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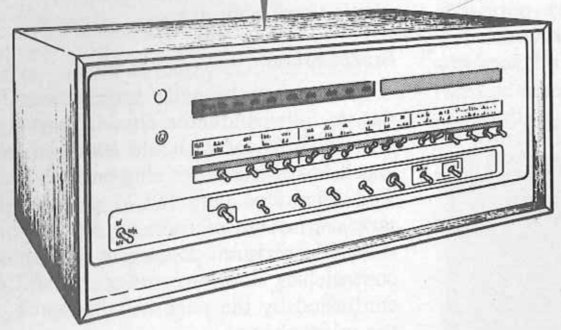
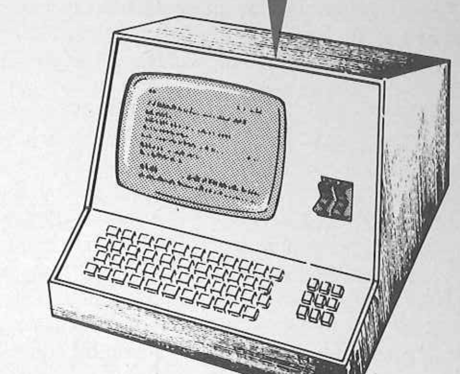
Digital Data Transmission— How A Computer Communicates





The value of a computer is greatly enhanced when the computer has the capability to communicate with peripheral devices, such as a CRT terminal, printer or floppy disc. Here's a look at the various transmission methods, transmission rates and interface schemes that are available for use.

PHIL HUGHES

THERE ARE MANY WAYS TO TRANSMIT BINARY DATA FROM ONE location to another. With the advent of the personal computer, it is important that we understand these different ways so that we can understand how a computer communicates with a peripheral device.

Transmitting digital data

Digital devices communicate with other digital devices on a direct current (DC) basis. Within this DC signaling there are two transmission modes—bit-serial and bit-parallel.

In the bit-serial mode each bit is transmitted sequentially. Figure 1 shows a DC circuit in which a receiving device is

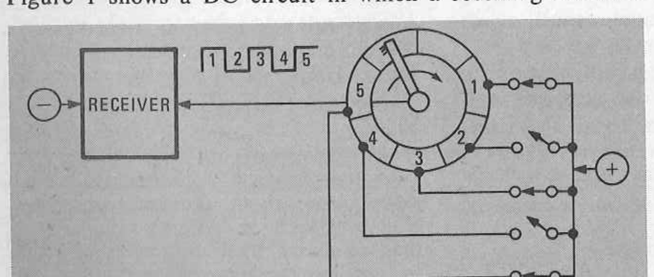


FIG. 1—BIT-SERIAL TRANSMISSION. For illustrative purposes only, the transmitter is shown as an electromechanical device. The transmitted character consists of five data bits.

connected to a bit-serial transmission mechanism. This hypothetical mechanism consists of a plate that has seven electrically isolated segments. One segment for each of the five bits required to transmit a character, plus two additional segments that serve to transmit a space in between each transmitted character. A wiper arm makes contact with each segment individually and completes one revolution for each character transmitted.

Each segment is wired to a sensing contact, which, in turn, can be operated by a mechanical component of the transmitter such as a paper-tape sensing pin. Current flows in the circuit connecting this transmitter to the receiver when the wiper arm crosses a segment whose associated sensing contact is closed. Because the wiper arm tests each segment sequentially, the circuit responds accordingly, and the generated code bits are presented serially to the receiver.

Bit-parallel transmission is performed by preparing all the character bits simultaneously and then issuing a clock signal to indicate to the receiver that a character is ready (see Fig. 2).

From this you can see that bit-serial transmission requires only one circuit to send a complete character whereas in bit-parallel transmission, a separate circuit is required for each character bit (plus the clocking information). The advantage of bit-parallel transmission is that data can be transmitted faster because all bits within a character are made available simultaneously. This is why bit-parallel interfaces are normally used to connect up to a high-speed printer whereas the slower teletypewriter circuits use bit-serial transmission.

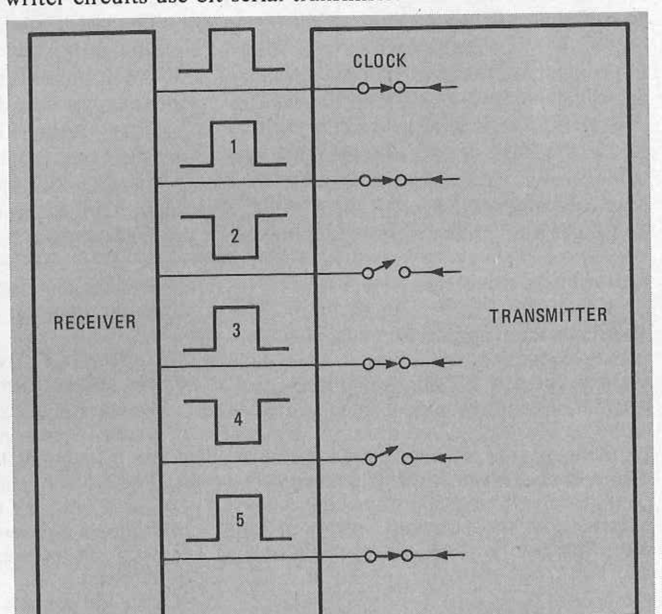


FIG. 2—BIT-PARALLEL TRANSMISSION. All data bits are transmitted simultaneously over five individual circuits.

Transmission method

A communications receiver accepts and acts upon the information contained within the transmitted signal. If the circuit operates in the bit-serial mode, the receiver must know when the first bit of a character is available and the time interval separating each sequential bit. In the bit-parallel mode the receiver must distinguish between the idle condition of the circuit and the occurrence of a character. The transmitter and the receiver must be synchronized, and, because there is no mechanical linkage between them, the timing information must be conveyed on the circuit connecting them. This synchronization is established by one of two methods: *asynchronous* or *synchronous*.

In asynchronous transmission the timing information is derived from each character transmitted. The normal idle condition of an asynchronous circuit is current-on (called *mark*). To initiate operation, the transmitter precedes each character with a *start* (current-off) bit. This current-off condition (called *space*) advises the receiver that a character will follow and that it should start looking at the predetermined intervals for the character bits. The transmitter follows the last data bit with a return to the normal idle condition by adding a *stop* (current-on) interval. The length of this interval is determined by when the next character is available for transmission. The term asynchronous is synonymous with *start/stop* and implies that the receiver comes to rest between each character. The start bit provides the synchronization with each incoming character.

The bit-serial transmission mechanism shown in Fig. 3 is

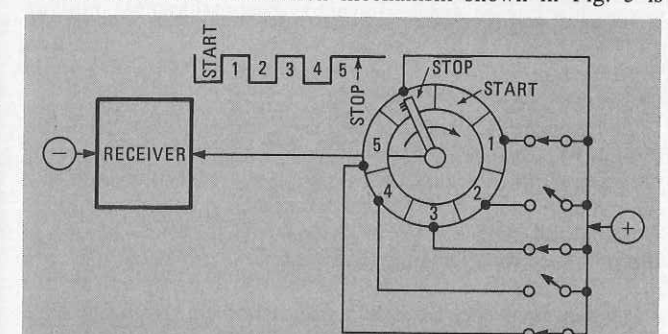


FIG. 3—ASYNCHRONOUS SERIAL TRANSMISSION includes start and stop bits in addition to the data bits.

similar to that shown in Fig. 1, but with the addition of start and stop bits. Note that the stop bit has a fixed length, but this is meaningful only when there is a continuous flow of characters, otherwise the stop bit is indistinguishable from the idle (mark) condition of the line. This, according to old Western Union operators, is where the expression 'just marking time' comes from.

In a bit-parallel circuit the receiver uses a timing or clock pulse to signal the arrival of data. The clock contact shown in Fig. 2 is operated whenever a character is available.

The synchronous transmission method is more sophisticated than the asynchronous mode. It assumes that the transmitter and receiver are being driven at identical clock rates and that the corresponding functions of each (bit generation by the transmitter and the detection of that bit by the receiver) occur at the same time. The clock rates of the transmitter and receiver are matched by the transmission of a timing pattern. These timing patterns are called synchronization (or sync) characters.

In some systems during idle line time (when no data is ready for transmission), a continuous stream of sync characters is transmitted. In other systems, a fixed number of sync characters are sent immediately preceding the data characters. In all systems, the receiver does a bit-by-bit comparison of the incoming bit stream to the bit configuration of the sync character. When a match is detected, the receiver is said to be *locked-on*, and the data characters can be sent without additional timing information. The receiver can then distinguish between the individual bits of a data character because the position of the sync character has been established.

In asynchronous transmission, timing information is included with each character. This timing overhead represents from 20% to almost 50% of the character time, depending on what code is being transmitted. Synchronous transmission has the advantage of handling its timing overhead with a few sync characters at the beginning of a message. This significantly reduces transmission overhead attributable to timing information.

Transmission rates

Digital data can be transmitted at many different speeds, and individual devices can frequently operate at two or more rates. These rates can be expressed as characters-per-second (CPS), words-per-minute (WPM) and *baud* or bits-per-second, the term baud is used interchangeably with bits-per-second. For bit-serial transmission, the meaning of characters-per-second is clear. For bit-parallel transmission, bits-per-second and characters-per-second are equivalent because each bit requires a separate circuit. Bit-serial devices have a varying number of bits in each character, and transmission facilities are concerned with the maximum number of electrical transitions they are required to handle. Therefore, bit-serial devices and transmission limitations are expressed in terms of bits-per-second.

To determine the transmission rate, we must first determine the number of bits contained in a transmitted character. This number is generally not equal to the number of bits that are required to define the character because transmission-overhead bits must be added. For example, the ASCII code requires only seven bits to define a character, but the synchronous transmitter adds a parity bit for error checking. Thus, transmitting the ASCII code over a synchronous data link requires eight bits-per-character. The following formula can be used to compute the data rate on a synchronous link:

Bits-per-second = characters-per-second × bits-per-character (data bits + parity bit).

For asynchronous transmission, add the start and stop bits as well as a parity bit. If the start and stop bit times are equal to the character bit times, then 10 bit times (seven data bits + parity + stop + start) are required to transmit an ASCII character. Actually, in asynchronous transmission the stop bit is frequently longer than the data bits. For example, an ASCII teletypewriter requires a stop bit that is equal to twice the length of a data bit, thus requiring 11 bit times to transmit a character. The Baudot (an older five-bit level code) teletypewriters generally require a stop bit that is equal in length to 1.42 bit times. Because of this difference between various asynchronous transmitters, the character is expressed in terms of bit-lengths. This bit-length-per-character is called the *unit code*. For example, an ASCII code with a parity bit, a start bit and a stop bit equal in length to one data bit is a 10 unit code. A Baudot device with five data bits, a start bit, and a 1.42 unit stop bit form a 7.42 unit code. Table 1

TABLE 1–UNIT CODE FOR COMMON DEVICES

	Bell System Baudot TTY	Western Union TTY	10 characters per second ASCII TTY	30 characters per second ASCII terminal
Start	1	1	1	1
Data bits	5	5	7	7
Parity bits	Not used	Not used	1	1
Stop	1.42	1	2	1
Total unit code	7.42	7	11	10

shows some common devices and representative code lengths.

Using the unit code concept, the following formula determines the data rate for asynchronous circuits:

Bits-per-second = characters-per-second × unit code.

Communications interface

The communications interface is the electrical connection between the computer and the communications equipment. The latter is generally a data set or modem. (A modem is a device that converts DC signals into AC signals suitable for transmission over telephone circuits and then converts them back to DC signals for reception.) The computer equipment is either an I/O port or a terminal.

It is fairly common for two pieces of computer equipment to be connected together. Although this does not fit into the strict definition of a communications interface, the definition can be stretched a little. The two pieces of connected equipment are generally called the *data terminal equipment* and the *data communications equipment*. Since the data terminal equipment will exist whether the terminal is connected to a communications interface or to a computer, the terminal itself can be defined as the data terminal equipment. Data communications equipment refers to either the data equipment or the computer. In other words the data communications equipment will always refer to whatever it is that you are connecting to a terminal. Now that we have the hardest definition out of the way let's look at a couple of common interfaces. We'll see what they are, how they differ and how they are applied.

Figure 4 shows a 20 mA (20-mil) current-loop interface. The circuit has only two wires, with the earth commonly used in place of one wire. A mark condition or logic 1 is defined as a complete circuit; a space or logic 0 is an open circuit; and information is transmitted as is shown in Fig. 3. This circuit is the standard interface for teletypewriter devices.

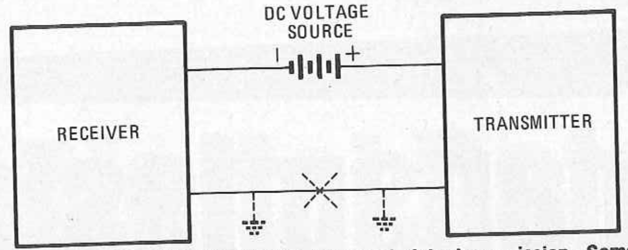


FIG. 4—20-MIL CURRENT LOOP for serial data transmission. Some systems replace the return path with a common ground. This reduces the number of wires running between the transmitter and receiver to one.

The other common interface is the Electronic Industries Association (EIA) No. RS-232-C. This interface is the most popular even though it predates integrated circuits and is therefore not tailored to IC levels. The telephone companies use this standard as the interface with which their data sets are designed to operate.

The RS-232-C standard is defined in terms of voltage levels. A voltage from +3 to +15 is defined as a space or logic 0, and a voltage from −3 to −15 is defined as a mark or logic 1. The transmitter specifications are from +5 to +15 volts for a space, and −5 to −15 volts for a mark. This allows for noise and a loss of up to 2 volts in the circuit.

A standard RS-232-C communications circuit consists of a data path in both directions, a ground return and status and

TABLE 2–STANDARD RS-232-C PIN ASSIGNMENTS

Pin No.	Description	Data direction
1	Protective (chassis) ground	
2	Transmitted data	From terminal
3	Received data	To terminal
4	Request to send	From terminal
5	Clear to send	To terminal
6	Data set ready	To terminal
7	Signal ground	
8	Data carrier detect	To terminal
20	Data terminal ready	From terminal

control lines. Table 2 shows the standard pin assignments for the most common signals and the direction of data flow. Note that if a computer is directly connected to a terminal, it is necessary to alter some connections such as attaching the receive-data lead from the terminal to the transmit-data lead of the computer and vice versa.

The protective ground is equivalent to the third pin on a standard household electrical outlet. It insures that the chassis potential of all the equipment is equal, which should result in a longer equipment life. It also eliminates possibly hazardous potential differences between chassis. Signal ground is used as the reference for all the interface levels.

Transmitted data is the data that comes from the transmitter and is sent to a receiver; receive data is transmitted in the other direction, with the information to be displayed.

All other RS-232-C interface signals are for supervisory or control purposes. Some send information to the terminal, and others request information from the terminal. *Data set ready* signals the terminal that the communications equipment is powered up and ready. *Data terminal ready* indicates that the terminal is powered up and ready.

The *request to send* and *clear to send* lines are used for handshaking between the terminal and data set. When the terminal wants to send data, it activates the *request to send* line and then waits for the communications equipment to activate the *clear to send* line before data is actually sent. This gives the data set time to turn on the transmit signal. The delay between *request to send* and *clear to send* is called *line turnaround time* and can vary between 0 and 200 ms. The actual delay is selected based on circuit characteristics and then set by the circuitry within the data set. **R-E**

Noise Interference In Mobile Rigs How To Get Rid Of It

Eliminating interference in mobile radios can be simple when you find the source. Here's how to find and get rid of most noise.

JOSEPH J. CARR

NOISE INTERFERENCE IS PERHAPS ONE OF THE MOST IRRITATING problems encountered when installing a mobile rig. Some noise problems seem so difficult to eliminate that many simply put up with the irritation, and accept it. However, most noise problems are relatively easy to solve, and are amenable to almost simplistic solutions.

The first step in troubleshooting any mobile noise problem is to identify the *types* (notice the use of the plural form!) of noise present. Generally, noises come in bunches, each of which must be solved by a slightly different approach. Is it, for example, spark plug/ignition noise? Is it alternator whine? Or is it the sloshy-sounding tick of the gasoline level sensor in the fuel tank? You should not fall prey to the trap of assuming that only one form of noise is present, even when they sound enough alike to mask each other.

Suppression methods

Table 1 shows the most common types of noise in mobile broadcast and communications receivers, along with their recommended cures. Be aware, though, that many transceivers may not be able to use all of these techniques because of the high current demands of the transmitter. For example, if the L-section filter is used to suppress alternator whine, the recommended choke will have too high a resistance for a 100-watt transmitter. In these cases, you could open the transceiver and insert the filter in the power-supply line feeding the receiver and thus leave the power-supply line feeding the transmitter circuits intact. If this is possible, it will also allow you to fuse the power-supply line feeding the receiver at a much lower current than the rating of the primary fuse for the transmitter. It has been known to happen, especially where solid-state receivers are used, that the receiver power supply could burn up rather spectacularly, yet the power-supply current would not blow the 25- to 50-ampere fuse needed to sustain the normal transmitter supply current.

Also, be aware that some automobile manufacturers will have installed some suppression techniques that could be superior to those given in this article for specific automobile models. This is especially true for alternator whine or where a grounding or shielding problem in the vehicle has been detected. A call to the local automobile dealership or to the field-service department of the auto maker often yields rich information.

The capacitor method of suppressing ignition noises works well on the old-fashioned Kettering coil/breaker-points type of ignition that is standard on almost all cars, but it may not work

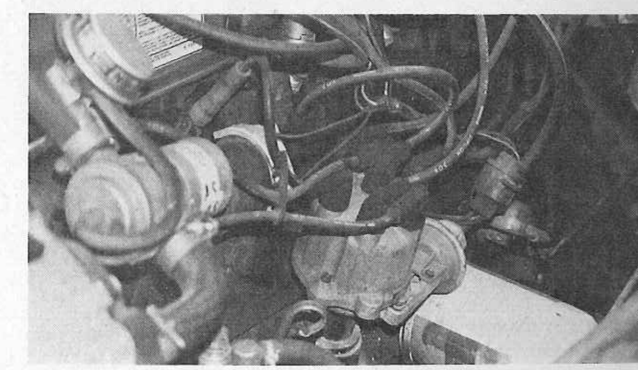


FIG. 1—IGNITION SYSTEM is the most dominant source of RF interference in automotive installations. Early amateur radio operators often used ignition coils from Model-T cars as transmitters.

or may cause damage to the newer solid-state ignition systems. In this case, contact the car manufacturer (either the car maker if it is O.E.M. equipment or the ignition manufacturer if it is an after-market product).

The ignition system (shown in Fig. 1) is not the only source of spark-like interference. There are numerous small DC motors in your car that are often overlooked. One of the prime offenders is the motor (see Fig. 2) that drives the blower in the heating/air-conditioning system.

Standard suppressors

Some of the suppression techniques recommended (see Table