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## NTE987/NTE987SM Integrated Circuit Quad, Low Power OP Amp

### **Description:**

The NTE987 and NTE987SM are low cost quad operational amplifiers with true differential inputs. These have several distinct advantages over standard operational amplifier types in single supply applications. The quad amplifier can operate at supply voltages as low as 3V or as high as 32V with quiescent currents about one fifth of those associated with the NTE941 (on a per amplifier basis). The common mode input range includes the negative supply, thereby eliminating the necessity for external biasing components in many applications. The output voltage range also includes the negative power supply voltage.

### **Features:**

- Available in 14-Lead DIP (NTE987) and Surface Mount, SOIC-14 (NTE987SM)
- Short Circuit Protected Outputs
- True Differential Input Stage
- Single Supply Operation: 3V to 32V
- Four Amplifiers per Package
- Internally Compensated
- Common Mode Range Extends to Negative Supply
- Industry Standard Pin-Outs

### **Absolute Maximum Ratings:** ( $T_A = +25^{\circ}\text{C}$ unless otherwise specified)

#### Power Supply Voltages

Single Supply,  $V_{CC}$  ..... 32V

Split Supplies,  $V_{CC}$   $V_{EE}$  .....  $\pm 16\text{V}$

Input Differential Voltage Range (Split Power Supplies),  $V_{IDR}$  .....  $\pm 32\text{V}$

Input Common Mode Voltage range,  $V_{ICR}$  .....  $-0.3$  to  $32\text{V}$

Input Forward Current ( $V_I < 0.3\text{V}$ , Note 1),  $I_{IF}$  ..... 50mA

Output Short Circuit Duration,  $t_S$  ..... Continuous

Operating Junction Temperature,  $T_J$  .....  $+150^{\circ}\text{C}$

Operating Ambient Temperature Range,  $T_A$  .....  $0^{\circ}$  to  $+70^{\circ}\text{C}$

Storage Temperature Range,  $T_{stg}$  .....  $-55^{\circ}$  to  $+125^{\circ}\text{C}$

Note 1. This input current will only exist when the voltage is negative at any of the input leads. Normal output states will reestablish when the input voltage returns to a voltage greater than  $-0.3\text{V}$ .

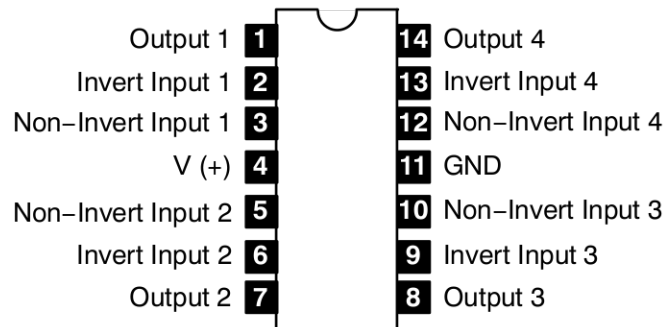
**Electrical Characteristics:** ( $V_{CC} = 5V$ ,  $V_{EE} = GND$ ,  $T_A = +25^{\circ}C$  unless otherwise specified)

| Parameter                                               | Symbol                   | Test Conditions                                                                                |                             | Min | Typ  | Max      | Unit              |
|---------------------------------------------------------|--------------------------|------------------------------------------------------------------------------------------------|-----------------------------|-----|------|----------|-------------------|
| Input Offset Voltage                                    | $V_{IO}$                 | $V_{CC} = 5V$ to $30V$ ,<br>$V_{ICR} = 0$ to $V_{CC}-1.7V$ ,<br>$V_O = 1.4V$ , $R_S = 0\Omega$ |                             | –   | 2    | 7        | mV                |
|                                                         |                          |                                                                                                | $T_A = 0$ to $+70^{\circ}C$ | –   | –    | 9        | mV                |
| Average Temperature Coefficient of Input Offset Voltage | $\Delta V_{IO}/\Delta T$ | $T_A = 0$ to $+70^{\circ}C$                                                                    |                             | –   | 7    | –        | $\mu V/^{\circ}C$ |
| Input Offset Current                                    | $I_{IO}$                 |                                                                                                |                             | –   | 5    | 50       | nA                |
|                                                         |                          | $T_A = 0$ to $+70^{\circ}C$                                                                    |                             | –   | –    | 150      | nA                |
| Average Temperature Coefficient of Input Offset Current | $\Delta I_{IO}/\Delta T$ | $T_A = 0$ to $+70^{\circ}C$                                                                    |                             | –   | 10   | –        | $pA/^{\circ}C$    |
| Input Bias Current                                      | $I_{IB}$                 |                                                                                                |                             | –   | –90  | –250     | nA                |
|                                                         |                          | $T_A = 0$ to $+70^{\circ}C$                                                                    |                             | –   | –    | –500     | nA                |
| Input Common-Mode Voltage Range                         | $V_{ICR}$                | $V_{CC} = 30V$                                                                                 |                             | 0   | –    | 28.3     | V                 |
|                                                         |                          |                                                                                                | $T_A = 0$ to $+70^{\circ}C$ | 0   | –    | 28.0     | V                 |
| Differential Input Voltage Range                        | $V_{IDR}$                |                                                                                                |                             | –   | –    | $V_{CC}$ | V                 |
| Large Signal Open-Loop Voltage Gain                     | $A_{VOL}$                | $R_L = 2k\Omega$ , $V_{CC} = 15V$ ,<br>For Large $V_O$ Swing                                   |                             | 25  | 100  | –        | V/mV              |
|                                                         |                          |                                                                                                | $T_A = 0$ to $+70^{\circ}C$ | 15  | –    | –        | V/mV              |
| Channel Separation                                      |                          | $1kHz \leq f \leq 20kHz$ , Input Referenced                                                    |                             | –   | –120 | –        | dB                |
| Common-Mode Rejection Ratio                             | CMRR                     | $R_S \leq 10k\Omega$                                                                           |                             | 65  | 70   | –        | dB                |
| Power Supply Rejection Ratio                            | PSRR                     |                                                                                                |                             | 65  | 100  | –        | dB                |
| Output Voltage Range                                    | $V_{OR}$                 | $R_L = 2k\Omega$                                                                               |                             | 0   | –    | 3.3      | V                 |
| Output Voltage – High Limit                             | $V_{OH}$                 | $V_{CC} = 30V$ ,<br>$T_A = 0$ to $+70^{\circ}C$                                                | $R_L = 2k\Omega$            | 26  | –    | –        | V                 |
|                                                         |                          |                                                                                                | $R_L = 10k\Omega$           | 27  | 28   | –        | V                 |
| Output Voltage – Low Limit                              | $V_{OL}$                 | $V_{CC} = 5V$ , $R_L = 10k\Omega$ , $T_A = 0$ to $+70^{\circ}C$                                |                             | –   | 5    | 20       | mV                |
| Output Source Current                                   | $I_{Source}$             | $V_{ID} = 1V$ , $V_{CC} = 15V$                                                                 |                             | 20  | 40   | –        | mA                |
|                                                         |                          |                                                                                                | $T_A = 0$ to $+70^{\circ}C$ | 10  | 20   | –        | mA                |
| Output Sink Current                                     | $I_{Sink}$               | $V_{ID} = -1V$ , $V_{CC} = 15V$                                                                |                             | 10  | 20   | –        | mA                |
|                                                         |                          |                                                                                                | $T_A = 0$ to $+70^{\circ}C$ | 5   | 8    | –        | mA                |
|                                                         |                          | $V_{ID} = -1V$ , $V_O = 200mV$                                                                 |                             | 12  | 50   | –        | $\mu A$           |
| Output Short Circuit to GND                             | $I_{OS}$                 | Note 3                                                                                         |                             | –   | 40   | 60       | mA                |
| Power Supply Current                                    | $I_{CC}$                 | $V_O = 0$ , $R_L = \infty$ ,<br>$T_A = 0$ to $+70^{\circ}C$                                    | $V_{CC} = 30V$              | –   | –    | 3.0      | mA                |
|                                                         |                          |                                                                                                | $V_{CC} = 5V$               | –   | –    | 1.2      | mA                |

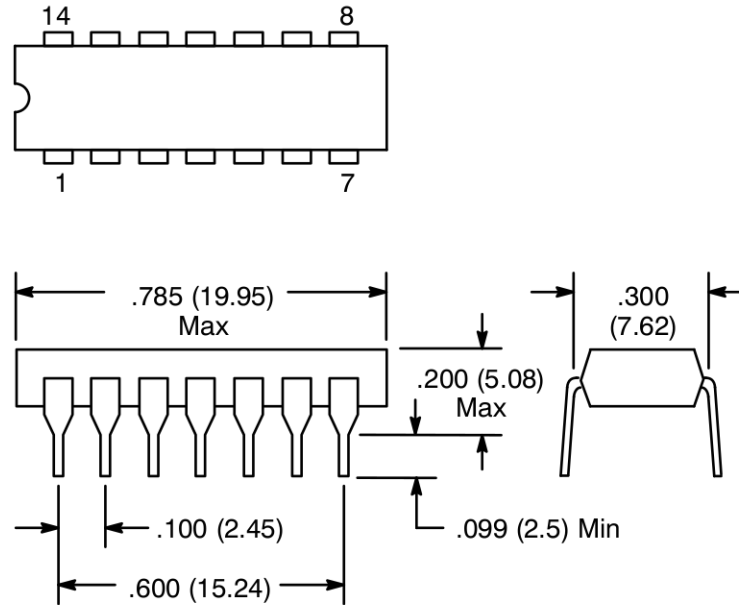
Note 2. The input common-mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is  $V_{CC}-1.7V$ , but either or both inputs can go to +32V without damage.

Note 3. Short circuits from the output to  $V_{CC}$  can cause excessive heating and eventual destruction. Destructive dissipation can result from simultaneous shorts on all amplifiers.

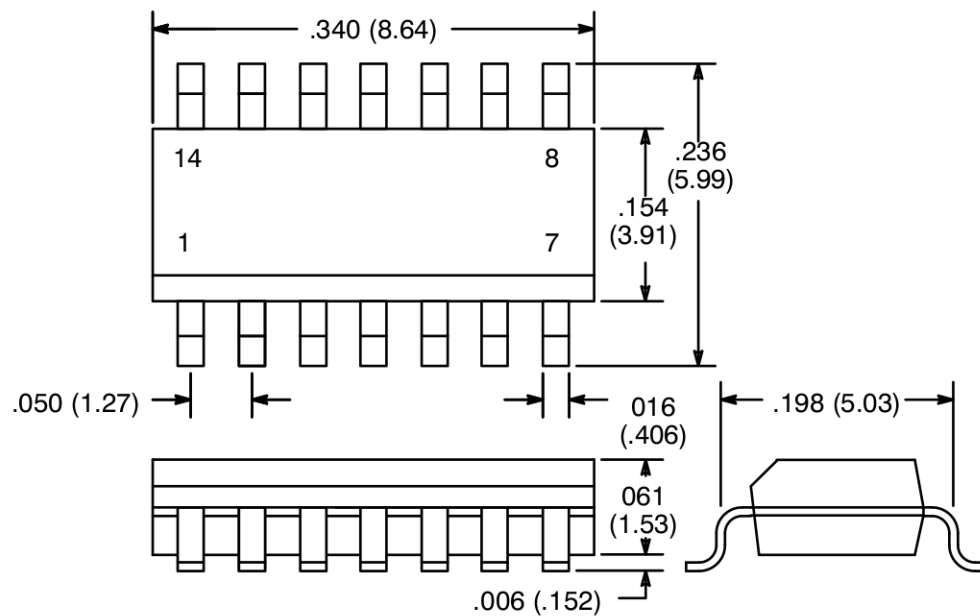
### Pin Connection Diagram



### NTE987



### NTE987SM



NOTE: Pin1 on Beveled Edge