National Semiconductor

July 2000

DS481
Low Power RS-485/RS-422 Multipoint Transceiver with Sleep Mode

General Description

The DS481 is a low-power transceiver for RS-485 and RS-422 communication. The device contains one driver and one receiver. The drivers slew rate allows for operation up to 2.0 Mbps (see Applications Information section).

The transceiver draws 200 µA of supply current when unloaded or 0.2 µA when in the automatic sleep mode. Sleep mode is activated by inactivity on the enables (DE and RE (Note 1)). Holding DE =L and RE (Note 1)=H for greater than 600 ns will enable the sleep mode. The DS481 operates from a single +5V supply.

The driver is short-circuit current limited and is protected against excessive power dissipation by thermal shutdown circuitry that places the driver outputs into TRI-STATE® (High Impedance state) under fault conditions. The driver guarantees a minimum of 1.5V differential output voltage with maximum loading across the common mode range (V_{OD3}).

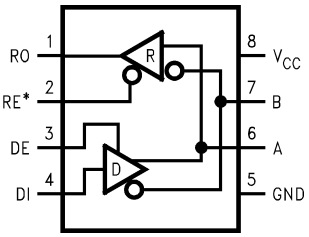
The receiver has a failsafe feature that guarantees a logic-high output if the input is open circuit.

The DS481 is available in a surface mount package and is characterized for Industrial temperature range operation.

Features

- Meets TIA/EIA RS-485 multipoint standard
- Sleep mode reduces I_{CC} to 0.2 µA
- Guaranteed full load output voltage (V_{OD3})
- Low quiescent current: 200 µA typ
- −7V to +12V common-mode input voltage range
- TRI-STATE outputs on driver and receiver
- AC performance:
  - — Driver transition time: 25 ns typ
  - — Driver propagation delay: 40 ns typ
  - — Driver skew: 1 ns typ
  - — Receiver propagation delay: 200 ns typ
  - — Receiver skew: 20 ns typ
- Half-duplex flow through pinout
- Operates from a single 5V supply
- Allows up to 64 tranceivers on the bus
- Current-limiting and thermal shutdown for driver overload protection
- Industrial temperature range operation
- Pin and functional compatible with MAX481C and MAX481E

Connection and Logic Diagram



01291901

*Note: Non Terminated, Open Input only

Order Number	Temp. Range	Package/###
DS481TM	−40˚C to +85˚C	SOP/M08A

Truth Table

DRIVER SECTION				
RE (Note 1)	**DE**	**DI**	**A**	**B**
X	H	H	H	L
X	H	L	L	H
X	L	X	Z	Z (Note 2)
RECEIVER SECTION				
RE (Note 1)	**DE**	**A-B**		**RO**
L	L	≥+0.2V		H
L	L	≤−0.2V		L
H	X	X		Z (Note 2)
L	L	OPEN (Note 1)		H

X = indeterminate
Z = TRI-STATE

Note 1: Non Terminated, Open Input only

Note 2: Device enters sleep mode if enable conditions are held > 600 ns, DE = L and RE (Note 1) = H.

TRI-STATE® is a registered trademark of National Semiconductor Corporation.

Absolute Maximum Ratings (Note 3)

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

Supply Voltage (V_{CC})	+12V
Enable Input Voltage (RE (Note 1), DE)	−0.5V to (V_{CC} + 0.5V)
Driver Input Voltage (DI)	−0.5V to (V_{CC} + 0.5V)
Driver Output Voltage (A, B)	−14V to +14V
Receiver Input Voltage (A, B)	−14V to +14V
Receiver Output Voltage (RO)	−0.5V to (V_{CC} + 0.5V)
Maximum Package Power Dissipation @ +25˚C	
M Package	1.19W
Derate M Package 9.5 mW/˚C above +25˚C	
Maximum Package Power Dissipation @ +70˚C	
M Package	0.76W
Storage Temperature Range	−65˚C to +150˚C
Lead Temperature Range (Soldering, 4 sec.)	+260˚C
ESD (HBM)	≥2 kV

Recommended Operating Conditions

	Min	Typ	Max	Units
Supply Voltage (V_{CC})	+4.75	+5.0	+5.25	V
Operating Free Air Temperature (T_A)				
DS481T	−40	+25	+85	˚C
Bus Common Mode Voltage	−7		+12	V

Electrical Characteristics

Over Supply Voltage and Operating Temperature Ranges, unless otherwise specified (Notes 4, 5)

Symbol	Parameter	Conditions		Pin	Min	Typ	Max	Units
V_{OD1}	Differential Driver Output Voltage	(No Load)		A, B	1.5		5	V
V_{OD2}	Differential Driver Output Voltage with Load	R_L = 50Ω, (RS422), *Figure 1*			2	2.8		V
		R_L = 27Ω, (RS485), *Figure 1*			1.5	2.3	5	V
ΔV_{OD}	Change in Magnitude of Output Differential Voltage	R_L = 27Ω or 50Ω (Note 6)					0.2	|V|
V_{OD3}	Differential Driver Output Voltage— Full Load with Max V_{CM}	R1 = 54Ω, R2 = 375Ω V_{TEST} = −7V to +12V, *Figure 2*			1.5	2.0	5	V
V_{OC}	Driver Common-Mode Output Voltage	R_L = 27Ω or 50Ω, *Figure 1*			0		3	V
ΔV_{OC}	Change in Magnitude of Common-Mode Output Voltage	R_L = 27Ω or 50Ω, *Figure 1* (Note 6)					0.2	|V|
V_{IH}	Input High Voltage			DI, DE, RE (Note 1)	2.0			V
V_{IL}	Input Low Voltage						0.8	V
I_{IN1}	Input Current	V_{IN} = 0V or V_{CC}					±2	µA
I_{IN2}	Input Current (Note 7) DE = 0V, V_{CC} = 0V or 5.25V	V_{IN} = +12V	DS481T	A, B	0	190	500	µA
		V_{IN} = −7V			0	−100	−400	µA
V_{TH}	Receiver Differential Threshold Voltage	−7V ≤ V_{CM} ≤ +12V			−0.2		0.2	V
ΔV_{TH}	Receiver Input Hysteresis	V_{CM} = 0V				70		mV
V_{OH}	Receiver Output High Voltage	I_O = −4 mA, V_{ID} = 0.2V		RO	3.5			V
V_{OL}	Receiver Output Low Voltage	I_O = 4 mA, V_{ID} = −0.2V					0.5	V
I_{OZR}	TRI-STATE Output Current at Receiver	0.4V ≤ V_O ≤ 2.4V					±1	µA
R_{IN}	Receiver Input Resistance	−7V ≤ V_{IN} ≤ +12V	DS481T	A, B	24			kΩ
I_{CC}	No-Load Supply Current (Note 8)	DE = V_{CC}, RE (Note 1) = 0V or V_{CC}		V_{CC}		200	500	µA
		DE = 0V, RE (Note 1) = 0V or V_{CC}				200	500	µA
I_{CCX}	Sleep Mode Supply Current	DE = GND RE (Note 1)= V_{CC} *(Figure 14)*		V_{CC}		0.2	10	µA
I_{OSD1}	Driver Short Circuit Current, V_O = HIGH	−7V ≤ V_O ≤ +12V		A, B			250	mA
I_{OSD2}	Driver Short Circuit Current, V_O = LOW	−7V ≤ V_O ≤ +12V					−250	mA
I_{OSR}	Receiver Short Circuit Current	V_O = GND		RO	7		85	mA

Switching Characteristics

Over Supply Voltage and Operating Temperature Ranges, unless otherwise specified (Notes 5, 9, 10)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{PLHD}	Driver Differential Propagation Delay—Low to High	R_L = 54Ω, C_L = 100 pF	10	40	80	ns
t_{PHLD}	Driver Differential Propagation Delay—High to Low		10	39	80	ns
t_{SKEW}	Differential Skew $\|t_{PHLD} - t_{PLHD}\|$		0	1	10	ns
t_r	Driver Rise Time		3	25	50	ns
t_f	Driver Fall Time		3	25	50	ns
t_{ZH}	Driver Enable to Output High	C_L = 100 pF		50	200	ns
t_{ZL}	Driver Enable to Output Low	C_L = 100 pF		65	200	ns
t_{LZ}	Driver Disable from Output Low	C_L = 15 pF		80	200	ns
t_{HZ}	Driver Disable from Output High	C_L = 15 pF		80	200	ns
t_{PSH}	Driver Enable from Sleep Mode to Output High	C_L = 100 pF (Note 12) *(Figures 5, 6)*	70	98	250	ns
t_{PSL}	Driver Enable from Sleep Mode to Output Low	C_L = 100 pF (Note 12) *(Figures 7, 8)*	70	98	250	ns
t_{PLHD}	Receiver Differential Propagation Delay—Low to High	C_L = 15 pF (RO)	30	190	400	ns
t_{PHLD}	Receiver Differential Propagation Delay—High to Low		30	210	400	ns
t_{SKEW}	Differential Skew $\|t_{PHLD} - t_{PLHD}\|$		0	20	50	ns
t_{ZH}	Receiver Enable to Output High	C_L = 15 pF		45	150	ns
t_{ZL}	Receiver Enable to Output Low			40	150	ns
t_{LZ}	Receiver Disable from Output Low			50	150	ns
t_{HZ}	Receiver Disable from Output High			55	150	ns
t_{PSH}	Receiver Enable from Sleep Mode to Output High	C_L = 15 pF (Note 12) *(Figures 11, 13)*	70	97	250	ns
t_{PSL}	Receiver Enable from Sleep Mode to Output Low	C_L = 15 pF (Note 12) *(Figures 11, 12)*	70	95	250	ns
t_{SLEEP}	Time to Sleep (Device)	DE = L and RE (Note 1) = H *(Figure 14)*	50		600	ns
f_{max}	Maximum Data Rate	(Note 11)	2.0			Mbps

Note 3: "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 4: Current into device pins is defined as positive. Current out of device pins is defined as negative. All voltages are referenced to ground except $V_{OD1/2/3}$ and V_{ID}.

Note 5: All typicals are given for: V_{CC} = +5.0V, T_A = +25˚C.

Note 6: $\Delta|V_{OD}|$ and $\Delta|V_{OC}|$ are changes in magnitude of V_{OD} and V_{OC} respectively, that occur when the input changes state.

Note 7: I_{IN2} includes the receiver input current and driver TRI-STATE leakage current.

Note 8: Supply current specification is valid for loaded transmitters when DE = 0V or enabled (DE = H) with no load.

Note 9: f = 1 MHz, t_r and $t_f \leq 6$ ns, Z_O = 50Ω.

Note 10: C_L includes jig and probe capacitance.

Note 11: f_{max} is the guaranteed data rate for 50 ft of twisted pair cable. f_{max} may be conservatively determined from the ratio of driver transition time (t_r) to the data rate unit interval ($1/f_{max}$). Using a 10% ratio yields f_{max} = (0.1)/50 ns = 2.0 Mb/s. Higher data rates may be supported by allowing larger ratios.

Note 12: For enable from sleep mode delays DE = L and RE (Note 1) = H for greater than 600 ns prior to test (device is in sleep mode).

Parameter Measurement Information

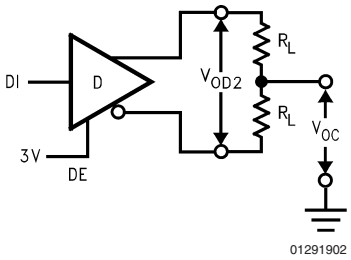


FIGURE 1. V_{OD}

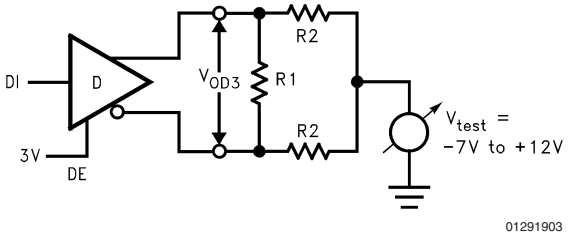


FIGURE 2. V_{OD3}

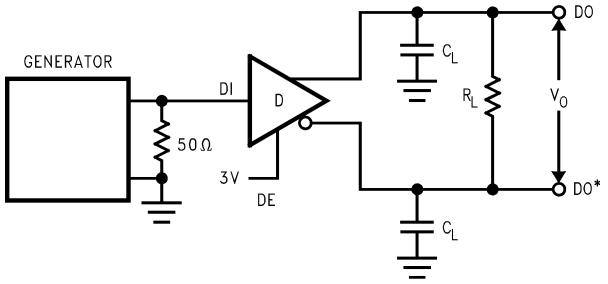


FIGURE 3.

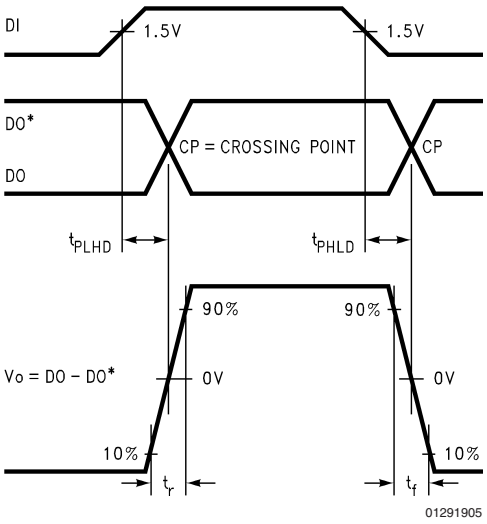


FIGURE 4.

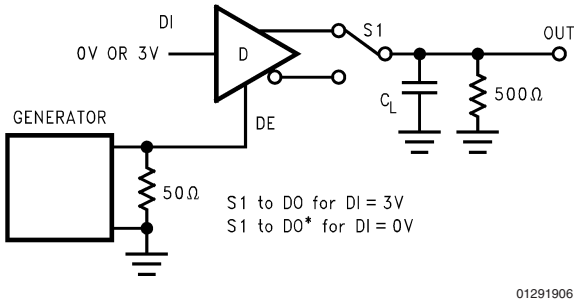


FIGURE 5.

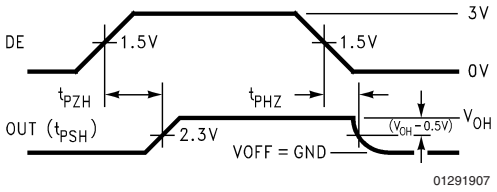


FIGURE 6.

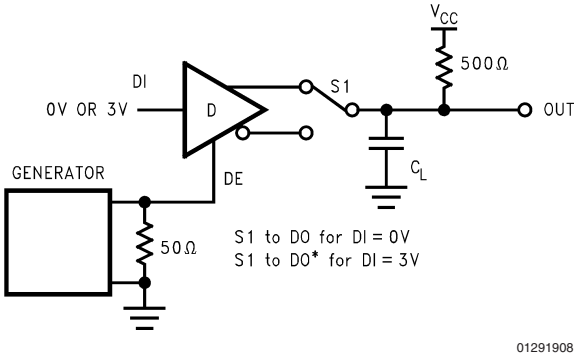


FIGURE 7.

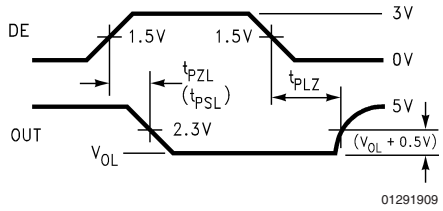


FIGURE 8.

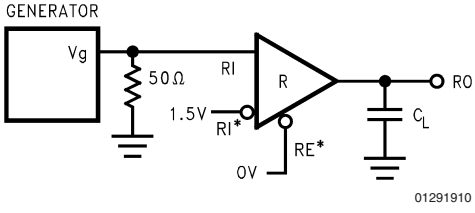


FIGURE 9.

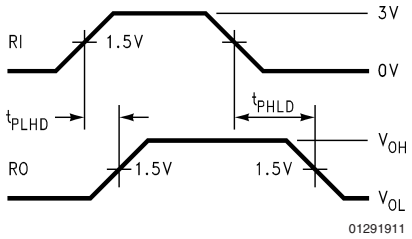


FIGURE 10.

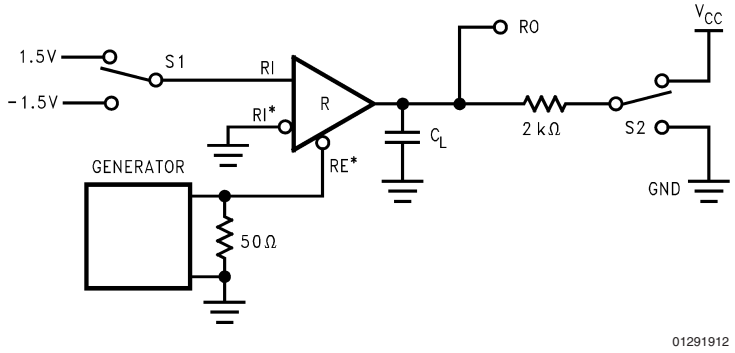


FIGURE 11.

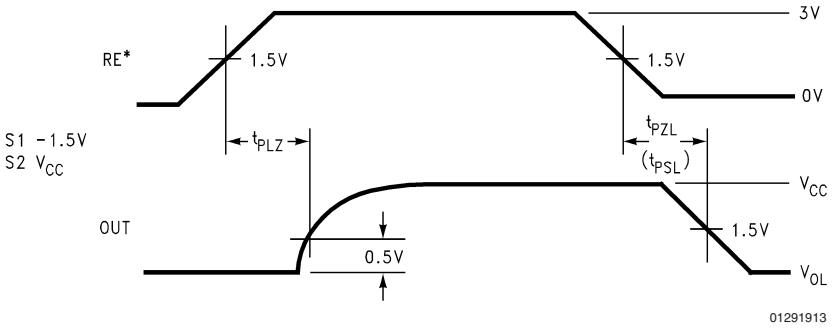


FIGURE 12.

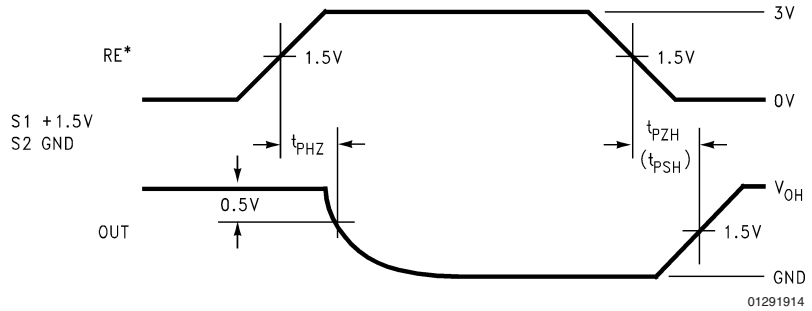
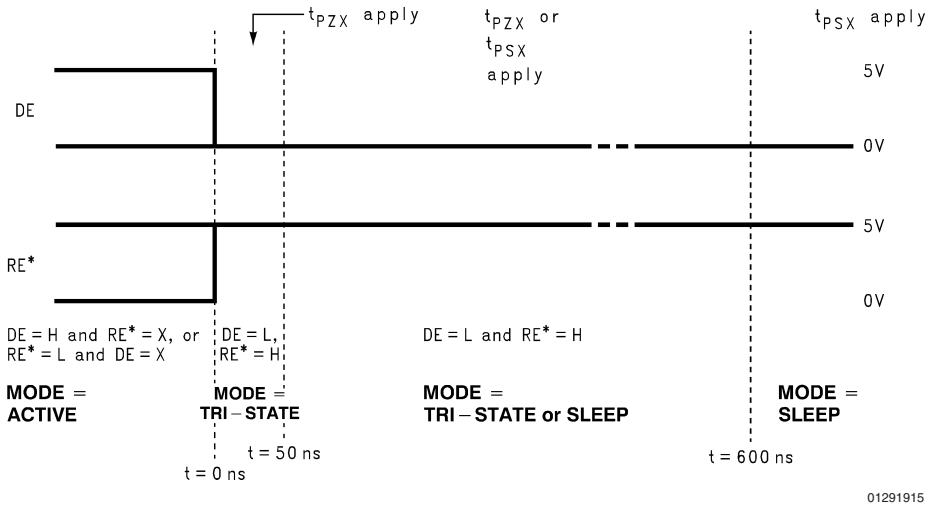


FIGURE 13.

Parameter Measurement Information (Continued)



*Note: Non Terminated, Open Input only

FIGURE 14. Entering Sleep Mode Conditions (modes and exit parameters shown)

TABLE 1. Device Pin Descriptions

Pin No.	Name	Description
1	RO	Receiver Output: When RE (Receiver Enable) is LOW, the receiver is enabled (ON), if DO/RI ≥ DO (Note 1)/RI (Note 1) by 200 mV, RO will be HIGH. If DO/RI ≤ DO (Note 1)/RI (Note 1) by 200 mV, RO will be LOW. Additionally RO will be HIGH for OPEN (Non-terminated) Inputs.
2	RE (Note 1)	Receiver Output Enable: When RE (Note 1) is LOW the receiver output is enabled. When RE (Note 1) is HIGH, the receiver output is in TRI-STATE (OFF). When RE (Note 1) is HIGH and DE is LOW, the device will enter a low-current sleep mode after 600 ns.
3	DE	Driver Output Enable: When DE is HIGH, the driver outputs are enabled. When DE is LOW, the driver outputs are in TRI-STATE (OFF). When RE (Note 1) is HIGH and DE is LOW, the device will enter a low-current sleep mode after 600 ns.
4	DI	Driver Input: When DE (Driver Enable) is HIGH, the driver is enabled, if DI is LOW, then DO/RI will be LOW and DO (Note 1)/RI (Note 1) will be HIGH. If DI is HIGH, then DO/RI is HIGH and DO (Note 1)/RI (Note 1) is LOW.
5	GND	Ground Connection.
6	DO/RI	Driver Output/Receiver Input, 485 Bus Pin.
7	DO (Note 1) /RI (Note 1)	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 an 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 15*). An RS-485 driver is capable of driving up to 32 unit loads. This allows up to 32 nodes on a single bus. Although sufficient for many applications, it is sometimes desirable to have even more nodes.

The DS481 has ½ unit load and will allow up to 64 nodes guaranteed over temperature.

For a ½ UL device the top and bottom borders shown in *Figure 15* 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 15*). 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 15*).

Unit Load (Continued)

The advantage of the ½ UL device is the increased number of nodes on one bus. In a single master multi-slave type of application where the number of slaves exceeds 32, the DS481 may save in the cost of extra devices like repeaters, extra media like cable, and/or extra components like resistors.

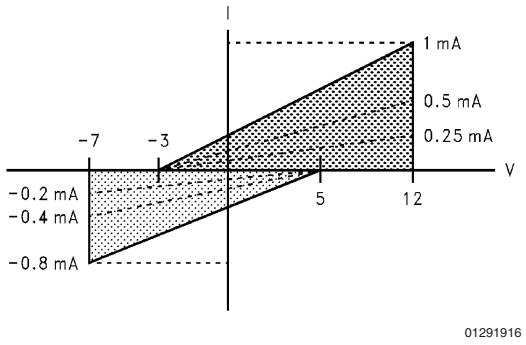


FIGURE 15. Input Current vs Input Voltage Operating Range

Sleep Mode

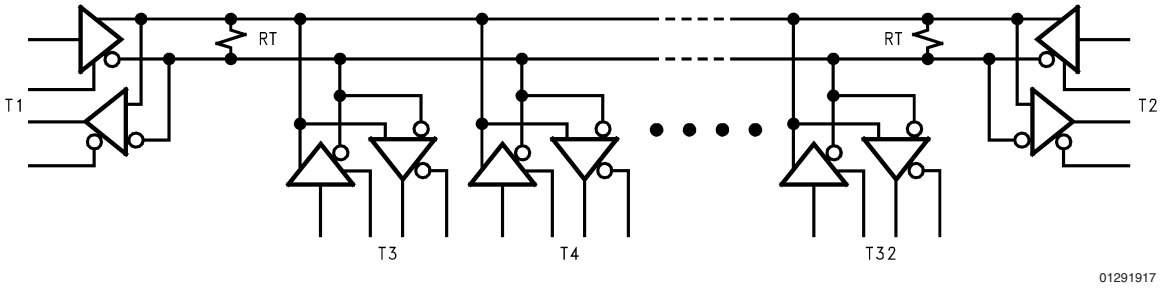
The DS481 features an automatic sleep mode that allows the device to save power when not transmitting data. Since the sleep mode is automatic, no external components are required. It may be used as little or as much as the application requires. The more the feature is utilized, the more power it saves.

The sleep mode is automatically entered when both the driver and receiver are disabled. This occurs when both the DE pin is asserted to a logic low and the RE (Note 1) pin is asserted to a logic high. Once both pins are asserted the device will enter sleep mode after 50 ns. The DS481 is guaranteed to go into sleep mode within 600 ns after both pins are asserted. The device wakes up (comes out of sleep mode) when either the DE pin is asserted to a logic high and/or the RE (Note 1) pin is asserted to a logic low. After the device enters sleep mode it will take longer for the device to wake up than it does for the device to enable from TRI-STATE. Refer to datasheet specifications t_{PSL} and t_{PSH} and compare with t_{PZL} and t_{PZH} for timing differences.

The benefit of the DS481 is definitely its power savings. When active the device has a maximum I_{CC} of 500 µA. When in sleep mode the device has a maximum I_{CC} of only 10 µA, which is 50 times less power than when active. The I_{CC} when the device is active is already very low but when in sleep mode the $I_{CC}$is ultra low.

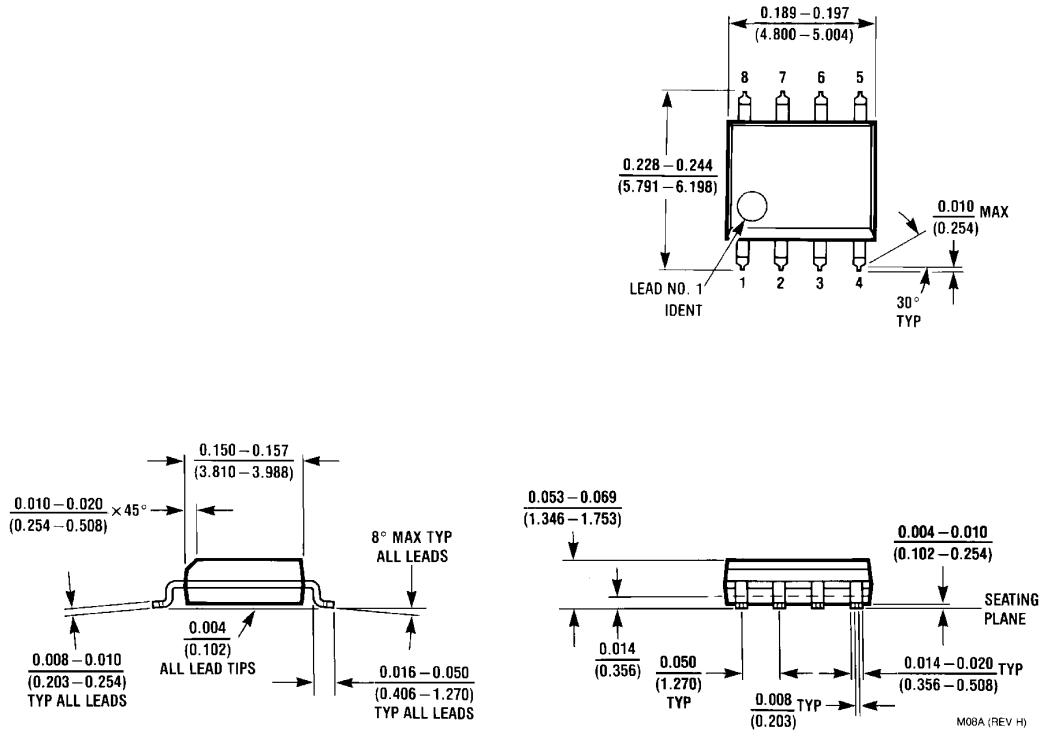
Applications Information

Multipoint RS-485 Application



Physical Dimensions inches (millimeters)

unless otherwise noted



Order Number DS481TM
NS Package Number M08A

National Semiconductor
Americas Customer
Support Center
Email: new.feedback@nsc.com
Tel: 1-800-272-9959

www.national.com

National Semiconductor
Europe Customer Support Center
Fax: +49 (0) 180-530 85 86
Email: europe.support@nsc.com
Deutsch Tel: +49 (0) 69 9508 6208
English Tel: +44 (0) 870 24 0 2171
Français Tel: +33 (0) 1 41 91 8790

National Semiconductor
Asia Pacific Customer
Support Center
Email: ap.support@nsc.com

National Semiconductor
Japan Customer Support Center
Fax: 81-3-5639-7507
Email: jpn.feedback@nsc.com
Tel: 81-3-5639-7560