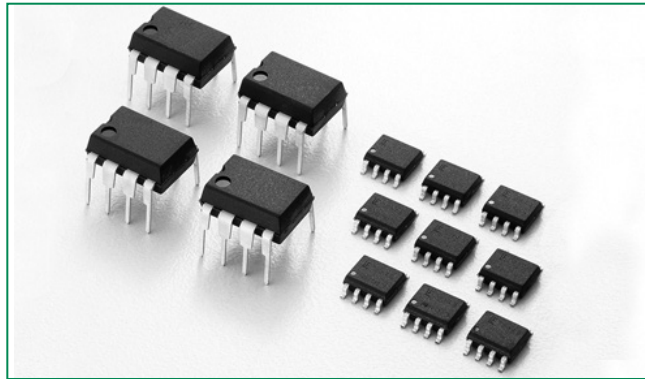
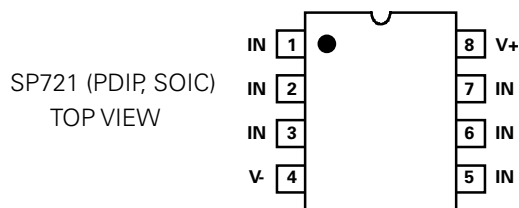


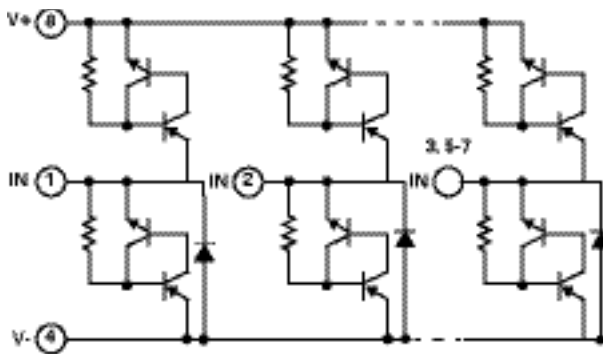
## SP721 Series 3pF 4kV Diode Array



### Pinout



### Functional Block Diagram



### Description

The SP721 is an array of SCR/Diode bipolar structures for ESD and over-voltage protection to sensitive input circuits. The SP721 has 2 protection SCR/Diode device structures per input. There are a total of 6 available inputs that can be used to protect up to 6 external signal or bus lines. Over-voltage protection is from the IN (Pins 1 - 3 and Pins 5 - 7) to V+ or V-.

The SCR structures are designed for fast triggering at a threshold of one  $+V_{BE}$  diode threshold above V+ (Pin 8) or a  $-V_{BE}$  diode threshold below V- (Pin 4). From an IN input, a clamp to V+ is activated if a transient pulse causes the input to be increased to a voltage level greater than one  $V_{BE}$  above V+. A similar clamp to V- is activated if a negative pulse, one  $V_{BE}$  less than V-, is applied to an IN input. Standard ESD Human Body Model (HBM) Capability is:

### Features

- ESD Interface Capability for HBM Standards
  - MIL STD 3015.7 ..... 15kV
  - IEC 61000-4-2, Direct Discharge,
  - Single Input ..... 4kV (Level 2)
  - Two Inputs in Parallel ..... 8kV (Level 4)
  - IEC 61000-4-2, Air Discharge ..... 15kV (Level 4)
- High Peak Current Capability
  - IEC 61000-4-5 (8/20 $\mu$ s) .....  $\pm$ 3A
  - Single Pulse, 100 $\mu$ s Pulse Width .....  $\pm$ 2A
  - Single Pulse, 4 $\mu$ s Pulse Width .....  $\pm$ 5A
- Designed to Provide Over-Voltage Protection
  - Single-Ended Voltage Range to ..... +30V
  - Differential Voltage Range to .....  $\pm$ 15V
- Fast Switching ..... 2ns Rise Time
- Low Input Leakages ..... 1nA at 25°C Typical
- Low Input Capacitance ..... 3pF Typical
- An Array of 6 SCR/Diode Pairs
- Operating Temperature Range ..... -40°C to 105°C

### Additional Information



Resources



Samples

### Applications

- Microprocessor/Logic Input Protection
- Analog Device Input Protection
- Data Bus Protection
- Voltage Clamp

### Absolute Maximum Ratings

| Parameter                                                                        | Rating                | Units |
|----------------------------------------------------------------------------------|-----------------------|-------|
| Continuous Supply Voltage, (V+) - (V-)                                           | +35                   | V     |
| Forward Peak Current, $I_{IN}$ to $V_{CC}$ , $I_{IN}$ to GND (Refer to Figure 5) | $\pm 2$ , 100 $\mu$ s | A     |

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

Note:

ESD Ratings and Capability (Figure 1, Table 1)

Load Dump and Reverse Battery (Note 2)

### Thermal Information

| Parameter                                                        | Rating        | Units |
|------------------------------------------------------------------|---------------|-------|
| Thermal Resistance (Typical, Note 1)                             | $\theta_{JA}$ | °C/W  |
| PDIP Package                                                     | 160           | °C/W  |
| SOIC Package                                                     | 170           | °C/W  |
| Maximum Storage Temperature Range                                | -65 to 150    | °C    |
| Maximum Junction Temperature (Plastic Package)                   | 150           | °C    |
| Maximum Lead Temperature (Soldering 20-40s)(SOIC Lead Tips Only) | 260           | °C    |

1.  $\theta_{JA}$  is measured with the component mounted on an evaluation PC board in free air.

### Electrical Characteristics $T_A = -40^\circ\text{C}$ to $105^\circ\text{C}$ , $V_{IN} = 0.5V_{CC}$ , Unless Otherwise Specified

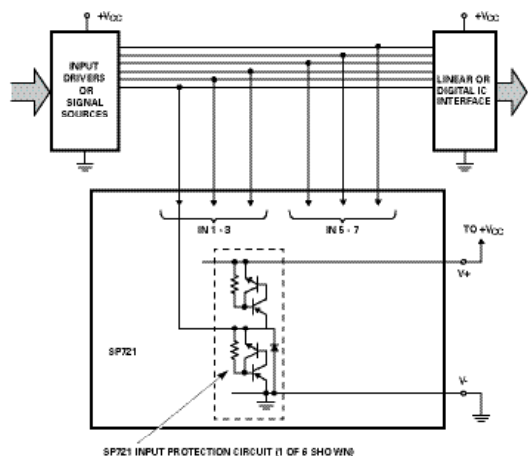
| Parameter                    | Symbol          | Test Conditions                   | Min | Typ     | Max | Units    |
|------------------------------|-----------------|-----------------------------------|-----|---------|-----|----------|
| Operating Voltage Range,     | $V_{SUPPLY}$    |                                   | -   | 2 to 30 | -   | V        |
| $V_{SUPPLY} = [(V+) - (V-)]$ |                 |                                   |     |         |     |          |
| Forward Voltage Drop         |                 |                                   |     |         |     |          |
| IN to V-                     | $V_{FWDL}$      | $I_{IN} = 1\text{A}$ (Peak Pulse) | -   | 2       | -   | V        |
| IN to V+                     | $V_{FWDH}$      |                                   | -   | 2       | -   | V        |
| Input Leakage Current        | $I_{IN}$        |                                   | -20 | 5       | +20 | nA       |
| Quiescent Supply Current     | $I_{QUIESCENT}$ |                                   | -   | 50      | 200 | nA       |
| Equivalent SCR ON Threshold  |                 | Note 3                            | -   | 1.1     | -   | V        |
| Equivalent SCR ON Resistance |                 | $V_{FWD}/I_{FWD}$ ; Note 3        | -   | 1       | -   | $\Omega$ |
| Input Capacitance            | $C_{IN}$        |                                   | -   | 3       | -   | pF       |
| Input Switching Speed        | $t_{ON}$        |                                   | -   | 2       | -   | ns       |

Notes:

- In automotive and battery operated systems, the power supply lines should be externally protected for load dump and reverse battery. When the V+ and V- Pins are connected to the same supply voltage source as the device or control line under protection, a current limiting resistor should be connected in series between the external supply and the SP721 supply pins to limit reverse battery current to within the rated maximum limits. Bypass capacitors of typically 0.01 $\mu$ F or larger from the V+ and V- Pins to ground are recommended.
- Refer to the Figure 3 graph for definitions of equivalent "SCR ON Threshold" and "SCR ON Resistance". These characteristics are given here for thumb-rule information to determine peak current and dissipation under EOS conditions.

### Typical Application of the SP721

(Application as an Input Clamp for Over-voltage, Greater than  $1V_{BE}$  Above V+ or less than  $-1V_{BE}$  below V-)



## ESD Capability

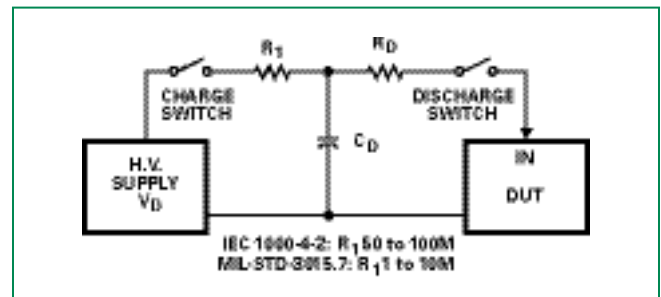
ESD capability is dependent on the application and defined test standard. The evaluation results for various test standards and methods based on Figure 1 are shown in Table 1.

For the "Modified" MIL-STD-3015.7 condition that is defined as an "in-circuit" method of ESD testing, the V+ and V- pins have a return path to ground and the SP721 ESD capability is typically greater than 15kV from 100pF through 1.5kΩ. By strict definition of MIL-STD-3015.7 using "pin-to-pin" device testing, the ESD voltage capability is greater than 6kV. The MIL-STD-3015.7 results were determined from AT&T ESD Test Lab measurements.

The HBM capability to the IEC 61000-4-2 standard is greater than 15kV for air discharge (Level 4) and greater than 4kV for direct discharge (Level 2). Dual pin capability (2 adjacent pins in parallel) is well in excess of 8kV (Level 4).

For ESD testing of the SP721 to EIAJ IC121 Machine Model (MM) standard, the results are typically better than 1kV from 200pF with no series resistance.

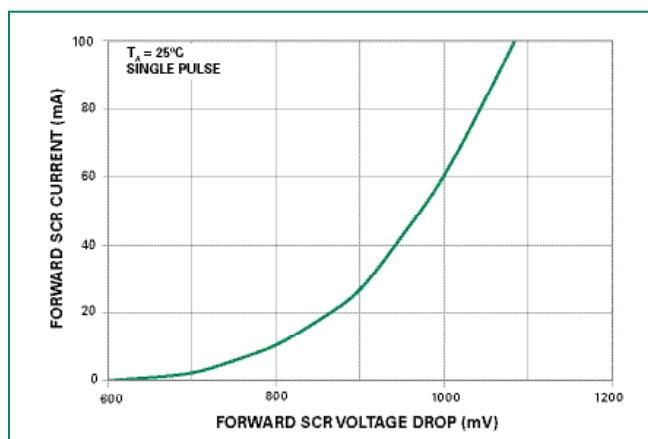
**Figure 1: Electrostatic Discharge Test**



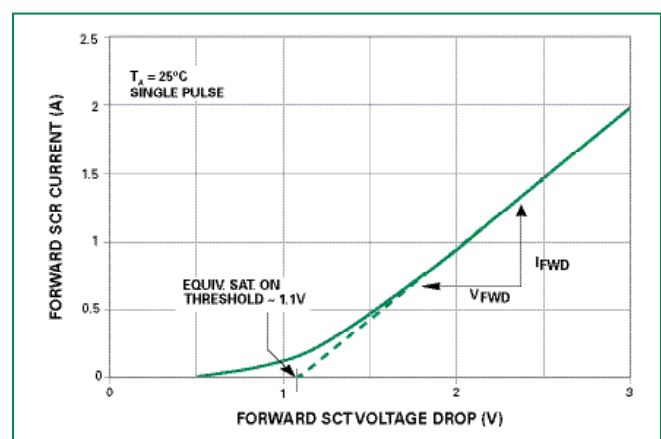
**Table 1: ESD Test Conditions**

| Standard       | Type/Mode                                      | R <sub>D</sub> | C <sub>D</sub> | ±V <sub>D</sub> |
|----------------|------------------------------------------------|----------------|----------------|-----------------|
| MIL STD 3015.7 | Modified HBM                                   | 1.5kΩ          | 100pF          | 15kV            |
|                | Standard HBM                                   | 1.5kΩ          | 100pF          | 6kV             |
| IEC 61000-4-2  | HBM, Air Discharge                             | 330Ω           | 150pF          | 15kV            |
|                | HBM, Direct Discharge                          | 330Ω           | 150pF          | 4kV             |
|                | HBM, Direct Discharge, Two Parallel Input Pins | 330Ω           | 150pF          | 8kV             |
| EIAJ IC121     | Machine Model                                  | 0kΩ            | 200pF          | 1kV             |

**Figure 2: Low Current SCR Forward Voltage Drop Curve**



**Figure 3: High Current SCR Forward Voltage Drop Curve**



## Peak Transient Current Capability of the SP721

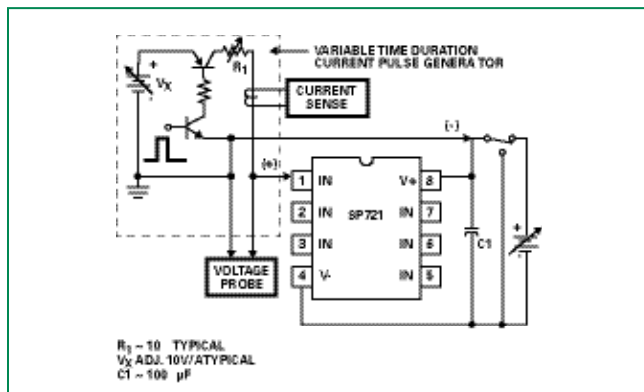
The peak transient current capability rises sharply as the width of the current pulse narrows. Destructive testing was done to fully evaluate the SP721's ability to withstand a wide range of peak current pulses vs time. The circuit used to generate current pulses is shown in Figure 4.

The test circuit of Figure 4 is shown with a positive pulse input. For a negative pulse input, the (-) current pulse input goes to an SP721 'IN' input pin and the (+) current pulse input goes to the SP721 V- pin. The V+ to V- supply of the SP721 must be allowed to float. (i.e., It is not tied to the ground reference of the current pulse generator.) Figure 5 shows the point of overstress as defined by increased leakage in excess of the data sheet published limits.

The maximum peak input current capability is dependent on the ambient temperature, improving as the temperature is reduced. Peak current curves are shown for ambient temperatures of 25°C and 105°C and a 15V power supply condition. The safe operating range of the transient peak current should be limited to no more than 75% of the measured overstress level for any given pulse width as shown in the curves of Figure 5.

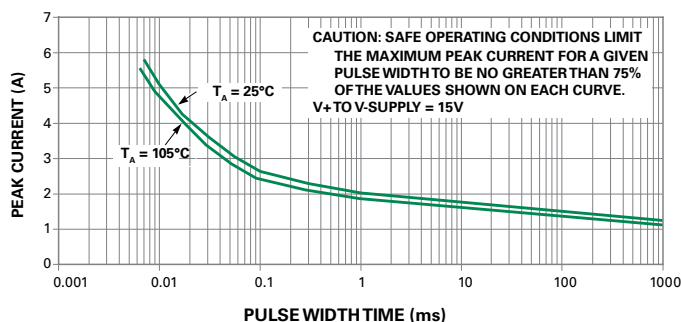
Note that adjacent input pins of the SP721 may be paralleled to improve current (and ESD) capability. The sustained peak current capability is increased to nearly twice that of a single pin.

**Figure 4: Typical SP721 Peak Current Test Circuit with a Variable Pulse Width Input**



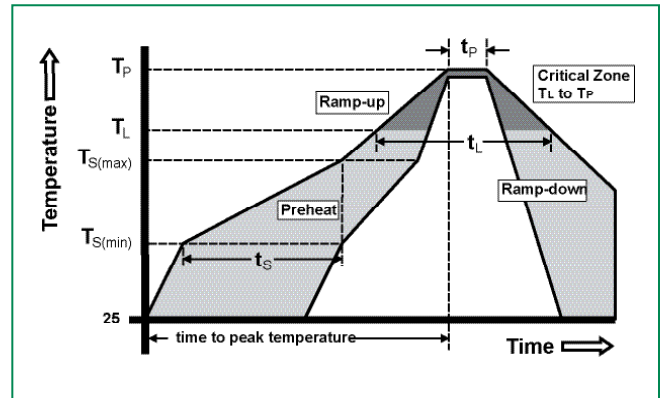
**Figure 5: SP721 Typical Single Peak Current Pulse Capability**

Showing the Measured Point of Overstress in Amperes vs pulse width time in milliseconds

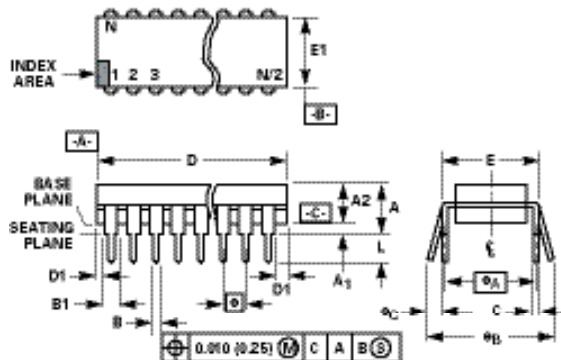


## Soldering Parameters

|                                                        |                                    |                         |
|--------------------------------------------------------|------------------------------------|-------------------------|
| Reflow Condition                                       |                                    | Pb – Free assembly      |
| Pre Heat                                               | - Temperature Min ( $T_{s(min)}$ ) | 150°C                   |
|                                                        | - Temperature Max ( $T_{s(max)}$ ) | 200°C                   |
|                                                        | - Time (min to max) ( $t_s$ )      | 60 – 180 secs           |
| Average ramp up rate (Liquidus) Temp ( $T_L$ ) to peak |                                    | 5°C/second max          |
| $T_{s(max)}$ to $T_L$ - Ramp-up Rate                   |                                    | 5°C/second max          |
| Reflow                                                 | - Temperature ( $T_L$ ) (Liquidus) | 217°C                   |
|                                                        | - Temperature ( $t_L$ )            | 60 – 150 seconds        |
| Peak Temperature ( $T_P$ )                             |                                    | 260 <sup>+0/-5</sup> °C |
| Time within 5°C of actual peak Temperature ( $t_p$ )   |                                    | 20 – 40 seconds         |
| Ramp-down Rate                                         |                                    | 5°C/second max          |
| Time 25°C to peak Temperature ( $T_P$ )                |                                    | 8 minutes Max.          |
| Do not exceed                                          |                                    | 260°C                   |



## Package Dimensions — Dual-In-Line Plastic Packages (PDIP)

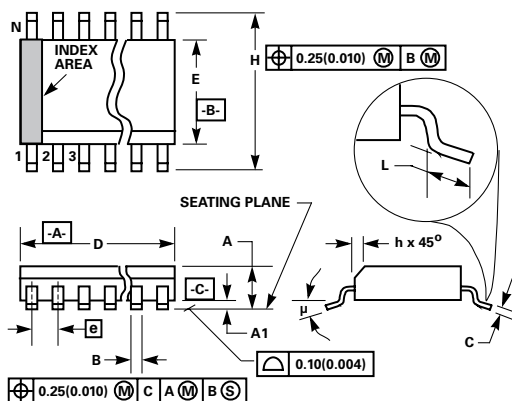


### Notes:

- Controlling Dimensions: INCH. In case of conflict between English and Metric dimensions, the inch dimensions control.
- Dimensioning and tolerancing per ANSI Y14.5M-1982.
- Symbols are defined in the "MO Series Symbol List" in Section 2.2 of Publication No. 95.
- Dimensions A, A1 and L are measured with the package seated in JEDEC seating plane gauge GS-3.
- D, D1, and E1 dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.010 inch (0.25mm).
- E and  $e_A$  are measured with the leads constrained to be perpendicular to datum  $C_1$ .
- $e_B$  and  $e_C$  are measured at the lead tips with the leads unconstrained.  $e_C$  must be zero or greater.
- B1 maximum dimensions do not include dambar protrusions. Dambar protrusions shall not exceed 0.010 inch (0.25mm).
- N is the maximum number of terminal positions.
- Corner leads (1, N, N/2 and N/2 + 1) for E8.3, E16.3, E18.3, E28.3, E42.6 will have a B1 dimension of 0.030 - 0.045 inch (0.76 - 1.14mm).

| Package              | PDIP                |       |           |       |       |
|----------------------|---------------------|-------|-----------|-------|-------|
| Pins                 | 8 Lead Dual-in-Line |       |           |       |       |
| JEDEC                | MS-001              |       |           |       |       |
|                      | Millimeters         |       | Inches    |       | Notes |
|                      | Min                 | Max   | Min       | Max   |       |
| <b>A</b>             | -                   | 5.33  | -         | 0.210 | 4     |
| <b>A1</b>            | 0.39                | -     | 0.015     | -     | 4     |
| <b>A2</b>            | 2.93                | 4.95  | 0.115     | 0.195 | -     |
| <b>B</b>             | 0.356               | 0.558 | 0.014     | 0.022 | -     |
| <b>B1</b>            | 1.15                | 1.77  | 0.045     | 0.070 | 8, 10 |
| <b>C</b>             | 0.204               | 0.355 | 0.008     | 0.014 | -     |
| <b>D</b>             | 9.01                | 10.16 | 0.355     | 0.400 | 5     |
| <b>D1</b>            | 0.13                | -     | 0.005     | -     | 5     |
| <b>E</b>             | 7.62                | 8.25  | 0.300     | 0.325 | 6     |
| <b>E1</b>            | 6.10                | 7.11  | 0.240     | 0.280 | 5     |
| <b>e</b>             | 2.54 BSC            |       | 0.100 BSC |       | -     |
| <b>e<sub>A</sub></b> | 7.62 BSC            |       | 0.300 BSC |       | 6     |
| <b>e<sub>B</sub></b> | -                   | 10.92 | -         | 0.430 | 7     |
| <b>L</b>             | 2.93                | 3.81  | 0.115     | 0.150 | 4     |
| <b>N</b>             | 8                   |       | 8         |       | 9     |

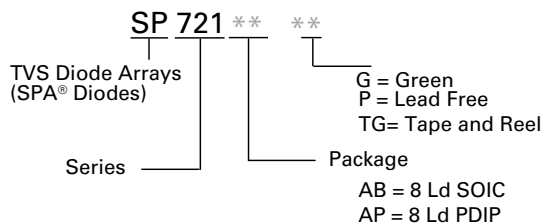
### Package Dimensions — Small Outline Plastic Packages (SOIC)



#### Notes:

- Symbols are defined in the "MO Series Symbol List" in Section 2.2 of Publication Number 95.
- Dimensioning and tolerancing per ANSI Y14.5M-1982.
- Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion and gate burrs shall not exceed 0.15mm (0.006 inch) per side.
- Dimension "E" does not include interlead flash or protrusions. Inter-lead flash and protrusions shall not exceed 0.25mm (0.010 inch) per side.
- The chamfer on the body is optional. If it is not present, a visual index feature must be located within the crosshatched area.
- "L" is the length of terminal for soldering to a substrate.
- "N" is the number of terminal positions.
- Terminal numbers are shown for reference only.
- The lead width "B" as measured 0.36mm (0.014 inch) or greater above the seating plane, shall not exceed a maximum value of 0.61mm (0.024 inch).
- Controlling dimension: MILLIMETER. Converted inch dimensions are not necessarily exact.

### Part Numbering System



| Package | SOIC        |      |           |        |       |
|---------|-------------|------|-----------|--------|-------|
| Pins    | 8           |      |           |        |       |
| JEDEC   | MS-012      |      |           |        |       |
|         | Millimeters |      | Inches    |        | Notes |
|         | Min         | Max  | Min       | Max    |       |
| A       | 1.35        | 1.75 | 0.0532    | 0.0688 | -     |
| A1      | 0.10        | 0.25 | 0.0040    | 0.0098 | -     |
| B       | 0.33        | 0.51 | 0.013     | 0.020  | 9     |
| C       | 0.19        | 0.25 | 0.0075    | 0.0098 | -     |
| D       | 4.80        | 5.00 | 0.1890    | 0.1968 | 3     |
| E       | 3.80        | 4.00 | 0.1497    | 0.1574 | 4     |
| e       | 1.27 BSC    |      | 0.050 BSC |        | -     |
| H       | 5.80        | 6.20 | 0.2284    | 0.2440 | -     |
| h       | 0.25        | 0.50 | 0.0099    | 0.0196 | 5     |
| L       | 0.40        | 1.27 | 0.016     | 0.050  | 6     |
| N       | 8           |      | 8         |        | 7     |
| μ       | 0°          | 8°   | 0°        | 8°     | -     |

### Product Characteristics

|                     |                        |
|---------------------|------------------------|
| Lead Plating        | Matte Tin              |
| Lead Material       | Copper Alloy           |
| Lead Coplanarity    | 0.004 inches (0.102mm) |
| Substitute Material | Silicon                |
| Body Material       | Molded Epoxy           |
| Flammability        | UL 94 V-0              |

### Ordering Information

| Part Number | Temp. Range (°C) | Package                 | Environmental Informaton | Marking                 | Min. Order |
|-------------|------------------|-------------------------|--------------------------|-------------------------|------------|
| SP721APP    | -40 to 105       | 8 Ld PDIP               | Lead-free                | SP721AP(P) <sup>1</sup> | 2000       |
| SP721ABG    | -40 to 105       | 8 Ld SOIC               | Green                    | SP721A(B)G <sup>2</sup> | 1960       |
| SP721ABTG   | -40 to 105       | 8 Ld SOIC Tape and Reel | Green                    | SP721A(B)G <sup>2</sup> | 2500       |

#### Notes:

- SP721AP(P) means device marking either SP721AP or SP721APP.
- SP721A(B)G means device marking either SP721AG or SP721ABG which are good for types SP721ABG and SP721ABTG.

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