

**MNLP2951-X REV 1B1**

Original Creation Date: 08/01/95  
Last Update Date: 05/19/98  
Last Major Revision Date: 11/11/96

**ADJUSTABLE MICROPPOWER VOLTAGE REGULATORS**
**General Description**

The LP2951 is a micropower voltage regulator with very low dropout voltage (typ. 40 mV at light loads and 380 mV at 100 mA). It is ideally suited for use in battery-powered systems. Furthermore, the quiescent current of the LP2951 increases only slightly in dropout, prolonging battery life.

An attractive feature is an error flag output which warns of a low output voltage, often due to falling battery voltage on the input. It may be used for a power-on reset. A second feature is the logic-compatible shutdown input which enables the regulator to be switched on and off. Also, the part may be pin-strapped for a 5V output or programmed from 1.24V to 29V with an external pair of resistors.

Careful design of the LP2951 has minimized all contributions to the error budget. This includes a tight initial tolerance(0.5% typ.), extremely good load and line regulation (0.05% typ.) and a very low output voltage temperature coefficient, making the part useful as a low-power voltage reference.

**Industry Part Number**

LP2951

**NS Part Numbers**

LP2951E/883\*  
LP2951H/883\*\*  
LP2951J/883\*\*\*  
LP2951WG/883\*\*\*\*

**Prime Die**

LP2951

**Controlling Document**

See Features Page

**Processing**

MIL-STD-883, Method 5004

**Quality Conformance Inspection**

MIL-STD-883, Method 5005

| Subgrp | Description         | Temp ( °C) |
|--------|---------------------|------------|
| 1      | Static tests at     | +25        |
| 2      | Static tests at     | +125       |
| 3      | Static tests at     | -55        |
| 4      | Dynamic tests at    | +25        |
| 5      | Dynamic tests at    | +125       |
| 6      | Dynamic tests at    | -55        |
| 7      | Functional tests at | +25        |
| 8A     | Functional tests at | +125       |
| 8B     | Functional tests at | -55        |
| 9      | Switching tests at  | +25        |
| 10     | Switching tests at  | +125       |
| 11     | Switching tests at  | -55        |

**Features**

- Error flag warns of output dropout.
- Logic-controlled electronic shutdown.
- Output programmable from 1.24 to 29V.
- SMD : 5962-38705M2A\*, MGA\*\*, MPA\*\*\*, MXA\*\*\*\*

**(Absolute Maximum Ratings)**

(Note 1)

|                                             |                                     |
|---------------------------------------------|-------------------------------------|
| Power Dissipation                           |                                     |
| METAL CAN                                   | 675mW at +25 C                      |
| CERDIP                                      | 1.0W at +25 C                       |
| LCC                                         | 1.25W at +25 C                      |
| CERAMIC SOIC                                | 1.0W at +25 C                       |
| Storage Temperature Range                   | -65 C to +150 C                     |
| Operating Ambient Temperature Range         | -55 C to +125 C                     |
| Absolute Maximum Junction Temperature       | +160 C                              |
| Input Supply Voltage                        | -0.3 to +30V                        |
| Feedback Input Voltage<br>(Note 3, 4)       | -1.5 to +30V                        |
| Shutdown Input Voltage<br>(Note 3)          | -0.3 to +30V                        |
| Error Comparator Out. Voltage<br>(Note 3)   | -0.3 to +30V                        |
| Lead Temperature<br>(Soldering, 10 seconds) | 260 C                               |
| Thermal Resistance                          |                                     |
| ThetaJA                                     |                                     |
| METAL CAN                                   | (Still Air @ 0.5W) 163 C/W          |
|                                             | (500LF/Min Air flow @ 0.5W) 95 C/W  |
| CERDIP                                      | (Still Air @ 0.5W) 131 C/W          |
|                                             | (500LF/Min Air flow @ 0.5W) 75 C/W  |
| LCC                                         | (Still Air @ 0.5W) 95 C/W           |
|                                             | (500LF/Min Air flow @ 0.5W) 66 C/W  |
| CERAMIC SOIC                                | (Still Air @ 0.5W) 215 C/W          |
|                                             | (500LF/Min Air flow @ 0.5W) 130 C/W |
| ThetaJC                                     |                                     |
| METAL CAN                                   | 51 C/W                              |
| CERDIP                                      | 21 C/W                              |
| LCC                                         | 24 C/W                              |
| CERAMIC SOIC                                | 24 C/W                              |
| Package Weight<br>(Typical)                 | TBD                                 |
| ESD Rating                                  | 500V                                |

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. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.

Note 2: The maximum power dissipation must be derated at elevated temperatures and is dictated by  $T_{jmax}$  (maximum junction temperature),  $\Theta_{JA}$  (package junction to ambient thermal resistance), and  $T_A$  (ambient temperature). The maximum allowable power dissipation at any temperature is  $P_{dmax} = (T_{jmax} - T_A)/\Theta_{JA}$  or the number given in the Absolute Maximum Ratings, whichever is lower.

Note 3: May exceed input supply voltage.

Note 4: When used in dual-supply systems where the output terminal uses loads returned to a negative supply, the output voltage should be diode-clamped to ground.

## Electrical Characteristics

### DC PARAMETERS

(The following conditions apply to all the following parameters, unless otherwise specified.)

DC:  $V_{in} = 6V$ ,  $I_l = 100\mu A$ ,  $C_l = 1\mu F$ ,  $V_{out} = 5V$ ,  $V_{shutdown} = \leq 0.8V$

| SYMBOL | PARAMETER                  | CONDITIONS                                 | NOTES | PIN-NAME | MIN   | MAX   | UNIT    | SUB-GROUPS |
|--------|----------------------------|--------------------------------------------|-------|----------|-------|-------|---------|------------|
|        | Output Voltage             |                                            |       |          | 4.975 | 5.025 | V       | 1          |
|        |                            |                                            |       |          | 4.94  | 5.06  | V       | 2, 3       |
|        | Line Regulation            | $6V \leq V_{in} \leq 30V$                  |       |          | -5    | 5     | mV      | 1          |
|        |                            | $I_l = 1mA$                                |       |          | -25   | 25    | mV      | 2, 3       |
|        | Load Regulation            | $100\mu A \leq I_l \leq 100mA$             |       |          | -5    | 5     | mV      | 1          |
|        |                            | $100\mu A \leq I_l \leq 100mA$             |       |          | -25   | 25    | mV      | 2, 3       |
|        | Dropout Voltage            | $I_l = 100mA$                              | 1, 2  |          |       | 450   | mV      | 1          |
|        |                            |                                            | 1, 2  |          |       | 600   | mV      | 2, 3       |
|        |                            |                                            | 1, 2  |          |       | 80    | mV      | 1          |
|        |                            |                                            | 1, 2  |          |       | 150   | mV      | 2, 3       |
|        | Ground Current             | $V_{out} = 15V$ , $I_l = 100mA$            |       |          | 0     | 15    | mA      | 1          |
|        |                            |                                            |       |          | 0     | 20    | mA      | 2, 3       |
|        |                            | $I_l = 100mA$                              |       |          | 0     | 12    | mA      | 1          |
|        |                            |                                            |       |          | 0     | 14    | mA      | 2, 3       |
|        |                            | $V_{in} = 6-30V$                           |       |          | 0     | 30    | $\mu A$ | 1          |
|        |                            |                                            |       |          | 0     | 50    | $\mu A$ | 2, 3       |
|        | Quiescent Ground Current   |                                            |       |          | 0     | 120   | $\mu A$ | 1          |
|        |                            |                                            |       |          | 0     | 140   | $\mu A$ | 2, 3       |
|        |                            | $I_l = 10\mu A$ , $V_{out} = 15V$          |       |          | 0     | 120   | $\mu A$ | 1          |
|        |                            |                                            |       |          | 0     | 140   | $\mu A$ | 2, 3       |
|        | Dropout Ground Current     | $V_{in} = 4.5V$                            |       |          | 0     | 170   | $\mu A$ | 1          |
|        |                            |                                            |       |          | 0     | 200   | $\mu A$ | 2, 3       |
|        | Comparator Lower Threshold |                                            | 1, 3  |          |       | 95    | mV      | 1          |
|        |                            |                                            | 1, 3  |          |       | 140   | mV      | 2, 3       |
|        | Comparator Upper Threshold |                                            | 1, 3  |          | 40    |       | mV      | 1          |
|        |                            |                                            | 1, 3  |          | 25    |       | mV      | 2, 3       |
|        | Thermal Regulation         | $V_{in} = 30V$ , $I_l = 50mA$ , $T = 2mS$  |       |          | -12.5 | 12.5  | mV      | 1          |
|        |                            | $V_{in} = 30V$ , $I_l = 50mA$ , $T = 10mS$ |       |          | -12.5 | 12.5  | mV      | 1          |
|        | ISC Current Limit          | $V_{out} = 0V$                             |       |          | 0     | 200   | mA      | 1          |
|        |                            |                                            |       |          | 0     | 220   | mA      | 2, 3       |

## Electrical Characteristics

### DC PARAMETERS(Continued)

(The following conditions apply to all the following parameters, unless otherwise specified.)

DC:  $V_{in} = 6V$ ,  $I_l = 100\mu A$ ,  $C_l = 1\mu F$ ,  $V_{out} = 5V$ ,  $V_{shutdown} = \leq 0.8V$

| SYMBOL | PARAMETER                          | CONDITIONS                                               | NOTES | PIN-NAME | MIN  | MAX  | UNIT    | SUB-GROUPS |
|--------|------------------------------------|----------------------------------------------------------|-------|----------|------|------|---------|------------|
|        | Reference Voltage                  |                                                          |       |          | 1.22 | 1.25 | V       | 1          |
|        |                                    |                                                          |       |          | 1.20 | 1.26 | V       | 2, 3       |
|        | Reference Line Regulation          | $2.3V \leq V_{in} \leq 30V$                              |       |          | -1.9 | 1.9  | mV      | 1          |
|        |                                    | $2.3V \leq V_{in} \leq 30V$                              |       |          | -10  | 10   | mV      | 2, 3       |
|        | Reference Output Regulation        | $V_{ref} \leq V_{out} \leq (V_{in}-1V)$ , $V_{in} = 30V$ |       |          | -1.2 | 1.2  | mV      | 1          |
|        |                                    | $V_{ref} \leq V_{out} \leq (V_{in}-1V)$ , $V_{in} = 30V$ |       |          | -5   | 5    | mV      | 2, 3       |
|        | Feedback Bias Current              |                                                          |       |          | -40  | 40   | nA      | 1          |
|        |                                    |                                                          |       |          | -60  | 60   | nA      | 2, 3       |
|        | Comparator Off Leakage             | $V_o = 30V$                                              |       |          | -1   | 1    | $\mu A$ | 1          |
|        |                                    |                                                          |       |          | -2   | 2    | $\mu A$ | 2, 3       |
|        | Comparator Output Low Voltage      | $V_{in} = 4.5V$ , $I_{ol} = 400\mu A$                    |       |          | 0    | 250  | mV      | 1          |
|        |                                    |                                                          |       |          | 0    | 400  | mV      | 2, 3       |
|        | Shutdown Input Current             | $V_{shutdown} = 2.4V$                                    |       |          | 0    | 50   | $\mu A$ | 1          |
|        |                                    |                                                          |       |          | 0    | 100  | $\mu A$ | 2, 3       |
|        |                                    | $V_{shutdown} = 30V$                                     |       |          | 0    | 600  | $\mu A$ | 1          |
|        |                                    |                                                          |       |          | 0    | 750  | $\mu A$ | 2, 3       |
|        | Output Leakage Current in Shutdown | $V_{shutdown} = 1.5V$ , $V_{in} = 30V$                   |       |          | -10  | 10   | $\mu A$ | 1          |
|        |                                    |                                                          |       |          | -20  | 20   | $\mu A$ | 2, 3       |
|        | Shutdown Input Logic Voltage       | (LOW)                                                    | 1     |          |      | 0.6  | V       | 1, 2, 3    |
|        |                                    | (HIGH)                                                   | 1     |          | 2    |      | V       | 1, 2, 3    |

Note 1: Functional test only.

Note 2: Dropout voltage is defined as the input to output differential at which the output drops 100mV below its nominal values measured at 1V differential. At very low values of programmed output voltage, the minimum input supply voltage of 2V (2.3V over temperature) must be taken into account.

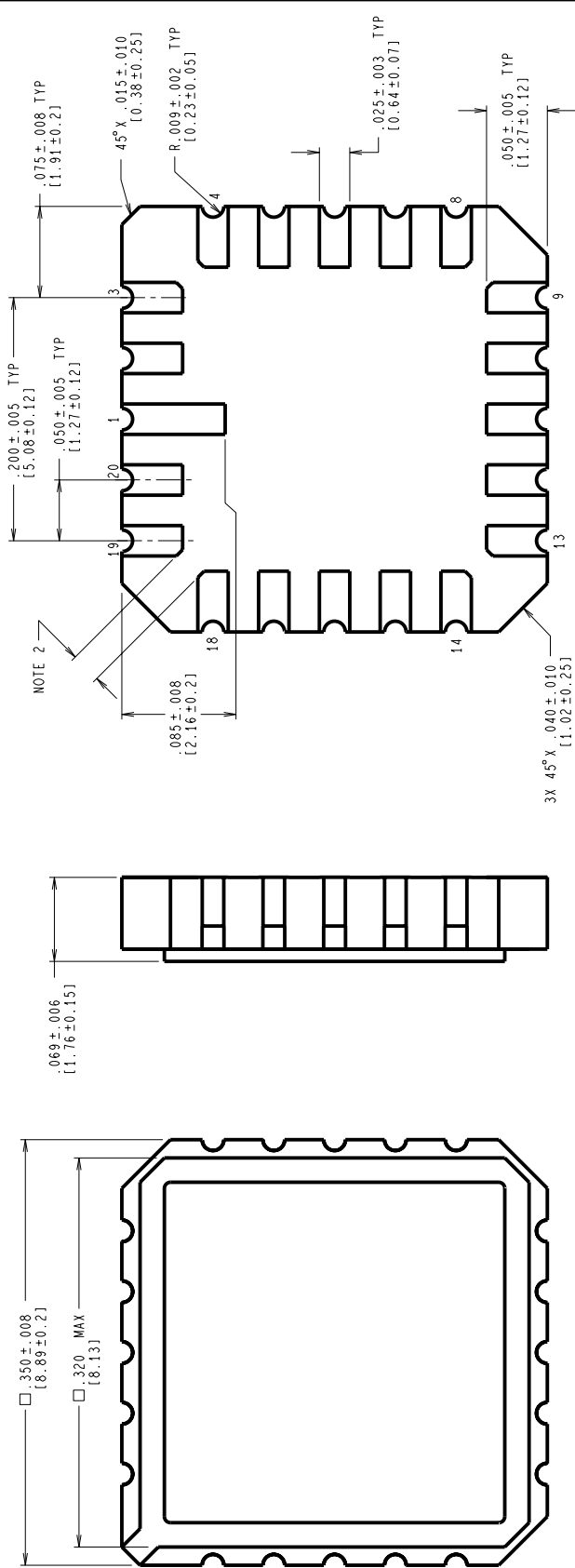
Note 3: Comparator thresholds are expressed in terms of a voltage differential at the Feedback terminal below the nominal reference voltage measured at  $V_{in} = 6V$ . To express these thresholds in terms of output voltage change, multiply by the error amplifier Gain= $V_{out}/V_{in}=(R_1 + R_2)/R_2$ . For example, at a programmed output voltage of 5V, the error output is guaranteed to go low when the output drops by  $95mV \times 5V/1.235V = 384mV$ . Thresholds remain constant as a percent of  $V_{out}$  as  $V_{out}$  is varied, with the dropout warning occurring at typically 5% below nominal, 7.5% guaranteed.

## Graphics and Diagrams

| GRAPHICS# | DESCRIPTION                                        |
|-----------|----------------------------------------------------|
| 05810HRA2 | METAL CAN (H), TO-99, 8LD, .200 DIA P.C. (B/I CKT) |
| 06059HRA2 | CERDIP (J), 8 LEAD (B/I CKT)                       |
| 06146HRA2 | LCC (E), TYPE C, 20 TERMINAL(B/I CKT)              |
| 06341HRA1 | CERPACK (W), 10 LEAD (B/I CKT)                     |
| E20ARE    | LCC (E), TYPE C, 20 TERMINAL(P/P DWG)              |
| H08CRF    | METAL CAN (H), TO-99, 8LD, .200 DIA P.C. (P/P DWG) |
| J08ARL    | CERDIP (J), 8 LEAD (P/P DWG)                       |
| P000205A  | METAL CAN (H), 8 LEAD (PINOUT)                     |
| P000206A  | CERDIP (J), 8 LEAD (PINOUT)                        |
| P000251B  | LCC (E), 20 LEAD (PINOUT)                          |
| P000374A  | CERAMIC SOIC (WG), 10 LEAD (PINOUT)                |
| WG10ARC   | CERAMIC SOIC (WG), 10 LEAD (P/P DWG)               |

See attached graphics following this page.

| REVISIONS |                   |        |               |
|-----------|-------------------|--------|---------------|
| LTR       | DESCRIPTION       | E.C.N. | DATE          |
| E         | REVISE AND REDRAW | 10005  | 02/10/94 DEG/ |



CONTROLLING DIMENSION IS INCH  
VALUES IN [ ] ARE MILLIMETERS

NOTES: UNLESS OTHERWISE SPECIFIED.

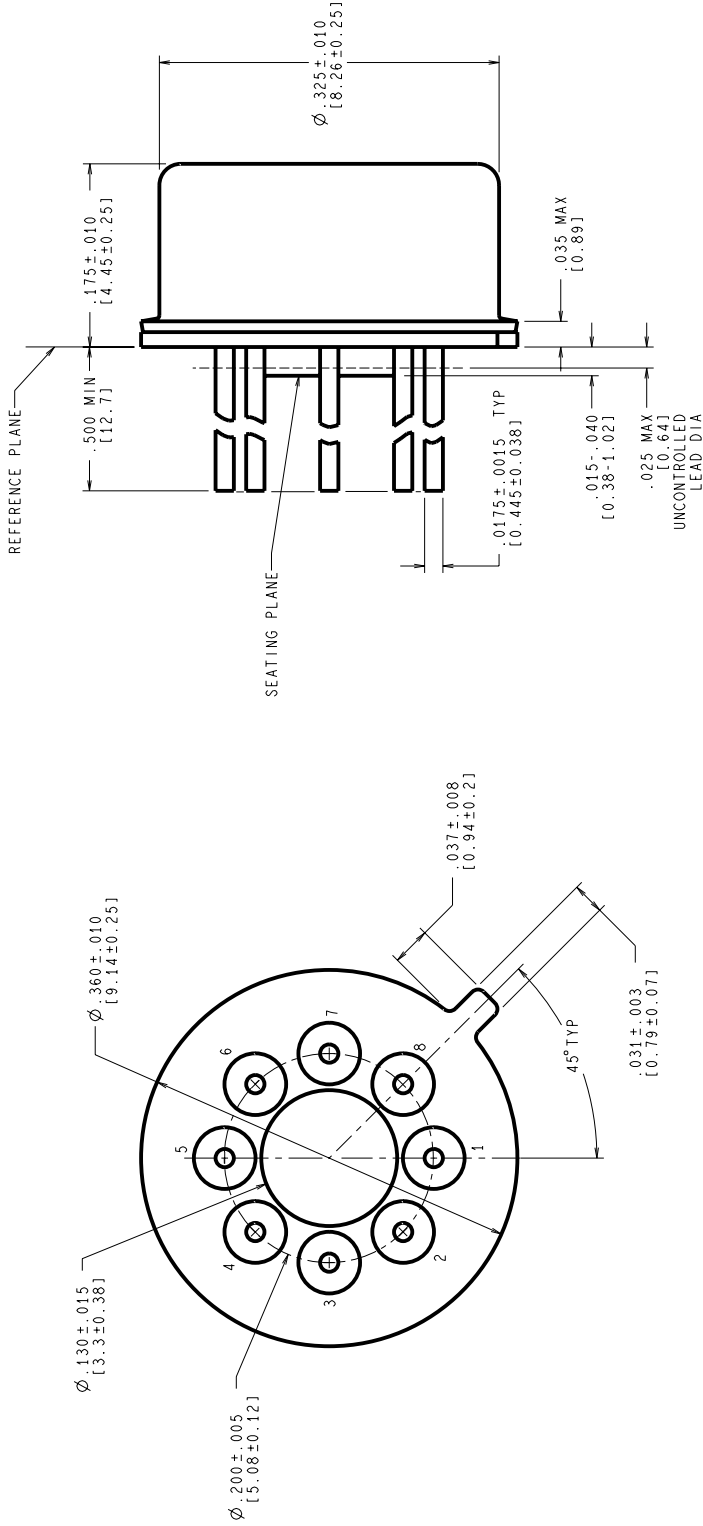
1. LEAD FINISH TO BE ONE OF THE FOLLOWING:

- 50 MICRONS/12.7 MICROMETERS MINIMUM GOLD PLATING OVER 50-350 MICRONS/1.27-8.89 MICROMETERS NICKEL.
  - SOLDER DIP.
  - SOLDER THICKNESS PER LATEST REVISION OF MIL-STD-1835.
2. CORNER PADS MAY HAVE A  $45^\circ$  X  $.020$  IN/0.51mm MAXIMUM CHAMFER TO ACCOMPLISH THE .015 IN/0.38mm DIMENSION.
4. REFERENCE JEDEC REGISTRATION MS-004, VARIATION CB, DATED 7/90.

# MIL/AERO CONFIGURATION CONTROL

| APPROVALS  |              | DATE                 | NATIONAL SEMICONDUCTOR CORPORATION                   |              |
|------------|--------------|----------------------|------------------------------------------------------|--------------|
| DESIGN     | Design Grady | 02/10/94             | 2000 Semiconductor Drive, Santa Clara, CA 95052-8000 |              |
| ESTG. CHK. |              |                      | LEADLESS CHIP CARRIER, TYPE C, 20 TERMINAL           |              |
| ENGR. CHK. |              |                      |                                                      |              |
| APPROVAL   |              |                      |                                                      |              |
| PROJECTION |              | SCALE                | SIZE                                                 | REV          |
|            |              | N/A                  | C                                                    | MKT-E20A     |
|            |              | DO NOT SCALE DRAWING |                                                      | E            |
|            |              |                      |                                                      | SHEET 1 of 1 |

| REVISIONS |                                                                         |        |          |
|-----------|-------------------------------------------------------------------------|--------|----------|
| LTR       | DESCRIPTION                                                             | E.C.N. | DATE     |
| F         | REVISE & REDRAW PER CURRENT STANDARD;<br>UPDATE MIL/AERO STAMP & TITLE. | 11002  | 06/22/95 |
|           |                                                                         |        | MS/      |



CONTROLLING DIMENSION IS INCH  
VALUES IN [ ] ARE MILLIMETERS

MIL-I-38535  
CONFIGURATION CONTROL

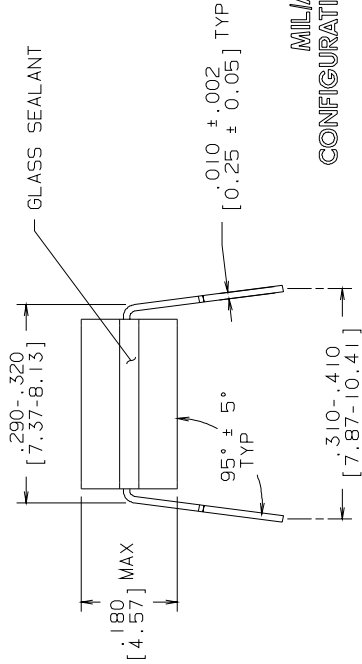
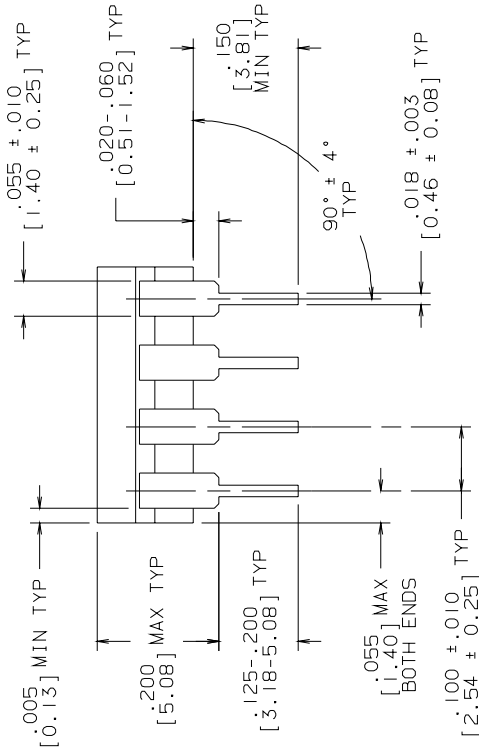
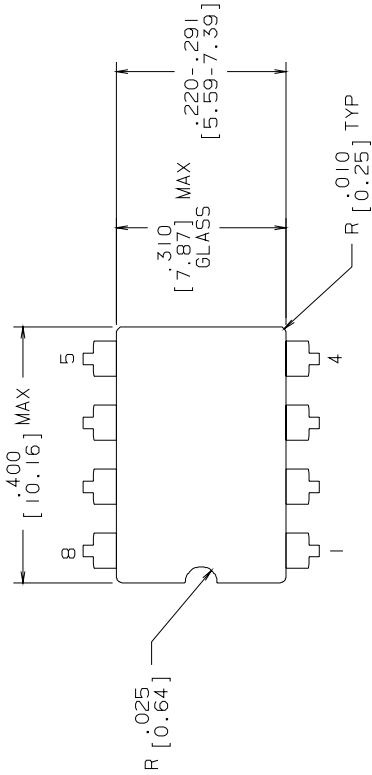
NOTES: UNLESS OTHERWISE SPECIFIED

- LEADS TO BE LOCATED WITHIN .007 IN/ 0.18 mm OF THEIR TRUE POSITIONS RELATIVE TO A MAXIMUM WIDTH TAB.
- STANDARD METAL CAN TYPE: SOLID BASE WITH CERAMIC STANDOFF.
- APPLIES TO MIL-AERO AND LINEAR PRODUCTS.
- REFERENCE JEDEC REGISTRATION TO-99, JEDEC PUBLICATION No. 95.

| APPROVALS  |             | DATE     | <br>National Semiconductor<br>2000 Semiconductor dr., Santa Clara, CA 95052-8000<br>METAL CAN,<br>TO-99, 8 LEAD,<br>.200 DIA P.C.<br>SCALE: N/A SIZE: C DRAWING NUMBER: MKT-H08C REV: F<br>DO NOT SCALE DRAWING SHEET 1 of 1 |
|------------|-------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DESIGN     | MARIA SUCHY | 06/22/95 |                                                                                                                                                                                                                              |
| DFTG       | CHK         |          |                                                                                                                                                                                                                              |
| ENGR       | CHK         |          |                                                                                                                                                                                                                              |
| PROJECTION |             |          |                                                                                                                                                                                                                              |
|            |             |          |                                                                                                                                                                                                                              |



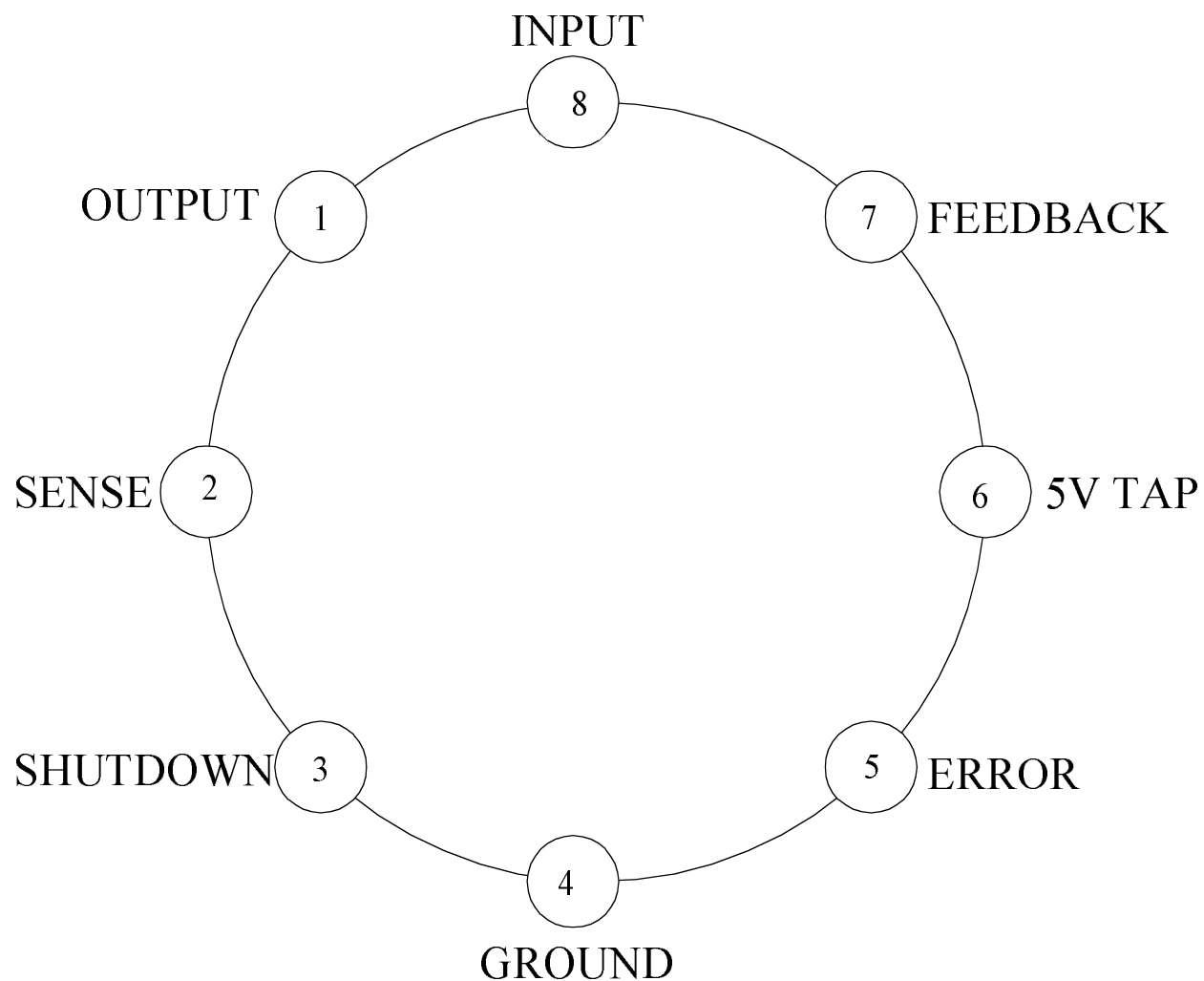
| R E V I S I O N S |                                |        |          |          |
|-------------------|--------------------------------|--------|----------|----------|
| LTR               | DESCRIPTION                    | E.C.N. | DATE     | BY/APP'D |
| L                 | REVISE PER CURRENT STD; REDRAW | 10002  | 09/21/93 | TL/      |



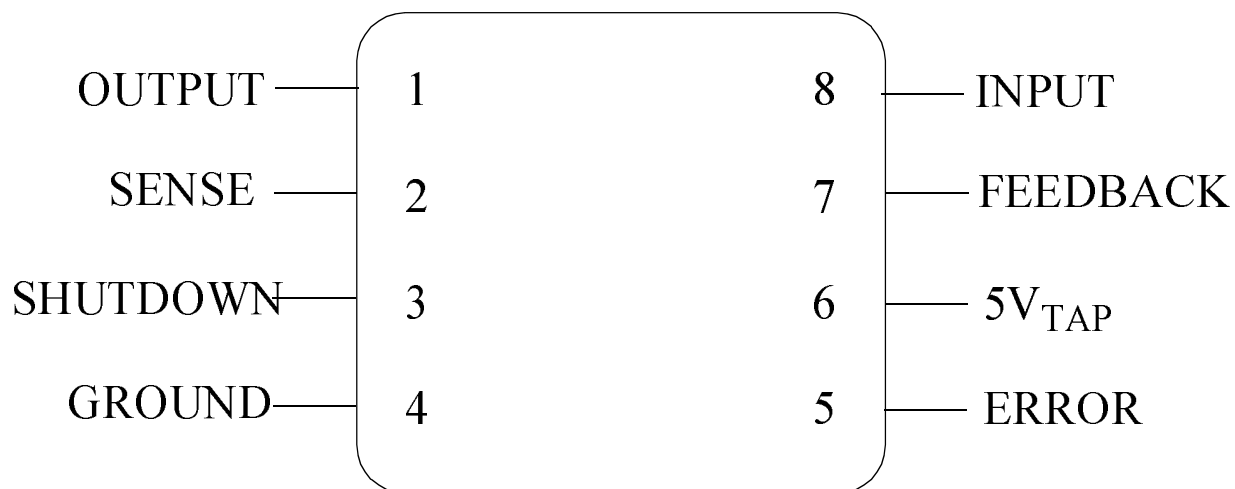
MIL-AERO  
CONFIGURATION CONTROL  
MIL-M-38510  
CONFIGURATION CONTROL

| CONTROLLING DIMENSION: INCH                                               |  |          |                                                      |      |                |     |
|---------------------------------------------------------------------------|--|----------|------------------------------------------------------|------|----------------|-----|
| APPROVALS                                                                 |  | DATE     | NATIONAL SEMICONDUCTOR CORPORATION                   |      |                |     |
| DRAWN <b>LEQUANG</b>                                                      |  | 09/21/93 | 2900 Semiconductor Drive, Santa Clara, CA 95052-8090 |      |                |     |
| DFTG. CHK.                                                                |  |          | CERDIP (J) ,<br>8 LEAD                               |      |                |     |
| ENGR. CHK.                                                                |  |          |                                                      |      |                |     |
| APPROVAL                                                                  |  |          |                                                      |      |                |     |
| <div><div>PROJECTION</div><div><div>1 INCH<br/>[ 25.4 ]</div></div></div> |  |          | SCALE                                                | SIZE | DRAWING NUMBER | REV |
|                                                                           |  |          | N/A                                                  | B    | MKT-J08A       | L   |
|                                                                           |  |          | DO NOT SCALE DRAWING                                 |      | SHEET          | OF  |
|                                                                           |  |          |                                                      |      | 1              | 1   |

- NOTES: UNLESS OTHERWISE SPECIFIED
1. LEAD FINISH TO BE 200 MICRONS / 5.08 MICROMETERS MINIMUM SOLDER MEASURED AT THE CREST OF THE MAJOR FLATS.
  2. JEDEC REGISTRATION MO-036, VARIATION AA, DATED 04/1981.



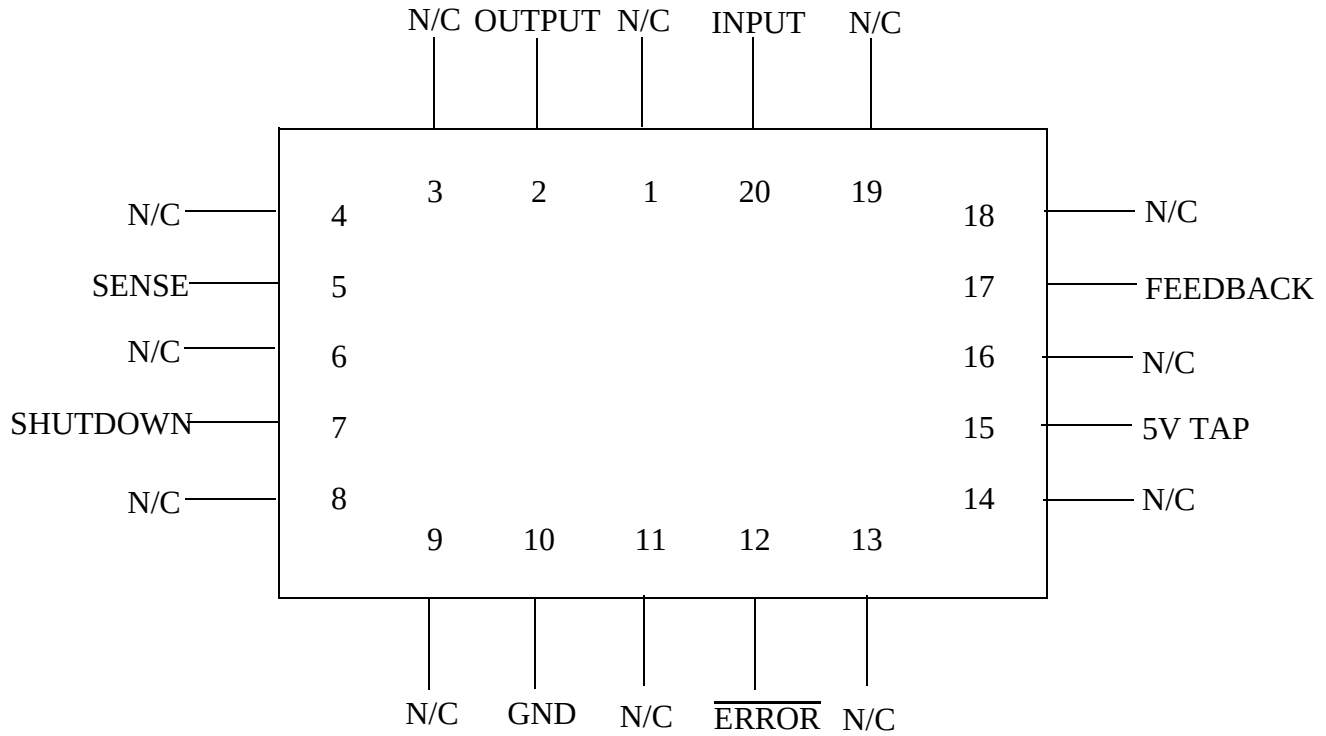
LP2951H  
8 - PIN METAL CAN  
CONNECTION DIAGRAM  
TOP VIEW  
P000205A



LP2951J  
8 - LEAD DIP  
CONNECTION DIAGRAM  
TOP VIEW  
P000206A



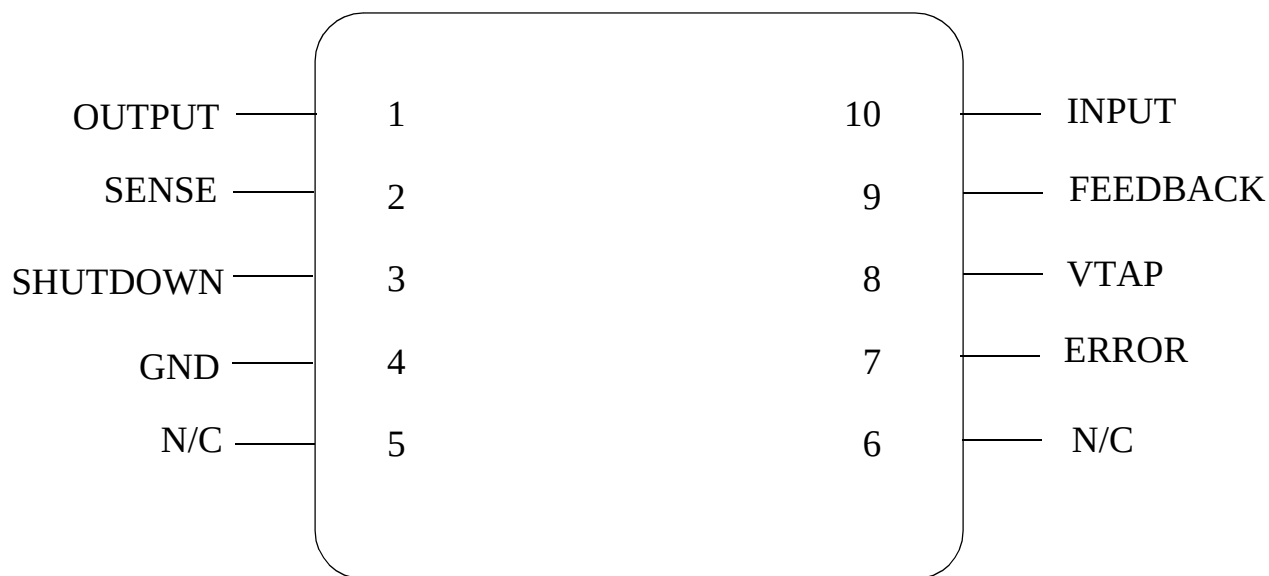
National Semiconductor™  
MIL/AEROSPACE OPERATIONS  
2900 SEMICONDUCTOR DRIVE  
SANTA CLARA, CA 95050



LP2951E  
20 - LEAD LCC  
CONNECTION DIAGRAM  
TOP VIEW  
P000251B



National Semiconductor™  
MIL/AEROSPACE OPERATIONS  
2900 SEMICONDUCTOR DRIVE  
SANTA CLARA, CA 95050



LP2951WG  
10 - LEAD CERAMIC SOIC  
CONNECTION DIAGRAM  
TOP VIEW  
P000374A



**Revision History**

| Rev | ECN #    | Rel Date | Originator    | Changes                                                                                                                                                                                                                                                                                                                    |
|-----|----------|----------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1B1 | M0002864 | 05/19/98 | Barbara Lopez | Update MDS: MNLP2951-X Rev. 1A0 to MNLP2951-X Rev. 1B1. Added WG package to SMD number and NSID. Updated power dissipation to reflect all packages. Updated thermal resistance to reflect all packages. Updated ESD rating. Updated Absolute junction temperature. Added graphics for all packages. Added Package Weights. |