for best CMRR}$$

$$R3 = R4$$

$$R1 = R6 = 10 R3$$

$$\text{Gain} = \frac{R6}{R7}$$

Figure 23. Instrumentation Amplifier with High Common Mode Rejection



**Figure 24. Precision Amplifier  $A_{VCL} = 1000$**

## REVISION HISTORY

| Changes from Revision C (April 2013) to Revision D         | Page               |
|------------------------------------------------------------|--------------------|
| • Changed layout of National Data Sheet to TI format ..... | <a href="#">11</a> |

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### Applications

|                               |                                                                                          |
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| Computers and Peripherals     | <a href="http://www.ti.com/computers">www.ti.com/computers</a>                           |
| Consumer Electronics          | <a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>                   |
| Energy and Lighting           | <a href="http://www.ti.com/energy">www.ti.com/energy</a>                                 |
| Industrial                    | <a href="http://www.ti.com/industrial">www.ti.com/industrial</a>                         |
| Medical                       | <a href="http://www.ti.com/medical">www.ti.com/medical</a>                               |
| Security                      | <a href="http://www.ti.com/security">www.ti.com/security</a>                             |
| Space, Avionics and Defense   | <a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a> |
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