

**Source:** Mitsubishi Electric Corporation<sup>1</sup>

**Title:** Test Results of Mitsubishi AMR-NS solution based on TS 26.077

**Agenda Item:** 6 (SQ)

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## 1 Introduction

Mitsubishi reports details on the following aspects of its AMR Noise Suppression (AMR-NS) solution based on 3GPP TS26.077 [1] to be endorsed by TSG-S4:

- Description of the Noise Suppression algorithm
- Performance assessed by Objective Means
  - Bit Exactness of the Speech Encoder and Decoder
  - Impact on Speech Path Delay
  - Impact on Channel Activity (Voice Activity Factor Measurements)
- Performance assessed by Subjective tests by the third party
- Objective Performance Measures
  - Impact on Active Speech Level
  - Objective Speech Quality Measures (NPLR and SNRI)
- Interaction with various services

## 2 Description of the Noise Suppression algorithm

The Mitsubishi AMR-NS algorithm is based on Spectral Subtraction method. Frame length is 20ms, the same as AMR speech encoder. Figure 2.1 shows the block diagram of the Mitsubishi AMR-NS algorithm. Pre-processed input speech sample is transformed into frequency domain by using 256 points FFT, amplitude and phase spectrum are obtained. Voice/Noise decision is also performed for each frame. The Noise spectrum is updated using noise frame spectrum when the current frame is detected as noisy frame by the Voice/Noise detector. SNR for each sub-band spectrum are estimated from the current frame spectrum and the Noise spectrum.

Factors for spectrum subtraction and spectrum suppression are both estimated from current frame amplitude spectrum, Noise spectrum and the sub-band SNR. Using these factors, spectral subtraction and spectral amplitude suppression are performed respectively, and noise suppressed speech signal is obtained.

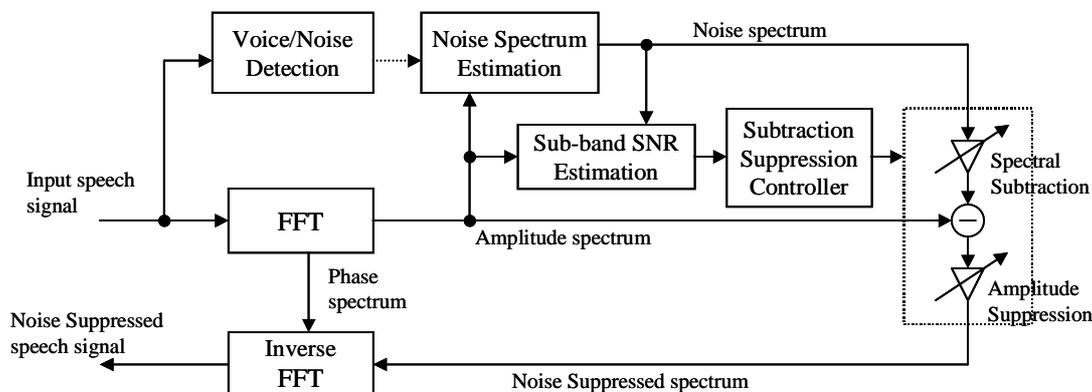


Figure 2.1: Block diagram of Noise Suppression algorithm.

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<sup>1</sup> Shinya Takahashi ([takahashi@isl.melco.co.jp](mailto:takahashi@isl.melco.co.jp))

### 3 Performance assessed by Objective Means

#### 3.1 Bit Exactness of the Speech Encoder

The Mitsubishi AMR-NS is embedded in the encoder of AMR as shown in Figure 3.1. The AMR-NS module operate on the pre-processed input speech buffer “old\_speech[L\_TOTAL]” in the structure “cod\_amrState” in the AMR C code [3GPP TS06.73] after the pre-processing module of the speech encoder. The signals at Test points 1 and 2 is identical and the Reference Encoder is the part of [3GPP TS06.73] after the pre-processing module.

Furthermore, The AMR-NS function is controllable by the enable/disable switch independently of AMR speech codec.

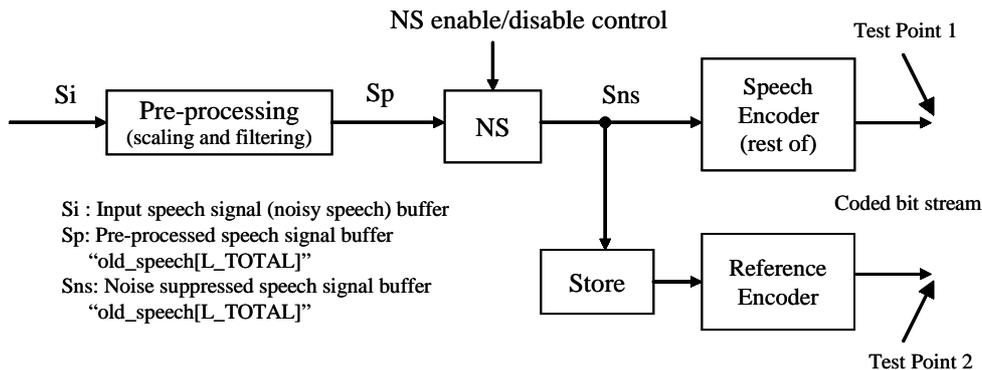


Figure 3.1: Verification of AMR speech encoder bit-exactness for embedded NS

#### 3.2 Bit Exactness of the Speech Decoder

The Mitsubishi AMR-NS does not also alter the AMR speech decoder.

#### 3.3 Impact on Speech Path Delay

An additional algorithmic delay of the Mitsubishi AMR-NS algorithm is 5 ms due to overlapping 40 samples for FFT. The algorithmic delay does not change even if embedded system or non-embedded (stand-alone) system.

The processing complexity (WMOPS) was counted using the measuring tool of ETSI basic operators in the C source code, the Worst case (WorstWC) of 1584 noisy speech samples was 5.04 WMOPS. The processing delay is calculated as defined in TS26.077 as follows

$$\begin{aligned} \text{delay(proc)} &= \text{WMOPS} * 20 / (\text{E} * \text{S} * \text{P}), \quad \text{E} * \text{S} * \text{P} = 50 \\ &= 5.04 * 20 / 50 \\ &= 2.016 \text{ (ms)} \end{aligned}$$

Since processing delay is 2.016ms, the total additional delay (comprising of algorithm and processing delays) is 7.016 ms. It is clear that this result satisfies the requirement of not exceeding 10ms.

#### 3.4 Impact on Channel Activity (Voice Activity Factor Measure)

The VAF measurement tests for both AMR VAD two options in two languages, Japanese and North American English (NA English), were performed. All the noisy speech materials used in the subjective test in the chapter 4 were used in this VAF test. The materials used were offered from the listing test laboratory after the AMR-NS algorithm had been fixed. Table 3.1 and 3.2 shows the average value for each noise condition in two languages respectively. “Difference to Max(x,y)” denotes the difference of W and Max(X,Y) in these tables. A negative value denotes a decrease in VAF. VAF measurements tool is defined in Tdoc. SMG11/S4 363/99 provided by Nortel Networks with the program and repaired in order to suit to the new conditions in TS 26.077.

The test results show that VAF is decreasing for both VAD two options in all conditions when NS active. The Mitsubishi AMR-NS does not degrade channel activity.

Table 3.1: VAF measurement result in case of Japanese speech material

| Condition | W<br>(AMR-NS with clean speech + noise) |       | X<br>(AMR with clean speech) |       | Y<br>(AMR with clean speech + noise) |       | Max(X, Y) |       | Difference to Max(x, y) |        | Judgement |      |
|-----------|---|-------|------------------------------|-------|--------------------------------------|-------|-----------|-------|-------------------------|--------|-----------|------|
|           | VAD1                                    | VAD2  | VAD1                         | VAD2  | VAD1                                 | VAD2  | VAD1      | VAD2  | VAD1                    | VAD2   | VAD1      | VAD2 |
| Total     | 0.780                                   | 0.816 | 0.630                        | 0.652 | 0.821                                | 0.859 | 0.821     | 0.859 | -4.10%                  | -4.29% | Pass      | Pass |
| Car       | 0.618                                   | 0.655 | 0.630                        | 0.652 | 0.628                                | 0.668 | 0.630     | 0.668 | -1.13%                  | -1.34% | Pass      | Pass |
| Street    | 0.804                                   | 0.864 | 0.630                        | 0.652 | 0.873                                | 0.932 | 0.873     | 0.932 | -6.87%                  | -6.81% | Pass      | Pass |
| Babble    | 0.917                                   | 0.929 | 0.630                        | 0.652 | 0.962                                | 0.977 | 0.962     | 0.977 | -4.44%                  | -4.73% | Pass      | Pass |

Table 3.2: VAF measurement result in case of NA English speech material

| Condition | W<br>(AMR-NS with clean speech + noise) |       | X<br>(AMR with clean speech) |       | Y<br>(AMR with clean speech + noise) |       | Max(X, Y) |       | Difference to Max(x, y) |        | Judgement |      |
|-----------|---|-------|------------------------------|-------|--------------------------------------|-------|-----------|-------|-------------------------|--------|-----------|------|
|           | VAD1                                    | VAD2  | VAD1                         | VAD2  | VAD1                                 | VAD2  | VAD1      | VAD2  | VAD1                    | VAD2   | VAD1      | VAD2 |
| Total     | 0.789                                   | 0.822 | 0.664                        | 0.682 | 0.831                                | 0.865 | 0.831     | 0.865 | -4.19%                  | -4.28% | Pass      | Pass |
| Car       | 0.630                                   | 0.667 | 0.664                        | 0.681 | 0.646                                | 0.686 | 0.664     | 0.686 | -3.48%                  | -1.89% | Pass      | Pass |
| Street    | 0.814                                   | 0.868 | 0.665                        | 0.683 | 0.881                                | 0.931 | 0.881     | 0.931 | -6.66%                  | -6.32% | Pass      | Pass |
| Babble    | 0.923                                   | 0.932 | 0.664                        | 0.683 | 0.966                                | 0.978 | 0.966     | 0.978 | -4.25%                  | -4.64% | Pass      | Pass |

## 4 Performance assessed by subjective tests by the third party

The subjective test for the Mitsubishi AMR-NS based on TS 26.077 was performed by the third party, NTT-Advanced Technology Corp. (NTT-AT), as a subjective testing laboratory. The subjective test method and results are reported in “Performance Assessment of Mitsubishi Electric Noise Suppressor”, Tdoc S4-020252, by NTT-AT [2].

As the subjective test should be performed at least two different languages, Japanese and North American English (NA English) were chosen for the test. The AMR-NS subjective tests are split into the four main experiments and seven sub-experiments listed in Table 4.1. The mode of AMR VAD option was Option 1 (ENS) in all experiments. The first 2 seconds of each listening samples is deleted before presentation to listeners for initial convergence time. Four expert listeners confirmed that this process does not reduce intelligibility or introduce clipping or similar effect in the 64 samples, which selected at random but including all experiments.

Table 4.1: Summary of Listening Test Experiments

| Exp. No. | Title   | No. of Sub-Exp. |
|----------|---|-----------------|
| 1        | Degradation in Clean Speech (PC)  | 1               |
| 2        | No degradation of Speech and no Undesirable Effects in Residual Noise in Conditions with Background Noise (Mod-ACR) | 3               |
| 3        | Performance in Background Noise Conditions (Mod-CCR)  | 2               |
| 4        | Influence of Input Level, Voice Activity Detection and Discontinuous Transmission (Mod-CCR)                         | 1               |
|          | Total Number of Sub-Experiments   | 7               |

The subjective testing laboratory reports that the Mitsubishi AMR-NS had satisfied all requirements in the subjective test based on TS 26.077 (see [2]).

## 5 Performance Objectives assessed by Objective Measures

### 5.1 Impact on Active Speech Level

The requirement for Active Speech Level (ASL) is that the absolute difference between the average level of clean speech material and the average level of the processed material with AMR NS activated, must be less than 2dB for all experiments.

Table 5.1 shows results of Active Speech Level measurement using ITU-T P.56 speech level meter in both Japanese and NA English. The measuring tool used was “actlev (subset of sv56demo)” of ITU-T Rec. G.791 software tool library. The test conditions (AMR bit rate mode, VAD/DTX etc.) and materials were same ones used in the subjective tests. This objective test was performed after the AMR-NS subjective test had been finished. Table 5.1 shows that the results satisfy the requirement for ASL.

Table 5.1: Results of Active Speech Level Measurement

| Condition | Average of absolute difference x and y (dB) |                        |
|-----------|---|------------------------|
|           | Japanese                                    | North American English |
| Exp.1     | 0.805                                       | 0.728                  |
| Exp.2a    | 1.483                                       | 1.329                  |
| Exp.2b    | 1.259                                       | 1.156                  |
| Exp.2c    | 1.362                                       | 1.304                  |
| Exp.3a    | 1.636                                       | 1.456                  |
| Exp.3b    | 1.209                                       | 1.088                  |
| Exp.4     | 1.256                                       | 1.119                  |

### 5.2 Objective Speech Quality Measures

The objective measures of Noise Power Level Reduction (NPLR) and signal-to-noise ratio improvement (SNRI) were performed using the measurement tool attached in TS 26.077 Annex A. These measures will be used to provide only additional information and are not to be considered to be requirements. Table 5.2 shows NLPR and SNRI measuring test conditions and the performance is measured in condition 11a. Table 5.3 shows the performance objectives of NPLR and SNRI.

Table 5.4 details the results in the case of Japanese speech material and table 5.5 details the results in the case of NA English speech material. The results show that the Mitsubishi AMR-NS has satisfied the performance objectives of TS 26.077.

Table 5.2: NLPR and SNRI measuring test conditions

| No.        | Test Condition   |
|------------|--|
| 1a         | CAR NOISE@3dB, Level = -26dBov, AMR12.2                              |
| 1b         | CAR NOISE@3dB, Level = -26dBov, AMR5.9                               |
| 2a         | CAR NOISE@6dB, Level = -26dBov, AMR12.2                              |
| 2b         | CAR NOISE@6dB, Level = -26dBov, AMR5.9                               |
| 3a         | CAR NOISE@9dB, Level = -26dBov, AMR12.2                              |
| 3b         | CAR NOISE@9dB, Level = -26dBov, AMR5.9                               |
| 4a         | CAR NOISE@12dB, Level = -26dBov, AMR12.2                             |
| 4b         | CAR NOISE@12dB, Level = -26dBov, AMR5.9                              |
| 5a         | CAR NOISE@15dB, Level = -26dBov, AMR12.2                             |
| 5b         | CAR NOISE@15dB, Level = -26dBov, AMR5.9                              |
| 6a         | STREET NOISE@6dB, Level = -26dBov, AMR12.2                           |
| 6b         | STREET NOISE@6dB, Level = -26dBov, AMR5.9                            |
| 7a         | STREET NOISE@9dB, Level = -26dBov, AMR12.2                           |
| 7b         | STREET NOISE@9dB, Level = -26dBov, AMR5.9                            |
| 8a         | STREET NOISE@12dB, Level = -26dBov, AMR12.2                          |
| 8b         | STREET NOISE@12dB, Level = -26dBov, AMR5.9                           |
| 9a         | STREET NOISE@15dB, Level = -26dBov, AMR12.2                          |
| 9b         | STREET NOISE@15dB, Level = -26dBov, AMR5.9                           |
| 10a        | STREET NOISE@18dB, Level = -26dBov, AMR12.2                          |
| 10b        | STREET NOISE@18dB, Level = -26dBov, AMR5.9                           |
| <b>11a</b> | <b>AVERAGE MEASURE FOR CAR 6dB&amp;15dB CONDITIONS (2a,2b,5a,5b)</b> |
| 12a        | AGGREGATE MEASURE FOR 20 CONDITIONS (1a,1b ... 10a,10b)              |

Table 5.3: Performance objectives of NPLR and SNRI

| Objective quality measure / test condition   | Performance objective |
|--|-----------------------|
| <p align="center"><b>NPLR</b></p> <p><i>Assessment:</i> To be evaluated using a predefined set of material (as used in the AMR/NS Selection Phase) comprising speech mixed with stationary car noise in the SNR conditions of 6 dB and 15 dB, following otherwise the guidelines set forth in [Annex 1].</p> | -7 dB or lower        |
| <p align="center"><b>SNRI</b></p> <p><i>Assessment:</i> To be evaluated using a predefined set of material (as used in the AMR/NS Selection Phase) comprising speech mixed with stationary car noise in the SNR conditions of 6 dB and 15 dB, following otherwise the guidelines set forth in [Annex 1].</p> | 6 dB or higher        |

Table 5.4: Results in the case of Japanese speech material

| Cond | Files | Total Frames | Noise Frames | Speech Frames | NPLR(dB)            | SNRI(dB)           | SNRI_h      | SNRI_m      | SNRI_l      |
|------|-------|--------------|--------------|---------------|---------------------|--------------------|-------------|-------------|-------------|
| 1a   | 24    | 43200        | 17.30%       | 82.70%        | -9.85+/-0.07        | 7.19+/-0.25        | 8.69+/-0.11 | 5.11+/-0.31 | 6.22+/-1.42 |
| 1b   | 24    | 43200        | 17.30%       | 82.70%        | -9.71+/-0.09        | 7.08+/-0.26        | 8.63+/-0.12 | 5.08+/-0.34 | 5.67+/-1.32 |
| 2a   | 24    | 43200        | 17.30%       | 82.70%        | -9.41+/-0.12        | 7.85+/-0.18        | 8.67+/-0.11 | 6.85+/-0.23 | 6.86+/-0.93 |
| 2b   | 24    | 43200        | 17.30%       | 82.70%        | -9.23+/-0.14        | 7.67+/-0.18        | 8.53+/-0.12 | 6.73+/-0.26 | 6.25+/-0.81 |
| 3a   | 24    | 43200        | 17.30%       | 82.70%        | -8.51+/-0.16        | 7.66+/-0.18        | 8.00+/-0.15 | 7.19+/-0.19 | 7.49+/-0.45 |
| 3b   | 24    | 43200        | 17.30%       | 82.70%        | -8.34+/-0.18        | 7.49+/-0.18        | 7.82+/-0.18 | 7.08+/-0.19 | 7.18+/-0.43 |
| 4a   | 24    | 43200        | 17.30%       | 82.70%        | -7.29+/-0.28        | 6.76+/-0.27        | 6.90+/-0.28 | 6.52+/-0.27 | 6.91+/-0.37 |
| 4b   | 24    | 43200        | 17.30%       | 82.70%        | -7.02+/-0.30        | 6.51+/-0.29        | 6.64+/-0.30 | 6.31+/-0.28 | 6.62+/-0.36 |
| 5a   | 24    | 43200        | 17.30%       | 82.70%        | -5.45+/-0.32        | 5.14+/-0.31        | 5.15+/-0.32 | 5.01+/-0.30 | 5.72+/-0.31 |
| 5b   | 24    | 43200        | 17.30%       | 82.70%        | -5.04+/-0.38        | 4.76+/-0.36        | 4.72+/-0.37 | 4.66+/-0.35 | 5.45+/-0.37 |
| 6a   | 24    | 43200        | 17.26%       | 82.74%        | -6.97+/-0.57        | 5.90+/-0.52        | 6.34+/-0.54 | 5.31+/-0.48 | 5.62+/-1.01 |
| 6b   | 24    | 43200        | 17.26%       | 82.74%        | -6.78+/-0.61        | 5.79+/-0.59        | 6.17+/-0.59 | 5.21+/-0.54 | 5.73+/-1.00 |
| 7a   | 24    | 43200        | 17.26%       | 82.74%        | -6.02+/-0.56        | 5.46+/-0.54        | 5.58+/-0.54 | 5.11+/-0.48 | 6.19+/-1.43 |
| 7b   | 24    | 43200        | 17.26%       | 82.74%        | -5.87+/-0.58        | 5.34+/-0.55        | 5.44+/-0.57 | 5.06+/-0.49 | 5.89+/-1.00 |
| 8a   | 24    | 43200        | 17.26%       | 82.74%        | -5.12+/-0.53        | 4.77+/-0.51        | 4.79+/-0.53 | 4.63+/-0.48 | 5.22+/-0.57 |
| 8b   | 24    | 43200        | 17.26%       | 82.74%        | -4.83+/-0.57        | 4.52+/-0.54        | 4.50+/-0.55 | 4.42+/-0.50 | 5.07+/-0.61 |
| 9a   | 24    | 43200        | 17.26%       | 82.74%        | -3.99+/-0.50        | 3.77+/-0.48        | 3.73+/-0.50 | 3.71+/-0.46 | 4.31+/-0.47 |
| 9b   | 24    | 43200        | 17.26%       | 82.74%        | -3.60+/-0.54        | 3.43+/-0.52        | 3.35+/-0.53 | 3.38+/-0.50 | 4.21+/-0.52 |
| 10a  | 24    | 43200        | 17.26%       | 82.74%        | -2.67+/-0.46        | 2.55+/-0.45        | 2.46+/-0.46 | 2.53+/-0.44 | 3.24+/-0.45 |
| 10b  | 24    | 43200        | 17.26%       | 82.74%        | -2.22+/-0.49        | 2.15+/-0.48        | 2.00+/-0.48 | 2.15+/-0.47 | 3.10+/-0.46 |
| 11a  | 96    | 172800       | 17.30%       | 82.70%        | <b>-7.28+/-0.43</b> | <b>6.36+/-0.31</b> | 6.77+/-0.39 | 5.81+/-0.24 | 6.07+/-0.34 |
| 12a  | 480   | 864000       | 17.28%       | 82.72%        | -6.40+/-0.22        | 5.59+/-0.17        | 5.90+/-0.20 | 5.10+/-0.15 | 5.65+/-0.20 |

Table 5.5: Results in the case of NA English speech material

| Cond | Files | Total Frames | Noise Frames | Speech Frames | NPLR(dB)            | SNRI(dB)           | SNRI_h      | SNRI_m      | SNRI_l      |
|------|-------|--------------|--------------|---------------|---------------------|--------------------|-------------|-------------|-------------|
| 1a   | 24    | 43200        | 22.36%       | 77.64%        | -9.92+/-0.04        | 7.25+/-0.31        | 8.79+/-0.05 | 5.42+/-0.37 | 6.03+/-1.50 |
| 1b   | 24    | 43200        | 22.36%       | 77.64%        | -9.89+/-0.08        | 7.31+/-0.40        | 8.79+/-0.09 | 5.43+/-0.36 | 6.52+/-2.02 |
| 2a   | 24    | 43200        | 22.36%       | 77.64%        | -9.72+/-0.07        | 7.98+/-0.17        | 9.01+/-0.07 | 6.98+/-0.27 | 6.53+/-0.88 |
| 2b   | 24    | 43200        | 22.36%       | 77.64%        | -9.65+/-0.08        | 7.96+/-0.18        | 8.96+/-0.08 | 7.01+/-0.25 | 6.52+/-0.97 |
| 3a   | 24    | 43200        | 22.36%       | 77.64%        | -9.13+/-0.12        | 8.11+/-0.11        | 8.64+/-0.12 | 7.77+/-0.18 | 6.99+/-0.60 |
| 3b   | 24    | 43200        | 22.36%       | 77.64%        | -9.11+/-0.11        | 8.15+/-0.13        | 8.63+/-0.11 | 7.85+/-0.17 | 7.13+/-0.68 |
| 4a   | 24    | 43200        | 22.36%       | 77.64%        | -8.26+/-0.13        | 7.65+/-0.12        | 7.90+/-0.13 | 7.51+/-0.16 | 7.08+/-0.34 |
| 4b   | 24    | 43200        | 22.36%       | 77.64%        | -8.15+/-0.17        | 7.58+/-0.17        | 7.79+/-0.17 | 7.48+/-0.17 | 7.09+/-0.41 |
| 5a   | 24    | 43200        | 22.36%       | 77.64%        | -6.74+/-0.18        | 6.42+/-0.17        | 6.46+/-0.18 | 6.37+/-0.19 | 6.43+/-0.24 |
| 5b   | 24    | 43200        | 22.36%       | 77.64%        | -6.67+/-0.19        | 6.39+/-0.18        | 6.38+/-0.19 | 6.37+/-0.19 | 6.52+/-0.28 |
| 6a   | 24    | 43200        | 22.39%       | 77.61%        | -7.64+/-0.58        | 6.46+/-0.58        | 7.05+/-0.56 | 5.94+/-0.62 | 5.73+/-1.28 |
| 6b   | 24    | 43200        | 22.39%       | 77.61%        | -7.57+/-0.61        | 6.53+/-0.65        | 6.98+/-0.59 | 5.98+/-0.65 | 6.24+/-1.58 |
| 7a   | 24    | 43200        | 22.39%       | 77.61%        | -7.19+/-0.56        | 6.51+/-0.50        | 6.78+/-0.55 | 6.35+/-0.54 | 6.01+/-0.80 |
| 7b   | 24    | 43200        | 22.39%       | 77.61%        | -7.11+/-0.54        | 6.50+/-0.46        | 6.70+/-0.53 | 6.37+/-0.50 | 6.20+/-0.70 |
| 8a   | 24    | 43200        | 22.39%       | 77.61%        | -6.07+/-0.56        | 5.73+/-0.55        | 5.77+/-0.55 | 5.62+/-0.52 | 5.84+/-0.70 |
| 8b   | 24    | 43200        | 22.39%       | 77.61%        | -5.99+/-0.55        | 5.74+/-0.54        | 5.69+/-0.53 | 5.65+/-0.51 | 6.11+/-0.73 |
| 9a   | 24    | 43200        | 22.39%       | 77.61%        | -4.96+/-0.53        | 4.79+/-0.52        | 4.74+/-0.53 | 4.74+/-0.51 | 5.08+/-0.55 |
| 9b   | 24    | 43200        | 22.39%       | 77.61%        | -4.79+/-0.53        | 4.69+/-0.52        | 4.56+/-0.53 | 4.70+/-0.52 | 5.14+/-0.53 |
| 10a  | 24    | 43200        | 22.39%       | 77.61%        | -3.53+/-0.36        | 3.45+/-0.36        | 3.34+/-0.36 | 3.46+/-0.36 | 3.81+/-0.42 |
| 10b  | 24    | 43200        | 22.39%       | 77.61%        | -3.21+/-0.37        | 3.17+/-0.37        | 3.01+/-0.37 | 3.18+/-0.37 | 3.69+/-0.41 |
| 11a  | 96    | 172800       | 22.36%       | 77.64%        | <b>-8.19+/-0.31</b> | <b>7.19+/-0.18</b> | 7.70+/-0.27 | 6.68+/-0.13 | 6.50+/-0.33 |
| 12a  | 480   | 864000       | 22.38%       | 77.62%        | -7.27+/-0.20        | 6.42+/-0.15        | 6.80+/-0.18 | 6.01+/-0.14 | 6.04+/-0.22 |

## 6 Interaction with various services

### 6.1 Interaction with supplementary services

#### 6.1.1 Explicit Call Transfer (ECT)

No interaction.

#### 6.1.2 Call wait/Call hold

No interaction.

#### 6.1.3 Multiparty

No interaction.

#### 6.1.4 Service Announcements

No interaction.

### 6.2 Interaction with Alternate and Followed by services

The objective tests of data transmission were performed in both synchronous mode and asynchronous mode (character mode). Table 6.1 shows the data transmission test conditions and Figure 6.1 shows the data transmission test system. Data transparency was checked by comparing the error rate of AMR without NS and AMR with NS activated. The sending-out data from PC1 (Sender Terminal) was converted to acoustic signal by modem, the acoustic signal was encoded and decoded by AMR codec or AMR with NS activated. The output signal from the AMR codec was inputted into artificial subscriber line and it was converted to the demodulated data signal. The received data was analyzed in PC2 (Receiver Terminal).

Synchronous mode test was performed by sending random binary data (total 50k bytes) and asynchronous mode test was performed by intermittence (discontinuous) transmission of ASCII characters (1000 characters). The modem transmission mode was 8 bits non parity and stop bit was 1 bit. The bit rate modes of AMR were 12.2kbit/s and 5.9bit/s in both data transmission modes. The AMR speech codec and the AMR-NS were performed by real-time simulation on the Digital Signal Processor (DSP) evaluation board. Table 6.2 shows the results of data transmission test. In the Table 6.2, AMR is AMR without NS and AMR/NS is AMR with NS activated. Table 6.2 shows that there was no bit error or no character error for both AMR without NS and AMR with NS activated in both synchronous mode test and asynchronous mode test, and it shows that the Mitsubishi AMR-NS does not affect to the data transmission.

Table 6.1: Data transmission test conditions

| Conditions                 | Apparatus  |
|----------------------------|--|
| Modem                      | Microcom V.34ESII<br>specified in ITU-T Rec.V.21 (300 bps) |
| Artificial subscriber line | NISHIYAMA EXCEL-5000                                       |

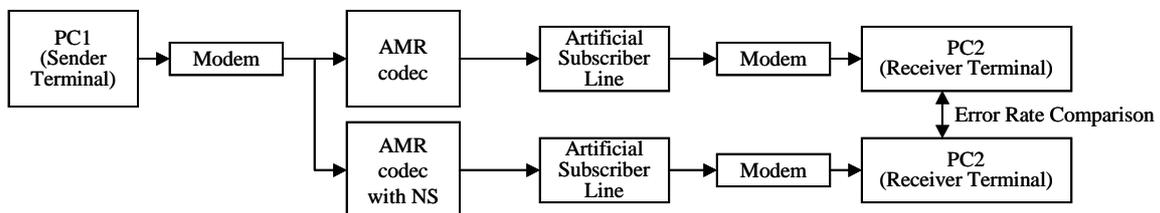


Figure 6.1: Data transmission test system

Table 6.2: Results of data transmission test

| Bit rate       | Sync. mode |          | Async. Mode |          |
|----------------|------------|----------|-------------|----------|
|                | AMR        | AMR/NS   | AMR         | AMR/NS   |
| AMR@12.2kbit/s | No error   | No error | No error    | No error |
| AMR@5.9kbit/s  | No error   | No error | No error    | No error |

### 6.3 Interaction with other speech services

There is no requirement for Noise Suppression in ASCII services.

### 6.4 Interaction with DTMF

The objective test of DTMF transparency was performed. The test condition is shown in Table 6.3 and the evaluation system used to generate, process and detect DTMF signals are shown in Figure 6.2. The DTMF generation, A-law codec and AMR speech codec were performed by software simulations respectively and the DTMF detection was performed by hardware.

The evaluation tests were performed at two AMR bit rate modes 5.9kbit/s and 12.2kbit/s, with error free conditions in both modes. Undetected percentage of DTMF digits is shown in Table 6.4. The result of AMR without NS is same as the result of AMR with NS activated. Therefore DTMF transmission performance during the Mitsubishi AMR-NS activated is not worse than the case where NS is turned off. Undetected percentage of DTMF digits in table 6.4 is almost the same value once evaluated by BT Laboratories for AMR speech codec [3].

Table 6.3: The conditions of objective test for DTMF transparency

| Conditions           | Method / Apparatus                                  |
|----------------------|---|
| DTMF signal          | All digits specified in ITU-T Rec.Q.23              |
| DTMF signal patterns | Random 32 digits * 8 sequence patterns (256 digits) |
| Tone level           | High: -20dBm (-26dBov), Low: -20dBm (-26dBov)       |
| Twist                | 0dB   |
| Digit duration       | 50ms  |
| Frequency deviation  | None  |
| DTMF detector        | ANDO AE-9303 Telephone Unit Tester                  |

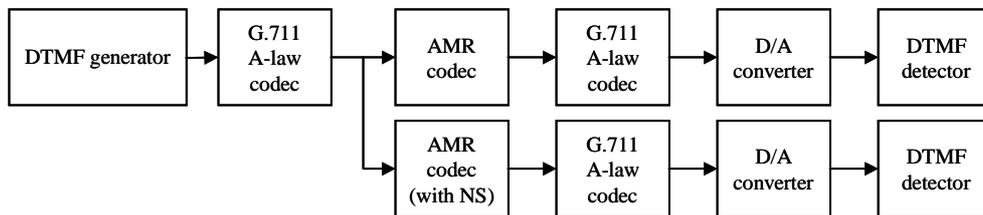


Figure 6.2: DTMF generation, processing and detection

Table 6.4: Percentage of DTMF digits undetected

| AMR bit rate   | AMR without NS                   | AMR with NS active               |
|----------------|----------------------------------|----------------------------------|
| AMR@12.2kbit/s | 0.0 % (0 digit per 256 digits)   | 0.0 % (0 digit per 256 digits)   |
| AMR@5.9kbit/s  | 21.1% (54 digits per 256 digits) | 21.1% (54 digits per 256 digits) |

### 6.5 Interaction with Lawful Intercept

It is clear that the Mitsubishi AMR-NS does not degrade the speech quality by referring to the subjective test results in Chapter 4. Therefore the AMR-NS does not cause any degradation in the speech quality received by the A and B parties.

### 6.6 Interaction with TFO

No interaction.

## 7 Conclusion

This report has shown the technical description of the Mitsubishi Noise Suppressor for the AMR speech codec and its subjective/objective evaluation test results. The evaluation results revealed that the Mitsubishi AMR-NS solution satisfies all requirements specified in the technical specification TS 26.077, which is mandatory to be endorsed by TSG-S4.

## References

- [1] 3GPP TS26.077: “Minimum Performance Requirements for Noise Suppressor Application to the AMR Speech Encoder (Release 4)”.
- [2] “Performance Assessment of Mitsubishi Electric Noise Suppressor (AMR-NS)”, NTT-AT, Tdoc S4-020252
- [3] “DTMF transparency of the ENS1 AMR speech codecs”, BT Lab., ETSI/SMG11 TD97/99