Real World Range Testing Using CC85xx

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Keywords

- *CC85xx*
- *PurePath Wireless*
- *Range Test*
- *Multipath Fading*
- *Frequency Hopping*

1 Introduction

The range of RF products is usually communicated as a single number which refers to the longest line of sight (LOS) distance that holds a stable link. This number is usually measured in a large, open place far from any obstacles or interferers. For the CC8520 the LOS range is 35m+ and 130m+ when adding the range extender CC2590 in the RF chain. The CC8520 will rarely operate under such conditions, but more likely in difficult RF environments including reflectors like walls and floors. Reflectors can of course block the LOS component, but it will also give rise to several transmission paths and thereby multipath fading. Multipath fading can lead to several “dead spots” (positions where the RF link is lost) well within the LOS range. In order to present more practical range information than what lies in the LOS range of the CC8520, a *real world* range test have been conducted where the performance in several test positions inside an office environment is presented.

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2 Abbreviations

ACK	Acknowledge
DSC	Data Side Channel
EHIF	External Host Interface
EM	Evaluation Module
LCD	Liquid Crystal Display
LNA	Low Noise Amplifier
LOS	Line of Sight
MCU	Micro Controller Unit
PA	Power Amplifier
RF	Radio Frequency
USB	Universal Serial Bus

3 Test Setup

The Real World Range Test involves a CC8520 protocol master and a CC8520 protocol slave which are both controlled by external MCUs via the External Host Interface (EHIF). More details about EHIF can be found in [1]. The test is basically showing how well the master is able to stream audio to the slave when placed in different locations in a test environment. The protocol slave has a fixed position during the whole test, and its external MCU is connected to a PC via the USB interface. The protocol master is powered by batteries so it can be moved around. The two nodes are pictured in Figure 1 and Figure 2.

The test is based on the statistics commands PS_RF_STATS and PS_AUDIO_STATS from EHIF. Each time these commands are called a set of counter values are returned and the counters are reset. Thus, by calling the commands at *test start* and *test end* the statistics for the period between the calls will be available. PS_AUDIO_STATS holds counters for the audio statistics, like for instance the number of audio samples, the number of samples "reconstructed" by the error concealment algorithm, the number of muted samples and the number of mute events. PS_RF_STATS on the other hand holds counters for the RF statistics, like for instance the number of timeslots, the number of audio slices received/transmitted, the number of corrupted audio slices, the number of network dropouts etc.

The test is started by executing a PC application on the slave side that controls the slave's external MCU. On the master side the external MCU is programmed with test firmware that enables the operator to make inputs with a push button and monitor relevant information on an LCD display. The test flow is pictured in Figure 3 (simplified) and is performed as follows:

- The network ID (being the master's unique device ID), the test length in each test position and the number of test positions are entered as arguments to the PC application on the slave side. When started the PC application repeatedly performs join commands which makes the slave try to join the network with the specified network ID.
- Pairing between master and slave is then performed when the operator enables the network with a push button on the master side. Immediately after pairing the slave transmits the selected test length to the master via the data side channel (DSC).
- The operator connects an audio source to the master, and audio is streaming continuously from this time point.
- The test enters the *position selection phase*. The operator places the master device in one of the test positions and then cycles through the different test positions on the LCD display until reaching the correct one.
- The operator starts the test with a push button on the master side. The selected test position is transmitted to the slave via the DSC and stored by the PC application. The test now enters the *count down phase.* The operator is given 6 seconds to move out of the near field of the antenna before the test really starts.
- When the 6 seconds are counted down the master transmits a *test start* packet to the slave via the DSC. The master then resets all the statistics counters. Immediately after the slave receives the packet the slave resets the counters as well.
- When the test length (30 seconds in this case) is reached, the master transmits a *test stop* packet to the slave via the DSC, and the statistics counters on both sides are stopped. The counter values for the master is transmitted to the slave via the DSC, and an ACK holding the same data is returned to confirm that the information wasn't corrupted.
- The statistics are stored by the PC application and linked to the test position. When all the test positions are tested the PC application terminates and the logged information is printed out in a text file. This text file together with a bitmap of the test

environment is then input to another PC application which generates a coverage map. A section of a typical coverage map is pictured in Figure 4.

If the master is out of range, or the RF link for some reason is degraded enough, the slave drops out of the network. The master however will keep the network enabled. The PC application enters a state where it repeatedly tries to re-join the slave to the network. This can of course happen during all the three test phases: *position selection phase*, *count down phase* or *logging phase*. If the network goes down and comes up again during *logging phase* the statistics counter for network dropouts is incremented and no harm is done. If however the network is down when the master is transmitting the *test start* or *test stop* packet, the test for that position has to be redone. Also if the network is down when in *position selection phase* the operator is unable to start a test.

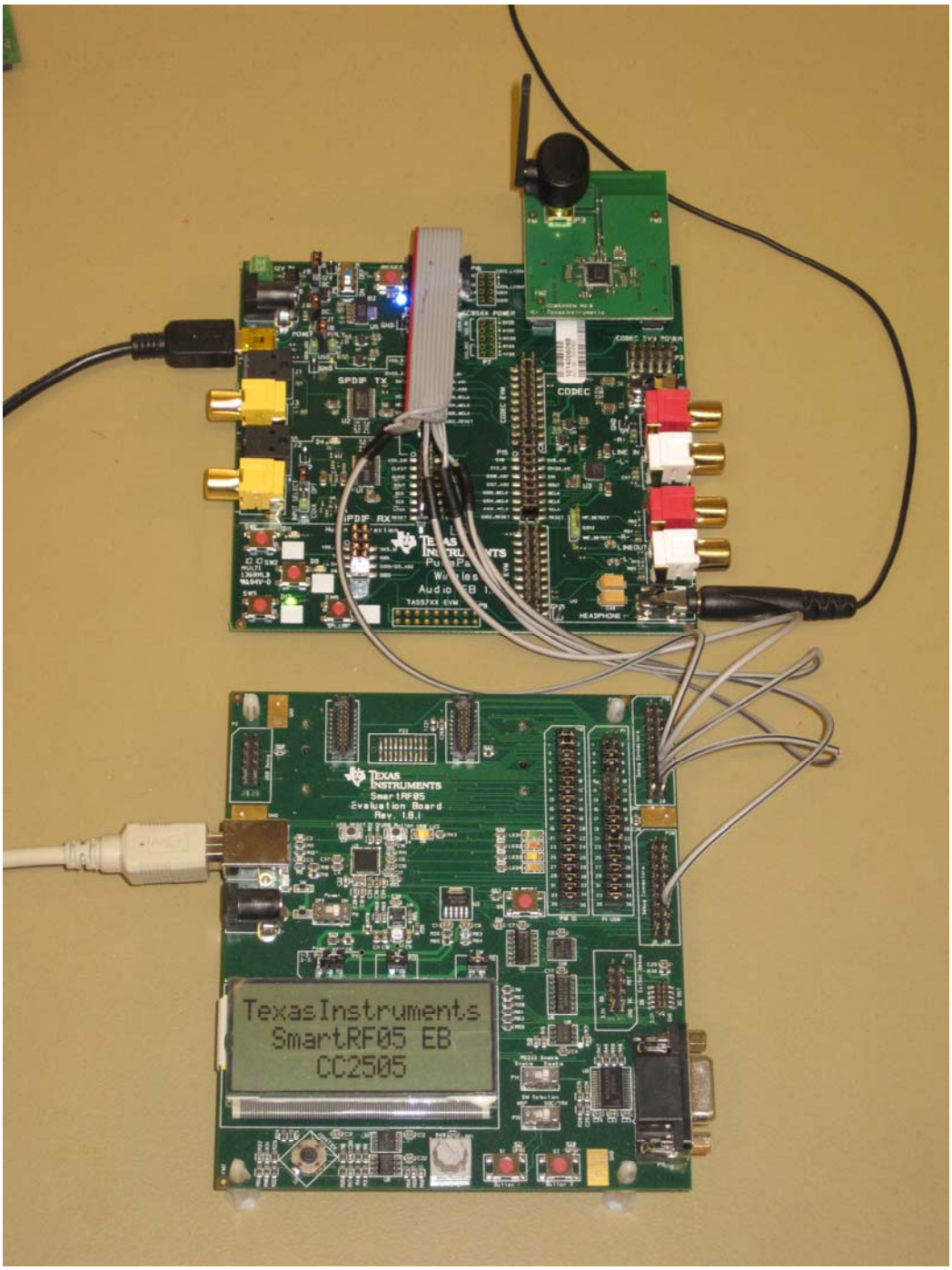

Figure 1: The slave node.

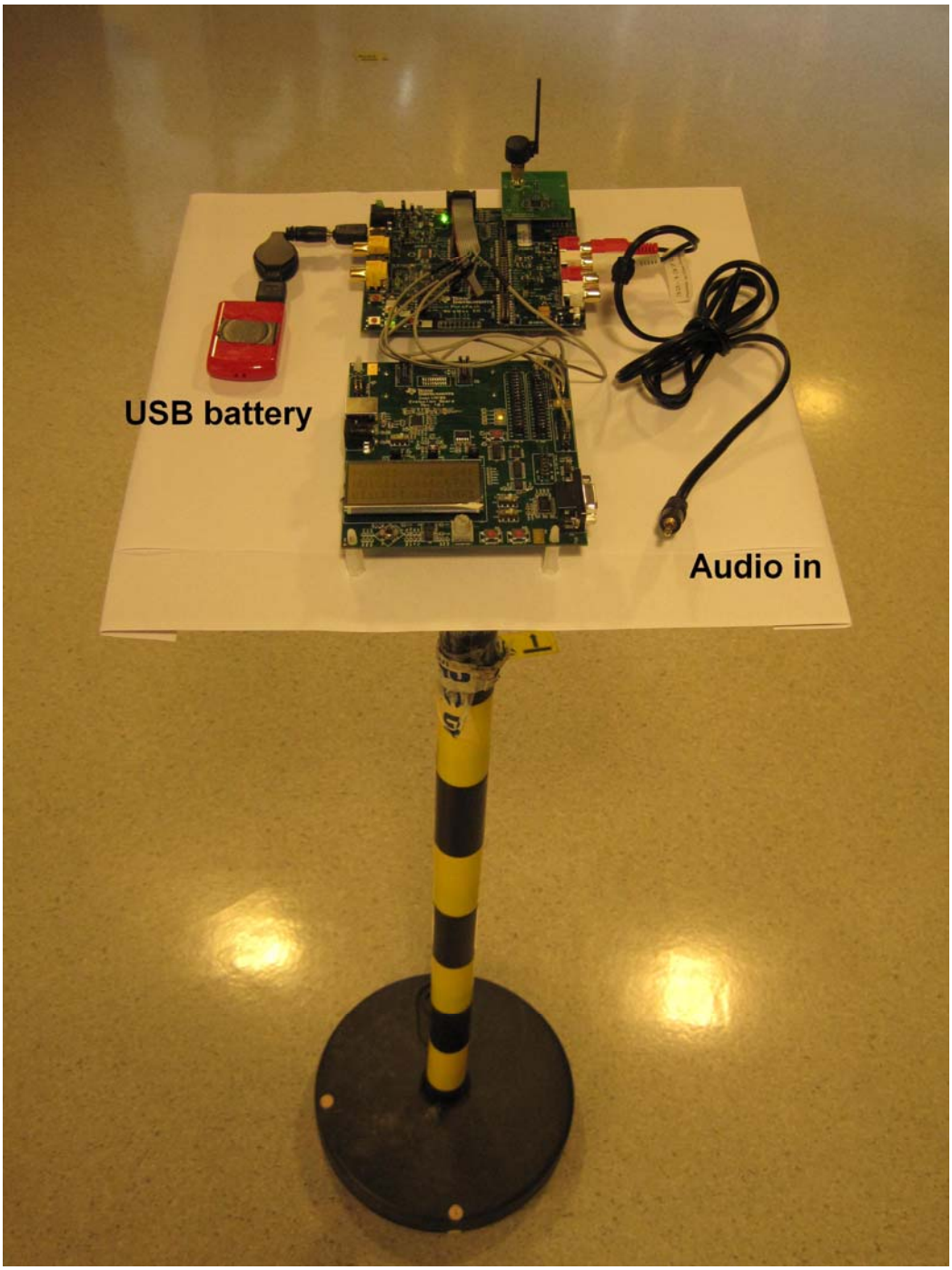

Figure 2: The master node placed on top of a moveable pole.

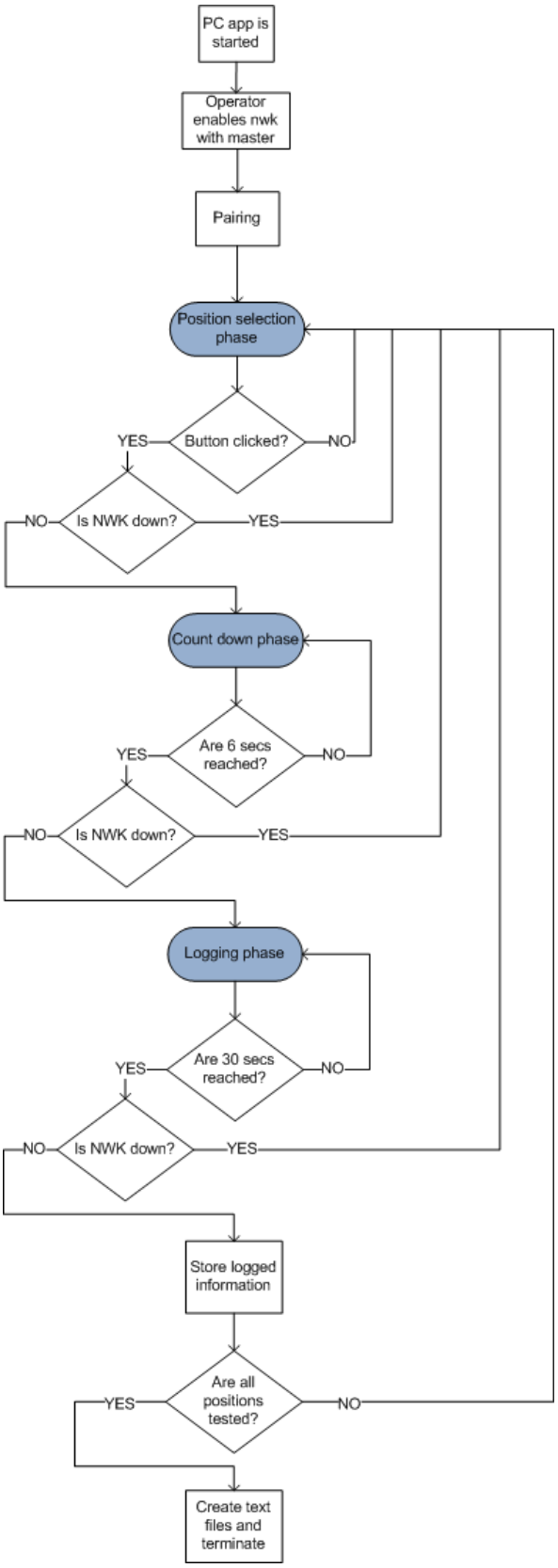

Figure 3: Flow chart for the complete test.

3.1 The test environment

The test environment is an office environment with many walls of different materials (glass, glass with aluminum blinds, plaster and reinforced concrete). The different wall materials are marked with colors on the coverage maps.

3.2 The different tests

Tests have been conducted using both the CC85XXEM and also the CC85XX – CC2590EM. The first one uses the CC8520 only while the latter uses CC8520 + CC2590. The CC2590 [2] is an RF front end including an LNA as well as an additional PA for increased sensitivity and output power respectively. Table 1 shows the different combinations that have been tested.

Table 1: The different combinations tested

Test #	EM (on master and slave)	Streaming format	Sample rate [Hz]	Latency
1	CC85XX	PCM16	44100	23.22 ms (1024 samples)
2	CC85XX – CC2590EM	PCM16	44100	23.22 ms (1024 samples)

4 Interpreting the results

The final result of a Real World Range Test is a coverage map. The coverage map is a floor plan of the test environment with the numbered test positions (blue font) and performance information plotted on top. A section of a typical coverage map is pictured in Figure 4.

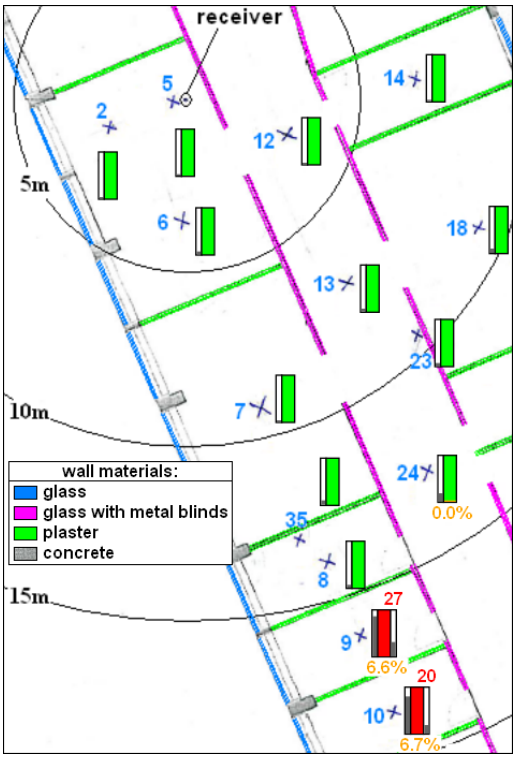

Figure 4: Section of a typical coverage map.

The explanation of the performance information is shown in Figure 5. There are two main types of outcome in each test position: green and red. The green type means that no samples were muted during the test period. The red type is shown when samples have been muted.

The green type can also include a portion of orange which shows how many of the total samples that was actually missing but was “reconstructed” with the error concealment algorithm. When this is the case the same portion is displayed in orange below the color bars as a percentage. (The precision of this number is only one decimal, so when very few samples are concealed this number can be presented as 0.0%). When no error concealment has taken place the bar is all green and no percentage is showing. The red type can also include a portion of dark red which shows how long the network was down during the test period.

The grey portion of the left column shows the usage of the retransmission capacity. E.g. if the column is completely grey, this means that the full capacity was used, whether a completely white column means that retransmission of audio slices never was necessary.

The right column is only present for red test positions (i.e. test positions where some of the audio was muted). The grey portion of this column shows how much of the audio that was muted (e.g. if the column is completely grey, this means that no audio was played at the slave side).

The red number to the right above the columns displays the number of mute events. A mute event is defined as the situation when the audio stops playing (so if the audio is muted the entire test period there is actually 0 mute events). This number can only appear in the red test positions.

The dark red number to the left above the columns displays the number of network dropouts. During a network dropout obviously no audio is played, so this number can only be present above the red columns.

If the nodes are totally out of range when the master is placed in a test position the operator will be unable to start the test. This is shown as a complete dark red color bar only (no numbers are present and the right and left columns are absent).

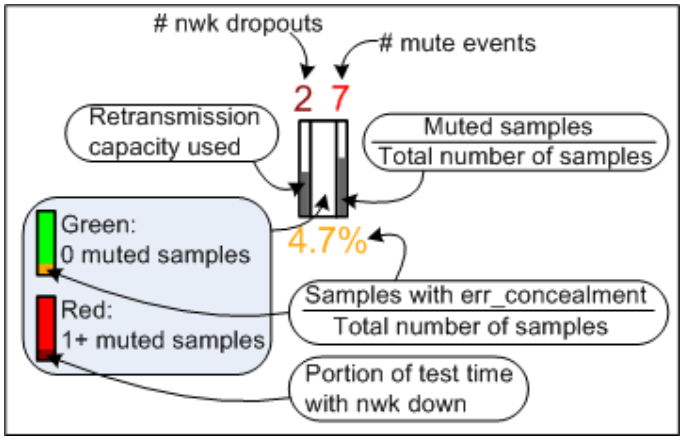

Figure 5: Explanation of the performance information displayed in each test position.

5 Measurements

The coverage maps of the tests from Table 1 is showed in Figure 6 and Figure 7.

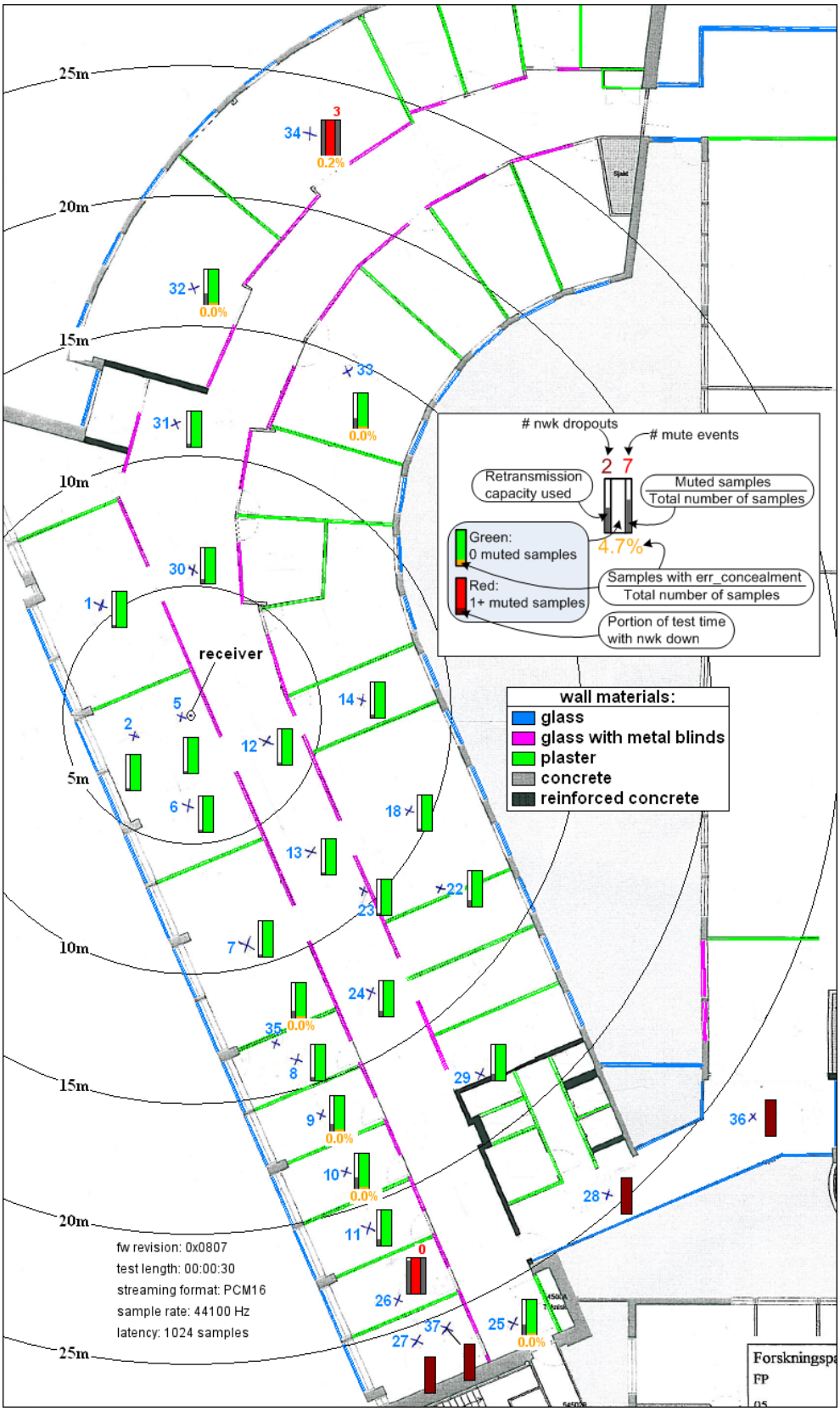

Figure 6: Test 1. CC8520EM, PCM16, latency: 23.22 ms.

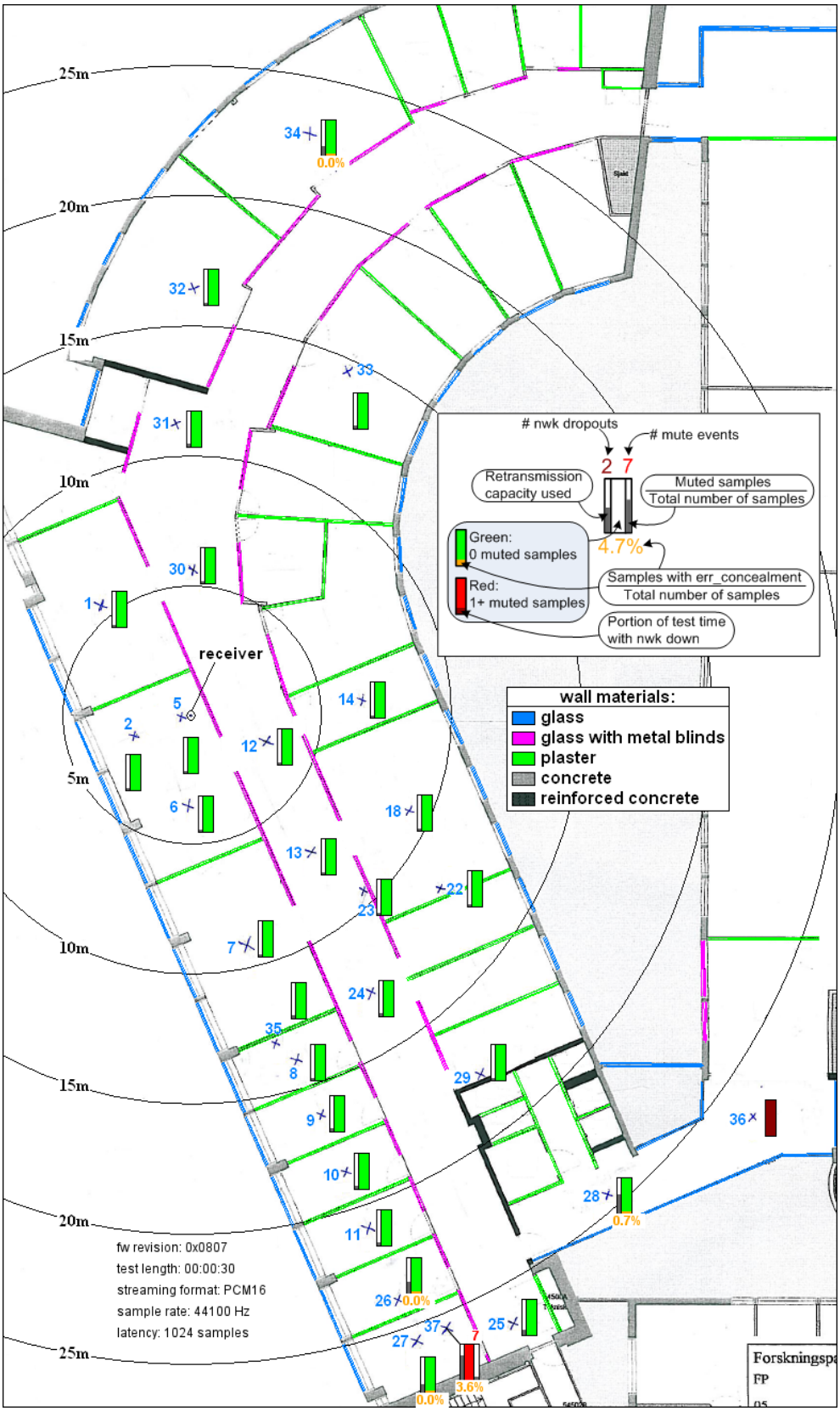

Figure 7: Test 2. CC8520 – CC2590EM, PCM16, latency: 23.33 ms

6 Conclusion

As opposed to just display the line of sight range for the CC8520, test software has been written to illustrate the performance in a typical operation environment. A CC8520 protocol master have been placed in a number of test positions while streaming audio to a fixed CC8520 protocol slave, and the performance have been logged for 30 seconds in each position. Two tests have been conducted: one using the CC8520 alone, and one using the range extender CC2590 in addition.

The test environment is a difficult RF environment with many walls and interferers.

Without the range extender, CC8520 has perfect coverage within a radius of more than 10 m. When approaching 15 m some error concealment is present, but no samples are muted. Muting of audio samples first occurs when the distance between master and slave exceeds 20 m.

When the CC2590 range extender are included in the RF chain the coverage is perfect within a radius of more than 20 m. This is even through five office walls.

It is observed that the need for retransmission of audio is increased with increased communication distance.

7 References

[1] CC85XX Family User Guide, http://www.ti.com/lit/swru250

[2] CC2590 2.4-GHz RF Front End, http://focus.ti.com/lit/ds/symlink/cc2590.pdf

8 General Information

8.1 Document History

Revision	Date	Description/Changes
SWRA320	2010.06.30	Initial release.

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