

How does data communications work?



The purpose of data communications is to transfer information between two or more units. As a rule, it is characters (text or numbers) and/or instructions (commands) which are transmitted, although it can also be drawings and pictures.

The simplest level of computer language is *binary characters* where each character is composed of seven to eight 1's or 0's. Most computers operate at this level.

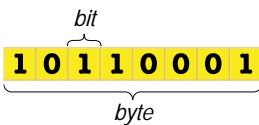
Data communications is basically a matter of ones and zeros

The computer processes binary characters, made up of *ones* and *zeros*. Each of the characters is called a *bit*. By combining several bits, a *binary character* set can be constructed. The most common system, *ASCII*, contains 128 characters, each of which is made up of 7 bits. Each of these characters (or bit patterns) is known as a *byte*. Please note that a kilobyte is made up of 1 024 ASCII characters.

All communication is carried out at this level, internally within the computer as well as externally with other units. Internal communication within the computer is simple. However, as soon as the computer has to communicate with external units, a series of factors must be synchronized and controlled to ensure that the transmission of data takes place correctly.

See the ASCII table on page 21.

Bits and bytes



One bit at a time, or a whole byte?

There are two ways of transmitting data: by parallel or serial transmission.

Parallel transmission is faster and simpler since the entire character with its 8 bits is transmitted in a single operation using 8 transmission paths, one for each bit. All communication within the computer itself takes place via parallel paths in the internal data bus, so that an entire character or several characters can be simultaneously transmitted.

Parallel transmission via a multi-conductor cable (Centronics-type) can only be carried out at short distances for practical and economic reasons. Therefore, the majority of all external data communications is achieved through serial transmission, i.e. the bits are sent, one at a time, on a single transmission path.

Serial transmission places higher demands on the receiver and the transmitter which has to keep track of when a character starts and ends and of the inherent sequence of the bits. The transmitter and receiver must transmit and receive at the same rate. This is known as the transmission speed and is expressed in bit/s (bits per second).

In order to tell the receiver where a character starts and ends, the transmitter sends out extra bits, a *start bit* and one or several *stop bits*.

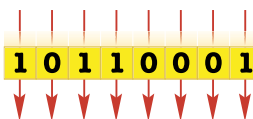
One character at a time or whole sentences?

There are two methods of serial transmission: asynchronous transmission and synchronous transmission. In *asynchronous transmission*, the transmitter transmits the characters one at a time, with their respective start and stop bits. The receiver knows that each start bit will be followed by a character which has to be interpreted. The stop bit completing the message re-sets the receiver. About 90-95% of serial data transmission is asynchronous.

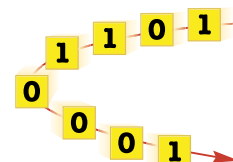
In *synchronous transmission* the entire message is sent in an even flow. The rate is maintained by a clock signal on a separate wire or modulated on the data signal.

The advantage of asynchronous transmission is that it is simple and inexpensive. The disadvantage is that it is inefficient in comparison with synchronous transmission as it contains as much as 20-25% of message content comprising parity bits.

Parallel and serial transmission



Parallel transmission



Serial transmission



Start bit

Stop bit

Asynchronous and synchronous transmission



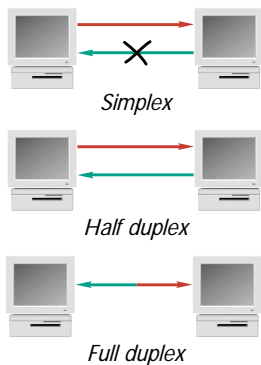
In asynchronous transmission, one byte is transmitted at a time. The byte starts with a start bit and ends with a stop bit.



In synchronous transmission, the whole set of data is transmitted at once, in a continuous stream.

Transmitters and receivers

Simplex and duplex



Within the field of data communications, we define hardware as transmitters or receivers. Two units, e.g. a PC and a robot can both be transmitters and receivers, although this is seldom possible at the same time.

When communication only takes place in one direction, e.g. a computer which sends an "on/off" instruction to a motor, this is called *simplex* transmission. On the other hand, if the motor then has to reply that it is functioning and report its speed, duplex transmission is required.

Half-duplex transmission means that the communicating units must take turns in sending out signals, i.e. communication can take place in both directions but not simultaneously.

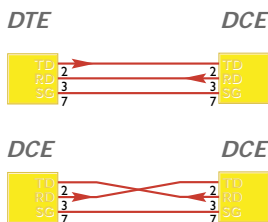
Full-duplex transmission is two-way simultaneous transmission. One example is a telephone conversation where both parties can speak at the same time.

The right connection

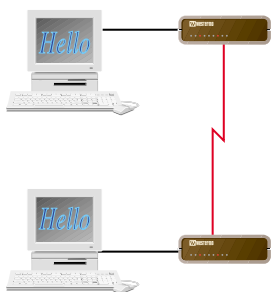
Two terms which recur in data communications are DTE (Data Terminal Equipment) and DCE (Data Communication Equipment).

Computers and terminals are usually DTEs, modems and communications hardware are generally DCEs while other equipment such as multiplexers and printers can be DTEs or DCEs (refer to the relevant equipment manual). DTEs transmit and receive data on different pins in the connector than DCEs. Therefore, to avoid common errors when connecting equipment, it is important to know the definition of the particular item of equipment.

If you connect a DTE with a DCE, the DTE will transmit data on pin 2 while the DCE will receive data on pin 2 (in spite of the fact that the signal is called TD, Transmit Data in both cases). If you connect two DCEs, you have to connect pin 2 and pin 3 in order for the transmitter to be connected to the receiver (for more detailed information turn to page 19).



Transparent Communication



When connecting two or more modems together to create a network the modems do not influence the data. "What goes in one end comes out the other" describes why the term transparent communication is used. Transparency also means that all units will hear all messages.

Master-Slave configuration and addresses

The vast majority of industrial networks are based on a master slave configuration where one or several masters sequentially send messages to the slaves who in turn respond. This sequence is called polling. As the system is transparent a prerequisite for this procedure is that each slave has its own address.

A master sends a message starting with the specific slave's address. The slave recognizes its address and performs the commands included in the message. In many protocols an acknowledgment is returned to the master who will proceed to the next slave.

The format of the address and the message is all part of the protocol used by the specific control system. The modems are not concerned with this fact as long as the signals conform to the standard of the communications protocol.

If the slaves are unintelligent (no address) so called addressable modems can be used.

A message intended for all slaves is called a broadcast message. This can typically be a message from the master instructing all slaves to perform the same task. An example would be a number of PLCs controlling sirens. In case of a general alarm all sirens should sound and this could be achieved by sending a broadcast message.

Transmission speeds

Bit/s and baud

The optimum transmission speed is not the same as the fastest possible speed since the risk of transmission errors and interference increases with an increase in the transmission speed. It is the type of cable and the distance which define the optimum speed. The aim is always to achieve a highly secure and reliable transmission as well as immunity to interference.

In order to send digital data signals over an ordinary copper wire, the signals must be transformed. The length of the cable will attenuate and alter the signals. At high speeds, this effect will be critical.

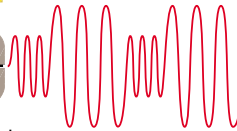
Two terms which are easily confused are those used to describe transmission speeds: bit/s and baud.

The transmission speed is measured in *bit/s* (data bits per second). Since approximately 10 bits are required to transmit one character, it is simple to calculate how many characters are transmitted per second. At a transmission speed of 9 600 bit/s, about 960 characters per second are transmitted.

In order to transform the digital signal into a signal which can be transmitted on the network, a modem is used. The modem transforms (modulates) the signal and the *baud rate* indicates how many times per second the signal is transformed. Each transformation is a "packet" which is sent along the line to the receiver's modem which unpacks (demodulates) the information into digital signals again.

Short-haul modems are transparent and the transmission is not modulated so that data is received exactly as it was transmitted. The PTT modem can function as a short-haul modem or with a built-in buffer to hold the bits before they are sent. For every transmission more than one bit can be sent so the value for transmission speed-bit/s and the transmission times per second-baud differ. If a modem transmits at 2 400 baud and there are four bits in every transmission, the transmission rate will be 9 600 bits/s.

1 0 1 1 0 0 0 1



Modulated analogue electrical signal



1 0 1 1 0 0 0 1

Modulation

The term, modem, is an acronym of the term *m*odulation, i.e. signal transformation, and the term *d*emodulation, which is the recreation of the original signal. The data signals must be transformed and adapted so that they can be transported over different types of cable. The digital signal levels (1's and 0's) must be transformed into readable changes for the selected cable.

There are three types of modulation:

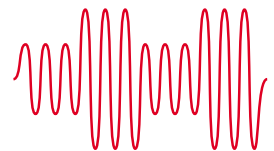
Frequency modulation, where different frequencies are used to represent a 1 and a 0.

Phase modulation where the phase of the carrier sine wave is shifted abruptly to represent the 1's and the 0's. This is the most common method used for PTT modems which transmit across the telecommunications network.

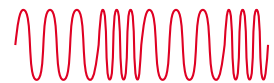
Amplitude modulation uses the strength of the signal or amplitude peaks to create readable 1's and 0's.

Phase/Amplitude modulation is a combination that allows more bits per baud to be transmitted.

Modulation and demodulation



Amplitude modulation



Frequency modulation



Phase modulation