XAP Acoustic Echo Troubleshooting Guide

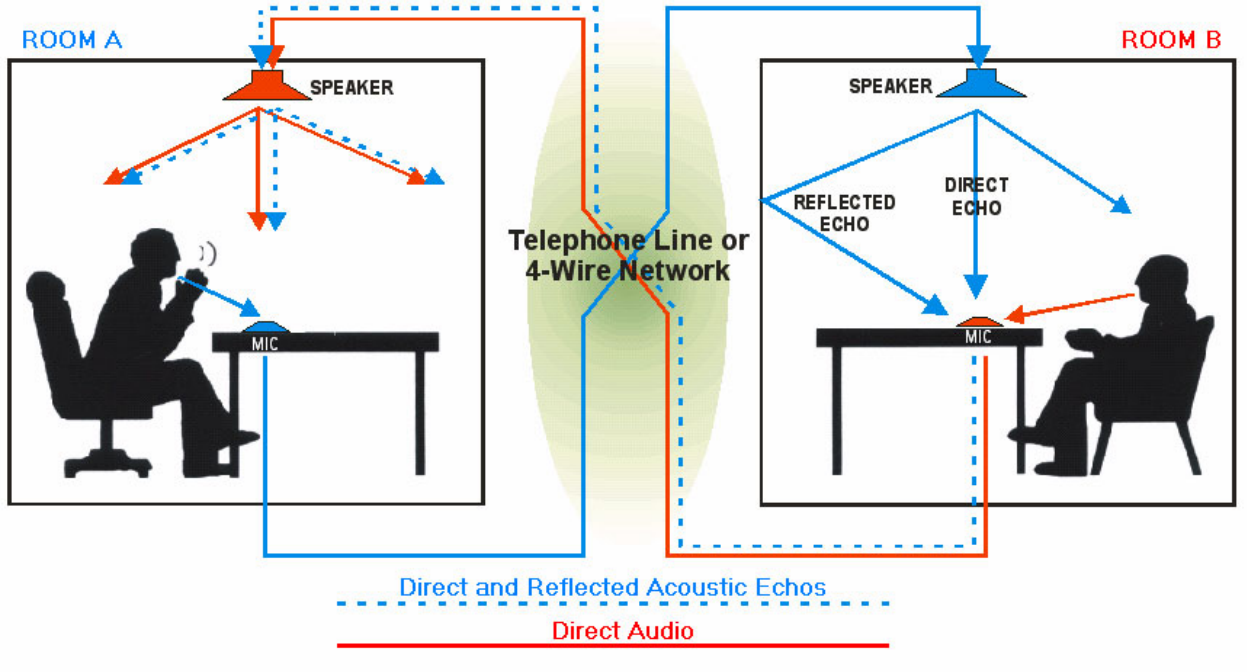
Introduction
This document describes acoustic echo cancellation (AEC) troubleshooting methods and solutions

Description
This guide provides information on how to determine the cause of an acoustic echo problem and lists solutions for eliminating echo.

What is Acoustic Echo?
Acoustic echo is caused when audio is transmitted from one location (Room A - solid blue line) to another location (Room B) typically via a telephone circuit. The audio is then produced in Room B's audio system. This audio travels from the loudspeaker either directly or by reflection to the microphones in Room B and then is retransmitted to the originating site (A – blue dotted line) with delay.

An acoustic echo canceller placed in Room B will eliminate the acoustic echo that is being sent to Room A thus allowing Room A to have a natural conversation with Room B.

***Note**: An echo cancellation system placed in Room B will benefit people calling into that room, it will not benefit the person calling from Room B.*



How does acoustic echo cancellation work?
The echo cancellation process begins with audio that is received from a telephone, ISDN or IP based network. That audio is sampled at the output of the conferencing unit before it passes through to the speakers in the room. When the audio returns to the microphones the echo cancellers apply the sampled signal 180 degrees out of phase with the original signal to eliminate it.

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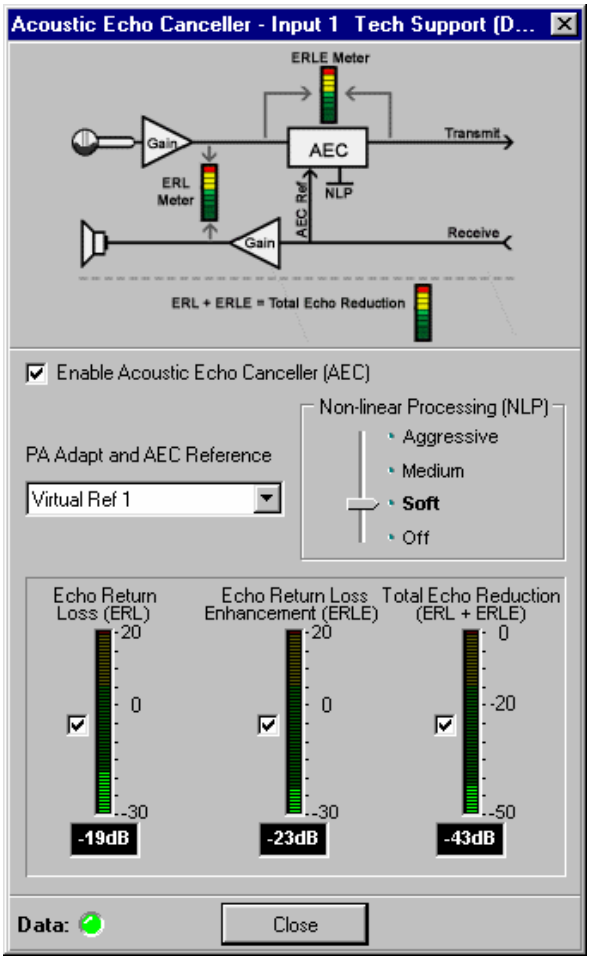
Echo and echo cancellation measurement tools
G-Ware software provides metering capability for measuring ERL (Echo Return Loss), ERLE (Echo Return Loss Enhancement) and Total Echo Reduction. The meters can be accessed in the microphone input screen as part of the AEC setup screen.

Echo Return Loss: ERL is a measurement in dB of acoustic echo loss through decay and absorption as it travels from the speaker system to microphone either directly or through reflection. This measurement is affected by the levels at the output to the speakers, and the microphone input sensitivity. Echo cancellation performance is enhanced when there is a measured dB loss of echo at this meter stage. ERL is affected by the amount of gain at the amplifier powering the PA system as well as room acoustics microphone and speaker placement and proximity and ambient room noise. Higher levels will mean less echo return loss, which can require the AEC to work harder to try and eliminate the acoustic echo. High microphone gains also can affect ERL. A more sensitive microphone will pick up signals that may otherwise fall into the noise floor of the room audio and not need echo cancellation.

Echo Return Loss Enhancement: ERLE is also a dB measurement of the echo canceller and Non-Linear Processor performance. This measures how much loss the echo canceller or NLP adds to the transmitted signal to remove echo from the microphone audio. This should also measure as a negative dB value.

Total Echo Reduction: This is the sum of the ERL and ERLE measurements to give a total level of echo cancellation performance.



AEC Window
This example shows levels that will allow for proper echo cancellation performance. The ERL meter shows a level of –19dB, which is the loss of level in the room environment. The ERLE meter shows the echo cancellers performance in eliminating the echo and the last meter shows Total Echo Reduction which is ERL + ERLE to give you the overall performance on the particular echo cancellation channel.

Measured levels will vary from room to room due to acoustics and system design. There is no fixed value to look for with regards to these meters. Echo cancellers work best when ERL is metered as a negative number the more loss of audio the better.

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Troubleshooting acoustic echo
One simple method for determining if the echo is caused by acoustic coupling of speaker audio back to a microphone or a routing error is to mute the microphones in the conferencing unit in the room that the echo is being heard from. Example: Room A from the picture above is hearing echo, room B would then mute their microphones. After the microphones have been muted at the site B the caller talks from site A and listens for an echo to return to them. If the echo goes away and returns when the microphones are un-muted it is an acoustic echo. If the echo continues while the microphones are muted it is a routing error where an input from a phone hybrid or video codec has been routed back to its' own output. This is not related to telephone network failures, which are not covered in this document.

***Note**: Unplugging the microphone is not a valid test because the incoming audio is still sampled and applied 180 degrees out of phase. Without a signal from the microphone to cancel against the sample audio is sent back as an echo.*

Determining the cause of acoustic echo

Echo Cancellation reference setup
Verify the AEC reference is correct and that all the microphones are using the correct reference. Also check that all the audio sources that need to be echo cancelled are included in the reference channel. For more information on echo cancellation reference setup refer to the technical document on echo cancellation configuration.

Gain structure.
Check gain structure. Echo cancellers work most efficiently with a unity gain structure from input to output. Levels that are too low may not be sampled by the echo canceller or may produce an incomplete reference. Since the echo canceller was unable to sample the audio due to the low level it has no echo cancellation to apply at the microphone to stop the echo.
If the signal is too loud or clipped the distorted signal again provides an incomplete sample for the echo canceller to work with. When the audio is passed to the PA system it is then amplified beyond the ability of the echo canceller to be able to remove it. (Refer to technical document XAP_GWARE 104 Setting the initial gain structure of a XAP system)

Microphone levels
Setting microphone sensitivity too high in order to try and pick up talkers that are too far from the microphone can also effect echo cancellation by raising ERL (Echo Return Loss).
(Refer to technical document XAP_GWARE 104 Setting the initial gain structure of a XAP system)

Routing
Check audio routing. Is the audio input from the codec or telephone hybrid routed to the output that feeds the same device. Also, some VCRs and video codec's will loop audio through from input to output. Try muting or disconnecting the output to the VCR or codec and see if the echo goes away.

Microphone Muting
Check for external microphone muting. The acoustic echo cancellers on the microphone inputs are constantly updating the filter model for the room and adapting (converging) to that model. In systems with push to talk/push to mute microphones if the microphone is muted at the element the echo canceller on that input channel will no longer be able to update its' sample and will stop updating (diverge) and cause echo until it converges again once the microphone is unmuted. Microphones with logic cabling for use with the control and status pins on the XAP allow for programming in the unit to mute the inputs with the microphones button while allowing the echo cancellers to receive an audio sample to update the echo reference and not affect performance.

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Volume control
Check external gain control. As with the microphone muting problem described above, the AEC is constantly updating the filter model and converging to it. In a system with an external volume control there is potential for echo because the AEC is not updated with the change in amplitude of the signal that is being sent to the PA system. The echo canceller will adapt to the signal over time but the caller will hear echo until the echo canceller is converged again.

Audio processor/Feedback eliminator
Check for feedback eliminator in the AECs reference or cancellation path. Feedback eliminators are used to eliminate feedback in microphone reinforcement systems. If the feedback eliminator is on the output that feeds the far end audio to the PA system it can change the frequencies of the signal that was sampled so that when the echo canceller applies the sample 180 degrees out of phase to the audio coming back to the microphone the altered frequencies pass through the AEC to the far end as echo. A feedback eliminator can be used with a mix of the microphone audio sent to an output that is separate from the audio from the telephone or videoconference system.

External echo canceller
Check for another echo canceller in-line, such as the AEC in a video codec. In a system where two echo cancellers may be active the audio will appear low and distorted to the distant site due to both echo cancellers making independent decisions as to what audio to cancel. By the time the already echo cancelled audio reaches the second AEC it will be suppressed by that echo canceller.

Conclusion
The steps listed below will help in optimizing the performance of the AEC

Maximize ERL
- Room acoustics - treat the room to eliminate reflections
- Microphone location and pickup pattern - close to the talkers with a unidirectional pickup pattern
- Microphone/speaker placement - maximize the distance between the speaker and the microphone
- Loudspeaker and microphone gain

Minimize Ambient Noise
- Excessive noise can slow AEC convergence
- Talker to microphone distance – keep the microphone close to the talker when possible
- Microphone location and pickup pattern – unidirectional microphones will reject background noise that is outside its' pickup pattern.
- Room acoustics – acoustic treatment can help minimize noise

Proper Levels
- Good signal to noise at the AEC reference point
- Avoid clipping or distortion of the audio signal
- Proper gain structure – unity gain helps echo cancellation performance

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