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### 1.0 Where do echoes come from in the telephone network?

The public telephone networks create echoes where analog phone lines interface to the network. A 2-to-4 wire hybrid makes this interface in the switching equipment located at the telephone switching office, on-premise PBX, or Key System. Because the interface is not perfect, the voice signals echo at the hybrid. Wireless, Satellite, ATM, Frame Relay, Internet and Trunk systems introduce delay that makes the echo perceivable to the subscriber. Echo cancellers remove this echo. See Figure 1 below.

### 2.0 What is an echo canceller?

An echo canceller is a specially designed filter for removing echo created in the telephone network. It performs several tasks: it measures the echo path, adjusts an adaptive filter that estimates and replicates the echo, subtracts the replicated echo from the actual echo, and removes any residual echo by using non-linear processing techniques. These tasks are extremely complex DSP functions.

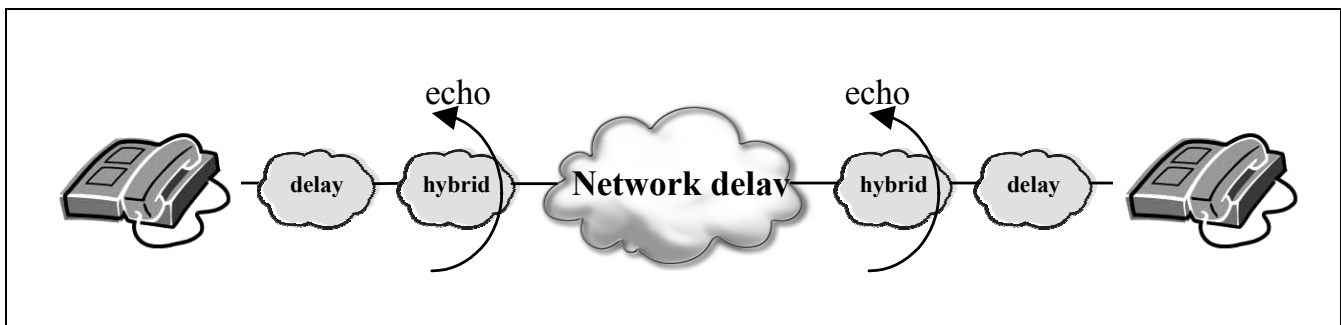


Figure 1 - Echo Sources

### 3.0 Why is a Non-Linear Processor needed?

Given 'non-linearities' in today's telecommunication systems, it is impossible to completely remove the echo with an echo canceller. A Non-Linear Processor is used to remove this residual echo. The background noise is also removed thereby creating an audible switching effect that is very annoying to the subscriber. The ZL502xx's Non-Linear Processor removes the residual echo and injects comfort noise at roughly the same loudness as the original background noise to mask-out this switching effect. The result is an excellent sounding telephone connection with no echo and switching effects. See Figure 2 below.

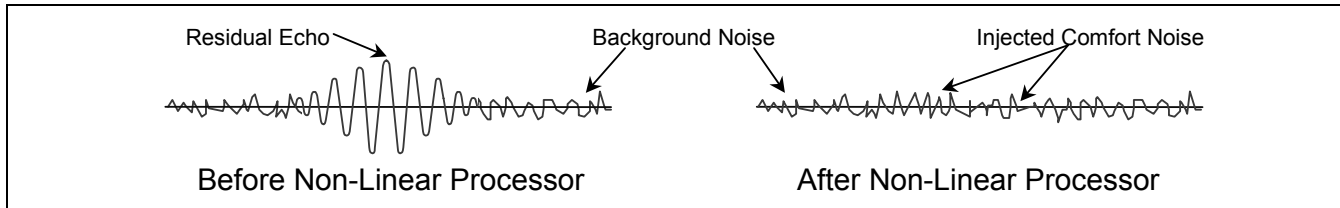


Figure 2 - Effects of NLP and Comfort Noise Injection

### 4.0 Why is Comfort Noise Injection needed?

When the NLP is activated, this results in an additional 30dB attenuation of the residual signal. To prevent a perceived decrease in background noise due to the activation of the NLP, a spectrally shaped comfort noise, equivalent in power level to the background noise, is injected. This keeps the perceived noise level constant. Consequently, the user does not hear the activation and de-activation of the NLP. Without comfort noise, the telephone line would appear to be 'dead' to the listener when the NLP is activated.

### 5.0 Why is Double-Talk detection needed?

Please refer to the diagram below. Talker A's speech and its echo "trains" the echo canceller to adapt and remove the echo. When talker B starts speaking, it interferes with talker A's echo causing the echo canceller to incorrectly adapt and worsen its performance. To prevent the effects of the interference from talker B, the ZL502xx VECs have Double-Talk detection. The Double-Talk detection determines when talkers A and B are speaking simultaneously and freezes the echo canceller to stay adapted and maintain excellent performance

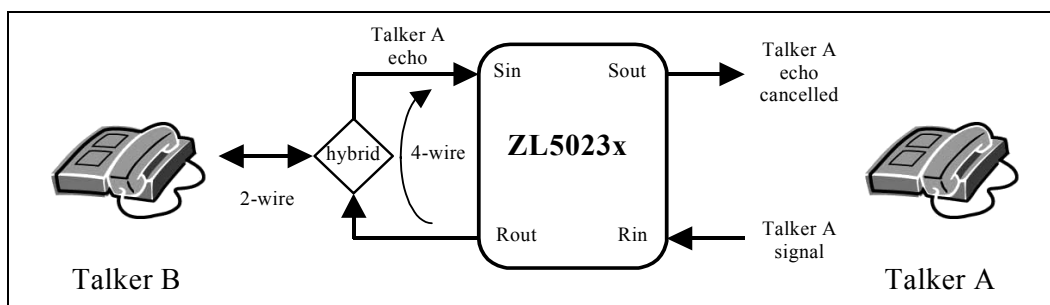


Figure 3 - Double-Talk Detection

### 6.0 Why is Disable Tone signal detection needed?

Recent vintage V.32/V.32bis/V.34 modems as well as fax machines have their own built-in adaptive filters designed to minimize bit-errors for high speed data transmission. Voice echo cancellers in the network can cause these adaptive filters to incorrectly adapt resulting in increased bit-errors during data transmission. To minimize bit-errors, manufacturers of V.32/V.32bis/V.34 modems expect to disable and bypass voice echo cancellers with a Disable Tone per ITU-T recommendations such as G.165. To support these transmissions, the ZL502xx has Disable Tone signal detection for each channel that allows bypassing of its echo canceller function. It is configurable for either ITU-T G.165 or G.164 recommendations.

## **7.0 Why is Narrow-Band signal detection needed?**

Once fully adapted, the echo canceller does a very good job of removing the echo. Narrow-Band signals such as DTMF and Call Progress tones can make the echo canceller incorrectly adapt and significantly worsen its performance. The Narrow-Band detector detects these discrete tones, and freezes the echo canceller to stay adapted and maintain excellent performance.

## **8.0 Why is a path change detector needed?**

The ZL502xx family of echo canceller has two convergence speeds, fast and slow. Fast convergence speed is used primarily during the initial convergence on an echo path. Once the VEC has converged, it switches over to a slow convergence speed in order to track subtle changes in the echo channel. This provides better performance with small path variations than simply staying in fast convergence all the time. When a major path change occurs though, the echo canceller needs to move from slow convergence back to fast convergence in order to quickly eliminate the new echo. The path change detector provides the push from slow to fast convergence.

## **9.0 How much delay is there through the ZL502xx VEC family?**

The throughput delay of the ZL502xx VEC varies according to the devices' state. For all active device configurations (normal, back-to-back and extended delay), Rin to Rout has a delay of two frames (250 $\mu$ s) and Sin to Sout has a delay of three frames (375 $\mu$ s). In Bypass mode, the Rin to Rout and Sin to Sout paths both have a delay of 2 frames (250 $\mu$ s). The ITU-T G.168 standard requires a maximum delay of 1ms, which the Zarlink families of VECs all easily exceed.

## **10.0 Why is power consumption in wireless base stations important?**

Installation cost of base stations is an important issue. If the base station is 'AC' or 'mains' powered, there is an additional cost to install a power outlet close to the base station. Most base station designs today are line powered from a centrally located access controller in an effort to minimize the installation costs. Most designers face very strict power consumption budgets to achieve the line powering objective, the ZL502xx consumes much less power (150 milliwatts typically for 32 channels) thereby facilitating the base station design. The ZL502xx has the ability to turn off the individual blocks when all the channels are not functional at the same time, thereby reducing the power consumption drastically.

## **11.0 Is the ZL502xx family of VECs suitable for speakerphone or acoustic applications?**

The ZL502xx family was designed for canceling network or 'electrical' echoes. Speakerphone or acoustic applications have a different set of complex problems involving room acoustics. The ZL502xx family was not designed to solve these acoustic problems; use the MT93L16 for acoustic applications.

## 12.0 Relevant VEC Terminology

**Acoustic Echo:** echo that occurs from sounds reflecting off surfaces in the surrounding environment

**Backplane:** A system bus residing on the motherboard of a card cage that connects to a series of connectors. Cards access the system bus by plugging into these connectors.

**CO:** Central Office

**COM:** Combined loss =  $ERL+ERLE+NLPlloss$

**Comfort Noise Insertion:** Ability to inject artificial background noise where the Non-Linear Processor removes residual echo. This has the effect of greatly improving subjective speech quality of the echo canceller.

**CPE:** Customer Premise Equipment.

**Decibel (dB):** the unit of measurement to measure sound pressure levels; it characterizes the way human beings actually perceive a sound

**DCME:** Digital Circuit Multiplication Equipment, this usually refers to satellite communications and multiplexers.

**Disable Tone Signal Detector:** Ability to detect "disable tone" signals to bypass the echo canceller.

**Double-Talk Detector:** Ability to detect the case when non-echo speech is present to freeze the echo canceller.

**DTDT:** Double Talk Detection Threshold

**DSP:** Digital Signal Processor or Digital Signal Processing.

**Echo Tail:** Refers to the length of an echo; usually measured in milliseconds (ms).

**End Path Delay (EPD):** A measure of the maximum delay the echo canceller can handle; usually measured in milliseconds (ms).

**EMC:** Electro Magnetic Compatibility.

**EMI:** Electro Magnetic Interference.

**ERL:** Echo Return Loss

**ERLE:** Echo Return Loss Enhancement

**ETSI:** European Telecommunications Standards Institute. A European standards body affiliated with the ITU.

**FCC:** Federal Communications Commission. American Government telecommunications regulatory body.

**FRAD:** Frame Relay Access Device. Also known as Frame Relay Assembler-Disassembler.

**Hybrid Echo:** see network echo

**ITU:** International Telecommunications Union. A worldwide standards body located in Geneva, Switzerland.

**KTS:** Key Telephone System.

**Lres:** Residual echo level =  $Lrin-ERL-ERLE$

**Lrin:** Receive-in power level

**Lsin:** Send-in power level

**Mean Opinion Score (MOS):** a standardized method used to subjectively evaluate the sound quality of telephone signals using actual people

**Narrow-Band Signal Detector:** Ability to detect discrete "tones" or sinusoids to freeze the adaptive filter in the echo canceller. Examples of 'tones' are DTMF signals and whistling.

**Network Echo:** echo that occurs where two-wire-to-four-wire conversion takes place

**Noise Reduction:** reducing the background noise by selective

**Non-Linear Processor (NLP):** A signal processing technique to remove residual echo that substantially improves subjective speech quality.

**NLPloss:** Amount of signal level reduction in dB provided by the NLP

**PBX:** Private Branch Exchange.

**PCS:** Personal Communication System, this usually refers to a public digital cordless or wireless system.

**PCM:** Pulse Code Modulation, this refers to digital coding of analog signals.

**PSTN:** Public Telephone Network or Public Switched Telephone Network.

**QoS:** Quality of Service.

**RES:** Residual echo signal

**RET:** Returned echo level =  $L_{rin} - COM$

**Rin:** Receive-in reference signal

**Rout:** Reference signal output, same signal as Rin except it is auto zeroed and may have been attenuated by internal gain pads.

**RSVP:** Resource Reservation Protocol.

**RTCP:** Real-time Transport Control Protocol

**RTP:** Real-time Transport Protocol.

**Sin:** Send-in signal, receive signal + return echo

**Sout:** Transmit output signal. The echo residual remaining after NLP.

**ST-Bus:** Serial-Telecom Bus, this refers to Zarlink's PCM highway standard.

**T.30:** Fax protocol standard.

**VoFR:** Voice Over Frame Relay.

**VoIP:** Voice Over Internet Protocol.

**VON:** Voice Over Net.

**VTOA:** Voice and Telephony Over ATM.

**V.32, V32bis, V34:** Analog modem standards.



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