3GPP TSG RAN #19 **RP-030172**

11th – 14th of March 2003, Birmingham, UK

Agenda Item: 8.4

Source: Nokia

Title: Background information of L3 filtering simulation results

Document for: information

1. Introduction

RAN#17 has given a task to RAN4 to investigate whether linear or dB domain L3 filtering should be used for different UE measurements particularly for CPICH Ec/Io and CPICH RSCP in later releases. This document collects some of the documents presented in the last RAN WG4#26 meeting regarding this topic. In R4-030113 [1] presents simulation results for both of these filters and discusses differences of linear and dB filtering schemes. Based on the simulations results and analyses a proposal for ensuring a coherent UE behaviour is also made. In R4-030282 [2] we present some evaluation results based on the input in R4-040201, and analyse the cdf's between logarithmic and linear filter based on proposed L3 filtering behaviour. In [3] the simulation results on 1-tap Rayleigh fading channel with different sampling rate on L1 are studied.

2. References

[1] R4- 030113 Comparison of linear and dB scale L3 filters, Nokia, NTT Docomo

[2] R4- 030282 Additional L3 filter results, Nokia

[3] R4- 021484 L3 filtering, Nokia

3GPP TSG-RAN Working Group 4 (Radio) Meeting #25 **R4-021484**

Secaucus, New Jersey, USA, 11th – 15th November, 2002

Source: Nokia

Title: L3 filtering

Agenda Item: 5.7

Document for: Discussion and Decision

1. Introduction

RAN#17 has given an action to RAN4 to investigate whether linear or dB level L3 filtering should be used for different UE measurements. This document presents simulation results for both of these filters and discusses linear and dB filtering schemes in general. Based on the simulations results and analyses a proposal for ensuring a coherent UE behaviour is also made.

2. Simulation results

In this section we show simulation results in 1-tap Rayleigh fading propagation condition and in log-normally distributed slow fading environment. The value of L3 filter coefficient *k* is chosen to be 7, which gives almost the same parameter *a* value as used in [1]. The L3 filter and filter parameters are defined in 25.331.

First we present simulation results in 1-tap Rayleigh fading channel for UE speed of 3 km/h and 50 km/h. We have used 1 and 4 samples in L1 filtering. 4 sample averaging was used in the simulations when the existing fading test case in TS25.133 was derived. 1 sample average is not very realistic and it is only presented here as a reference because it shows the claimed higher difference between linear and dB filtering.

When more realistic than 1 sample L1 filtering is used we can observe from Figure 1 that the difference between linear and dB filtering is quite small. Difference in UE measurement accuracies will naturally also affect the final differences in measurement results. Hence, these simulation results seem to indicate that it is important to define performance requirements and test case for L3 filtering.

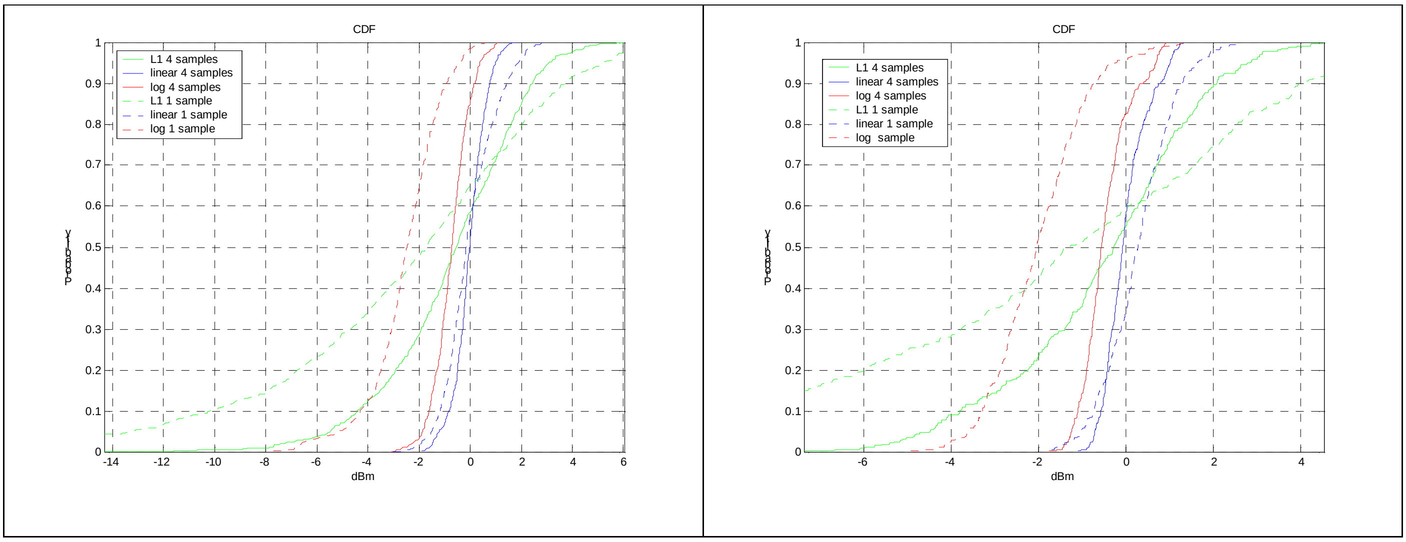

Figure 1 1-tap Rayleigh propagation conditions for 3 km/h (left) and 50 km/h (right).

Next we have simulated the impact of linear and dB level L3 filtering on measurement results in log-normally distributed shadow fading environment. Shadow fading used in the simulations has zero mean and standard deviation of 10 dB as in the macro cell propagation model of TR25.942. Shadow fading is implemented according to UMTS 30.03 (correlation distance = 20m and correlation coefficient = 0.5). We have not considered pathloss here in order to make it easier to understand the actual difference of these two filters. The reference level is thereby kept all the time in 0 dBm. The simulated UE speeds are 3 km/h, 30 km/h and 50 km/h.

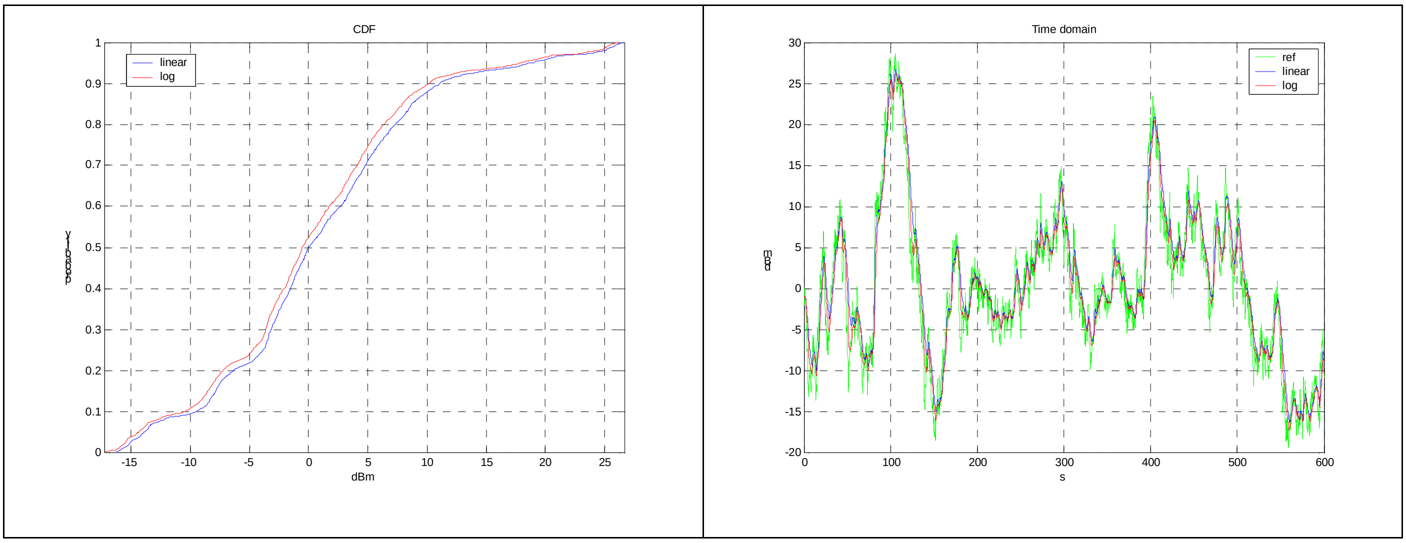

Figure 2 3 km/h (mean_lin = 1.01 dBm, mean_log = 0.27 dBm and mean_ref = 0.24 dBm)

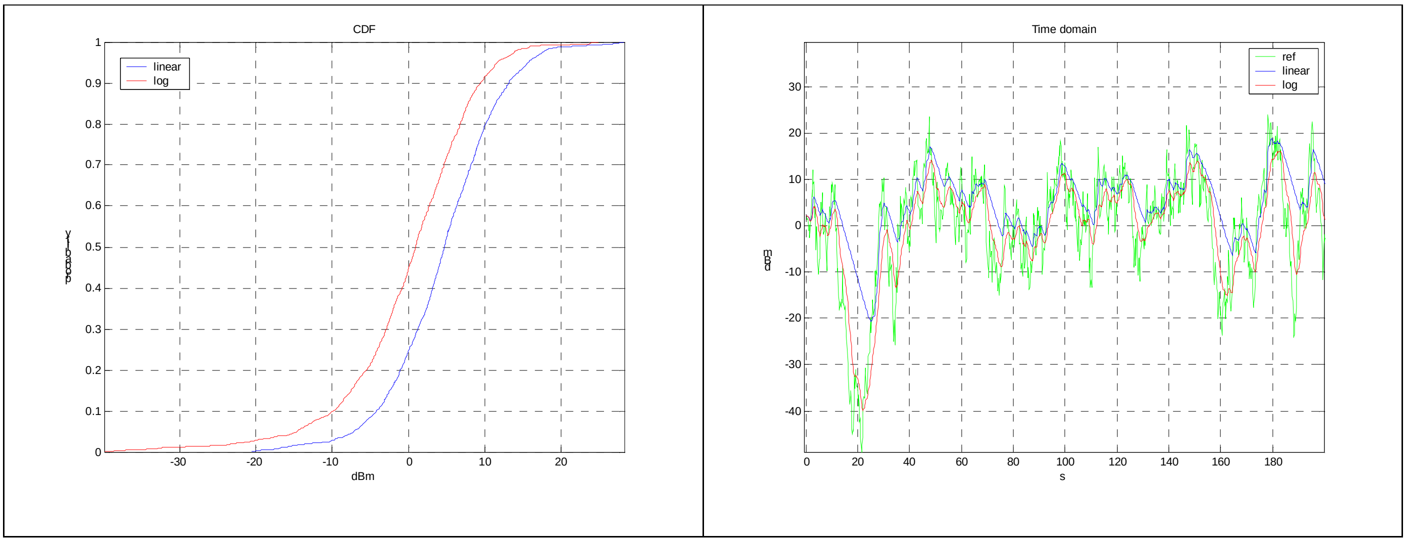

Figure 3 30 km/h (mean_lin = 4.53 dBm, mean_log = 0.06 dBm and mean_ref = 0.05 dBm)

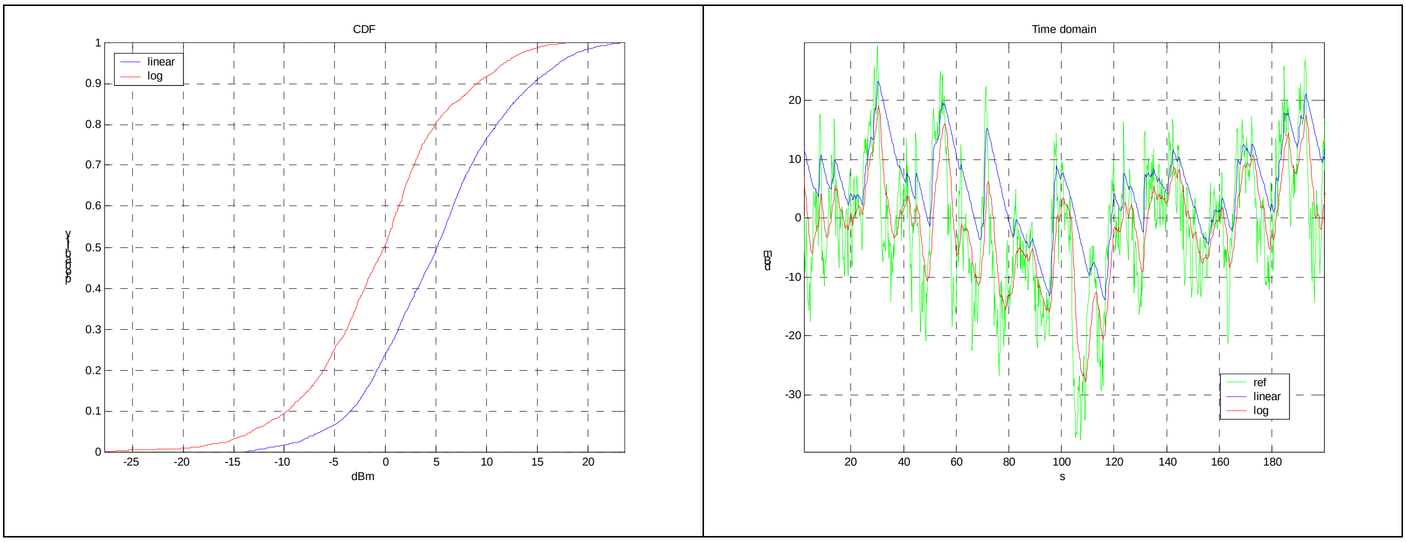

Figure 4 50 km/h (mean_lin = 5.1115 dBm, mean_log = -0.57 dBm and mean_ref = -0.58 dBm)

Figure 2 shows that there is nearly no difference between linear and dB filtering when the length of L3 filtering is such that samples used in L3 filtering are highly correlated. However, in case of higher UE speeds like in Figure 3 and Figure 4 log-normally distributed fading samples are no longer highly correlated over the whole L3 filtering period and thereby also difference between linear and dB filtering increases. In these cases linear filter starts overestimating the signal level and therefore the UE would expect pathloss to be less than it is in reality. The same effect can also be seen in the difference of mean signal levels. In the 30 km/h case the mean value of linear filter is biased by 4.5 dB and in the 50 km/h case as much as 5 dB.

3. Discussion

GSM RSSI has dB level L3 filtering and therefore in order to make the best possible comparison of CPICH RSCP and GSM carrier RSSI measurement results for the preparation of inter-RAT handover, it would be desirable to use the same L3 filtering schemes both GSM and UTRA FDD. This issue becomes increasingly important if the L3 filter coefficient k is set too high compared to UE speed for UE that is preparation process for UTRA FDD to GSM handover. This is likely to occur in any environment where all terminals do not have the same speed. Linear filter may significantly overestimate the level of UTRA FDD. On the other hand fast and accurate handover from UTRA FDD to GSM is particularly important when a terminal is moving fast out of the coverage area of UTRA FDD.

The implementation of dB filtering is already required in dualmode terminal for GSM RSSI measurement purposes. From the UE complexity point of view it does not seem reasonable to require two different implementations especially since we do not even gain in terms of performance. Furthermore, we also consider the number of bits required for L3 filtering as an important UE complexity issue particularly e.g. in case of CPICH RSCP measurements, which have rather large reporting range. In the simulations we did not take into account an additional uncertainty caused by limited number of bits in L3 filtering. In order to cover the whole reporting range of CPICH RSCP measurement quantity large number of bits is required. The number of required bits is expected to be even higher than what the reporting range in TS25.133 defines since the UE also has to fulfil the accuracy requirements of TS25.133.

4. Proposal

In our opinion the same L3 filtering scheme should be chosen for CPICH Ec/Io, CPICH RSCP, pathloss, UTRA carrier RSSI, UE transmitted power and GSM carrier RSSI measurements.

Based on simulation results and analyses we propose that measurement accuracy requirements will be defined for L3 filtering in order to ensure coherent behaviour of different terminals. If RAN4 considers that it is also necessary to define one unique unit for L3 filtering, we believe that dB filtering should be adopted due to its robustness and comparability with GSM RSSI levels.

5. References

[1] RP-020635, “Unit of layer 3 filtering”, source: Motorola

[2] RP-020641, “Layer 3 filtering considerations”, source: Qualcomm

3GPP TSG-RAN Working Group 4 (Radio) Meeting #26 **R4-030282**
Madrid, Spain, 17th – 21st February, 2003

Source: Nokia

Title: Additional L3 filter results

Agenda Item: 6.7

Document for: Discussion

1. Introduction

This document presents simulation results for the same simulation cases as [2]. The simulation model and assumptions are the same as presented in [1].

2. Simulation results

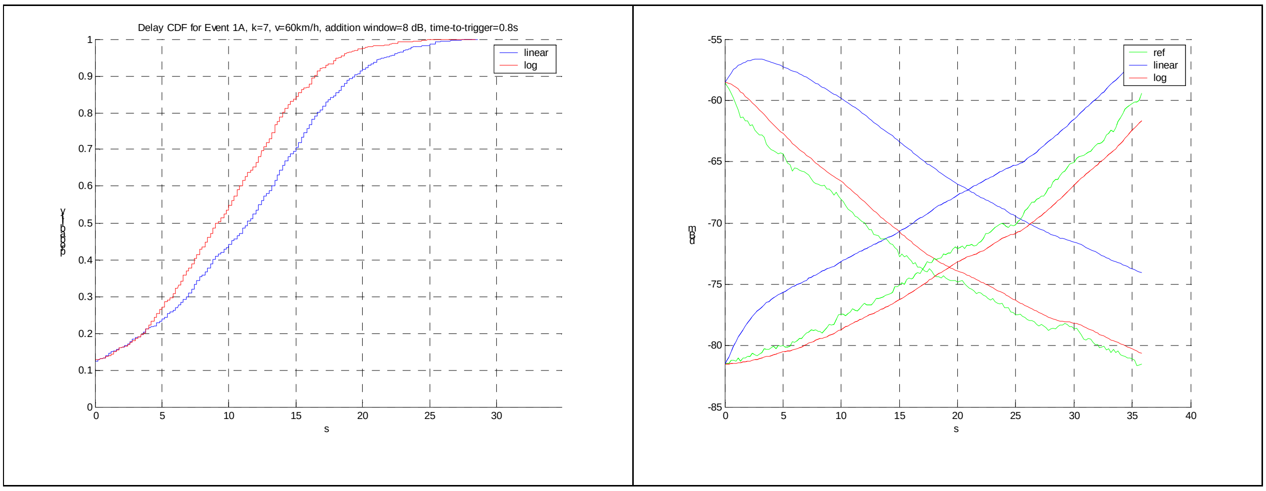

Figure 1 CDF of triggering delays for Event 1A, v = 60 km/h, k=7, addition window =8 dB and time-to-trigger=0.8s and CPICH RSCPs for BS1 and BS2.

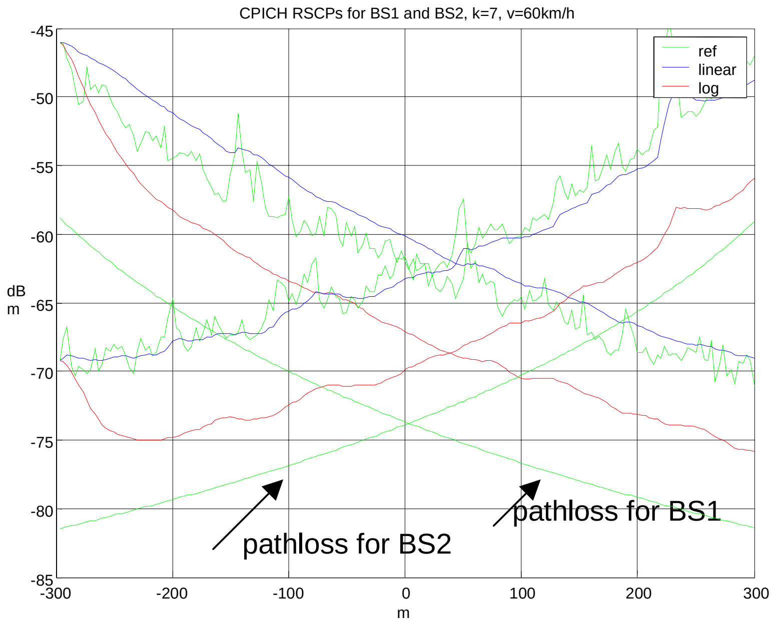

Figure 2 CPICH RSCPs for BS1 and BS2 when averaging of simulation runs is made in mW.

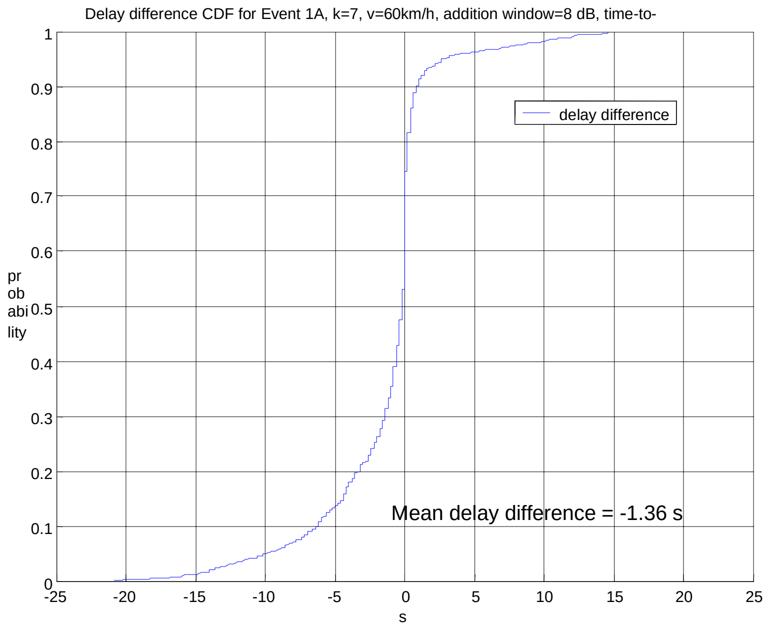

Figure 3 CDF of delay difference for triggering Event 1A, v = 60 km/h, k=7, addition window =8 dB and time-to-trigger=0.8s and CPICH RSCPs for BS1 and BS2. Negative difference means that the logarithmic L3 filter has triggered Event 1A first.

3. References

[1] R4-030113, “Comparison of linear and dB scale L3 filters”, Nokia, NTT DoCoMo

[2] R4-030201, “L3 Filtering”, Qualcomm

3GPP TSG-RAN Working Group 4 (Radio) Meeting #26 **R4-030113**
Madrid, Spain, 17th – 21st February, 2003

Source: Nokia, NTT DoCoMo

Title: Comparison of linear and dB scale L3 filters

Agenda Item: 6.7

Document for: Approval

1. Introduction

RAN#17 has given a task to RAN4 to investigate whether linear or dB domain L3 filtering should be used for different UE measurements particularly for CPICH Ec/Io and CPICH RSCP in later releases. This document presents simulation results for both of these filters and discusses differences of linear and dB filtering schemes. Based on the simulations results and analyses a proposal for ensuring a coherent UE behaviour is also made.

2. Simulation parameters and results

In this section we first present very simple step response results for linear and dB L3 filters. Then we investigate the differences of linear and dB L3 filters in a macro environment where two base stations are located 1 km from each other. CPICH RSCP levels are then recorded for BS1 and BS2 from 200 m distance from BS1 to 200 m distance from BS2.

In the simulations with two base stations we have used the same macro cell environment from TR25.842 as in the references in [4] and [5]. The simulation parameters are also selected to be the same as in [4] and [5].

BS Tx power = 43 dBm

CPICH Ec/Ior = -10 dB

BS antenna gain = 11 dB

UE antenna gain = 0 dB

Minimum Coupling Loss (MCL) = 70 dB

Macro cell propagation model is

Pathloss= 128.1 + 37.6 Log10(R) + LogF,

where R is BS-UE separation in kilometres and LogF log-normally distributed shadowing. Shadow fading has zero mean and standard deviation of 10 dB. Shadow fading is implemented according to UMTS 30.03 (correlation distance = 20m and correlation coefficient = 0.5). The simulated UE speeds are 3 km/h, 30 km/h, 60 km/h and 120 km/h. In the macro simulations the value of the L3 filter coefficient *k* is chosen to be 5 and 7 similarly to the references [2]-[5]. The L3 filter and filter parameters are defined in 25.331.

Figure 1 shows L3 filter responses for logarithmic and linear domain L3 filters with *k* values of 1 to 4. In Figure 2 the up slopes and down slopes are presented for *k*=7 in the same figure for both of the L3 filters. The curve "ref" in the figures represents L1 filtered results and linear and log illustrates results filtered with linear and logarithmic L3 filters respectively. It is hard to say which one of the filters is better by simply looking at Figure 1 and Figure 2. The figures, however, clearly show that by changing the L3 filter coefficient *k* we can control the behaviour and the response time of the L3 filter. In order to achieve faster response a smaller k value should naturally be chosen. Next we have performed further simulations in macro environment in order to better understand the behaviours of these two filters.

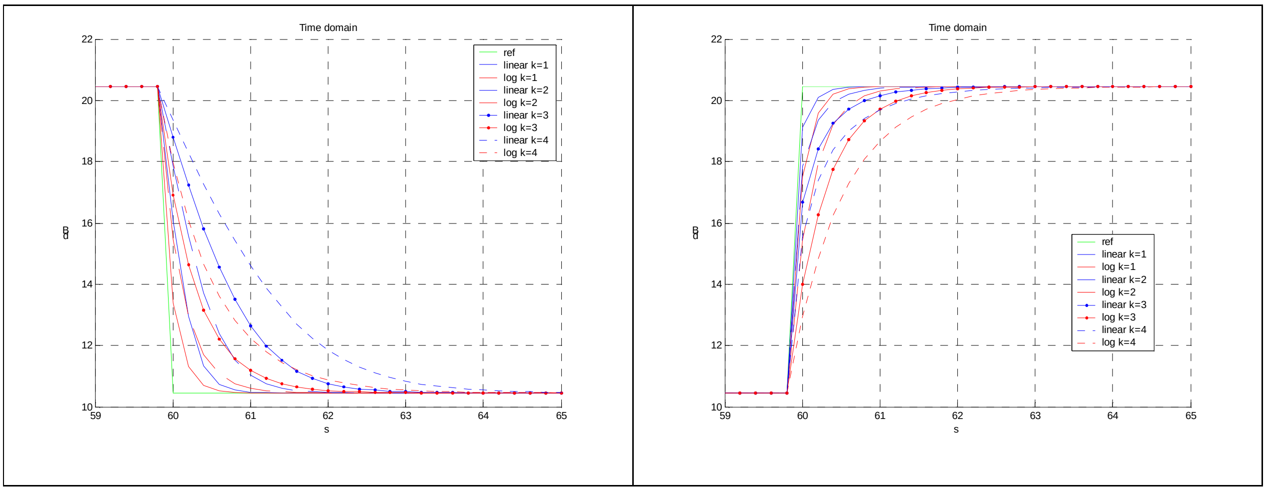

Figure 1 Step up and step down for L3 filter coefficients of 1, 2, 3 and 4

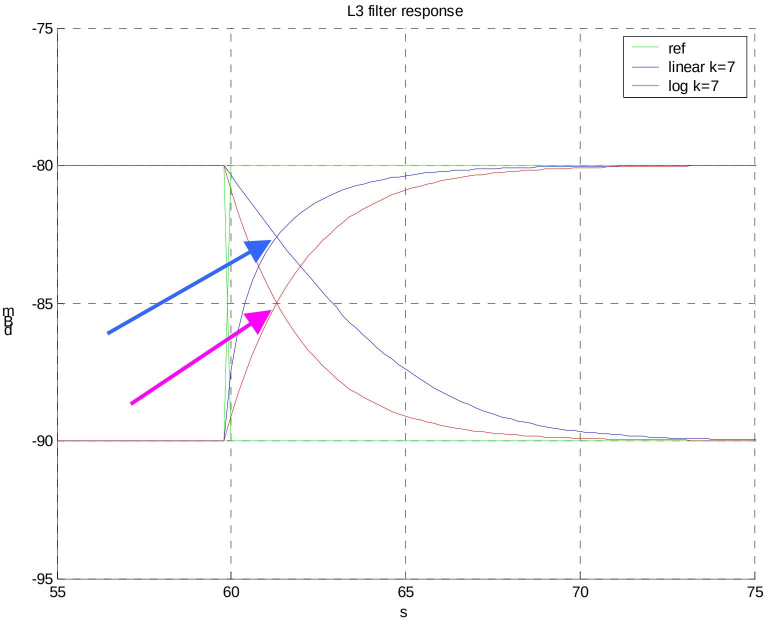

Figure 2 Filter responses for step up and down for *k*=7

The simulation results in Figure 3 - Figure 6 are based on many runs (in the order of 500-3000 runs depending on a need) since the variation due to fading is relatively high in one run only. 0 m in the results represents the middle point between BS1 and BS2. The terminal moves from BS1 to BS2 so that the CPICH RSCP level of BS1 is decreasing and the CPICH RSCP level of BS2 is increasing.

Figure 3 illustrates well that when terminal speed is relatively small compared to the filter coefficient e.g. 3 km/h for k=7, linear and logarithmic L3 filters do not differ much from each other or from L1 filtered results (the green reference curve). This because the samples used in L3 filtering are highly correlated i.e. variation of different input values to the filters is not high. The 30 km/h case in Figure 3 on the other hands already shows a typical trend, that when terminal speed increases but the L3 filter coefficient *k* remains the same, linear L3 filter starts delaying more the triggering of an event used for handover evaluation. In order to avoid dropped calls with higher terminal speeds this delay should be compensated by increasing soft handover area. Difference in triggering e.g. Event 1A, which is typically used for adding a new cell to the active set, is illustrated by pink and blue arrows in the simulations results. For simplicity we have used zero threshold for Event 1A, which means that the event is triggered when the CPICH RSCP2 of the neighbour cell BS2 is as higher as the CPICH RSCP1 of the active set cell BS1.

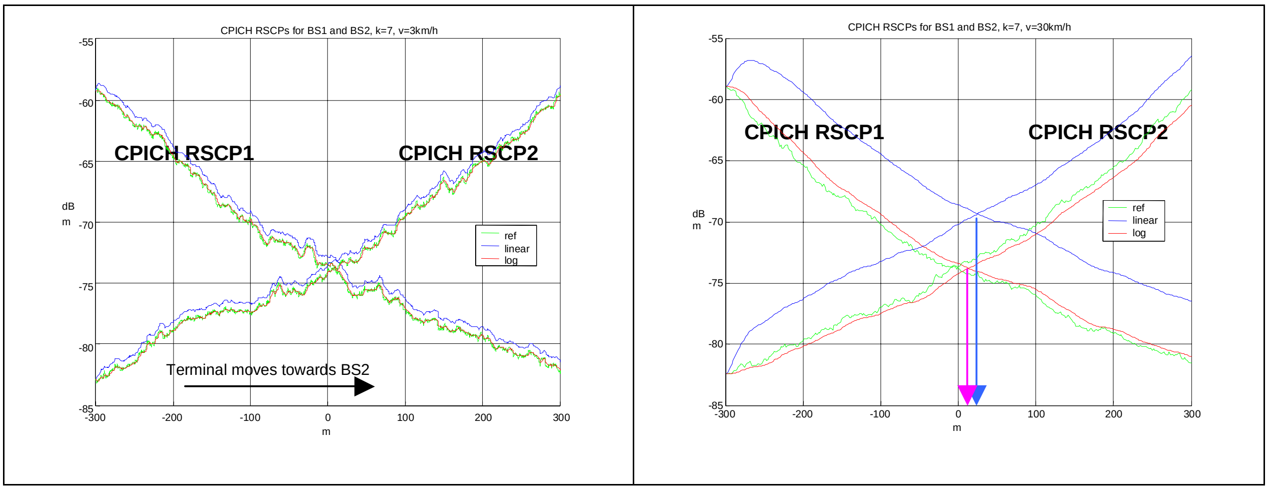

Figure 3 k=7 and UE speed is 3 km/h and 30 km/h

Figure 4 shows that if terminal speed is too high compared to the selected L3 filter coefficient handover decisions are delayed quite significantly. It is therefore important that this is carefully considered in the network planning. Figure 4 also shows that the handover delay in case of linear filter is substantially higher than in case of dB filter. In order to handle different UE speeds in the cell the size of the soft handover zone has to be 2*Δ wider for linear L3 filter than for dB L3 filter. Δ is illustrated in Figure 4. The size of Δ is dependent on the selected filter coefficient *k* and potential variation of terminals speeds in the cell. Terminal speed of 120 km/h is quite extreme for an environment where *k* equals 7 but it is shown here in order to illustrate the behaviour of linear and dB L3 filters.

Increased soft handover region naturally degrades system capacity and therefore it should be carefully considered whether this is a desired. Figure 3 and Figure 4 also show that the dB filter follows quite closely the actual path loss curve (i.e. the L1 reference curve) while linear L3 filter differ more and more from the actual pathloss curve less correlated log-normally distributed samples are in the filter. This is due to the fact that in case of linear filter small number of large values has an affect on the filtered output.

We have also calculated additional delay of the linear L3 filter compared to the logarithmic L3 filter in the figures.

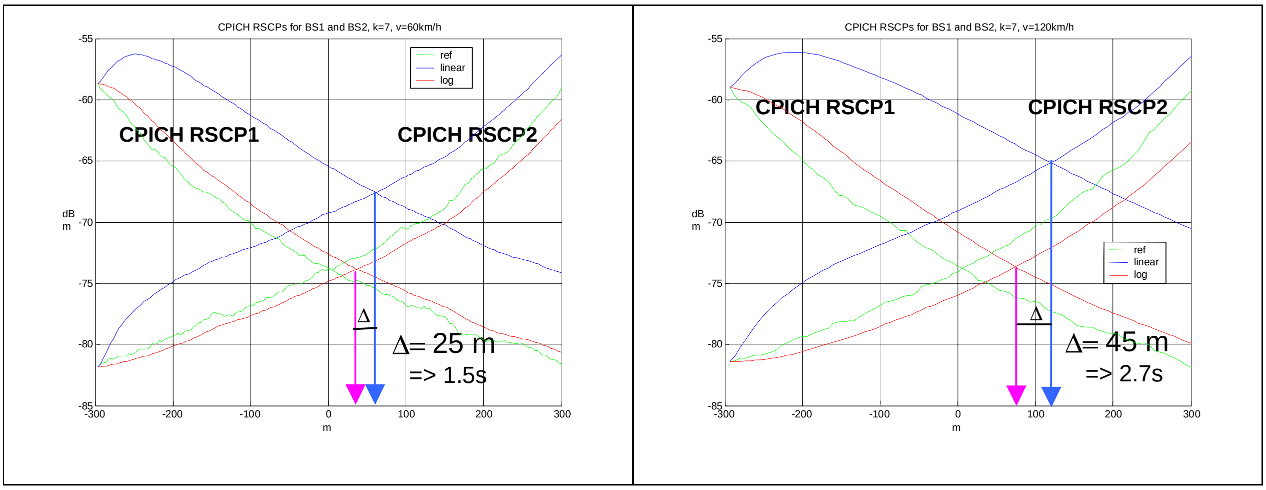

Figure 4 k=7 and UE speed is 60 km/h and 120 km/h **On the right hand picture the delta is correct , but additional delay is 1.35 s**

Figure 5 and Figure 6 illustrate how the filter coefficient and terminal speed affect the results. Low the terminal speed and *k* value are less differences there is between L1 and L3 filtered results.

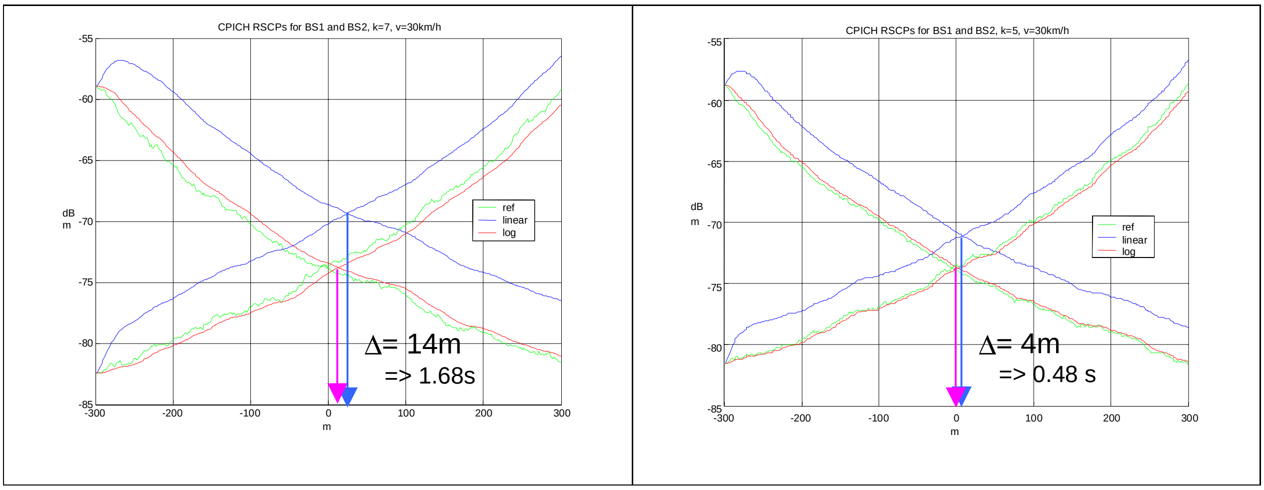

Figure 5 UE speed is 30 km/h and k= 7 and 5

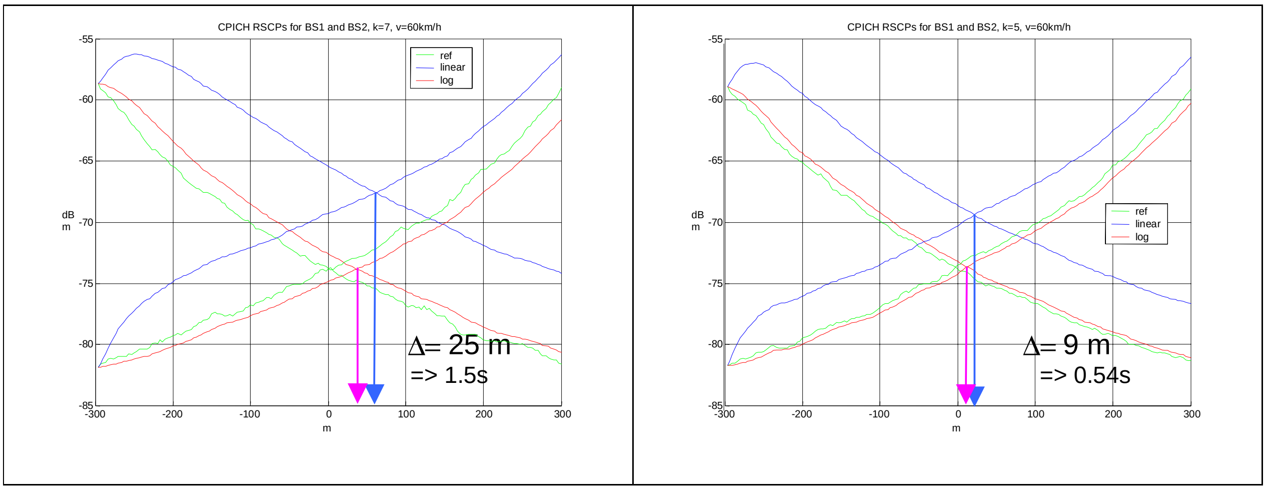

Figure 6 UE speed is 60 km/h and k= 7 and 5

We can also observe from the results in Figure 3 to Figure 6 how different UE speeds and *k* values affect a position (or time) where the UE recognises that it has crossed a certain absolute threshold. As an example we check where CPICH_RSCP2 exceeds –75 dBm.

k=7 and 3 km/h: linear ~ -30m and dB ~ -30m

k=7 and 30 km/h: linear ~ -170m and dB ~ -25m

k=7 and 60 km/h: linear ~ -200m and dB ~ -10m

k=7 and 120 km/h: linear ~ -200m and dB ~ 40m

When k=7 and UE speed varies from 3 km/h to 120 km/h a position where CPICH_RSCP2 exceeds an absolute threshold of –75 dBm changes –30 m to –200 m i.e. 170 m for linear L3 filter. For logarithmic L3 filter a variation in a triggering position is from –30 m to 40 m i.e. 70 m. 120 km/h is quite high speed for an environment, where a long L3 filter is used. Hence, it is more realistic to assume that in this kind of an environment an extreme UE speed would be in order of 60 km/h instead of 120 km/h. 120 km/h is shown here in order to illustrate a behavioural trend of these two L3 filters. When we limit the UE speed to 60 km/h the variation in triggering position for linear L3 filter is still approximately 170 m, which corresponds quite a significant area within a cell. For logarithmic L3 the variation in this case is only 20m.

If we do the same kind of observation for CPICH_RSCP1 crossing an absolute threshold of –70 dBm, we get the following results.

k=7 and 3 km/h: linear ~ -80 m and dB ~-100 m

k=7 and 30 km/h: linear ~ 40 m and dB ~ -80 m

k=7 and 60 km/h: linear ~ 140 m and dB ~ -70 m

k=7 and 120 km/h: linear ~ 270m and dB ~ -30 m

Again we can see large variation for linear L3 filter (350m for 3km/h-120km/h and 220m for 3km/h-60km/h) while for logarithmic filter the variation is quite moderate (70m for 3km/h-120km/h and 30m for 3km/h-60km/h).

3. Conclusions

Based on our analyses we can conclude that both of the L3 filters: dB and linear work but they may not have exactly the same performance when a terminal speed varies in a cell. The 3km/h case showed that there is nearly no difference between linear and dB filtering when the length of L3 filtering is such that samples used in L3 filtering are highly correlated. However, in case of higher UE speeds where log-normally distributed fading samples are no longer highly correlated over the whole L3 filtering period difference between linear and dB filtering increases. If we want L3 filtered results (e.g. CPICH RSCP or CPICH Ec/Io results) to follow the actual L1 behaviour better and we want to minimize required soft handover regions in deployments, where L3 filter is used and different terminals may be present in a cell, dB domain L3 filter should be selected. Logarithmic L3 filter also better allows to control the variation of reported absolute CPICH RSCP levels with different speeds.

In RAN4 considerations of L3 filtering, we believe that dB filtering should be adopted for CPICH Ec/Io, CPICH RSCP and pathloss due to its robustness with different terminal speeds within UTRAN system.

4. References

[1] R4-021484, “L3 filtering”, Nokia

[2] RP-020635, “Unit of layer 3 filtering”, Motorola

[3] R4-021479, “Unit of layer 3 filtering”, Motorola

[4] RP-020641, “Layer 3 filtering considerations”, Qualcomm

[5] R4-021534, “L3 Filtering”, Qualcomm