PERCEPTUAL AUDIO TESTING: POLQA AND PESQ

by David Mathew

About This Technote

Technote 121 (January 2016) provides an overview of the perceptual audio measurements available for Audio Precision's APx500 series of analyzers, with a particular focus on POLQA[1] measurements. This is a substantial revision of the original Technote 121, published in July 2013. Among other additions, this revision describes changes recommended in POLQA V2.4, and points out the importance of maintaining correct speech levels in POLQA measurements.

Abridged OPTICOM[2] manuals for both POLQA and PESQ[3] are included with this document, and are also available from the Audio Precision website. In particular, the document *Opticom POLQA manual Abridged for End User.pdf* provides much valuable information about the POLQA algorithm and recommendations for its use.

A wealth of additional information is available from ITU-T[4] and from OPTICOM GmbH. Links are provided in Notes at the end of this document.

Perceptual Audio Measurement

Perceptual methods were developed to provide subjective evaluation of audio quality in telecommunications channels and networks that use data compression codecs. In such cases, conventional objective audio measurements correspond poorly with subjective listening experiences.

Perceptual audio evaluation techniques are based on subjective experiments with listeners, and do not use simple periodic waveforms or sweeps as most APx measurements do; consequently, the perceptual evaluation results cannot be stated as physical values such as volts or hertz. Instead, listeners' opinions of quality (or algorithms designed to respond similarly) are averaged and scored.

MOS	Quality	Impairment
5	Excellent	Imperceptible
4	Good	Perceptible but not annoying
3	Fair	Slightly annoying
2	Poor	Annoying
1	Bad	Very annoying

Over the years, the ITU and other entities have cooperated in developing techniques and recommendations to perceptually evaluate speech quality of communications channels using machine testing, with the goal of providing MOS results comparable to those reported by human listeners, along with other results for cause analysis.

POLQA and PESQ are both methods of generating MOS results without actually using a room full of listeners. Instead, a pre-recorded speech sample is passed through a device under test (DUT) and is compared with the original speech sample. An algorithm evaluates the difference between the reference audio and the degraded audio, and produces a result.

Audio Precision offers perceptual audio evaluation measurements for speech using the two most current recommendations, POLQA and PESQ, for use in our APx500 series analyzers. PESQ was approved as an ITU-T recommendation in 2001 and is still in use. POLQA, approved by the ITU-T in 2011 and revised in 2014, is the successor to PESQ, and brings a number of improvements.

Speech passed through certain *Bluetooth*™ profiles, telephone networks, VoIP (Voice over Internet Protocol) connections, and other channels dependent upon lossy codecs are good candidates for perceptual audio evaluation, as are signal paths that include acoustic transducers and spaces.

Licensed Technologies

PESQ was developed by the companies OPTICOM GmbH, Psytechnics Limited, TNO Telecom and British Telecommunications as a successor to PSQM, and was standardized by the ITU-T in 2001 as Recommendation P.862.

POLQA was developed by the companies OPTICOM, SwissQual and TNO as an upgrade to PESQ. POLQA was standardized by the ITU-T in 2011 as Recommendation P.863.

The algorithms used in these measurements are protected by copyright. Each instance of POLQA and PESQ in an Audio Precision instrument is licensed by OPTICOM, who serve as the sole licensing agent for these technologies. An authorizing iButton key for using POLQA or PESQ in an APx analyzer can be purchased from Audio Precision.

Channel count

POLQA is licensed from OPTICOM on a per-channel basis. The Audio Precision POLQA-2 iButton key enables POLQA on audio channels 1 and 2 of the attached APx analyzer. Licensing for additional channels of POLQA can be purchased.

The Audio Precision PESQ iButton key enables all the channels of the attached APx analyzer.

POLQA or PESQ?

This Technote primarily discusses POLQA, the current and recommended model for perceptual audio measurements. Some users, however, may be required to use PESQ for legacy compatibility or regulatory compliance. PESQ is discussed beginning on page 16.

Here is a brief list of POLQA/PESQ comparisons:

- POLQA avoids weaknesses of the PESQ model and is extended to handle higher bandwidth audio signals. Further improvements target the handling of time-called signals and signals with many delay variations.
- PESQ supports narrowband measurements (8 kS/s sample rate, 300–3400 Hz) covering the common telephony band, and wideband measurements (16 kS/s sample rate, 100–7000 Hz) covering a broader range.
- POLQA adds super-wideband mode (48 kS/s sample rate, 50–14000 Hz) to accommodate the latest HD voice codecs and networks. An evaluation by the ITU-T has shown that POLQA clearly outperforms PESQ in both narrowband and wideband modes.
- POLQA more accurately scores level differences (as compared to subjective listening).
- POLQA weights linear frequency distortions in line with human perception, whereas PESQ was largely insensitive to such distortions.
- PESQ was sensitive to clock differences between converters, whereas POLQA compensates for clock differences and other time-scaling effects.
- POLQA comes with full support for acoustical measurements, supporting handset and transducer testing with head and torso simulators, mouth simulators and ear simulators.

...or STI?

On first consideration, STI (Speech Transmission Index) seems like a perceptual measurement model similar to POLQA or PESQ. However, there are important differences.

POLQA or PESQ are evaluations of audio quality, while STI is a measure of speech intelligibility.

Speech quality is defined as the difference between idealization and realization, whereas speech intelligibility is defined as the degree to which a normal person can understand speech.

The two are related, but they are not the same. An example of a transmission channel with high quality but low intelligibility is a system with high bandwidth but a tendency to drop entire words, as can occur in some VoIP systems. The extended bandwidth provides higher quality, enabling the speech to sound much more natural, but when words are dropped, intelligibility is poor. In contrast, a lower bandwidth system without dropouts, such as a POTS (plain old telephone service) telephone line, will have lower quality but higher intelligibility.

For more information about STI, see Audio Precision's Technote 128, *Measuring STI with APx*.

POLQA Perceptual Model

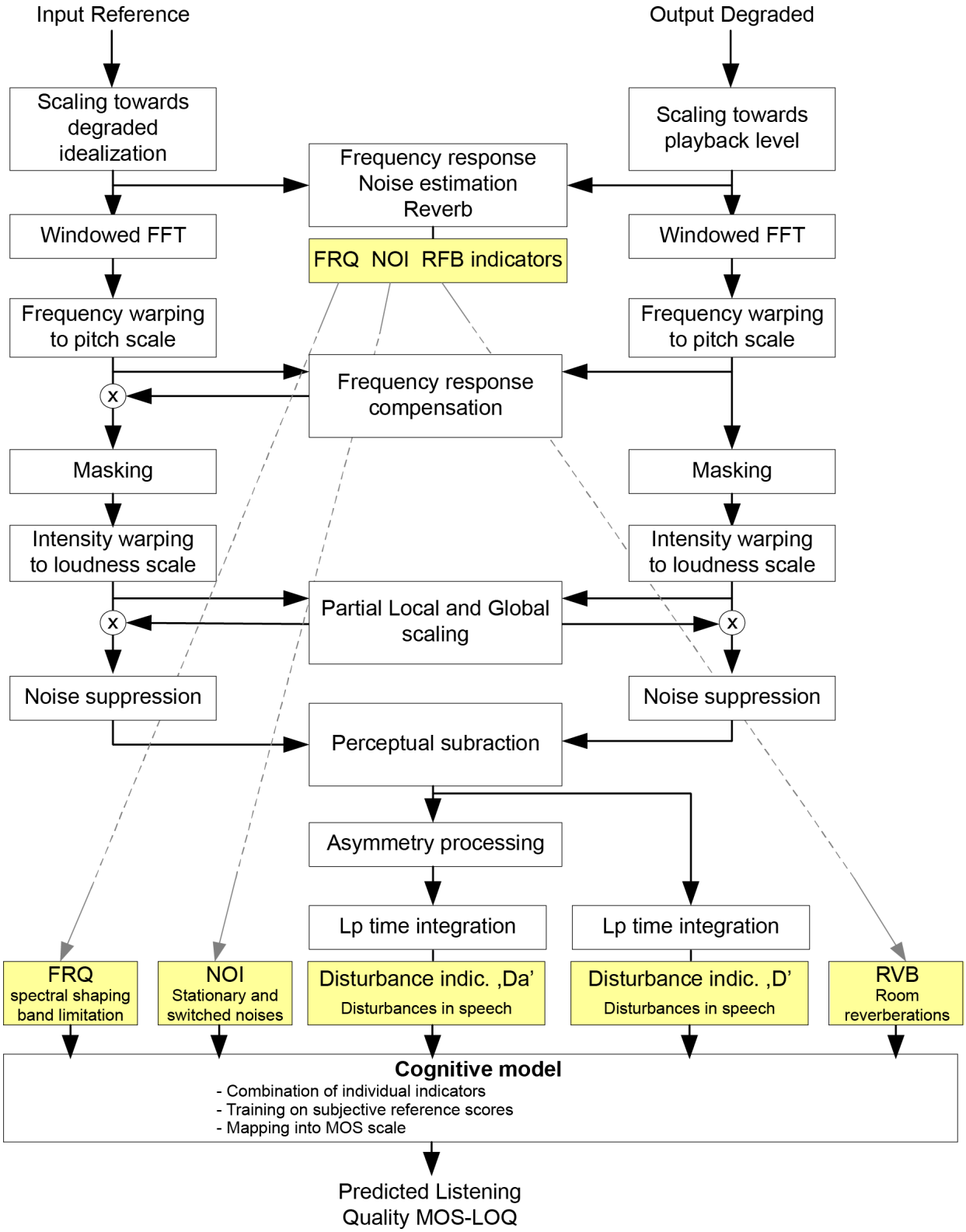


Figure 1. POLQA perceptual model, courtesy of OPTICOM GmbH.

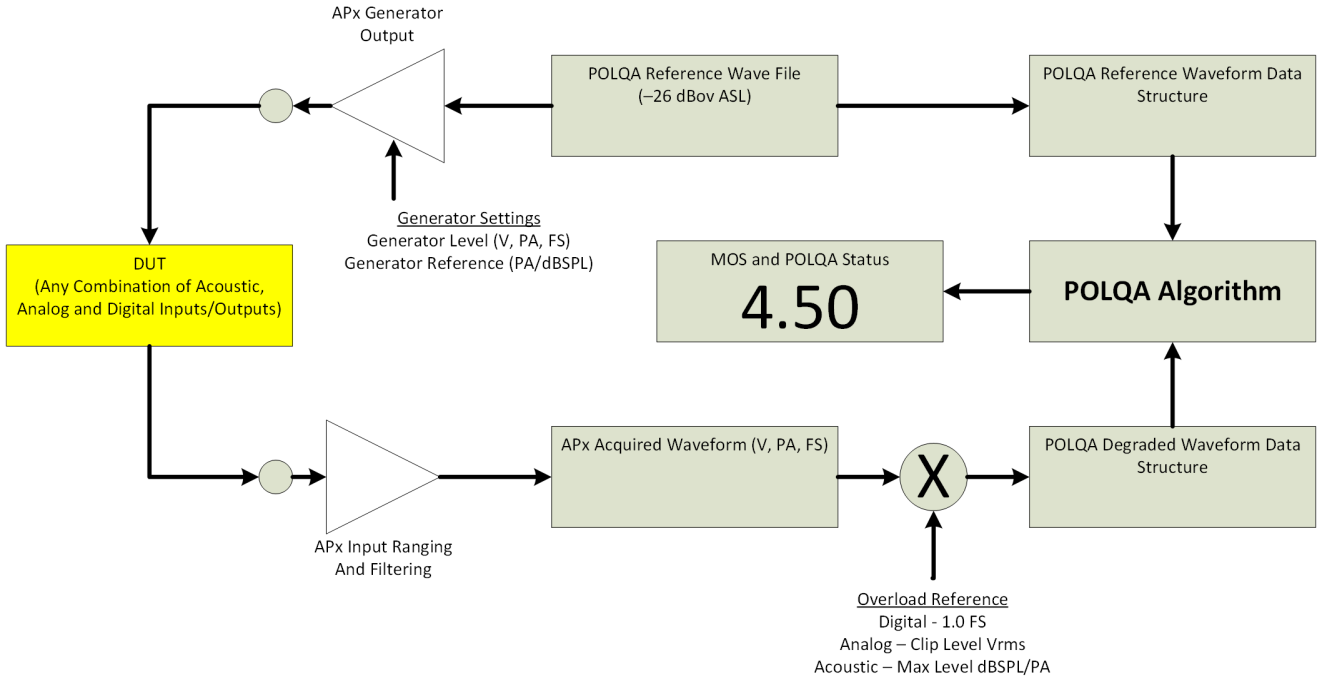


Figure 2. APx POLQA implementation block diagram.

APx POLQA Implementation

POLQA is an optional measurement technology for APx analyzers, and requires the purchase of a software option key to operate.

The APx POLQA and PESQ implementations are similar. For each method, there are two APx measurements, one providing results for a single acquisition, and the other providing results averaged over a series of acquisitions.

All POLQA and PESQ measurements require one or more properly formed speech samples. The undistorted speech samples are designated in APx as Reference Files, and can be displayed as Reference Waveforms. These are passed through the DUT or system under test. The degraded output of the DUT is designated in APx as the Acquisition, and can be displayed as the Acquired Waveform.

A functional diagram of the APx POLQA architecture is shown above.

Speech Samples

For POLQA, the APx500 solution provides one speech sample at a sample rate of 8 kS/s, one at 16 kS/s, and one at 48 kS/s embedded in the measurement. More speech sample files are provided as part of the APx distribution, and are saved to the installation directory (C:\Program Files\Audio Precision\APx500 [version]\Waveforms\POLQA\...). The collection includes 48 samples: eight with female talkers (split between two female voices) and eight with male talkers (split between two male voices), each at sample rates of 8, 16, and 48 kS/s.

The speech sample files provided by Audio Precision for POLQA have been optimized, with ASLs set to −26 dBov using the ITU-T P.56 meter[5]. In digital loopback, a POLQA measurement using the “Default 48 kHz” file will score at MOS 4.75 (the maximum for 48 kS/s). In other I/O configurations, generator level settings and DUT or system gain will typically change the level and the MOS score

If you need additional POLQA speech samples, the ITU and others have created samples designed to cover the range of speech sounds uttered by men and women in several languages. We suggest that you use the recommendations and samples provided by these institutions for consistent measurement results.[6]

If you wish to create a library of speech samples optimized for your language or application, care must be taken that the samples are properly prepared, using phonetically balanced phrases, plus high-pass and bandwidth filtering, as

recommended in the ITU P501E document linked in the Notes. Each signal must be less than 12 seconds long.

Additionally, POLQA is particularly sensitive to level, requiring speech samples be processed so that they have an ASL of −26 dBov. See the next topic for an explanation of ASL and level considerations in POLQA.

Active Speech Level (ASL) in POLQA

Active Speech Level (ASL) is a level definition in POLQA that is the result of a measurement of speech samples made by a specific method, compliant with a meter defined in ITU-T P.56. The P.56 meter has optimized measurement detection and ballistics for this purpose, and largely ignores the silences between utterances, focusing instead on the active portions of the speech waveform.

As noted previously, a key difference between POLQA and PESQ is in sensitivity to signal level. PESQ ignores level, but POLQA will produce poor MOS scores if the ASL presented to the algorithm is not matched (within a certain narrow range) to the ASL of the reference file, which itself must be ASL-optimized for POLQA at −26 dBov.

In the design of the POLQA algorithm, the assumption is made that the −26 dBov reference signal is applied to the DUT at an appropriate level to achieve the manufacturer's specified nominal operating level within the DUT. This requires that the gain of the DUT be taken into consideration. A further assumption is made that, under these conditions, the degraded signal at the output of the DUT is acquired and level-adjusted so that the correct ASL, −26 dBov, is applied to the input of the POLQA algorithm.

This should be accomplished by proper level adjustment and gain structure throughout the measurement loop. The APx POLQA measurement provides an aid in accomplishing this requirement, in the form of an Overload Reference field and an Auto Level Alignment checkbox in the POLQA control panel. See page 15.

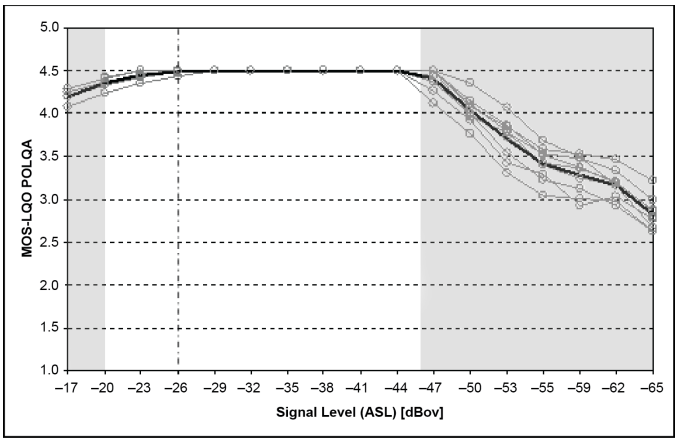


Figure 3. Level differences between reference and degraded signals are allowed, but must be within the range of +5 dB above to −20 dB below the −26 dBov level, as shown here.

POLQA Signal Paths And Use Cases

Notes regarding signal path issues are discussed here. Diagrams representing twelve use cases begin on page 6.

ASL in all-digital signal paths

In the digital domain, an ASL of −26 dBov is −26 dBFS. Since 0 dBFS is the overload point in a digital system, in most cases the −26 dBov ASL is correctly maintained throughout the path, and eventually input to the APx analyzer and passed to the POLQA algorithm at the correct level.

ASL in analog and cross-domain paths

The analog component of a signal path will have an arbitrary signal level scaling, and an analog overload point unrelated to 0 dBFS. In this case the input and/or output gain of the DUT must be adjusted to apply and maintain an ASL within the DUT of −26 dB, relative to the system overload point. Set the DUT overload point in the Overload Ref: field (see page 15) in APx to scale the signal properly.

You can find the overload point of a DUT using standard distortion measurement techniques. Measure the rms output level of a DUT that is on the threshold of overload, and use that value in the Overload Ref: field.

ASL in acoustic paths

For a system that includes an acoustic path, the electrical parts of the path should be set so that the test signal speech is at an ASL of −26 dBov (relative to the DUT's overload point), and the acoustic part of the path should be set so that the test signal speech is at an ASL of 73 dBA (dBSPL with A-weighting) for monotic narrow bandwidth

measurements, and at 79 dBA for diotic wideband measurements. The final part of the path is typically a microphone and preamplifier, and the microphone output must be scaled properly. Enter a value in the Overload Ref: field for scaling, and observe the "Active Speech Level (ASL) – Degraded" result in the POLQA log file. If the level in the log file is not close to −26 dBov, enter greater or lesser scaling factors until −26 dBov is attained.

It can be difficult to achieve an ideal ASL through an acoustic path, and you may find that setting Auto Level Alignment to ON is useful in producing satisfactory MOS-LQO results.

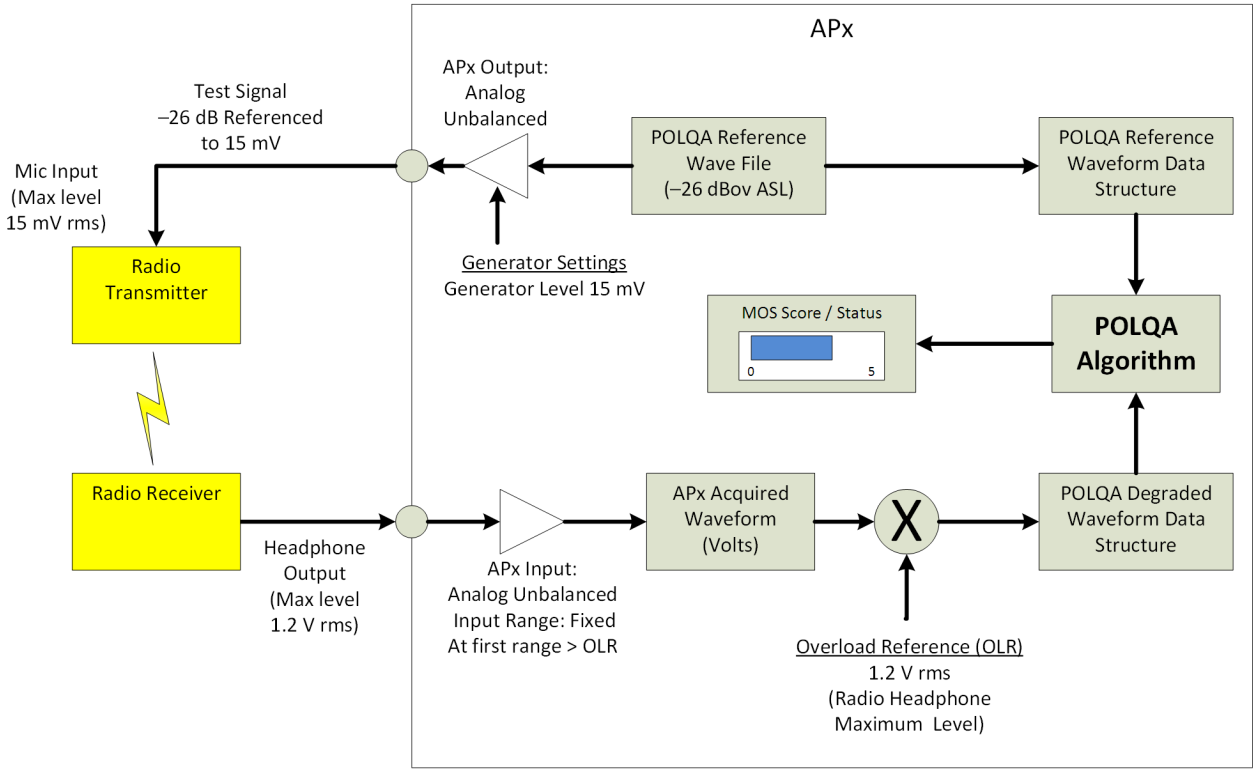
APx analyzer analog input ranging

Because the level of a speech signal varies, the analyzer's analog input range may change during a PESQ or POLQA measurement. This can occur in any signal path that uses an analog input, which includes most acoustic paths.

We recommend that you determine the maximum level that your DUT will present to the analyzer input, and set fixed ranging to accommodate that level.

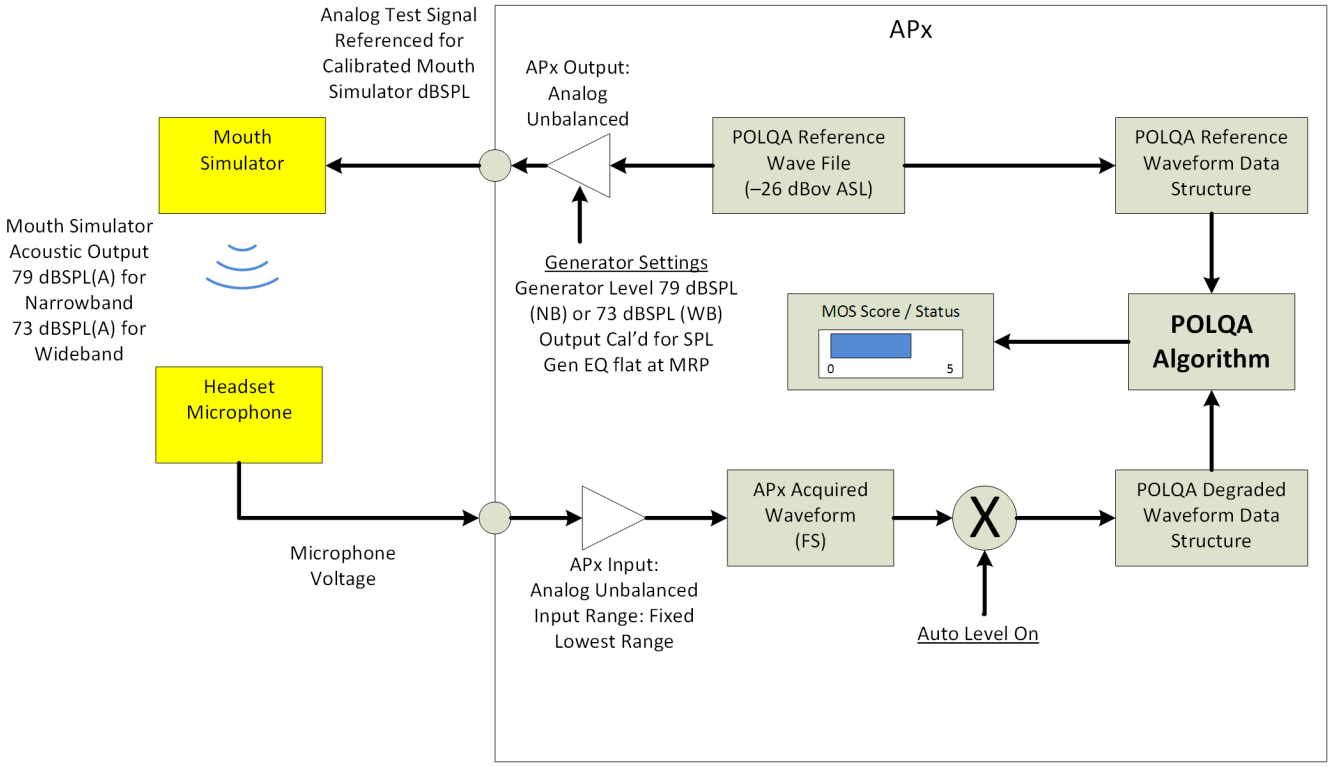
POLQA use case diagrams

POLQA Use Case 1: analog voltage out, analog voltage in

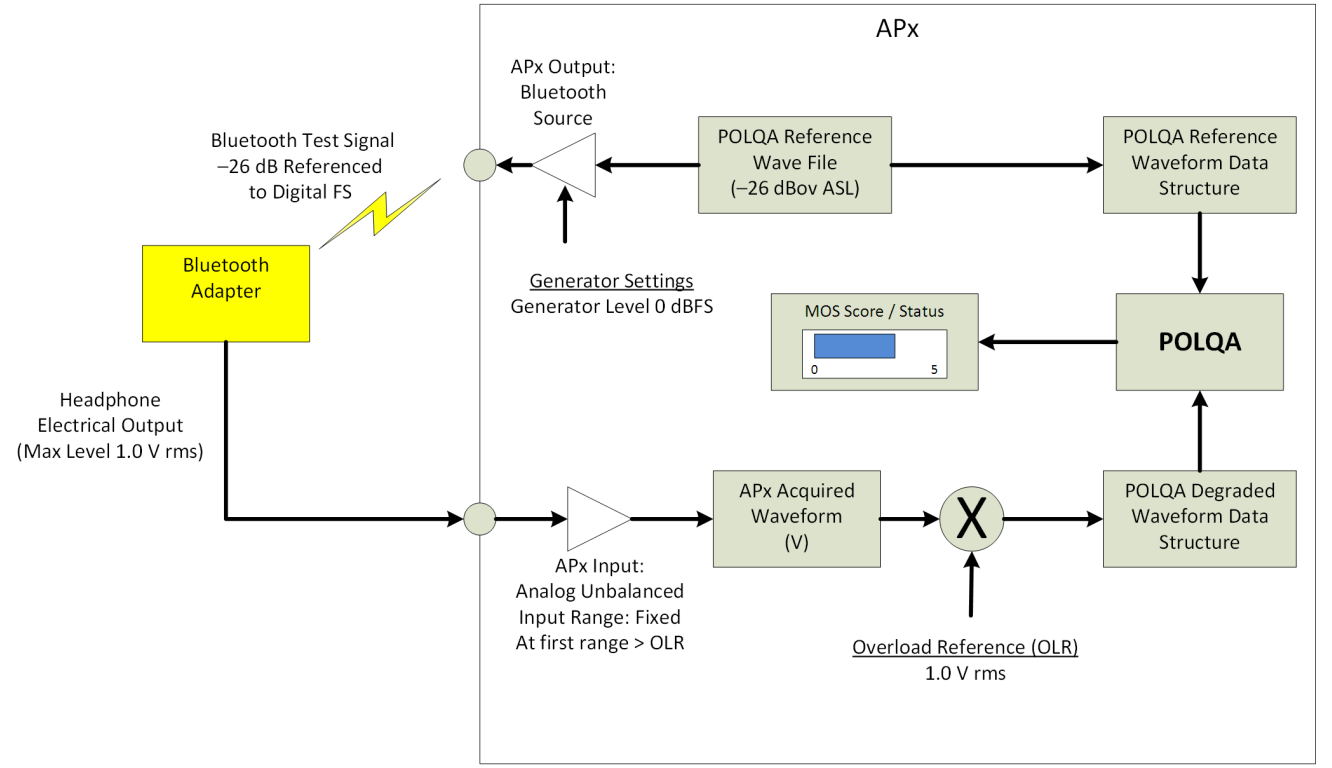


This illustration shows a radio link in the DUT system, but any analog-in, analog-out DUT system belongs to this use case.

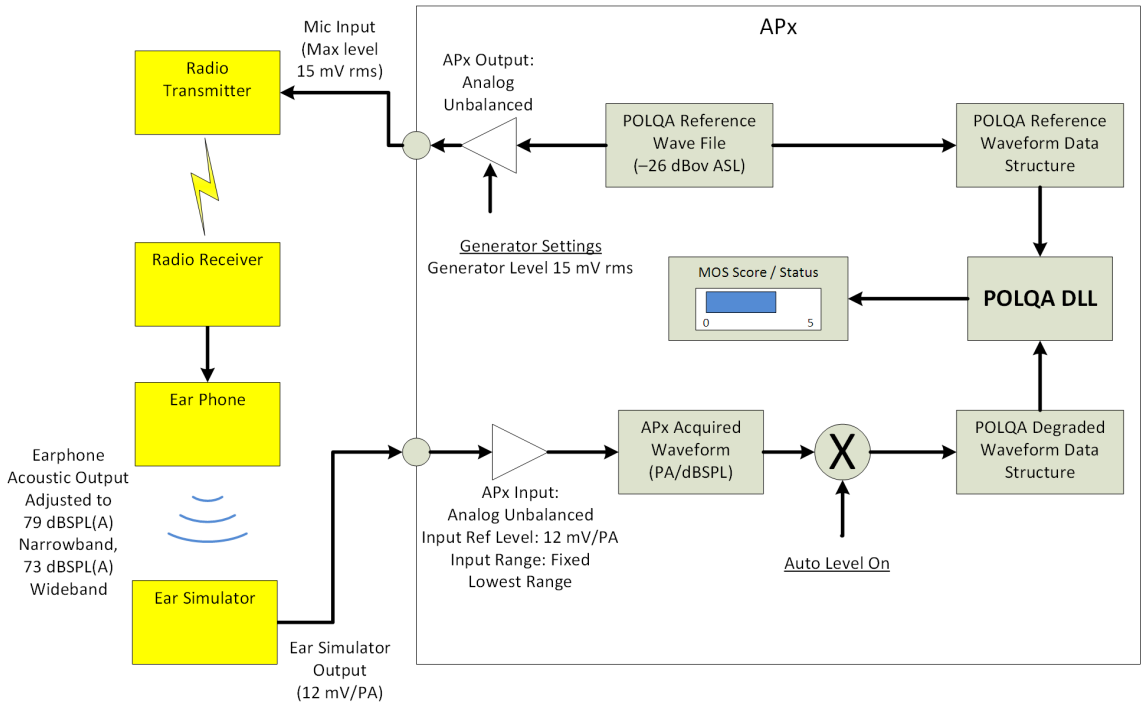
POLQA Use Case 2: acoustic referenced signal out, analog voltage in



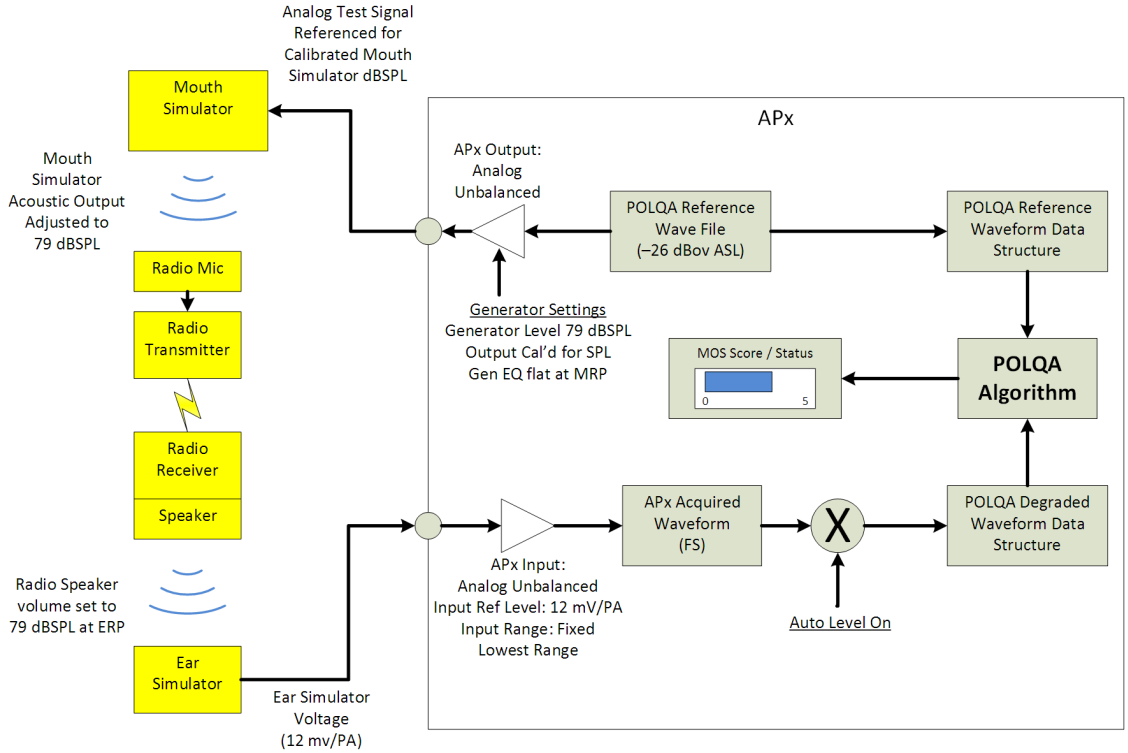
POLQA Use Case 3: digital signal out, analog voltage in



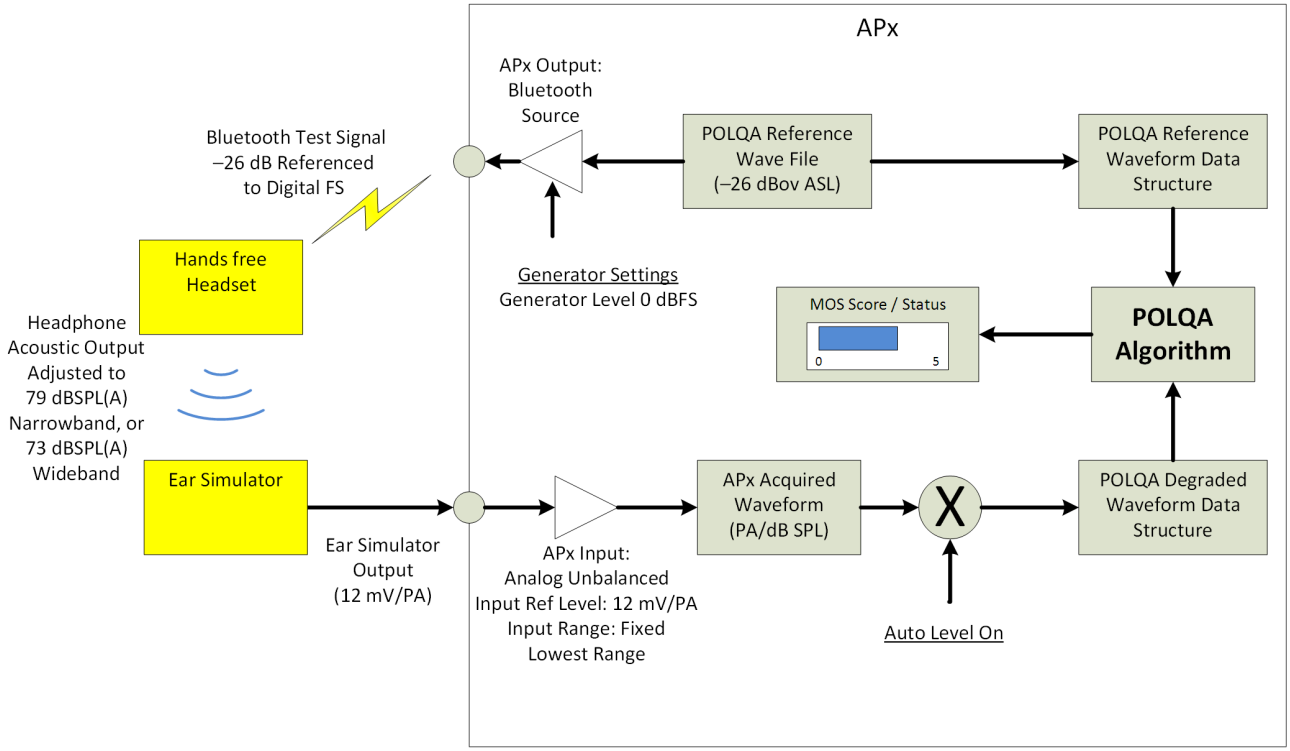
POLQA Use Case 4: analog voltage out, acoustic reference signal in



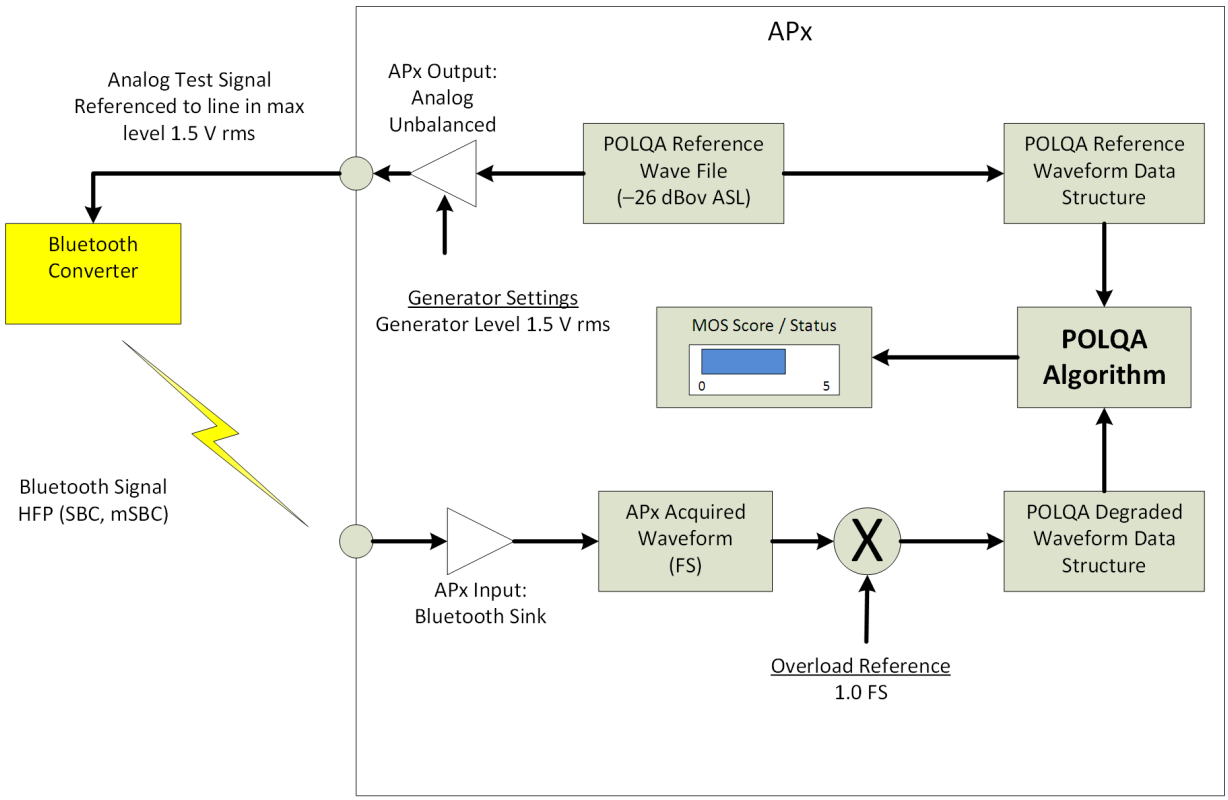
POLQA Use Case 5: acoustic referenced signal out and in



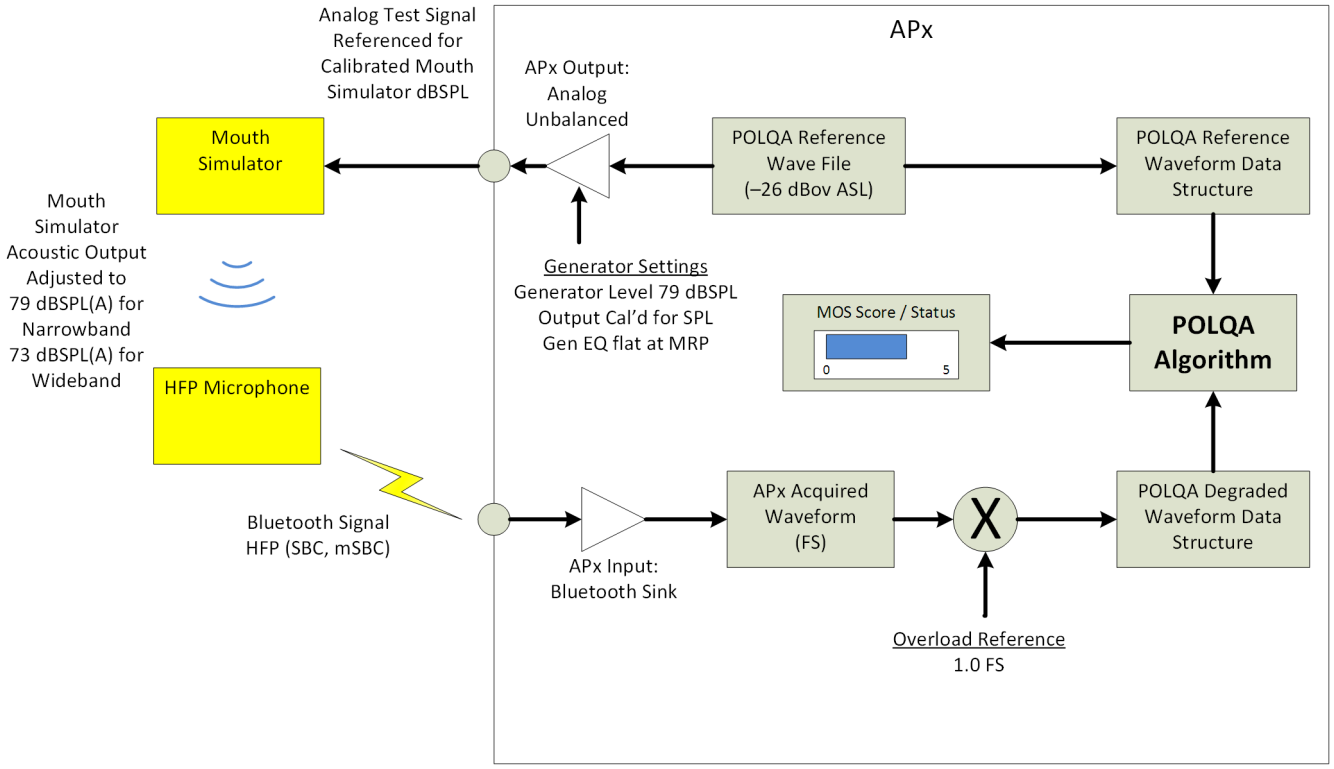
POLQA Use Case 6: digital signal out, acoustic referenced signal in



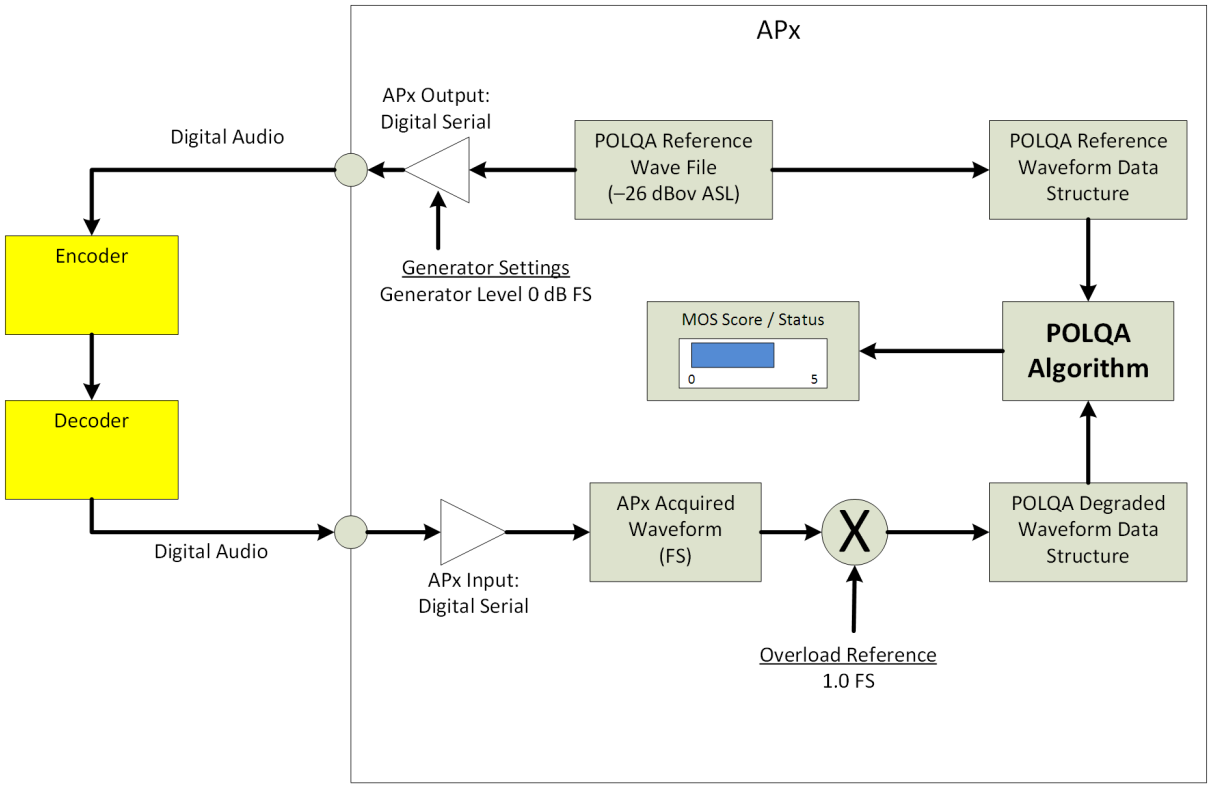
POLQA Use Case 7: analog signal out, digital signal in



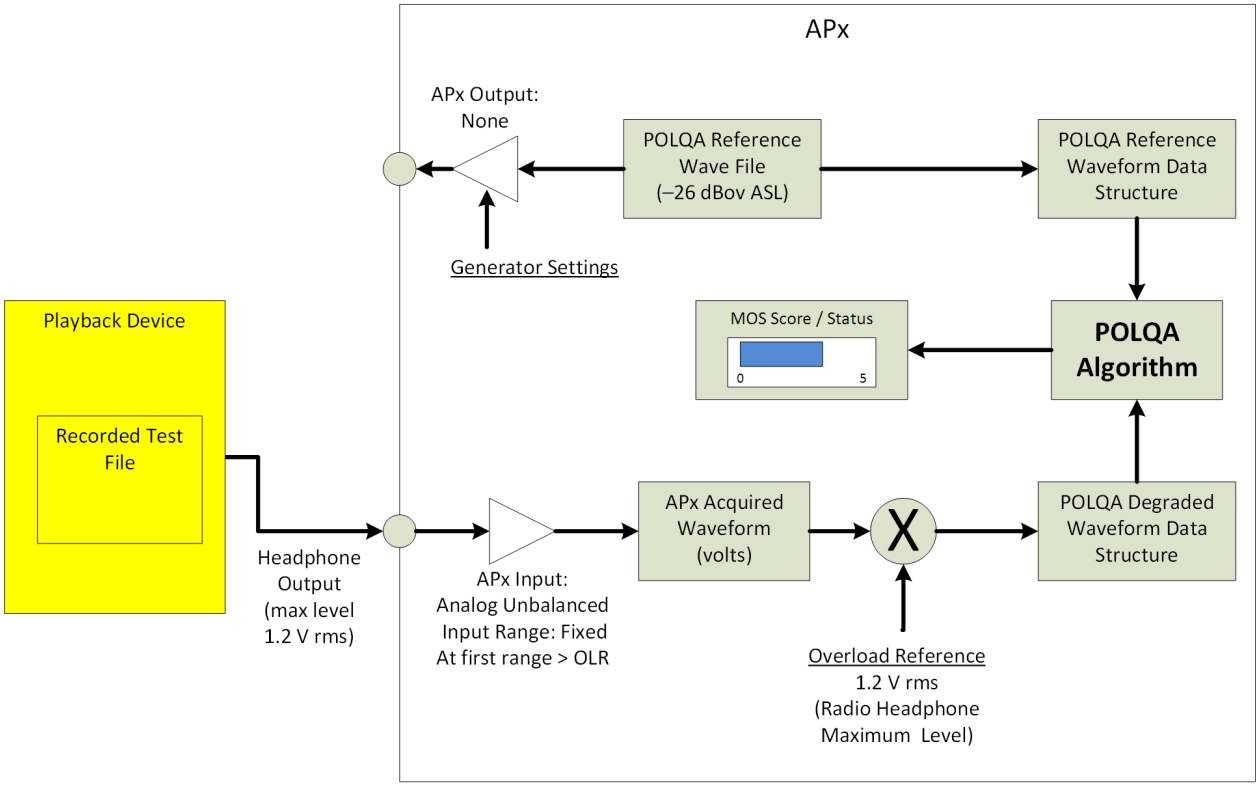
POLQA Use Case 8: acoustic referenced signal out, digital signal in



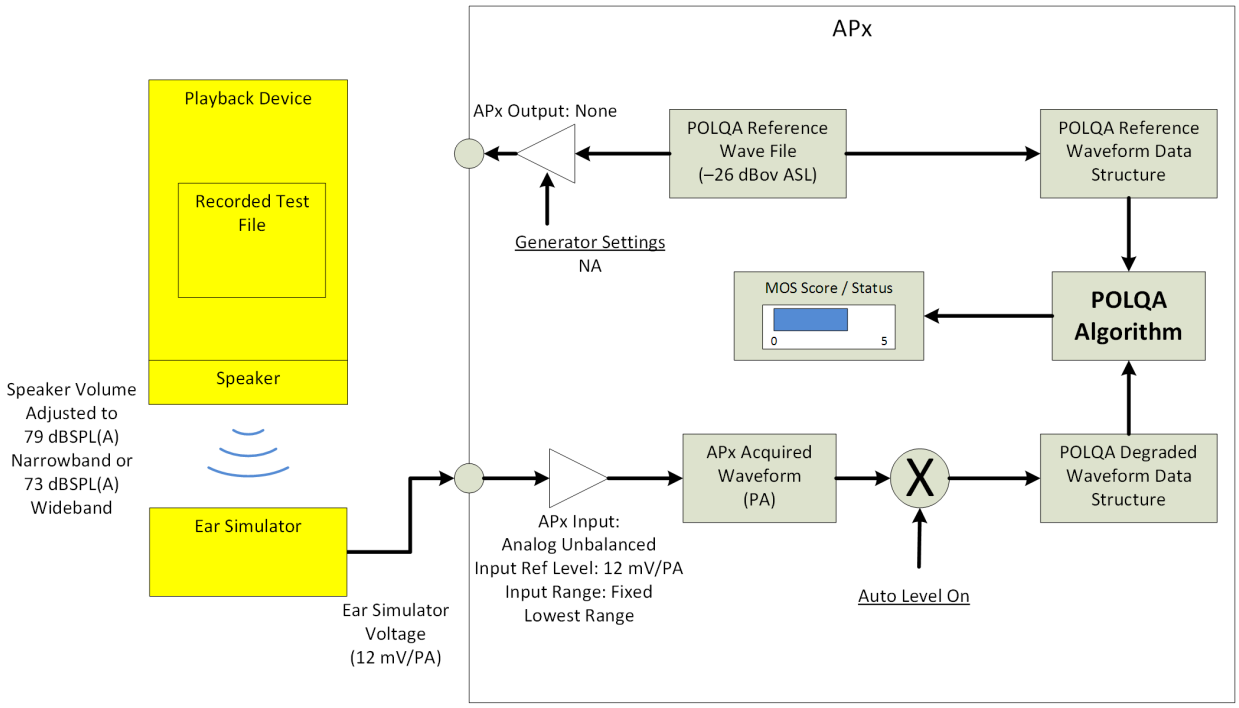
POLQA Use Case 9: digital signal out and in



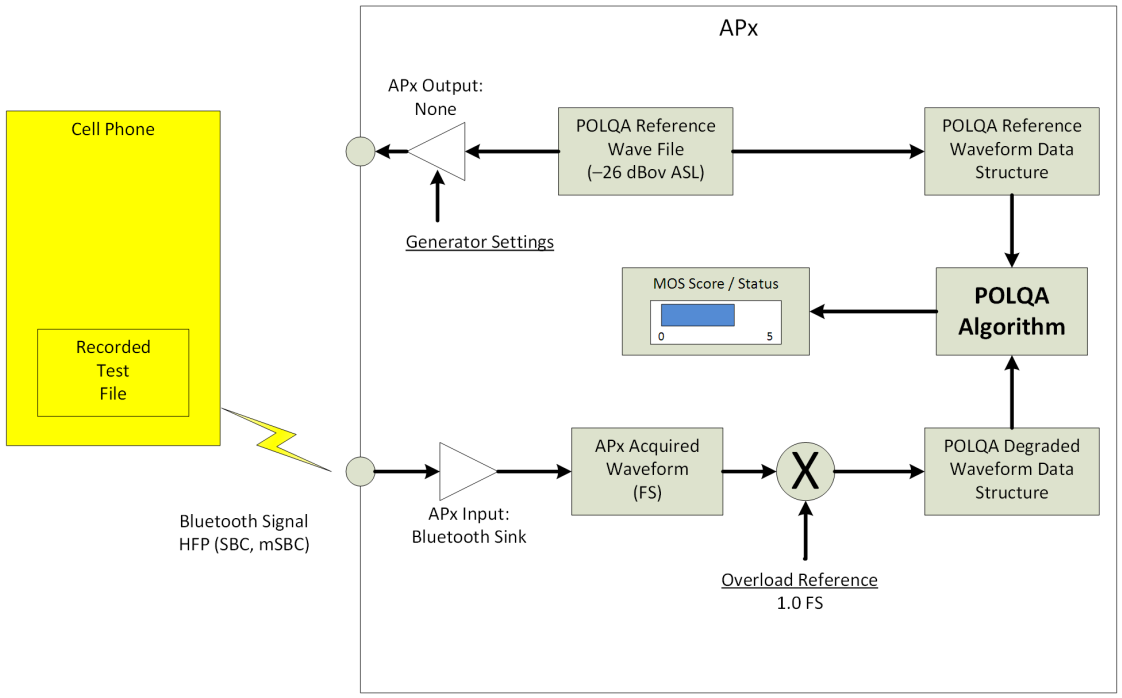
POLQA Use Case 10: no signal out, analog signal in



POLQA Use Case 11: no signal out, acoustic referenced signal in



POLQA Use Case 12: no signal out, digital signal in



POLQA results

The primary POLQA measurement provides results from one stimulus/acquisition cycle. This series of results is useful for setup and cause analysis.

MOS

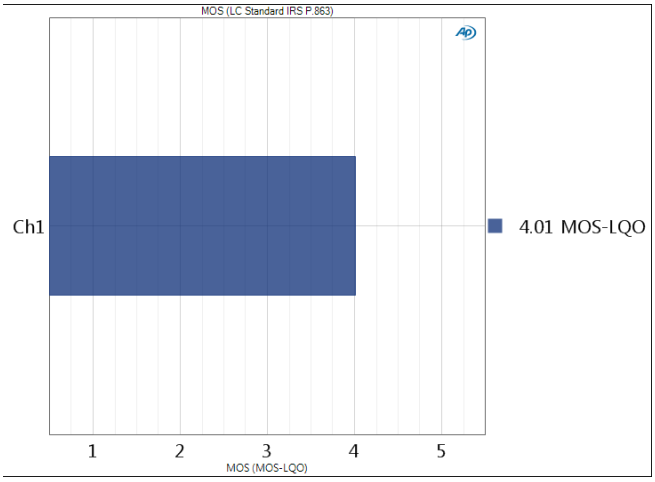


Figure 4. APx POLQA MOS result

This result displays the MOS score from the algorithm. This can be LC Standard IRS P.863 or LC SWide H P.863, depending upon the Mode setting.

POLQA G.107

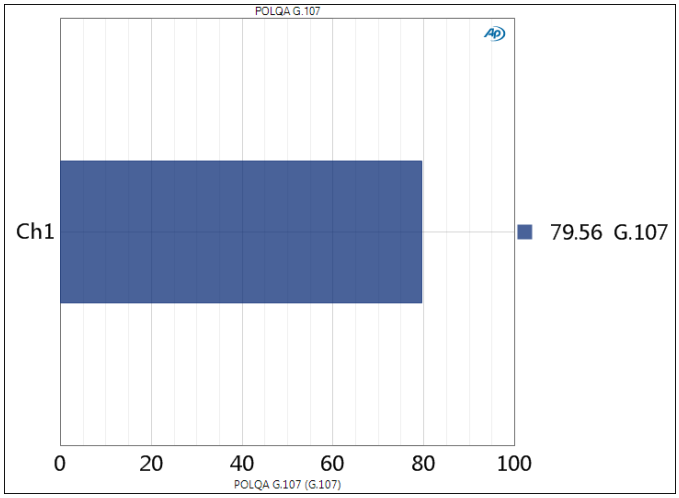


Figure 5. APx POLQA G.107 result

This result displays the raw POLQA result before conversion to MOS, conforming to G.107 (an ITU-T transmission rating model). The G.107 result is only available for Narrowband mode.

MOS vs. Time

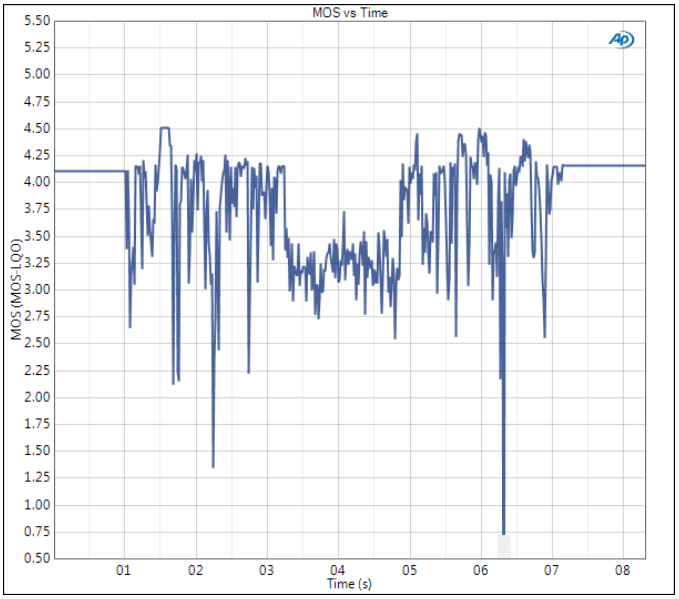


Figure 6. APx MOS vs. Time result

MOS vs. Time displays a graph of the MOS against the time span of the measurement.

Average Delay

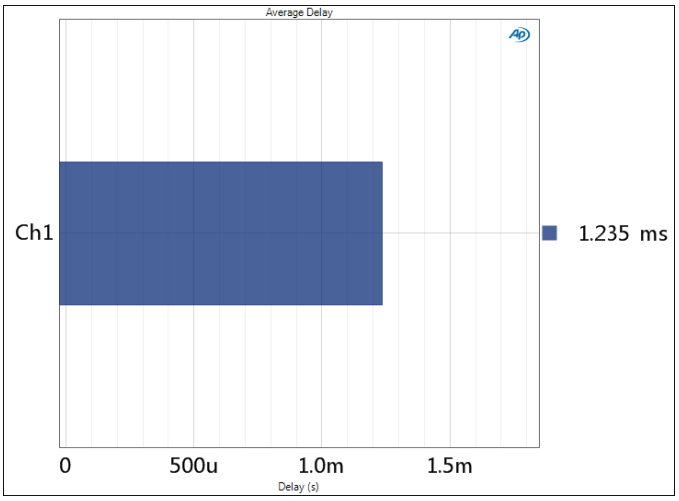


Figure 7. APx Average Delay result

The POLQA Average Delay result is useful for cause analysis. The result shows the average signal delay experienced over the entire measurement, for each channel.

Delay vs. Time

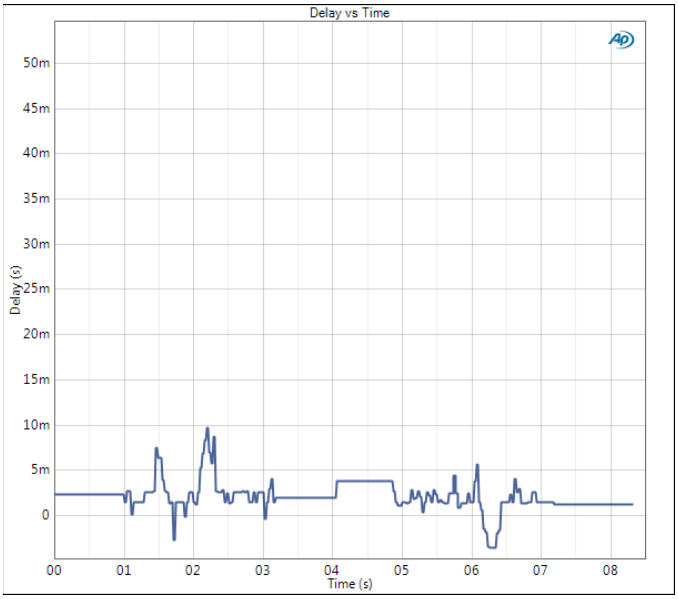


Figure 8. APx Delay vs. Time result

The POLQA Delay vs. Time result is useful for cause analysis. The result charts the delay between reference and acquisition over the time span of the measurement.

Acquired Waveform

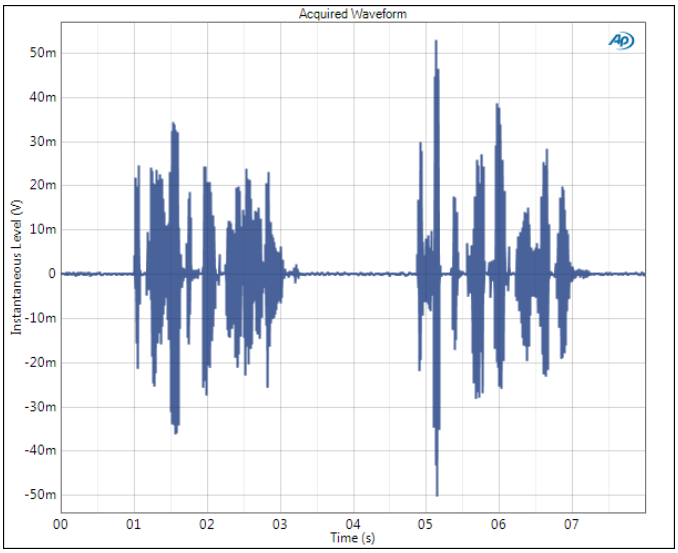


Figure 9. APx Acquired Waveform result

The POLQA Acquired Waveform result is useful for cause analysis. The result shows a time-domain view of the acquired (degraded) speech sample waveform. A Playback button under the graph allows you to play the acquired waveform through the Windows PC audio system. If Save To

File is set, the acquisition will be saved to disk as a WAV file.

Acquired Waveform VAD

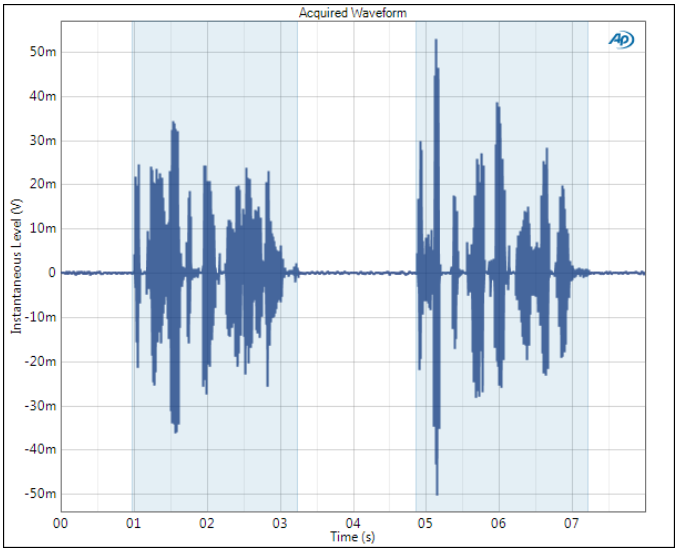


Figure 10. APx Acquired Waveform result (Show VAD set)

If Show VAD regions is set, the result will highlight the areas where the algorithm's Voice Activity Detector has found voice sounds and performed analysis.

Reference Waveform

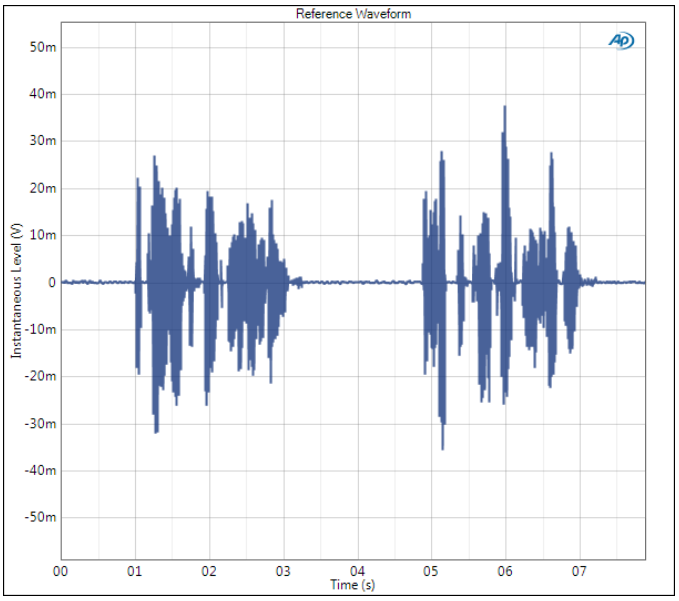


Figure 11. APx Reference Waveform result

The POLQA Reference Waveform result is useful for cause analysis. The result shows a time-domain view of the reference speech sample waveform. This result is scaled to represent the actual values at the output of the APx, based on the generator level setting.

POLQA Result Data

	Data	Ch1
1	MOS-LQO (P.863)	3.79
2	Active Speech Level (ASL) - Reference	-25.946 dBov
3	Active Speech Level (ASL) - Degraded	-24.870 dBov
4	Pause Level - Reference	-69.754 dBov
5	Pause Level - Degraded	-68.201 dBov
6	Active Speech Ratio (ASR) - Reference	0.587
7	Active Speech Ratio (ASR) - Degraded	0.587
8	Signal to Noise Ratio (SNR) - Reference	39.464 dB
9	Signal to Noise Ratio (SNR) - Degraded	38.202 dB
10	Level of Signal - Reference	-27.724 dB
11	Level of Signal - Degraded	-27.237 dB
12	Pitch - Reference	164.386 Hz
13	Pitch - Degraded	167.328 Hz
14	Attenuation	-1.076 dB
15	Minimum Transmission Delay	-5.000 s
16	Maximum Transmission Delay	7.500 s
17	Processing Sample Rate	8.00000 kHz
18	Estimated Sample Rate	8.00000 kHz
19	Resampling Applied	Disabled

Figure 12. APx POLQA Result Data

This result was added to the POLQA measurement as a diagnostic aid to help optimize MOS results. The values represent all of the data output from the POLQA algorithm. Of particular interest are lines 2 and 3, which show the ASL for the reference and degraded signals. Both of these should be as close to −26 dBov as possible.

These data are also saved in a CSV file at C:\Users\{user}\AppData\Local\Audio Precision\APx500\POLQA\PolqaResultData.csv.

POLQA (Averaged) results

ITU-T P.863 recommends that POLQA MOS results for testing a real communications system be an average of a number of acquisitions, using speech samples that vary in content, and that are a mix of male and female voices.

You can load up to 64 files into the Reference Files list. When you click Start, the first file is played through the system under test, acquired and processed by the POLQA algorithm to provide an MOS result. This is repeated throughout

the list of files, and a running average of the MOS results is displayed on the graph.

POLQA (Averaged): MOS Average

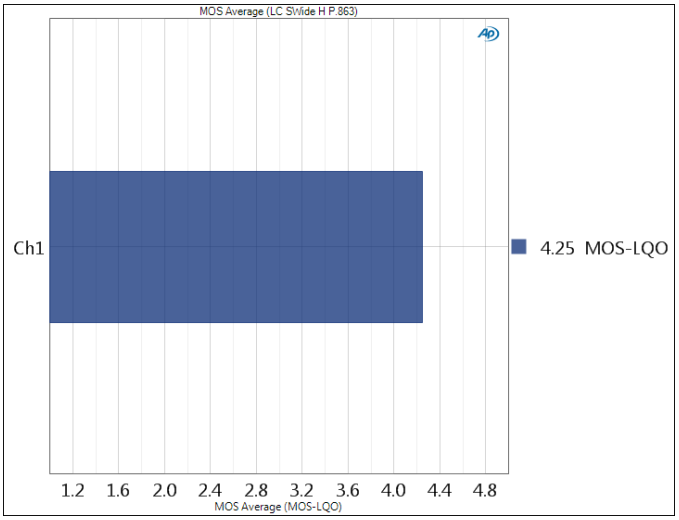


Figure 13. APx POLQA (Averaged) MOS Average result

This measurement result satisfies the P.863 recommendation, and should be considered the premier APx POLQA result when testing a real communications system. This can be LC Standard IRS P.863 or LC SWide H P.863, depending upon the Mode setting.

POLQA (Averaged): File MOS

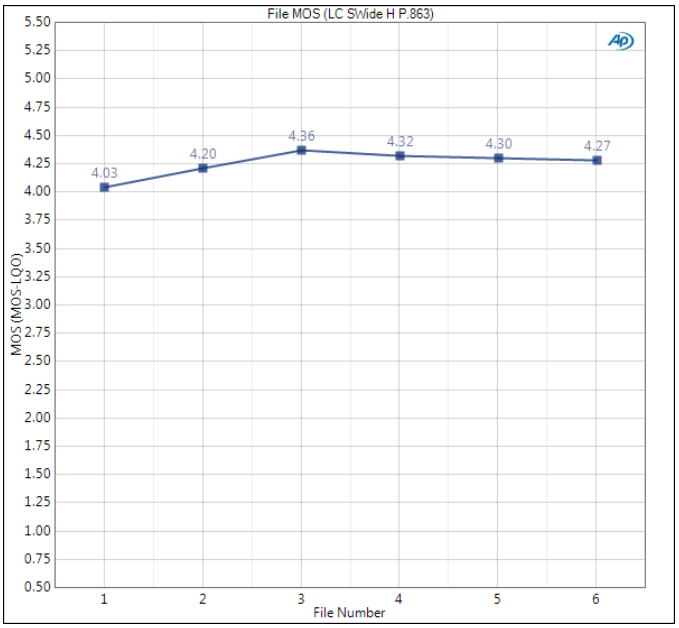


Figure 14. APx POLQA (Averaged) File MOS result

This measurement result displays the individual MOS result for each speech sample in the Reference Files list. This result is useful for cause analysis.

Mode

The Mode control sets the POLQA algorithm analysis mode.

- **Narrowband (P.863)**
  Narrowband (NB) mode supports a bandwidth of 300–3400 Hz. Digital representations of NB signals have a sample rate of 8 kS/s.
  MOS results range from 1 to 4.5.
- **Wideband (P.863)**
  Wideband (WB) mode supports a bandwidth of 100–7000 Hz. Digital representations of WB signals have a sample rate of 16 kS/s.
  MOS results range from 1 to 4.5.
- **SuperWide (P.863)**
  Super-wideband (SWB) mode supports a bandwidth of 50–14000 Hz. Digital representations of SWB signals have a sample rate of 48 kS/s.
  MOS results range from 1 to 4.75.

Extend Acquisition Time

If you are getting unexpectedly poor MOS results, observe the acquired waveform result. The waveform may be truncated due to delay through the DUT. If this is the case, you can extend the acquisition time so that the entire waveform is acquired.

Overload Ref

In some cases the gain of the DUT cannot be adjusted to pass the POLQA signal at the optimal level.

An Overload Ref: field is available to scale the gain at the analyzer input so that the degraded signal is presented to the POLQA algorithm at approximately −26 dBov. Enter the nominal overload point of the DUT (for analog signals, the value set here is typically the clipping point of the analog DUT; for digital signals, the value is typically 0 dBFS).

Reference Signal Selection

For open-loop testing, you must specify a Reference Signal. For closed-loop testing, the reference file is usually the generator file; however, for EQ'd or otherwise modified generator files, you may specify an alternative (not EQ'd, for example) reference file here.

Auto Level Alignment

APx provides an Auto level alignment checkbox to automatically align the input stream ASL within the algorithm to the level required, which makes good MOS scores easier to obtain. This is useful if your test requirements do not consider signal level, or if temporarily defeating level sensitivity is helpful in diagnosis. However, since the requirement that the DUT be operating at its nominal level is ignored under this condition, the APx POLQA measurement is not compliant with the ITU-T P.863 standard when Auto level alignment is ON.

Auto level alignment enables two simultaneous stages of compensation:

- APx automatically scales the signal so that it is applied to the algorithm at the optimal level.
- The POLQA algorithm implements its internal auto level mode, where both the reference signal and the degraded signal are forced to an ASL of −26 dBov.

Generally, for standards-compliant POLQA MOS results in APx the Auto level alignment checkbox must be OFF. You should optimize levels in your signal path so that the speech samples are at −26 dBov within the DUT or system under test, and so that the signal presented to the analyzer inputs is at the correct level to present an ASL of −26 dBov to the POLQA algorithm, after scaling in the analyzer input and converter stages.

Auto Resampling

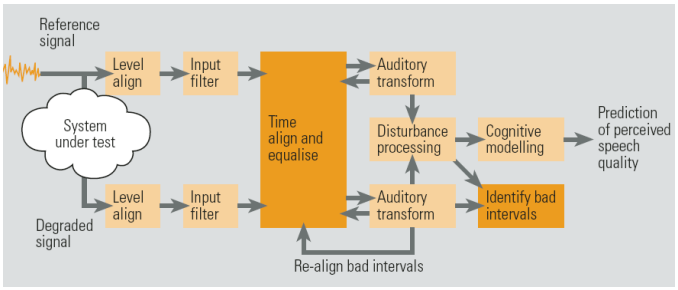
If this checkbox is checked, the POLQA algorithm defaults to the lowest sampling rate when it detects a difference between the reference and target signals, and suppresses the error that is thrown. This may result in an improved score, but the result will not be standards compliant.

High-Accuracy Mode

When checked, High-accuracy mode engages a mechanism in the POLQA algorithm that shifts the time alignment of the degraded signal in sub-sample steps to find the optimal (highest) MOS score. Use this feature if it provides better results in your test.

Sub-sample time shift is defined as an offset in the time alignment of the two signals greater than zero but less than one sample, which can occur in systems under test. Sub-sample time shift can adversely affect MOS scores.

PESQ



The PESQ (Perceptual Evaluation of Speech Quality) algorithm is defined in ITU-T Recommendation P.862 (2001). PESQ provides MOS results and other results useful for cause analysis.

PESQ offers a narrowband mode with a bandwidth of 300–3400 Hz, and a wideband mode with a bandwidth of 100–7000 Hz, chosen depending upon the application. The reference and degraded signal are processed and compared to generate a MOS result.

APx PESQ Implementation

PESQ is an optional measurement technology for APx analyzers, and requires the purchase of a software option key to operate.

The operation and result displays of the APx PESQ measurements are similar but not identical to those of the POLQA measurements.

PESQ Measurement

This measurement provides results from one stimulus/acquisition cycle. This series of results is useful for setup and cause analysis.

MOS

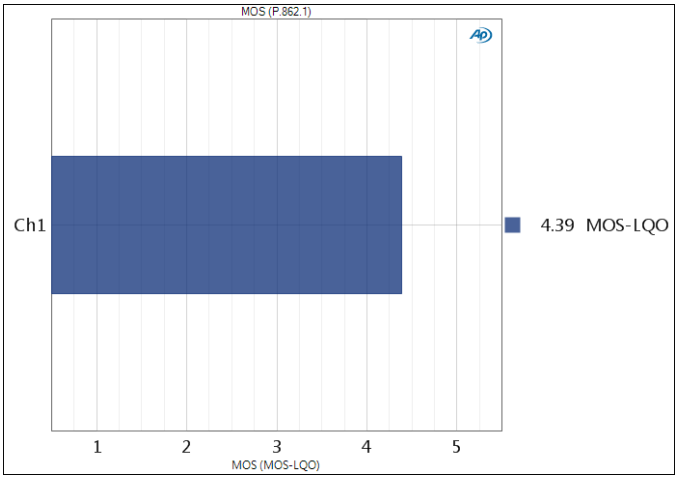


Figure 15. PESQ MOS result.

This result displays the MOS score from the algorithm. This can be P.862.1 or P.862.2, depending upon the Mode setting.

PESQ

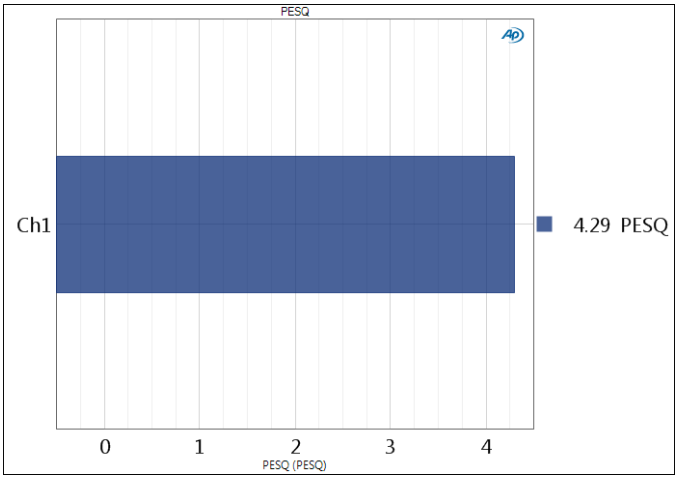


Figure 16. PESQ "PESQ" result.

This result displays the raw PESQ result before conversion to MOS. The result is only available for Narrowband Mode.

MOS vs. Time

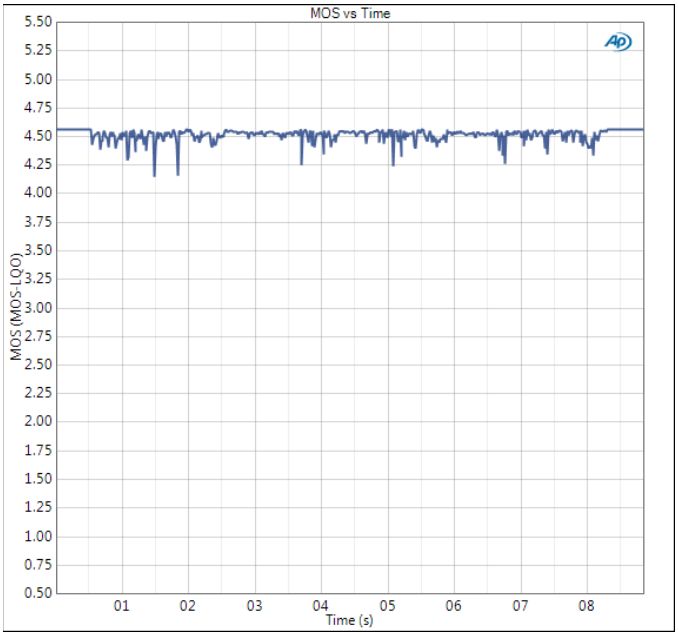


Figure 17. PESQ MOS vs. Time result.

MOS vs. Time displays a graph of the MOS against the time span of the measurement.

Average Delay

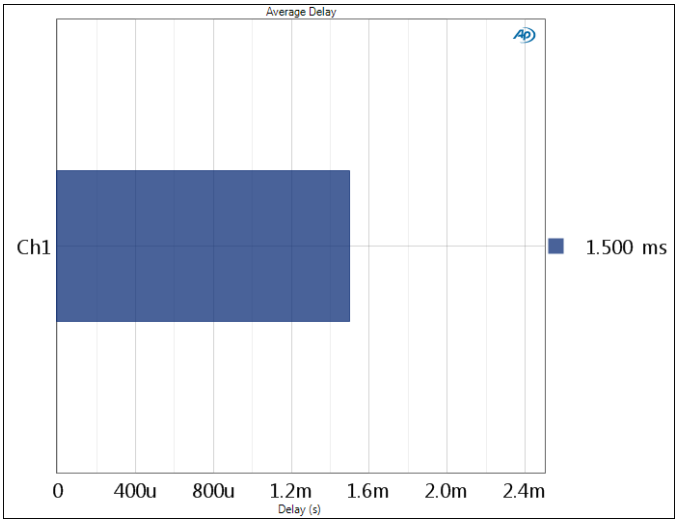


Figure 18. PESQ Average Delay result.

The PESQ Average Delay result is useful for cause analysis. The result shows the average signal delay experienced over the entire measurement, for each channel.

Delay vs. Time

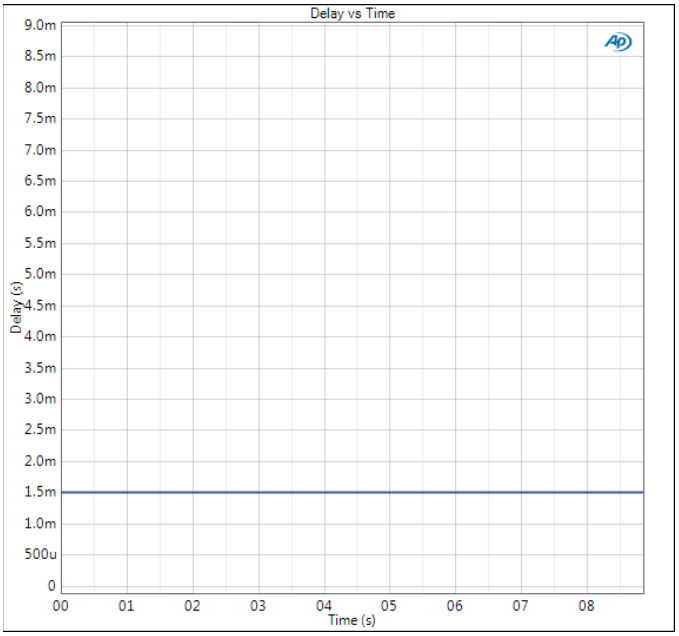


Figure 19. PESQ Delay vs. Time result.

The PESQ Delay vs. Time result is useful for cause analysis. The result charts the delay between reference and acquisition over the time span of the measurement.

Acquired Waveform

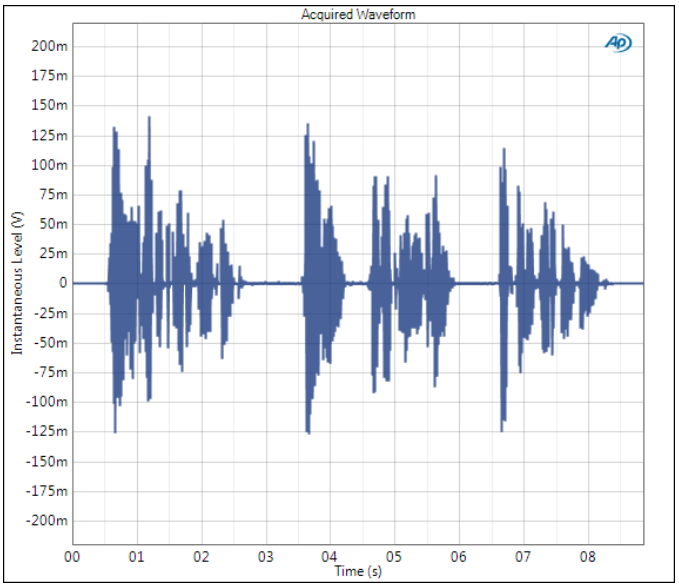


Figure 20. PESQ Acquired Waveform result.

The PESQ Acquired Waveform result is useful for cause analysis. The result shows a time-domain view of the acquired (degraded) speech sample waveform. A Playback button under the graph allows you to play the acquired waveform through the Windows PC audio system. If Save To File is set, the acquisition will be saved to disk as a WAV file.

Acquired Waveform Dropout Display

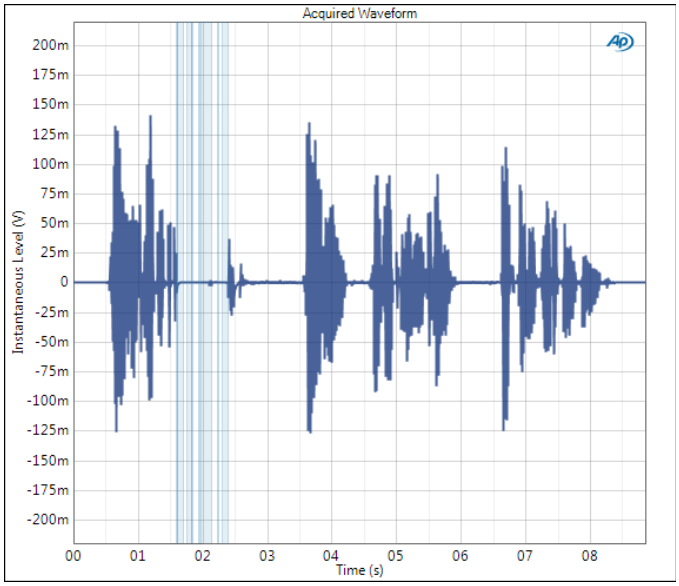


Figure 21. PESQ Acquired Waveform Dropout Display result.

When Show Dropouts is set, dropouts are highlighted. A dropout is a region where there is signal in the reference waveform but no signal in the acquired waveform.

Reference Waveform

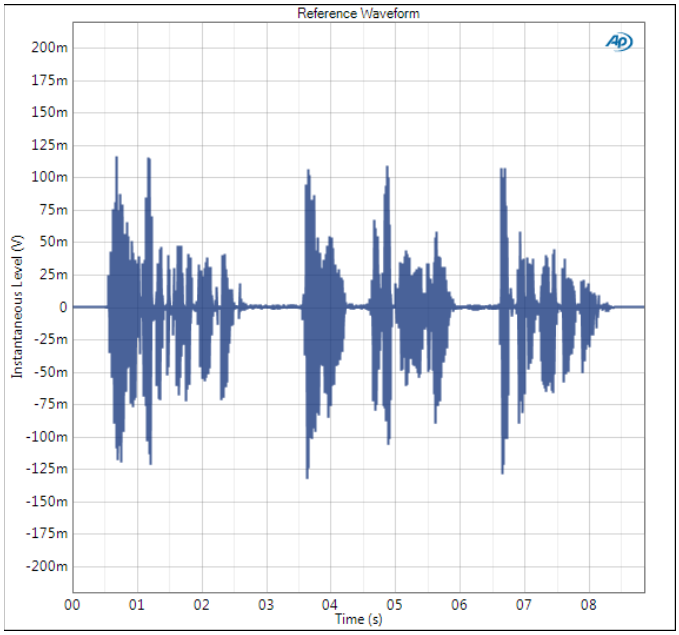


Figure 22. PESQ Reference Waveform result.

The PESQ Reference Waveform result is useful for cause analysis. The result shows a time-domain view of the reference speech sample waveform. This result is scaled to represent the actual values at the output of the APx, based on the generator level setting.

PESQ (Averaged) Measurement

ITU-T P.862 recommends that PESQ MOS results for testing a real communications system be an average of a number of acquisitions, using speech samples that vary in content, and that are a mix of male and female voices.

You can load up to 64 files into the Reference Files list. When you click Start, the first file is played through the system under test, acquired and processed by the PESQ algorithm to provide an MOS result. This is repeated throughout the list of files, and a running average of the MOS results is displayed on the graph.

PESQ (Averaged): MOS Average

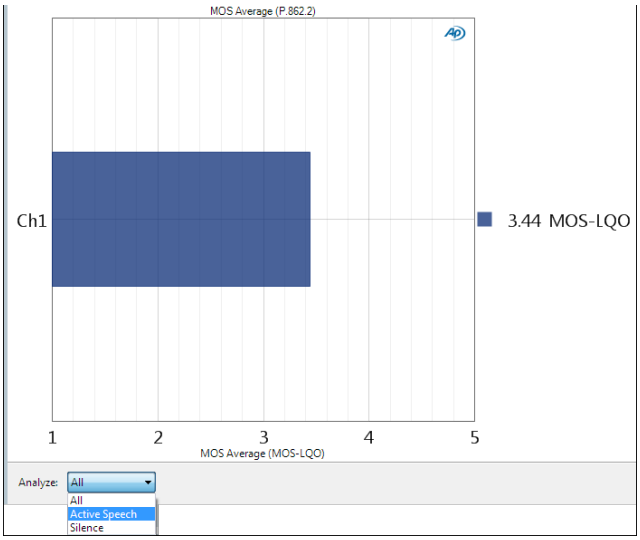


Figure 23. PESQ (Averaged) MOS Average result.

This measurement result satisfies the P.862 recommendation, and should be considered the premier APx PESQ result when testing a real communications system. As you can see in the screen shot, PESQ allows you to direct the analysis to All, Active Speech or Silence.

PESQ (Averaged): File MOS

This measurement result displays the individual MOS result for each speech sample in the Reference Files list. This result is useful for cause analysis.

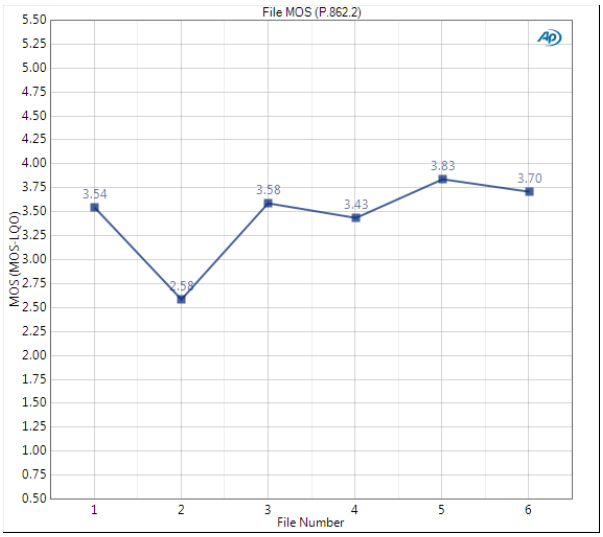


Figure 24. PESQ (Averaged) File MOS result.

Mode

The Mode control sets the PESQ algorithm analysis mode.

- **Narrowband (P.862)**
  Narrowband (NB) mode supports a bandwidth of 300–3400 Hz. Digital representations of NB signals have a sample rate of 8 kS/s.
  MOS results range from 1 to 4.5.
- **Wideband (P.862)**
  Wideband (WB) mode supports a bandwidth of 100–7000 Hz. Digital representations of WB signals have a sample rate of 16 kS/s.
  MOS results range from 1 to 4.5.

Extend Acquisition Time

If you are getting unexpectedly poor MOS results, look at the acquired waveform. It may be truncated due to delay through the DUT. If this is the case, you can extend the acquisition time so that the entire waveform is acquired.

Reference Signal Selection

For open-loop testing, you must specify a Reference Signal. For closed-loop testing, the reference file is usually the generator file; however, for EQ'd or otherwise modified generator files, you may specify an alternative (not EQ'd, for example) reference file here.

Analyze

PESQ also has an Analyze selector to choose whether the active speech portions of the signal, the silence, or the entire signal are analyzed.

Notes

[1] POLQA, Perceptual Objective Listening Quality Assessment (ITU-T Rec.863 (2014)).
http://www.opticom.de/technology/polqa.php
http://www.itu.int/en/ITU-T/publications/Pages/recs.aspx

[2] OPTICOM GmbH, the leading vendor of perceptual measurement technology.
http://www.opticom.de

[3] PESQ, Perceptual Evaluation of Speech Quality (ITU-T Rec. P.862).
http://www.pesq.org
http://www.itu.int/en/ITU-T/publications/Pages/recs.aspx

[4] International Telecommunication Union. Suffix -T denotes Telecommunication Standardization Sector; suffix -R denotes Radiocommunication Sector.

[5] Information about the P.56 meter is available at
http://www.itu.int/rec/T-REC-P.56

[6] Information about speech samples and speech sample files can be found at:
http://www.itu.int/net/itu-t/sigdb/genaudio/Pseries.htm
http://www.itu.int/rec/T-REC-P.501.
http://www.itu.int/en/ITU-T/publications/Pages/recs.aspx
http://www.itu.int/itu-t/recommendations/rec.aspx?rec=3302
http://www.itu.int/net/itu-t/sigdb/genaudio/AudioForm-g.aspx?val=10000501
http://www.voiptroubleshooter.com/open_speech
http://www.cs.columbia.edu/~hgs/audio/harvard.html

IEEE Recommended Practice for Speech Quality Measurements, *Audio and Electroacoustics, IEEE Transactions on*, Volume 17 Issue 3, September 1969, 225–246, ISSN 0018-9278, DOI 10.1109/TAU.1969.1162058 can be found at:
http://ieeexplore.ieee.org/xpl/login.jsp?arnumber=1162058

Audio precision
5750 SW Arctic Drive, Beaverton, Oregon 97005 | 503-627-0832
www.ap.com
Copyright © 2016, 2020 Audio Precision
XX08121316