# Implementing RS-485 on AVR

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# Chapter 1

# Introduction

*RS485* is the physical layer for many higher-level protocols, including *Modbus*[1], *Profibus*[2] and other *Fieldbus*[3] systems, *SCSI-2, SCSI-3, and Bit Bus*. Unlike *RS232*, which has a *transmit wire* and a *receive wire*, *RS485* has a *transmit wire pair*. Typically one wire is labelled *A* and the other is labelled *B*, and the wires are twisted together (*twisted pair*). This allows *RS485* to transmit over much longer distances, using equivalent wires and equivalent transmitters and receivers, than *RS232*. Many *RS485* implementations use 2 wires (1 pair). At all times, at most one device is transmitting on the pair, and all the other devices on the network are listening (half-duplex). It is the responsibility of user software to ensure that several different devices don't try to transmit at the same time, this can be a tricky coordination task.

## 1.1 Overview

*RS485* only specifies electrical characteristics of the driver and the receiver. It does not specify or recommend any communications protocol. *RS485* enables the configuration of inexpensive local networks and multi-drop communications links. It offers data transmission speeds of 35 Mbit/s up to 10 m and 100 kbit/s at 1200 m. Since it uses a differential balanced line over twisted pair (like *RS422*), it can span relatively large distances (up to 4,000 feet (1,200 m)). A rule of thumb is that the speed in bit/s multiplied by the length in meters should not exceed 108. Thus a 50 meter cable should not signal faster than 2 Mbit/s.

[1] It is a protocol developed by Modicom.

[2] It is another protocol developed by BMBF (German department of education and research)

[3] Protocol developed by

The recommended arrangement of the wires is as a connected series of point-to-point (multi-dropped) nodes, a line or bus, not a star, ring, or multiply connected network. Ideally, the two ends of the cable will have a termination resistor connected across the two wires. Without termination resistors, reflections of fast driver edges can cause multiple data edges that can cause data corruption. Termination resistors also reduce electrical noise sensitivity due to the lower impedance, and bias resistors are required. The value of each termination resistor should be equal to the cable impedance (typically, 100 ohms for twisted pairs).

## 1.2 Requirements

A full-duplex *RS485* system requires 3 twisted pairs, 2 twisted pairs for signalling, and another conductor for ground. This so-called four-wire *RS485* system requires 5 wires. A half-duplex system only requires 2 twisted pairs one twisted pair for signalling, and another conductor for ground. This so-called two-wire *RS485* system requires 3 wires.

The ground conductor can be eliminated in some cases, but it is safe to stick to *Three wire system.*

## 1.3 Limitations

Standard *RS485* is limited to a maximum speed of 35 Mbps with a network length of 12 meters, and 100 Kbps with a network length of 1200 meters. With interface devices that exceed standards and careful network design, higher throughput over longer cables is possible.

With the use of *Shielded twisted pair*(STP) or *Foiled twisted pair*(FTP) cable the throughput can be increased even more.

## 1.4 Handshaking

There is no hardware handshaking in *RS485.* If handshaking is required for *RS485* it can be done using *X-On / X-Off* handshaking protocol. The *RS485* standard originally used half-duplex communication and handshaking signals such as *RTS / CTS* to control the direction of data flow. Many USB to serial converters come with **ADDC** (*Automatic Data Direction Control*) to automatically sense and control data direction, making the handshaking signal method obsolete.

## 1.5 Termination

Perhaps the most controversial part of *RS485* is what to do at the end of the line. There are a wide variety of popular techniques, each of which works great under one narrow range of conditions.

- **Unterminated:** This is the simplest system, but only works if both the data rate and length are low enough. A good guideline for when it can be used is to keep the product of the data rate (in baud) and the longest end-to-end cable length below four hundred thousand. Number of transmitters / receivers aren't important (just keep them within *RS485* specification). This is the only case where a star bus topology works reliably.

- **One-way resistor termination:** Only works if there is only one transmitter, which must be at the opposite end (from the resistor) of a linear bus.

- **Two-way resistor termination:** Only works with a linear bus, but allows transmitters only at the endpoints of the bus.

- **AC termination:** While AC termination may work well on backplanes, others discourage its use on *RS485* lines: "In practice, I have never seen it"

## 1.6 Pin labeling

The **EIA-485** differential line consists of two pins:

- *A* aka – aka *TxD–/RxD–* aka *inverting* pin
- *B* aka + aka *TxD+/RxD+* aka *non-inverting* pin
- *SC* aka *G* aka *reference* pin

The SC line is the optional voltage reference connection. This is the reference potential used by the transceiver to measure the *A* and *B* voltages. The *B* line is positive (compared to *A*) when the line is idle (i.e, data is 1). In addition to the *A* and *B* connections, the EIA standard also specifies a third interconnection point called *C*, which is the common signal reference ground. These names are all in use on various equipment, but the actual standard released by EIA only uses the names *A* and *B*.

However, despite the unambiguous standard, there is much confusion about which is which, The EIA-485 signaling specification states that signal $A$ is the *inverting* or $'-'$ pin and signal $B$ is the $non-inverting$ or $'+'$ pin. This is in conflict with the $A/B$ naming used by a number of differential transceiver manufacturers, including, among others.

- Texas Instruments, as seen in their application handbook on EIA-422/485 communications (*A=non-inverting, B=inverting*).
- Intersil, as seen in their data sheet for the ISL4489 transceiver.
- Maxim, as seen in their data sheet for the MAX485 transceiver

These manufacturers are incorrect, but their practice is in widespread use. Therefore, care must be taken when using $A/B$ naming.

## 1.7 *RS485* in Real World

Now being used commonly in the pro audio industry to control digital audio and signal processors such as the DBX driverack and other manufacturers equivalent products. Preferred to *RS232* due to cheaper cabling run costs and the common availability of cables (similar to *RJ-45*). When wiring a *RS485* network, always connect $A$ to $A$, $B$ to $B$, and $G$ to $G$

Many people recommend writing prototype software as if it will be connected to a half-duplex *RS485* network. Then the software will work unchanged when connected to a full-duplex *RS485* network, a *RS232* network, and a variety of other communication media.

Many people recommend wiring things up on a prototype with *Category-5* cable connected as point-to-point full-duplex *RS485*. The *CAT-5* cable allows you to relatively quickly switch to half-duplex *RS485*, or the 3 wires of *RS232*, or a variety of other communication protocols without pulling any new cables. The point-to-point full-duplex *RS485* network allows you to get the complete prototype system fully operational quickly, since it is easier to debug and more immune to certain common problems on other systems (noise problems on *RS232*, turn-around problems on half-duplex *RS485*, etc.).

## 1.8 Waveform example

The image below shows potentials of the $'+'$ and $'-'$ pins of an EIA-485 line during transmission of one byte (0xD3, least significant bit first) of data using an asynchronous start-stop method.

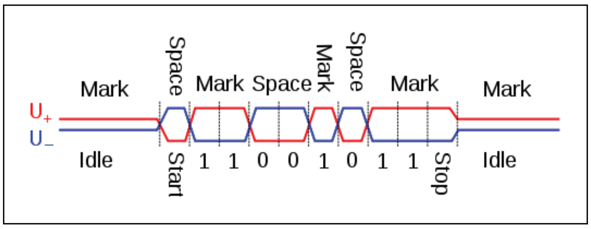


Figure 1.1: Waveform of **0xD3** transmitted on *RS485*

## 1.9 Differences between *RS232* and *RS485*

- *RS232* signal levels are typically -12 V to +12 V relative to the signal ground.
- *RS485* signal levels are typically 0 to +5 V relative to the signal ground.
- *RS232* uses point-to-point unidirectional signal wires: There are only two devices connected to a *RS232* cable. The *TxD* output of a first device connected to the *RxD* input of a second device, and the *TxD* output of the second device connected to the *RxD* input of the first device. In a *RS232* cable, data always flows in only one direction on any particular wire, from *TxD* to *RxD*.
- *RS485* typically uses a linear network with bidirectional signal wires: There are typically many devices along a *RS485* shared cable. The *A* output of each device is connected to the *A* output of every other device. In a *RS485* cable, data typically flows in both directions along any particular wire, sometimes from the *A* of the first device to the *A* of the second device, and at a later time from the *A* of the second device to the *A* of the first device.

# Chapter 2

# Characteristics of *RS485*

| Description | *RS485* |
|---|---|
| **Mode** | Differential |
| **Max number of drivers** | 32 |
| **Max number of receivers** | 32 |
| **Mode of operation** | Full Duplex or Half Duplex |
| **Network topology** | Multi-Drop |
| **Max distance (acc. standard)** | 1200m (4000ft) |
| **Max speed at 12 m** | 35 Mbs |
| **Max speed at 1200 m** | 100 kbs |
| **Receiver input resistance** | $\geq 12\Omega$ |
| **Driver load impedance** | $54\Omega$ |
| **Receiver input sensitivity** | $\pm$ 200mV |
| **Receiver input range** | -7...12V |
| **Max driver output voltage** | -7...12V |
| **Min driver output voltage (with load)** | 1.5V |

# Chapter 3

# MAX485 IC

The **MAX485** IC are low-power transceivers for RS-485 and RS- 422 communication. Each part contains one driver and one receiver. The driver slew rates of the IC are not limited, allowing them to transmit up to 2.5Mbps.

These transceiver draw between 120$\mu$A and 500$\mu$A of supply current when unloaded or fully loaded with disabled drivers. Drivers are short circuited protected against excessive power dissipation by thermal shut-down circuitry that places the driver output into High-impedance state. The receiver input has a fail-safe feature that guarantees a logic-high output if the input is open circuit.

The serial data on $DI$ pin is transmitted on the bus and the data on bus is received on $RO$ pin. The direction of data on bus is controlled by $RE$ and $DE$ pins, these pins are connected together and eventually connected to the control device.

- When $RE$ and $DE$ is low, data on the bus is received on $RO$.
- When they are high the data on $DI$, is transmitted on bus.

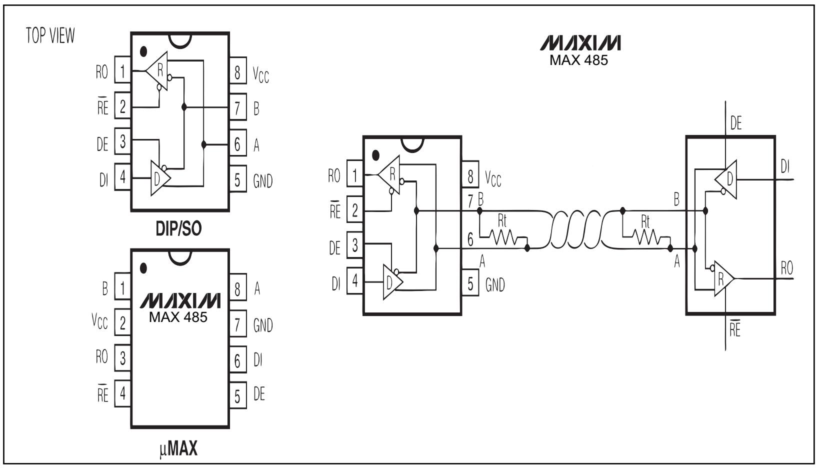


Figure 3.1: Pinout diagram of **MAX485** and its connection

# Chapter 4

# Hardware

**To build the hardware you will require the following things.**

1. **ATmega32** (AVR Family Micro-controller)
2. **MAX-485**
3. **Twisted Pair Cable**

## 4.1 Single Master and Slave

First we will build a simple hardware with one *master* and one *slave*, following are the instructions to building the hardware.

- First connect the *RO* pin of *MAX485* to *RxD* pin of *ATmega32*, then followed by *DI* pin to *TxD* pin.
- Connect the *RE* & *DE* pins of *MAX485* to anyone i/o pin of *ATmega32*.
- Build the same hardware, as stated above and connect it to other side (*i.e slave*) side.

**The following schematic shows you how to build the hardware**[1]

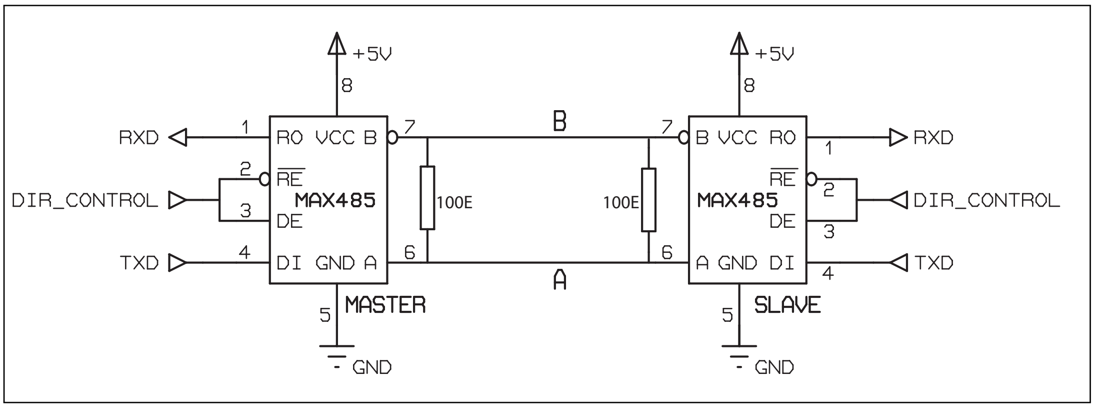


Figure 4.1: Simple *RS485* Communication

[1]The **RO** and **DI** pins MAX-485 pins are **TTL** compatible and not *RS232*

## 4.2 Multi Master and Slave

After you have done with simple point-to-point system, you can try complex systems with multi *master* and *slave*. In this section I have provided an example for two *master* and two *slaves*.

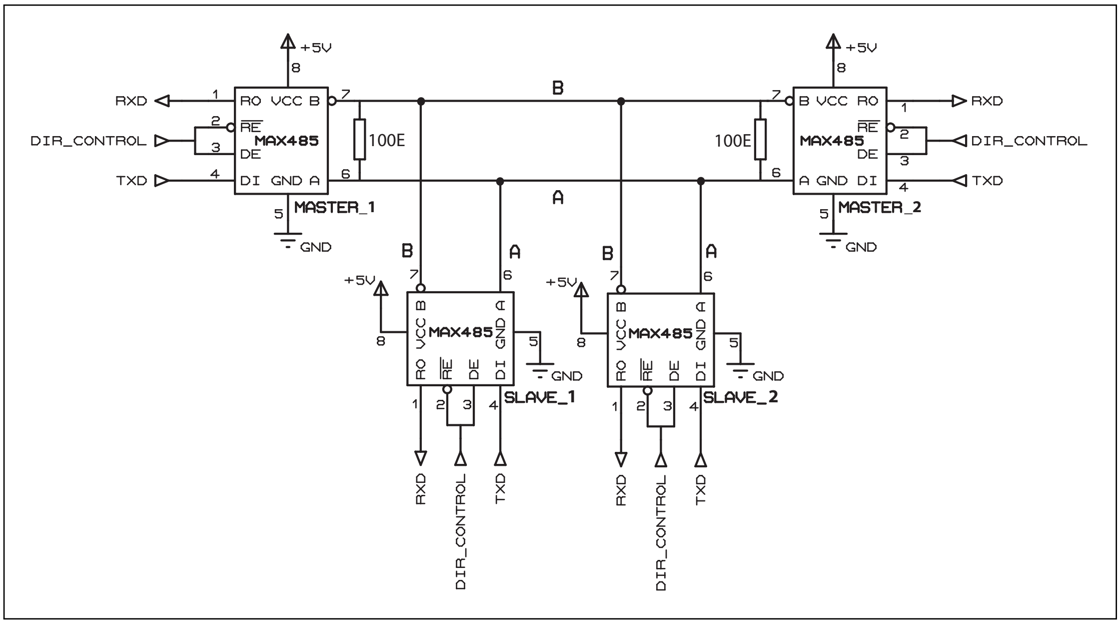


Figure 4.2: Multi Master-Slave *RS485* Communication

# Reference

- Wikipedia

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# Part II

# Datasheet

# MAX 485

19-0122; Rev 7; 6/03

# Low-Power, Slew-Rate-Limited RS-485/RS-422 Transceivers



## General Description

The MAX481, MAX483, MAX485, MAX487–MAX491, and MAX1487 are low-power transceivers for RS-485 and RS-422 communication. Each part contains one driver and one receiver. The MAX483, MAX487, MAX488, and MAX489 feature reduced slew-rate drivers that minimize EMI and reduce reflections caused by improperly terminated cables, thus allowing error-free data transmission up to 250kbps. The driver slew rates of the MAX481, MAX485, MAX490, MAX491, and MAX1487 are not limited, allowing them to transmit up to 2.5Mbps.

These transceivers draw between 120µA and 500µA of supply current when unloaded or fully loaded with disabled drivers. Additionally, the MAX481, MAX483, and MAX487 have a low-current shutdown mode in which they consume only 0.1µA. All parts operate from a single 5V supply.

Drivers are short-circuit current limited and are protected against excessive power dissipation by thermal shutdown circuitry that places the driver outputs into a high-impedance state. The receiver input has a fail-safe feature that guarantees a logic-high output if the input is open circuit.

The MAX487 and MAX1487 feature quarter-unit-load receiver input impedance, allowing up to 128 MAX487/MAX1487 transceivers on the bus. Full-duplex communications are obtained using the MAX488–MAX491, while the MAX481, MAX483, MAX485, MAX487, and MAX1487 are designed for half-duplex applications.

## Applications

- Low-Power RS-485 Transceivers
- Low-Power RS-422 Transceivers
- Level Translators
- Transceivers for EMI-Sensitive Applications
- Industrial-Control Local Area Networks

## Features

- **In µMAX Package: Smallest 8-Pin SO**
- **Slew-Rate Limited for Error-Free Data Transmission (MAX483/487/488/489)**
- **0.1µALow-Current Shutdown Mode (MAX481/483/487)**
- **Low Quiescent Current:**
  **120µA (MAX483/487/488/489)**
  **230µA (MAX1487)**
  **300µA (MAX481/485/490/491)**
- **-7V to +12V Common-Mode Input Voltage Range**
- **Three-State Outputs**
- **30ns Propagation Delays, 5ns Skew (MAX481/485/490/491/1487)**
- **Full-Duplex and Half-Duplex Versions Available**
- **Operate from a Single 5V Supply**
- **Allows up to 128 Transceivers on the Bus (MAX487/MAX1487)**
- **Current-Limiting and Thermal Shutdown for Driver Overload Protection**

## Ordering Information

| PART | TEMP RANGE | PIN-PACKAGE |
|---|---|---|
| **MAX481**CPA | 0°C to +70°C | 8 Plastic DIP |
| MAX481CSA | 0°C to +70°C | 8 SO |
| MAX481CUA | 0°C to +70°C | 8 µMAX |
| MAX481C/D | 0°C to +70°C | Dice* |

***Ordering Information continued at end of data sheet.***

**Contact factory for dice specifications.*

## Selection Table

| PART NUMBER | HALF/FULL DUPLEX | DATA RATE (Mbps) | SLEW-RATE LIMITED | LOW-POWER SHUTDOWN | RECEIVER/ DRIVER ENABLE | QUIESCENT CURRENT (µA) | NUMBER OF TRANSMITTERS ON BUS | PIN COUNT |
|---|---|---|---|---|---|---|---|---|
| **MAX481** | Half | 2.5 | No | Yes | Yes | 300 | 32 | 8 |
| **MAX483** | Half | 0.25 | Yes | Yes | Yes | 120 | 32 | 8 |
| **MAX485** | Half | 2.5 | No | No | Yes | 300 | 32 | 8 |
| **MAX487** | Half | 0.25 | Yes | Yes | Yes | 120 | 128 | 8 |
| **MAX488** | Full | 0.25 | Yes | No | No | 120 | 32 | 8 |
| **MAX489** | Full | 0.25 | Yes | No | Yes | 120 | 32 | 14 |
| **MAX490** | Full | 2.5 | No | No | No | 300 | 32 | 8 |
| **MAX491** | Full | 2.5 | No | No | Yes | 300 | 32 | 14 |
| **MAX1487** | Half | 2.5 | No | No | Yes | 230 | 128 | 8 |

# Low-Power, Slew-Rate-Limited RS-485/RS-422 Transceivers

## ABSOLUTE MAXIMUM RATINGS

Supply Voltage ($V_{CC}$)............................................................12V
Control Input Voltage ($\overline{RE}$, DE)...................-0.5V to ($V_{CC}$ + 0.5V)
Driver Input Voltage (DI).............................-0.5V to ($V_{CC}$ + 0.5V)
Driver Output Voltage (A, B)..................................-8V to +12.5V
Receiver Input Voltage (A, B)................................-8V to +12.5V
Receiver Output Voltage (RO).....................-0.5V to ($V_{CC}$ +0.5V)
Continuous Power Dissipation ($T_A$ = +70°C)
8-Pin Plastic DIP (derate 9.09mW/°C above +70°C) ....727mW
14-Pin Plastic DIP (derate 10.00mW/°C above +70°C) ..800mW
8-Pin SO (derate 5.88mW/°C above +70°C)................471mW
14-Pin SO (derate 8.33mW/°C above +70°C)...............667mW
8-Pin μMAX (derate 4.1mW/°C above +70°C)..............830mW
8-Pin CERDIP (derate 8.00mW/°C above +70°C).........640mW
14-Pin CERDIP (derate 9.09mW/°C above +70°C).......727mW
Operating Temperature Ranges
MAX4_ _C_ _/MAX1487C_ A ...............................0°C to +70°C
MAX4_ _E_ _/MAX1487E_ A............................-40°C to +85°C
MAX4_ _MJ_/MAX1487MJA ...........................-55°C to +125°C
Storage Temperature Range ............................-65°C to +160°C
Lead Temperature (soldering, 10sec) .............................+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.*

## DC ELECTRICAL CHARACTERISTICS

($V_{CC}$ = 5V ±5%, $T_A$ = $T_{MIN}$ to $T_{MAX}$, unless otherwise noted.) (Notes 1, 2)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Differential Driver Output (no load) | $V_{OD1}$ | | | | | 5 | V |
| Differential Driver Output (with load) | $V_{OD2}$ | R = 50Ω (RS-422) | | 2 | | | V |
| | | R = 27Ω (RS-485), Figure 4 | | 1.5 | | 5 | |
| Change in Magnitude of Driver Differential Output Voltage for Complementary Output States | $\Delta V_{OD}$ | R = 27Ω or 50Ω, Figure 4 | | | | 0.2 | V |
| Driver Common-Mode Output Voltage | $V_{OC}$ | R = 27Ω or 50Ω, Figure 4 | | | | 3 | V |
| Change in Magnitude of Driver Common-Mode Output Voltage for Complementary Output States | $\Delta V_{OD}$ | R = 27Ω or 50Ω, Figure 4 | | | | 0.2 | V |
| Input High Voltage | $V_{IH}$ | DE, DI, $\overline{RE}$ | | 2.0 | | | V |
| Input Low Voltage | $V_{IL}$ | DE, DI, $\overline{RE}$ | | | | 0.8 | V |
| Input Current | $I_{IN1}$ | DE, DI, $\overline{RE}$ | | | | ±2 | μA |
| Input Current (A, B) | $I_{IN2}$ | DE = 0V; $V_{CC}$ = 0V or 5.25V, all devices except MAX487/MAX1487 | $V_{IN}$ = 12V | | | 1.0 | mA |
| | | | $V_{IN}$ = -7V | | | -0.8 | |
| | | MAX487/MAX1487, DE = 0V, $V_{CC}$ = 0V or 5.25V | $V_{IN}$ = 12V | | | 0.25 | mA |
| | | | $V_{IN}$ = -7V | | | -0.2 | |
| Receiver Differential Threshold Voltage | $V_{TH}$ | -7V ≤ $V_{CM}$ ≤ 12V | | -0.2 | | 0.2 | V |
| Receiver Input Hysteresis | $\Delta V_{TH}$ | $V_{CM}$ = 0V | | | 70 | | mV |
| Receiver Output High Voltage | $V_{OH}$ | $I_O$ = -4mA, $V_{ID}$ = 200mV | | 3.5 | | | V |
| Receiver Output Low Voltage | $V_{OL}$ | $I_O$ = 4mA, $V_{ID}$ = -200mV | | | | 0.4 | V |
| Three-State (high impedance) Output Current at Receiver | $I_{OZR}$ | 0.4V ≤ $V_O$ ≤ 2.4V | | | | ±1 | μA |
| Receiver Input Resistance | $R_{IN}$ | -7V ≤ $V_{CM}$ ≤ 12V, all devices except MAX487/MAX1487 | | 12 | | | kΩ |
| | | -7V ≤ $V_{CM}$ ≤ 12V, MAX487/MAX1487 | | 48 | | | kΩ |

## DC ELECTRICAL CHARACTERISTICS (continued)

($V_{CC}$ = 5V ±5%, $T_A$ = $T_{MIN}$ to $T_{MAX}$, unless otherwise noted.) (Notes 1, 2)

| PARAMETER | SYMBOL | CONDITIONS | | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|---|
| No-Load Supply Current (Note 3) | $I_{CC}$ | MAX488/MAX489, DE, DI, $\overline{RE}$ = 0V or $V_{CC}$ | | | | 120 | 250 | μA |
| | | MAX490/MAX491, DE, DI, $\overline{RE}$ = 0V or $V_{CC}$ | | | | 300 | 500 | |
| | | MAX481/MAX485, $\overline{RE}$ = 0V or $V_{CC}$ | DE = $V_{CC}$ | | | 500 | 900 | |
| | | | DE = 0V | | | 300 | 500 | |
| | | MAX1487, $\overline{RE}$ = 0V or $V_{CC}$ | DE = $V_{CC}$ | | | 300 | 500 | |
| | | | DE = 0V | | | 230 | 400 | |
| | | MAX483/MAX487, $\overline{RE}$ = 0V or $V_{CC}$ | DE = 5V | MAX483 | | 350 | 650 | |
| | | | | MAX487 | | 250 | 400 | |
| | | | DE = 0V | | | 120 | 250 | |
| Supply Current in Shutdown | $I_{SHDN}$ | MAX481/483/487, DE = 0V, $\overline{RE}$ = $V_{CC}$ | | | | 0.1 | 10 | μA |
| Driver Short-Circuit Current, $V_O$ = High | $I_{OSD1}$ | -7V ≤ $V_O$ ≤12V (Note 4) | | | 35 | | 250 | mA |
| Driver Short-Circuit Current, $V_O$ = Low | $I_{OSD2}$ | -7V ≤ $V_O$ ≤12V (Note 4) | | | 35 | | 250 | mA |
| Receiver Short-Circuit Current | $I_{OSR}$ | 0V ≤ $V_O$ ≤ $V_{CC}$ | | | 7 | | 95 | mA |

## SWITCHING CHARACTERISTICS—MAX481/MAX485, MAX490/MAX491, MAX1487

($V_{CC}$ = 5V ±5%, $T_A$ = $T_{MIN}$ to $T_{MAX}$, unless otherwise noted.) (Notes 1, 2)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| Driver Input to Output | $t_{PLH}$ | Figures 6 and 8, $R_{DIFF}$ = 54Ω, $C_{L1}$ = $C_{L2}$ = 100pF | | 10 | 30 | 60 | ns |
| | $t_{PHL}$ | | | 10 | 30 | 60 | |
| Driver Output Skew to Output | $t_{SKEW}$ | Figures 6 and 8, $R_{DIFF}$ = 54Ω, $C_{L1}$ = $C_{L2}$ = 100pF | | | 5 | 10 | ns |
| Driver Rise or Fall Time | $t_R$, $t_F$ | Figures 6 and 8, $R_{DIFF}$ = 54Ω, $C_{L1}$ = $C_{L2}$ = 100pF | MAX481, MAX485, MAX1487 | 3 | 15 | 40 | ns |
| | | | MAX490C/E, MAX491C/E | 5 | 15 | 25 | |
| | | | MAX490M, MAX491M | 3 | 15 | 40 | |
| Driver Enable to Output High | $t_{ZH}$ | Figures 7 and 9, $C_L$ = 100pF, S2 closed | | | 40 | 70 | ns |
| Driver Enable to Output Low | $t_{ZL}$ | Figures 7 and 9, $C_L$ = 100pF, S1 closed | | | 40 | 70 | ns |
| Driver Disable Time from Low | $t_{LZ}$ | Figures 7 and 9, $C_L$ = 15pF, S1 closed | | | 40 | 70 | ns |
| Driver Disable Time from High | $t_{HZ}$ | Figures 7 and 9, $C_L$ = 15pF, S2 closed | | | 40 | 70 | ns |
| Receiver Input to Output | $t_{PLH}$, $t_{PHL}$ | Figures 6 and 10, $R_{DIFF}$ = 54Ω, $C_{L1}$ = $C_{L2}$ = 100pF | MAX481, MAX485, MAX1487 | 20 | 90 | 200 | ns |
| | | | MAX490C/E, MAX491C/E | 20 | 90 | 150 | |
| | | | MAX490M, MAX491M | 20 | 90 | 200 | |
| $\lvert t_{PLH} - t_{PHL} \rvert$ Differential Receiver Skew | $t_{SKD}$ | Figures 6 and 10, $R_{DIFF}$ = 54Ω, $C_{L1}$ = $C_{L2}$ = 100pF | | | 13 | | ns |
| Receiver Enable to Output Low | $t_{ZL}$ | Figures 5 and 11, $C_{RL}$ = 15pF, S1 closed | | | 20 | 50 | ns |
| Receiver Enable to Output High | $t_{ZH}$ | Figures 5 and 11, $C_{RL}$ = 15pF, S2 closed | | | 20 | 50 | ns |
| Receiver Disable Time from Low | $t_{LZ}$ | Figures 5 and 11, $C_{RL}$ = 15pF, S1 closed | | | 20 | 50 | ns |
| Receiver Disable Time from High | $t_{HZ}$ | Figures 5 and 11, $C_{RL}$ = 15pF, S2 closed | | | 20 | 50 | ns |
| Maximum Data Rate | $f_{MAX}$ | | | 2.5 | | | Mbps |
| Time to Shutdown | $t_{SHDN}$ | MAX481 (Note 5) | | 50 | 200 | 600 | ns |

# Low-Power, Slew-Rate-Limited RS-485/RS-422 Transceivers

## SWITCHING CHARACTERISTICS—MAX481/MAX485, MAX490/MAX491, MAX1487 (continued)

($V_{CC}$ = 5V ±5%, $T_A$ = $T_{MIN}$ to $T_{MAX}$, unless otherwise noted.) (Notes 1, 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Driver Enable from Shutdown to Output High (MAX481) | $t_{ZH(SHDN)}$ | Figures 7 and 9, $C_L$ = 100pF, S2 closed | | 40 | 100 | ns |
| Driver Enable from Shutdown to Output Low (MAX481) | $t_{ZL(SHDN)}$ | Figures 7 and 9, $C_L$ = 100pF, S1 closed | | 40 | 100 | ns |
| Receiver Enable from Shutdown to Output High (MAX481) | $t_{ZH(SHDN)}$ | Figures 5 and 11, $C_L$ = 15pF, S2 closed, A - B = 2V | | 300 | 1000 | ns |
| Receiver Enable from Shutdown to Output Low (MAX481) | $t_{ZL(SHDN)}$ | Figures 5 and 11, $C_L$ = 15pF, S1 closed, B - A = 2V | | 300 | 1000 | ns |

## SWITCHING CHARACTERISTICS—MAX483, MAX487/MAX488/MAX489

($V_{CC}$ = 5V ±5%, $T_A$ = $T_{MIN}$ to $T_{MAX}$, unless otherwise noted.) (Notes 1, 2)

| PARAMETER | SYMBOL | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| Driver Input to Output | $t_{PLH}$ | Figures 6 and 8, $R_{DIFF}$ = 54Ω, $C_{L1}$ = $C_{L2}$ = 100pF | 250 | 800 | 2000 | ns |
| | $t_{PHL}$ | | 250 | 800 | 2000 | |
| Driver Output Skew to Output | $t_{SKEW}$ | Figures 6 and 8, $R_{DIFF}$ = 54Ω, $C_{L1}$ = $C_{L2}$ = 100pF | | 100 | 800 | ns |
| Driver Rise or Fall Time | $t_R$, $t_F$ | Figures 6 and 8, $R_{DIFF}$ = 54Ω, $C_{L1}$ = $C_{L2}$ = 100pF | 250 | | 2000 | ns |
| Driver Enable to Output High | $t_{ZH}$ | Figures 7 and 9, $C_L$ = 100pF, S2 closed | 250 | | 2000 | ns |
| Driver Enable to Output Low | $t_{ZL}$ | Figures 7 and 9, $C_L$ = 100pF, S1 closed | 250 | | 2000 | ns |
| Driver Disable Time from Low | $t_{LZ}$ | Figures 7 and 9, $C_L$ = 15pF, S1 closed | 300 | | 3000 | ns |
| Driver Disable Time from High | $t_{HZ}$ | Figures 7 and 9, $C_L$ = 15pF, S2 closed | 300 | | 3000 | ns |
| Receiver Input to Output | $t_{PLH}$ | Figures 6 and 10, $R_{DIFF}$ = 54Ω, $C_{L1}$ = $C_{L2}$ = 100pF | 250 | | 2000 | ns |
| | $t_{PHL}$ | | 250 | | 2000 | |
| $\lvert t_{PLH} - t_{PHL} \rvert$ Differential Receiver Skew | $t_{SKD}$ | Figures 6 and 10, $R_{DIFF}$ = 54Ω, $C_{L1}$ = $C_{L2}$ = 100pF | | 100 | | ns |
| Receiver Enable to Output Low | $t_{ZL}$ | Figures 5 and 11, $C_{RL}$ = 15pF, S1 closed | | 20 | 50 | ns |
| Receiver Enable to Output High | $t_{ZH}$ | Figures 5 and 11, $C_{RL}$ = 15pF, S2 closed | | 20 | 50 | ns |
| Receiver Disable Time from Low | $t_{LZ}$ | Figures 5 and 11, $C_{RL}$ = 15pF, S1 closed | | 20 | 50 | ns |
| Receiver Disable Time from High | $t_{HZ}$ | Figures 5 and 11, $C_{RL}$ = 15pF, S2 closed | | 20 | 50 | ns |
| Maximum Data Rate | $f_{MAX}$ | $t_{PLH}$, $t_{PHL}$ < 50% of data period | 250 | | | kbps |
| Time to Shutdown | $t_{SHDN}$ | MAX483/MAX487 (Note 5) | 50 | 200 | 600 | ns |
| Driver Enable from Shutdown to Output High | $t_{ZH(SHDN)}$ | MAX483/MAX487, Figures 7 and 9, $C_L$ = 100pF, S2 closed | | | 2000 | ns |
| Driver Enable from Shutdown to Output Low | $t_{ZL(SHDN)}$ | MAX483/MAX487, Figures 7 and 9, $C_L$ = 100pF, S1 closed | | | 2000 | ns |
| Receiver Enable from Shutdown to Output High | $t_{ZH(SHDN)}$ | MAX483/MAX487, Figures 5 and 11, $C_L$ = 15pF, S2 closed | | | 2500 | ns |
| Receiver Enable from Shutdown to Output Low | $t_{ZL(SHDN)}$ | MAX483/MAX487, Figures 5 and 11, $C_L$ = 15pF, S1 closed | | | 2500 | ns |

## NOTES FOR ELECTRICAL/SWITCHING CHARACTERISTICS

**Note 1:** All currents into device pins are positive; all currents out of device pins are negative. All voltages are referenced to device ground unless otherwise specified.

**Note 2:** All typical specifications are given for $V_{CC}$ = 5V and $T_A$ = +25°C.

**Note 3:** Supply current specification is valid for loaded transmitters when DE = 0V.

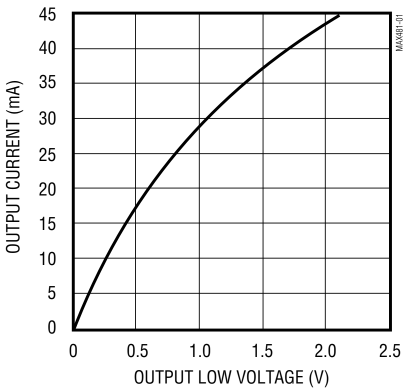
**Note 4:** Applies to peak current. See *Typical Operating Characteristics.*

**Note 5:** The MAX481/MAX483/MAX487 are put into shutdown by bringing $\overline{RE}$ high and DE low. If the inputs are in this state for less than 50ns, the parts are guaranteed not to enter shutdown. If the inputs are in this state for at least 600ns, the parts are guaranteed to have entered shutdown. See *Low-Power Shutdown Mode* section.

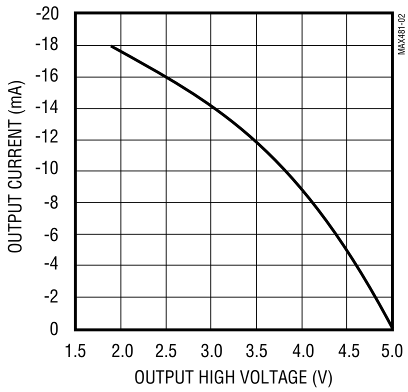
## Typical Operating Characteristics

($V_{CC}$ = 5V, $T_A$ = +25°C, unless otherwise noted.)

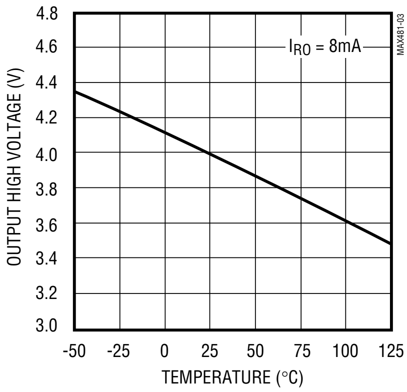
**OUTPUT CURRENT vs. RECEIVER OUTPUT LOW VOLTAGE**



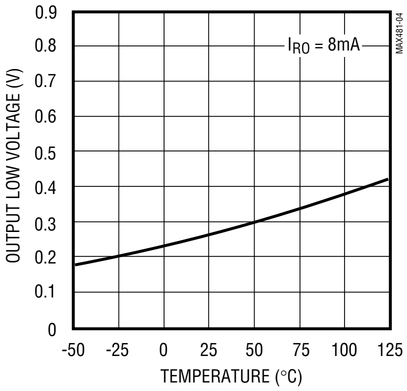

**OUTPUT CURRENT vs. RECEIVER OUTPUT HIGH VOLTAGE**



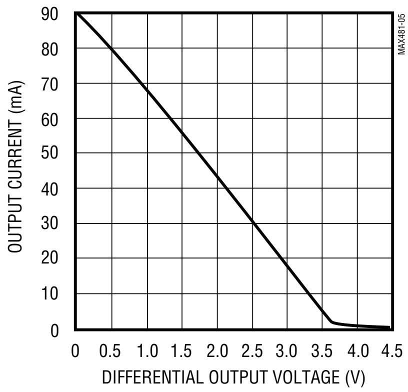

**RECEIVER OUTPUT HIGH VOLTAGE vs. TEMPERATURE**



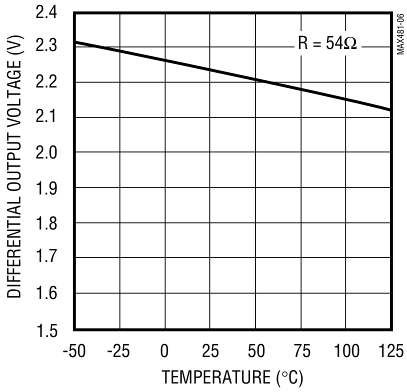

**RECEIVER OUTPUT LOW VOLTAGE vs. TEMPERATURE**




**DRIVER OUTPUT CURRENT vs. DIFFERENTIAL OUTPUT VOLTAGE**




**DRIVER DIFFERENTIAL OUTPUT VOLTAGE vs. TEMPERATURE**

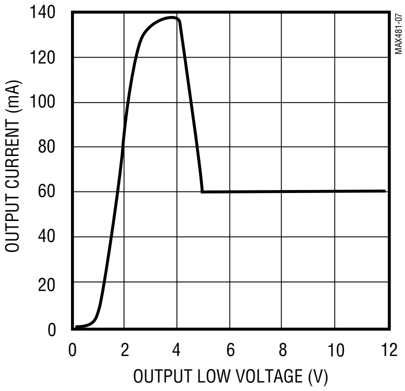


# Low-Power, Slew-Rate-Limited RS-485/RS-422 Transceivers

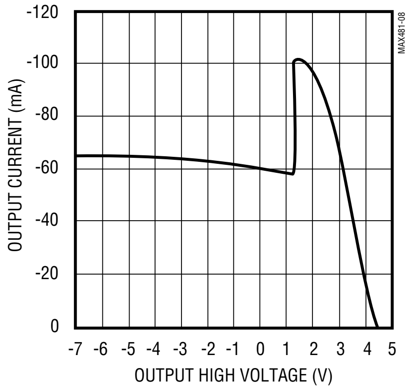
## Typical Operating Characteristics (continued)

($V_{CC}$ = 5V, $T_A$ = +25°C, unless otherwise noted.)

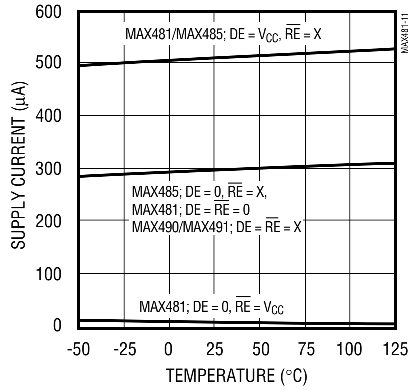
**OUTPUT CURRENT vs. DRIVER OUTPUT LOW VOLTAGE**



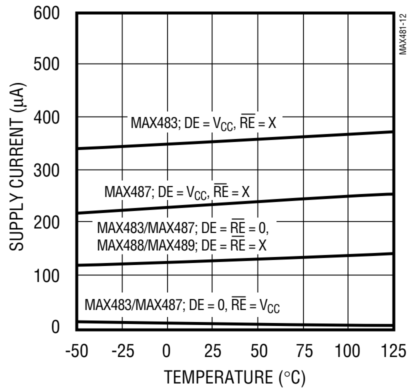

**OUTPUT CURRENT vs. DRIVER OUTPUT HIGH VOLTAGE**



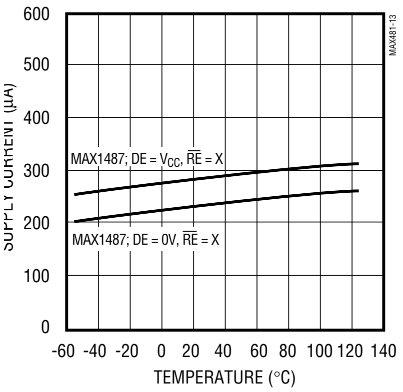

**MAX481/MAX485/MAX490/MAX491 SUPPLY CURRENT vs. TEMPERATURE**




**MAX483/MAX487–MAX489 SUPPLY CURRENT vs. TEMPERATURE**




**MAX1487 SUPPLY CURRENT vs. TEMPERATURE**



## Pin Description

| PIN | | | | | NAME | FUNCTION |
|---|---|---|---|---|---|---|
| MAX481/MAX483/ MAX485/MAX487/ MAX1487 | | MAX488/ MAX490 | | MAX489/ MAX491 | | |
| DIP/SO | µMAX | DIP/SO | µMAX | DIP/SO | | |
| 1 | 3 | 2 | 4 | 2 | RO | Receiver Output: If A > B by 200mV, RO will be high; If A < B by 200mV, RO will be low. |
| 2 | 4 | — | — | 3 | $\overline{RE}$ | Receiver Output Enable. RO is enabled when $\overline{RE}$ is low; RO is high impedance when $\overline{RE}$ is high. |
| 3 | 5 | — | — | 4 | DE | Driver Output Enable. The driver outputs, Y and Z, are enabled by bringing DE high. They are high impedance when DE is low. If the driver outputs are enabled, the parts function as line drivers. While they are high impedance, they function as line receivers if $\overline{RE}$ is low. |
| 4 | 6 | 3 | 5 | 5 | DI | Driver Input. A low on DI forces output Y low and output Z high. Similarly, a high on DI forces output Y high and output Z low. |
| 5 | 7 | 4 | 6 | 6, 7 | GND | Ground |
| — | — | 5 | 7 | 9 | Y | Noninverting Driver Output |
| — | — | 6 | 8 | 10 | Z | Inverting Driver Output |
| 6 | 8 | — | — | — | A | Noninverting Receiver Input and Noninverting Driver Output |
| — | — | 8 | 2 | 12 | A | Noninverting Receiver Input |
| 7 | 1 | — | — | — | B | Inverting Receiver Input and Inverting Driver Output |
| — | — | 7 | 1 | 11 | B | Inverting Receiver Input |
| 8 | 2 | 1 | 3 | 14 | $V_{CC}$ | Positive Supply: $4.75V \leq V_{CC} \leq 5.25V$ |
| — | — | — | — | 1, 8, 13 | N.C. | No Connect—not internally connected |

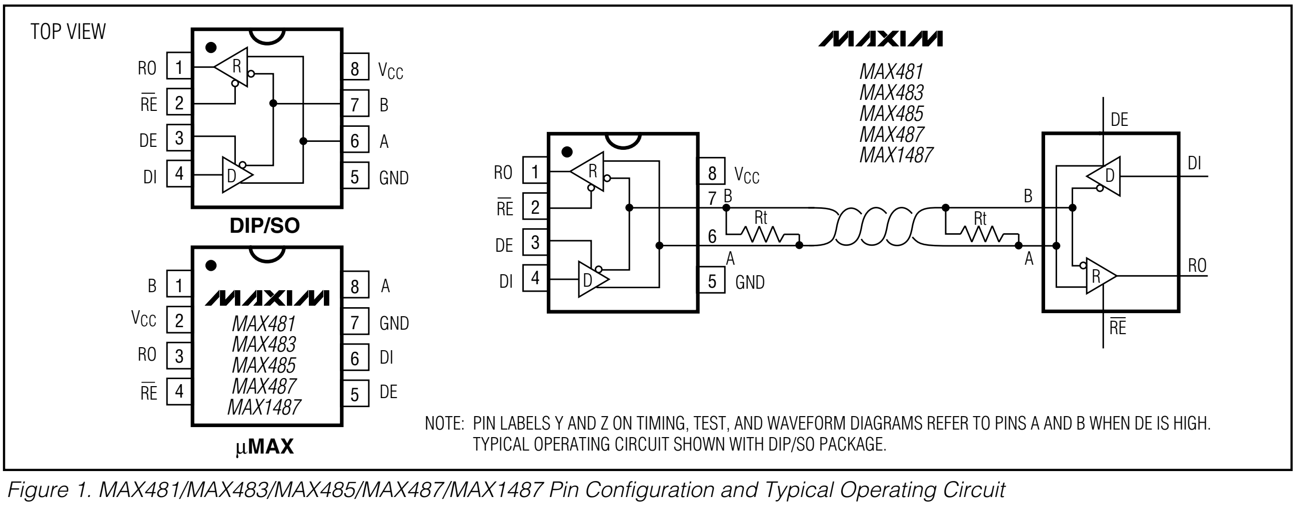



*Figure 1. MAX481/MAX483/MAX485/MAX487/MAX1487 Pin Configuration and Typical Operating Circuit*

# Low-Power, Slew-Rate-Limited RS-485/RS-422 Transceivers

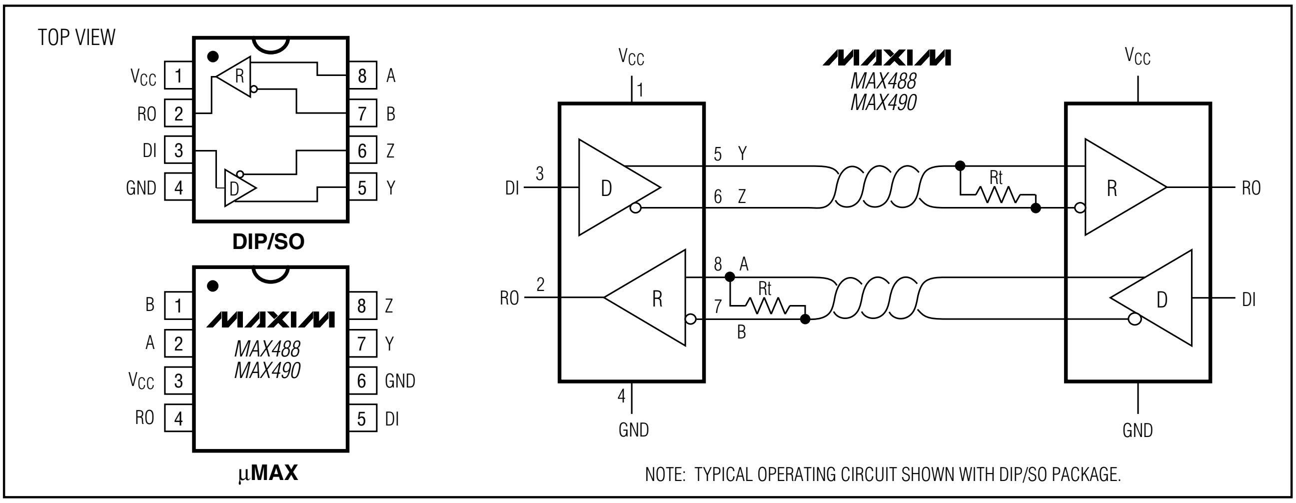



*Figure 2. MAX488/MAX490 Pin Configuration and Typical Operating Circuit*

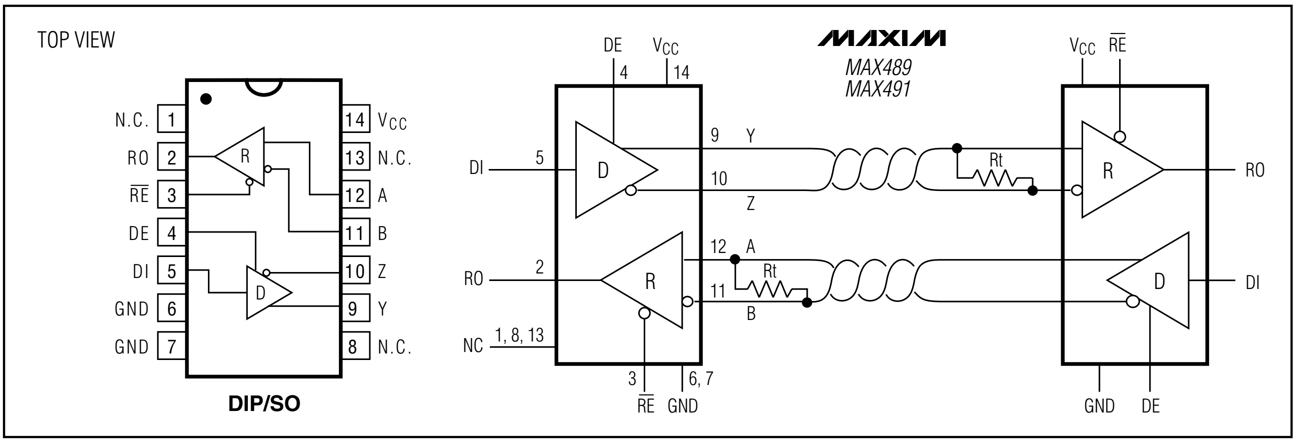



*Figure 3. MAX489/MAX491 Pin Configuration and Typical Operating Circuit*

## Applications Information

The MAX481/MAX483/MAX485/MAX487–MAX491 and MAX1487 are low-power transceivers for RS-485 and RS-422 communications. The MAX481, MAX485, MAX490, MAX491, and MAX1487 can transmit and receive at data rates up to 2.5Mbps, while the MAX483, MAX487, MAX488, and MAX489 are specified for data rates up to 250kbps. The MAX488–MAX491 are full-duplex transceivers while the MAX481, MAX483, MAX485, MAX487, and MAX1487 are half-duplex. In addition, Driver Enable (DE) and Receiver Enable (RE) pins are included on the MAX481, MAX483, MAX485, MAX487, MAX489, MAX491, and MAX1487. When disabled, the driver and receiver outputs are high impedance.

### MAX487/MAX1487: 128 Transceivers on the Bus

The 48kΩ, 1/4-unit-load receiver input impedance of the MAX487 and MAX1487 allows up to 128 transceivers on a bus, compared to the 1-unit load (12kΩ input impedance) of standard RS-485 drivers (32 transceivers maximum). Any combination of MAX487/MAX1487 and other RS-485 transceivers with a total of 32 unit loads or less can be put on the bus. The MAX481/MAX483/MAX485 and MAX488–MAX491 have standard 12kΩ Receiver Input impedance.

## Test Circuits

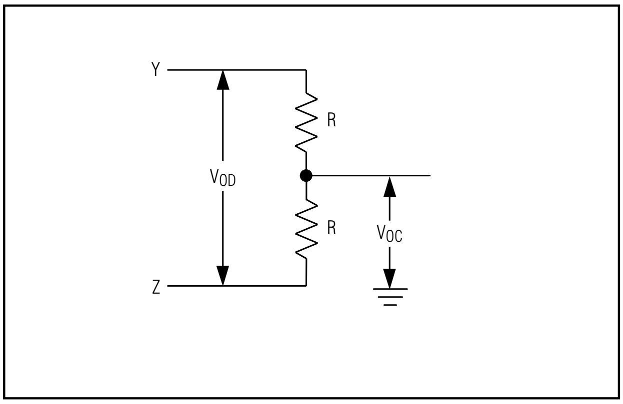



*Figure 4. Driver DC Test Load*

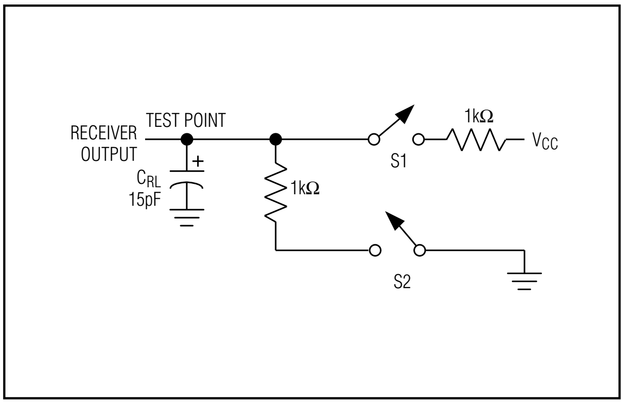



*Figure 5. Receiver Timing Test Load*

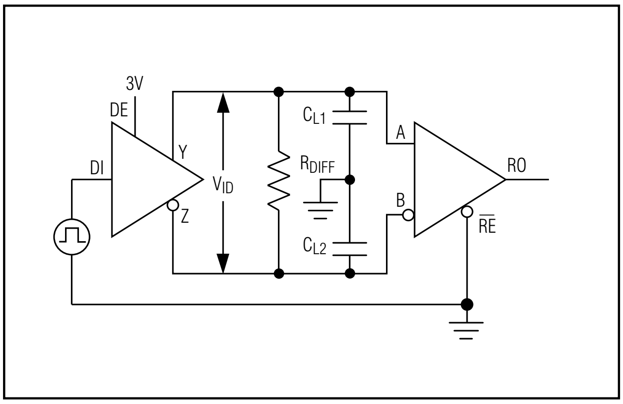



*Figure 6. Driver/Receiver Timing Test Circuit*

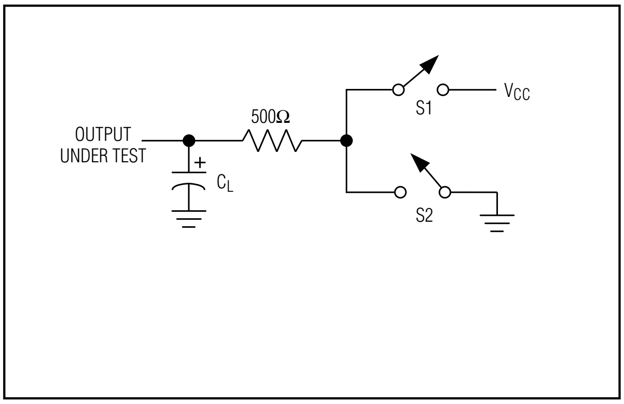



*Figure 7. Driver Timing Test Load*

### MAX483/MAX487/MAX488/MAX489: Reduced EMI and Reflections

The MAX483 and MAX487–MAX489 are slew-rate limited, minimizing EMI and reducing reflections caused by improperly terminated cables. Figure 12 shows the driver output waveform and its Fourier analysis of a 150kHz signal transmitted by a MAX481, MAX485, MAX490, MAX491, or MAX1487. High-frequency harmonics with large amplitudes are evident. Figure 13 shows the same information displayed for a MAX483, MAX487, MAX488, or MAX489 transmitting under the same conditions. Figure 13's high-frequency harmonics have much lower amplitudes, and the potential for EMI is significantly reduced.

# Low-Power, Slew-Rate-Limited RS-485/RS-422 Transceivers

## Switching Waveforms

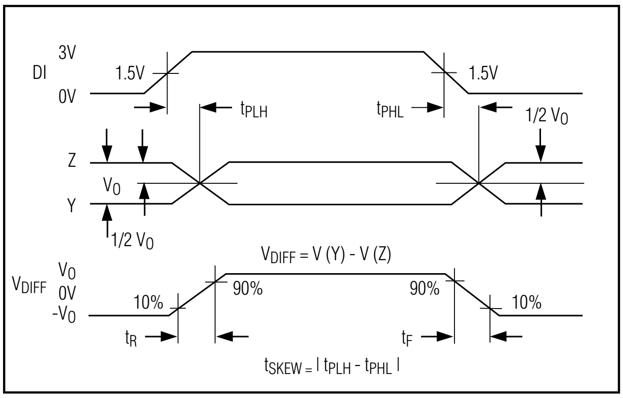



*Figure 8. Driver Propagation Delays*

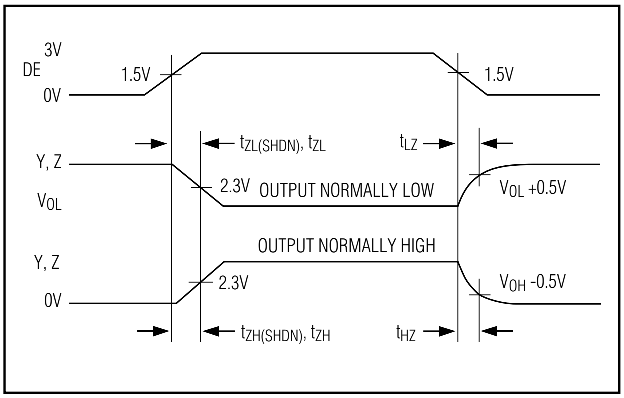



*Figure 9. Driver Enable and Disable Times (except MAX488 and MAX490)*

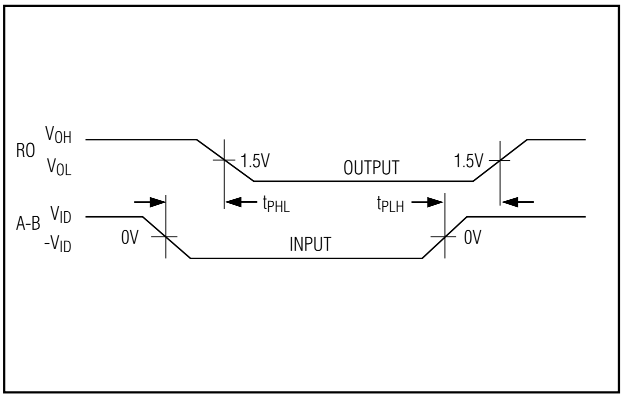



*Figure 10. Receiver Propagation Delays*

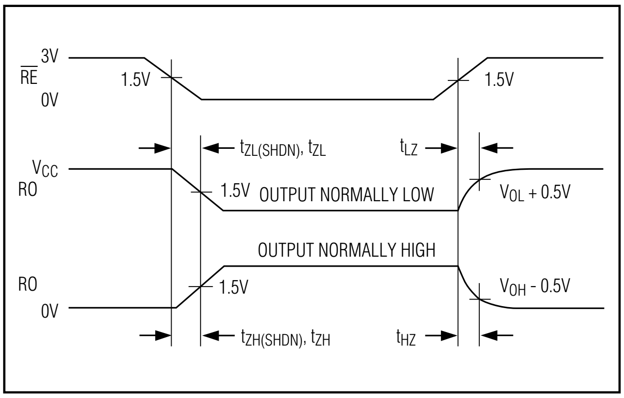



*Figure 11. Receiver Enable and Disable Times (except MAX488 and MAX490)*

## Function Tables (MAX481/MAX483/MAX485/MAX487/MAX1487)

### Table 1. Transmitting

| INPUTS | | | OUTPUTS | |
|---|---|---|---|---|
| $\overline{RE}$ | DE | DI | Z | Y |
| X | 1 | 1 | 0 | 1 |
| X | 1 | 0 | 1 | 0 |
| 0 | 0 | X | High-Z | High-Z |
| 1 | 0 | X | High-Z* | High-Z* |

X = Don't care
High-Z = High impedance
* Shutdown mode for MAX481/MAX483/MAX487

### Table 2. Receiving

| INPUTS | | | OUTPUT |
|---|---|---|---|
| $\overline{RE}$ | DE | A-B | RO |
| 0 | 0 | ≥ +0.2V | 1 |
| 0 | 0 | ≤ -0.2V | 0 |
| 0 | 0 | Inputs open | 1 |
| 1 | 0 | X | High-Z* |

X = Don't care
High-Z = High impedance
* Shutdown mode for MAX481/MAX483/MAX487

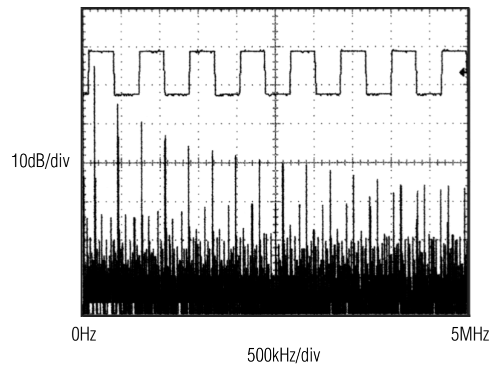



*Figure 12. Driver Output Waveform and FFT Plot of MAX481/MAX485/MAX490/MAX491/MAX1487 Transmitting a 150kHz Signal*

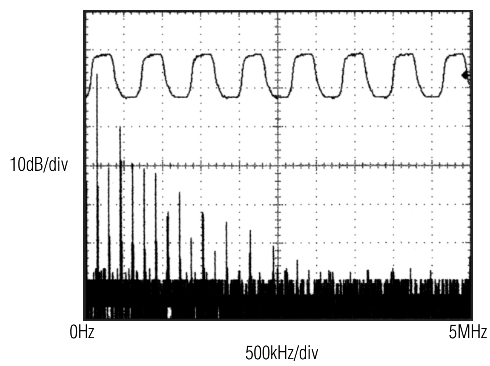



*Figure 13. Driver Output Waveform and FFT Plot of MAX483/MAX487–MAX489 Transmitting a 150kHz Signal*

### Low-Power Shutdown Mode (MAX481/MAX483/MAX487)

A low-power shutdown mode is initiated by bringing both $\overline{RE}$ high and DE low. The devices will not shut down unless both the driver and receiver are disabled. In shutdown, the devices typically draw only 0.1µA of supply current.

$\overline{RE}$ and DE may be driven simultaneously; the parts are guaranteed not to enter shutdown if $\overline{RE}$ is high and DE is low for less than 50ns. If the inputs are in this state for at least 600ns, the parts are guaranteed to enter shutdown.

For the MAX481, MAX483, and MAX487, the $t_{ZH}$ and $t_{ZL}$ enable times assume the part was not in the low-power shutdown state (the MAX485/MAX488–MAX491 and MAX1487 can not be shut down). The $t_{ZH(SHDN)}$ and $t_{ZL(SHDN)}$ enable times assume the parts were shut down (see *Electrical Characteristics*).

It takes the drivers and receivers longer to become enabled from the low-power shutdown state ($t_{ZH(SHDN)}$, $t_{ZL(SHDN)}$) than from the operating mode ($t_{ZH}$, $t_{ZL}$). (The parts are in operating mode if the $\overline{RE}$, DE inputs equal a logical 0,1 or 1,1 or 0, 0.)

### Driver Output Protection

Excessive output current and power dissipation caused by faults or by bus contention are prevented by two mechanisms. A foldback current limit on the output stage provides immediate protection against short circuits over the whole common-mode voltage range (see *Typical Operating Characteristics*). In addition, a thermal shutdown circuit forces the driver outputs into a high-impedance state if the die temperature rises excessively.

### Propagation Delay

Many digital encoding schemes depend on the difference between the driver and receiver propagation delay times. Typical propagation delays are shown in Figures 15–18 using Figure 14's test circuit.

The difference in receiver delay times, $| t_{PLH} - t_{PHL} |$, is typically under 13ns for the MAX481, MAX485, MAX490, MAX491, and MAX1487 and is typically less than 100ns for the MAX483 and MAX487–MAX489.

The driver skew times are typically 5ns (10ns max) for the MAX481, MAX485, MAX490, MAX491, and MAX1487, and are typically 100ns (800ns max) for the MAX483 and MAX487–MAX489.

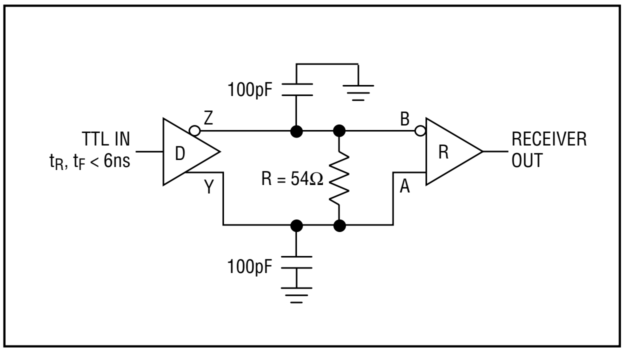



Figure 14. Receiver Propagation Delay Test Circuit

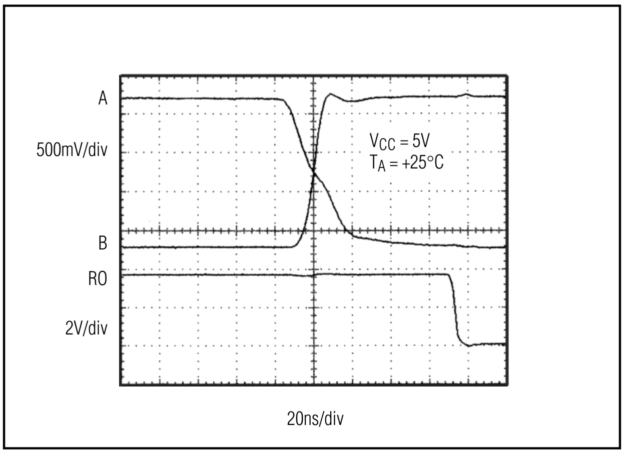



Figure 15. MAX481/MAX485/MAX490/MAX491/MAX1487 Receiver $t_{PHL}$

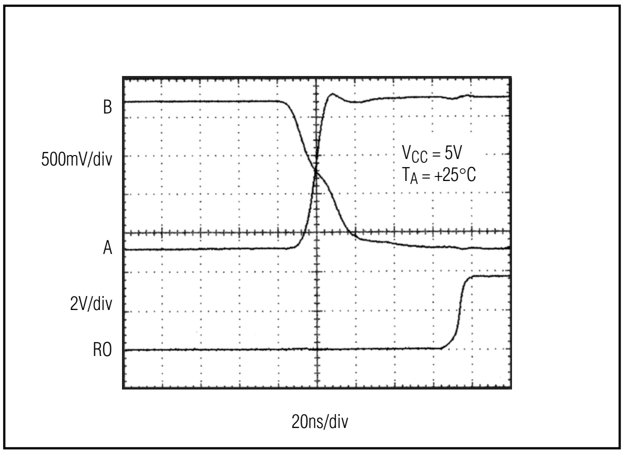



Figure 16. MAX481/MAX485/MAX490/MAX491/MAX1487 Receiver $t_{PLH}$

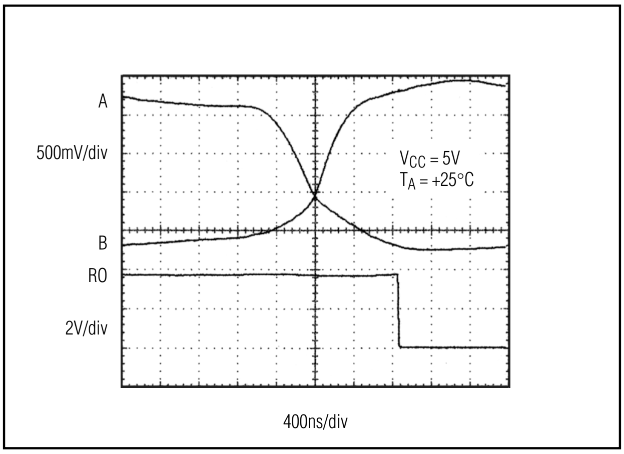



Figure 17. MAX483, MAX487–MAX489 Receiver $t_{PHL}$

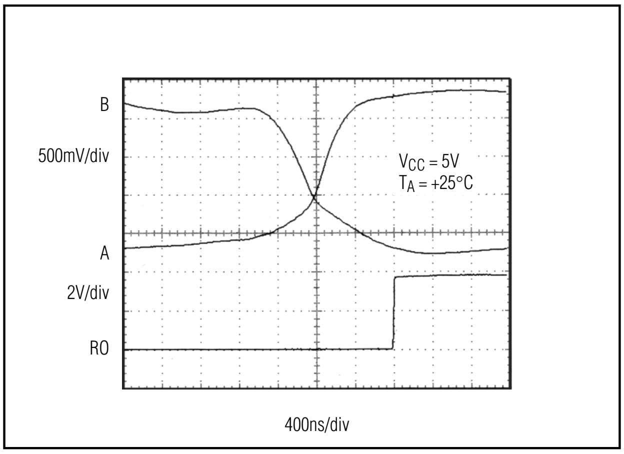



Figure 18. MAX483, MAX487–MAX489 Receiver $t_{PLH}$

### Line Length vs. Data Rate

The RS-485/RS-422 standard covers line lengths up to 4000 feet. For line lengths greater than 4000 feet, see Figure 23.

Figures 19 and 20 show the system differential voltage for the parts driving 4000 feet of 26AWG twisted-pair wire at 110kHz into 120Ω loads.

### Typical Applications

The MAX481, MAX483, MAX485, MAX487–MAX491, and MAX1487 transceivers are designed for bidirectional data communications on multipoint bus transmission lines. Figures 21 and 22 show typical network applications circuits. These parts can also be used as line repeaters, with cable lengths longer than 4000 feet, as shown in Figure 23.

To minimize reflections, the line should be terminated at both ends in its characteristic impedance, and stub lengths off the main line should be kept as short as possible. The slew-rate-limited MAX483 and MAX487–MAX489 are more tolerant of imperfect termination.

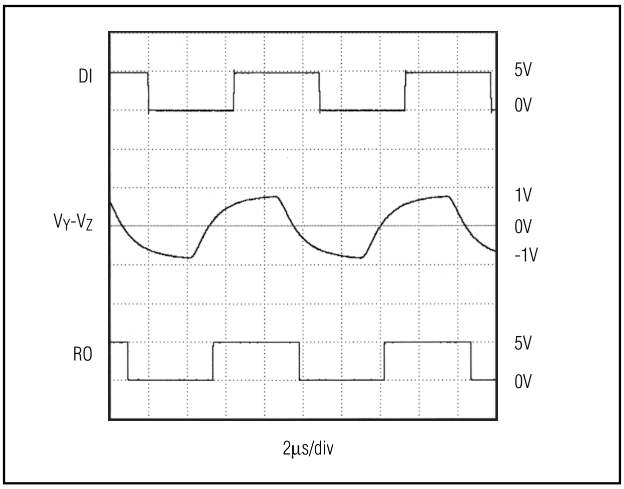



Figure 19. MAX481/MAX485/MAX490/MAX491/MAX1487 System Differential Voltage at 110kHz Driving 4000ft of Cable

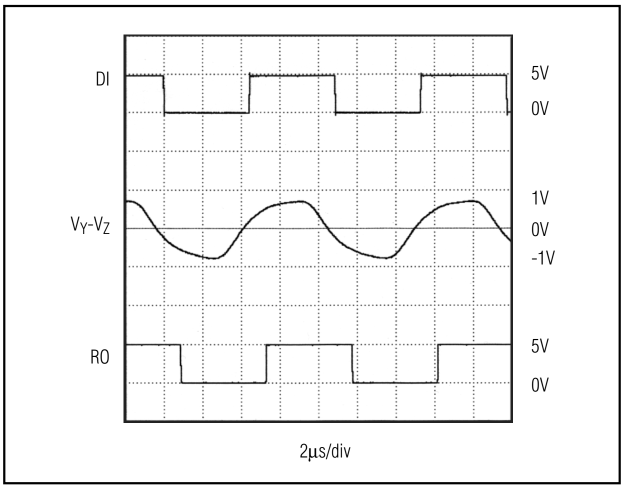



Figure 20. MAX483, MAX487–MAX489 System Differential Voltage at 110kHz Driving 4000ft of Cable

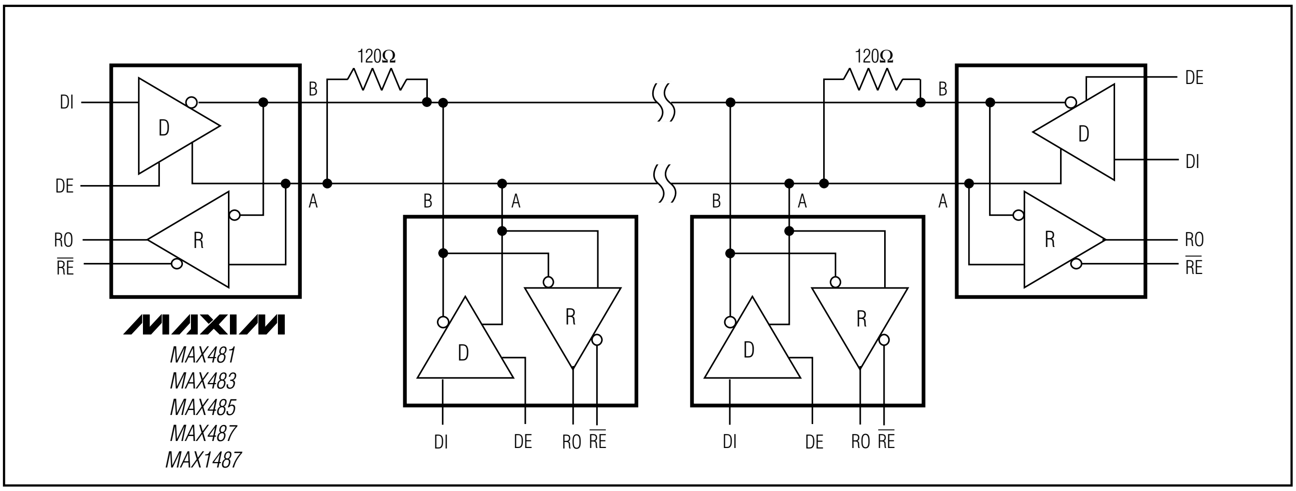



Figure 21. MAX481/MAX483/MAX485/MAX487/MAX1487 Typical Half-Duplex RS-485 Network

# Low-Power, Slew-Rate-Limited RS-485/RS-422 Transceivers

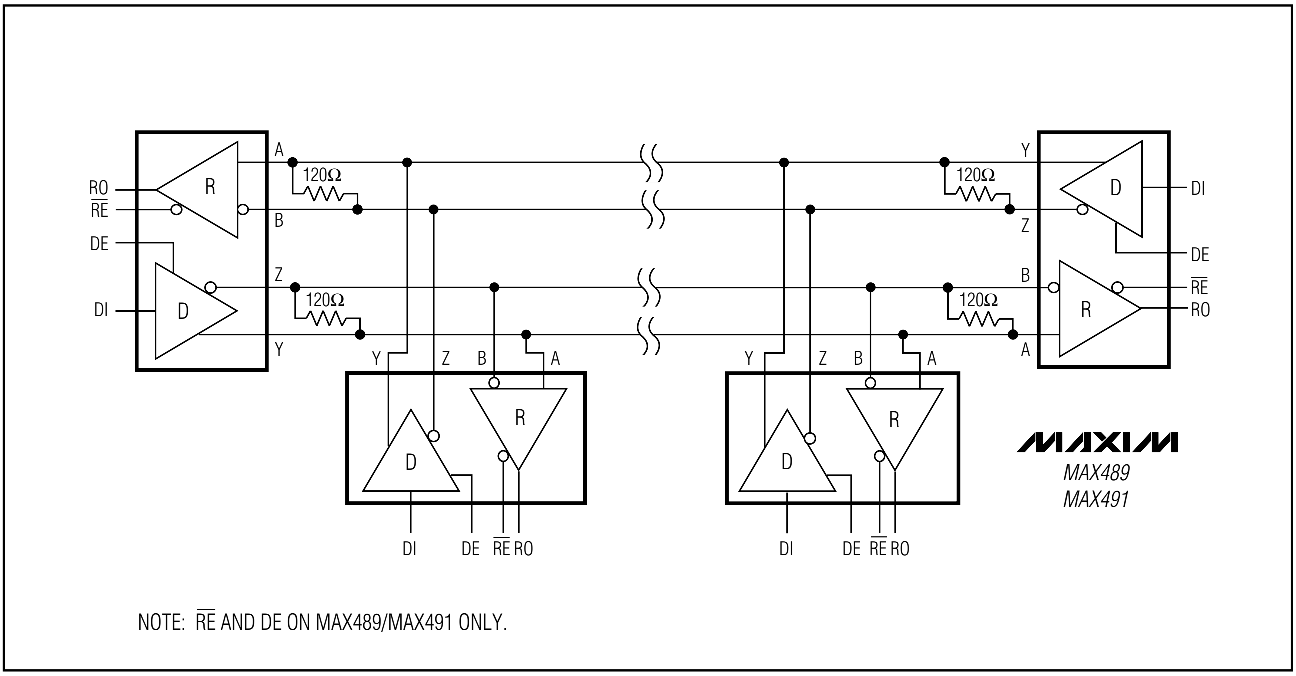



*Figure 22. MAX488–MAX491 Full-Duplex RS-485 Network*

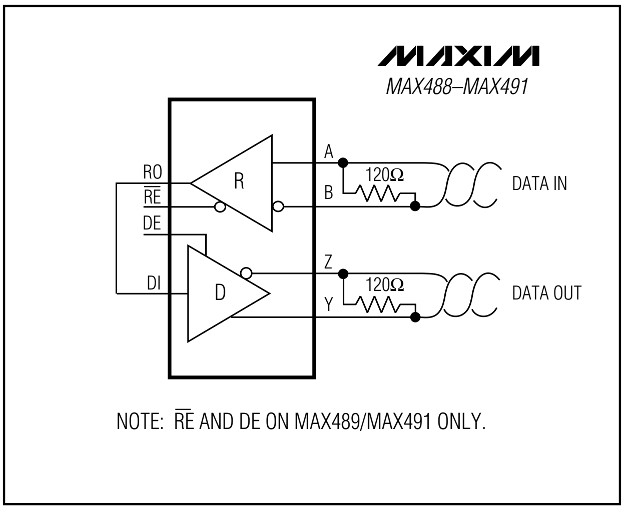



*Figure 23. Line Repeater for MAX488–MAX491*

### Isolated RS-485

For isolated RS-485 applications, see the MAX253 and MAX1480 data sheets.

## Ordering Information (continued)

| PART | TEMP. RANGE | PIN-PACKAGE |
|---|---|---|
| MAX481EPA | -40°C to +85°C | 8 Plastic DIP |
| MAX481ESA | -40°C to +85°C | 8 SO |
| MAX481MJA | -55°C to +125°C | 8 CERDIP |
| **MAX483**CPA | 0°C to +70°C | 8 Plastic DIP |
| MAX483CSA | 0°C to +70°C | 8 SO |
| MAX483CUA | 0°C to +70°C | 8 µMAX |
| MAX483C/D | 0°C to +70°C | Dice* |
| MAX483EPA | -40°C to +85°C | 8 Plastic DIP |
| MAX483ESA | -40°C to +85°C | 8 SO |
| MAX483MJA | -55°C to +125°C | 8 CERDIP |
| **MAX485**CPA | 0°C to +70°C | 8 Plastic DIP |
| MAX485CSA | 0°C to +70°C | 8 SO |
| MAX485CUA | 0°C to +70°C | 8 µMAX |
| MAX485C/D | 0°C to +70°C | Dice* |
| MAX485EPA | -40°C to +85°C | 8 Plastic DIP |
| MAX485ESA | -40°C to +85°C | 8 SO |
| MAX485MJA | -55°C to +125°C | 8 CERDIP |
| **MAX487**CPA | 0°C to +70°C | 8 Plastic DIP |
| MAX487CSA | 0°C to +70°C | 8 SO |
| MAX487CUA | 0°C to +70°C | 8 µMAX |
| MAX487C/D | 0°C to +70°C | Dice* |
| MAX487EPA | -40°C to +85°C | 8 Plastic DIP |
| MAX487ESA | -40°C to +85°C | 8 SO |
| MAX487MJA | -55°C to +125°C | 8 CERDIP |
| **MAX488**CPA | 0°C to +70°C | 8 Plastic DIP |
| MAX488CSA | 0°C to +70°C | 8 SO |
| MAX488CUA | 0°C to +70°C | 8 µMAX |
| MAX488C/D | 0°C to +70°C | Dice* |
| MAX488EPA | -40°C to +85°C | 8 Plastic DIP |
| MAX488ESA | -40°C to +85°C | 8 SO |
| MAX488MJA | -55°C to +125°C | 8 CERDIP |
| **MAX489**CPD | 0°C to +70°C | 14 Plastic DIP |
| MAX489CSD | 0°C to +70°C | 14 SO |
| MAX489C/D | 0°C to +70°C | Dice* |
| MAX489EPD | -40°C to +85°C | 14 Plastic DIP |
| MAX489ESD | -40°C to +85°C | 14 SO |
| MAX489MJD | -55°C to +125°C | 14 CERDIP |

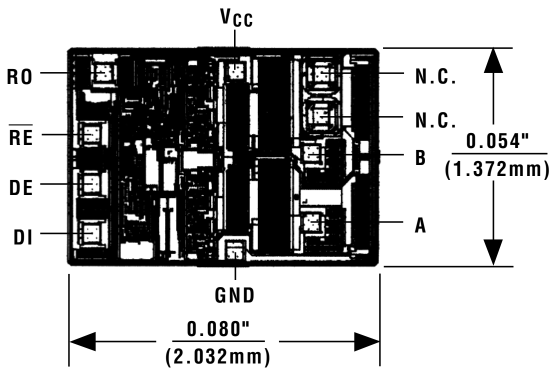
## Ordering Information (continued)

| PART | TEMP. RANGE | PIN-PACKAGE |
|---|---|---|
| **MAX490**CPA | 0°C to +70°C | 8 Plastic DIP |
| MAX490CSA | 0°C to +70°C | 8 SO |
| MAX490CUA | 0°C to +70°C | 8 µMAX |
| MAX490C/D | 0°C to +70°C | Dice* |
| MAX490EPA | -40°C to +85°C | 8 Plastic DIP |
| MAX490ESA | -40°C to +85°C | 8 SO |
| MAX490MJA | -55°C to +125°C | 8 CERDIP |
| **MAX491**CPD | 0°C to +70°C | 14 Plastic DIP |
| MAX491CSD | 0°C to +70°C | 14 SO |
| MAX491C/D | 0°C to +70°C | Dice* |
| MAX491EPD | -40°C to +85°C | 14 Plastic DIP |
| MAX491ESD | -40°C to +85°C | 14 SO |
| MAX491MJD | -55°C to +125°C | 14 CERDIP |
| **MAX1487**CPA | 0°C to +70°C | 8 Plastic DIP |
| MAX1487CSA | 0°C to +70°C | 8 SO |
| MAX1487CUA | 0°C to +70°C | 8 µMAX |
| MAX1487C/D | 0°C to +70°C | Dice* |
| MAX1487EPA | -40°C to +85°C | 8 Plastic DIP |
| MAX1487ESA | -40°C to +85°C | 8 SO |
| MAX1487MJA | -55°C to +125°C | 8 CERDIP |

** Contact factory for dice specifications.*

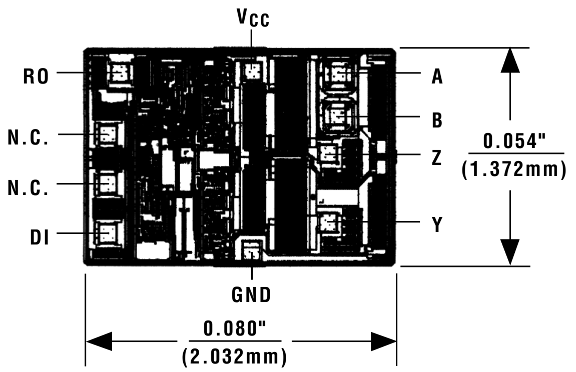
## Chip Topographies

**MAX481/MAX483/MAX485/MAX487/MAX1487**

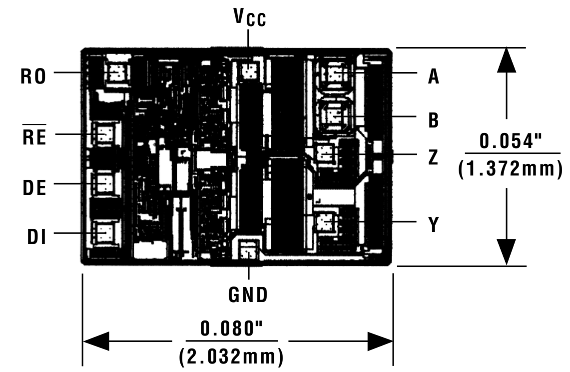


## Chip Topographies (continued)

MAX488/MAX490




MAX489/MAX491




TRANSISTOR COUNT: 248

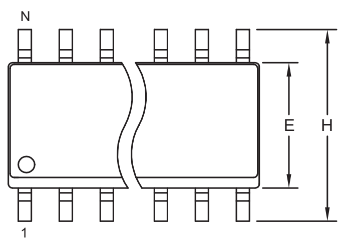
SUBSTRATE CONNECTED TO GND

## Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to **www.maxim-ic.com/packages**.)

SOICN .EPS

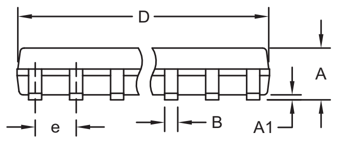
| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | 0.053 | 0.069 | 1.35 | 1.75 |
| A1 | 0.004 | 0.010 | 0.10 | 0.25 |
| B | 0.014 | 0.019 | 0.35 | 0.49 |
| C | 0.007 | 0.010 | 0.19 | 0.25 |
| e | 0.050 BSC | | 1.27 BSC | |
| E | 0.150 | 0.157 | 3.80 | 4.00 |
| H | 0.228 | 0.244 | 5.80 | 6.20 |
| L | 0.016 | 0.050 | 0.40 | 1.27 |



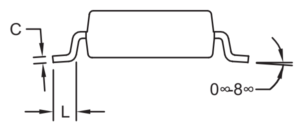

TOP VIEW

VARIATIONS:

| | INCHES | | MILLIMETERS | | | |
|---|---|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX | N | MS012 |
| D | 0.189 | 0.197 | 4.80 | 5.00 | 8 | AA |
| D | 0.337 | 0.344 | 8.55 | 8.75 | 14 | AB |
| D | 0.386 | 0.394 | 9.80 | 10.00 | 16 | AC |




FRONT VIEW




SIDE VIEW

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm (.006").
3. LEADS TO BE COPLANAR WITHIN 0.10mm (.004").
4. CONTROLLING DIMENSION: MILLIMETERS.
5. MEETS JEDEC MS012.
6. N = NUMBER OF PINS.

DALLAS SEMICONDUCTOR MAXIM

PROPRIETARY INFORMATION

TITLE:

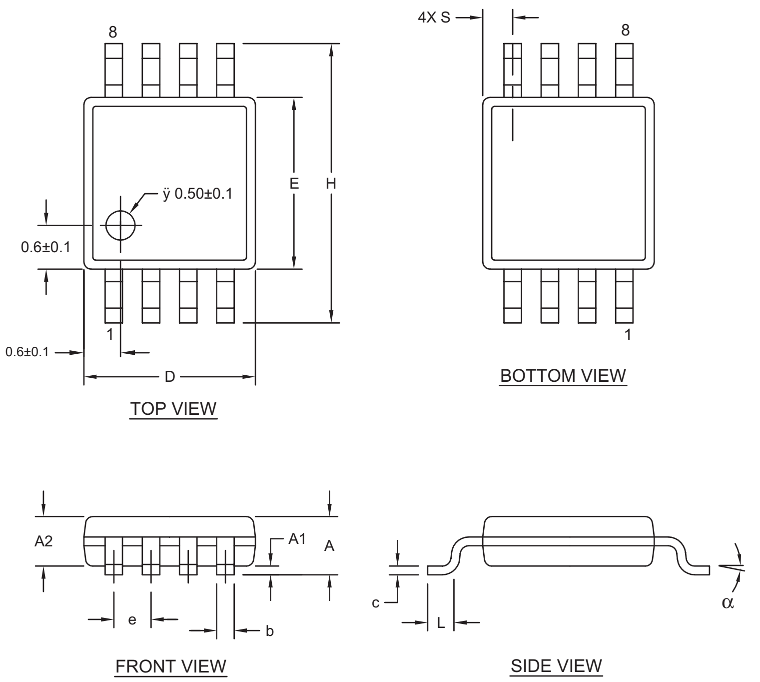
PACKAGE OUTLINE, .150" SOIC

| APPROVAL | DOCUMENT CONTROL NO. | REV. | |
|---|---|---|---|
| | 21-0041 | B | 1/1 |

## Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to **www.maxim-ic.com/packages**.)

8LUMAXD.EPS




| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | - | 0.043 | - | 1.10 |
| A1 | 0.002 | 0.006 | 0.05 | 0.15 |
| A2 | 0.030 | 0.037 | 0.75 | 0.95 |
| b | 0.010 | 0.014 | 0.25 | 0.36 |
| c | 0.005 | 0.007 | 0.13 | 0.18 |
| D | 0.116 | 0.120 | 2.95 | 3.05 |
| e | 0.0256 BSC | | 0.65 BSC | |
| E | 0.116 | 0.120 | 2.95 | 3.05 |
| H | 0.188 | 0.198 | 4.78 | 5.03 |
| L | 0.016 | 0.026 | 0.41 | 0.66 |
| α | 0∞ | 6∞ | 0∞ | 6∞ |
| S | 0.0207 BSC | | 0.5250 BSC | |

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15MM (.006").
3. CONTROLLING DIMENSION: MILLIMETERS.
4. MEETS JEDEC MO-187C-AA.

DALLAS SEMICONDUCTOR MAXIM

PROPRIETARY INFORMATION

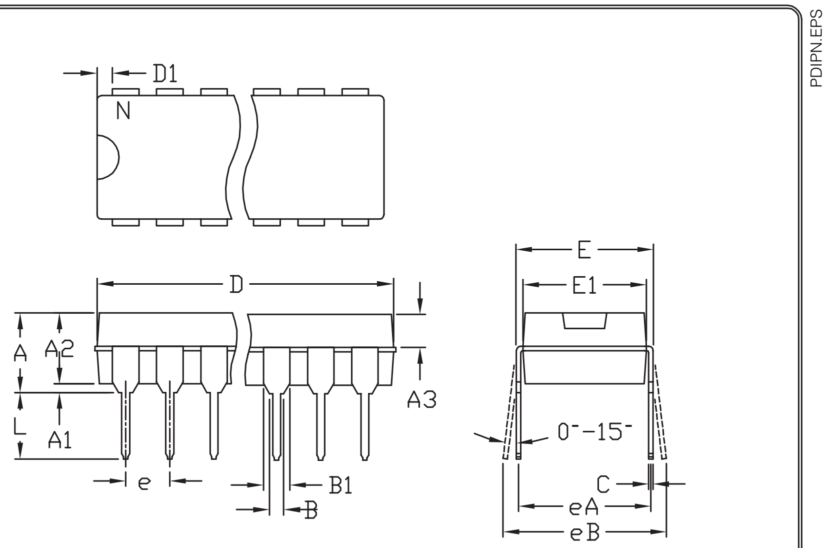
TITLE:

PACKAGE OUTLINE, 8L uMAX/uSOP

| APPROVAL | DOCUMENT CONTROL NO. | REV. | |
|---|---|---|---|
| | 21-0036 | J | 1/1 |

## Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to **www.maxim-ic.com/packages**.)




| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | --- | 0.180 | --- | 4.572 |
| A1 | 0.015 | --- | 0.38 | --- |
| A2 | 0.125 | 0.175 | 3.18 | 4.45 |
| A3 | 0.055 | 0.080 | 1.40 | 2.03 |
| B | 0.015 | 0.022 | 0.381 | 0.56 |
| B1 | 0.045 | 0.065 | 1.14 | 1.65 |
| C | 0.008 | 0.014 | 0.2 | 0.355 |
| D1 | 0.005 | 0.080 | 0.13 | 2.03 |
| E | 0.300 | 0.325 | 7.62 | 8.26 |
| E1 | 0.240 | 0.310 | 6.10 | 7.87 |
| e | 0.100 BSC. | | 2.54 BSC. | |
| eA | 0.300 BSC. | | 7.62 BSC. | |
| eB | 0.400 BSC. | | 10.16 BSC. | |
| L | 0.115 | 0.150 | 2.921 | 3.81 |

| | INCHES | | MILLIMETERS | | | |
|---|---|---|---|---|---|---|
| | MIN | MAX | MIN | MAX | N | MS001 |
| D | 0.348 | 0.390 | 8.84 | 9.91 | 8 | AB |
| D | 0.735 | 0.765 | 18.67 | 19.43 | 14 | AC |
| D | 0.745 | 0.765 | 18.92 | 19.43 | 16 | AA |
| D | 0.885 | 0.915 | 22.48 | 23.24 | 18 | AD |
| D | 1.015 | 1.045 | 25.78 | 26.54 | 20 | AE |
| D | 1.14 | 1.265 | 28.96 | 32.13 | 24 | AF |
| D | 1.360 | 1.380 | 34.54 | 35.05 | 28 | *5 |

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006")
3. CONTROLLING DIMENSION: MILLIMETER
4. MEETS JEDEC MS001-XX AS SHOWN IN ABOVE TABLE
5. SIMILIAR TO JEDEC MO-058AB
6. N = NUMBER OF PINS

MAXIM 120 SAN GABRIEL DR. SUNNYVALE CA 94086 FAX (408) 737 7194 PROPRIETARY INFORMATION | TITLE: PACKAGE FAMILY OUTLINE: PDIP .300" | 1/1 | DOCUMENT CONTROL NUMBER: 21-0043 | REV: D