AN01 Indoor GPS

Introduction

In order for a GPS receiver to acquire and track satellite signals, it must perform a two dimensional signal replication process of the received satellite signals. This two dimensional process consists first of a search for the phase of the desired satellite signal, and then a search for the carrier frequency plus Doppler of the satellite. The phase search is performed by shifting the phase of the replica PRN code generated by the receiver until it correlates with the received satellite PRN code.

The carrier frequency search is performed by adjusting the rate of the PRN code generator on the receiver until it correlates with the received satellite carrier frequency plus Doppler. These correlations are undertaken with multiple time/frequency bins and normal GPS receivers contain typically a few hundred to a few thousand correlators.

This means that for a GPS receiver with a few hundred correlators, a full sky search can take some significant time to perform which directly affects the Time to First Fix (TTFF) as well as the sensitivity of the receiver. This becomes even more evident as the received satellite signals reduce in strength, and with limited numbers of correlators the receiver sensitivity is rarely very much below –140 to –145dBm

Increased Sensitivity

The CW25 overcomes the issues of increased sensitivity and rapid TTFF by massively increasing the number of correlators applied to each receiver channel with a maximum number of 12,288 correlators.This means that the CW25 receiver module can perform very rapid sky searches for satellite signals even under very poor signal conditions.

This is achieved by allocating large numbers of correlators to each receiver channel to allow the receiver to search time/frequency bins in parallel rather than sequentially as in normal GPS receivers. In addition, the sensitivity of the CW25 receiver module is boosted to signal levels as low as –155dBm.

This is also achieved by the use of large numbers of correlators allocated to each receiver channel, allowing the receiver to achieve a correlation peak with an extra 20 to 30dB of gain in a short period of time. In summary therefore, the CW25 performance is governed by the very large number of correlators available within the baseband processor ASIC, and allows the CW25 to achieve very high sensitivity (-155dBm) without compromising TTFF or introducing any real time lag in positional updates.

CW25 Performance

The sensitivity performance of the CW25 receiver was measured with the test set up shown in Figure 1

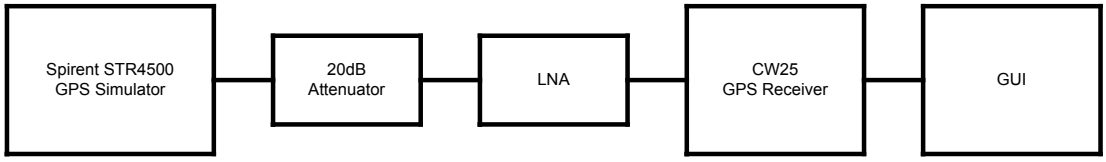

Figure 1

As GPS signals fluctuate in level considerably in poor signal strength locations due to fading of the satellite signals, it can be hard to establish the exact sensitivity of the GPS receiver under test. To overcome this, a GPS simulator was used in the test set up so that precise signal strengths can be set on the simulator to allow the tracking software to display the measured signal strength achieved by the GPS receiver.

The GPS simulator used in this test was the STR4500 from Spirent, with a 20dB attenuator applied to the output of the simulator to allow the signal levels applied to the receiver to be able to be lowered right down to –155dBm and below. Once the CW25 receiver was calibrated in terms of sensitivity with the use of the STR4500 simulator, the CW25 was connected to a GPS antenna so that the sensitivity performance of the CW25 could be assessed with live satellite signals in different locations

Test Results
Simulator Data
Table 1 shows that the CW25 GPS receiver can maintain tracking of satellite signals from the simulator at levels down to –155dBm

Simulator Output dBm	Measured CW25 Output dBm
-130dBm	-130dBm
-135dBm	-135dBm
-140dBm	-140dBm
-145dBm	-145dBm
-150dBm	-150dBm
-151dBm	-151dBm
-152dBm	-151.5dBm
-153dBm	-152.5dBm
-154dBm	-153.5dBm
-155dBm	-154.5dBm
-156dBm	-155.5dBm (fluctuating)

The CW25 receiver was tested in various real life scenarios with the following locations to demonstrate the ability of the CW25 receiver to track satellites in areas of poor signal strength;

1. Under heavy tree foliage
2. Inside the trunk of a car
3. Inside an internal office with no external windows

During the tests the CW25 was either allowed to acquire satellites autonomously if satellite signal strengths allowed, or by allowing the CW25 to acquire satellites under good signal strengths before moving the CW25 to the test location in the case of poor signal strengths in the test area. As an alternative, the CW25 can work in assisted GPS mode (A-GPS) by supplying the CW25 with external assist data to enable the CW25 to acquire satellites in very poor signal conditions (for further details, refer to AN02 Network Assistance)

Tree Foliage
The CW25 and antenna were tested under heavy tree foliage within a densely wooded area, with the location shown in Figure 2

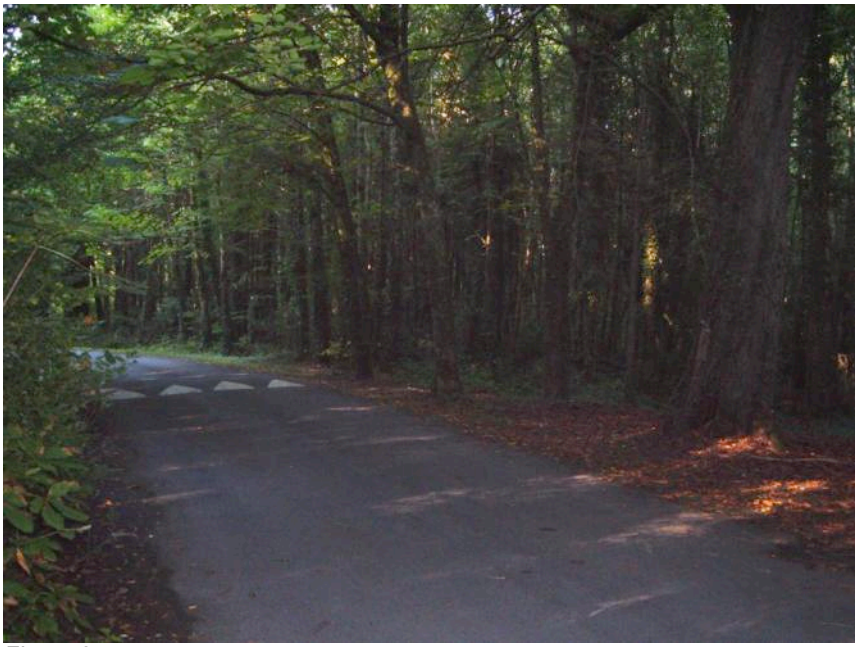

Figure 2

The CW25 tracked an average of 6 satellites with satellite signal strengths typically between levels of –157dBW and –182dBW, whilst maintaining a positional accuracy of 15m as shown in Figure 3

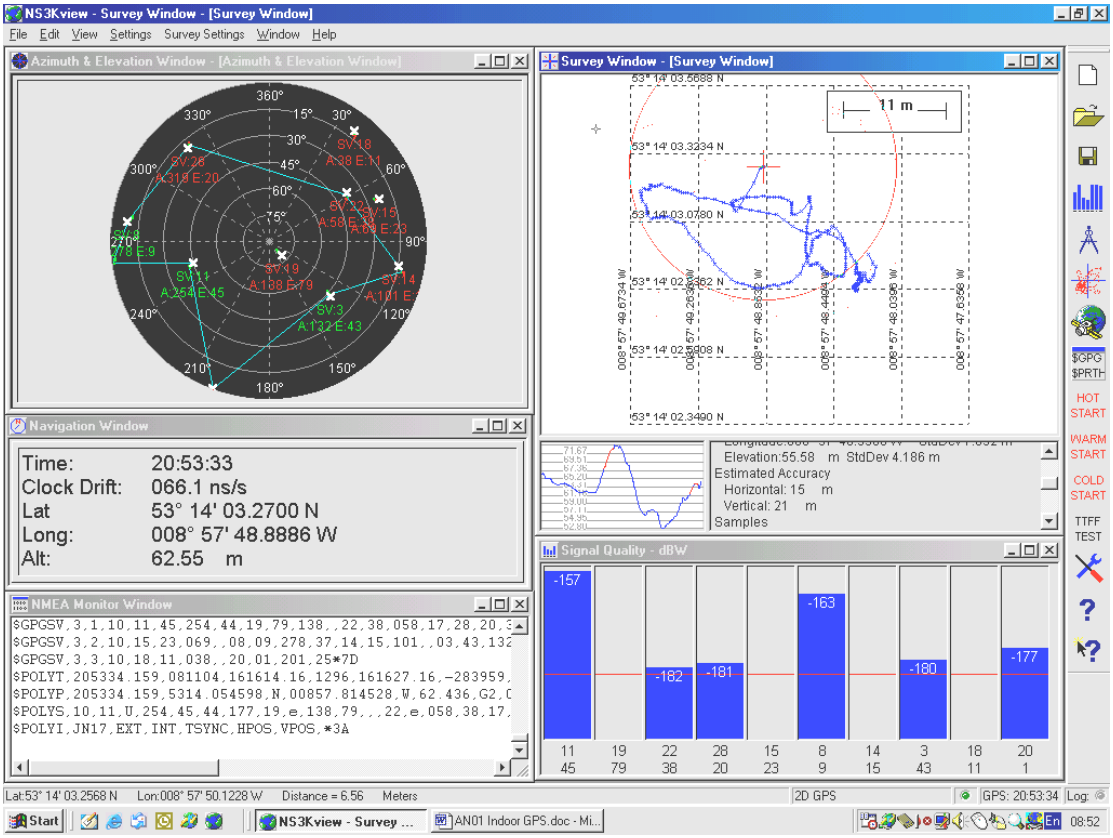

Figure 3

Car Trunk

The CW25 and antenna were placed entirely within the closed trunk of a car as shown in Figure 4

Figure 4

The CW25 tracked an average of 4 satellites with satellite signal strengths typically between levels of –171dBW and –182dBW, whilst maintaining a positional accuracy of 27m as shown in Figure 5

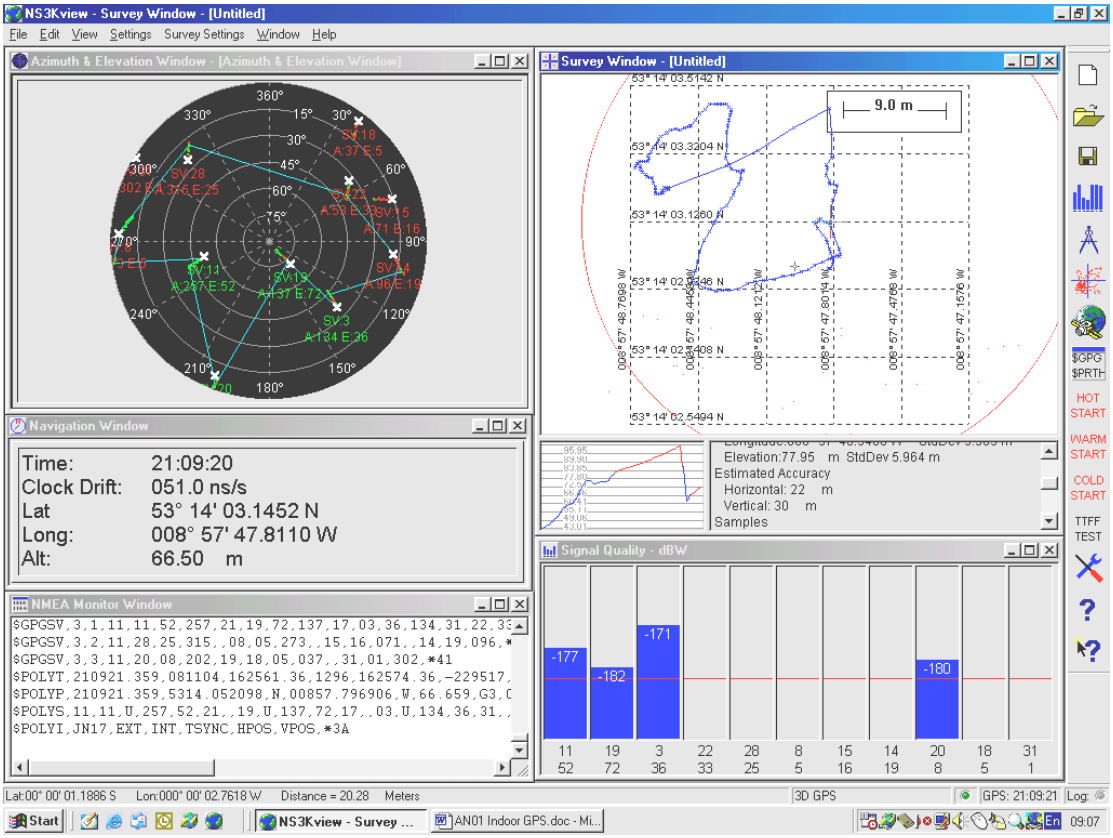

Figure 5

Internal Office

The CW25 and antenna were placed inside a building within an internal office as shown in Figure 6. The office had no external windows although there were windows in adjacent rooms

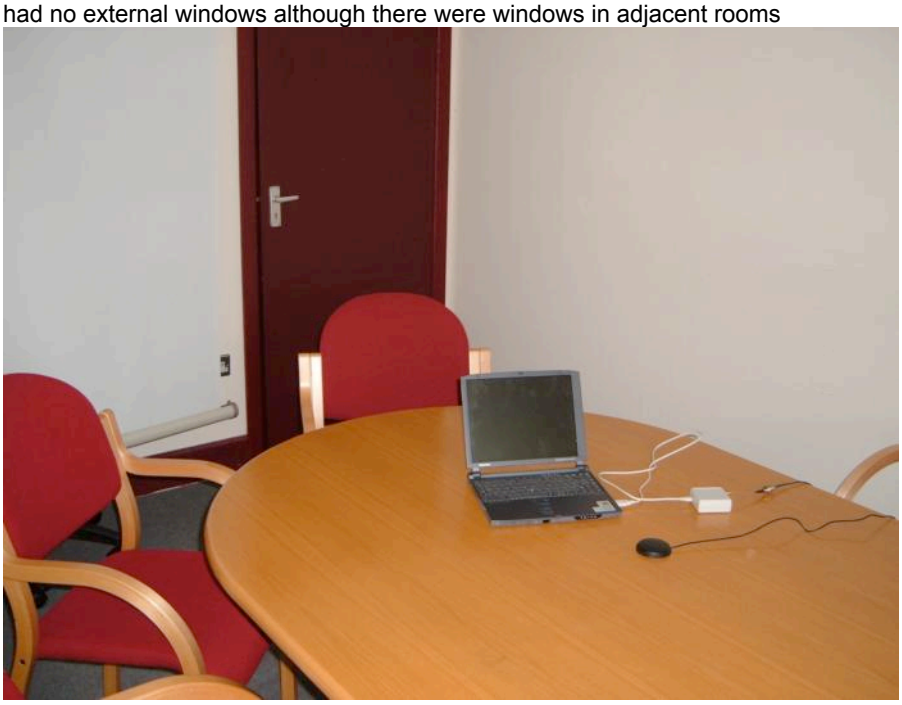

Figure 6

The CW25 tracked on average 9 satellites with satellite signal strengths typically between levels of –160dBW and –187dBW, whilst maintaining a positional accuracy of 17m as shown in Figure 7

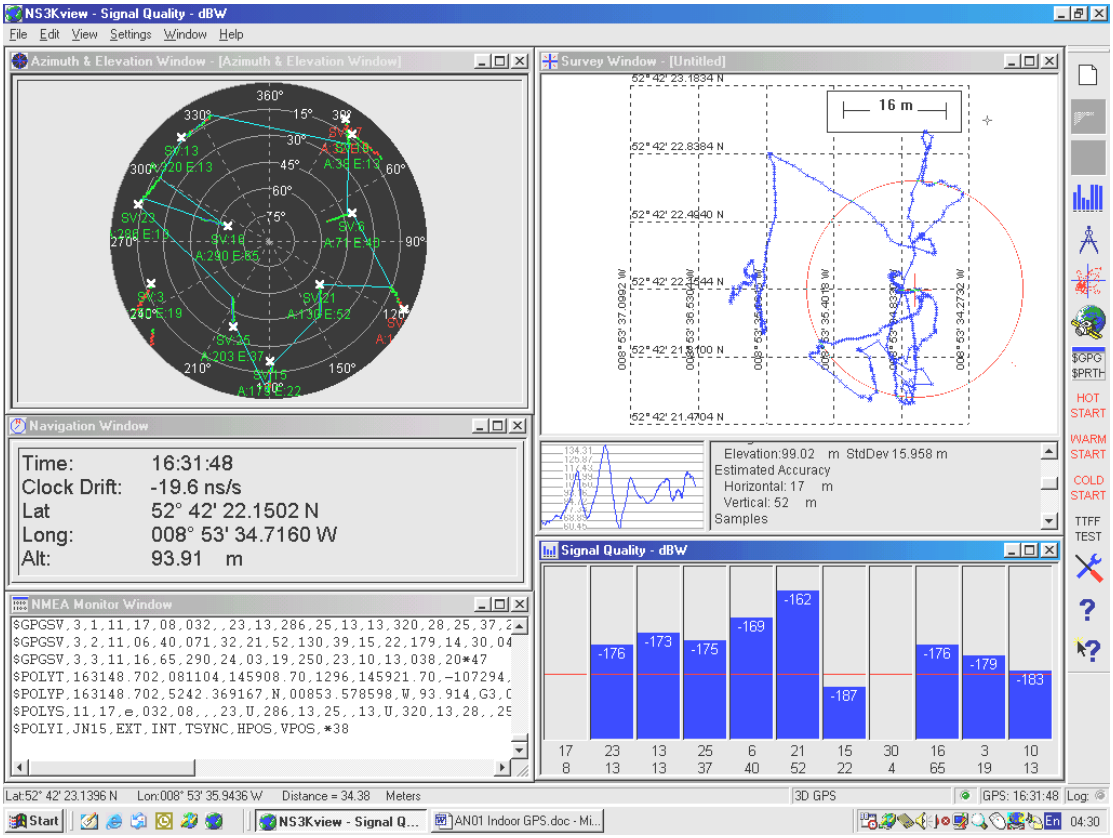

Figure 7

Conclusions

From the descriptions and test data presented in this application note it can be seen that the CW25 GPS receiver can provide positional fixes with a tracking sensitivity of down to –155dBm allowing the CW25 to be used in areas of very poor satellite signal strength such as in severe urban canyons, under dense foliage and even deep inside buildings. The CW25 can achieve a positional fix accuracy of between 5 and 50m depending on the received satellite signal strengths, but allows accurate tracking performance even completely inside buildings. The CW25 can also acquire satellites at signal levels down to –155dBm with the use of Network Assistance techniques (A-GPS) to achieve very rapid TTFF performance under such low signal strength conditions. This A-GPS capability also allows the CW25 receiver to maintain long term tracking inside buildings by the ability to acquire new satellites to maintain positional fixes (the operation of Network Assistance is further explained in AN02 Network Assistance). For further details of the CW25 GPS receiver, please contact NavSync (contact details are available on www.navsync.com).