## 1 FEATURES

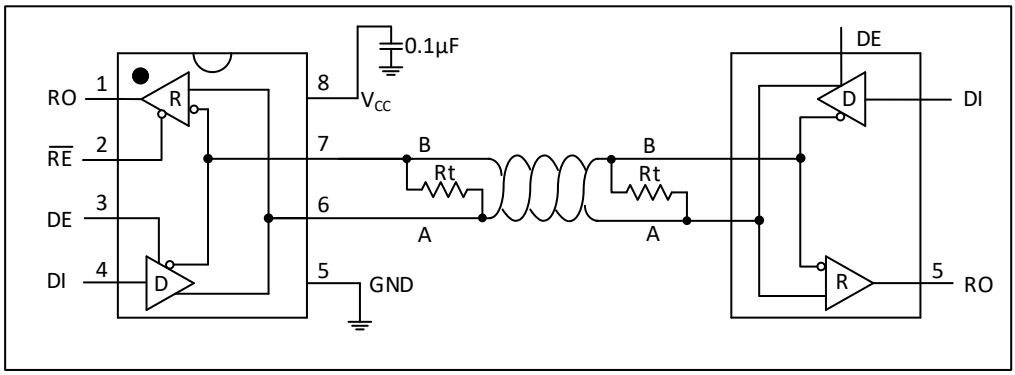
- 3.0~5.5V Operation
- Extended ESD Protection for RS-485/RS-422 I/O Pins ±15kV Human Body Model
- True Fail-Safe Receiver While Maintaining EIA/TIA-485 Compatibility
- Guaranteed 16Mbps Data Rate
  Low-Current Shutdown Mode
- Allow Up to 256 Transceivers on the Bus
- Available in Industry-Standard SOP8

## 2 APPLICATIONS

- Utility Meters
- Lighting Systems
- Industrial Control
- Telecom
- Security System
- Instrumentation
- Profibus

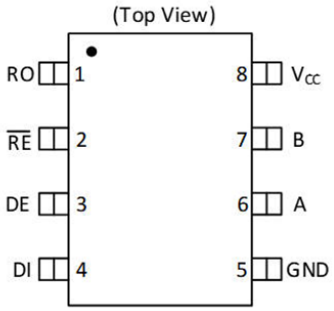
## 3 GENERAL DESCRIPTION

The NPS2821 are 3.0~5.5V,+15kV ESD-protected, RS-485/RS-422 transceiver features one driver and one receiver.The device includes fail-safe circuitry, guaranteeing a logic-high receiver output when receiver inputs are open or shorted. The receiver outputs a logic-high if all transmitters on a terminated bus are disabled (high impedance). The NPS2821 transmit at up to 16Mbps.The NPS2821 is ideal for half-duplex communications and it draws 0.5mA of supply current when unloaded or when fully loaded with the drivers disabled. The NPS2821 has a 1/8-unit load receiver input impedance, allowing up to 256 transceivers on the bus.The NPS2821 is available in SOP8 packages.




**TYPICAL HALF-DUPLES OPERATING CIRCUIT**

## 4 PIN CONFIGURATION AND FUNCTIONS




| Pin | | Description |
|---|---|---|
| Name | No. | |
| RO | 1 | Receiver Output. When $\overline{RE}$ is low and if (A-B)≧-50mV, RO is high; if (A-B)≤-200mV, RO is low. |
| $\overline{RE}$ | 2 | Receiver Output Enable.Drive $\overline{RE}$ low to enable the RO;Drive $\overline{RE}$ high to let the RO in high-impedance;Drive $\overline{RE}$ high and DE low to enter low-power shutdown mode. $\overline{RE}$ is a Hot-swap input(see the Hot-Swap Capability section for details). |
| DE | 3 | Driver Output Enable.Drive DE high to enable driver outputs;These outputs are high-impedance when DE is low;Drive $\overline{RE}$ high and DE low to enter low-power shutdown mode.DE is a hot-swap input(see the Hot-Swap Capability section for details). |
| DI | 4 | Driver Input. With DE high, a low on DI forces noninverting output low and inverting output high. Similarly, a high on DI forces noninverting output high and inverting output low. |
| GND | 5 | Ground |
| A | 6 | Noninverting Receiver Input and Noninverting Driver Output |
| B | 7 | Inverting Receiver Input and Inverting Driver Output |
| $V_{CC}$ | 8 | Positive Supply Vcc =3.0~5.5V.Bypass Vcc to GND with a 0.1μF capacitor. |

## 5 ABSOLUTE MAXIMUM RATINGS

| Parameter | Parameter | Rating | UNIT |
|---|---|---|---|
| $V_{CC}$ | Supply Voltage | +6 | V |
| /RE,DE | Control Input Voltage | -0.3 to +6 | V |
| DI | Driver Input voltage | -0.3 to +6 | V |
| A,B | Receiver Input Voltage | -8V to ±13 | V |
| A,B | Driver Output Voltage | -8V to ±13 | V |
| RO | Receiver Output Voltage | -0.3 to ($V_{CC}$+0.3) | V |
| P | SO(derate 5.9mW/°C above +70°C) | 471 | mW |
| $T_{OP}$ | Operating Temperature Range | -40 to +85 | °C |
| $T_J$ | Junction Temperature | +150 | °C |
| $T_{STO}$ | Storage Temperature Range | -65 to +150 | °C |
| $T_L$ | Lead Temperature(soldering,10s) | +300 | °C |

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## 6 DC ELECTRICAL CHARACTERISTICS

($V_{CC}$ = 5V ±5%, $T_A$ = $T_{MIN}$ to $T_{MAX}$.Typical values are at $V_{CC}$=+5V,$T_A$=25°C, unless otherwise noted.) (1)

| Parameter | Symbol | Test Conditions | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| **Driver** | | | | | | | |
| Supply voltage | $V_{CC}$ | | | 3.0 | | 5.5 | V |
| Differential Driver Output(No load) | $V_{OD1}$ | No load | | | | $V_{CC}$ | V |
| Differential Driver Output | $V_{OD2}$ | RL=100Ω(RS-422),Figure 1 | | 3 | | $V_{CC}$ | V |
| | | RL=54Ω(RS-485),Figure 1 | | 2 | | $V_{CC}$ | V |
| Change in Magnitude of Differential Output Voltage(2) | $\Delta V_{OD}$ | RL=100Ω or RL=54Ω,Figure 1 | | | | 0.2 | V |
| Driver Common- Mode Output Voltage | $V_{OC}$ | RL=100Ω or RL=54Ω,Figure 1 | | | $V_{CC}$/2 | 3 | V |
| Change in Magnitude of Common- Mode Voltage(2) | $\Delta V_{OC}$ | RL=100Ω or RL=54Ω,Figure 1 | | | | 0.2 | V |
| Input-High Voltage | $V_{IH1}$ | DE,DI,/RE | | 2 | | | V |
| Input-Low Voltage | $V_{IL1}$ | DE,DI,/RE | | | | 0.8 | V |
| Input Hysteresis | $V_{HYS}$ | DE,DI,/RE | | | 300 | | mV |
| Input Current | $I_{IN1}$ | DE,DI,/RE,$V_{CC}$ floating | | | | ±2 | μA |
| Input Impedance on First Transition at Power-Up | $R_{PWUP}$ | $V_{DE}$, $V_{RE}$ = $V_{RE}$ = 2V | | 3.65 | | 8.8 | kΩ |
| Input Impedance on First Transition after POR Delay | $R_{ft}$ | $V_{DE}$ = $V_{RE}$ = 2V | | 7 | | 60 | kΩ |
| Driver Short-Circuit Output Current | $I_{OSD}$ | 0≤$V_{OUT}$≤+12V(3) | | 40 | | 250 | mA |
| | | -7V≤$V_{OUT}$≤$V_{CC}$(3) | | -250 | | -40 | |
| Driver Short-Circuit Foldback Output Current | $I_{OSDF}$ | ($V_{CC}$-1V)≤$V_{OUT}$≤+12V(3) | | 20 | | | mA |
| | | -7V≤$V_{OUT}$≤±1V(3) | | | | -20 | |
| Thermal-Shutdown Threshold | $T_{TS}$ | | | | 175 | | °C |
| Thermal-Shutdown Hysteresis | $T_{TSH}$ | | | | 15 | | °C |
| Input Current for A and B | $I_{A,B}$ | DE=GND,$V_{CC}$=GND or $V_{CC}$ | $V_{IN}$=+12V | | | 220 | μA |
| | | | $V_{IN}$=-7V | -220 | | | |
| **Receiver** | | | | | | | |
| Receiver Differential Threshold Voltage | $V_{TH}$ | -7V≤$V_{CM}$≤12V | | -200 | -125 | -50 | mV |
| Receiver Input Hysteresis | $\Delta V_{TH}$ | $V_A$+$V_B$=0V | | | 15 | | mV |
| Receiver Output-High Voltage | $V_{OH}$ | $I_O$= -1mA | | $V_{CC}$-0.6 | | $V_{CC}$ | V |
| Receiver Output-Low Voltage | $V_{OL}$ | $I_O$= 1mA | | | | 0.4 | V |
| Three-State Output Current at Receiver | $I_{OZR}$ | 0V≤$V_O$≤$V_{CC}$ | | | | ≤1 | μA |
| Receiver Input Resistance | $R_{IN}$ | -7V≤$V_{CM}$≤12V | | 96 | | | kΩ |
| Receiver Output Short-Circuit Current | $I_{OSR}$ | 0V≤$V_{RO}$≤$V_{CC}$ | | | | ≤110 | mV |
| **Supply Current** | | | | | | | |
| Supply current | $I_{CC}$ | No load, /RE=GND DE=$V_{CC}$ | | | 0.5 | 0.7 | mA |
| | | No load, /RE=$V_{CC}$, DE=$V_{CC}$ | | | 0.5 | 0.7 | |
| | | No load, /RE=GND DE=GND | | | 0.5 | 0.7 | |
| Supply Current in Shutdown Mode | $I_{SHDN}$ | /RE=GND DE=GND | | | 2.0 | 10 | μA |
| **ESD Protection** | | | | | | | |
| ESD Protection (A, B) | ESD | Human Body Mode | | | ±15 | | kV |
| | | Contact Discharge IEC 61000-4-2 | | | ±8 | | kV |
| | | Air-Gap Discharge IEC 61000-4-2 | | | ±15 | | |

## 7 DRIVER SWITCHING CHARACTERISTICS

（$V_{CC}$=+5V±10%,$T_A$=$T_{MIN}$~$T_{MAX}$,Typical values are at $V_{CC}$=+5V and $T_A$=25°C;unless otherwise noted.(1)

| Parameter | Symbol | Conditions | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Driver Propagation Delay | $t_{DPLH}$ | $R_L$=54Ω,$C_L$=50pF,Figure 2 and Figure 3 | 1 | 22 | 35 | ns |
| | $t_{DPHL}$ | | 1 | 22 | 35 | |
| Driver Output Skew $\|t_{DPLH} - t_{DPHL}\|$ | $t_{DHKEW}$ | $R_L$=54Ω,$C_L$=50pF,Figure 2 and Figure 3 | | -3 | ±10 | ns |
| Driver Differential Output Rise or Fall Time | $t_R$ , $t_F$ | $R_L$=54Ω,$C_L$=50pF,Figure 2 and Figure 3 | 3 | 12 | 25 | ns |
| Maximum Data Rate | $F_{MAX}$ | | 12 | | | Mbps |
| Driver Enable to Output High | $t_{DZH}$ | Figure 4 | | | 150 | ns |
| Driver Enable to Output Low | $t_{DZL}$ | Figure 5 | | | 150 | ns |
| Driver Disable Time from Low | $t_{DLZ}$ | Figure 5 | | | 100 | ns |
| Driver Disable Time from High | $t_{DHZ}$ | Figure 4 | | | 100 | ns |
| Driver Enable from Shutdown to Output High | $T_{DZH(SHDN)}$ | Figure 4 | | 650 | 900 | ns |
| Driver Enable from Shutdown to Output Low | $t_{DZH(SHDN)}$ | Figure 5 | | 650 | 900 | ns |
| Time to Shutdown | $t_{SHDN}$ | | 50 | 340 | 700 | ns |

## 8 RECEIVER SWITCHING CHARACTERISTICS

（$V_{CC}$=+5V±10%,$T_A$=$T_{MIN}$~$T_{MAX}$,Typical values are at $V_{CC}$=+5V and $T_A$=25°C;unless otherwise noted.(1)

| Parameter | Symbol | Conditions | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Receiver Propagation Delay | $t_{RPLH}$ | $C_L$=15pF,Figure 6 and Figure 7 | | 50 | | ns |
| | $t_{RPHL}$ | | | 50 | | |
| Receiver Output Skew $\|t_{DPLH} - t_{DPHL}\|$ | $t_{RSkEW}$ | $C_L$=15pF,Figure 6 and Figure 7 | | 0 | ±10 | ns |
| Maximum Data Rate | $F_{MAX}$ | | 12 | | | Mbps |
| Receiver Disable Time from High | $t_{RHZ}$ | Figure 8 | | 20 | 50 | ns |
| Receiver Disable Time from Low | $t_{RLZ}$ | Figure 8 | | 20 | 50 | ns |
| Receiver Enable to Output High | $t_{RZH}$ | Figure 8 | | 20 | 50 | ns |
| Receiver Enable to Output Low | $t_{RZL}$ | Figure 8 | | 300 | 400 | ns |
| Receiver Enable from Shutdown to Output High | $t_{RZH(SHDN)}$ | Figure 8 | | | 3500 | ns |
| Receiver Enable from Shutdown to Output Low | $t_{RZL(SHDN)}$ | Figure 8 | | | 3500 | ns |
| Time to Shutdown | $t_{SHDN}$ | | 50 | 340 | 700 | ns |

1.All currents into the device are positive. All currents out of the device are negative. All voltages are referred to device ground, unless otherwise noted.
2.$\Delta V_{OD}$ and $\Delta V_{OC}$ are the changes in $V_{OD}$ and $V_{OC}$, respectively, when the DI input changes state.
3.The short-circuit output current applies to peak current just prior to foldback current limiting. The short-circuit foldback output current applies during current limiting to allow a recovery from bus contention.

## 9 TEST CIRCUITS AND WAVEFORMS

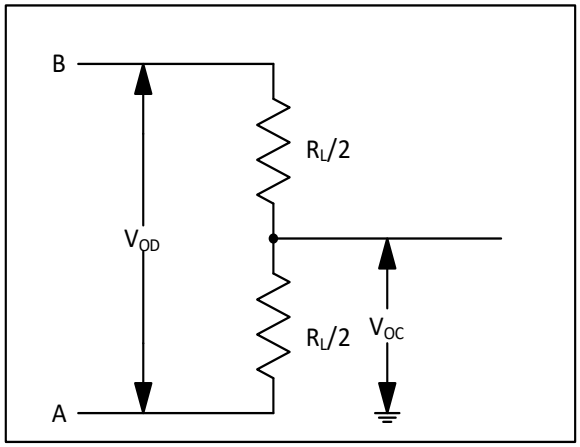



**Figure 1. Driver DC Test Load**

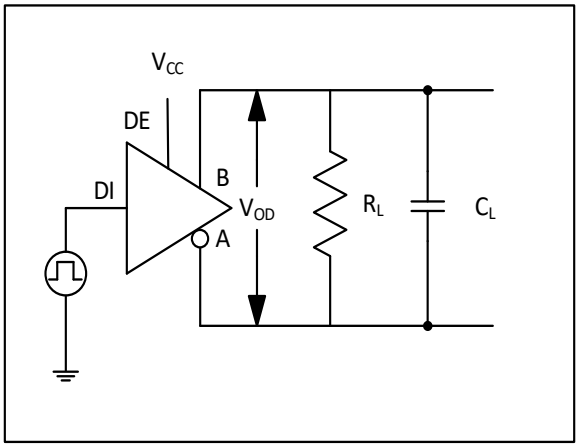



**Figure 2.Driver timing test load**

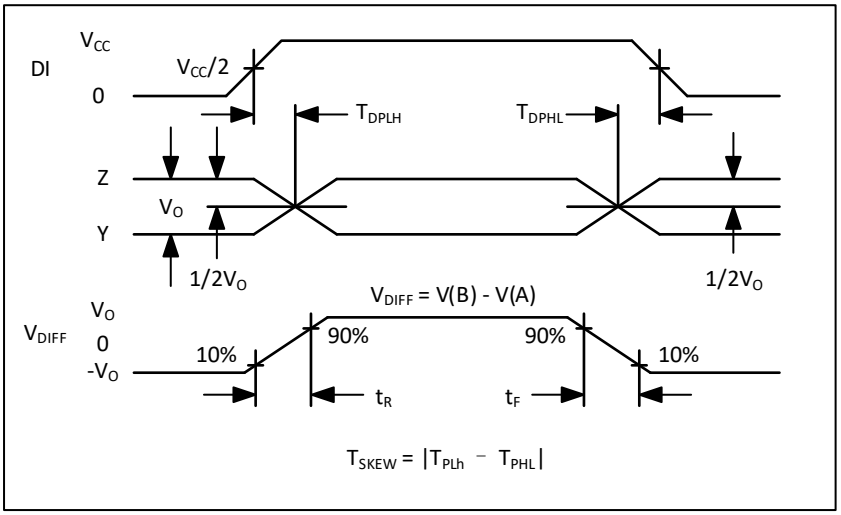



**Figure 3.Driver Propagation Delays**

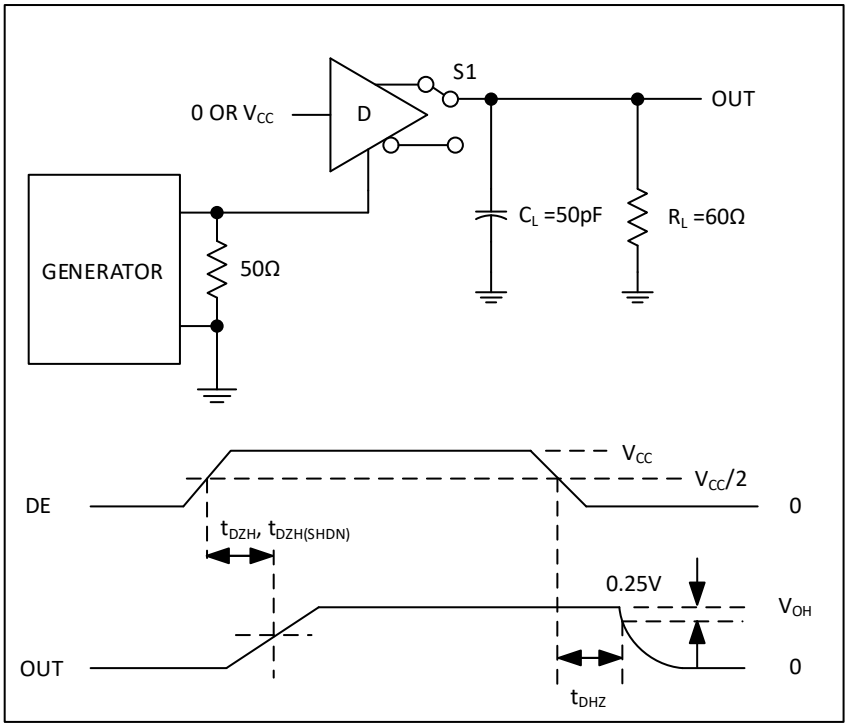



**Figure 4. Driver Enable and Disable Times ($t_{DHZ}$, $t_{DZH}$, $t_{DZH(SHDN)}$)**

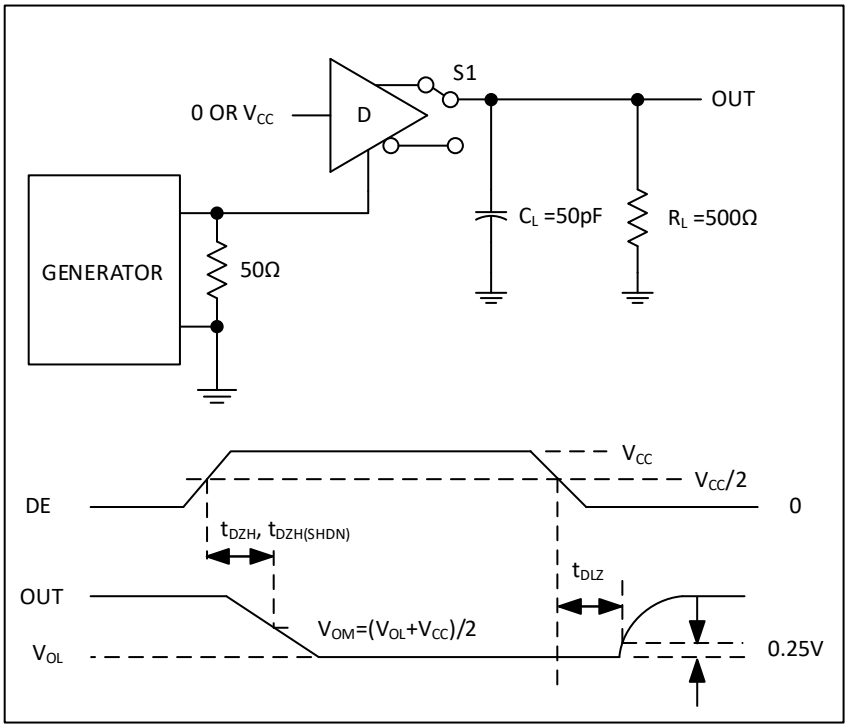



**Figure 5. Driver Enable and Disable Times ($t_{DZL}$, $t_{DLZ}$, $t_{DLZ(SHDN)}$)**

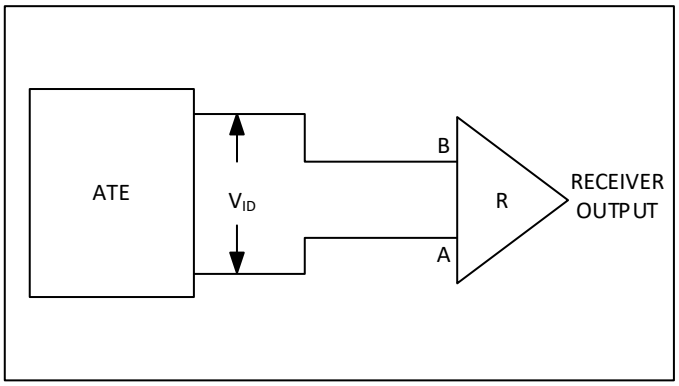



**Figure 6. Receiver Propagation Delay Test Circuit**

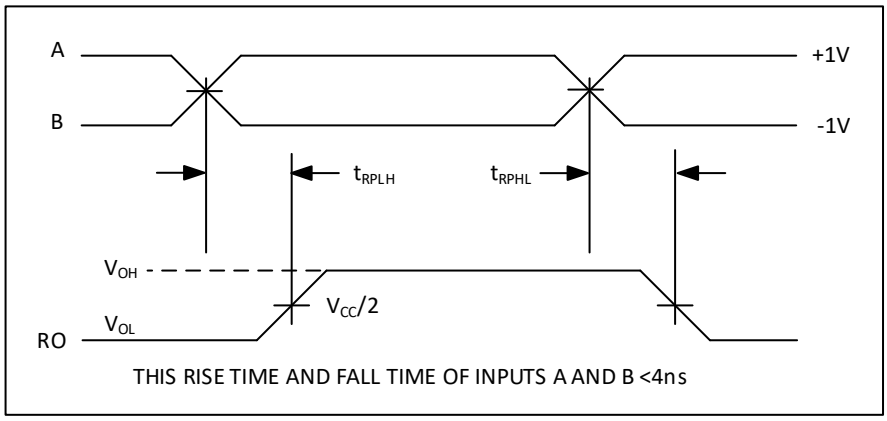
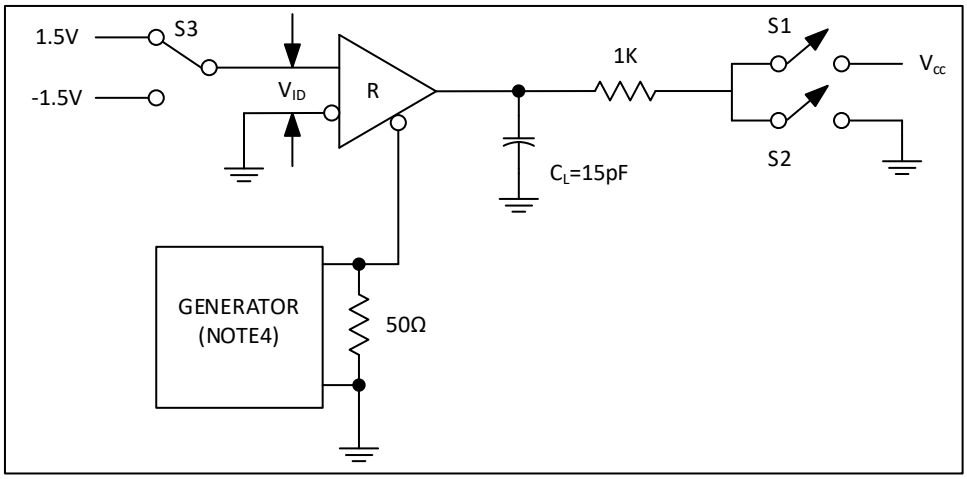



**Figure 7. Receiver Propagation Delays**



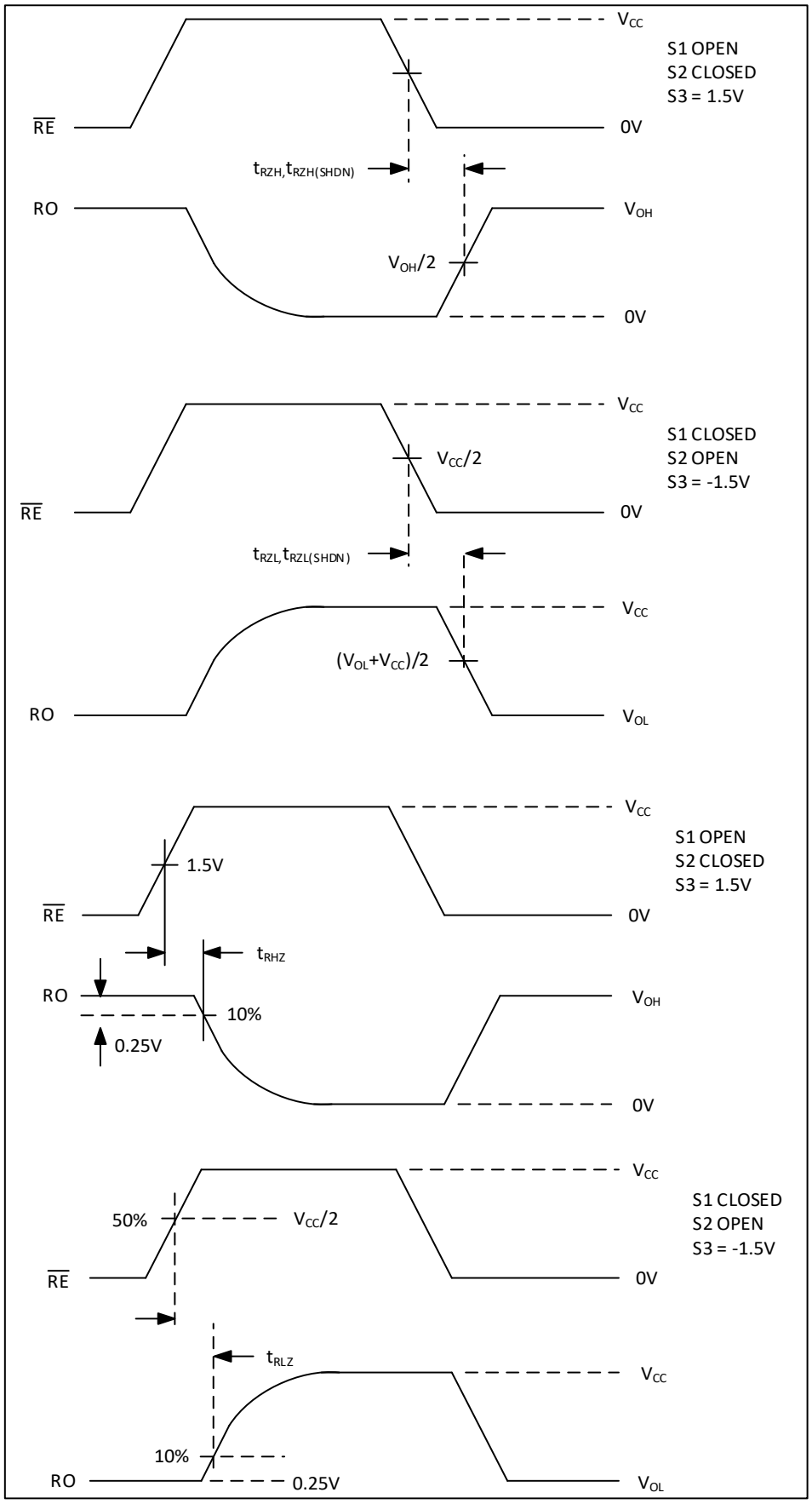
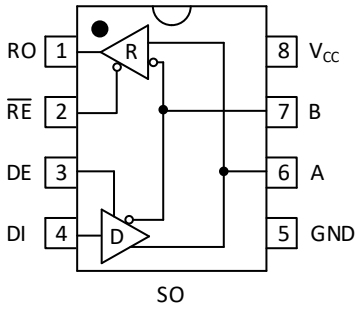



**Figure 8. Receiver Enable and Disable Times**

## 10 FUNCTION TABLES




| TRANSMITTING | | | | |
|---|---|---|---|---|
| **INPUTS** | | | **OUTPUTS** | |
| **DI** | **DE** | $\overline{RE}$ | **A** | **B** |
| 1 | 1 | X | 1 | 0 |
| 0 | 1 | X | 0 | 1 |
| X | 0 | 0 | Z | Z |
| X | 0 | 1 | Shutdown | |

| RECEIVING | | | |
|---|---|---|---|
| **INPUTS** | | | **OUTPUTS** |
| **/RE** | **DE** | **A - B** | **RO** |
| 0 | X | ≥ -50mV | 1 |
| 0 | X | ≤ -200mV | 0 |
| 0 | X | Open/Shorted | 1 |
| 1 | 1 | X | Z |
| 1 | 0 | X | Shutdown |

## 11 DETAILED DESCRIPTION

The NPS2821 high-speed transceiver for RS-485/RS-422 communication contains one driver and one receiver. This device features fail-safe circuitry, which guarantees a logic-high receiver output when the receiver inputs are open or shorted, or when they are connected to a terminated transmission line with all drivers disabled (see the Fail-Safe section). The NPS2821 transmit at up to 16Mbps.The NPS2821 is a half-duplex transceiver and operates from a single +3.0~5.5V supply. Drivers are output short-circuit current limited. Thermal-shutdown circuitry protects drivers against excessive power dissipation. When activated, the thermal-shutdown circuitry places the driver outputs into a high-impedance state.

### Fail-Safe

The NPS2821 guarantees a logic-high receiver output when the receiver inputs are shorted or open, or when they are connected to a terminated transmission line with all drivers disabled. This is done by setting the receiver input threshold between -50mV and -200mV. If the differential receiver input voltage (A - B) is greater than or equal to -50mV, RO is logic-high. If (A - B) is less than or equal to -200mV, RO is logic-low. In the case of a terminated bus with all transmitters disabled, the receiver's differential input voltage is pulled to 0V by the termination. With the receiver threshold of the NPS2821, this results in a logic-high with a 50mV minimum noise margin. Unlike previous fail-safe devices, the -50mV to -200mV threshold complies with the ±200mV EIA/TIA-485 standard.

## ±15kV ESD Protection

The driver output and receiver input of the NPS2821 have extra protection against static electricity.The ESD structures withstand high ESD in all states: normal operation, shutdown, and powered down. After an ESD event, the NPS2821 keeps working without latchup or damage.ESD protection can be tested in various ways. The transmitter output and receiver input of the NPS2821 are characterized for protection to the following limits:

- ±15kV using the Human Body Model
- ±8kV using the Contact Discharge method specified in IEC 61000-4-2
- ±15kV using the Air-Gap Discharge method specified in IEC 61000-4-2

## ESD Test Conditions

ESD performance depends on a variety of conditions.

## Human Body Model

Figure 10a shows the Human Body Model, and Figure 10b shows the current waveform it generates when discharged into a low impedance. This model consists of a 100pF capacitor charged to the ESD voltage of interest, which is then discharged into the test device through a 1.5kΩ resistor.

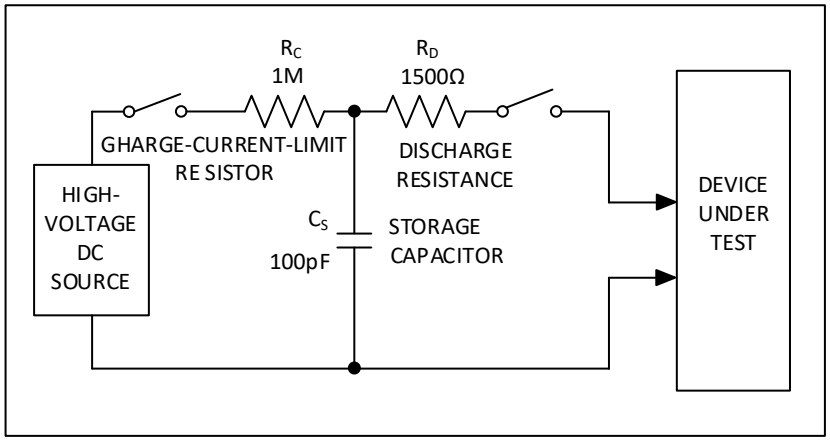



**Figure 10a. Human Body ESD Test Model**

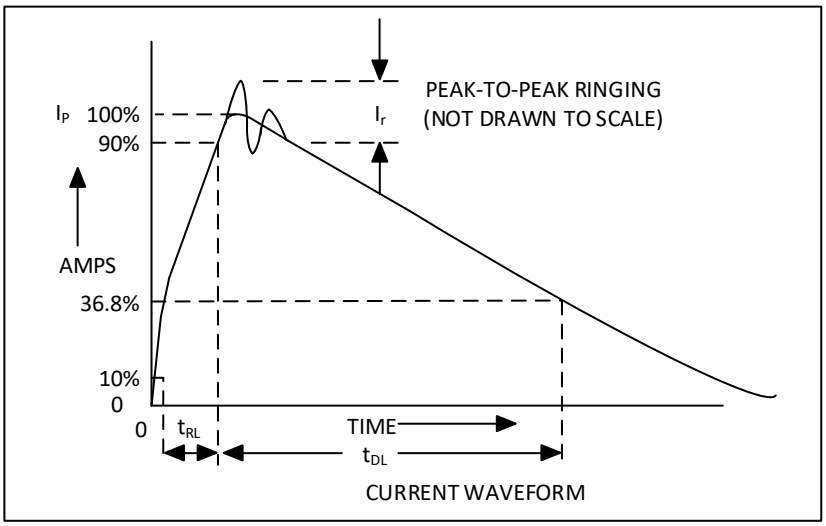



**Figure 10b. Human Body Current Waveform**

## IEC 61000-4-2

The IEC 61000-4-2 standard covers ESD testing and performance of finished equipment. However, it does not specifically refer to integrated circuits. The NPS2821 helps you design equipment to meet IEC 61000-4-2, without the need for additional ESD-protection components.The major difference between tests done using the Human Body Model and IEC 61000-4-2 is higher peak current in IEC 61000-4-2 because series resistance is lower in the IEC 61000-4-2 model. Hence, the ESD withstand voltage measured to IEC 61000-4-2 is generally lower than that measured using the Human Body Model. Figure 10c shows the IEC 61000-4-2 model, and Figure 10d shows the current waveform for IEC 61000-4-2 ESD Contact Discharge test.

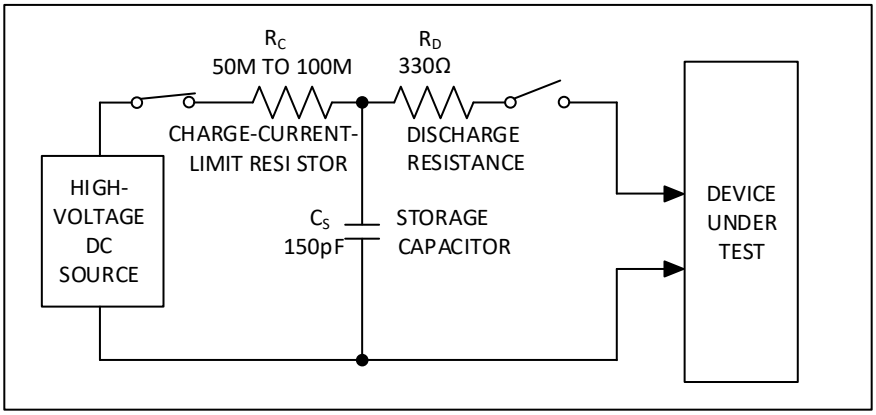



**Figure 10c. IEC 61000-4-2 ESD Test Model**

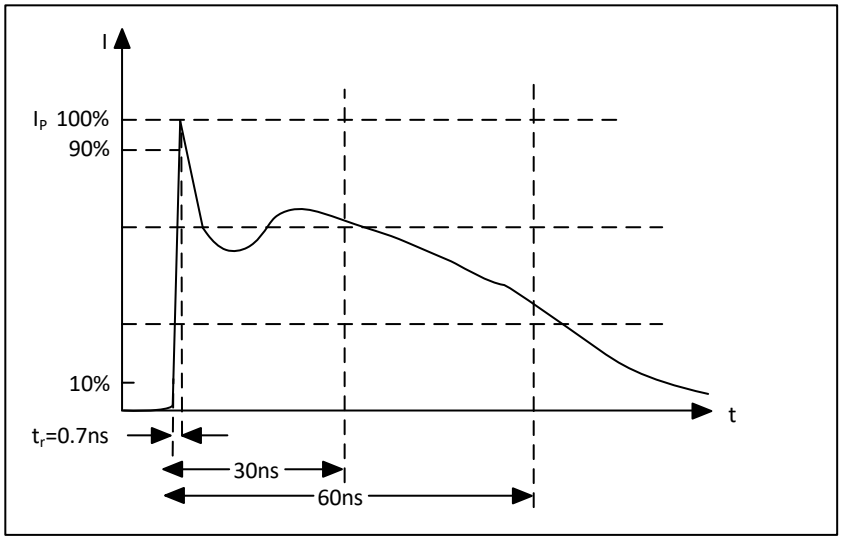



**Figure 10d. IEC 61000-4-2 ESD Generator Current Waveform**

## Machine Model

The machine model for ESD tests all pins using a 200pF storage capacitor and zero discharge resistance. The objective is to emulate the stress caused when I/O pins are contacted by handling equipment during test and assembly. Of course, all pins require this protection, not just RS-485 inputs and outputs.

## 12 APPLICATIONS INFORMATION

The standard RS-485 receiver input impedance is 12kΩ (1-unit load), and the standard driver can drive up to 32-unit loads. The NPS2821 has a 1/8-unit load receiver input impedance (96kΩ), allowing up to 256 transceivers to be connected in parallel on one communication line. Any combination of the NPS2821, as well as other RS-485 transceivers with a total of 32-unit loads or fewer, can be connected to the line.

### Low-Power Shutdown Mode

Low-power shutdown mode is initiated by bringing both RE high and DE low. In shutdown, the devices typically draw only 2.0µA of supply current.RE and DE can be driven simultaneously; the devices are guaranteed not to enter shutdown if RE is high and DE is low for less than 50ns. If the inputs are in this state for at least 700ns, the devices are guaranteed to enter shutdown.Enable times $t_{ZH}$ and $t_{ZL}$ (see the Switching Characteristics section) assume the devices were not in a low-power shutdown state. Enable times $t_{ZH}$(SHDN) and $t_{ZL}$(SHDN) assume the devices were in shutdown state. It takes drivers and receivers longer to become enabled from low-power shutdown mode ($t_{ZH}$(SHDN), $t_{ZL}$(SHDN)) than from driver/receiver-disable mode ($t_{ZH}$, $t_{ZL}$).

### Driver Output Protection

Two mechanisms prevent excessive output current and power dissipation caused by faults or by bus contention. The first, a foldback current limit on the output stage, provides immediate protection against short circuits over the whole common-mode voltage range (see the Typical Operating Characteristics). The second, a thermal-shutdown circuit, forces the driver outputs into a high-impedance state if the die temperature exceeds +175°C (typ).

## 13 TYPICAL APPLICATIONS

The NPS2821 transceiver is designed for bidirectional data communications on multipoint bus transmission lines. Figure 11 shows a typical network applications circuit.To minimize reflections, terminate the line at both ends in its characteristic impedance, and keep stub lengths off the main line as short as possible.

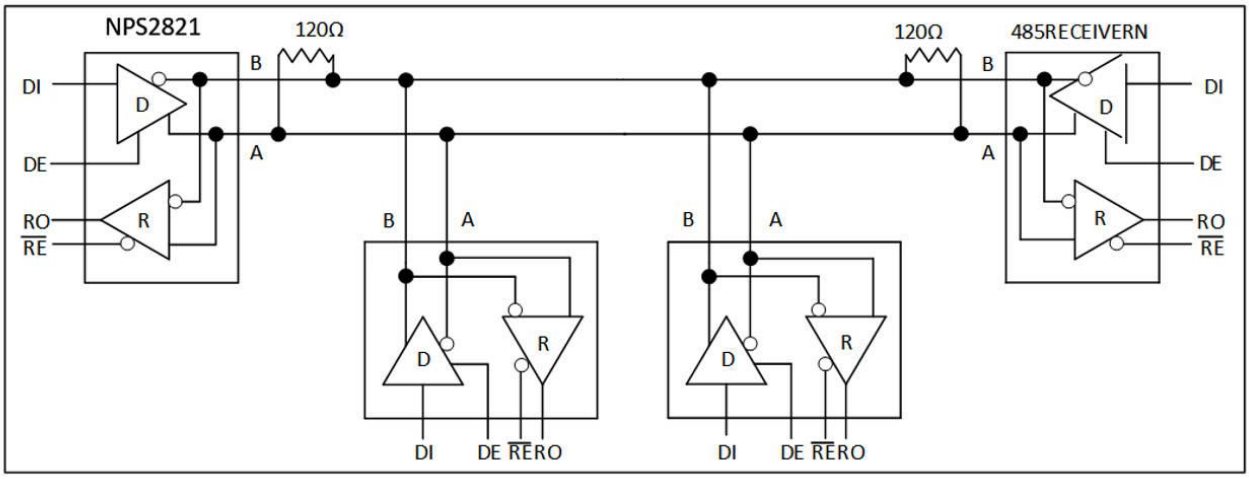
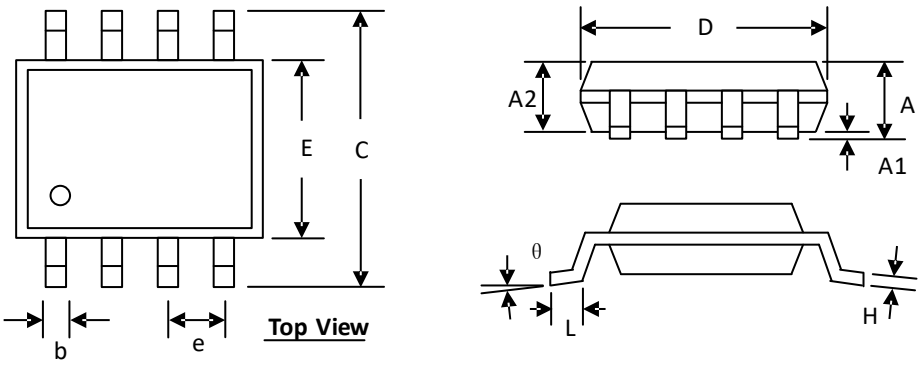



**Figure 11. Typical Half-Duplex RS-485 Network**

## PACKAGE DIMENSION SOP8-L




| SYMBOLS | DIMENSION (MM) | | DIMENSION (INCH) | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 1.300 | 1.752 | 0.051 | 0.069 |
| A1 | 0.000 | 0.203 | 0.000 | 0.008 |
| A2 | 1.350 | 1.550 | 0.053 | 0.061 |
| b | 0.330 | 0.510 | 0.013 | 0.020 |
| C | 5.790 | 6.200 | 0.228 | 0.244 |
| D | 4.700 | 5.110 | 0.185 | 0.201 |
| E | 3.800 | 4.000 | 0.150 | 0.157 |
| e | 1.270 BSC | | 0.050 BSC | |
| H | 0.170 | 0.254 | 0.007 | 0.010 |
| L | 0.400 | 1.270 | 0.016 | 0.050 |
| θ | 0° | 8° | 0° | 8° |

## Order Information

| Order number | Package | Marking information | Operation Temperature Range | MSL Grade | Ship, Quantity | Green |
|---|---|---|---|---|---|---|
| NPS2821 | SOP8-L | NPS2821 | -40 to 85°C | 3 | T&R, 5000 | RoHS |