CDMA Voice Quality in Degraded Channel Conditions

White Paper

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Improving The Mobile Experience

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1 Abstract

This paper outlines methods for evaluating wireless handset performance and service quality through the analysis of voice quality measurements taken under degraded radio conditions. In particular, the paper considers voice quality measurements collected from handsets resident in a simulated radio environment. The paper also assesses the merits of voice quality measurements in lieu of radio parameters such as FER and Ec/Io.

2 Introduction

Evaluating a mobile handset's performance using voice quality measurement provides insightful understanding of over-all handset performance and user-experience. Voice quality measurement offers the advantage of exercising both the radio subsystem and base-band processing subsystem for a mobile handset. This contrasts with testing that measures Frame Error Rate and focuses on exercising only the radio subsystem. The base-band processing subsystem performance, including the voice codec and related DSP processing, has been found to vary across mobile handset models; resulting in a varied user experience even under the same radio conditions.

3 Degraded Channel Test Environment

The degraded channel environment is created through the use of a BTS Simulator and Fading Simulator. The BTS Simulator provides for the generation of the radio environment and air-interface for the test call while the fading simulator enables the systemic degradation of the traffic channel through various fading profiles.

Channel degradation is additionally achieved by superimposing AWGN over the control signal. The degree to which the channel is degraded can be set by controlling the ratio of Eb/No in the fading simulation.

In the sample results provided below, voice quality measurements were taken for four Eb/No settings.

4 Measurement Methods

4.1 Voice Quality Measurement

Voice quality is effectively measured using standardized models that predict quality scores traditionally determined from subjective tests with human listeners. PESQ, an ITU-T recommendation P.862 standardized model for predictive speech quality, utilizes speech signals that are subjected to the communications link under test and compares the degraded speech to the original speech. Speech quality scores are provided on a 5-point scale (MOS-like listening quality score).

Score	Quality of Speech
5	Excellent
4	Good
3	Fair
2	Poor
1	Bad

4.2 Determination of Voice Quality Sample Size

The sample size, the quantity of voice quality measurements, will vary based on the desired statistical confidence level and the observed variance of the voice quality measurements in each degraded channel condition. Generally, the more degraded the channel condition the higher the voice quality variance and the greater the number of voice quality samples required.

4.3 Voice Coupling Method

When measuring voice quality performance in a lab-based test scenario, electrical coupling and acoustic coupling may both be used. The primary advantage of electrical coupling is that it eliminates the potential for introduction of unwanted (external) sounds affecting the voice quality scores. Acoustic coupling via an ITU-T P.57 compliant device may also be used if sufficient acoustic isolation is available and if testing of accessories is desired such as Bluetooth headsets.

5 Performance Evaluation – Sample Results

Voice quality measurements collected through empirical study can be evaluated using common statistical inference methods. Statistical comparisons of the average voice quality and standard deviation of voice quality from a particular set of samples may be considered for statistical inference conclusions.

5.1 Analysis of Voice Quality Average by Degraded Channel Condition

In this analysis, voice quality average for each Eb/No range tested is shown. It is also observed that the standard deviation of voice quality for each range increases as Eb/No decreases. Therefore, to maintain a consistent confidence interval an increasing number of voice samples is required as the Eb/No decreases.

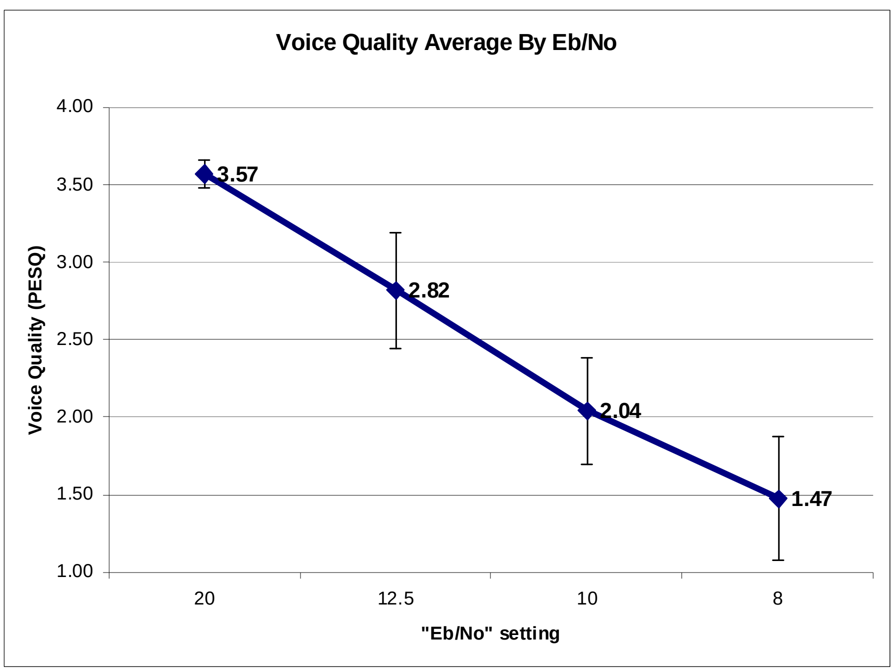


Figure 1 - Voice Quality by Average Eb/No

5.2 Comparison of Measured Voice Quality to Performance Threshold

In this analysis, performance compared to a desired threshold is shown. For each handset tested, the measured voice quality average is subtracted from a desired performance threshold. Handsets with performance below the 0.00 line are degraded and handsets above the 0.00 line are superior to the performance threshold.

As shown, Handset B outperformed Handset A and also exceeded the performance threshold.

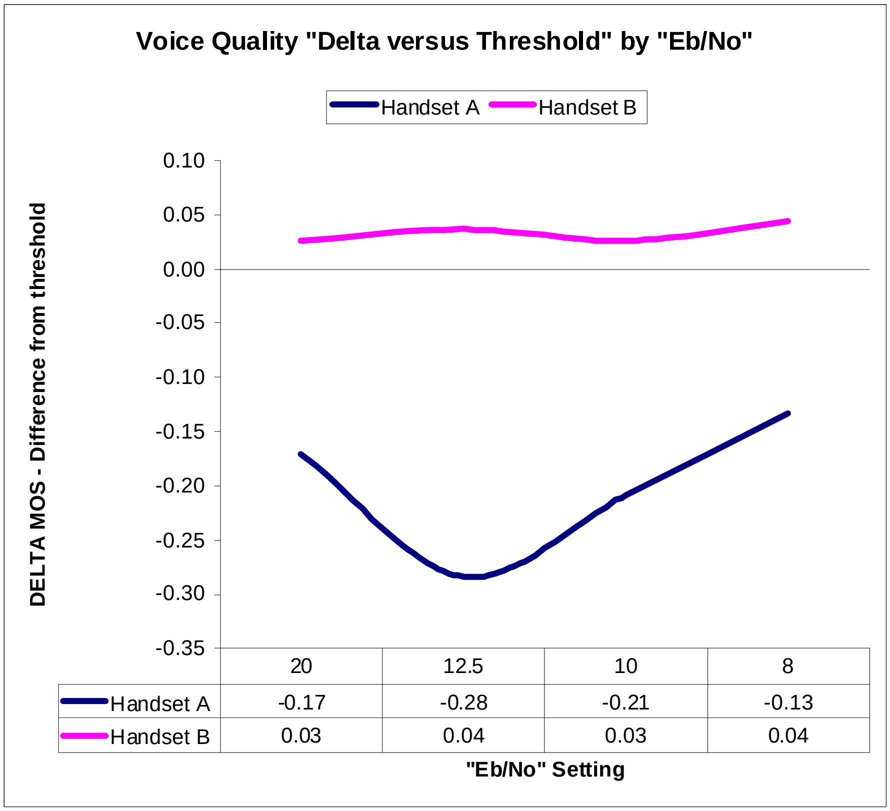
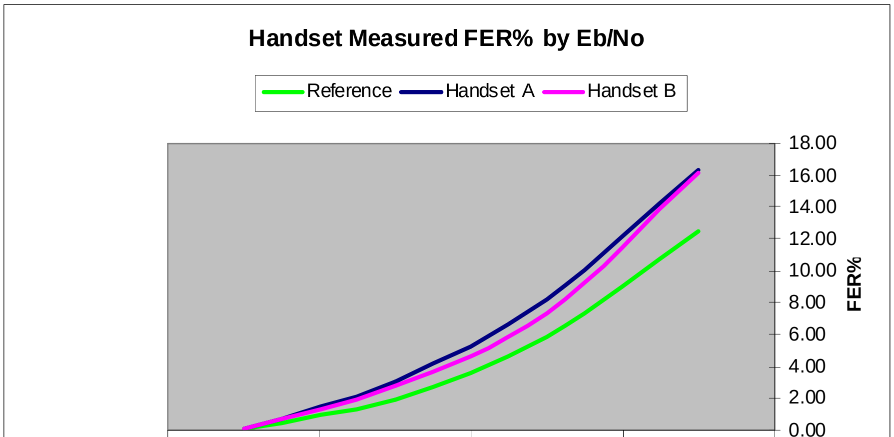


Figure 2 - Voice Quality "Delta versus Threshold" by Eb/No

5.3 Comparison of FER Measured / Reported by Handsets under Test

In this analysis, the average FER reported from each handset under each Eb/No condition is plotted (including a Reference device). Reported FER was measured using a mobile diagnostic monitor software application.

In the absence of voice quality measurements, one might conclude that the Handset A and Handset B experienced a similar voice quality when in fact they did not. Similarly, when comparing Handset B to the Reference device in the absence of voice quality measurements, one might conclude that the Reference device experienced a superior voice quality to the Handset B. Handset B performed slightly better than the Reference device. In fact the Reference device experienced voice quality that is equal to the "performance threshold" referenced in the previous section.



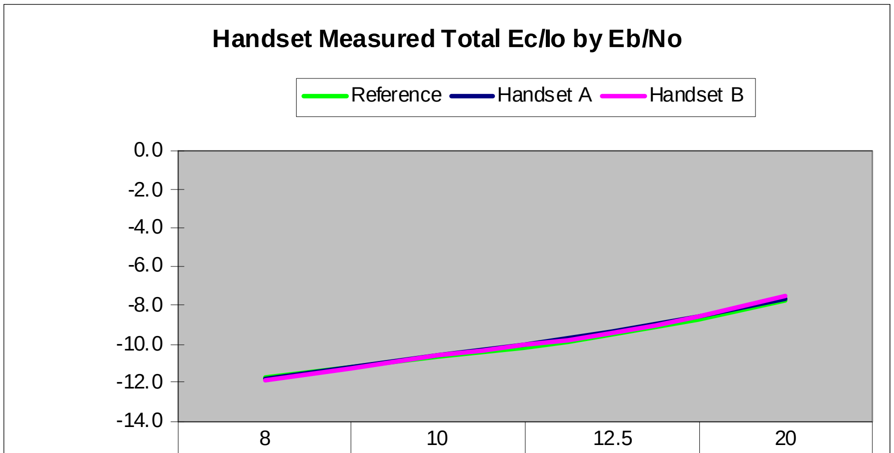
	20	12.5	10	8
Reference	0.08	1.97	5.83	12.47
Handset A	0.10	3.01	8.23	16.37
Handset B	0.10	2.79	7.31	16.18

Figure 3 - Handset Measured FER by Eb/No

5.4 Comparison of Ec/Io Measured / Reported by Handsets Under Test

In this analysis, the average Ec/Io reported from each handset under each Eb/No condition is plotted (including a Reference device). Reported Ec/Io was measured using a mobile diagnostic monitor software application.

In the absence of voice quality measurements, one might conclude that Handset A and Handset B experienced a similar voice quality when in fact they did not.



	8	10	12.5	20
Reference	-11.8	-10.7	-9.5	-7.8
Handset A	-11.8	-10.6	-9.4	-7.7
Handset B	-11.9	-10.6	-9.5	-7.6

Figure 4 - Handset Measured Total Ec/Io by Eb/No

5.5 Conclusions

Voice quality measurements can be used effectively to characterize and compare the performance of handsets under degraded channel conditions. In addition, the characterization of handset performance using radio parameters does not always agree with the characterization provided by voice quality measurements.