August 2002 Vol.4 No.8

LINK

Lava I/O News

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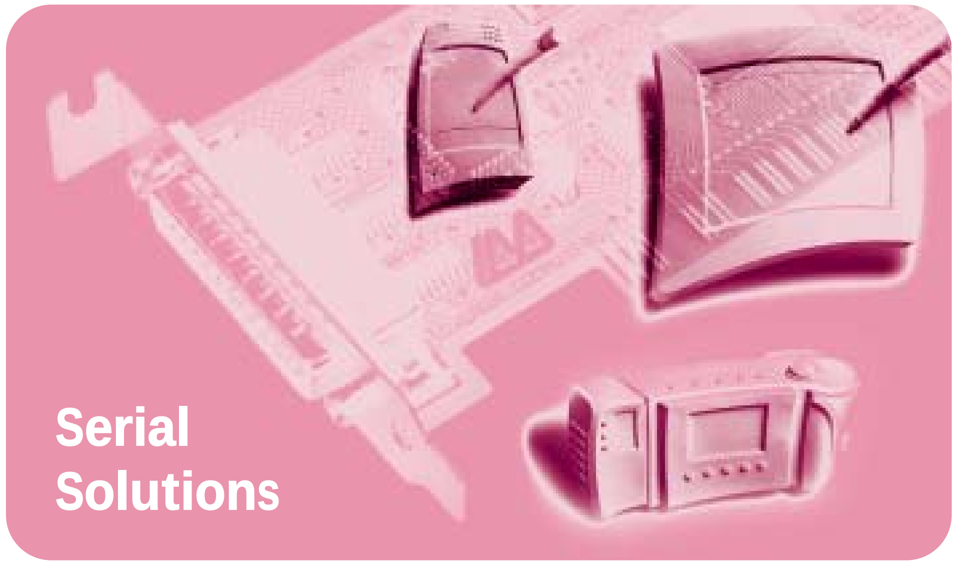


What is RS-232?

Last month's issue of LINK began by discussing serial connections from the point of view of the serial port's UART. This month we move outwards from that point to look at RS-232, the most common mode of serial communication among personal computers.

After the serial port's UART has done its work by composing data for serial transmission, the data must be moved across the wires of a serial port. One way of doing so is called "RS-232." RS-232 is a species of serial connection described in a specification written by the Electronic Industries Association (EIA) which, in conjunction with the Telecommunications Industry Association, defines the standards for traditional serial data transfer. Formally, the RS-232 standard is called EIA/TIA-232-F, reflecting the initials of the organizations that administer it.

The RS-232 specification describes RS-232 communications equipment as well as the signalling, electrical, and mechanical characteristics of RS-232 serial ports.

Serial Communications Equipment

The RS-232 specification defines two types of communication equipment: Data Terminal Equipment, (abbreviated as DTE); and Data Circuit-Terminating Equipment, or DCE. These two types of equipment differ in pin-out assignments — for practical purposes a PC can be considered a DTE, and a modem a DCE. Usually an RS-232 link connects a DTE and a DCE. A link can also use a crossover cable (sometimes called a "null-modem cable") to make the connection between two DTEs appear as if it were between a DTE and a DCE (as when connecting two PCs with a serial cable). DTE and DCE configurations for cables and connectors are shown on the next page.

Signalling

The RS-232 standard defines 25 signal lines in its interface, although in practice PCs rarely use more than nine of these lines. In fact, with just three of these lines — receive data (RD), transmit data (TD), and ground (GND) — bi-directional RS-232 communication can occur. The other lines are designated for a variety of control purposes. These include the remainder of the basic nine lines: data carrier detect (DCD), data terminal ready (DTR), data set ready (DSR), request to send (RTS), clear to send (CTS), and ring indicator (RI). These main nine serial signals are those typically used between a PC and a serial device such as a modem.

Electrical

RS-232 signals are indicated by voltage differences with respect to a ground signal, and can vary between +3 to +15 volts and -3 to -15 volts. At the same time, serial receivers must be undamaged by voltages up to ±25 volts. The control lines in an RS-232 link use a "positive" logic to indicate their state. That is, a positive voltage on a wire carrying a control signal (any of DCD, DTR, DSR, RTS, CTS, and RI on a nine-wire serial connection) indicates that the control signal involved can be described as "On," "Asserted,"or "True." A negative voltage on a control line indicates that the control signal involved can be described as "Off," "De-asserted," or "False."

The data lines are just the opposite. Data lines use a so-called "negative" logic, meaning that a negative voltage on the wire carrying the data signal (RD or TD) is described as "On," "Asserted," or "True." Conversely, a positive voltage on the wire is interpreted as "Off," "De-asserted," or "False."

RS-232 also defines the timing of electrical signalling. An RS-232 connection differentiates between the bits of a serial data stream by reading the voltage of its data lines. In the simplest terms, it monitors the lines for a start bit (described in last month's discussion of UARTs), and then reading the line at predefined intervals, with each interval representing the next bit in the stream of data. The timing of these intervals is determined by the data rate of the link. This process in effect makes the serial connection follow a clock within each byte, although the timing between one byte of data and the next is not dictated by a clock.

The number of readings taken within a byte is determined by the settings used by the UART for composing serial data: the number of data bits set for the link, whether the connection has a parity bit, and the configuration of stop bits. Once the stop bit is read, the connection waits for the next start bit to arrive.

Mechanical

Each line in an RS-232 interface is assigned a pin number for the various connectors that RS-232 can use. The nine primary lines, and their assignments in DB-9 and DB-25 connectors, are shown below.

Synchronous vs. asynchronous RS-232

RS-232 signals can be synchronous or asynchronous. Asynchronous RS-232 is by far the most common. Asynchronous RS-232 signals are delineated by voltage changes that will identify the start and stop of any byte of data, as described above. Within any byte of data, the receiver is actually applying a clock to measure the elements of the data transmission, and will sample the voltage level within the byte in a manner corresponding to the number of discrete bits of data it expects the byte, along with its framing and possible parity bits, to have.

Synchronous RS-232 signals are synchronized by a clock that dictates the timing of each bit that is sent. The timing provided by the clock is shared by both sides of the serial connection, so each side is aware of the timing of the next byte of data. Additional control lines beyond the basic nine lines are needed to support synchronous RS-232.

RS-232 Signal Descriptions

DTR: Data Terminal Ready

Used by a piece of Data Terminal Equipment to signal that it is available for communication.

DSR: Data Set Ready

The companion signal to DTR, it is used by a piece of Data Circuit-Terminating Equipment to signal that it is available for communication.

CTS: Clear to Send

Used by a piece of Data Circuit-Terminating Equipment to signal it is available to send data. This line is also used in response to an RTS request for data.

RTS: Request to Send

Used by a piece of Data Terminal Equipment to indicate that it has data to send.

DCD: Data Carrier Detect

Used by a piece of Data Circuit-Terminating Equipment to indicate to the Data Terminal Equipment that it has received a carrier signal from the modem and that real data is being transmitted. Sometimes abbreviated as CD.

RI: Ring Indicator

Used by a Data Circuit-Terminating Equipment modem to tell a piece of Data Terminal Equipment that the phone is ringing and that some data will be forthcoming.

TD: Transmit Data

This wire is used for sending data. Sometimes abbreviated as TXD. This wire will also be used to carry flow control information if software flow control is enabled.

RD: Receive Data

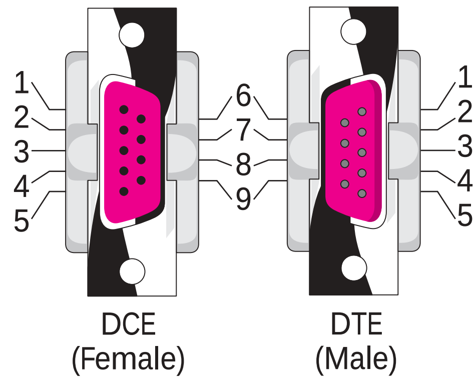
This wire is used for receiving data. Sometimes abbreviated as RXD. This wire will also be used to carry flow control information if software flow control is enabled.

GND: Ground

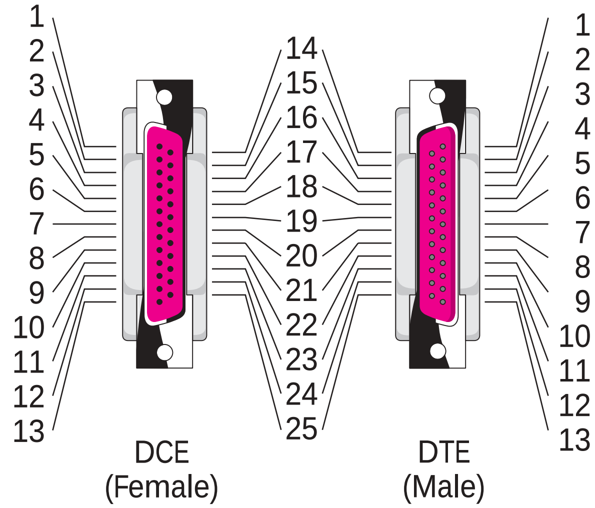
This wire is the same for Data Circuit-Terminating Equipment and Data Terminal Equipment, and it provides the return path for both data and handshake signals.

RS-232 Connectors

The diagrams below show standard RS-232 pin assignments for 9 and 25 pin connectors.



9-Pin D-sub (DE-9, often called DB-9)



25-Pin D-sub (DB-25)

RS-232 Cabling

The tables below show RS-232 wiring connections for straight cables (DTE-to-DCE) and crossover cables (DCE-to-DCE), when connecting DB-9 connectors to both DB-9 and DB-25 connectors. See Lava's white paper on RS-232 for DB-25-to-DB-25 straight and crossover cable diagrams.

TABLE 1. DTE-to-DCE DB-9 connection (Straight cable)

DB-9 DTE Device (Computer) Pin # / RS-232 Signal Name	Signal Direction	DB-9 DCE Device (Modem) Pin # / RS-232 Signal Name
#1 Data Carrier Detect (DCD)	←	#1 Data Carrier Detect (DCD)
#2 Receive Data (RD)	←	#2 Receive Data (RD)
#3 Transmit Data (TD)	→	#3 Transmit Data (TD)
#4 DTE Ready/Data Terminal Ready (DTR)	→	#4 DTE Ready/Data Terminal Ready (DTR)
#5 Signal Ground/Common (GND)	—	#5 Signal Ground/Common (GND)
#6 DCE Ready/Data Set Ready (DSR)	←	#6 DCE Ready/Data Set Ready (DSR)
#7 Request to Send (RTS)	→	#7 Request to Send (RTS)
#8 Clear to Send (CTS)	←	#8 Clear to Send (CTS)
#9 Ring Indicator (RI)	←	#9 Ring Indicator (RI)
Soldered to DB-9 metal—shield	—	Soldered to DB-9 metal—shield

TABLE 2. DCE-to-DCE DB-9 connection (Crossover cable)

DB-9 DCE Device (Modem) Pin # / RS-232 Signal Name	DB-9 DCE Device (Modem) Pin # / RS-232 Signal Name
#1 Data Carrier Detect (DCD)	#1 Data Carrier Detect (DCD)
#2 Receive Data (RD)	#2 Receive Data (RD)
#3 Transmit Data (TD)	#3 Transmit Data (TD)
#4 DTE Ready/Data Terminal Ready (DTR)	#4 DTE Ready/Data Terminal Ready (DTR)
#5 Signal Ground/Common (GND)	#5 Signal Ground/Common (GND)
#6 DCE Ready/Data Set Ready (DSR)	#6 DCE Ready/Data Set Ready (DSR)
#7 Request to Send (RTS)	#7 Request to Send (RTS)
#8 Clear to Send (CTS)	#8 Clear to Send (CTS)
#9 Ring Indicator (RI)	#9 Ring Indicator (RI)
Soldered to DB-9 metal—shield	Soldered to DB-9 metal—shield

Signal Direction

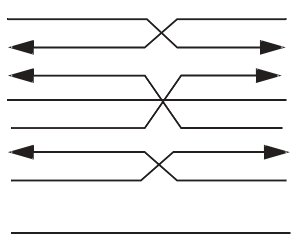


TABLE 3. DTE-to-DCE DB-9/DB-25 connection (Straight cable)

DB-9 DTE Device (Computer) Pin # / RS-232 Signal Name	DB-25 DCE Device (Modem) Pin # / RS-232 Signal Name
#1 Data Carrier Detect (DCD)	#1 Shield to Frame Ground
#2 Receive Data (RD)	#2 Transmit Data (TD)
#3 Transmit Data (TD)	#3 Receive Data (RD)
#4 DTE Ready/Data Terminal Ready (DTR)	#4 Request to Send (RTS)
#5 Signal Ground/Common (GND)	#5 Clear to Send (CTS)
#6 DCE Ready/Data Set Ready (DSR)	#6 DCE Ready/Data Set Ready (DSR)
#7 Request to Send (RTS)	#7 Signal Ground/Common (GND)
#8 Clear to Send (CTS)	#8 Data Carrier Detect (DCD)
#9 Ring Indicator (RI)	#20 DTE Ready/Data Terminal Ready (DTR)
Soldered to DB-9 metal—shield	#22 Ring Indicator (RI)

Signal Direction

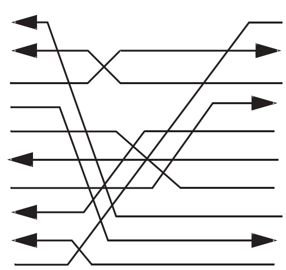
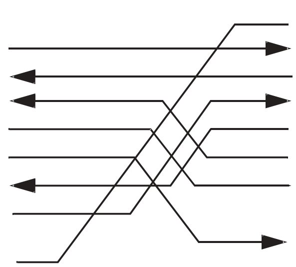


TABLE 4. DCE-to-DCE DB-9/DB-25 connection (Crossover cable)

DB-9 DCE Device (Modem) Pin # / RS-232 Signal Name	DB-25 DCE Device (Modem) Pin # / RS-232 Signal Name
#1 Data Carrier Detect (DCD)	#1 Shield to Frame Ground
#2 Receive Data (RD)	#2 Transmit Data (TD)
#3 Transmit Data (TD)	#3 Receive Data (RD)
#4 DTE Ready/Data Terminal Ready (DTR)	#4 Request to Send (RTS)
#5 Signal Ground/Common (GND)	#5 Clear to Send (CTS)
#6 DCE Ready/Data Set Ready (DSR)	#6 DCE Ready/Data Set Ready (DSR)
#7 Request to Send (RTS)	#7 Signal Ground/Common (GND)
#8 Clear to Send (CTS)	#8 Data Carrier Detect (DCD)
#9 Ring Indicator (RI)	#20 DTE Ready/Data Terminal Ready (DTR)
Soldered to DB-9 metal—shield	#22 Ring Indicator (RI)

Signal Direction



Profile

CompuSmart is Canada's largest computer superstore network with over 20 locations across the country, and $250 million in annual sales. They provide their customers with professional customer service, excellent product selection, and competitive prices, which is what has driven the CompuSmart name to the top of the pack.

CompuSmart carries the product lines of over 250 different computer-related hardware and software vendors, all of which are available at either their online store or in any of their locations. With local inventory warehouses in Montreal and Calgary as well as access to distribution centers in Toronto and Vancouver, CompuSmart provides industry leading order turn-around time.

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PRODUCT SUMMARY

Serial Boards

PCI	SSerial-PCI	Single 9-pin serial, 16550 UART
	SSerial-PCI/LP	Single 25-pin serial, 16550 UART, low profile
	DSerial-PCI	Dual 9-pin serial, 16550 UARTs
	DSerial-PCI/LP	Dual 9-pin serial, 16550 UARTs, low profile
	Quattro-PCI	Four-port 9-pin serial, 16550 UARTs
	Octopus-550	Eight-port 9-pin serial, 16550 UARTs
	LavaPort-650	Single 9-pin serial, 16650 UART
	LavaPort-PCI	Dual 9-pin serial, 16650 UARTs
	LavaPort-Quad	Four-port 9-pin serial, 16650 UARTs
ISA	SSerial-550	Single 25-pin serial, Com 1-4, 16550 UART, IRQ 3/4/5/7
	DSerial-550	Dual 9-pin serial, Com 1-4, 16550 UARTs, IRQ 2/3/4/5/7/10/11/12/15
	RS422-550	Dual 9-pin serial, 16550 UARTs, RS422 pinout
	LavaPort-ISA	Single 9-pin serial, Com 1-4 16650 UART, IRQ 2/3/4/5/10/11/12/15
	LavaPort-PnP	Single 9-pin serial, 16650 UART, plug and play

Parallel Boards

PCI	Parallel-PCI	Single EPP parallel
	Parallel-PCI/LP	Single EPP parallel, low profile
	Dual Parallel-PCI	Dual EPP parallel
ISA	Parallel Bi-directional	Single bi-directional parallel port, LPT 1/2/3, IRQ 5/7
	Parallel-ECP/EPP	Single ECP/EPP parallel, LPT 1-6, IRQ 2/3/4/5/7/10/11/12

Combo Boards

PCI	SP-PCI	Single 9-pin serial, 16550 UART + single bi-directional parallel
	2SP-PCI	Dual serial (9 & 25-pin), 16550 UARTs + single EPP parallel
	LavaPort-Plus	Dual serial (9 & 25 pin), 16650 UARTs + single EPP parallel
ISA	2SP-550	Dual 9-pin serial, Com 1-4, 16550 UARTs + single bi-dir. parallel, LPT 1-2

USB 2.0 & 1.1 Devices

	USB 2.0 Host Adapter	Dual USB 2.0 ports, 480 Mbps, fits in PCI slot
	Kazan	Hard drive enclosure with USB 2.0-to-IDE interface
	USB 1.1 Host Adapter	Dual USB 1.1 ports, 12 Mbps, fits in PCI slot

IEEE 1394 (FireWire®) Devices

	IEEE 1394 FireHost	Dual IEEE 1394 ports, 400 Mbps, fits in PCI slot
	FireDrive®	Hard drive enclosure with FireWire®-to-IDE interface
	IEEE 1394/IDE Controller	FireWire®-to-IDE hard drive interface

Specialty Boards

PCI	8255-PIO	8255 PIO interface card

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