



Future Technology Devices International Ltd.

Technical Note TN_111

What is a UART?

Document Reference No.: DocNo FT_000157

Version 1.0

Issue Date: 2009-08-07

The purpose of this technical note is to clarify the differences in the terms UART, Serial port, RS232, RS422 and RS485.

Future Technology Devices International Limited (FTDI)

Unit 1, 2 Seaward Place, Centurion Business Park, Glasgow G41 1HH, United Kingdom

Tel.: +44 (0) 141 429 2777 Fax: + 44 (0) 141 429 2758

E-Mail (Support): Support1.support@ftdichip.com Web: <http://www.ftdichip.com>

Copyright © 2009 Future Technology Devices International Limited

Table of Contents

| | | |
|------------|---|-----------|
| 1 | Introduction..... | 2 |
| 2 | The UART | 3 |
| 2.1 | Signals..... | 3 |
| 2.1.1 | RXD | 3 |
| 2.1.2 | TXD..... | 3 |
| 2.1.3 | RTS#..... | 3 |
| 2.1.4 | CTS#..... | 3 |
| 2.1.5 | DTR# | 3 |
| 2.1.6 | DSR# | 3 |
| 2.1.7 | DCD#..... | 3 |
| 2.2 | Data Format..... | 3 |
| 2.2.1 | Number of Start Bits | 4 |
| 2.2.2 | Number of Data Bits | 4 |
| 2.2.3 | Parity..... | 4 |
| 2.2.4 | Number of Stop Bits | 4 |
| 2.3 | Flow control | 4 |
| 2.3.1 | NONE | 4 |
| 2.3.2 | HARDWARE..... | 4 |
| 2.3.3 | SOFTWARE | 4 |
| 2.4 | Baud rate..... | 4 |
| 2.5 | Local Echo | 4 |
| 2.6 | Typical interconnect..... | 5 |
| 3 | RS232 | 6 |
| 4 | RS422 | 7 |
| 5 | RS485 | 8 |
| 6 | Comparison Table | 9 |
| 7 | What FTDI offer..... | 10 |
| 8 | Contact Information..... | 11 |
| | Appendix A - References | 13 |
| | Appendix B - Revision History..... | 14 |
| | Revision Record Sheet..... | 15 |

1 Introduction

Many users are confused by the interchangeable names used for a serial port. This is partly due to slang language and poor definitions.

The purpose of this technical note is to clarify what the differences between a UART, RS232, RS422 or RS485 port are.

2 The UART

The term UART means Universal Asynchronous Receiver Transmitter and is a commonly used interface to transfer serial data. Being asynchronous there is no clock signal but the structure of the transmitted data provides for a start and an end to a message. It is also important that both ends of the link decide to operate with the same pulse width defined as the baud rate. The UART of a micro-controller will normally operate at 3V3 or 5V TTL levels. The UART will only connect to one other device in the chain.

2.1 Signals

The following signals are used to create a UART interface however not every design needs to use every signal. A # symbol is used to designate an active low signal ie active at logic 0.

2.1.1 RXD

The RXD signal of a UART is the signal receiving the data. This will be an input and is usually connected to the TXD line of the downstream device.

2.1.2 TXD

The TXD signal of a UART is the signal transmitting the data. This will be an output and is usually connected to the RXD line of the downstream device.

2.1.3 RTS#

The RTS# (Ready to Send) signal of a UART is used to indicate to the downstream device that the device is ready to receive data. This will be an output and is usually connected to the CTS# line of the downstream device.

2.1.4 CTS#

The CTS# (Clear to Send) signal of a UART is used by the downstream device to identify that it is OK to transmit data to the upstream device. This will be an input and is usually connected to the RTS# line of the upstream device.

2.1.5 DTR#

The DTR# (Data Terminal Ready) signal of a UART is often used for flow control in modems, but many serial interfaces do not use this signal. It is used to signal that the modem is ready to connect.

2.1.6 DSR#

The DSR# (Data Set Ready#) signal of a UART interface is mostly seen in modem applications otherwise the pin is frequently unused.

2.1.7 DCD#

The DCD# (Device Carrier Detect) signal of a UART interface is mostly seen in modem applications otherwise the pin is frequently unused. It is used to indicate a connection is established.

2.2 Data Format

The format of the data is basically made up of start – data – parity – stop, however the number of bits in each section may vary. The data is sent with the least significant bit (LSB) first.

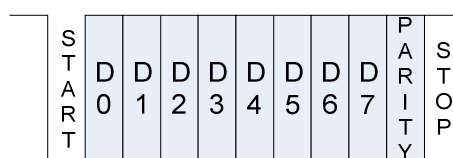


Figure 1: 1 start bit, 8 data bits, 1 parity bit and a stop bit.

2.2.1 Number of Start Bits

There is always only ever 1 start bit.

2.2.2 Number of Data Bits

The number of data bits usually varies between 5, 6, 7, 8 or 9 bits. 8 data bits is most common.

2.2.3 Parity

Parity has many settings, NONE, EVEN, ODD, MARK and SPACE.

2.2.4 Number of Stop Bits

The number of stop bits usually varies between 1, 1.5 and 2.

2.3 Flow control

Flow control is used to control the flow of data and prevent buffer overrun if a device cannot accept more data. It is also sometimes termed as handshaking. There are 3 main settings for flow control as described in the following sections.

2.3.1 NONE

This setting does not use flow control at all and relies on the application or device to be able to move data fast enough to prevent overrun.

2.3.2 HARDWARE

This setting uses the RTS# and CTS# lines. The RTS# line of one device (A) drives the CTS# line of the other device (B) and vice versa. If the RTS# line of device (A) is active it is stating the device (A) is able to accept more data by driving the CTS# input of the device (B) at the other end of the link active. Otherwise device (B) should stop transmitting.

2.3.3 SOFTWARE

This setting uses special characters to start and stop data flow. These are termed XON and XOFF. The XON character tells the downstream device to start send data. The XOFF character tells the downstream device to stop sending data. Usually it is possible to define these characters in an application. Typical defaults for XON is 0x11 and for XOFF is 0x13.

2.4 Baud rate

The baud rate is a measure of how fast the transmission will occur.

A typical baud rate may be 9600 baud.

In terms of bits per second of data this is equal to $9600 / 10 = 960$ bits per second. The value of 10 in the divisor assumes 1 start bit + 8 data bits + no parity + 1 stop bit.

In terms of a pulse width each bit is $1 / 9600 = 104$ uSec wide.

2.5 Local Echo

Local echo is the term used when data transmitted is also echoed back to the transmitting device. It is mostly used in RS485 systems but can be a useful debug technique also to determine if data is being transferred.

2.6 Typical interconnect

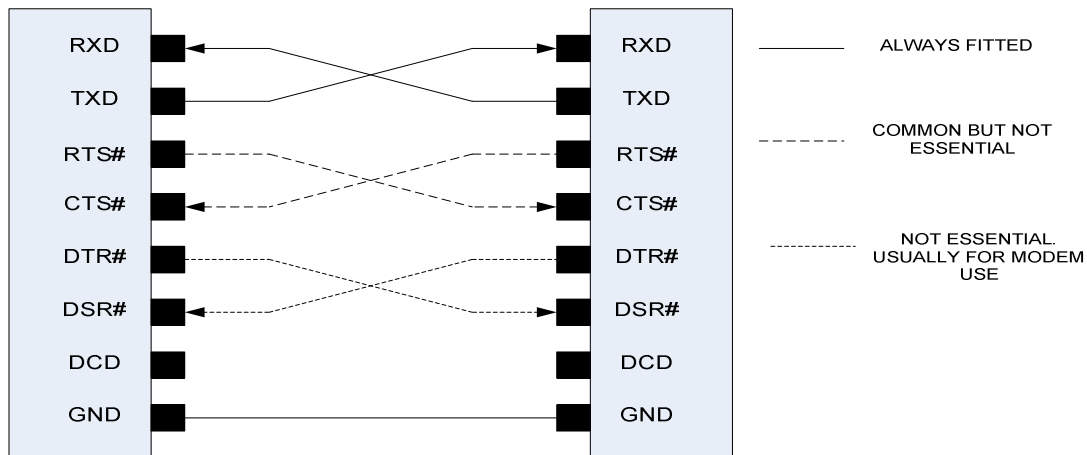


FIGURE 2: RXD and TXD lines are always used to transfer data, the other lines support flow control and are optional. There are also many different combinations of flow control used for example RTS# and CTS# could be connected together on the same device to bypass flow control. You should refer to the manual supplied with your equipment to determine the correct cabling.

3 RS232

RS232 is effectively the same as the basic TTL level UART of section 2, but an additional line driver IC is added to increase the signal strength. It is still a full duplex single ended system meaning it uses a single wire for RX and a single wire for TX. A typical RS232 signal could operate between +/- 5V to +/-15V. This allows the signal to travel along a cable up to 10m long. A typical FTDI product will have a signal swing approximately +/- 6V.

An RS232 system will have 1 driver transmitting to 1 receiver.

A typical application for an RS232 interface is modems.

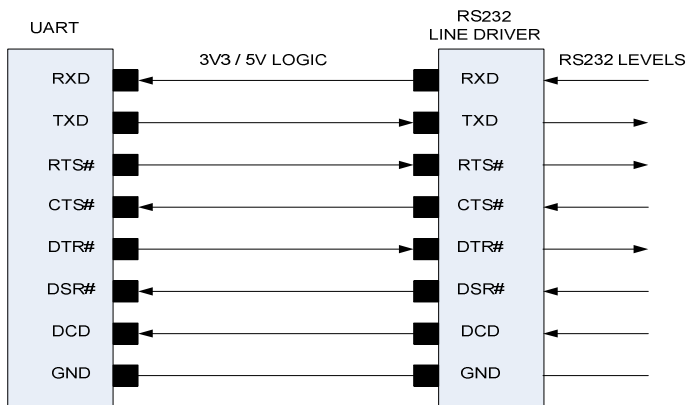


Figure 3: Example of connecting a UART to a Line driver for RS232.

4 RS422

RS422 or ANSI/TIA/EIA-422 designs use the same basic UART but with a different line driver IC. The line driver will convert the single ended UART signal into a differential signal. This gives four data lines, TXD+, TXD-, RXD+ and RXD-. The benefit of using a differential signal as opposed to a single ended signal is that the system has better immunity to noise allowing for longer cable lengths. The signals drive between +/- 2.0V.

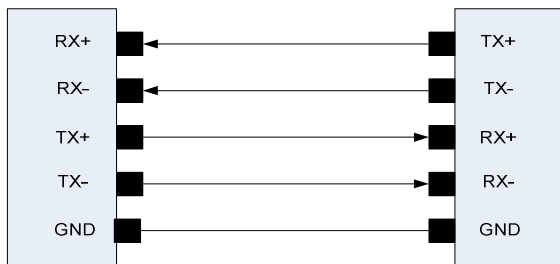


Figure 4: Typical RS422 interconnect.

RS422 systems can have 1 device transmitting at a time with 10 devices receiving in a system. RS422 systems are often used in industrial controllers.

5 RS485

RS485 or ANSI/TIA/EIA-485 designs use the same basic UART but with a different line driver IC. The line driver will convert the single ended UART signal into a bi-directional differential signal. This gives two data lines, Data A and Data B. The benefit of using a differential signal as opposed to a single ended signal is that the system has better immunity to noise allowing for longer cable lengths. The signals drive between +/- 1.5V.

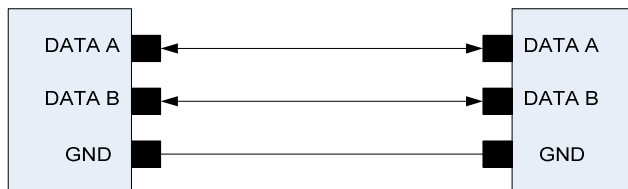


Figure 5: Typical RS485 interconnect.

RS485 systems can have 32 devices transmitting in a system with 32 devices receiving.

RS485 systems are often used in CCTV applications to control the Pan, Tilt and Zoom functions.

6 Comparison Table

The table below gives a quick guide to the differences between the main serial port configurations.

| | TTL UART | RS232 | RS422 | RS485 |
|--|------------------------|------------------------|-------------------------|--------------------------|
| Signal Swing | 0v to 3V3/5V | +/-5V to +/-15V | +/-2V | +/-1.5V |
| Termination | Single ended | Single Ended | Differential | Differential |
| Transmission length | ~2m | ~15m | ~1200m | ~1200m |
| No of transmitters/receivers on a line | 1 Driver 1 Receiver | 1 Driver 1 Receiver | 1 Driver 10 Receiver | 32 Driver 32 Receiver |

7 What FTDI offer

FTDI chipset FT232BL, FT232R, FT2232D, FT2232H and FT4232H can offer a USB conversion to a UART interface. The level of the UART is either 3V3 or 5V depending on the device configuration.

The FT2232D, FT2232H and FT4232H can offer multiple UART channels in one chip package, each channel being independently controlled by the royalty free drivers supplied by FTDI.

By adding different line drivers to the FTDI chipset UART interface they can also offer USB to RS232, USB to RS422 or USB to RS485 solutions.

8 Contact Information

Head Office – Glasgow, UK

Future Technology Devices International Limited
Unit 1, 2 Seaward Place, Centurion Business Park
Glasgow G41 1HH
United Kingdom

Tel: +44 (0) 141 429 2777
Fax: +44 (0) 141 429 2758

E-mail (Sales) sales1@ftdichip.com
E-mail (Support) support1@ftdichip.com
E-mail (General Enquiries) admin1@ftdichip.com
Web Site URL <http://www.ftdichip.com>
Web Shop URL <http://www.ftdichip.com>

Branch Office – Taipei, Taiwan

Future Technology Devices International Limited (Taiwan)
2F, No 516, Sec. 1 NeiHu Road
Taipei 114
Taiwan, R.O.C.
Tel: +886 (0) 2 8797 1330
Fax: +886 (0) 2 8751 9737

E-mail (Sales) tw.sales1@ftdichip.com
E-mail (Support) tw.support1@ftdichip.com
E-mail (General Enquiries) tw.admin1@ftdichip.com
Web Site URL <http://www.ftdichip.com>

Branch Office – Hillsboro, Oregon, USA

Future Technology Devices International Limited (USA)
7235 NW Evergreen Parkway, Suite 600
Hillsboro, OR 97123-5803
USA
Tel: +1 (503) 547 0988
Fax: +1 (503) 547 0987

E-Mail (Sales) us.sales@ftdichip.com
E-Mail (Support) us.admin@ftdichip.com
Web Site URL <http://www.ftdichip.com>

Branch Office – Shanghai, China

Future Technology Devices International Limited (China)
Room 408, 317 Xianxia Road,
ChangNing District,
ShangHai, China

Tel: +86 (21) 62351596
Fax: +86(21) 62351595

E-Mail (Sales): cn.sales@ftdichip.com
E-Mail (Support): cn.support@ftdichip.com
E-Mail (General Enquiries): cn.admin1@ftdichip.com
Web Site URL: <http://www.ftdichip.com>

Distributor and Sales Representatives

Please visit the Sales Network page of the FTDI Web site for the contact details of our distributor(s) and sales representative(s) in your country.

Neither the whole nor any part of the information contained in, or the product described in this manual, may be adapted or reproduced in any material or electronic form without the prior written consent of the copyright holder. This product and its documentation are supplied on an as-is basis and no warranty as to their suitability for any particular purpose is either made or implied. Future Technology Devices International Ltd will not accept any claim for damages howsoever arising as a result of use or failure of this product. Your statutory rights are not affected. This product or any variant of it is not intended for use in any medical appliance, device or system in which the failure of the product might reasonably be expected to result in personal injury. This document provides preliminary information that may be subject to change without notice. No freedom to use patents or other intellectual property rights is implied by the publication of this document. Future Technology Devices International Ltd, Unit 1, 2 Seaward Place, Centurion Business Park, Glasgow G41 1HH United Kingdom. Scotland Registered Number: SC136640

Appendix A - References

<http://www.eia.org/> Electronics Industry Alliance (EIA) have defined the RS232, RS422 and RS485 standards.

Appendix B - Revision History

Revision History

| | | |
|-------|---------------|------------------------------|
| Draft | Initial Draft | June, 2009 |
| V1.0 | First Release | 7 th August, 2009 |