

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

P.862

Amendment 2
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SERIES P: TELEPHONE TRANSMISSION QUALITY,
TELEPHONE INSTALLATIONS, LOCAL LINE
NETWORKS

Methods for objective and subjective assessment of
quality

Perceptual evaluation of speech quality (PESQ): An
objective method for end-to-end speech quality
assessment of narrow-band telephone networks
and speech codecs

**Amendment 2: Revised Annex A – Reference
implementations and conformance testing for
ITU-T Recs P.862, P.862.1 and P.862.2**

ITU-T Recommendation P.862 (2001) – Amendment 2

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For further details, please refer to the list of ITU-T Recommendations.

ITU-T Recommendation P.862

Perceptual evaluation of speech quality (PESQ): An objective method for end-to-end speech quality assessment of narrow-band telephone networks and speech codecs

Amendment 2

Revised Annex A – Reference implementations and conformance testing for ITU-T Recs P.862, P.862.1 and P.862.2

Summary

This revision to Annex A/P.862 describes the revised ANSI C reference implementation of PESQ, which includes modes of operation for Recommendation P.862.1 (narrowband MOS-LQO mapping) and Recommendation P.862.2 (the wideband extension). It also describes the conformance testing procedures for P.862 and P.862.2. This revision replaces Annex A to P.862 (February 2001) and Amendment 1 to P.862 (March 2003).

Source

Amendment 2 to ITU-T Recommendation P.862 (2001) was approved on 29 November 2005 by ITU-T Study Group 12 (2005-2008) under the ITU-T Recommendation A.8 procedure.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure e.g. interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

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As of the date of approval of this Recommendation, ITU had received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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ITU-T Recommendation P.862

Perceptual evaluation of speech quality (PESQ): An objective method for end-to-end speech quality assessment of narrow-band telephone networks and speech codecs

Amendment 2

Revised Annex A – Reference implementations and conformance testing for ITU-T Recs P.862, P.862.1 and P.862.2

A.1 Files provided

A.1.1 List of files provided for the ANSI-C reference implementation

The ANSI-C reference implementation of ITU-T Recs P.862, P.862.1 and P.862.2 is contained in the following text files which are provided in the `source` sub-directory of the CD-ROM distribution:

- `dsp.c` *Basic DSP routines*
- `dsp.h` *Header file for dsp.c*
- `pesq.h` *General header file*
- `pesqdsp.c` *PESQ DSP routines*
- `pesqio.c` *File input/output*
- `pesqmain.c` *Main program*
- `pesqmod.c` *PESQ high-level model*
- `pesqpar.h` *PESQ perceptual model definitions*

The ANSI-C reference implementation is provided in separate files and forms an integral part of this Recommendation and ITU-T Recs P.862.1 and P.862.2. The ANSI-C reference implementation shall take precedence in case of conflicts between the high-level description and the ANSI-C reference implementation.

A.1.2 List of files provided for conformance validation

The conformance validation process described below makes reference to the following files, which are provided in the `conform` sub-directory of the CD-ROM distribution:

- `supp23_16k.txt` *File pairs and PESQ scores for test 1(a)*
- `supp23_16k.bat` *Batch script to assist with test 1(a)*
- `supp23_8k.txt` *File pairs and PESQ scores for test 1(b)*
- `supp23_8k.bat` *Batch script to assist with test 1(b)*
- `voipref_16k.txt` *File pairs and PESQ scores for test 2(a)*
- `voipref_16k.bat` *Batch script to assist with test 2(a)*
- `voipref_8k.txt` *File pairs and PESQ scores for test 2(b)*
- `voipref_8k.bat` *Batch script to assist with test 2(b)*
- `process.bat` *Sample batch script to assist with preparing material for tests 1(b) and 2(a)*
- `supp23_wb.txt` *File pairs and P.862.2 scores for conformance validation to Supplement 23 (wideband operation)*

- `supp23_wb.bat` *Batch script to assist with validation of P.862.2 scores*
- *Speech files provided for validation of P.862 with variable delay:*

<code>or105.wav</code>	<code>or109.wav</code>	<code>or114.wav</code>	<code>or129.wav</code>	<code>or134.wav</code>	<code>or137.wav</code>
<code>or145.wav</code>	<code>or149.wav</code>	<code>or152.wav</code>	<code>or154.wav</code>	<code>or155.wav</code>	<code>or161.wav</code>
<code>or164.wav</code>	<code>or166.wav</code>	<code>or170.wav</code>	<code>or179.wav</code>	<code>or221.wav</code>	<code>or229.wav</code>
<code>or246.wav</code>	<code>or272.wav</code>	<code>dg105.wav</code>	<code>dg109.wav</code>	<code>dg114.wav</code>	<code>dg129.wav</code>
<code>dg134.wav</code>	<code>dg137.wav</code>	<code>dg145.wav</code>	<code>dg149.wav</code>	<code>dg152.wav</code>	<code>dg154.wav</code>
<code>dg155.wav</code>	<code>dg161.wav</code>	<code>dg164.wav</code>	<code>dg166.wav</code>	<code>dg170.wav</code>	<code>dg179.wav</code>
<code>dg221.wav</code>	<code>dg229.wav</code>	<code>dg246.wav</code>	<code>dg272.wav</code>		
<code>u_ams01.wav</code>	<code>u_ams02.wav</code>	<code>u_ams03.wav</code>			
<code>u_ams01b1c1.wav</code>	<code>u_ams01b1c7.wav</code>	<code>u_ams01b1c15.wav</code>	<code>u_ams02b1c9.wav</code>		
<code>u_ams03b1c16.wav</code>	<code>u_ams03b1c18.wav</code>	<code>u_ams01b2c1.wav</code>	<code>u_ams01b2c8.wav</code>		
<code>u_ams02b2c4.wav</code>	<code>u_ams02b2c5.wav</code>	<code>u_ams02b2c14.wav</code>	<code>u_ams03b2c5.wav</code>		
<code>u_ams03b2c6.wav</code>	<code>u_ams03b2c7.wav</code>	<code>u_ams03b2c11.wav</code>	<code>u_ams03b2c18.wav</code>		
<code>u_af1s01.wav</code>	<code>u_af1s02.wav</code>	<code>u_af1s03.wav</code>			
<code>u_af1s01b2c16.wav</code>	<code>u_af1s03b2c16.wav</code>	<code>u_af1s02b2c17.wav</code>	<code>u_af1s03b2c17.wav</code>		

The variable delay speech files are in Wave format (16-bit linear PCM, Intel byte ordering, 44 byte header), at 8 kHz sample rate.

These files form an integral part of this annex.

A.2 Sampling rate

An implementation of ITU-T Rec. P.862 may, at the implementer's discretion, operate at 8 kHz sampling rate, 16 kHz sampling rate, or both. However, the implementation must pass the conformance tests set for all sampling rates that are offered by the implementation.

Implementations of the P.862.2 wideband extension must operate at 16kHz sampling rate.

A.3 Conformance tests

A.3.1 Conformance data sets

The data sets for the conformance tests are as follows.

Test	Number of file pairs	(a) 16 kHz data set	(b) 8 kHz data set	Type of test
1	1736	ITU-T P-series Supplement 23	Downsampled from ITU-T P-series Supplement 23 using ITU-T Software Tool Library (version 2000, release 3 ¹) and <code>process.bat</code> .	Mandatory
2	40	Upsampled from P.862 VoIP variable delay data using Software Tool Library (version 2000, release 3) and <code>process.bat</code> .	ITU-T Rec. P.862 Annex A VoIP variable delay data.	Mandatory
3	No data set defined. This test is open-ended, based on general, unknown data.			Mandatory
4	1736	ITU-T P-series Supplement 23	Not applicable	Mandatory for P.862.2

¹ ITU-T Rec. G.191 (2005), *Software tools for speech and audio coding standardization*.

A.3.2 Conformance requirements

The test requirements are summarized in the following table and are set out in detail below. The requirements are based on the absolute difference in PESQ score between the implementation under test and the ANSI-C reference implementation, calculated for each reference and degraded file pair. For the conformance tests defined in Annex A/P.862 (February 2001), there is no change.

Test	Number of file pairs	Lower threshold	Upper threshold	Type of test
1(a)	1736	Difference may not exceed 0.05 in any situation.	Not applicable	Mandatory
1(b)	1736	Difference may exceed 0.05 in not more than 2 file pairs (approx. 0.1% of cases).	Difference may not exceed 0.1 in any case.	Mandatory
2(a)	40	Difference may exceed 0.05 in not more than 1 file pair (2.5% of cases).	Difference may not exceed 0.5 in any case.	Mandatory
2(b)	40	Difference may exceed 0.05 in not more than 1 file pair (2.5% of cases).	Difference may not exceed 0.5 in any case.	Mandatory
3	No data set defined	Difference may exceed 0.05 in not more than 0.5% of cases.	Difference may exceed 0.05 in not more than 5% of cases.	Lower threshold is advisory. Upper threshold is mandatory.
4	1736	Difference may not exceed 0.05 in any situation.	Not applicable	Mandatory for P.862.2 operation

A.3.2.1(a) Conformance test 1(a) (16 kHz sampling rate)

In this test, all files from all ten experiments as released with ITU-T P-series Supplement 23 are used, on a file-by-file basis. The Supplement 23 data is all at 16 kHz sampling rate. The original and degraded file names, and the PESQ score given by the reference implementation, are provided in the files listed above.

An implementation passes this test when the absolute difference in the raw PESQ score compared to the reference implementation is not greater than 0.05 in all cases.

This conformance test is mandatory for all implementations of PESQ at 16 kHz sampling rate.

ITU-T P-series Supplement 23 can be obtained separately from the ITU.

A.3.2.1(b) Conformance test 1(b) (8 kHz sampling rate)

In this test, 8 kHz resampled versions of the Supplement 23 files are used, on a file-by-file basis. The original and degraded files must be downsampled using the ITU-T Software Tool Library 2000 release 3, program `filter`, using the following command:

```
filter -down HQ2 inputfile.raw outputfile.raw
```

This assumes that the 16 kHz input speech file is called `inputfile.raw` and the 8 kHz output file is called `outputfile.raw`.

A batch script to assist with this, and the original and degraded file names, and the raw PESQ score given by the reference implementation, are provided in the files listed above.

An implementation passes this test when the absolute difference in the raw PESQ score compared to the reference implementation is not greater than 0.05 in more than 2 file pairs (these may be any two of the file pairs), and not greater than 0.1 in all cases.

This conformance test is mandatory for all implementations of PESQ at 8 kHz sampling rate.

ITU-T P-series Supplement 23 can be obtained separately from the ITU.

A.3.2.2(a) Conformance test 2(a) (16 kHz sampling rate)

This test is based on data provided with PESQ and described in this annex. In this test, 16 kHz resampled versions of the Annex A/P.862 VoIP test files are used on a file-by-file basis. The original and degraded files must be upsampled using the ITU-T Software Tool Library 2000 release 3, program `filter`, using the following command:

```
filter -up HQ2 inputfile.raw outputfile.raw
```

This assumes that the 8 kHz input speech file is called `inputfile.raw` and the 16 kHz output file is called `outputfile.raw`.

A batch script to assist with this, and the original and degraded file names, and the raw PESQ score given by the reference implementation, are provided in the files listed above.

An implementation passes this test when the absolute difference in the raw PESQ score compared to the reference implementation is not greater than 0.05 in more than 1 file pair (this may be any one of the file pairs), and not greater than 0.5 in all cases.

This conformance test is mandatory for all implementations of PESQ at 16 kHz sampling rate.

A.3.2.2(b) Conformance test 2(b) (8 kHz sampling rate)

A composite database was constructed for Annex A/P.862 from 40 conditions (file pairs) from two subjective tests covering real and simulated VoIP connections that exhibit time-varying delay. Many of these file pairs also trigger the bad interval realignment process. This data is provided at 8 kHz sampling rate as the Annex A/P.862 VoIP test files, and these are used on a file-by-file basis.

The original and degraded file names, and the raw PESQ score given by the reference implementation, are provided in the files listed above.

An implementation passes this test when the absolute difference in the raw PESQ score compared to the reference implementation is not greater than 0.05 in more than 1 file pair (this may be any one of the file pairs), and not greater than 0.5 in all cases.

This conformance test is mandatory for all implementations of PESQ at 8 kHz sampling rate.

A.3.2.3 Conformance test 3 (8 kHz or 16 kHz sampling rate) – Additional comparisons

To prevent implementers from specifically tailoring an algorithm to conform to requirements for the files described above, a further test is available. An implementation of PESQ that conforms to ITU-T Rec. P.862 must, in at least 95% of cases, give an output score that is within 0.05 of the raw PESQ score given by the ANSI-C reference implementation. These cases must be based on speech files covering a representative sample of reasonable telephone network conditions, and must lie within the scope of ITU-T Rec. P.862.

In practice it has been found that this is a much wider margin than required for most implementations. Users should expect that, in at least 99.5% of cases, an implementation should give an output score that is within 0.05 of the raw PESQ score given by the ANSI-C reference implementation. This should be considered to be a desirable level of accuracy, but it is not mandatory.

A.3.2.4 Conformance test 4 (16 kHz sampling rate) – P.862.2 operation

This test applies to implementations of the wideband extension to P.862 defined in ITU-T Rec. P.862.2. Wideband operation of the ANSI-C reference code is enabled by using the `+wb` command line option.

In this test, all files from all ten experiments as released with ITU-T P-series Supplement 23 are used, on a file-by-file basis. The Supplement 23 data is all at 16 kHz sampling rate. The original and degraded file names, and the wideband PESQ score given by the reference implementation, are provided in the files listed above.

An implementation passes this test when the absolute difference in the wideband PESQ score compared to the reference implementation is not greater than 0.05 in all cases.

This conformance test is mandatory for all implementations of P.862.2.

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