# *National Semiconductor*

# DS36C280
# Slew Rate Controlled CMOS EIA-RS-485 Transceiver

## General Description

The DS36C280 is a low power differential bus/line transceiver designed to meet the requirements of RS-485 Standard for multipoint data transmission. In addition, it is compatible with TIA/EIA-422-B.

The slew rate control feature allows the user to set the driver rise and fall times by using an external resistor. Controlled edge rates can reduce switching EMI.

The CMOS design offers significant power savings over its bipolar and ALS counterparts without sacrificing ruggedness against ESD damage. The device is ideal for use in battery powered or power conscious applications. $I_{CC}$ is specified at 500 µA maximum.

The driver and receiver outputs feature TRI-STATE® capability. The driver outputs operate over the entire common mode range of −7V to +12V. Bus contention or fault situations are handled by a thermal shutdown circuit, which forces the driver outputs into the high impedance state.

The receiver incorporates a fail safe circuit which guarantees a high output state when the inputs are left open (Note 1) .

## Features

■ 100% RS-485 compliant
  — Guaranteed RS-485 device interoperation
■ Low power CMOS design:   $I_{CC}$ 500 µA max
■ Adjustable slew rate control
  — Minimizes EMI affects
■ Built-in power up/down glitch-free circuitry
  — Permits live transceiver insertion/displacement
■ SOIC packages
■ Industrial temperature range:   −40˚C to +85˚C
■ On-board thermal shutdown circuitry
  — Prevents damage to the device in the event of excessive power dissipation
■ Wide common mode range:   −7V to +12V
■ Receiver open input fail-safe (Note 1)
■ ¼ unit load (DS36C280):   ≥128 nodes
■ ½ unit load (DS36C280T):   ≥64 nodes
■ ESD (human body model):   ≥2 kV

## Connection and Logic Diagram



DS012052-1
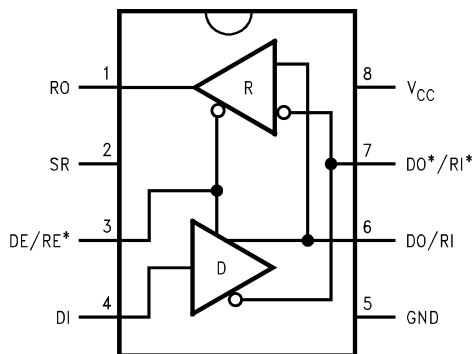
**Order Number DS36C280M, DS36C280TM**
**See NS Package Number M08A**

**DRIVER SECTION**

| DE/RE* | DI | DO/RI | DO*/RI* |
|--------|-----|-------|---------|
| H | H | H | L |
| H | L | L | H |
| L | X | Z | Z |

**RECEIVER SECTION**

| DE/RE* | RI-RI* | RO |
|--------|--------|-----|
| L | ≥+0.2V | H |
| L | ≤−0.2V | L |
| H | X | Z |
| L | OPEN (Note 1) | H |

**Note 1:** Non-terminated, Open Inputs only

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## Absolute Maximum Ratings (Note 2)

**If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.**

| | |
|---|---|
| Supply Voltage ($V_{CC}$) | +12V |
| Input Voltage (DE/RE*, & DI) | −0.5V to ($V_{CC}$ +0.5V) |
| Common Mode ($V_{CM}$) | |
| Driver Output/Receiver Input | ±15V |
| Input Voltage (DO/RI, DO*/RI*) | ±14V |
| Receiver Output Voltage | −0.5V to ($V_{CC}$ +0.5V) |
| Maximum Package Power Dissipation @ +25˚C | |
| M Package 1190 mV, derate | 9.5 mW/˚C above +25˚C |
| Storage Temperature Range | −65˚C to +150˚C |

Lead Temperature         +260˚C
(Soldering 4 sec.)

## Recommended Operating Conditions

| | Min | Typ | Max | Units |
|---|---|---|---|---|
| Supply Voltage ($V_{CC}$) | +4.75 | +5.0 | +5.25 | V |
| Bus Voltage | −7 | | +12 | V |
| Operating Free Air Temperature ($T_A$) | | | | |
| DS36C280T | −40 | +25 | +85 | ˚C |
| DS36C280 | 0 | +25 | +70 | ˚C |

## Electrical Characteristics (Notes 3, 4)

Over Supply Voltage and Operating Temperature ranges, unless otherwise specified

| Symbol | Parameter | Conditions | | Reference | | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|---|---|---|
| **DIFFERENTIAL DRIVER CHARACTERISTICS** | | | | | | | | | |
| $V_{OD1}$ | Differential Output Voltage | $I_O$ = 0 mA (No Load) | | (422) | | 1.5 | | 5.0 | V |
| $V_{OD0}$ | Output Voltage | $I_O$ = 0 mA | | (485) | | 0 | | 5.0 | V |
| $V_{OD0*}$ | Output Voltage | (Output to GND) | | | | 0 | | 5.0 | V |
| $V_{OD2}$ | Differential Output Voltage (Termination Load) | $R_L$ = 50Ω | | (422) | Figure 1 | 2.0 | 2.8 | | V |
| | | $R_L$ = 27Ω | | (485) | | 1.5 | 2.3 | 5.0 | V |
| $\Delta V_{OD2}$ | Balance of $V_{OD2}$ $|V_{OD2} - V_{OD2*}|$ | $R_L$ = 27Ω or 50Ω | | (Note 5) (422, 485) | | −0.2 | 0.1 | +0.2 | V |
| $V_{OD3}$ | Differential Output Voltage (Full Load) | R1 = 54Ω, R2 = 375Ω | | Figure 2 | | 1.5 | 2.0 | 5.0 | V |
| | | $V_{TEST}$ = −7V to +12V | | | | | | | |
| $V_{OC}$ | Driver Common Mode Output Voltage | $R_L$ = 27Ω | | (485) | Figure 1 | 0 | | 3.0 | V |
| | | $R_L$ = 50Ω | | (422) | | 0 | | 3.0 | V |
| $\Delta V_{OC}$ | Balance of $V_{OC}$ $|V_{OC} - V_{OC*}|$ | $R_L$ = 27Ω or $R_L$ = 50Ω | | (Note 5) (422, 485) | | −0.2 | | +0.2 | V |
| $I_{OSD}$ | Driver Output Short-Circuit Current | $V_O$ = +12V | | (485) Figure 4 | | | 200 | +250 | mA |
| | | $V_O$ = −7V | | (485) | | | −190 | −250 | mA |
| **RECEIVER CHARACTERISTICS** | | | | | | | | | |
| $V_{TH}$ | Differential Input High Threshold Voltage | $V_O$ = $V_{OH}$, $I_O$ = −0.4 mA −7V ≤ $V_{CM}$ ≤ +12V | | (Note 6) (422, 485) | | | +0.035 | +0.2 | V |
| $V_{TL}$ | Differential Input Low Threshold Voltage | $V_O$ = $V_{OL}$, $I_O$ = 0.4 mA −7V ≤ $V_{CM}$ ≤ +12V | | | | −0.2 | −0.035 | | V |
| $V_{HST}$ | Hysteresis | $V_{CM}$ = 0V | | | | | 70 | | mV |
| $R_{IN}$ | Input Resistance | −7V ≤ $V_{CM}$ ≤ +12V | | DS36C280T | | 24 | 68 | | kΩ |
| $R_{IN}$ | Input Resistance | −7V ≤ $V_{CM}$ ≤ +12V | | DS36C280 | | 48 | 68 | | kΩ |
| $I_{IN}$ | Line Input Current (Note 8) | Other Input = 0V DE = $V_{IL}$, RE* = $V_{IL}$ $V_{CC}$ = 4.75 to 5.25 or 0V | DS36C280 | $V_{IN}$ = +12V | | 0 | 0.19 | 0.25 | mA |
| | | | | $V_{IN}$ = −7V | | 0 | −0.1 | −0.2 | mA |
| | | | DS36C280T | $V_{IN}$ = +12V | | 0 | 0.19 | 0.5 | mA |
| | | | | $V_{IN}$ = −7V | | 0 | −0.1 | −0.4 | mA |
| $I_{ING}$ | Line Input Current Glitch (Note 8) | Other Input = 0V DE = $V_{IL}$, RE* = $V_{IL}$ $V_{CC}$ = +3.0V or 0V $T_A$ = 25˚C | DS36C280 | $V_{IN}$ = +12V | | 0 | 0.19 | 0.25 | mA |
| | | | | $V_{IN}$ = −7V | | 0 | −0.1 | −0.2 | mA |
| | | | DS36C280T | $V_{IN}$ = +12V | | 0 | 0.19 | 0.5 | mA |
| | | | | $V_{IN}$ = −7V | | 0 | −0.1 | −0.4 | mA |
| $I_B$ | Input Balance Test | RS = 500Ω | | (422) (Note 10) | | | | ±400 | mV |
| $V_{OH}$ | High Level Output Voltage | $I_{OH}$ = −4 mA, $V_{ID}$ = +0.2V | | RO Figure 11 | | 3.5 | 4.6 | | V |
| $V_{OL}$ | Low Level Output Voltage | $I_{OL}$ = +4 mA, $V_{ID}$ = −0.2V | | | | | 0.3 | 0.5 | V |

## Electrical Characteristics (Notes 3, 4) (Continued)

Over Supply Voltage and Operating Temperature ranges, unless otherwise specified

| Symbol | Parameter | Conditions | | Reference | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|---|---|
| **RECEIVER CHARACTERISTICS** | | | | | | | | |
| $I_{OSR}$ | Short Circuit Current | $V_O$ = GND | | RO | 7 | 35 | 85 | mA |
| $I_{OZR}$ | TRI-STATE Leakage Current | $V_O$ = 0.4V to 2.4V | | | | | ±1 | µA |
| **DEVICE CHARACTERISTICS** | | | | | | | | |
| $V_{IH}$ | High Level Input Voltage | | | DE/RE*, DI | 2.0 | | $V_{CC}$ | V |
| $V_{IL}$ | Low Level Input Voltage | | | | GND | | 0.8 | V |
| $I_{IH}$ | High Level Input Current | $V_{IH}$ = $V_{CC}$ | | | | | 2 | µA |
| $I_{IL}$ | Low Level Input Current | $V_{CC}$ = 5.0V | $V_{IL}$ = 0V | | | | −2 | µA |
| | | $V_{CC}$ = +3.0V | | | | | −2 | µA |
| | | SR = 0V | | SR | | | −1 | mA |
| $I_{CCR}$ | Power Supply Current | Driver OFF, Receiver ON | | $V_{CC}$ | | 200 | 500 | µA |
| $I_{CCD}$ | (No Load) | Driver ON, Receiver OFF | | | | 200 | 500 | µA |

## Switching Characteristics (Notes 4, 9, 11)

Over Supply Voltage and Operating Temperature ranges, unless otherwise specified

| Symbol | Parameter | Conditions | Reference | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|---|
| **DRIVER CHARACTERISTICS** | | | | | | | |
| $t_{PHLD}$ | Differential Propagation Delay High to Low | $R_L$ = 54Ω, $C_L$ = 100 pF | Figures 5, 6 | 10 | 399 | 1000 | ns |
| $t_{PLHD}$ | Differential Propagation Delay Low to High | | | 10 | 400 | 1000 | ns |
| $t_{SKD}$ | Differential Skew $|t_{PHLD} - t_{PLHD}|$ | | | 0 | 1 | 10 | ns |
| $t_r$ | Rise Time | SR = Open | | | 2870 | | ns |
| $t_f$ | Fall Time | | | | 3070 | | ns |
| $t_r$ | Rise Time | SR = 100 kΩ | | | 1590 | | ns |
| $t_f$ | Fall Time | | | | 1640 | | ns |
| $t_r$ | Rise Time | SR = Short | | 100 | 337 | 1000 | ns |
| $t_f$ | Fall Time | | | 100 | 348 | 1000 | ns |
| $t_{PHZ}$ | Disable Time High to Z | $C_L$ = 15 pF | Figures 7, 8 | | 1100 | 2000 | ns |
| $t_{PLZ}$ | Disable Time Low to Z | | Figures 9, 10 | | 500 | 800 | ns |
| $t_{PZH}$ | Enable Time Z to High | $C_L$ = 100 pF | Figures 7, 8 | | 300 | 500 | ns |
| $t_{PZL}$ | Enable Time Z to Low | | Figures 9, 10 | | 300 | 500 | ns |
| **RECEIVER CHARACTERISTICS** | | | | | | | |
| $t_{PHL}$ | Propagation Delay High to Low | $C_L$ = 15 pF | | 30 | 210 | 400 | ns |
| $t_{PLH}$ | Propagation Delay Low to High | | Figures 12, 13 | 30 | 190 | 400 | ns |
| $t_{SK}$ | Skew, $|t_{PHL} - t_{PLH}|$ | | | 0 | 20 | 50 | ns |
| $t_{PLZ}$ | Output Disable Time | $C_L$ = 15 pF | | | 50 | 150 | ns |
| $t_{PHZ}$ | | | Figures 14, 15, 16 | | 55 | 150 | ns |
| $t_{PZL}$ | Output Enable Time | | | | 40 | 150 | ns |
| $t_{PZH}$ | | | | | 45 | 150 | ns |

**Note 2:** "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. They are not meant to imply that the devices should be operated at these limits. The table of "Electrical Characteristics" specifies conditions of device operation.

**Note 3:** Current into device pins is defined as positive. Current out of device pins is defined as negative. All voltages are referenced to ground except $V_{OD1}$ and $V_{OD2}$.

**Note 4:** All typicals are given for: $V_{CC}$ = +5.0V, $T_A$ = + 25°C.

**Note 5:** Delta $|V_{OD2}|$ and Delta $|V_{OC}|$ are changes in magnitude of $V_{OD2}$ and $V_{OC}$, respectively, that occur when input changes state.

## Switching Characteristics (Notes 4, 9, 11)  (Continued)

**Note 6:** Threshold parameter limits specified as an algebraic value rather than by magnitude.

**Note 7:** Hysteresis defined as $V_{HST} = V_{TH} - V_{TL}$.

**Note 8:** $I_{IN}$ includes the receiver input current and driver TRI-STATE leakage current.

**Note 9:** $C_L$ includes probe and jig capacitance.

**Note 10:** For complete details of test, see RS-485.

**Note 11:** SR = GND for all Switching Characteristics unless otherwise specified.

## Parameter Measurement Information
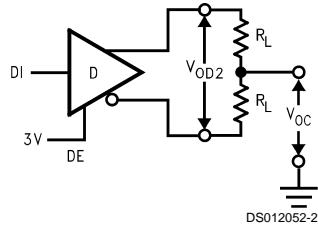


FIGURE 1. Driver $V_{OD2}$ and $V_{OC}$
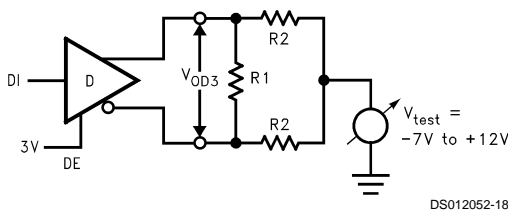


FIGURE 2. Driver $V_{OD3}$
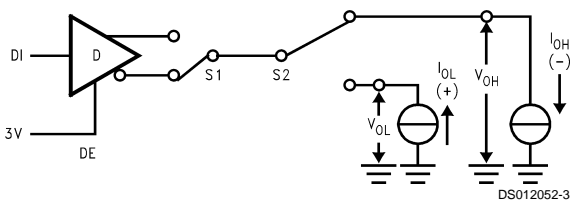


FIGURE 3. Driver $V_{OH}$ and $V_{OL}$
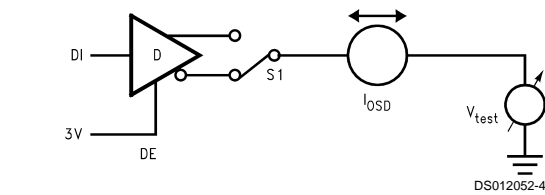


Vtest = −7V to +12V

FIGURE 4. Driver $I_{OSD}$
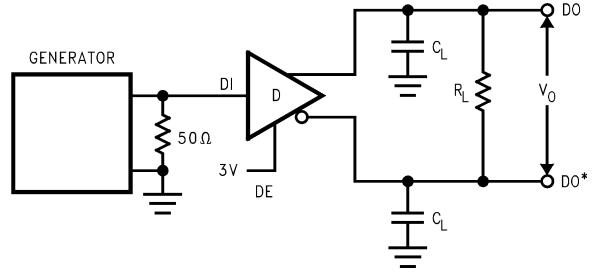


FIGURE 5. Driver Differential
Propagation Delay Test Circuit
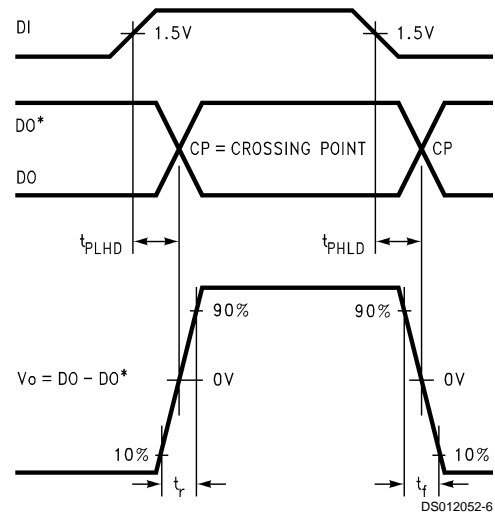


FIGURE 6. Driver Differential Propagation Delays
and Differential Rise and Fall Times
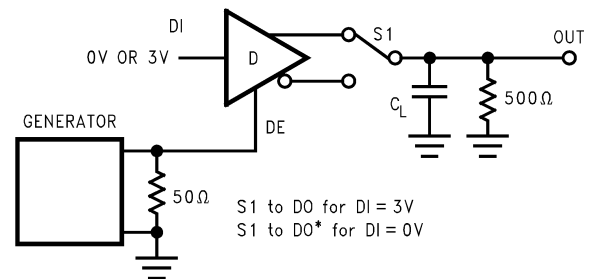


FIGURE 7. TRI-STATE Test Circuit ($t_{PZH}$ , $t_{PHZ}$)

# Parameter Measurement
## Information (Continued)
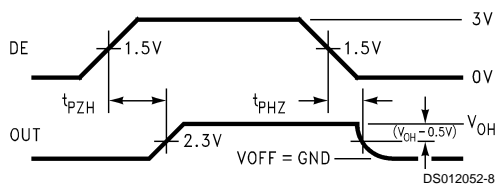


FIGURE 8. TRI-STATE Waveforms (t$_{PZH}$, t$_{PHZ}$)



FIGURE 9. TRI-STATE Test Circuit (t$_{PZL}$, t$_{PLZ}$)



FIGURE 10. TRI-STATE Waveforms (t$_{PZL}$, t$_{PLZ}$)
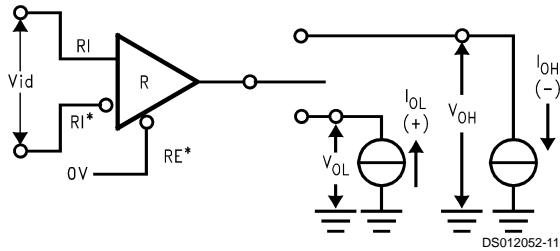


FIGURE 11. Receiver V$_{OH}$ and V$_{OL}$
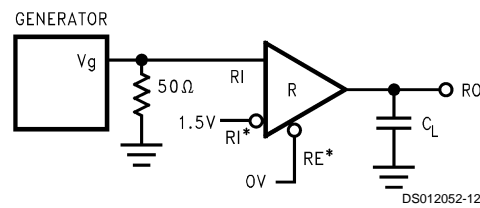


FIGURE 12. Receiver Differential
Propagation Delay Test Circuit
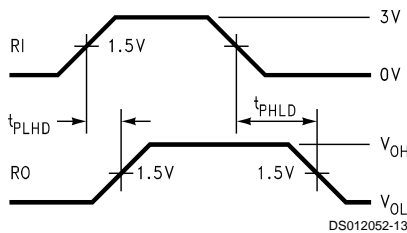


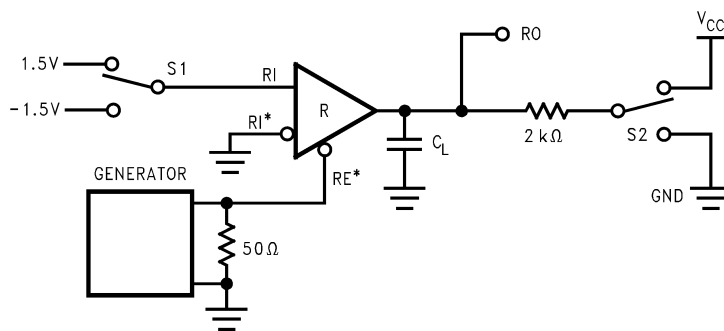FIGURE 13. Receiver Differential Propagation Delay Waveforms



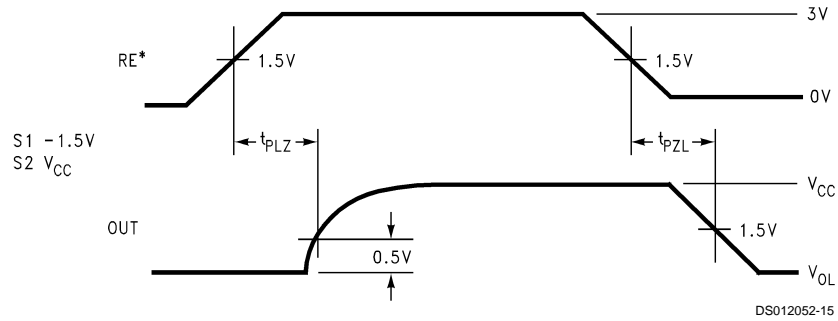FIGURE 14. Receiver TRI-STATE Test Circuit

# Parameter Measurement Information (Continued)



**FIGURE 15. Receiver Enable and Disable Waveforms (t$_{PLZ}$, t$_{PZL}$)**
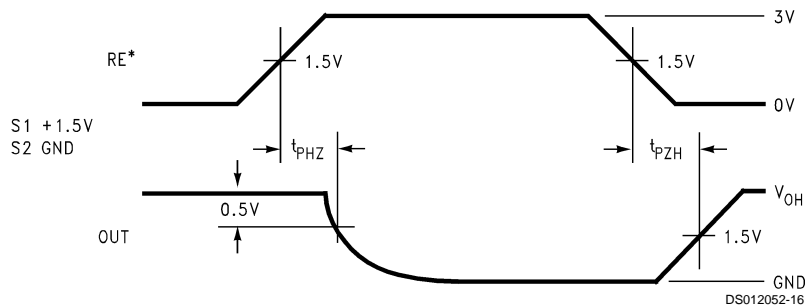


**FIGURE 16. Receiver Enable and Disable Waveforms (t$_{PHZ}$, t$_{PZH}$)**

# Typical Application Information
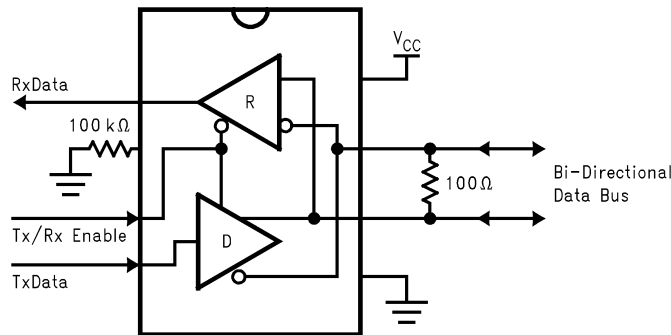


**FIGURE 17. Typical Pin Connection**

**TABLE 1. Device Pin Descriptions**

| Pin # | Name | Description |
|---|---|---|
| 1 | RO | Receiver Output: When DE/RE* (Receiver Enable) is LOW, the receiver is enabled (ON), if DO/RI ≥ DO*/RI* by 200 mV, RO will be HIGH. If DO/RI ≤ DO*/RI* by 200 mV, RO will be LOW. Additionally RO will be HIGH for OPEN (Non-terminated) inputs. |
| 2 | SR | Slew Rate Control: A resistor connected to Ground controls the Driver Output rising and falling edge rates. |
| 3 | DE/RE* | Combined Driver and Receiver Output Enable: When signal is LOW the receiver output is enabled and the driver outputs are in TRI-STATE (OFF). When signal is HIGH, the receiver output is in TRI-STATE (OFF) and the driver outputs are enabled. |
| 4 | DI | Driver Input: When DE/RE* is HIGH, the driver is enabled, if DI is LOW, then DO/RI will be LOW and DO*/RI* will be HIGH. If DI is HIGH, then DO/RI is HIGH and DO*/RI* is LOW. |

## Typical Application Information (Continued)

**TABLE 1. Device Pin Descriptions** (Continued)

| Pin # | Name | Description |
|---|---|---|
| 5 | GND | Ground Connection |
| 6 | DO/RI | Driver Output/Receiver Input, 485 Bus Pin. |
| 7 | DO*/RI* | Driver Output/Receiver Input, 485 Bus Pin. |
| 8 | $V_{CC}$ | Positive Power Supply Connection: Recommended operating range for $V_{CC}$ is +4.75V to +5.25V. |

## Unit Load

A unit load for a RS-485 receiver is defined by the input current versus the input voltage curve. The gray shaded region is the defined operating range from −7V to +12V. The top border extending from −3V at 0 mA to +12V at +1 mA is defined as one unit load. Likewise, the bottom border extending from +5V at 0 mA to −7V at −0.8 mA is also defined as one unit load (see *Figure 18*). A RS-485 driver is capable of driving up to 32 unit loads. This allows upto 32 nodes on a single bus. Although sufficient for many applications, it is sometime desirable to have even more nodes. For example an aircraft that has 32 rows with 4 seats per row could benefit from having 128 nodes on one bus. This would allow signals to be transferred to and from each individual seat to 1 main station. Usually there is one or two less seats in the last row of the aircraft near the restrooms and food storage area. This frees the node for the main station.

The DS36C278, the DS36C279, and the DS36C280 all have ½ unit load and ¼ unit load (UL) options available. These devices will allow upto 64 nodes or 128 nodes guaranteed over temperature depending upon which option is selected. The ½ UL option is available in industrial temperature and the ¼ UL is available in commercial temperature.

First, for a ½ UL device the top and bottom borders shown in *Figure 18* are scaled. Both 0 mA reference points at +5V and −3V stay the same. The other reference points are +12V at +0.5 mA for the top border and −7V at −0.4 mA for the bottom border (see *Figure 18*). Second, for a ¼ UL device the top and bottom borders shown in *Figure 18* are scaled also. Again, both 0 mA reference points at +5V and −3V stay the same. The other reference points are +12V at +0.25 mA for the top border and −7V at −0.2 mA for the bottom border (see *Figure 18*).

The advantage of the ½ UL and ¼ UL devices is the increased number of nodes on one bus. In a single master multi-slave type of application were the number of slaves exceeds 32, the DS36C278/279/280 may save in the cost of extra devices like repeaters, extra media like cable, and/or extra components like resistors.

The DS36C279 and DS36C280 have addition feature which offer more advantages. The DS36C279 has an automatic sleep mode function for power conscious applications. The

DS36C280 has a slew rate control for EMI conscious applications. Refer to the sleep mode and slew rate control portion of the application information section in the corresponding datasheet for more information on these features.
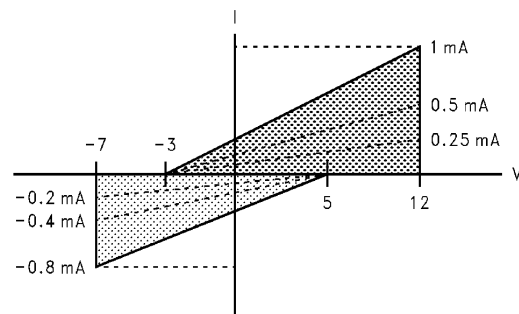


DS012052-19

**FIGURE 18. Input Current vs Input Voltage Operating Range**

## Slew Rate Control

The DS36C280 features an adjustable slew rate control. This feature allows more control over EMI levels than tradition fixed edge rate devices. The slew rate control may be adjusted with or without any external components. The DS36C280 offers both low power ($I_{CC}$ 500 µA max) and low EMI for an RS-485 interface.

The slew rate control is located at pin two of the device and only controls the driver output edges. The slew rate control pin (SR) may be left open or shorted to ground, with or without a resistor. When the SR pin is shorted to ground without a resistor, the driver output edges will transition typically 350 ns. When the SR pin is left open, the driver output edges will transition typically 3 µs. When the SR pin is shorted to ground with a resistor, the driver output edges will transition between 350 ns and 3 µs depending on the resistor value. Refer to the slew rate versus resistor value curve in this datasheet for determining resistor values and expected typical slew rate value. Please note, when slowing the edge rates of the device (see *Figure 19*) will decrease the maximum data rate also.
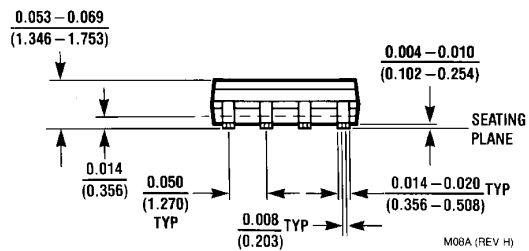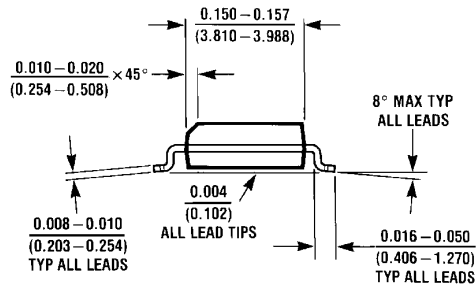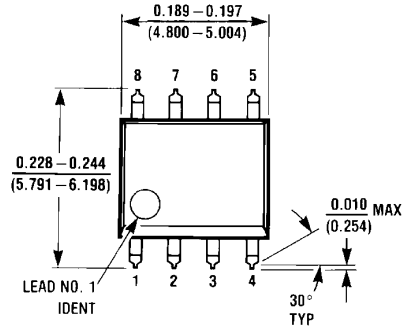
## Slew Rate Control (Continued)

**Differential Rise/Fall Time
vs Slew Rate Resistor**



DS012052-20
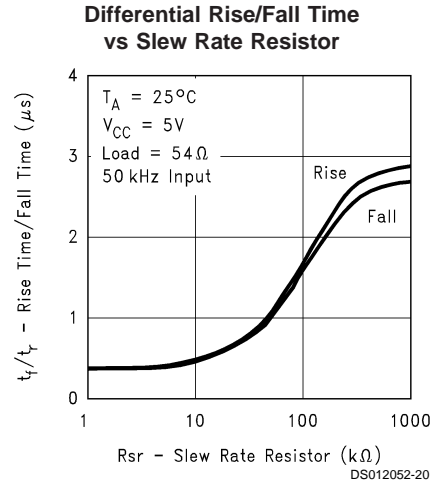
**FIGURE 19. Slew Rate Resistor
vs Rise/Fall Time**

# Physical Dimensions inches (millimeters) unless otherwise noted

0.189 − 0.197
(4.800 − 5.004)

8  7  6  5

0.228 − 0.244
(5.791 − 6.198)

0.010 MAX
(0.254)

LEAD NO. 1
IDENT

1  2  3  4

30°
TYP

0.150 − 0.157
(3.810 − 3.988)

0.010 − 0.020 × 45°
(0.254 − 0.508)

8° MAX TYP
ALL LEADS

0.004
(0.102)
ALL LEAD TIPS

0.008 − 0.010
(0.203 − 0.254)
TYP ALL LEADS

0.016 − 0.050
(0.406 − 1.270)
TYP ALL LEADS

0.053 − 0.069
(1.346 − 1.753)

0.004 − 0.010
(0.102 − 0.254)

SEATING
PLANE

0.014
(0.356)

0.050
(1.270)
TYP

0.008 TYP
(0.203)

0.014 − 0.020 TYP
(0.356 − 0.508)

M08A (REV H)

**8-Lead (0.150" Wide) Molded Small Outline Package, JEDEC**
**Order Number DS36C280M or DS36C280TM**
**NS Package Number M08A**