Echo Cancellation on Quadro

Revision: 1.3

Abstract: **This document describes basic echo parameters and steps for troubleshooting echo cancellation using the Echo Analyzer tool.**

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Document Revision History

Revision	Date	Revision	Valid for SW	Valid for models
1.0	04-Sep-2007	Initial version	4.1.x	All Quadro products
1.1	10-Oct-2007	Updated	4.1.x	All Quadro products
1.2	8-Nov-2007	Revised	4.1.x	All Quadro products
1.3	15-Nov-07	Edited	4.1.x	All Quadro products

1 Introduction

This document describes the types and causes of echo in VoIP communication as well as basic echo parameters and steps for troubleshooting echo cancellation using the Echo Analyzer tool.

2 Requirements

- The Quadro is connected to the network and all network settings are properly configured
- The Echo Analyzer is running on the PC

3 General Description

There are two main two types of echo in VoIP communication networks: acoustic echo and line echo.

Acoustic echo typically exists when using hands-free units and is caused by acoustic wave reflections from the walls or any other enclosure. Another source of acoustic echo may be the insufficient acoustic isolation between the earpiece and the microphone of the handsets. It is common practice to handle acoustic echo on the terminal equipment where the echo source is located.

The primary echo of today's VoIP communication networks is the **Line echo**. The sources of line echo are electrical reflections in the voice network caused by impedance differential between the 4-wire switch connection and the 2-wire local loop (see Figure1).

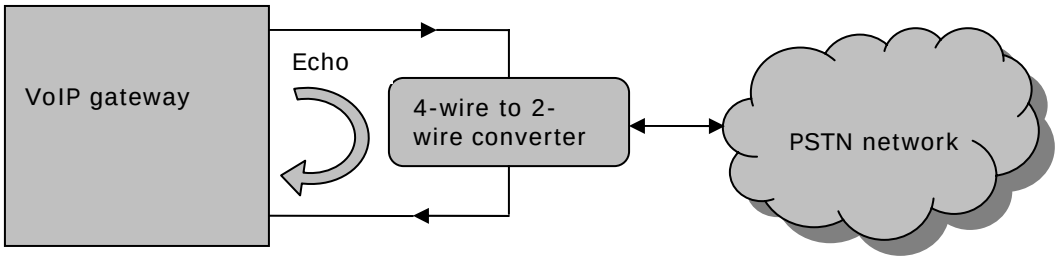

Figure1

The closer the impedance match between the 4-wire and the 2-wire interfaces, the less line echo will be in the network. The impedance of the 2-wire loop depends on characteristics of the cable used, as well as on the impedance of the terminal equipment (telephone, modem, etc.) at the customer premises. In practice, the balance here is achieved by proper configuration of the FXS/FXO ports.

Line echo canceller creates the mathematical model of the echo source based on the near-end (receive or Rx) and the far-end (transmit or Tx) signals (see Figure 2). The Tx signal is transmitted through the Adaptive Linear Filter, which produces an echo estimate. This echo estimate is then digitally subtracted from the Rx signal. The difference between these two signals (error signal) is used for the filter adaptation for the periods where the Rx signal consists of pure

echo (no voice activity on the near-end). As the process repeats, the error signal is minimized and the echo estimate matches the original echo closer and closer.

The Nonlinear Processor (NLP) is used to remove the residual echo signal, in other words, the components that could not be removed by the linear filter alone. The NLP is not activated during periods of double talk (when both participants talk simultaneously).

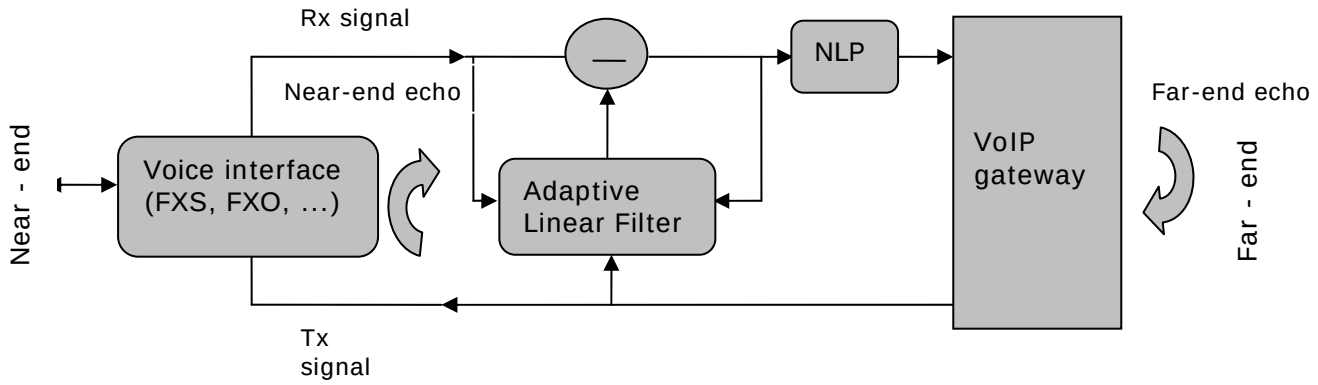

Figure 2

It is common practice to cancel echo at the near-end because of the stationary echo path at the near-end. In other words, once the call path is established, the round trip delay of the echo signal does not vary in opposite to far-end echo which may have a variable and much bigger delay.

4 Echo Parameters (ERL, Tail, Delay, NLP, Convergence Time)

The strength of the echo reflection is expressed in terms of **Echo Return Loss** (ERL). This provides the signal loss (expressed in decibels) relative to the original signal's strength. *ERL (dB) = Original Signal Level (dBm) – Echo Signal Level (dBm)*

The smaller the ERL, the louder the echo. For example, an ERL of 0 dB means that the echo signal is as strong as the original one, while an ERL of 40 dB means a low-level echo. For the echo canceller to be effective, a minimal ERL of 6 dB is required. ERL depends on the degree of impedance matching between the 4-wire and the 2-wire interfaces (see Figure1). This may be improved by the proper configuration of FXS/FXO ports.

An echo signal is not a single reflection of the original signal, but it is a series of reflections over a period of time. This process has a certain duration, or ***tail***, which is less than 10 ms for typical line echo. The echo tail must be stationary for successful reproduction by the adaptive linear filter. This condition is being violated if two or more echo cancellers operate sequentially on the same signal.

In addition to ERL, the perception of echo depends on the ***delay*** between the original voice and the corresponding echo signal. With increasing delay, the echo becomes more noticeable.

In VoIP gateways, the overall echo delay may be expressed as ***internal delay*** + PSTN or local loop propagation delay. Internal delay is caused by the codec processing, packetization and buffering.

Non Linear Processor (NLP) operation depends on two parameters: NLP Diff (dB) and NLP Shift. If the near-end signal passing through the canceller's adaptive filter is being decreased by NLP

Diff value or more, then it is being identified as an echo signal which requires further suppression. Suppression of the non-linear residual signal implies division by 2 repeated NLP Shift times. Every division by 2 corresponds to decreasing the signal by 6 dB, so the final echo residual signal after NLP will be decreased by NLP Shift x 6 dB.

Adaptive Linear Filter Convergence Time is defined by G.168 as follows: "For a defined echo path, the interval between the instant a defined test signal is applied to the receive-in port of an echo canceller with the estimated echo path impulse response initially set to zero, and the instant the returned echo level at the send-out port reaches a defined level".

If the echo path changes during the call (for example, because of a call transfer or conference call), the Adaptive Linear Filter re-converges to produce a new model of the echo. The faster an echo canceller converges, the less time talkers hear echo at the start of a call. A normal echo canceller converges to ERL+30 dB or better within 50 ms. Convergence time up to 1-2 seconds is possible and acceptable.

5 Echo Cancellation Troubleshooting Using Echo Analyzer

This section presents the necessary steps for troubleshooting echo cancellation.

If echo is present in the call, then the following steps must first be taken:

1. Check the type of echo (line or acoustic) and the source (near-end or far-end). Acoustic echo cancellation or far-end echo cancellation is out of the VoIP gateway's control and it needs to be resolved at the local source (see section General Description). The examples of echo types cancelled on Quadro are as follows:
   - User on an analogue (FXS) extension of the Quadro is in call with the PSTN user through the FXO/ISDN BRI/E1/T1 interface and hears echo (own voice).
   - User on the local IP extension (IP phone) of the Quadro is in call with the PSTN user through the FXO/ISDN BRI/E1/T1 interface and hears echo (own voice).
   - User on the remote IP extension of the Quadro or the remote SIP user is in call with the PSTN user through the Quadro FXO/ISDN BRI/E1/T1 interface and hears echo (own voice).
   - User on the local or remote IP extension (IP phone) of the Quadro is in call with the user of the local analogue extension of the Quadro and hears echo (own voice).
2. If the echo path includes the FXO port, make sure that the regional settings of the Quadro correspond to the CO line settings. Regional settings affect the impedance matching of the FXO port and the CO line so the incorrect settings may worsen the echo characteristics (ERL, echo linearity, etc.)

If everything is normal with the conditions above and echo still persists, then an analysis is required on the echo canceller input signals (Rx and Tx, see Figure 2) captured on the DSP during an echoing call. To capture on the DSP the samples of Rx/Tx voice streams, you can use either the callcapture.cgi hidden page on Quadro GUI or dspcapture.cgi for earlier firmware versions. **The resulting files** with PCM data will be used by the echo analysis tool provided by Epygi (see Figure 3). The latter emulates the echo cancellation algorithm of Quadro devices on the PC. With PC emulation it is much easier to get the needed characteristics of the echo signal not available in a real-time processing environment.

Please Note: Make sure to submit Rx and Tx signals of the near-end. In the above listed examples, the capture needs to be done on FXO, ISDN, FXS or E1/T1 interfaces.

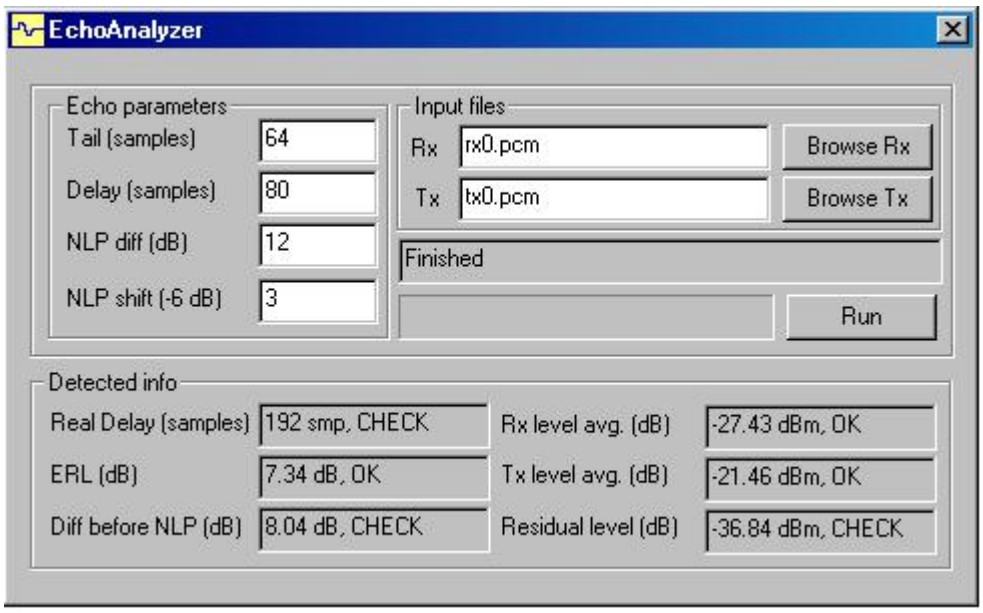

Figure 3

Here are the steps to use the **Echo Analyzer:**

1. Select the proper **device – interface** (Quadro 2x – FXO, Quadro 4x/16x – ISDN) pair from the provided list to set the Quadro's default echo canceller parameter values (Tail, Delay, NLP Diff, NLP shift). By default the Delay parameter of echo canceller is set equal to the internal delay of the corresponding device-interface (see Table 1). It is not recommended to change the Delay as it may become longer than the real delay of the echo which will impede the normal cancellation. It is also recommended to set the NLP parameters to default values provided by the last version of the Echo Analyzer. To configure the echo cancellation parameters or to find the current values, use the corresponding web GUI pages specified in Table 1.

Table1 – Echo cancellation default parameters for Epygi products

Device – Interface	Tail	Internal Delay	Web GUI page
Quadro 2x –FXO	64	100	Fxoconfig.cgi
Quadro 2x – FXS	48	80	linesconfig.cgi
Quadro 2x – ISDN	128	80	trunkecho.cgi
Quadro 4x/16x – FXO (HW version 0306)	64	80	Fxoconfig.cgi
Quadro 4x/16x – FXO (HW version 0307)	64	100	Fxoconfig.cgi
Quadro 4x/16x – FXS	48	80	linesconfig.cgi
Quadro 4x/16x – ISDN	128	80	trunkecho.cgi
Quadro 6 FXO – FXO	64	180	Fxoconfig.cgi
Quadro ISDN – ISDN	128	80	trunkecho.cgi
Quadro E1/T1- FXS	48	80	linesconfig.cgi
Quadro E1/T1- E1,T1	128	80	trunkecho.cgi

2. Specify the captured Rx/Tx files as input files and press **Run. High pass filtering** must be enabled. When the processing is finished look at the **Detected info**.
3. Acceptable **ERL** must be greater than 6 dB. If the ERL is less than 6 dB then echo path analysis is required (FXO port proper configuration for most of the cases) because the echo canceller cannot function properly.
4. The **Residual level** is given in the following format: "Echo signal decrease level (difference) before NLP" / "Residual (final) signal level after NLP". These values show the effectiveness of echo canceller processing. For successful echo cancellation the echo signal difference before NLP must be greater than the NLP Diff value and the level of the final echo residual signal less than -50 dBm. The final output signal after processing is being saved in the out.pcm file in the same folder where the captured samples are located. You can play this on your PC to check if you hear any echo.
5. The average levels of **Rx/Tx** signals must meet the following conditions:
   - -40 dBm < Tx level avg < -3 dBm
   - -40 dBm < Rx level avg < -3 dBm and Tx level avg - Rx level avg < 6 dB.

   A problem here may be fixed by using the codec gain control from the Quadro web GUI (reducing Tx gain) or by properly configuring FXO regional settings (in case of FXO).
6. The recommended values for **Minimal tail** value and **TX gain change** are provided after processing.
7. If the problem requires deeper analysis, contact Epygi's Technical Support team.