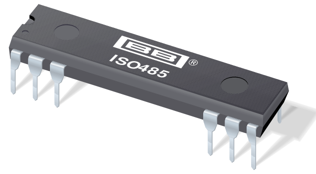
BURR - BROWN ®



ISO485

Isolated RS-485 DIFFERENTIAL BUS TRANSCEIVER

FEATURES

- RS-485 AND RS-422 COMPATIBLE
- 100% TESTED FOR HIGH-VOLTAGE BREAKDOWN
- RATED 1500Vrms
- SINGLE-WIDE 24-PIN PLASTIC DIP
- EASY TO USE
- LOW POWER: 180mW typ at 5Mbit/s

APPLICATIONS

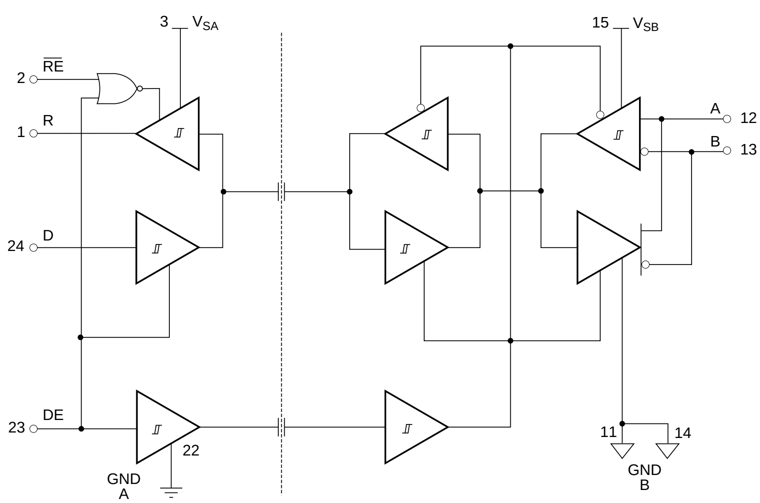
- MULTIPOINT DATA TRANSMISSION ON LONG BUS LINES IN NOISY ENVIRONMENTS

DESCRIPTION

The ISO485 differential, isolated bus transceiver uses Burr-Brown's capacitively coupled isolation technology to provide high-speed, low cost bus isolation. The ISO485 is designed for bi-directional data communication on multipoint bus transmission lines and meets EIA Standard RS-485 as well as EIA Standard RS-422A requirements.

The ISO485 uses high voltage 0.4pF capacitors instead of the LED and photodetector which are used in equivalent optocoupler solutions. As a consequence the part count of the isolated RS-485 channel is reduced from multiple optocoupler channels, an RS-485 transceiver chip and supporting circuitry to one ISO485. The capacitors in the ISO485 provide a high voltage barrier, 1500Vrms and greatly reduce current spikes on the power line.

The ISO485 combines a 3-state differential line driver and a differential-input line receiver both of which operate from a single 5V power supply. The driver differential outputs and the receiver differential input/output bus ports are designed to offer minimum loading to the bus whenever the driver is disabled or $V_S = 0V$.



TRUTH TABLE

DE	$\overline{RE}$	RS-485 BUS
0	0	R_X
0	1	HIGH Z
1	0	HIGH Z
1	1	T_X

International Airport Industrial Park • Mailing Address: PO Box 11400 • Tucson, AZ 85734 • Street Address: 6730 S. Tucson Blvd. • Tucson, AZ 85706
Tel: (520) 746-1111 • Twx: 910-952-1111 • Cable: BBRCORP • Telex: 066-6491 • FAX: (520) 889-1510 • Immediate Product Info: (800) 548-6132

PDS-1280C

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SBOS049

SPECIFICATIONS

At T_A = +25°C, V_S = 5V, unless otherwise specified.

PARAMETER	CONDITION	ISO485P MIN	ISO485P TYP	ISO485P MAX	UNITS
DRIVER DC CHARACTERISTICS					
Input Voltage					
High MIN				2	V
Low MAX		0.8			V
Input Current					
High-Level	V_{IN} = 2.4V			±1	µA
Low-Level	V_{IN} = 0.4V			±1	µA
Output Voltage	I_{OUT} = 0	0		5	V
Differential Output Voltage	$I_{OA} - I_{OB}$ = 0	1.5		5	V
	R_{LOAD} = 100Ω	2	2.5	5	V
	R_{LOAD} = 54Ω	1.5	2.5	5	V
Change In Magnitude of Differential Output Voltage	R_{LOAD} = 54Ω or 100Ω			±0.5	V
Common-Mode Output Voltage	R_{LOAD} = 54Ω or 100Ω			3	V
Change in Magnitude of Common-Mode Output Voltage	R_{LOAD} = 54Ω or 100Ω			±0.2	V
Output Current	V_{OUT} = 7V, output disabled			1	mA
	V_{OUT} = –7V, output disabled			–0.8	mA
Short-Circuit Output Current (1 sec max)	V_{OUT} = –7V		–250		mA
	V_{OUT} = 0V		–150		mA
	V_{OUT} = V_S		250		mA
	V_{OUT} = 12V		250		mA
DRIVER SWITCHING CHARACTERISTICS					
Propagation Delay Time, Low-to-High Level Output	R_{LOAD} = 54Ω			60	ns
Propagation Delay Time, High-to-Low Level Output	R_{LOAD} = 54Ω			60	ns
Input to Output Propagation Delay Skew	R_{LOAD} = 54Ω		10		ns
Output Rise Time	R_{LOAD} = 54Ω		10		ns
Output Fall Time	R_{LOAD} = 54Ω		10		ns
RECEIVER DC CHARACTERISTICS					
Differential-Input-Threshold Voltage					
High	V_{OUT} = 2.7V, I_{OUT} = –0.4mA			0.2	V
Low	V_{OUT} = 0.5V, I_{OUT} = 8mA	–0.2			V
Hysteresis			70		mV
High-Level Output Voltage	V_{ID} = 200mV, I_{OH} = 400µA	2.4			V
Low-Level Output Voltage	V_{ID} = 200mV, I_{OL} = 8mA			0.4	V
High-Impedance-State Output Current	V_{OUT} = 1.4V			±1	µA
Line Input Current	V_{IN} = 12V, other output = 0V		0.7		mA
	V_{IN} = –7V, other output = 0V		–0.6		mA
Enable-Input Current					
High	V_{IH} = 2.7V			1	µA
Low	V_{IL} = 0.4V			1	µA
Input Resistance		12			kΩ
Short-Circuit Output Current	1 sec max		40		mA
RECEIVER SWITCHING CHARACTERISTICS					
Propagation Delay Time,					
Low-to-High Level Output	V_{ID} = –1.5V to 1.5V, C_L = 15pF		35	60	ns
High-to-Low Level Output	V_{ID} = –1.5V to 1.5V, C_L = 15pF		30	60	ns
Input to Output Propagation Delay Skew			10		ns
Output Rise Time	R_L = 54Ω		8		ns
Output Fall Time	R_L = 54Ω		8		ns
TRANSCEIVER SPECIFICATIONS					
Maximum Data Rate		20	35		Mbits/s
Propagation Delay Driver to Receiver			75		ns
Driver Output Enable Time	R_L = 110Ω		155	200	ns
Driver Output Disable Time	R_L = 110Ω		185	280	ns
Propagation Delay Receiver to Driver			13		ns
Receiver Output Enable Time	C_L = 15pF		110	180	ns
Receiver Output Disable Time	C_L = 15pF		120	185	ns

SPECIFICATIONS (CONT)

At T_A = +25°C, V_S = 5V, unless otherwise specified.

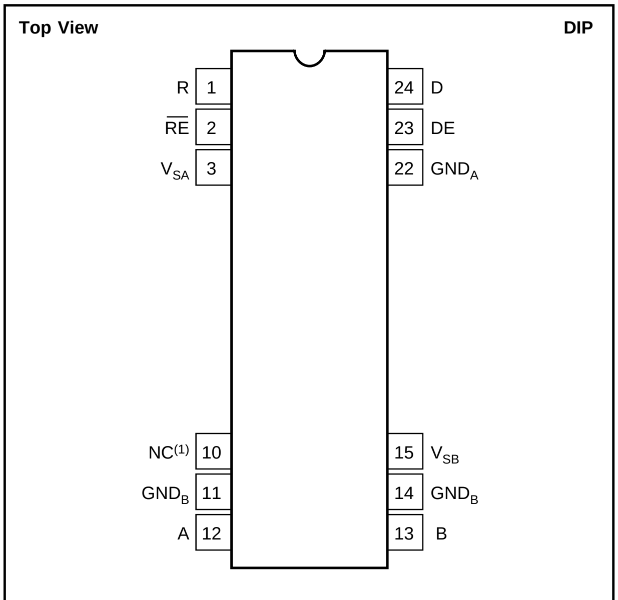
PARAMETER	CONDITION			ISO485P MIN	TYP	MAX	UNITS
TRANSCEIVER SPECIFICATIONS (CONT)							
Supply Voltage							
V_SA				3	5	5.5	V
V_SB				4.75	5	5.25	V
Supply Current	**DE**	**RE**	**RS-485 BUS**				
V_SA	0	0	Rx			5	mA
V_SA	0	1	HIGH Z			0.4	mA
V_SA	1	0	HIGH Z			0.4	mA
V_SA	1	1	Tx			0.4	mA
V_SB	0	0	Rx			55	mA
V_SB	0	1	HIGH Z			55	mA
V_SB	1	0	HIGH Z			51	mA
V_SB	1	1	Tx			51	mA
RECOMMENDED OPERATING CONDITIONS							
Voltage at Any Bus Terminal	(separately or common-mode)			–7		12	V
High-Level Driver Input Voltage				2			V
Low-Level Driver Input Voltage						0.8	V
Differential Receiver Input Voltage						±12	V
Output Current High-Level							
	Driver					–60	mA
	Receiver					–400	µA
Output Current Low-Level							
	Driver					60	mA
	Receiver					8	mA
TEMPERATURE RANGE							
Operating				–40		85	°C
Storage				–40		125	°C
ISOLATION PARAMETERS							
Rated Voltage, Continuous	50Hz			1500			Vrms
Partial Discharge, 100% Test(1)	1s, 5pC			2400			Vrms
Creepage Distance (External) DIP = "P" Package					16		mm
Internal Isolation Distance					0.10		mm
Isolation Voltage Transient Immunity(2)					1.6		kV/µs
Barrier Impedance					> 10^{14} || 7		Ω || pF
Leakage Current	240Vrms, 60Hz				0.6		µArms

NOTES: (1) All devices receive a 1s test. Failure criterion is ≥ 5 pulses of ≥ 5pC. (2) The voltage rate-of-change across the isolation barrier that can be sustained without data errors.

ABSOLUTE MAXIMUM RATINGS

Supply Voltages, V_S	5.5V
Voltage at any bus terminal	–10 to 15V
Enable Input Voltage	0 to V_{CC} + 0.5V
Continuous total dissipation at 25°C free-air temp.	750mW
Lead solder temperature, 260°C for 10s, 1.6mm below seating plane	300°C
Junction Temperature	150°C
Package thermal transfer, θ_{JA}	75°C/W

PIN CONFIGURATION



NOTE: (1) Pin 10 must be left unconnected.

PACKAGE INFORMATION

MODEL	PACKAGE	PACKAGE DRAWING NUMBER[1]
ISO485P	24-Pin Single-Wide DIP	243-1

NOTE: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix D of Burr-Brown IC Data Book.

PIN ASSIGNMENTS

PIN #	NAME	DESCRIPTION
1	R	Data Received From Transmission Line
2	$\overline{RE}$	Receive Switch Controlling Receiving Of Data
3	V_{SA}	+5V Supply Pin For Side A
10	NC	This Pin MUST Be Left Unconnected
11	GND_B	Ground Pin For Side B. Also Connected To Pin 14
12	A	Data, Driver Out/Receiver In
13	B	Data, Driver Out/Receiver In
14	GND_B	Ground Pin For Side B. Also Connected To Pin 11
15	V_{SB}	+5V Supply Pin For Side B
22	GND_A	Ground Pin For Side A
23	DE	Driver Switch Controlling Output Of Data
24	D	Data To Be Transmitted

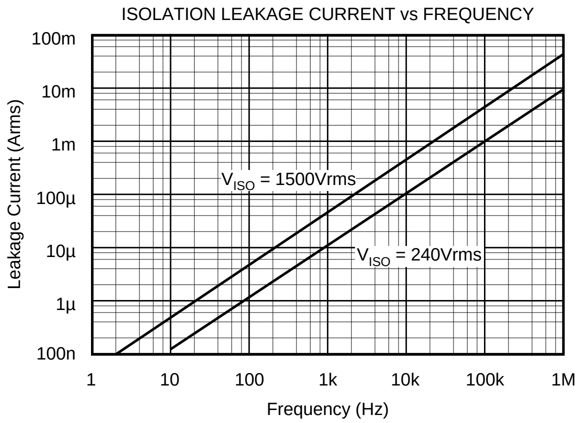
ELECTROSTATIC DISCHARGE SENSITIVITY

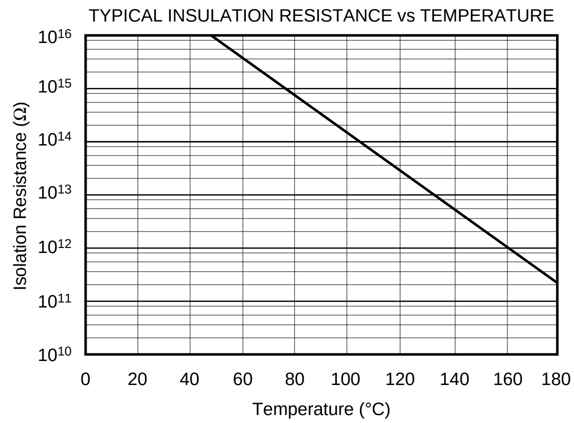
This integrated circuit can be damaged by ESD. Burr-Brown recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

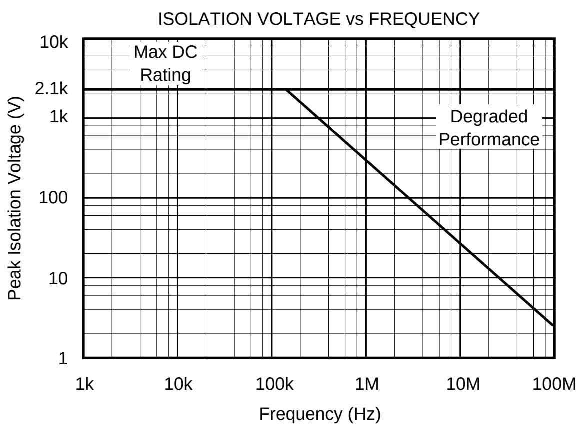
ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

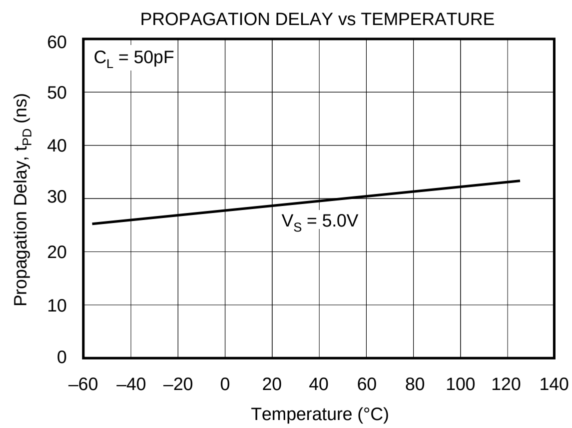
TYPICAL PERFORMANCE CURVES

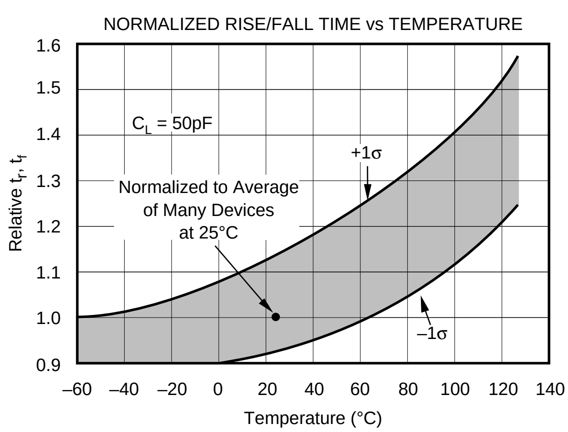
At T_A = +25°C, V_S = +5V, unless otherwise noted.

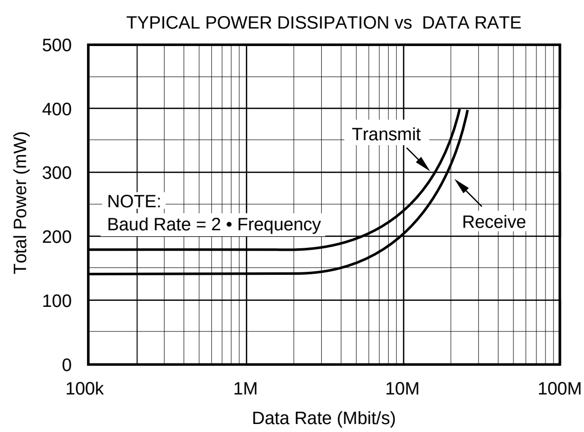






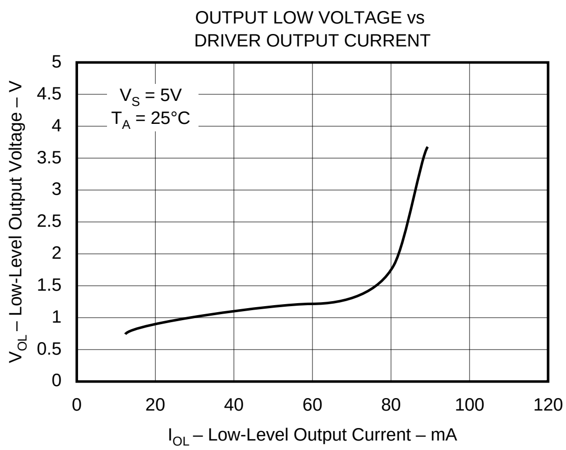


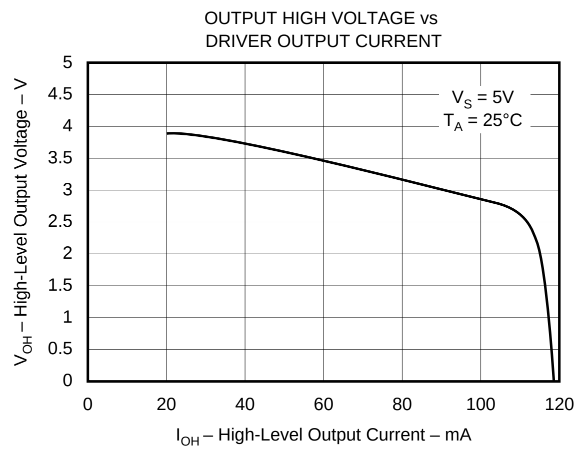


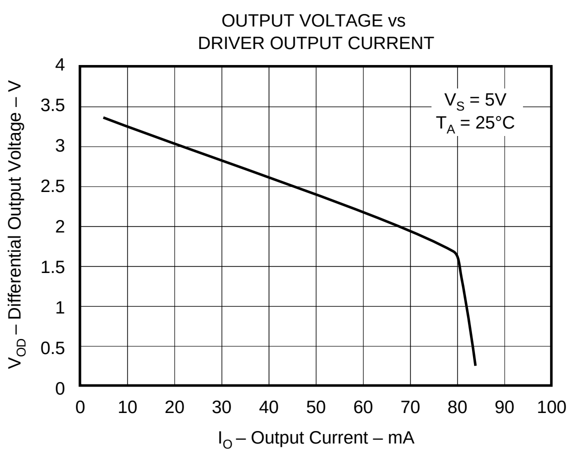


TYPICAL PERFORMANCE CURVES (CONT)

At T_A = +25°C, V_S = +5V, unless otherwise noted.







MODE OF OPERATION

The ISO485 is a differential, isolated transceiver for half duplex multi-point communication, and complies with the EIA Interface Standards summarized in Table I. The signals transmitted across the isolation barrier can achieve transmission rates up to 35Mbit/s typical. The barrier is designed to perform in harsh electrical environments without signal degradation, while providing high isolation and good transient immunity.

Referring to the block diagram on the front page, data present at the D input can be transmitted across the barrier when the data enable pin DE is a logic high. The data appears as a differential signal on the outputs A and B and within the output range 0V to +5V. The isolated side of the DE logic high also inhibits the isolated side of data read R. The input NOR gate arrangement prevents attempts to transmit and receive simultaneously. The truth table shows the conditions on the RS-485 bus for the possible states of DE and $\overline{RE}$.

ISOLATION BARRIER

Data is transmitted by coupling complementary logic pulses to the receiver through two 0.4pF capacitors. These capacitors are built into the ISO485 package with Faraday shielding to guard against false triggering by external electrostatic fields.

The integrity of the isolation barrier of the ISO485 is verified by partial discharge testing. 2400Vrms, 50Hz, is applied across the barrier for one second while measuring any tiny discharge currents that may flow through the barrier. These current pulses are produced by localized ionization within the barrier. This is the most sensitive and reliable indicator of barrier integrity and longevity, and does not damage the barrier. A device fails the test if five or more current pulses of 5pC or greater are detected.

Conventional isolation barrier testing applies test voltage far in excess of the rated voltage to catastrophically break down a marginal device. A device that passes the test may be weakened, and lead to premature failure.

APPLICATION EXAMPLE

Consider an RS-485 network in an industrial area. The system specifications are:

- Distance between master controller and the farthest outstation 50 meters.
- System data rate is to be 30Mbit/s.
- One daisy-chain cable will link the master controller to the outstations.

The main design considerations in implementing this system are:

- Line loading and termination
- Selection of correct cable for requirements
- Attenuation and distortion of the signal
- Fault protection and fail-safe operation

LOADING

RS-485 recommends a maximum of 32 unit loads on any one line: the unit loading being derived from the 12kΩ input impedance and the 12V maximum common-mode voltage. The ISO485 represents 1 unit load. We could, therefore, connect up to 31 outstations to the master controller and comply with the specification.

TERMINATION

When a signal starts to change at the output of a transmitter, the other end of the line will eventually see this change and a reflection will occur. If this reflection returns to the transmitter before the transmitted signal has reached its maximum value, the line may be considered as a "lumped parameter" model. In this case no termination is necessary because the line has a negligible effect on the system.

If the rise of the signal at the receiver T_{RISE} is much less than the time taken for the signal to go from transmitter to receiver and back again $2T_{PD}$ termination of the line is necessary. It is usual to terminate the line with its characteristic impedance, Z_O when the following rule applies:

$$2T_{PD} \geq 5T_{RISE} \quad (1)$$

For this installation we have selected an Alpha Wire Corporation cable, No. 6072C. The cables characteristics are shown in Figure 2. The rise time T_{RISE} at the receiver was measured between the 10% and 90% points.

$$T_{RISE} = 10\text{ns} \quad (2)$$

From Figure 1 we can see that the velocity of propagation V_P is given as 80%. Since this is the ratio of the signal speed in air, to the signal speed in the cable, we have

$$V_P = 3 \times 10^8 \times 0.8 = 2.4 \times 10^8 \text{ m/s} \quad (3)$$

therefore $T_{PD} = 1/V_P = 4.2\text{ns/m}$

For the cable $2T_{PD} = 4.2 \times 10^{-9} \times 50 \times 2 = 42\text{us}$

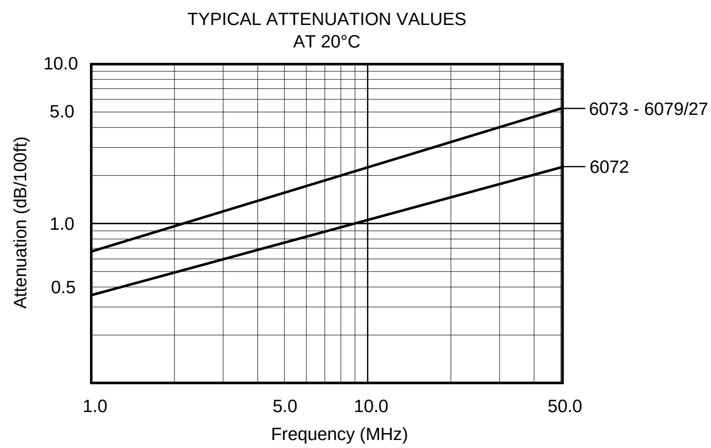
Equation 1 holds, therefore the line must be terminated with its characteristic impedance.

EYE PATTERNS AND Z_O

Eye patterns can be used to assess the signal distortion and noise on the transmission line. It is also a convenient method of determining the characteristic impedance of the line. The term 'eye' comes from the shape of the trace on the oscilloscope. See Figures 2 and 3.

The eye pattern was obtained using the non return zero pseudo-noise generator circuit shown in Figure 5. Figure 2 shows the effects of the termination resistor for the three cases: $Z_T > Z_O$, $Z_T = Z_O$, $Z_T < Z_O$ with $Z_T = Z_O$ the eye pattern is clear. In practice a precision decade resistance box was used to determine the exact value of Z_T to use.

As the data rate is increased we can see from Figure 3 how the signal distortion also increases. From the graph in Figure 1 we can see that the specified attenuation figures given agree with those obtained by measurement; approximately –1.3db/100ft, at 30Mbit/s (15MHz).



TYPICAL ELECTRICAL CHARACTERISTICS Capacitance						
ALPHA WIRE CORP. NO.	CDR. to CDR.		CDR. to (CDR. AND SHIELD)		VP. %	Z_0 at 1MHz, Ω
	pF/ft	(pF/m)	pF/ft	pF/m)		
6072C	8.7	(28, 5)	5.9	(52, 2)	80	150
6073C thru 6079/27C	12.5	(41, 0)	22.0	(72, 5)	80	150

FIGURE 1. Cable Characteristics.

PARAMETER		EIA-232	RS-432-A	RS-422-A	RS-485
Mode of Operation		Single-Ended	Single-Ended	Differential	Differential
Number of Drivers and Receivers		1 Driver 1 Receiver	1 Driver 10 Receivers	1 Driver 10 Receivers	32 Drivers 32 Receivers
Maximum Cable Length (m)		15	1200	1200	1200
Maximum Data Rate (bps)		20k	100k	10M	10M
Maximum Common-Mode Voltage (V)		±25	±6	6 to –0.25	12 to –7
Driver Output	Loaded	±5	±3.6	±2	±1.5
Levels (V)	Unloaded	±15	±6	±5	±5
Driver Load (Ω)		3k to 7k	450 (min)	100 (min)	60 (min)
Driver Slew Rate		30V/µs (max)	External Control	NA	NA
Driver Output Short Circuit		500 to V_{CC}	150 to GND	150 to GND	150 to GND
Current Limit (mA)					250 to –7 or 12V
Driver Output Resistance	Power on	NA	NA	NA	12k
High Z state (Ω)	Power off	300	60k	60k	12k
Receiver Input Resistance (Ω)		3 to 7	4	4	12
Receiver Sensitivity		±3V	±200mV	±200mV	±200mV

TABLE I. Summary of EIA Interface Standards.

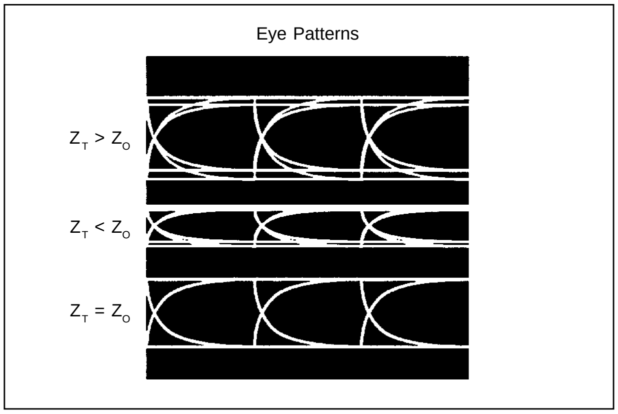


Figure 2. Eye Patterns.

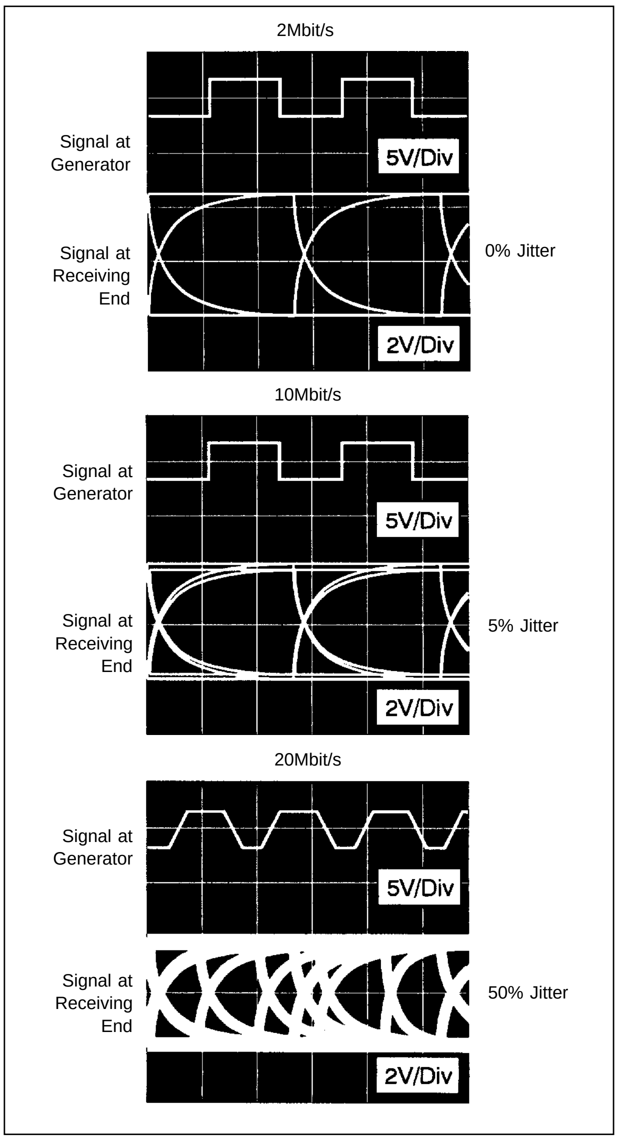


Figure 3. ISO485 Signal Distortion vs Data Rate.

STUB LENGTH

If the outstations are not to act as transmission lines, they too must meet the criteria determined by equation 1. They must be seen as a lumped parameter. As a rule-of-thumb, the transition time of the pulse from the transmitter, T_{RISE} should be ten times longer than the propagation delay, pd_{STUB} down the stub to the outstation.

$$T_{RISE} \geq 10pd_{STUB} \qquad (4)$$

From $pd = 1/V_P \times \text{stub length}$

$$T_{RISE} \geq 10 \times 1/V_P \times \text{stub length}$$

$$16.5 \times 10^{-9} \geq 10 \times \frac{1}{3 \times 10^8 \times 0.8} \times \text{stub length}$$

Therefore stub length = 396mm (15.6") maximum

START-UP CIRCUIT

Because the ISO485 is a capacitively coupled device, it is possible to power up an indeterminate state. The circuit of Figure 4 ensures that the ISO485 powers up in the receive mode, thus avoiding any conflict on the transmission line.

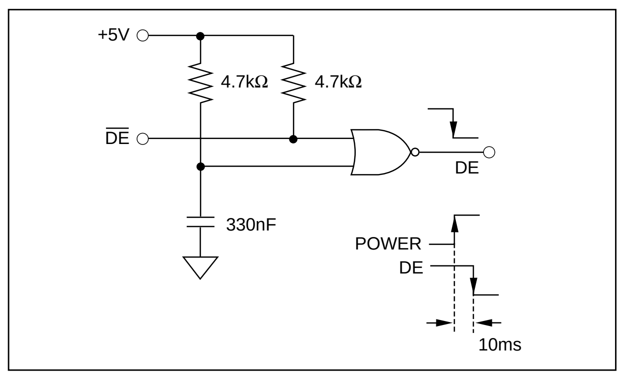


Figure 4. Start-up Circuit.

TRANSMIT/RECEIVE MODE

Because the ISO485 is a capacitively coupled device, indeterminate states can occur when the change from transmit to receive or, from receive to transmit is initiated. This is easily overcome by transmitting an edge prior to the data of interest. The four possible conditions which could happen are detailed in Figures 5a, 5b, 6a, and 6b. Thereafter, data is known and correct.

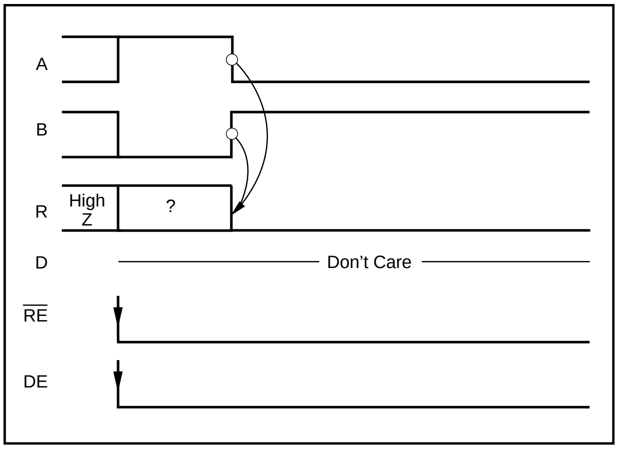


Figure 5a. Transmit to Receive.

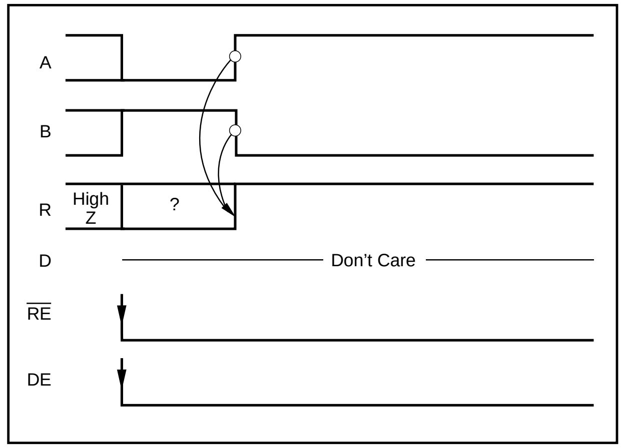


Figure 5b. Transmit to Receive.

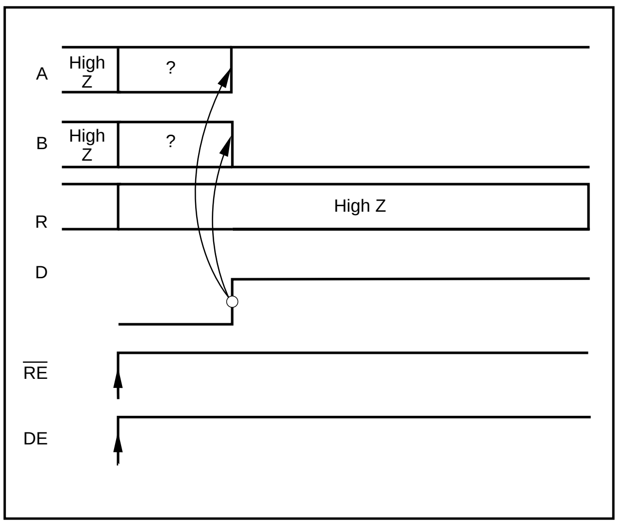


Figure 6a. Receive to Transmit

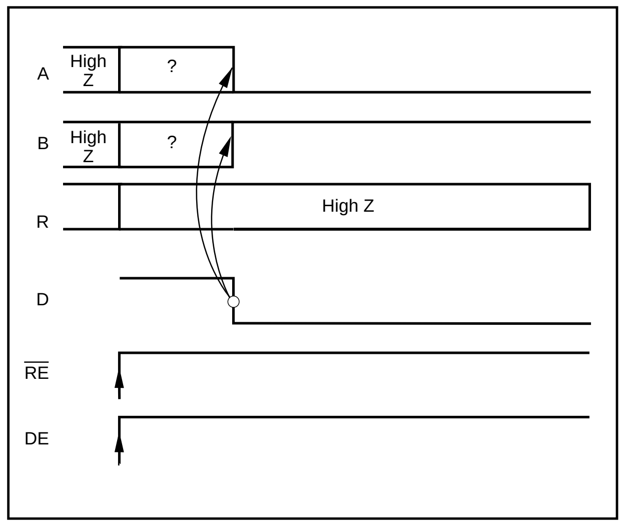


Figure 6b. Receive to Transmit.

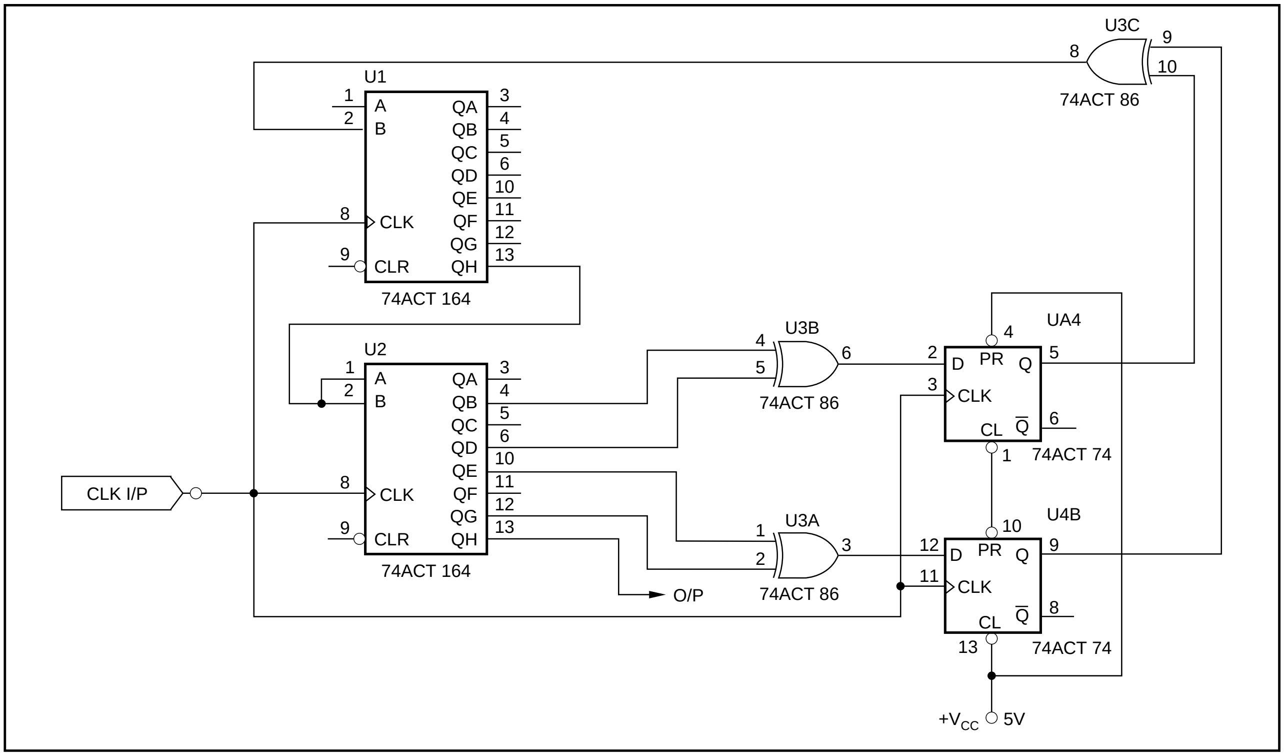
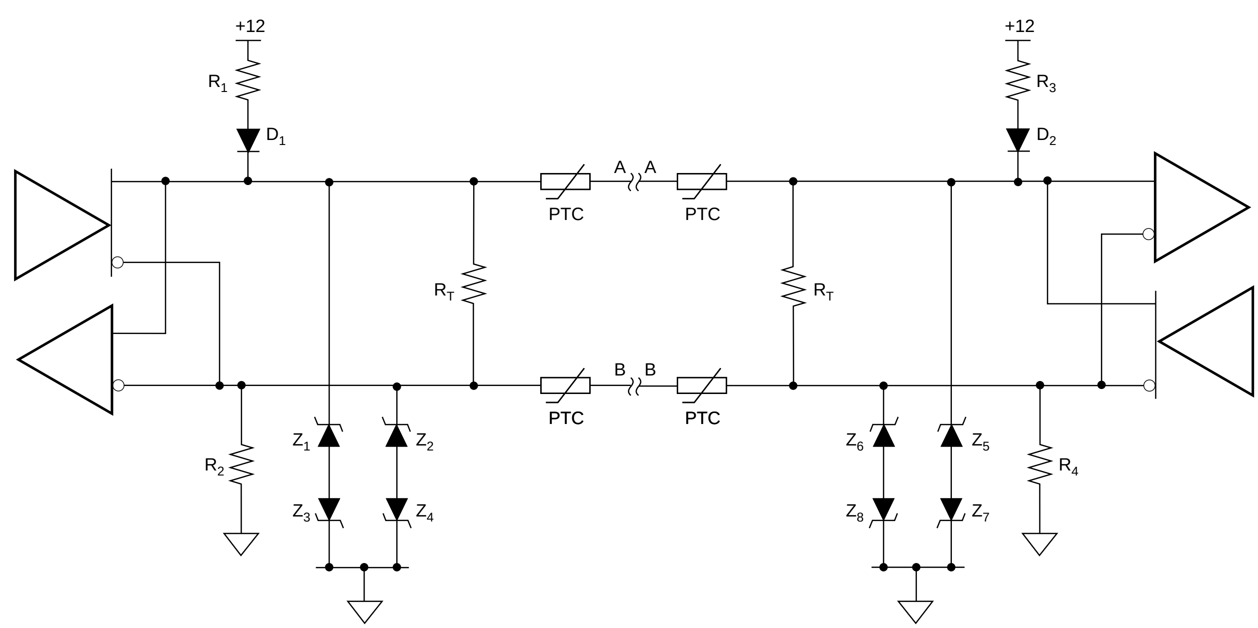


FIGURE 7. NRZ Psuedo-Noise Generator.



a) $R_1 = R_3$ and $R_2 = R_4$
For open circuit conditions this biases the line to a logic '1'

b) $Z_1 = Z_3 = Z_5 = Z_7$ = BZX85 = 12V
$Z_2 = Z_4 = Z_6 = Z_8$ = BZX85 = 6.8V
$D_1 = D_2$ = IN4048

The zener diode in conjunction with the ptc thermistors limit the current drawn on the line when taken beyond the +12V and –7V. The ptc thermistors also current limit on the line being shorted to the ground.

c) $$R_1 = R_2 = 0.5 \times Z_0 \left(1 + \frac{V_{CC}}{V_{TH}}\right)$$

$$R_T = Z_0 \left(1 + \frac{V_{TH}}{V_{CC}}\right)$$

NOTE: PTC = Positive Temperature Coefficient Thermistor.

FIGURE 8. RS-485 Line with Fail-Safe Protection.

IMPORTANT NOTICE

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In order to minimize risks associated with the customer's applications, adequate design and operating safeguards must be provided by the customer to minimize inherent or procedural hazards.

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