



Technical Documentation

ANR 2.1 - TRD Tests Results

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Acronyms

ANR	Ambient Noise Reduction
FTA	Full Type Agreement
NPLR	Noise Power Level Reduction
PESQ	Perceptual Evaluation of Speech Quality
PTT	Push-To-Talk
SNR	Signal-to-Noise Ratio
SNRI	Signal-to-Noise Ratio Improvement
THD	Total Harmonic Distortion
TRD	Technical Requirement Document
VAD	Voice Activity Detector
VAF	Voice Activity Factor

List of References

- [1] [L1D_AS118-1 – TRD for the Noise Suppressor – ANR 2.x, 3.x](#)

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1 Introduction

This document applies to the Ambient Noise Reduction (ANR 2.1x). The purpose of this document is to presents TRD test results of ANR 2.13.

2 ANR 1.x C-Fixed Point Validation/TRD

2.1 TRD Tests Definition

The tests definitions for the validation of ANR 2.13 algorithm are available in the Technical Requirement Document (TRD) [1].

2.2 TRD Tests Results

The test results from the C-fixed point ANR 2.13 model are presented in the next developments. TRD tests are done using the C-fixed point models of ANR 2.13 and Voice Activity Detector (VAD 1.11). The corresponding labels of C-fixed point models under ClearCase are:

```
<L1D_CFIX_ANR_VERSION_02_13_01>;  
<L1D_CFIX_VAD_VERSION_01_11_02>.
```

2.2.1 Test 1 – Active Speech Level Attenuation

The active speech level criterion assesses the ability of ANR to preserve speech frames against unexpected attenuation [1](4.1). The objective performance criterion is the I/O difference of active speech level. The acceptance criterion is attenuation less than 2dB in any condition except car 0dB Signal-to-Noise Ratio (SNR) where acceptance criterion is attenuation less than 5dB. The performances of ANR 2.13 compared to the previous version ANR 2.0 are presented below (Figure 2.1).

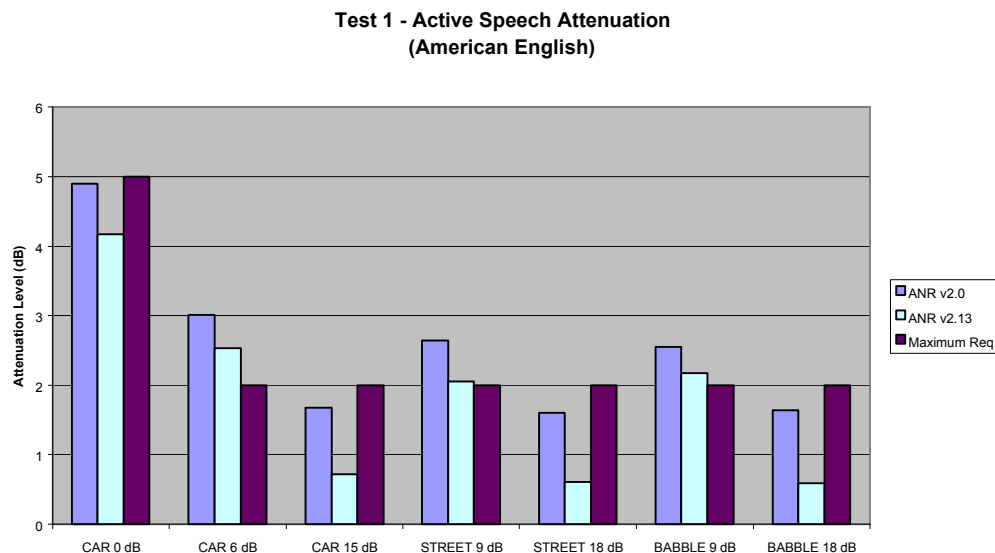


Figure 2.1 The ANR 2.13 C-Fixed Point Test Results (TRD Test 1)

The test results indicate that ANR 2.13 is 0.5dB, 1dB better than ANR2.0 in all conditions (Figure 2.1). ANR 2.13 is compliant to TRD test 1 for SNR ≥ 15 dB in any condition (car, street, babble).

2.2.2 Test 2 – Clean Speech Degradation

The clean speech degradation test assesses the ability of ANR not to degrade the speech quality [1](4.2). The performance criterion is the Perceptual Evaluation of Speech Quality (PESQ) score. The acceptance criterion is PESQ score higher than or equal to 4.0. The performances of ANR 2.13 compared to the previous version ANR 2.0 are presented below (Figure 2.2).

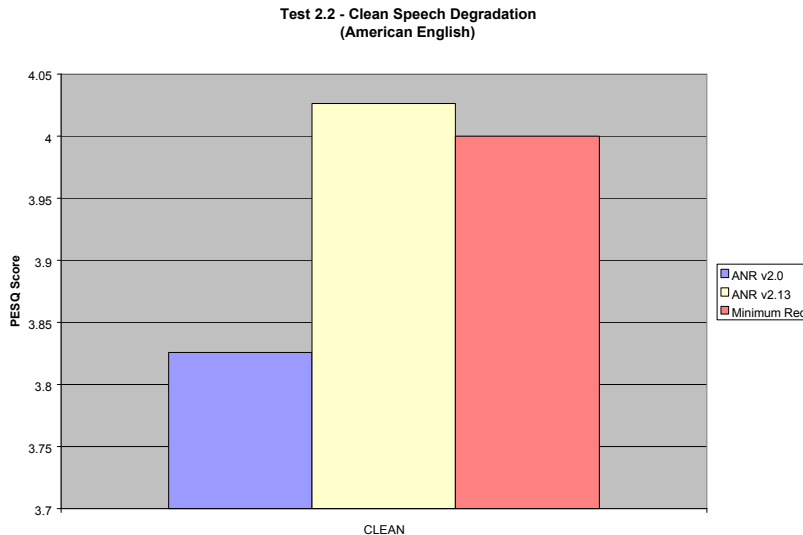


Figure 2.2 The ANR 2.13 C-Fixed Point Test Results (TRD Test 2)

The test results indicate that ANR 2.13 provides better perceptual quality of speech than ANR2.0. The ANR 2.13 improves the speech quality while the ANR 2.0 degrades noticeably the speech (Figure 2.2). ANR 2.13 is compliant to TRD test 2.

2.2.3 Test 3 – Speech Degradation and Undesirable Effects in Background Noise

The speech degradation in background noise test assesses the ability of ANR to preserve the speech quality and to avoid artifacts in background noise [1](4.3).

The first performance criterion (Test 3.2) is an objective measurement of Noise Power Level Reduction (NPLR) compared to SNR Improvement (SNRI) [1](4.3.2). The acceptance criterion is NPLR not be higher than SNRI by 3dB for car environment with SNR equal to 6 and 15dB conditions and NPLR not be higher than SNRI by 5dB for car environment with SNR equal to 0dB. The performances of ANR 2.13 compared to the previous version ANR 2.0 are presented below (Figure 2.3).

The test results indicate that ANR 2.13 provides less speech degradation and less undesirable attenuation in background noise compared to ANR 2.0 in any condition (Figure 2.3). ANR 2.13 is compliant to TRD test 3.2.

The second performance criterion (Test 3.3) is an objective measurement of spectral deviation of the background noise at the ANR I/O leading to increasing of the spectral deviation factor S_{dev} [1](4.3.3). The acceptance criterion is S_{dev} I/O increases less than 1%. The performances of ANR 2.13 compared to the previous version ANR 2.0 are presented below (Figure 2.4).

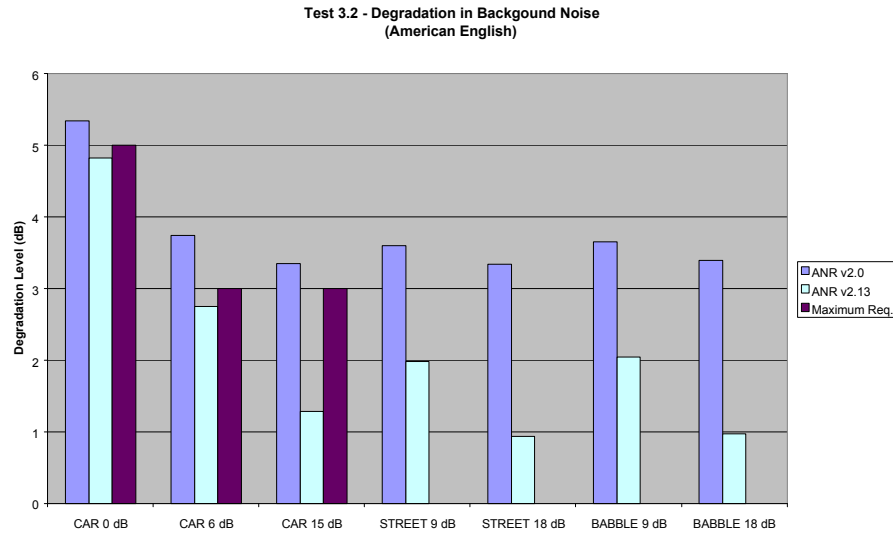


Figure 2.3 The ANR 2.13 C-Fixed Point Test Results (TRD Test 3.2)

The test results indicate that ANR 2.13 provides less S_{dev} increasing than ANR 2.0 except for babble noise with 18dB SNR (Figure 2.4). ANR 2.13 is compliant to TRD test 3.3.

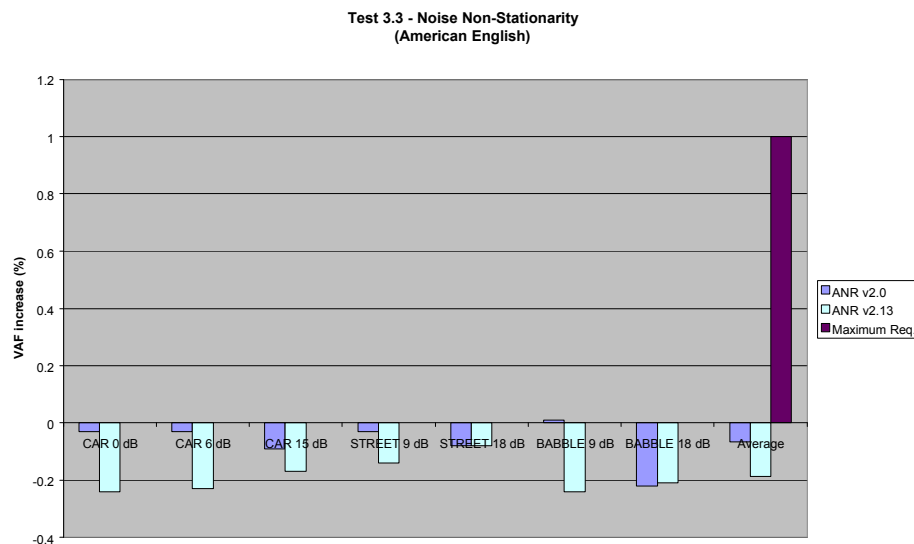


Figure 2.4 The ANR 2.13 C-Fixed Point Test Results (TRD Test 3.3)

The third performance criterion (Test 3.4) is the PESQ score of speech degradation in background noise condition [1](4.3.4). The acceptance criterion is PESQ at the ANR output statistically better than at the ANR input in at least 5 conditions out of 7 conditions. For PESQ statistical analysis, assume two results are equivalent if the score difference is 0.1 or smaller. The performances of ANR 2.13 compared to the previous version ANR 2.0 are presented below (Figure 2.5).

The test results indicate that ANR 2.13 provides better PESQ score than ANR 2.0 in any condition (Figure 2.5). ANR 2.13 is compliant to TRD test 3.4.

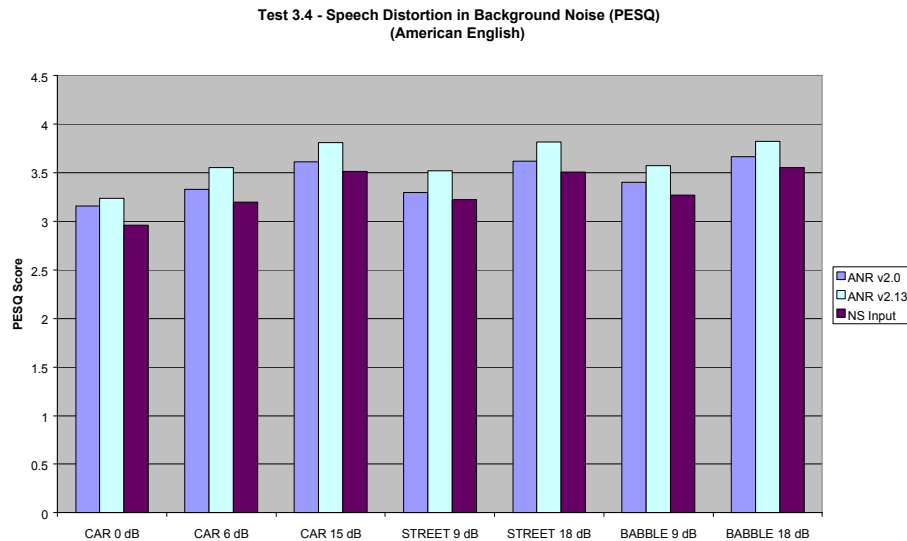


Figure 2.5 The ANR 2.13 C-Fixed Point Test Results (TRD Test 3.4)

2.2.4 Test 4 – Performances Improvement in Background Noise

The test 4 assesses the ability of the ANR to have close performances to ideal noise suppression [1](4.4) .

The first performance criterion (Test 4.3) is the PESQ score at the ANR output compared to ideal noise suppression -4dB and -6dB, and ANR input [1](4.4.3). The acceptance criterion against ANR input is that ANR output must be statistically better than ANR input at least 4 out of 6 noise conditions, and statistically better than or equal to ANR input in the remaining condition. The acceptance criterion against ideal noise suppression is that ANR output must be statistically better than or equal to -6 dB ideal noise suppression at least 2 out of 6 noise conditions, and statistically better than or equal to -4 dB ideal noise suppression at least 4 out of 6 noise conditions. The performances of ANR 2.13 compared to the previous version ANR 2.0 are presented below (Figure 2.6).

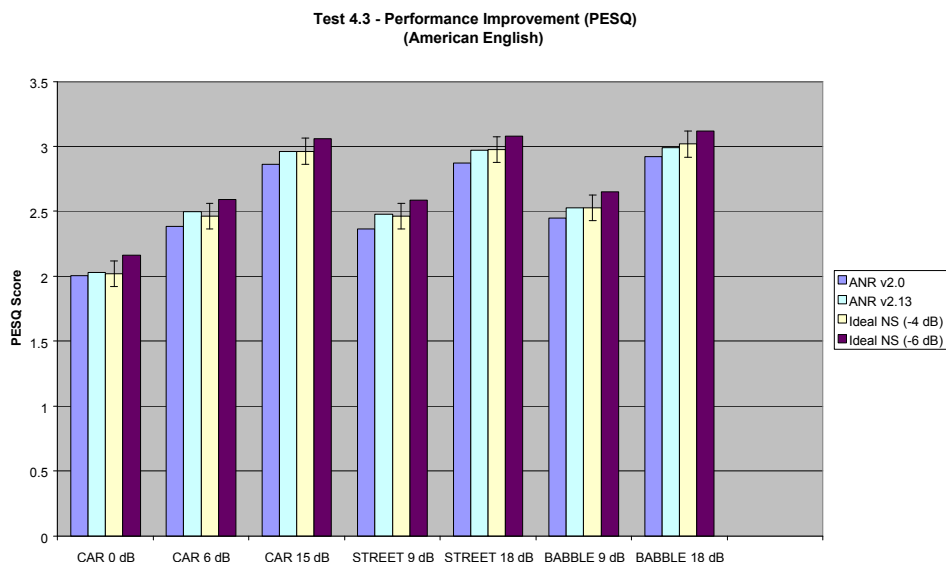


Figure 2.6 The ANR 2.13 C-Fixed Point Test Results (TRD Test 4.3)

The test results indicate that ANR 2.13 is better than ANR 2.0 in all conditions (Figure 2.6). The ANR 2.13 meets the acceptance criteria against both ANR input and ideal noise suppression.

The second performance criterion (Test 4.4.4) is the NPLR at the ANR output compared to the input [1](4.4.4.1). The acceptance criterion is that NPLR is 7dB or higher in all car noise. The performances of ANR 2.13 compared to the previous version ANR 2.0 are presented below (Figure 2.7).

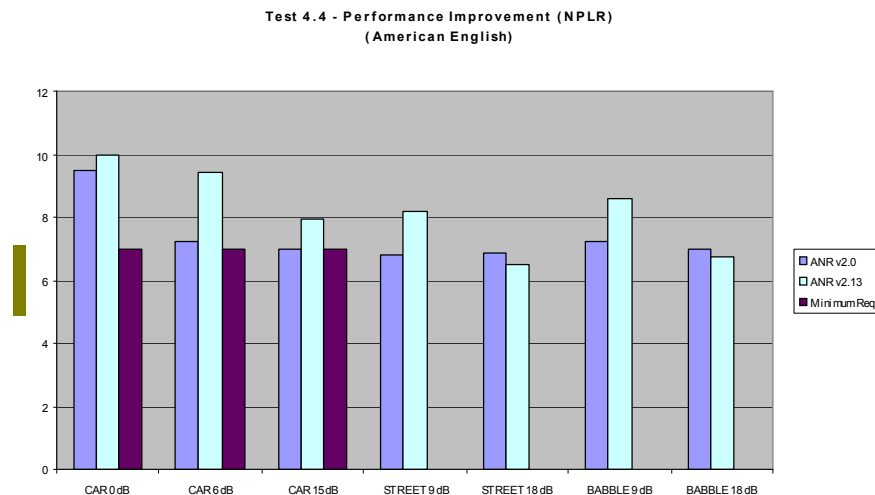


Figure 2.7 The ANR 2.13 C-Fixed Point Test Results (TRD Test 4.4.1)

The test results indicate that ANR 2.13 is better than ANR 2.0 except for street and babble conditions with 18dB SNR (Figure 2.7). The ANR 2.13 meets the acceptance criterion in all car noise conditions.

The third performance criterion (Test 4.4.2) is the SNRI at the ANR output compared to the input [1](4.4.4.2). The acceptance criterion is that SNRI is 6dB or higher in all car conditions. The performances of ANR 2.13 compared to the previous version ANR 2.0 are presented below (Figure 2.8).

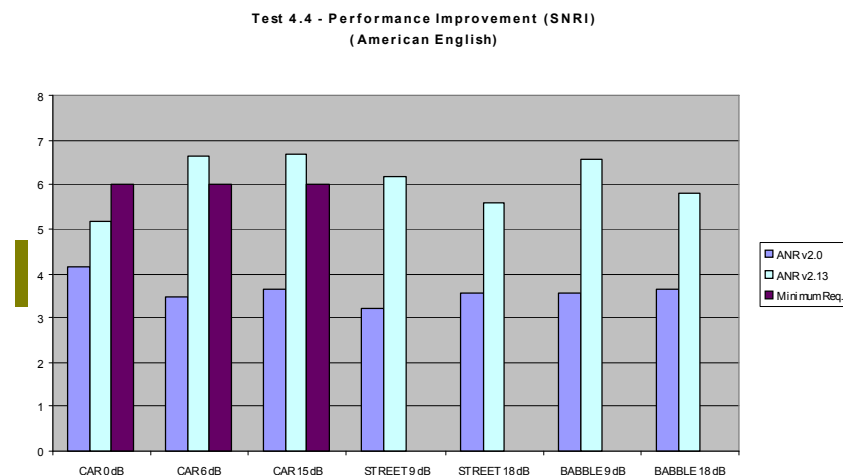


Figure 2.8 The ANR 2.13 C-Fixed Point Test Results (TRD Test 4.4.2)

The test results indicate that ANR 2.13 is better than ANR 2.0 in all conditions (Figure 2.8). The ANR 2.13 meets the acceptance criterion in all car noise conditions.

2.2.5 Test 5 – Impact on VAD/DTX

The test 5 assesses the ability of the ANR to have minimal impact on the Adaptive Multirate (AMR) Vocoder VAD [1](4.5).

The performance criterion is the average difference value of Voice Activity Factor (VAF) between ANR input and output for clean speech, noisy speech and ANR/NS-processed speech. The acceptance criterion is: average VAF value of ANR/NS-processed speech over all noise conditions should not be higher than the VAF value of ANR/NS input speech by 5 %. The performances of ANR 2.13 compared to the previous version ANR 2.0 are presented below (Figure 2.9).

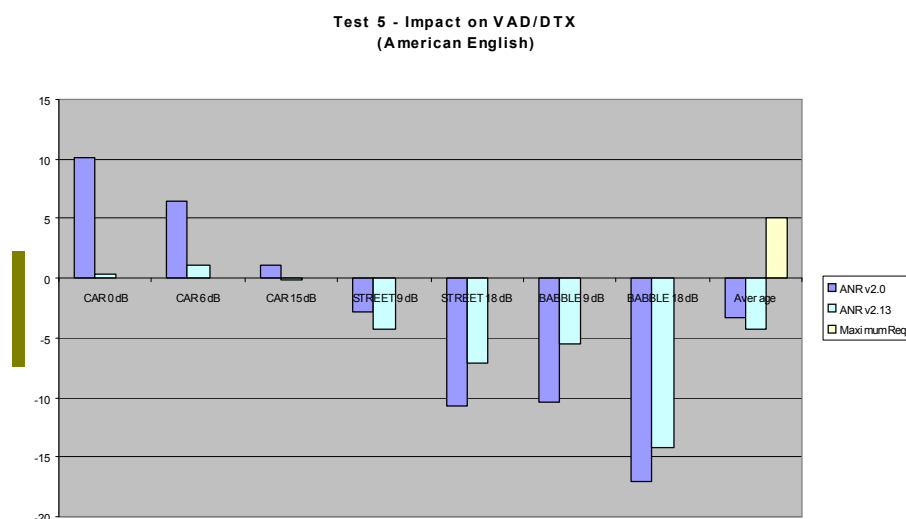


Figure 2.9 The ANR 2.13 C-Fixed Point Test Results (TRD Test 5)

The test results indicate that ANR 2.13 is better than ANR 2.0 in car conditions for all SNR values (Figure 2.9). For street and babble conditions, ANR 2.0 is generally better than ANR 2.13. In all cases, the ANR 2.13 meets the acceptance criterion of TRD.

2.2.6 Test 6 – Performances in Special Cases

The test 6 assesses the ANR performances in special cases such as Push-To-Talk (PTT) use case or sensitivity to zero conditions (including initial conditions) [1](4.6).

The first performance criterion is the NPLR in PTT condition [1](4.6.1.1). The acceptance criterion is Noise power level of NS-processed material should be lower than the one of NS input material by at least 3dB for any noise conditions. The performances of ANR 2.13 compared to the previous version ANR 2.0 are presented below (Figure 2.10).

The test results indicate that ANR 2.13 is better than ANR 2.0 in all conditions except for babble SNR18dB condition where ANR 2.13 and ANR 2.0 have quite the same performances (Figure 2.10). In all cases, the ANR 2.13 meets the acceptance criterion of TRD.

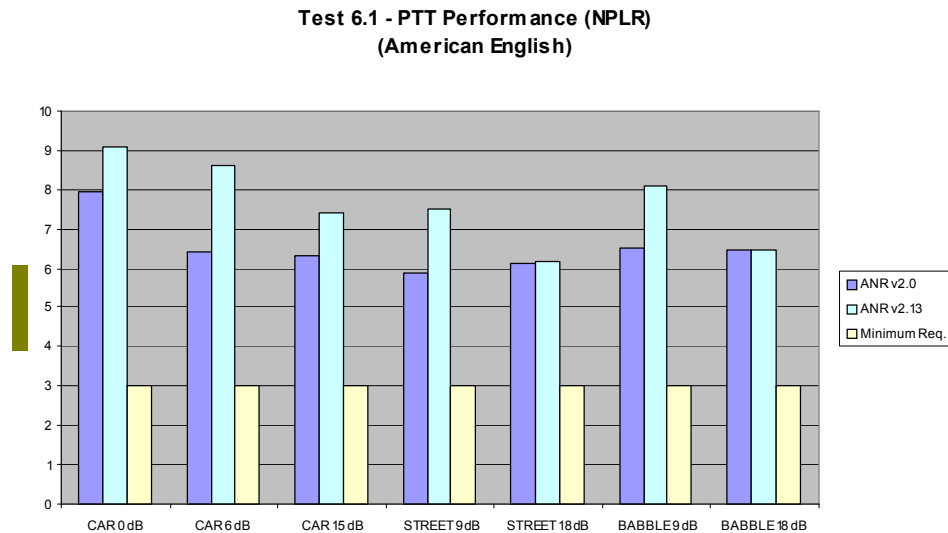


Figure 2.10 The ANR 2.13 C-Fixed Point Test Results (TRD Test 6.1.1)

The second performance criterion is the measurement of SNRI in PTT condition by comparison of the noise SNR of NS-processed speech and original noisy speech (NS input) [1](4.6.1.2). The acceptance criterion is the SNRI to be at least 2 dB for any noise conditions. The performances of ANR 2.13 compared to the previous version ANR 2.0 are presented below (Figure 2.11).

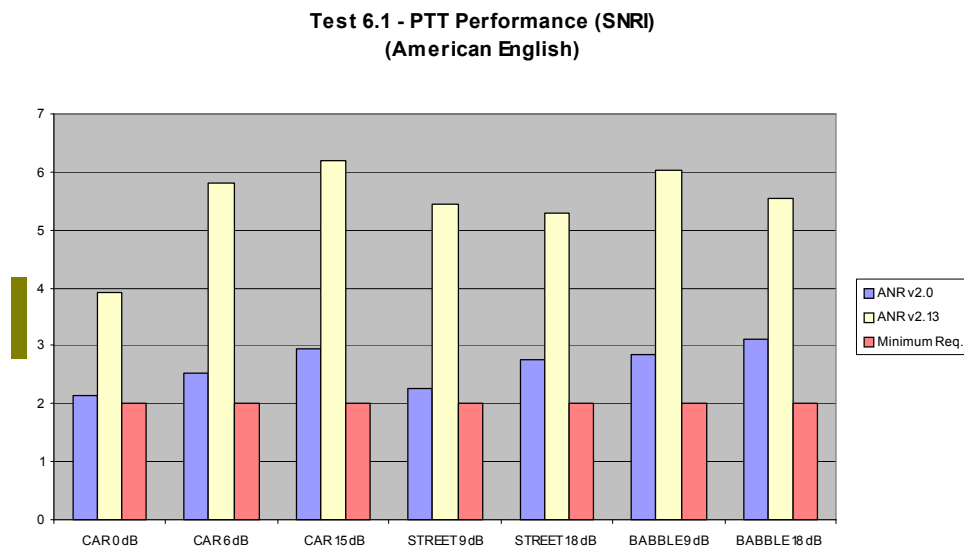


Figure 2.11 The ANR 2.13 C-Fixed Point Test Results (TRD Test 6.1.2)

The test results indicate that ANR 2.13 is better than ANR 2.0 in all conditions (Figure 2.11). In all cases, the ANR 2.13 meets the acceptance criterion of TRD.

The third performance criterion is the NPLR in zero initialization condition by measurement of the noise power level of NS-processed speech and original noisy speech (NS input) [1](4.6.2.1). The acceptance criterion is: noise power level of NS-processed material should be lower than the one of

NS input material by at least 3dB for any noise conditions. The performances of ANR 2.13 compared to the previous version ANR 2.0 are presented below (Figure 2.12).

**Test 6.2 - Zero Initialization (NPLR)
(American English)**

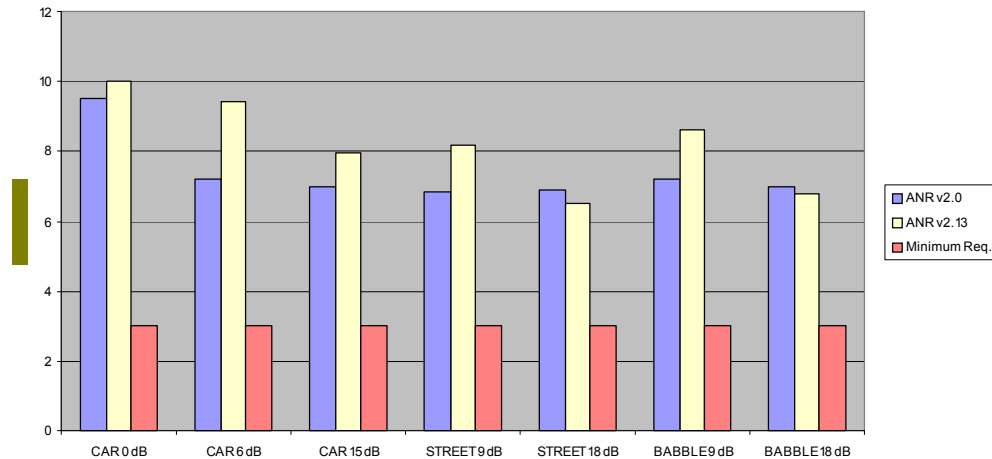


Figure 2.12 The ANR 2.13 C-Fixed Point Test Results (TRD Test 6.2.1)

The test results indicate that ANR 2.13 is better than ANR 2.0 in all conditions except for street and babble SNR 18dB conditions (Figure 2.12). In all cases, the ANR 2.13 meets the acceptance criterion of TRD.

The fourth performance criterion is the SNRI in zero initialization condition by measurement the noise SNR of NS-processed speech and original noisy speech (NS input) [1](4.6.2.2). The acceptance criterion is: the SNR of NS-processed material should be higher than the NS input material by at least 2 dB for any noise conditions. The performances of ANR 2.13 compared to the previous version ANR 2.0 are presented below (Figure 2.13).

**Test 6.2 - Zero Initialization (SNRI)
(American English)**

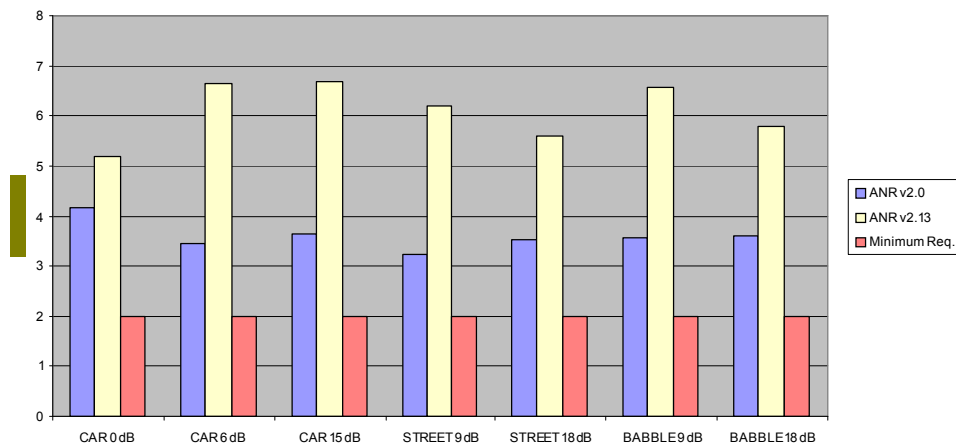


Figure 2.13 The ANR 2.13 C-Fixed Point Test Results (TRD Test 6.2.2)

The test results indicate that ANR 2.13 is better than ANR 2.0 in all conditions (Figure 2.13). In all cases, the ANR 2.13 meets the acceptance criterion of TRD.

2.2.7 Test 7 – Performances in Noise Environment Change

The test 7 assesses the ANR performances in noise environment change such as clean to noise condition and inverse [1](4.7).

The first performance criterion is measurement of PESQ score of ANR/NS-processed noisy speech in clean to noise condition [1](4.7.1). PESQ scores for NS input and ideal NS speech (-4 and -6 dB) are the same as ones in Test 4.3. The PESQ reference is the corresponding ideal noise suppression speech. The acceptance criterion is: the ANR/NS-processed speech PESQ score must be statistically better than the original noisy speech score (ANR/NS input) in at least 5 out of 7 conditions, and must be better than or equal to the original noisy speech score in the remaining conditions. The ANR/NS-processed speech PESQ score must be statistically better than or equal to the ideal ANR/NS speech of -6 dB in at least 3 out of 7 conditions, and must be statistically better than or equal to the ideal ANR/NS speech of -4 dB in at least 5 out of 7 conditions. For PESQ statistical analysis, assume two results are equivalent if the score difference is 0.1 or smaller. The performances of ANR 2.13 compared to the previous version ANR 2.0 are presented below (Figure 2.14).

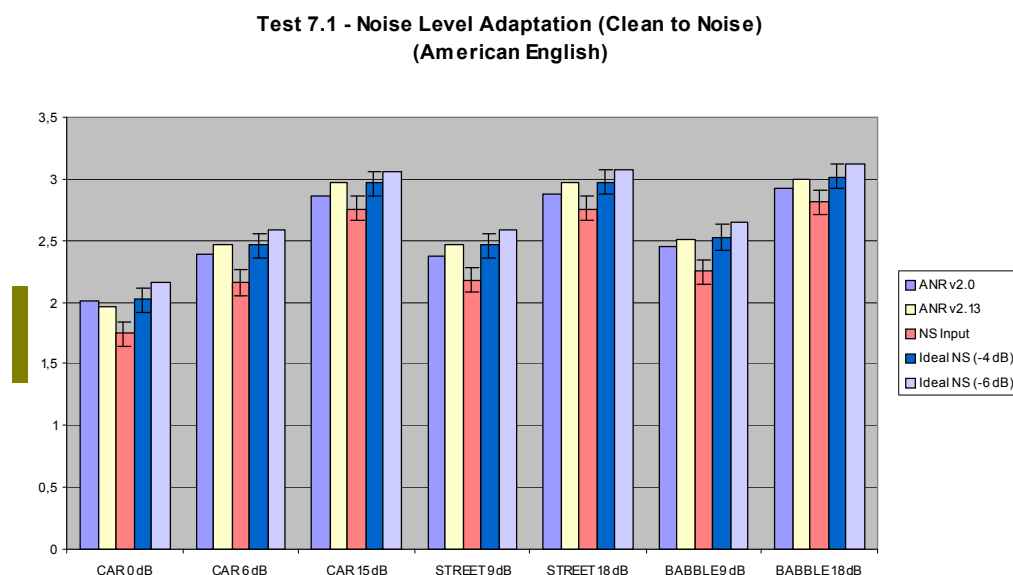


Figure 2.14 The ANR 2.13 C-Fixed Point Test Results (TRD Test 7.1)

The test results indicate that ANR 2.13 is better than ANR 2.0 in all conditions except in car SNR 0dB (Figure 2.14). ANR 2.13 meets acceptance criteria against ANR input, but does not meet against ideal noise suppression speech.

The second performance criterion is measurement of PESQ score of ANR/NS-processed noisy speech in noise to clean condition [1](4.7.2). The acceptance criterion is: the PESQ score of ANR/NS-processed speech should be 4.0 or higher. The performances of ANR 2.13 compared to the previous version ANR 2.0 are presented below (Figure 2.15).

The test results indicate that ANR 2.13 is better than ANR 2.0 (Figure 2.15). The ANR 2.13 is compliant to the acceptance criterion of TRD.

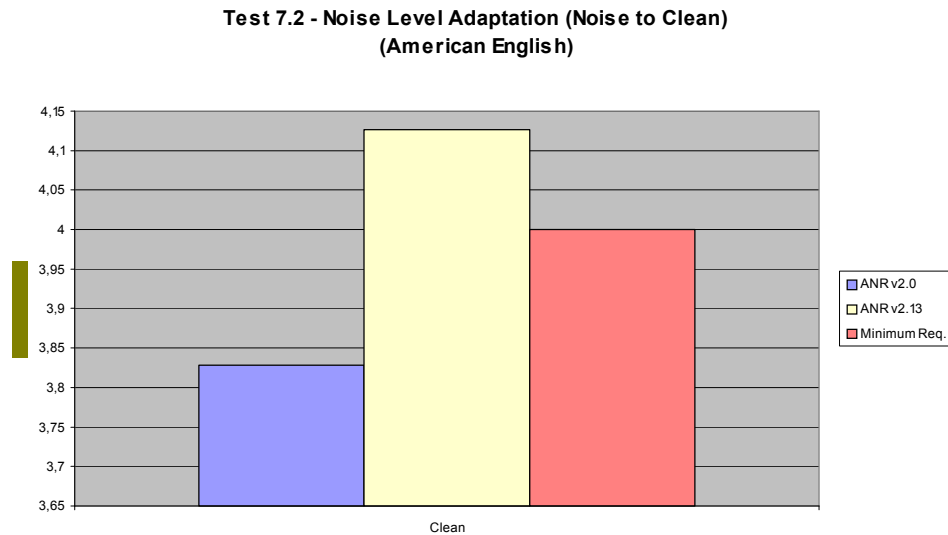


Figure 2.15 The ANR 2.13 C-Fixed Point Test Results (TRD Test 7.2)

2.2.8 Test 8 – Preservation of Test Signals FTA R99/R4

ANR 2.0 was found to degrade the Full Type Agreement (FTA) test signal for sending distortion test as defined in 3GPP 26.131 and 26.132. The ANR 2.13 C-fixed point model was tested for preservation of test signals. The simulation results are presented in (A. Appendix).

Additional tests definition and C-fixed point results for FTA R99/R4 signals preservation are proposed in (Chapter **Error! Reference source not found.**) as references for post-integration testing.

Appendices

A. Appendix: ANR 2.13 TRD Test Results (FTA R99, R4)

Input Level = -8dBm0

Freq (Hz)	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	Avg
ANR v2.0	-1.1731	-1.3459	-1.1287	-1.0747	-1.3095	-1.0713	-0.9864	-0.9112	-0.9236	-0.9328	-0.999	-0.9237	-0.8729	-0.1775	-0.9878786
ANR v2.1	-1.4526	-1.5894	-1.491	-1.3767	-1.6209	-1.4328	-1.2542	-1.2565	-1.261	-1.252	-1.374	-1.2754	-1.2054	-0.0821	-1.2802857
ANR v2.13	-0.0068	-0.097	-0.0243	-0.0787	-0.0402	-0.045	-0.0726	-0.0661	-0.0493	-0.0799	-0.1115	-0.0602	-0.0118	0.8169	0.00525

Input Level = -10dBm0

Freq (Hz)	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	Avg
ANR v2.0	-1.549	-1.6099	-1.503	-1.4342	-1.8069	-1.4951	-1.3556	-1.2717	-1.2705	-1.2988	-1.3428	-1.2913	-1.271	-1.1679	-1.4048357
ANR v2.1	-1.426	-1.4511	-1.4348	-1.2886	-1.5573	-1.3629	-1.1782	-1.1736	-1.1865	-1.1611	-1.2467	-1.1917	-1.1809	-1.0957	-1.2810786
ANR v2.13	-0.001	-0.0052	0.0199	-0.0053	0.0104	0.0057	-0.0091	0.0013	0.0077	-0.0038	-0.0132	0.0009	-0.0001	-0.0969	-0.0063357

Input Level = -16dBm0

Freq (Hz)	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	Avg
ANR v2.0	-4.2206	-4.303	-4.1202	-4.1779	-4.3536	-3.9889	-3.9792	-3.9273	-3.9431	-3.9534	-3.9788	-3.9293	-3.92	-3.7496	-4.0389214
ANR v2.1	-1.4242	-1.438	-1.433	-1.2516	-1.5253	-1.3358	-1.1551	-1.159	-1.1617	-1.1197	-1.2105	-1.1672	-1.1563	-0.8104	-1.2391286
ANR v2.13	0.0094	0.0238	0.0345	0.0179	0.0319	0.0339	0.0139	0.0187	0.0247	0.0299	0.0229	0.0262	0.0255	0.0362	0.0249571

R99 Single Tone (1015 Hz) Input Level = -16dBm0 / Idle Channel Level = -77 dBm0

* For single tone input, only the frequency band that contains tone should affect SLR measurement (shown in red).

Freq (Hz)	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	Avg
ANR v2.13	-3.0867	-2.8157	-2.6631	-2.4411	-2.174	-1.6056	-0.7912	0.0232	0.7669	2.182	3.5108	4.7548	5.6421	6.0608	*