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## NTE928M & NTE928SM Integrated Circuit Low Power Dual Operational Amplifier

**Description:**

Utilizing the circuit designs perfected for recently introduced Quad Operational Amplifiers, the NTE928M/NTE928SM dual operational amplifier features low power drain, a common mode input voltage range extending to ground/ $V_{EE}$ , and Single Supply or Split Supply Operation.

This amplifier has several distinct advantages over standard operational amplifier types in single supply applications. It can operate at supply voltages as low as 3.0 Volts or as high as 32 Volts 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 power supply voltage.

**Features:**

- Short Circuit Protected Outputs
- True Differential Input Stage
- Single Supply Operation: 3.0 to 32 Volts
- Low Input Bias Currents
- Internally compensated
- Common Mode Range Extends to Negative Supply
- Single and Split Supply Operation

**Maximum Ratings:**

Power Supply Voltages	
Single Supply, $V_{CC}$ .....	32V
Split Supplies, $V_{CC}$ $V_{EE}$ .....	$\pm 16V$
Input Differential Voltage Range (Note 1), $V_{IDR}$ .....	$\pm 32V$
Input Common Mode Voltage Range (Note 2), $V_{ICR}$ .....	-0.3 to 32V
Input Forward Current ( $V_I$ -0.3V, Note 3), $I_{IF}$ .....	50mA
Output Short Circuit Duration, $t_S$ .....	Continuous
Junction Temperature, $T_J$ .....	-55° to +125°C
Operating Ambient Temperature Range, $T_A$ .....	0° to +70°C

Note 1. Split Power Supplies

Note 2. For supply voltages less than 32V, the absolute maximum input voltage is equal to the supply voltage.

Note 3. 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 0.3V.

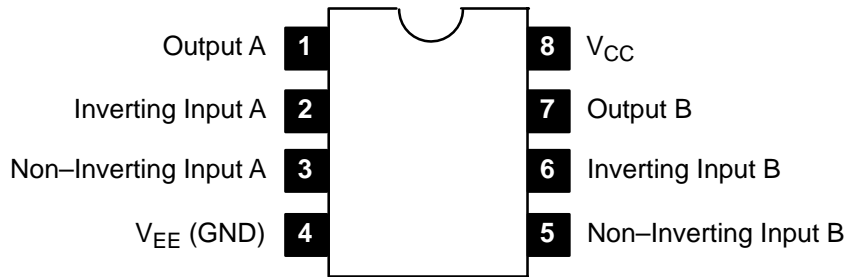
**Electrical Characteristics:** ( $V_{CC} = 5V$ ,  $V_{EE} = \text{Gnd}$ ,  $T_A = +25^\circ\text{C}$  unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit	
Input Offset Voltage	$V_{IO}$	$V_{CC} = 5V$ to $30V$ , $V_{IC} = 0$ to $V_{CC} - 1.7V$ , $V_O \approx 1.4V$ , $R_S = 0\Omega$		–	2.0	7.0	mV
			$0^\circ \leq T_A \leq +70^\circ\text{C}$	–	–	9.0	mV
Average Temperature Coefficient of Input Offset Voltage	$\Delta V_{IO}/\Delta T$	$0^\circ \leq T_A \leq +70^\circ\text{C}$	–	7.0	–	$\mu\text{V}/^\circ\text{C}$	
Input Offset Current	$I_{IO}$		–	5.0	50	nA	
		$0^\circ \leq T_A \leq +70^\circ\text{C}$	–	–	150	nA	
Average Temperature Coefficient of Input Offset Current	$\Delta I_{IO}/\Delta T$	$0^\circ \leq T_A \leq +70^\circ\text{C}$	–	10	–	$\text{pA}/^\circ\text{C}$	
Input Bias Current	$I_{IB}$		–	–45	–250	nA	
		$0^\circ \leq T_A \leq +70^\circ\text{C}$	–	–50	–500	nA	
Input Common-Mode Voltage Range	$V_{ICR}$	$V_{CC} = 30V$ , Note 4		0	–	28.3	V
			$0^\circ \leq T_A \leq +70^\circ\text{C}$	0	–	28	V
Differential Input Voltage Range	$V_{IDR}$		–	–	$V_{CC}$	V	
Large Signal Open-Loop Voltage Gain	$A_{VOL}$	$R_L = 2k\Omega$ , $V_{CC} = 15V$ , For Large $V_O$ Swing		25	100	–	V/mV
			$0^\circ \leq T_A \leq +70^\circ\text{C}$	15	–	–	V/mV
Channel Separation		$1\text{kHz} \leq f \leq 20\text{kHz}$ , 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	$V_{OH}$	$V_{CC} = 30V$ , $0^\circ \leq T_A \leq +70^\circ\text{C}$	$R_L = 2k\Omega$	26	–	–	V
			$R_L = 10k\Omega$	27	28	–	V
Output Voltage – Low Limit	$V_{OL}$	$V_{CC} = 5V$ , $R_L = 10k\Omega$ , $0^\circ \leq T_A \leq +70^\circ\text{C}$	–	5	20	mV	
Output Source Current	$I_{O+}$	$V_{ID} = +1V$ , $V_{CC} = 15V$	20	40	–	mA	
Output Sink Current	$I_{O-}$	$V_{ID} = -1V$ , $V_{CC} = 15V$	10	20	–	mA	
		$V_{ID} = -1V$ , $V_O = 200\text{mV}$	12	50	–	$\mu\text{A}$	
Output Short-Circuit to GND	$I_{OS}$	Note 5	–	40	60	mA	
Power Supply Current	$I_{CC}$	$V_O = 0$ , $R_L = \infty$ , $0^\circ \leq T_A \leq +70^\circ\text{C}$	$V_{CC} = 30V$	–	1.5	3.0	mA
			$V_{CC} = 5V$	–	0.7	1.2	mA

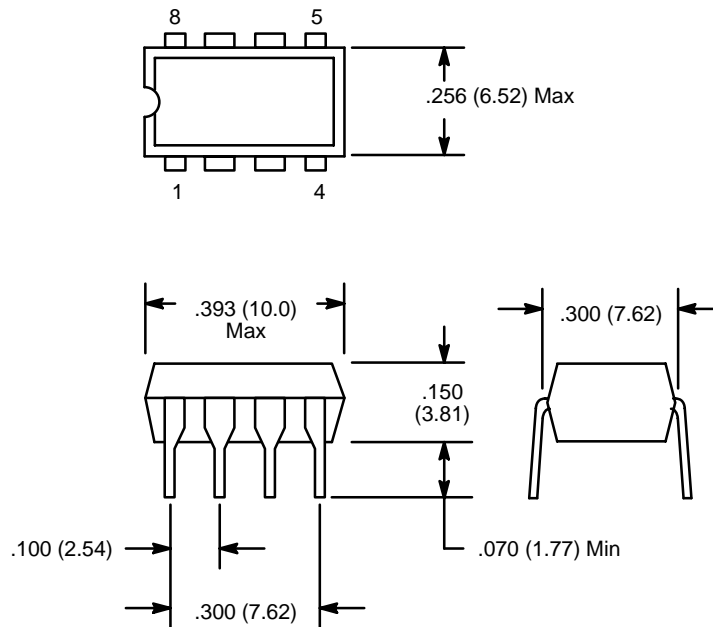
Note 4. The input common-mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is  $V_{CC} - 1.7V$ , but either or both inputs can go to +32V without damage.

Note 5. Short circuit from the output to  $V_{CC}$  can cause excessive heating and eventual destruction. Destructive dissipation can result from simultaneous shorts on all amplifiers.

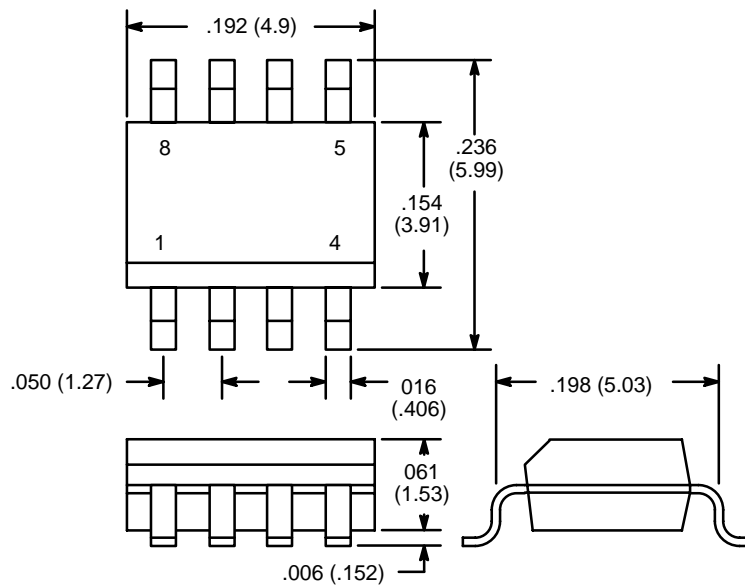
### Pin Connection Diagram



### NTE928M



### NTE928SM



NOTE: Pin1 on Beveled Edge