

## **NTE953**

### **Linear Integrated Circuit**

### **4-Terminal Positive Adjustable Voltage Regulator**

#### **Description:**

The NTE953 4-Terminal adjustable voltage regulator is designed to deliver continuous load currents of up to 1.0A with a maximum input voltage of +40V. Output current capability can be increased to greater than 1.0A through the use of one or more external transistors. The output voltage range is 5V to 30V. For systems requiring both a positive and negative, the NTE953 and NTE954 are excellent for use as a dual tracking regulator with appropriate external circuitry.

#### **Features:**

- Output Current in Excess of 1A
- Positive Output 5V to 30V
- Internal Thermal Overload Protection
- Internal Short Circuit Protection
- Output Transistor Safe-Area Protection
- Power Watt Package

#### **Absolute Maximum Ratings:**

|                                                |                         |
|------------------------------------------------|-------------------------|
| Input Voltage .....                            | 40V                     |
| Control Pin Voltage .....                      | $0 \leq V \leq V_{OUT}$ |
| Power Dissipation .....                        | Internally Limited      |
| Operating Junction Temperature Range .....     | 0°C to 150°C            |
| Storage Temperature Range .....                | -55°C to +150°C         |
| Lead Temperature (During soldering, 10s) ..... | +230°C                  |

**Electrical Characteristics:** ( $-0^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ ,  $V_{IN} = 10\text{V}$ ,  $I_{OUT} = 500\text{mA}$ ,  $C_{IN} = 0.33\mu\text{F}$ ,  $C_{OUT} = 0.1\mu\text{F}$ , unless otherwise specified.)

| Parameter                                         | Test Conditions (Note 1, Note 3)                                                                                                                                                              |                                                       | Min    | Typ    | Max          | Unit                                 |
|---------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|--------|--------|--------------|--------------------------------------|
| Input Voltage Range                               | $T_J = 25^{\circ}\text{C}$                                                                                                                                                                    |                                                       | 7.5    | –      | 40           | V                                    |
| Output Voltage Range                              | $V_{IN} = V_{OUT} + 5\text{V}$                                                                                                                                                                |                                                       | 5.0    | –      | 30           | V                                    |
| Output Voltage Tolerance                          | $V_{OUT} + 3\text{V} \leq V_{IN} \leq V_{OUT} + 15\text{V}$ ,<br>$5\text{mA} \leq I_{OUT} \leq 1.0\text{A}$ ,<br>$P_D \leq 15\text{W}$ , $V_{IN(\text{max})} = 38\text{V}$                    | $T_J = 25^{\circ}\text{C}$                            | –      | –      | 4.0          | $\%(V_{OUT})$                        |
|                                                   |                                                                                                                                                                                               |                                                       | –      | –      | 5.0          | $\%(V_{OUT})$                        |
| Line Regulation                                   | $T_J = 25^{\circ}\text{C}$ , $V_{OUT} \leq 10\text{V}$ ,<br>$(V_{OUT} + 2.5\text{V}) \leq V_{IN} \leq (V_{OUT} + 20\text{V})$                                                                 |                                                       | –      | –      | 1.0          | $\%(V_{OUT})$                        |
|                                                   | $T_J = 25^{\circ}\text{C}$ , $V_{OUT} \geq 10\text{V}$ ,<br>$(V_{OUT} + 3\text{V}) \leq V_{IN} \leq (V_{OUT} + 15\text{V})$<br>$(V_{OUT} + 3\text{V}) \leq V_{IN} \leq (V_{OUT} + 7\text{V})$ |                                                       | –<br>– | –<br>– | 0.75<br>0.67 | $\%(V_{OUT})$                        |
| Load Regulation                                   | $T_J = 25^{\circ}\text{C}$ ,<br>$V_{IN} = V_{OUT} + 5\text{V}$                                                                                                                                | $250\text{mA} \leq I_{OUT} \leq 750\text{mA}$         | –      | –      | 1.0          | $\%(V_{OUT})$                        |
|                                                   |                                                                                                                                                                                               | $5\text{mA} \leq I_{OUT} \leq 1.5\text{A}$            | –      | –      | 2.0          | $\%(V_{OUT})$                        |
| Control Pin Current                               | $T_J = 25^{\circ}\text{C}$                                                                                                                                                                    |                                                       | –      | 1.0    | 5.0          | $\mu\text{A}$                        |
|                                                   |                                                                                                                                                                                               |                                                       | –      | –      | 8.0          | $\mu\text{A}$                        |
| Quiescent Current                                 | $T_J = 25^{\circ}\text{C}$                                                                                                                                                                    |                                                       | –      | 3.2    | 5.0          | $\mu\text{A}$                        |
|                                                   |                                                                                                                                                                                               |                                                       | –      | –      | 6.0          | $\mu\text{A}$                        |
| Ripple Rejection                                  | $8\text{V} \leq V_{IN} \leq 18\text{V}$ , $V_{OUT} = 5\text{V}$ , $f = 120\text{Hz}$                                                                                                          |                                                       | 62     | 78     | –            | dB                                   |
| Output Noise Voltage                              | $T_J = 25^{\circ}\text{C}$ , $10\text{Hz} \leq f \leq 100\text{kHz}$ ,<br>$V_{OUT} = 5\text{V}$ , $I_{OUT} = 5\text{mA}$                                                                      |                                                       | –      | 8      | 40           | $\mu\text{V}/V_{OUT}$                |
| Dropout Voltage                                   | Note 2                                                                                                                                                                                        |                                                       | –      | –      | 2.5          | V                                    |
| Short Circuit Current                             | $T_J = 25^{\circ}\text{C}$ , $V_{IN} = 30\text{V}$                                                                                                                                            |                                                       | –      | 0.75   | 1.2          | A                                    |
| Peak Output Current                               | $T_J = 25^{\circ}\text{C}$                                                                                                                                                                    |                                                       | 1.3    | 2.2    | 3.3          | A                                    |
| Average Temperature Coefficient of Output Voltage | $V_{OUT} = 5\text{V}$ ,<br>$I_{OUT} = 5\text{mA}$                                                                                                                                             | $T_J = -55^{\circ}\text{C}$ to $+25^{\circ}\text{C}$  | –      | –      | 0.4          | $\text{mV}/^{\circ}\text{C}/V_{OUT}$ |
|                                                   |                                                                                                                                                                                               | $T_J = +25^{\circ}\text{C}$ to $+150^{\circ}\text{C}$ | –      | –      | 0.3          |                                      |
| Control Pin Voltage (Reference)                   | $T_J = 25^{\circ}\text{C}$                                                                                                                                                                    |                                                       | 4.8    | 5.0    | 5.2          | V                                    |
|                                                   |                                                                                                                                                                                               |                                                       | 4.75   | –      | 5.25         | V                                    |

Note 1.  $V_{OUT}$  is defined as:  $V_{OUT} = \frac{R1 + R2}{R2} (5.0)$

Note 2. Dropout Voltage is defined as that input–output voltage differential which causes the output voltage to decrease by 5% of its initial value.

Note 3. All characteristics except noise voltage and ripple rejection ratio are measured using pulse techniques ( $t_W \leq 10\text{ms}$ , duty cycle  $\leq 5\%$ ). Output voltage changes due to changes in internal temperature must be taken into account separately.

### **Design Considerations:**

The NTE953 adjustable voltage regulator has an output voltage which varies from  $V_{\text{CONTROL}}$  to typically

$$V_{\text{IN}} - 2\text{V by } V_{\text{OUT}} = V_{\text{CONTROL}} \frac{(R1 + R2)}{R2}$$

The nominal reference in the NTE953 is 5.0V. If we allow 1.0mA to flow in the control string to eliminate bias current effects, we can make  $R2 = 2.2\text{k}\Omega$ . The output voltage is then:

$$V_{\text{OUT}} = (R1 + R2)V, \text{ where } R1 \text{ and } R2 \text{ are in k}\Omega\text{s.}$$

Example: If  $R2 = 5\text{k}\Omega$  and  $R1 = 10\text{k}\Omega$  then

$$V_{\text{OUT}} = 15\text{V nominal}$$

By proper wiring of the feedback resistors, load regulation of the device can be improved significantly.

The NTE953 voltage regulator contains thermal-overload protection from excessive power, internal short-circuit protection which limits each circuit's maximum current, and output transistor safe-area protection for reducing the output current as the voltage across each pass transistor is increased.

Although the internal power dissipation is limited, the junction temperature must be kept below the maximum specified temperature in order to meet data sheet specifications. To calculate the maximum junction temperature or heat sink required, the following thermal resistance values should be used:

| Typ<br>°C/W          | Max<br>°C/W          | Typ<br>°C/W          | Max<br>°C/W          |
|----------------------|----------------------|----------------------|----------------------|
| $\Theta_{\text{JC}}$ | $\Theta_{\text{JC}}$ | $\Theta_{\text{JA}}$ | $\Theta_{\text{JA}}$ |
| 7.5                  | 11                   | 75                   | 80                   |

$$P_{\text{D(max)}} = \frac{T_{\text{J(max)}} - T_{\text{A}}}{\Theta_{\text{JC}} + \Theta_{\text{CA}}} \quad \text{or} \quad \frac{T_{\text{J(max)}} - T_{\text{A}}}{\Theta_{\text{JA}}} \\ \text{(Without a heat sink)}$$

$$\Theta_{\text{CA}} = \Theta_{\text{CS}} + \Theta_{\text{SA}}$$

Solving for  $T_{\text{J}}$ :

$$T_{\text{J}} = T_{\text{A}} + P_{\text{D}} (\Theta_{\text{JC}} + \Theta_{\text{CA}}) \quad \text{or} \\ T_{\text{A}} + P_{\text{D}} \Theta_{\text{JA}} \quad \text{(Without heat sink)}$$

Where:

- $T_{\text{J}}$  = Junction Temperature
- $T_{\text{A}}$  = Ambient Temperature
- $P_{\text{D}}$  = Power Dissipation
- $\Theta_{\text{JA}}$  = Junction to Ambient Thermal Resistance
- $\Theta_{\text{JC}}$  = Junction to Case Thermal Resistance
- $\Theta_{\text{CA}}$  = Case to Ambient Thermal Resistance
- $\Theta_{\text{CS}}$  = Case to Heat Sink Resistance
- $\Theta_{\text{SA}}$  = Heat Sink to Ambient Thermal Resistance

