Encoding Questions

- How long should a voltage stay on for each bit?
- How long should the pause be between bits?
- What guarantee is there that a transmitter and a receiver agree on timing?

Answer: That's where standards come in!

Organizations Publishing Standards

- International Telecommunications Union (ITU)
- Electronic Industries Association (EIA)
- Institute for Electrical and Electronic Engineers (IEEE)

RS-232-C (or simply RS-232)

- The standard used to transfer characters across copper wires between a computer and a device such as a keyboard, a terminal, and a modem.
- Produced by EIA.
- Communication is serial.
- Communication is asynchronous.
- Connection is reliable up to 50 feet.
- “1” corresponds to –15 volts; “0” to +15 volts.
- Uses a 25-pin connector.

RS-232-C (or simply RS-232)

- Transmitter never leaves 0 volts on the wire. When idle, it puts –15 volts (bit “1”) on the wire.
- Transmitter indicates the start of the next character by transmitting a “0” called the start bit.
- A minimum idle period is specified between the end of one character and the beginning of the next. Since idle means –15 volts (bit “1”), we can think of a phantom “1” bit being sent after each character. This is called the stop bit.
- Thus, to transmit a 7-bit character, 9 bits are sent.

Timing, Baud Rate, Reality

- Instead of specifying the time per bit, the number of bits per second (bps) is specified.
- baud - the number of times a signal changes each second.
- In RS-232, each signal change represents one bit, and so the baud rate and the bps are the same. In general, baud and bps need not be the same.
- bandwidth - a measure of the capacity of a transmission system measured in cycles per second or Hertz (Hz).

Nyquist's Theorem

$D = 2 B \log_2 K$, where

D = maximum data rate in bits per second,
B = bandwidth,
K = number of voltage values.

- For RS-232 which uses 2 voltages, D = 2 B.

Shannon's Theorem

$C = B \log_2 (1 + S/N)$, where

C = effective data rate in bits per second,

B = bandwidth,

S = average signal power,

N = average noise power.

Signal-to-Noise Ratio

- S/N is called the signal-to-noise ratio.
- decibel (dB) - a unit for measuring the relative loudness of sounds or, more generally, the relative levels of two energies. A bel is 10 dB.
- If P_1 and P_2 are two power levels, the number of dB between the two power levels is

$$10 \log_{10} (P_2 / P_1).$$

Examples

- Doubling a power level corresponds to an increase of 3 dB.
- A sound 10 dB louder than another sound (that is, a sound 10 times more powerful) appears to the ear to be twice as loud.

dB Levels above Audibility

- Rustle of leaves - 10 dB
- Average whisper - 20 dB
- Average home - 40 dB
- Ordinary speech - 60 dB
- Busy street traffic - 75 dB
- Train - 95 dB
- Jackhammer - 100 dB
- Rocket, threshold of pain - 120 dB