BLUETOOTH LATENCY AND DATA

Application Note v1.0

1 INTRODUCTION

This document describes and presents the results from a series of tests to determine overall Bluetooth data throughput, given inherent latencies present in a packet-based protocol such as Bluetooth.

This transfer protocol results in a lot of data in one direction and minimal data in the reverse direction. One device sends a single byte acknowledgement, and the other takes this acknowledgement as a cue to send a large packet. One protocol which behaves in this fashion is Xmodem.

This document describes the creation of a test procedure, which uses an application on a Windows PC to measure the latencies and throughput, and makes suggestion as to how the overall data throughput can be increased.

2 TEST SETUP

The test setup consists of a sufficiently fast Windows PC (>2Ghz processor) with two serial ports capable of rates up to 460800 baud, two Laird Bluetooth Intelligent serial modules, and an application which transfers data between the two serial ports and measures various time intervals using a very high resolution timer. This timer is accurate to within microseconds.

The physical setup is as shown in Figure 1.

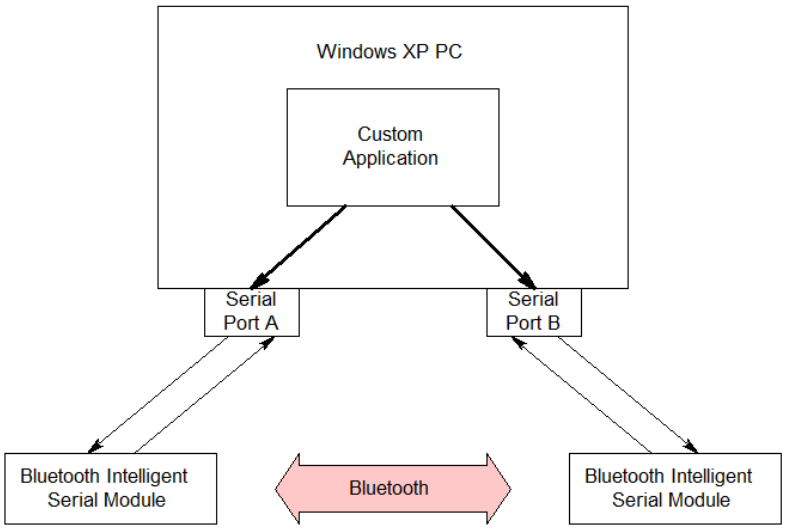

Figure 1: Latency Test Setup

The application sends an 'X' character out from serial port A and on receipt of that character at serial port B, sends a packet (1029 bytes) out from serial port B which is subsequently received at serial port A.

The large packet consists of a string made up of the characters '0' to '9' and the '.' character. In addition the packet is delimited by a '*' as the first character and '#' as the last character. These special delimiting characters, plus the 'X' trigger character in the reverse direction allows the application to measure various time intervals.

These time measurements are collected into various histogram arrays, all rounded up to the nearest millisecond.

2.1 Normal Test vs. Optimized Test

In one set of tests (Normal), the time measurements/markers are as shown in Figure 2.

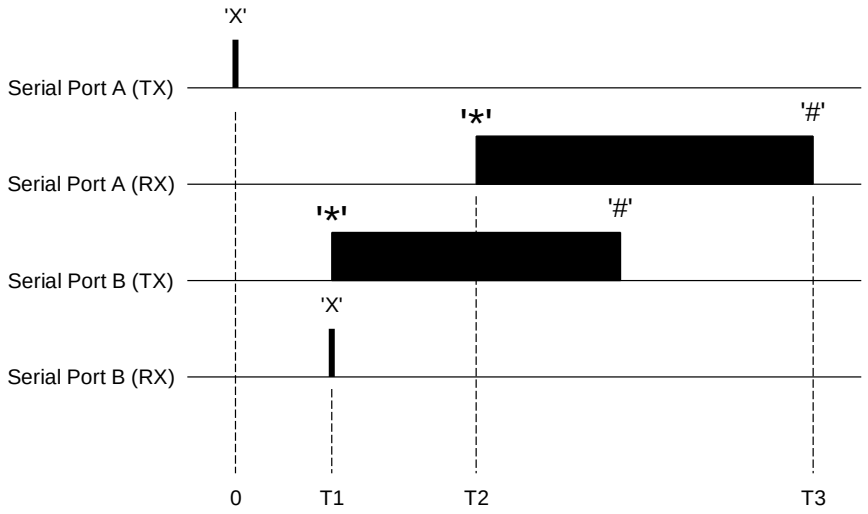

Figure 2: Timing - Normal Test

In the second set of tests (Optimised), the time measurement/markers are as below. When data transfer starts, many trigger characters are sent to ensure that the data transfer direction is kept primed. For each packet received, fresh acknowledgements are sent. This is shown in Figure 3.

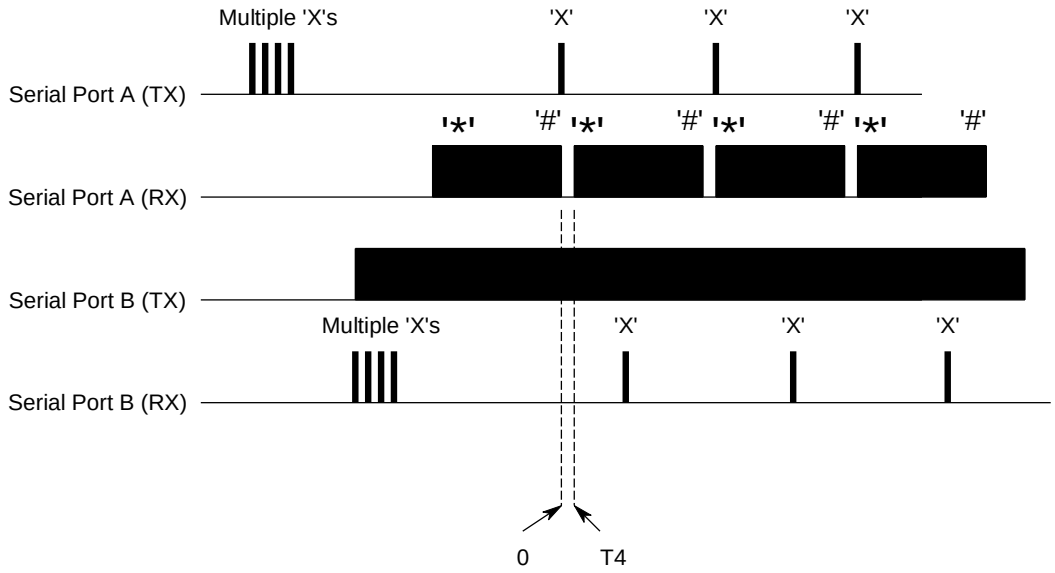

Figure 3: Timing - Optimised Test

3 TEST RESULTS

3.1 Normal Test 1

- SReg507=0
- Baud rate=115200
- Packet Len = 1029 (89ms to send at 115200)
- ACK from port A is sent every 1000ms

Test results are shown in Figure 4.

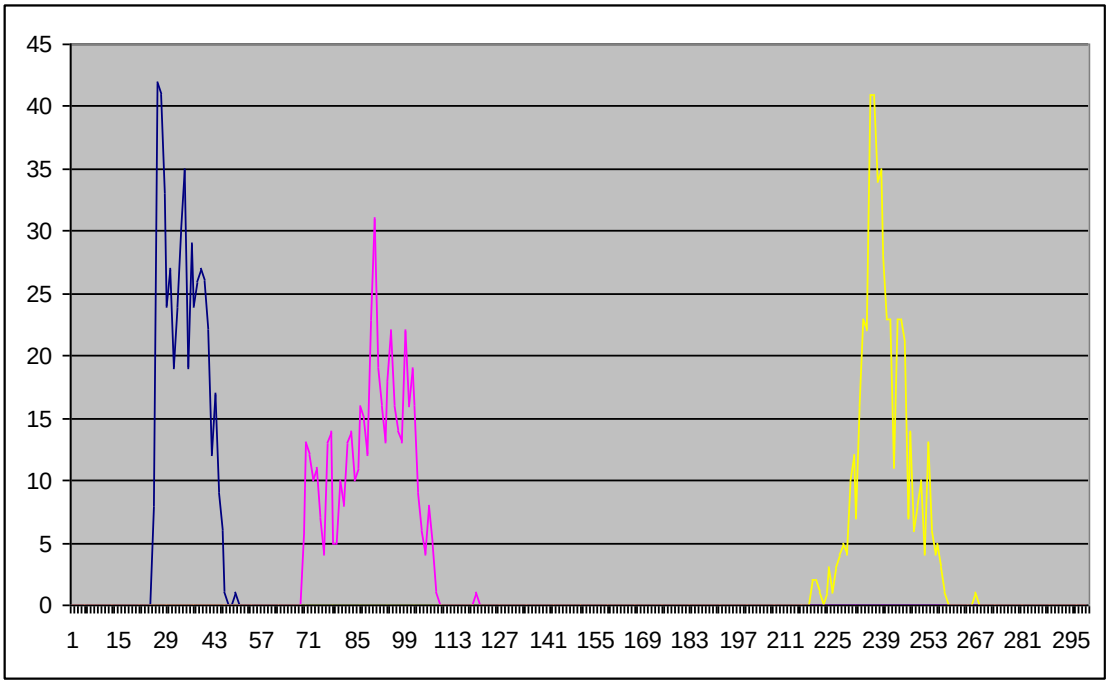

Figure 4: Normal Test 1 Results

The first band is the frequency distribution (ms) for the gap between sending 'X' from port A to receiving that character at port B. The second band is the frequency distribution for the gap between sending 'X' from port A and receiving the start of the 1029 packet ('*' character) at port A. The third band is the frequency distribution for the gap between sending 'X' from port A and receiving the end of the 1029 packet ('#' character) at port A.

Result: Calculations show that it takes 89 milliseconds to send 1029 bytes at 115200 over a serial cable.

The histogram above shows that the second band 'starts' at about 72msec and ends at 113msec. This proves point T2 is very close to point T1, transmission starts very soon after UART data is received by the appropriate module.

3.2 Normal Test 2

- SReg507=0
- Baud rate=460800
- Packet Len = 1029 (22ms to send at 460800)
- ACK from port A is sent every 1000ms

Test results are shown in Figure 5.

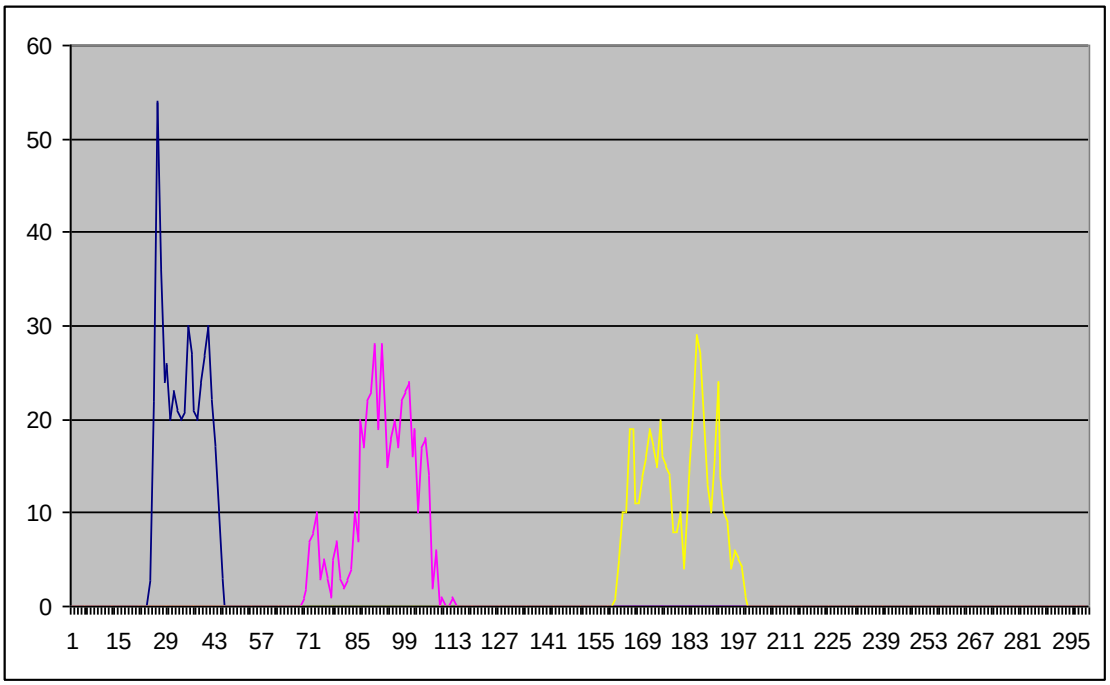

Figure 5: Normal Test 2 Results

The first band is the frequency distribution (ms) for the gap between sending 'X' from port A to receiving that character at port B. The second band is the frequency distribution for the gap between sending 'X' from port A and receiving the start of the 1029 packet ('*' character) at port A. The third band is the frequency distribution for the gap between sending 'X' from port A and receiving the end of the 1029 packet ('#' character) at port A.

Result: Calculations show that it takes 22 milliseconds to send 1029 bytes at 460800 over a serial cable.

The histogram above shows that the second band 'starts' at about 72msec and ends at 113msec but unlike Test 1, the end of the packet reaches much sooner.

3.3 Normal Test 3

- SReg507=2
- Baud rate=460800
- Packet Len = 1029 (22ms to send at 460800)
- ACK from port A is sent every 1000ms

Test results are shown in Figure 6.

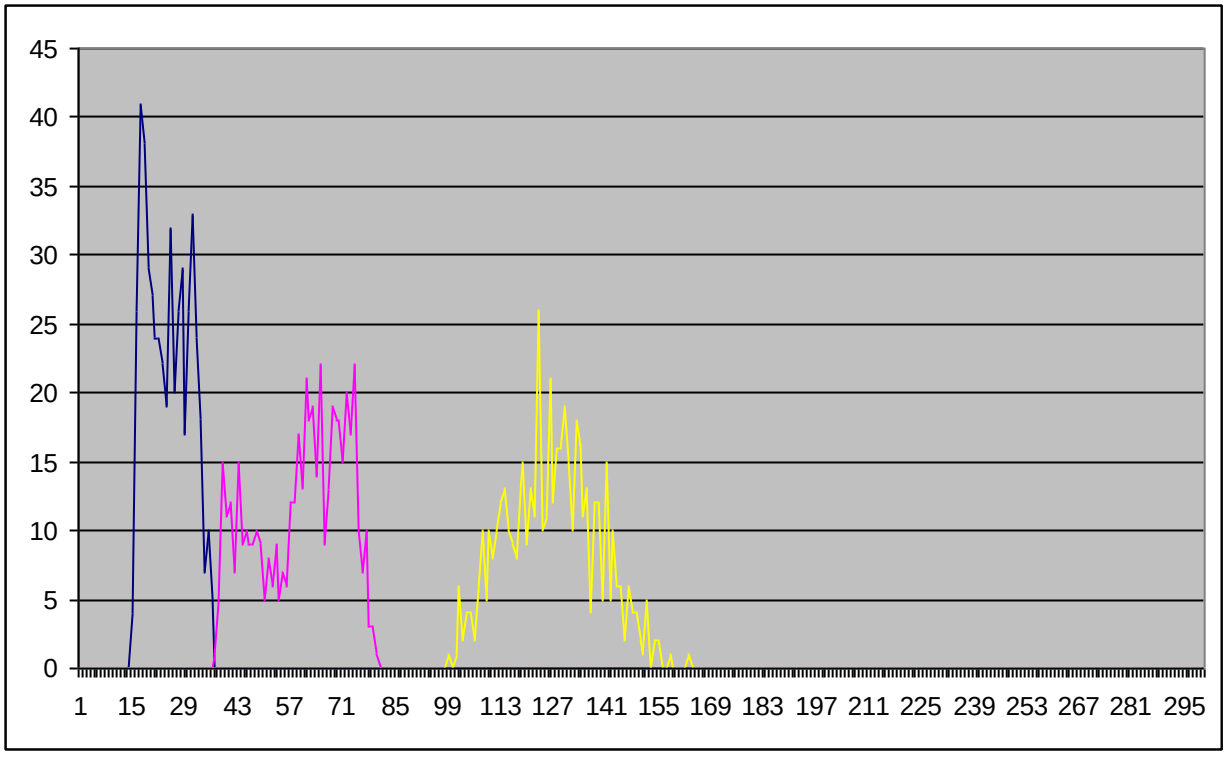

Figure 6: Normal Test 3 Results

The first band is the frequency distribution (ms) for the gap between sending 'X' from port A to receiving that character at port B. The second band is the frequency distribution for the gap between sending 'X' from port A and receiving the start of the 1029 packet ('*' character) at port A. The third band is the frequency distribution for the gap between sending 'X' from port A and receiving the end of the 1029 packet ('#' character) at port A.

Result: Calculations show that it takes 22 milliseconds to send 1029 bytes at 460800 over a serial cable.

The histogram above shows that the second band 'starts' at about 43msec and ends at 85msec but unlike Test 1, the end of the packet reaches significantly sooner.

3.4 Normal Test 4

- SReg507=0
- Baud rate=115200
- Packet Len = 1029 (89ms to send at 115200)
- ACK from port A is sent as soon as the '#' character of packet is received. This test results allows the maximum throughput to be measured.

Result: 238 packets of 1029 characters where transferred in 60 seconds giving an overall throughput of 4082 bytes per second (32654 bits per second)

3.5 Normal Test 5

- SReg507=0
- Baud rate=460800
- Packet Len = 1029 (22ms to send at 460800)
- ACK from port A is sent as soon as the '#' character of packet is received. This test results allows the maximum throughput to be measured.

Result: 315 packets of 1029 characters where transferred in 60 seconds giving an overall throughput of 5402 bytes per second (43218 bits per second)

3.6 Normal Test 6

- SReg507=2
- Baud rate=460800
- Packet Len = 1029 (22ms to send at 460800)
- ACK from port A is sent as soon as the '#' character of packet is received. This test results allows the maximum throughput to be measured.

Result: 470 packets of 1029 characters where transferred in 60 seconds giving an overall throughput of 8060 bytes per second (64484 bits per second)

3.7 Optimised Test 7

- SReg507=2
- Baud rate=460800
- Primed with 8 Acks at the beginning.
- Packet Len = 1029 (22ms to send at 460800)
- ACK from port A is sent as soon as the '#' character of packet is received. This test results allows the maximum throughput to be measured.

Result: 893 packets of 1029 characters where transferred in 60 seconds giving an overall throughput of 15315 bytes per second (122519 bits per second)

3.8 Optimised Test 8

- SReg507=2
- Baud rate=460800
- Primed with 16 Acks at the beginning.
- Packet Len = 1029 (22ms to send at 460800)
- ACK from port A is sent as soon as the '#' character of packet is received. This test results allows the maximum throughput to be measured.

Result: 1120 packets of 1029 characters where transferred in 60 seconds giving an overall throughput of 19208 bytes per second (153664 bits per second).

3.9 Optimised Test 9

- SReg507=2
- Baud rate=115200
- Primed with 16 Acks at the beginning.
- Packet Len = 1029 (89ms to send at 115200)
- ACK from port A is sent as soon as the '#' character of packet is received. This test results allows the maximum throughput to be measured.

Result: 580 packets of 1029 characters where transferred in 60 seconds giving an overall throughput of 9947 bytes per second (79576 bits per second).

3.10 Normal Test 10

- Bluetooth Serial Module to Bluetooth USB Adapter
- (Simulates DSP to PC scenario)
- SReg507=2
- Baud rate=460800
- Packet Len = 1029 (22ms to send at 460800)
- ACK from port A is sent as soon as the '#' character of packet is received. This test results allows the maximum throughput to be measured.

Result: 792 packets of 1029 characters where transferred in 60 seconds giving an overall throughput of 13583 bytes per second (108662 bits per second)

3.11 Optimised Test 11

- Bluetooth Serial Module to Bluetooth USB Adapter
- (Simulates DSP to PC scenario)
- SReg507=2
- Baud rate=460800
- Primed with 16 Acks at the beginning.
- Packet Len = 1029 (22ms to send at 460800)
- ACK from port A is sent as soon as the '#' character of packet is received. This test results allows the maximum throughput to be measured.

Result: 1511 packets of 1029 characters where transferred in 60 seconds giving an overall throughput of 25914 bytes per second (207309 bits per second).

4 SUMMARY

These tests demonstrate that latency is an inherent feature of Bluetooth. To minimise these effects, adopt a windowed acknowledgement scheme that produces the best throughput. Additionally, to increase overall throughput, configure the baud rate to the highest possible setting.

5 REVISION HISTORY

Revision	Date	Description	Initiated By
1.0	03 Sept 2014	Initial Release	Jonathan Kaye