Interfaces; RS-232, RS-422, NMEA 0183, ...

Introduction

The NMEA 0183 Standard, along with RS-232, RS-422, etc., belongs to the class of "Asynchronous Serial" interfaces. This means that data is transmitted serially (bit-by-bit) on a single line. Furthermore, the transmission is asynchronous because no "clock" signal is transmitted with the data.

When using asynchronous communications, "TIMING IS EVERYTHING". In order to synchronize to the incoming data, a receiver needs to know the bit rate (baud) of the incoming data and the number of Start, Stop, and Data bits. Without this information ahead of time, the receiver (usually a UART) has no chance of correctly deciphering the Serial bit stream. The receiver will "resynch" on each new byte of data when it receives the "Start" bit. This allows for timing errors of a few percent to be tolerated. The tradeoff is that nearly 40% of the channel bandwidth is used for overhead (synchronization).

What distinguishes NMEA 0183, RS-232, and RS-422 from each other is their physical voltage and current interface levels. NMEA 0183 originally allowed "single-ended" drive, but was later updated to differential drive (RS-422). RS-232 is a bipolar interface and RS-422 is differential drive. These are explained in more detail next.

RS-232

The RS-232 has been around since the very early days of Digital Communications. Early implementations required elaborate hardware "handshaking" to maintain communication. Twenty-five pin connectors with several handshaking and "flow-control" lines were needed in most installations. Later, with the advent of microprocessors, hardware handshaking disappeared in favor of software flow control. Nowadays, most RS-232 interfaces use only a "transmit Data" (TD) wire, a "receive data" (RD) wire, and "ground" (GND). For one-way transmission (or reception), only two wires are needed.

An RS-232 line will go to a negative or positive voltage with respect to Ground, depending on whether a binary "one" or "zero" is transmitted. Any voltage greater than +3.0 is considered a "zero" (space), whereas any voltage less than -3.0 is taken as a "one" (mark). The range between +3.0 and -3.0 volts is undefined. These voltages worked fine in early communication systems, but they do not interface easily with modern digital electronics which operate in the 0-5 volt range.

The RS-232 interface is intended for use in high-impedance circuits. This means that the drivers are not expected to provide large drive currents. Receivers will usually have impedance in excess of several k-ohms. RS-232 interfaces are somewhat sensitive to environmental noise (motors, ignition pulses, etc.) and are therefore usually limited to installations of tens of feet or less.

RS-422

RS-422 is most commonly called "differential drive". Two wires, A and B are used for this interface, but neither wire is grounded. A "zero" is produced by making A positive with respect to B and a "one" by making B positive with respect to A. It is therefore the direction of current flow rather than a voltage level that determines the logic state. It is important to note that neither RS-422 signal line (A and B) can be connected to Ground.

RS-422 is a low impedance interface and can often drive loads down to tens of ohms. It is very immune to external noise, and so can be used over greater distances (hundreds of feet). Under the latest version of NMEA 0183, all talkers are supposed to be RS-422. RS-422 is not strictly compatible with RS-232, but most RS-422 drivers will act like a single-ended driver if only one output line is used. In this way, the RS-422 "A" output can be used to drive either an RS-232 input directly. The "B" line is simply left unconnected.

NMEA 0183

Early versions of the NMEA 0183 Standard specified that "listeners" must be isolated from ship's ground but allowed "talkers" to be simple single-ended drivers (referenced to ground). Furthermore, the input impedance of a listener was specified to be greater than 500 ohms, and opto-isolation was recommended. Later versions of the Standard retained the opto-isolated listener recommendation, but revised the talker requirement to be RS-422 compliant. As a result, there exist some instruments (talkers) with single-ended outputs and others with RS-422 (differential) outputs. Fortunately, both types of outputs will drive opto-isolated listeners.

Single-ended drivers are perhaps the simplest to design. The desired state indicated by the presence or absence of a voltage above some threshold. For NMEA 0183 (ver. 1.5), a "one" was any voltage less than +0.5, while a 'zero' was any voltage greater than +4.0. Besides their design simplicity, single ended drivers need only one wire to transmit data. Since voltages are referenced to Ground, no signal return line is needed.

The conversion of NMEA 0183 talkers to RS-422 (ver. 2.0) was a good move, although it increased the confusion factor among installers and required the use of "two-wire" connections. RS-422 has excellent noise immunity even in long cable runs and has ample drive capacity. A single RS-422 talker can easily drive 4 or more opto-isolated listeners.

On the listener side, most manufacturers seemed to have adopted the NMEA "opto-isolation" recommendation. Opto-isolators are actually quite simple devices. They consist of a light source (LED) coupled to a phototransistor. The input data signal turns the LED on and off which causes the phototransistor to switch on and off. The LED and phototransistor are completely isolated from each other electrically. The data source (talker) must provide sufficient current and voltage to power the LED. A current limiting resistor in series with the LED is generally used for protection. The advantage of opto-isolated inputs is that virtually any type of driver can activate them.

Interface Compatibility

The question of interface compatibility often comes up in NMEA 0183 installations. Here is a summary of what to expect:

- Almost any type of driver (TTL, RS-232, RS-422, etc.) will drive at least one opto-isolated NMEA 0183 listener. RS-232 drivers will usually drive two listeners while RS-422 will often drive more than four listeners.
- RS-232 listeners (i.e., computers) can only be reliably driven by RS-232 drivers because of the negative voltage in the "idle" state. In practice, however, many RS-232 receivers will interpret a O-volt input as an "idle" (logic 1) state and thereby correctly interpret data from single-ended drivers such as TTL or older NMEA 0183 talkers. This is why some GPS units have been successfully connected directly to a PC serial input without any signal conversion.
- RS-232 listeners can also usually be driven by RS-422 drivers connected in "single-ended' mode. This is done by connecting the 'A' output to the RS-232 input and leaving the 'B' output disconnected.
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The bottom line on interfacing is that most interface types are interconnectable once you know what you have.