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## NTE2028 Integrated Circuit 7–Segment High Voltage Decoder/Driver

### Description:

The NTE2028 is an integrated circuit in a 16–Lead DIP type package custom designed to decode four lines of BCD and drive a gas–filled seven–segment display tube.

Each output constitutes a switchable, adjustable current sink which provides constant current to the tube segment, even with high tube anode supply tolerance or fluctuation. These current sinks have a voltage compliance from 3V to at least 80V; typically the output current varies 1% for output voltage changes of 3 to 50V. Each bit line of the decoder switches a current sink on or off as prescribed by the input code. Each current sink is ratioed to the b–output current as required for even illumination of all segments.

Output currents may be varied over the 0.2 to 1.5 mA range for driving various tube types or multiplex operation. The output current is adjusted by connecting an external program resistor ( $R_p$ ) from  $V_{CC}$  to the Program input in accordance with the programming curve. The circuit design provides a one–to–one correlation between program input current and b–segment output current.

The Blanking Input provides unconditional blanking of any output display, while the Ripple Blanking pins allow simple leading or trailing zero blanking.

### Features:

- Current Sink Outputs
- Adjustable Output Current: 0.2 to 1.5mA
- High Output Breakdown Voltage: 110V Typ
- Suitable for Multiplex Operation
- Blanking and Ripple Blanking Provisions
- Low Fan–In and Low Power

### Absolute Maximum Ratings: (Note 1)

|   |                |
|---|----------------|
| Supply Voltage, $V_{CC}$ .....                          | 7V             |
| Input Voltage (Except BI) .....                         | 6V             |
| Input Voltage (BI) .....                                | $V_{CC}$       |
| Segment Output Voltage .....                            | 80V            |
| Power Dissipation, $P_D$ .....                          | 600mW          |
| Transient Segment Output Current (Note 2) .....         | 50mA           |
| Storage Temperature Range, $T_{stg}$ .....              | –65° to +150°C |
| Lead Temperature (During Soldering, 10sec), $T_L$ ..... | +300°C         |

Note 1. “Absolute Maximum Ratings” are those values beyond which the safety of the device cannot be guaranteed. Except for “Operating Temperature Range” they are not meant to imply that the device should be operated at these limits. The table of “Electrical Characteristics” provides conditions for actual device operation.

Note 2. In all applications transient segment output current must be limited to 50mA. This may be accomplished in DC applications by connecting a 2.2k resistor from the anode–supply filter capacitor to the display anode, or by current limiting the anode driver in multiplex applications.

### Recommended Operating Conditions:

| Parameter             | Symbol   | Test Conditions | Min  | Typ | Max  | Unit |
|-----------------------|----------|-----------------|------|-----|------|------|
| Supply Voltage        | $V_{CC}$ |                 | 4.75 | –   | 5.25 | V    |
| Operating Temperature | $T_A$    |                 | 0    | –   | 70   | °C   |

### Electrical Characteristics: (Note 3, Note 4)

| Parameter   | Symbol            | Test Conditions  | Min                         | Typ   | Max  | Unit          |               |
|---|-------------------|--|-----------------------------|-------|------|---------------|---------------|
| Logical “1” Input Voltage                         | $V_{IH}$          | $V_{CC} = \text{Min}$  | 2.0                         | –     | –    | V             |               |
| Logical “0” Input Voltage                         | $V_{IL}$          | $V_{CC} = \text{Min}$  | –                           | –     | 0.8  | V             |               |
| Logical “1” Output Voltage                        | $V_{OH}$          | $V_{CC} = \text{Min}$ , $I_{OUT} = -200\mu\text{A}$ , RBO  | 2.4                         | 3.7   | –    | V             |               |
| Logical “0” Output Voltage                        | $V_{OL}$          | $V_{CC} = \text{Min}$ , $I_{OUT} = 8\text{mA}$ , RBO   | –                           | 0.13  | 0.4  | V             |               |
| Logical “1” Input Current                         | $I_{IH}$          | $V_{CC} = \text{Max}$ , Except BI  | $V_{IN} = 2.4\text{V}$      | –     | 2    | 15            | $\mu\text{A}$ |
|   |                   |  | $V_{IN} = 5.5\text{V}$      | –     | 4    | 400           | $\mu\text{A}$ |
| Logical “0” Input Current                         | $I_{IL}$          | $V_{CC} = \text{Max}$ , $V_{IN} = 0.4\text{V}$   | Except BI                   | –     | –300 | –600          | $\mu\text{A}$ |
|   |                   |  | BI                          | –     | –1.2 | –2.0          | $\text{mA}$   |
| Power Supply Current                              | $I_{CC}$          | $V_{CC} = \text{Max}$ , $R_P = 2.2\text{k}$ , All Inputs = 0V  | –                           | 27    | 43   | $\text{mA}$   |               |
| Input Diode Clamp Voltage                         | $V_{CD}$          | $V_{CC} = \text{Max}$ , $T_A = +25^\circ\text{C}$ , $I_{IN} = -12\text{mA}$  | –                           | –0.9  | –1.5 | V             |               |
| Segment Outputs “ON” Current Ratio                | $I_O$             | All Outputs = 50V,<br>$I_{OUTb} = \text{Ref}$  | Outputs a, f, g             | 0.84  | 0.93 | 1.02          |               |
|   |                   |  | Output c                    | 1.12  | 1.25 | 1.38          |               |
|   |                   |  | Output d                    | 0.90  | 1.00 | 1.10          |               |
|   |                   |  | Output e                    | 0.99  | 1.10 | 1.21          |               |
| Output b “ON” Current                             | $I_{b\text{ ON}}$ | $V_{CC} = 5\text{V}$ ,<br>$V_{OUTb} = 50\text{V}$ ,<br>All Other Outputs $\geq 5\text{V}$ ,<br>$T_A = +25^\circ\text{C}$ | $R_P = 18.1\text{k}$        | 0.15  | 0.20 | 0.25          | $\text{mA}$   |
|   |                   |  | $R_P = 7.03\text{k}$        | 0.45  | 0.50 | 0.55          | $\text{mA}$   |
|   |                   |  | $R_P = 3.40\text{k}$        | 0.90  | 1.00 | 1.10          | $\text{mA}$   |
|   |                   |  | $R_P = 2.20\text{k}$        | 1.35  | 1.50 | 1.65          | $\text{mA}$   |
| Output Saturation Voltage                         | $V_{SAT}$         | $V_{CC} = \text{Min}$ , $R_P = 1\text{k} \pm 5\%$ ,<br>$I_{OUTb} = 2\text{mA}$ , Note 5                                  | –                           | 0.8   | 2.5  | V             |               |
| Output Leakage Current                            | $I_{CEX}$         | $V_{OUT} = 75\text{V}$ , BI = 0V, $R_P = 2.2\text{k}$  | –                           | 0.003 | 3.0  | $\mu\text{A}$ |               |
| Output Breakdown Voltage                          | $V_{BR}$          | $I_{OUT} = 250\mu\text{A}$ , BI = 0V, $R_P = 2.2\text{k}$  | 80                          | 110   | –    | V             |               |
| Propagation Delays<br>BCD Input to Segment Output | $t_{pd}$          | $V_{CC} = 5\text{V}$ , $T_A = +25^\circ\text{C}$   | BCD Input to Segment Output | –     | 0.4  | 10            | $\mu\text{s}$ |
|   |                   |  | BI to Segment Output        | –     | 0.4  | 10            | $\mu\text{s}$ |
|   |                   |  | RBI to Segment Output       | –     | 0.7  | 10            | $\mu\text{s}$ |
|   |                   |  | RBI to RBO                  | –     | 0.4  | 10            | $\mu\text{s}$ |

Note 3. Unless otherwise specified, Min/Max limits apply across  $T_A = 0^\circ$  to  $+70^\circ\text{C}$ . All typical values are at  $T_A = +25^\circ\text{C}$  and  $V_{CC} = 5\text{V}$ .

Note 4. All currents into device pins shown as positive, out of device pins as negative, all voltages referenced to GND unless otherwise specified. All values shown as Max or Min on absolute value basis.

Note 5. For saturation mode the segment output currents are externally limited and ratioed.

**Truth Table:**

| Decimal or Function | RBI <sup>†</sup> | D | C | B | A | BI/RBO | a | b | c | d | e | f | g | Display |
|---------------------|------------------|---|---|---|---|--------|---|---|---|---|---|---|---|---------|
| 0                   | 1                | 0 | 0 | 0 | 0 | 1      | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0       |
| 1                   | X                | 0 | 0 | 0 | 1 | 1      | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1       |
| 2                   | X                | 0 | 0 | 1 | 0 | 1      | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 2       |
| 3                   | X                | 0 | 0 | 1 | 1 | 1      | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 3       |
| 4                   | X                | 0 | 1 | 0 | 0 | 1      | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 4       |
| 5                   | X                | 0 | 1 | 0 | 1 | 1      | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 5       |
| 6                   | X                | 0 | 1 | 1 | 0 | 1      | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 6       |
| 7                   | X                | 0 | 1 | 1 | 1 | 1      | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 7       |
| 8                   | X                | 1 | 0 | 0 | 0 | 1      | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8       |
| 9                   | X                | 1 | 0 | 0 | 1 | 1      | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 9       |
| 10                  | X                | 1 | 0 | 1 | 0 | 1      | 0 | 0 | 0 | 1 | 0 | 0 | 0 | A       |
| 11                  | X                | 1 | 0 | 1 | 1 | 1      | 1 | 1 | 0 | 0 | 0 | 0 | 0 | b       |
| 12                  | X                | 1 | 1 | 0 | 0 | 1      | 0 | 1 | 1 | 0 | 0 | 0 | 1 | C       |
| 13                  | X                | 1 | 1 | 0 | 1 | 1      | 1 | 0 | 0 | 0 | 0 | 1 | 0 | d       |
| 14                  | X                | 1 | 1 | 1 | 0 | 1      | 0 | 1 | 1 | 0 | 0 | 0 | 0 | E       |
| 15                  | X                | 1 | 1 | 1 | 1 | 1      | 0 | 1 | 1 | 1 | 0 | 0 | 0 | F       |
| BI *                | X                | X | X | X | X | 0 *    | 1 | 1 | 1 | 1 | 1 | 1 | 1 |         |
| RBI                 | 0                | 0 | 0 | 0 | 0 | 0      | 1 | 1 | 1 | 1 | 1 | 1 | 1 |         |

\* BI/RBO used as input only.

† X = Don't care.

**Pin Connection Diagram**



