Signaling

Signaling is a mechanism to send the digital data in form of bits as voltage pulses.

There are two types of signaling generally used in digital electronics :
1.) Single-ended signaling
2.) Differential signaling.

1.) Single-ended signaling:

This type of signaling is generally used in half-duplex method or other similar methods where one signal requires only 1 wire to transmit bits, and 1 wire acts as common ground if multiple signals has to be transmitted.
So for exchanging 10 different signals, one need a cable with 11 wires, 10 for voltage pulses and 1 for common ground with whose relative the pulse potential would be.

A probable problem with single-ended signaling is that noise can cause signal distortion, in order to neglect the signal distortion/noise, the magnitude of voltage pulse must be significantly higher than the noise voltage, thus requires higher power for transmission, Single-ended signaling typically requires signal voltage to be ~5V or more or the design must be using some sort of noise cancellation mechanism in order to reduce higher power consumption.

2.) Differential signaling:

This type of signaling is used in CAN networks and other requirement specific circuits, this signaling requires two wires to transmit a single signal along with a common ground.
At the receiver's end, their must be a differential amplifier to take the difference of the potential between two wires.
If one need to transmit 10 signals, 21 wires will be required, 20 for signals, 1 for common ground.

But how does the differential signaling works ???

The wires are assigned names as D+ and D- , both wires carries same potential but of opposite polarity at each instant of time when the circuit is in operable state.

logical 1 is represented when D+ is at higher potential than D- , say D+ at 2.5V and D- at -2.5V.

logical 0 is represented when D- is at higher potential than D+ , say D- at 2.5V and D+ at -2.5V.

note that at every time instant when the device is in operable state, both wires are at equal but opposite potential.

Advantages of differential signaling :
* Common mode rejection :

Any piece of small signal which is common on both the wires will be cancelled out by the differential amplifier, say a noise is induced in both the D+ and D- signals, then at the receiver's end, when the differential amplifier performs the operation : (D+) - (D-) , the common noise signal will be cancelled giving it name as 'Common mode rejection'.

* Lower power consumption :

In case of Single-ended signaling, in order to overcome the noise impact on original signal, the voltage level of bit carrying pulses must be high in order to correctly interpret the potential, but in case of differential signaling, the noise cancellation is handled by differential amplifier at receiver's end, thus we don’t need to worry about noise, then why should we even use higher voltage levels for pulse/bit transfer ?, definitely not, the small pulse voltages are used to transmit bits over the channel, and also the signal gets amplified at receiver's end as well, thus signal potential must only be large enough that differential amplifier can significantly work with it.