Hong Kong Polytechnic University

Department of Electronic and Information Engineering

Test Report of UWB trail - Permit No. T00189

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1. Objective

- To evaluate the performance of a UWB device (Freescale DS-UWB mini-PCI module) in an indoor environment.

- Trial period : 20-Oct-2006 to 19-Apr-2007.

2. Introduction

Ultra Wideband (UWB) is defined as any radio technology having a spectrum that occupies a bandwidth greater than 20 percent of the center frequency, or a bandwidth of at least 500 MHz. This is a wireless technology designed for short-range, personal area networks, or PANs. This technology allows devices transfer data with low power consumption for distances of less than 10 meters, or about 30 feet, which is very applicable to the digital home requirements. Transfer of high quality video data from a set-top box to an entertainment PC is one usage of this technology. Another emerging application of UWB is wireless USB (WUSB). Few manufacturers already launch their evaluation kit.

At present, Freescale is the only manufacturer of Direct-Sequence UWB module. Another popular standard, OFDM-UWB, is supported by various manufacturers. Recently, Freescale has discontinued the development of DS-UWB business. In other words, this module is no longer available in market.

In this trial report, Freescale UWB XS110 module was employed. This module comprises of 3 chips: baseband chip (MC270123), MAC controller(MC270141) chip and RF transceiver chip(MC270113). Logical block diagram of XS110 transceiver is depicted in figure 1. Figure 2 shows the mini-PCI hardware module.

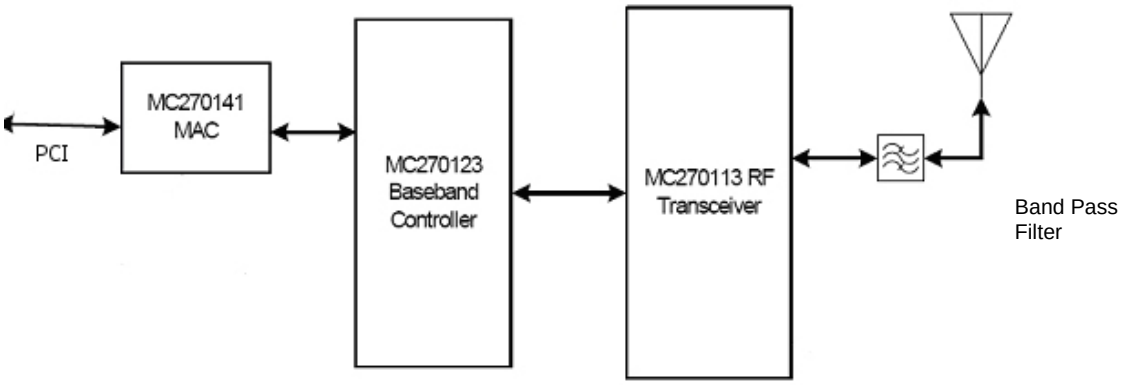

Figure 1. Functional block diagram of XS110

Figure 2. UWB mini-PCI hardware module

Through the trial, we can estimate the performance of Freescale DS-UWB mini-PCI module in indoor environment.

3. Trial Configuration

3.1 Test site

Trial test was performed at different locations in Room EF502. The dimension of this room is 11.89m × 12.78m. Many different electronic equipments can be found in this research laboratory. The layout plan of EF502 and the test locations were shown in figure 3. Location named “1” was station running iperf server application. While stations named A,B,C, etc were station running iperf client application.

The distance between 1 and test point A is about 2.2m.
The distance between 1 and test point B is about 2.7m.
The distance between 1 and test point C is about 5.7m.
The distance between 1 and test point D is about 8.8m.
The distance between 1 and test point E is about 3.6m.
The distance between 1 and test point F is about 7.0m.
The distance between 1 and test point G is about 9.0m.
The distance between 1 and test point H is about 5.8m.
The distance between 1 and test point I is about 8.5m.
The distance between 1 and test point J is about 10m.
The distance between 1 and test point K is about 9.1m.
The distance between 1 and test point L is about 10m.
The distance between 1 and test point M is about 11m.

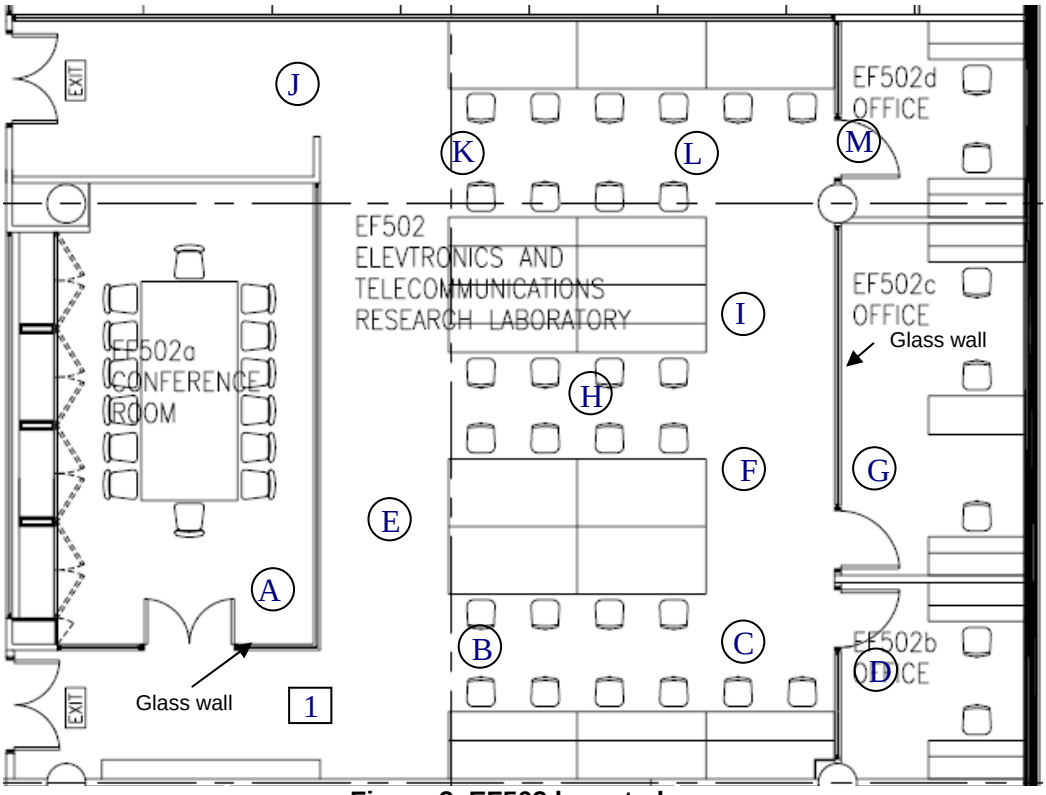

Figure 3. EF502 layout plan

3.2 Hardware setup

The UWB mini-PCI was plugged in a PCI slot of a typical PC computer. The antenna was placed at the top of PC, linked by a RF cable and antenna stand. The hardware configurations are listed below in the following sections.

3.2.1 UWB mini-PCI module Description

- Data rate : 114Mbps
- Frame size : 32kbytes
- FEC :0.75
- Retry limit : 10
- Power consumption : 750mW
- Superframe duration : 59ms
- Transmitter power : – 41.3dBm/MHz
- Antenna height : 1.5m

3.2.2 PC configuration

- CPU : Intel 2.4GHz
- RAM : 256MB

3.2.3 Antenna

Omron SMD plastic antenna, model number : WXA-N1SL[1].

3.3 Software setup

Open source software, Iperf(version 1.7.0)[2], was used in trial tests. Iperf is a tool to measure maximum TCP bandwidth, allowing the tuning of various parameters and UDP characteristics. Iperf reports bandwidth, delay jitter, datagram loss. The operating system used was Linux Fedora Core 3.

3.3.1 Test items

One potential usage of this UWB module is distribution of high quality video data. To estimate its entertainment networking capability, tests were run using User Data Protocal(UDP), which is a connectionless protocol without guarantee of data delivery. Streaming media, real-time multiplayer games and voice over IP (VoIP) are examples of applications that use UDP. Iperf provides performance metrics like data rate and packet error rate(PER) in UDP test.

To stimulate the data network scenario, tests using Transport Control Protocal(TCP) are appropriated. Since TCP is error free protocol, only data rate metric is measured.

3.3.1.1 TCP throughput test settings

We monitored the TCP throughput between server and client in 300 seconds (5 minutes), average throughput (Mbps) will be noted. The TCP window size was 216K bytes.

Iperf commands used for TCP test were:

IPerf Server:
iperf –s –w 216k –i 10

where:
-s -- indicates that this is the server instance of IPerf
-w -- instructs IPerf to use 216k bytes as the TCP window size for the test
-i 10 – instructs the IPerf application to report performance statistics every 10 seconds

IPerf Client:
iperf –c <ipaddress> -w 216k –i 10 –t 300

where:
-c <ipaddress> -- indicates that this is the client instance of IPerf, and that the server to connect to is at IP Address <ipaddress>
-w -- instructs IPerf to use 216k bytes as the TCP window size for the test
-i 10 -- instructs the IPerf application to report performance statistics every 10 seconds
-t 300 – instructs IPerf to execute this test for 900 seconds

[1] Omron antenna specification cannot be published here since it is confidential and under development.
[2] Iperf URL : http://dast.nlanr.net/Projects/Iperf/

3.3.1.2 UDP throughput test settings

The maximum data rate of UWB module is 114Mbps. We sent data from server to client using 100Mbps, for 300 seconds. Data throughput (Mbps), jitter and packet error rate(PER) will be recorded.

Iperf commands used for UDP test were:

IPerf Server:
iperf –s –u –i 10

where:
-s -- indicates that this is the server instance of IPerf
-u -- instructs IPerf to use UDP as the protocol for the test
-i 10 --instructs the IPerf application to report performance statistics every 10 seconds

IPerf Client:
iperf –c <ipaddress> -u –b 100M –i 10 –t 300

where:
-c <ipaddress> -- indicates that this is the client instance of IPerf, and that the server to connect to is at IP Address <ipaddress>
-u -- instructs IPerf to use UDP as the protocol for the test
-b 100M – instructs IPerf to send a stream of 200Mbps for the duration of the test
-i 10 -- instructs the IPerf application to report performance statistics every 10 seconds
-t 300 – instructs IPerf to execute this test for 900 seconds

4. Trail Results Summary

4.1 TCP throughput test

Position	Throughput (Mbps)	LOS/NLOS
A	0.0943	NLOS
B	61.7	LOS
C	60.5	LOS
D	25.8	NLOS
E	53	LOS
F	5.22	LOS
G	Fail	NLOS
H	4.97	LOS
I	6.28	LOS
J	Fail	NLOS
K	4.81	LOS
L	Fail	NLOS
M	Fail	LOS

4.2 UDP throughput test

Location	Throughput (Mbps)	Jitter(ms)	PER(%)	LOS/NLOS
A	1.41	25.48	78	NLOS
B	71.9	0.49	0.00	LOS
C	69.7	0.49	0.00	LOS
D	42.5	0.45	0.00	NLOS
E	61.3	0.15	0.00	LOS
F	15.3	2.45	0.22	LOS
G	Fail	Fail	Fail	NLOS
H	13.8	3.58	0.06	LOS
I	18.8	8.38	19.00	LOS
J	Fail	Fail	Fail	NLOS
K	17.6	3.08	0.16	LOS
L	Fail	Fail	Fail	NLOS
M	Fail	Fail	Fail	LOS

5. Conclusion

5.1 LOS locations

In this trial test, it was observed that in distance less than 4m and LOS environment, the system data rate can achieve 70Mbps. UWB showed this strength in short range LOS communication. When distance is greater than 4m, data rate decreased rapidly. Comparing results in location K(9.1m) and in location I(8.5m), fewer objects were found along the path in location K than those in location I, the resultant jitter and packet error rate(PER) found in location K was much better than those in location I. Thus, surrounding environment became more important factor affecting the data transfer. Distance exceeded 10m (location M), wireless link cannot maintain even in LOS environment.

5.2 NLOS locations

In Location D, it was observed that UWB signal can penetrated glass wall in NLOS environment. However, in Location A, although the distance is short, the system performance degraded significantly (PER = 78%), it may be due to the antenna orientation mismatch between the antenna pair. In addition to this, glass wall attenuated certain amount of signal. For other NLOS locations, wireless connections terminated. Simply speaking, there was no clear evident to prove that wireless link cannot establish in NLOS environment, test site environment and the antenna were factors to be concerned.