

RS232 Data Interface

a Tutorial

RS-232 is simple, universal, well understood and supported but RS-232 has some serious shortcomings as a data interface. The standards for RS-232 and similar interfaces usually restrict RS-232 to 256kbps or less and line lengths of 15M (50 ft) or less but today we see high speed ports on our home PC running very high speeds and with high quality cable maximum distance has increased greatly. The rule of thumb for the length a data cable depends on speed of the data, quality of the cable.

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Electronic data communications between elements will generally fall into two broad categories: single-ended and differential. RS232 (single-ended) was introduced in 1962, and despite rumors for its early demise, has remained widely used through the industry.

Independent channels are established for two-way (full-duplex) communications. The RS232 signals are represented by voltage levels with respect to a system common (power / logic ground). The "idle" state (MARK) has the signal level negative with respect to common, and the "active" state (SPACE) has the signal level positive with respect to common. RS232 has numerous handshaking lines (primarily used with modems), and also specifies a communications protocol.

The RS-232 interface presupposes a common ground between the DTE and DCE. This is a reasonable assumption when a short cable connects the DTE to the DCE, but with longer lines and connections between devices that may be on different electrical busses with different grounds, this may not be true.

RS232 data is bi-polar.... +3 TO +12 volts indicates an "ON or 0-state (SPACE) condition" while A -3 to -12 volts indicates an "OFF" 1-state (MARK) condition.... Modern computer equipment ignores the negative level and accepts a zero voltage level as the "OFF" state. In fact, the "ON" state may be achieved with lesser positive potential. This means circuits powered by 5 VDC are capable of driving RS232 circuits directly, however, the overall range that the RS232 signal may be transmitted/received may be dramatically reduced.

The output signal level usually swings between +12V and -12V. The "dead area" between +3v and -3v is designed to absorb line noise. In the various RS-232-like definitions this dead area may vary. For instance, the definition for V.10 has a dead area from +0.3v to -0.3v. Many receivers designed for RS-232 are sensitive to differentials of 1v or less.

This can cause problems when using **pin powered widgets** - line drivers, converters, modems etc. These type of units need enough voltage & current to power them self's up. Typical URART (the RS-232 I/O chip) allows up to 50ma per output pin - so if the device needs 70ma to run we would need to use at least 2 pins for power. Some devices are very efficient and only require one pin (some times the Transmit or DTR pin) to be high - in the "SPACE" state while idle.

An RS-232 port can supply only limited power to another device. The number of output lines, the type of interface driver IC, and the state of the output lines are important considerations.

The types of driver ICs used in serial ports can be divided into three general categories:

- **Drivers which require plus (+) and minus (-) voltage power supplies such as the 1488 series of interface integrated circuits. (Most desktop and tower PCs use this type of driver.)**
- **Low power drivers which require one +5 volt power supply. This type of driver has an internal charge pump for voltage conversion. (Many industrial microprocessor controls use this type of driver.)**
- **Low voltage (3.3 v) and low power drivers which meet the EIA-562 Standard. (Used on notebooks and laptops.)**

Data is transmitted and received on pins 2 and 3 respectively. Data Set Ready (DSR) is an indication from the Data Set (i.e., the modem or DSU/CSU) that it is on. Similarly, DTR indicates to the Data Set that the DTE is on. Data Carrier Detect (DCD) indicates that a good carrier is being received from the remote modem.

Pins 4 RTS (Request To Send - from the transmitting computer) and 5 CTS (Clear To Send - from the Data set) are used to control. In most Asynchronous situations, RTS and CTS are constantly on throughout the communication session. However where the DTE is connected to a multipoint line, RTS is used to turn carrier on the modem on and off. On a multipoint line, it's imperative that only one station is transmitting at a time (because they share the return phone pair). When a station wants to transmit, it raises RTS. The modem turns on carrier, typically waits a few milliseconds for carrier to stabilize, and then raises CTS. The DTE transmits when it sees CTS up. When the station has finished its transmission, it drops RTS and the modem drops CTS and carrier together.

Clock signals (pins 15, 17, & 24) are only used for synchronous communications. The modem or DSU extracts the clock from the data stream and provides a steady clock signal to the DTE. Note that the transmit and receive clock signals do not have to be the same, or even at the same baud rate.

Note: Transmit and receive leads (2 or 3) can be reversed depending on the use of the equipment - DCE Data Communications Equipment or a DTE Data Terminal Equipment.

Glossary of Abbreviations etc.

CTS	Clear To Send [DCE --> DTE]
DCD	Data Carrier Detected (Tone from a modem) [DCE --> DTE]
DCE	Data Communications Equipment eg. modem
DSR	Data Set Ready [DCE --> DTE]
DSRS	Data Signal Rate Selector [DCE --> DTE]
DTE	Data Terminal Equipment eg. computer, printer
DTR	Data Terminal Ready [DTE --> DCE]
FG	Frame Ground (screen or chassis)
NC	No Connection
RcK	Receiver (external) Clock input
RI	Ring Indicator (ringing tone detected)
RTS	Ready To Send [DTE --> DCE]
RxD	Received Data [DCE --> DTE]
SG	Signal Ground
SCTS	Secondary Clear To Send [DCE --> DTE]
SDCD	Secondary Data Carrier Detected (Tone from a modem) [DCE --> DTE]
SRTS	Secondary Ready To Send [DTE --> DCE]
SRxD	Secondary Received Data [DCE --> DTE]

STxD Secondary Transmitted Data [DTE --> DTE]

TxD Transmitted Data [DTE --> DTE]

Is Your Interface a DTE or a DCE?

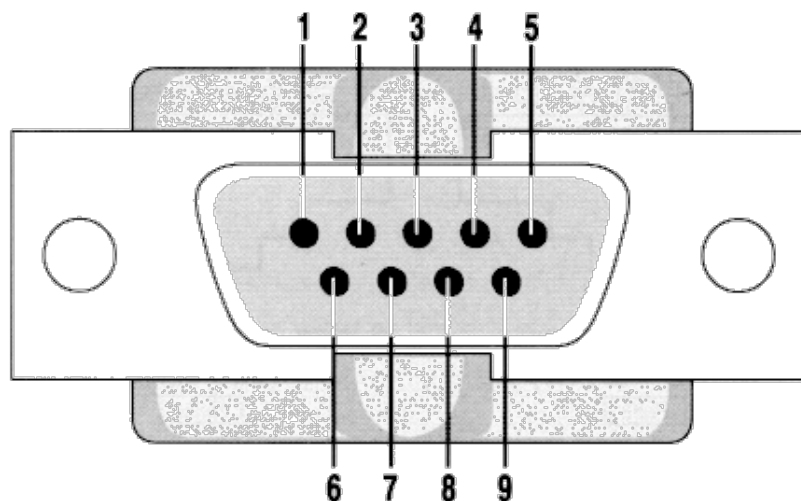
Find out by following these steps: The point of reference for all signals is the terminal (or PC).

- 1) Measure the DC voltages between (DB25) pins 2 & 7 and between pins 3 & 7. Be sure the black lead is connected to pin 7 (Signal Ground) and the red lead to whichever pin you are measuring.
- 2) If the voltage on pin 2 (TD) is more negative than -3 Volts, then it is a DTE, otherwise it should be near zero volts.
- 3) If the voltage on pin 3 (RD) is more negative than -3 Volts, then it is a DCE.
- 4) If both pins 2 & 3 have a voltage of at least 3 volts, then either you are measuring incorrectly, or your device is not a standard EIA-232 device. Call technical support.
- 5) In general, a DTE provides a voltage on TD, RTS, & DTR, whereas a DCE provides voltage on RD, CTS, DSR, & CD.

PC Com Port - EIA-574

RS-232 pin out DB-9 pin

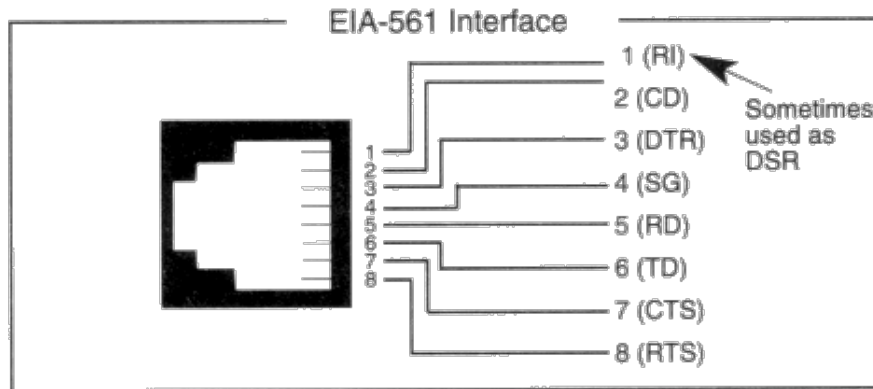
used for Asynchronous Data



Pin	Signal	Pin	Signal
1	Data Carrier Detect	6	Data Set Ready
2	Received Data	7	Request to Send
3	Transmitted Data	8	Clear to Send
4	Data Terminal Ready	9	Ring Indicator
5	Signal Ground		

➤ jump to [9 pin to 9 pin null modem cable](#)

EIA-561 defines RS-232 on a modular connector. (For nonsynchronous applications only, since it does not provide for the synchronous clocking signals.)



This is a standard 9 to 25 pin cable layout for async data on a PC AT serial cable

➤ jump to [AT modem cable 9 to 25 pin connectors diagram](#) page

Description	Signal	9-pin DTE	25-pin DCE	Source DTE or DEC
Carrier Detect	CD	1	8	from Modem
Receive Data	RD	2	3	from Modem
Transmit Data	TD	3	2	from Terminal/Computer
Data Terminal Ready	DTR	4	20	from Terminal/Computer
Signal Ground	SG	5	7	from Modem
Data Set Ready	DSR	6	6	from Modem
Request to Send	RTS	7	4	from Terminal/Computer
Clear to Send	CTS	8	5	from Modem
Ring Indicator	RI	9	22	from Modem

25 pin D-shell connector RS232
commonly used for Async. data

PIN SIGNAL DESCRIPTION

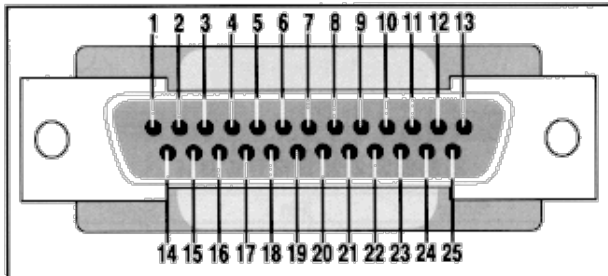
- 1 PGND Protective Ground
- 2 TXD Transmit Data
- 3 RXD Receive Data
- 4 RTS Ready To Send
- 5 CTS Clear To Send
- 6 DSR Data Set Ready
- 7 SG Signal Ground
- 8 CD Carrier Detect
- 20 DTR Data Terminal Ready
- 22 RI Ring Indicator

Some applications require more pins

than a simple async. configurations.

RS-232 Interface

RS-232 (EIA Std.) applicable to the 25 pin interconnection of Data Terminal Equipment (DTE) and Data Communications Equipment (DCE) using serial binary data

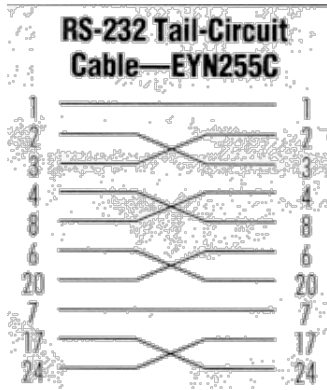


Pin	Description	EIA CKT	From DCE	To DCE
1	Frame Ground	AA		
2	Transmitted Data	BA		D (Data)
3	Received Data	BB	D	
4	Request to Send	CA		C (Control)
5	Clear to Send	CB	C	
6	Data Set Ready	CC	C	
7	Signal Gnd/Common Return	AB		
8	Rcvd. Line Signal Detector	CF	C	
11	Undefined			
12	Secondary Rcvd. Line Sig. Detector	SCF	C	
13	Secondary Clear to Send	SCB	C	
14	Secondary Transmitted Data	SBA		D
15	Transmitter Sig. Element Timing	DB	T (Timing)	
16	Secondary Received Data	SBB	D	
17	Receiver Sig. Element Timing	DD	T	
18	Undefined			
19	Secondary Request to Send	SCA		C
20	Data Terminal Ready	CD		C
21	Sig. Quality Detector	CG		C
22	Ring Indicator	CE	C	
23	Data Sig. Rate Selector (DCE)	CI	C	
23	Data Sig. Rate Selector (DTE)	CH		C
24	Transmitter Sig. Element Timing	DA		T
25	Undefined			

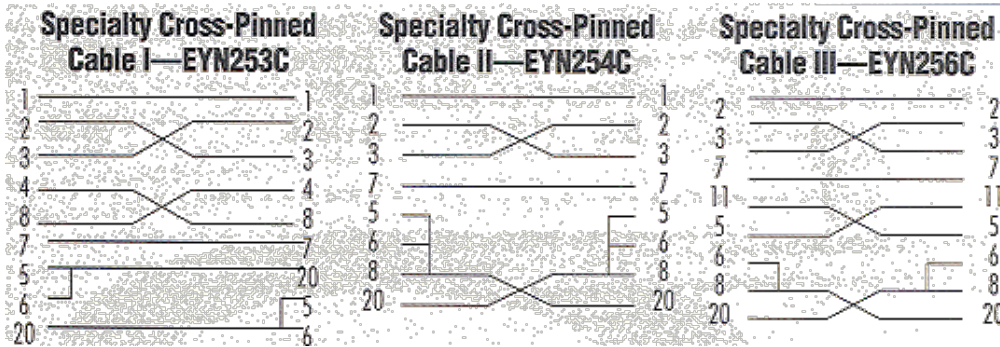
Pins used for Synchronous data

RS232 (25 pin) Tail Circuit Cable

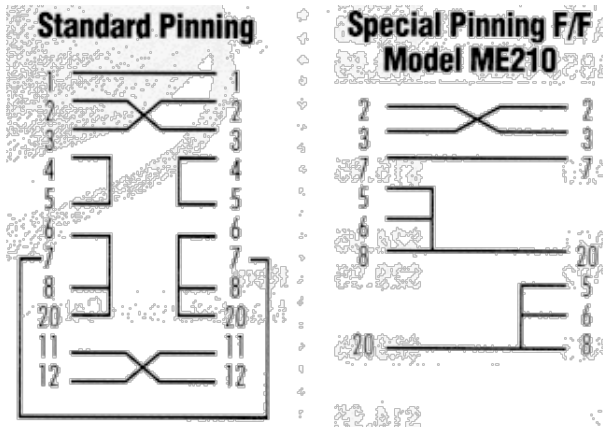
Null Modem Cable for Async or Sync data



Cross Pinned cables for Async data.



Pin out for local Async Data transfer



RS232D uses RJ45 type connectors (similar to telephone connectors)

		Male	Female		
	RJ45	8 1	1		
Pin No.	Signal Description	Abbr.	DTE	DCE	
1	DCE Ready, Ring Indicator	DSR/RI	<input type="checkbox"/>	<input type="checkbox"/>	
2	Received Line Signal Detector	DCD	<input type="checkbox"/>	<input type="checkbox"/>	
3	DTE Ready	DTR	<input type="checkbox"/>	<input type="checkbox"/>	

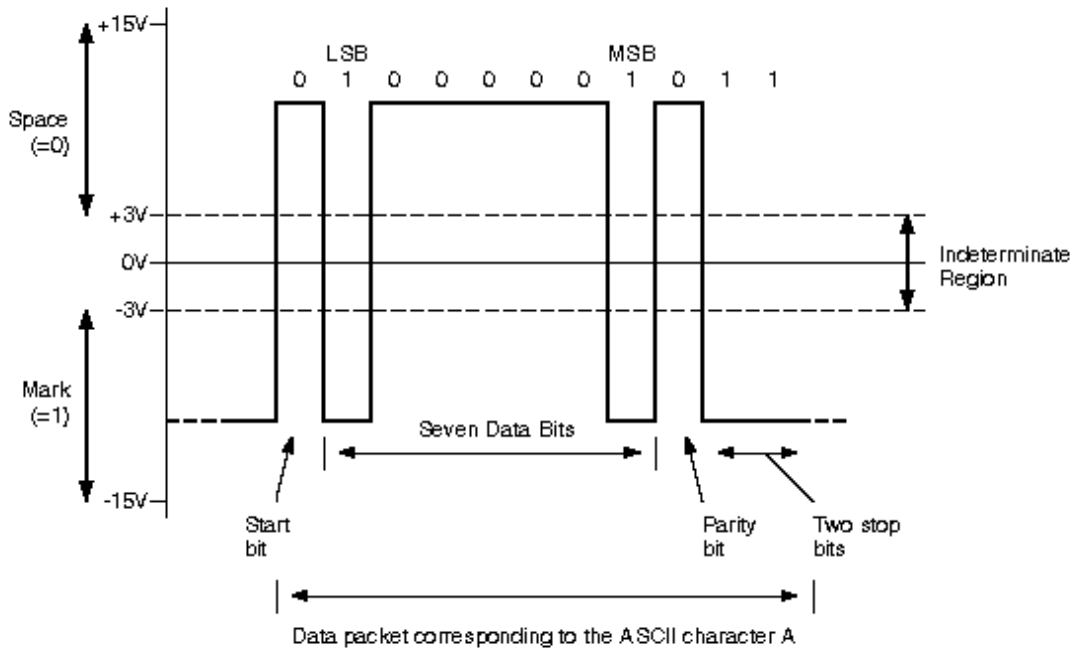
4	Signal Ground	SG	<input type="checkbox"/>	<input type="checkbox"/>
5	Received Data	RxD	<input type="checkbox"/>	<input type="checkbox"/>
6	Transmitted Data	TxD	<input type="checkbox"/>	<input type="checkbox"/>
7	Clear To Send	CTS	<input type="checkbox"/>	<input type="checkbox"/>
8	Request To Send	RTS	<input type="checkbox"/>	<input type="checkbox"/>

➤ jump to [all types of cable pin outs diagrams](#) page

RS-232 Specs.

SPECIFICATIONS		RS232	RS423
Mode of Operation		SINGLE -ENDED	SINGLE -ENDED
Total Number of Drivers and Receivers on One Line		1 DRIVER 1 RECVR	1 DRIVER 10 RECVR
Maximum Cable Length		50 FT.	4000 FT.
Maximum Data Rate		20kb/s	100kb/s
Maximum Driver Output Voltage		+/-25V	+/-6V
Driver Output Signal Level (Loaded Min.)	Loaded	+/-5V to +/-15V	+/-3.6V
Driver Output Signal Level (Unloaded Max)	Unloaded	+/-25V	+/-6V
Driver Load Impedance (Ohms)		3k to 7k	>=450
Max. Driver Current in High Z State	Power On	N/A	N/A
Max. Driver Current in High Z State	Power Off	+/-6mA @ +/-2v	+/-100uA
Slew Rate (Max.)		30V/uS	Adjustable
Receiver Input Voltage Range		+/-15V	+/-12V
Receiver Input Sensitivity		+/-3V	+/-200mV
Receiver Input Resistance (Ohms)		3k to 7k	4k min.

One byte of async data



Cabling considerations - you should use cabling made for RS-232 data but I have seen low speed data go over 250' on 2 pair phone cable. Level 5 cable can also be used but for best distance use a low capacitance data grade cable.

The standard maxim length is 50' but if data is async you can increase that distance to as much as 500' with a good grade of cable.

The RS-232 signal on a single cable is impossible to screen effectively for noise. By screening the entire cable we can reduce the influence of outside noise, but internally generated noise remains a problem. As the baud rate and line length increase, the effect of capacitance between the different lines introduces serious crosstalk (this especially true on synchronous data - because of the clock lines) until a point is reached where the data itself is unreadable. Signal Crosstalk can be reduced by using low capacitance cable and shielding each pair

Using a high grade cable (individually shield low capacitance pairs) the distance can be extended to 4000'

At higher frequencies a new problem comes to light. The high frequency component of the data signal is lost as the cable gets longer resulting in a rounded, rather than square wave signal.

The maxim distance will depend on the speed and noise level around the cable run.

On longer runs a line driver is needed. This is a simple modem used to increase the maxim distance you can run RS-232 data.

Making sense of the specifications

Selecting data cable isn't difficult, but often gets lost in the shuffle of larger system issues. Care should be taken. however, because intermittent problems caused by marginal cable can be very difficult to troubleshoot.

Beyond the obvious traits such as number of conductors and wire gauge, cable specifications include a handful of less intuitive terms.

Characteristic Impedance (Ohms): A value based on the inherent conductance, resistance, capacitance and inductance of a cable that represents the impedance of an infinitely long cable. When the cable is out to any length and terminated with this Characteristic Impedance, measurements of the cable will be identical to values obtained from the infinite length cable. That is to say that the termination of the cable with this impedance gives the cable the appearance of being infinite length, allowing no reflections of the transmitted signal. If termination is required in a system, the termination impedance value should match the Characteristic Impedance of the cable.

Shunt Capacitance (pF/ft): The amount of equivalent capacitive load of the cable, typically listed in a per foot basis. One of the factors limiting total cable length is the capacitive load. Systems with long lengths benefit from using low capacitance cable.

Propagation velocity (% of c): The speed at which an electrical signal travels in the cable. The value given typically must be multiplied by the speed of light (c) to obtain units of meters per second. For example, a cable that lists a propagation velocity of 78% gives a velocity of $0.78 \times 300 \times 10^6 = 234 \times 10^6$ meters per second.

Plenum cable

Plenum rated cable is fire resistant and less toxic when burning than non-plenum rated cable. Check building and fire codes for requirements. Plenum cable is generally more expensive due to the sheathing material used.

The specification recommends 24AWG twisted pair cable with a shunt capacitance of 16 pF per foot and 100 ohm characteristic impedance.

It can be difficult to qualify whether shielding is required in a particular system or not, until problems arise. We recommend erring on the safe side and using shielded cable. Shielded cable is only slightly more expensive than unshielded.

There are many cables available meeting the recommendations of RS-422 and RS-485, made specifically for that application. Another choice is the same cable commonly used in the Twisted pair Ethernet cabling. This cable, commonly referred to as Category 5 cable, is defined by the EIA/TIA/ANSI 568 specification. The extremely high volume of Category 5 cable used makes it widely available and very inexpensive, often less than half the price of specialty RS422/485 cabling. The cable has a maximum capacitance of 17 pF/ft (14.5 pF typical) and characteristic impedance of 100 ohms.

Category 5 cable is available as shielded twisted pair (STP) as well as unshielded twisted pair (UTP) and generally exceeds the recommendations making it an excellent choice for RS232 systems.
