Information on Sage's 3rd-generation Echo Sounder

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1 Introduction

Sage Instruments debuted a telephony echo detection method named "Echo Sounder" in early 2000 [1]. Echo Sounder measures, through common telephony interfaces such as analog 2-wire POTS and digital DS1 interface, the delays and levels of multiple echoes. The improved second version was released in 2001 [2]. This 3rd generation Echo Sounder, currently implemented in Sage's 960 and 925, includes the following further improvements:

1. It now measures the transient echo (or echo convergence due to adaptive filtering inside an echo canceler).
2. It measures the far-end total return loss.
3. The test signal is much better designed to allow for the fast FFT-based cross correlation computation. The first 2 versions of Echo Sounder took about 8 seconds to perform a measurement. This 3rd generation of Echo Sounder takes less than 1.5 seconds.

The importance of echo control and echo measurement in a telephony network can never be overemphasized, and is well described in our previous papers. This document only explains the two newer additional measurements: the transient echo characterization, and the far-end total return loss.

2 Transient Echo Measurement

Figure 1 shows a hypothetical test signal $x(t)$ (top part of Figure 1) that Sage's Echo Sounder transmits into the network under test and the returned echo signal $e(t)$ (lower part of Figure 1) that is received by Echo Sounder. Notice that the scenario in Figure 1 applies to 4-wire interface only where the transmitted signal and received signal are nicely separated. But on a 2-wire POTS interface, the signal received by Echo Sounder contains not only the true returned echo signal, it also includes a copy of the transmitted signal that is leaked back to the receiver. Echo Sounder's unique advantage lies on its ability to recover the weak and transient true echo signal from the strong interfering signal caused by the 2-wire POTS interface.

The hypothetical echo return signal shown in Figure 1 contains 2 distinctive parts, the first 200 ms transient echo and the steady-state echo signal after 200 ms. More specifically, the echo signal first shows up at time delay 100 ms, with signal amplitude similar to the original transmitted signal. The echo signal's amplitude quickly "decays" down to about 0.2 times the original signal

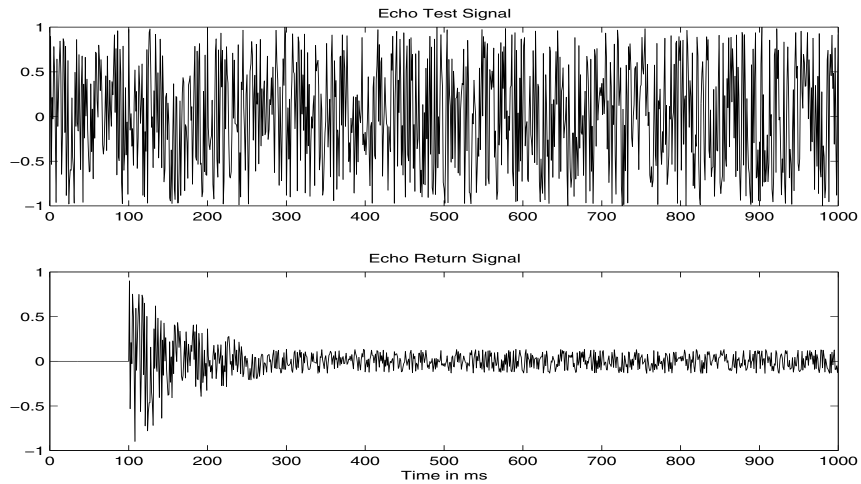

Figure 1: A hypothetical Echo Sounder test signal (top) and returned echo signal (bottom).

amplitude 200 ms later (at time index 300 ms). After time index 300 ms, the echo signal amplitude has stabilized.

The echo signal between 100 ms and 300 ms in Figure 1 can be considered as a transient echo. It is typically caused by the adaptive convergence of an echo canceler under test. The echo signal after 300 ms can be considered as steady-state echo, and its presence is detected through cross-correlation. An example of the cross-correlation trace using Echo Sounder's unique signal is shown in paper [2].

To characterize the transient echo, we approximate the transient echo with the following mathematical model:

$$e(t) \approx A(t - t_0)x(t - t_0)$$

where $A(t)$ is the "smooth" and decaying transient envelop that is amplitude-modulating the transmitted Echo Sounder signal $x(t)$. t_0 is the echo delay. Apparently, the decaying transient amplitude $A(t)$ and echo delay t_0 completely characterizes the intrinsic attributes of the transient echo. This 3rd generation Echo Sounder has a unique ability to recover the $A(t)$ signal and the delay t_0 from the received signal $e(t)$. The recovered $A(t)$ and t_0 is then presented in logarithmic scale as:

$$Echo_{transient}(t) = 20 \log 10(|A(t - t_0)|)$$

This is exactly what's been shown on Sage's 960. On Sage's 925, due to limited display space, the whole graph cannot be displayed. Instead, the user can enter a targeted convergence echo level (-50 dB, for example), and the test instrument will automatically measure the convergence time required for the transient echo to reach below -50 dB.

3 Far-end Total Return Loss

In a VoIP environment, the echo path may include certain lossy low-bit-rate vocoders. The returned "echo" signal may no longer be correlated with the original transmitted signal, therefor, Echo Sounder may declare it as "no-echo". But to a human listener, the returned signal still sound like severely distorted echoes. The Far-end Total Return Loss (FERTL) measurement is designed to address this issue.

When the test connection is a 2-wire POTS, the conventional analog-circuitry based ERL (Echo-Return-Loss) measurement does not discriminate between the near and far echoes. In fact, the near return echo always dominates the measurement reading. For example, the conventional 2-wire ERL measurement on 923/925 always gives a user 12 dB type of reading no matter whether or not there is a far-end echo (300 ms delay at -20 dB, for instance). From voice quality point of view, the near-end echo return is merely perceived as a side-tone. Only the far-end echo return is perceived as true annoying echo.

The new FETRL measurement will, through its unique signal design and correlation, suppress the returned signal power within the first 10 ms, and measure only the total returned power that is delayed more than 10 ms in the correlation-domain. For example, if FERTL measures 20 dB, this -20 dB is truly the echo return from the far-end, and it does not include the near-end echo return.

On Sage's 960 platform, where the test interface is 4-wire digital DS1, the FERTL measurement includes the returned signal power at all delays, just like the conventional ERL measurement.

References

[1] Renshou Dai, "A white paper on Sage's Echo Sounder Test," Sage Document, April, 2000.

[2] Renshou Dai, "White paper on Sage's Echo Sounder and Echo Generator," Sage Document, April, 2001.