ZLS38501

Firmware for Hands-Free Applications

Firrmware Data Sheet

January 2008

Features

- Selectable Acoustic and Line Echo Cancellers (AEC & LEC) plus patented Noise Reduction
- Programmable echo tail cancellation length from 8 to 256 ms
- AEC and Noise Reduction bypass for handset operation
- Noise reduction - up to 20 dB for white noise and up to 30 dB in a typical car environment
- Handles up to 10 dB acoustic echo return signal measured from Rout to Sin
- Handles up to -6 dB line echo return signal measured from Sout to Rin
- Fast re-convergence on echo path change
- No divergence due to double-talk (patented Adaption Control)
- Programmable gain at Rin, Sin and Sout to accommodate system requirements
- User gain control provided on speaker range (Rout) from -21 dB to +24 dB in 3 dB steps
- Programmable DC offset nulling filter cutoff frequency on send and receive paths
- 16-bit linear coding at acoustic interface (Rout & Sin)
- Programmable coding (μ/A-law ITU-T G.711 or 8-bit sign magnitude or 16-bit linear) at Line interface (Sout & Rin)
- Superior voice quality with patented Non-Linear Processor (NLP)
- Patented Narrow-band signal divergence protection
- Provides mute capability on Rout and Sout independently
- Patented Anti-howling - prevents oscillation in echo canceller audio path
- Speaker path AGC (Rout)
- Application specific tuneable performance
- Run-time programmable parameters

Applications

- Hands-free car kits
- Full duplex speaker-phone for digital telephone
- Echo cancellation for video conference systems
- Intercom Systems
- Security Systems

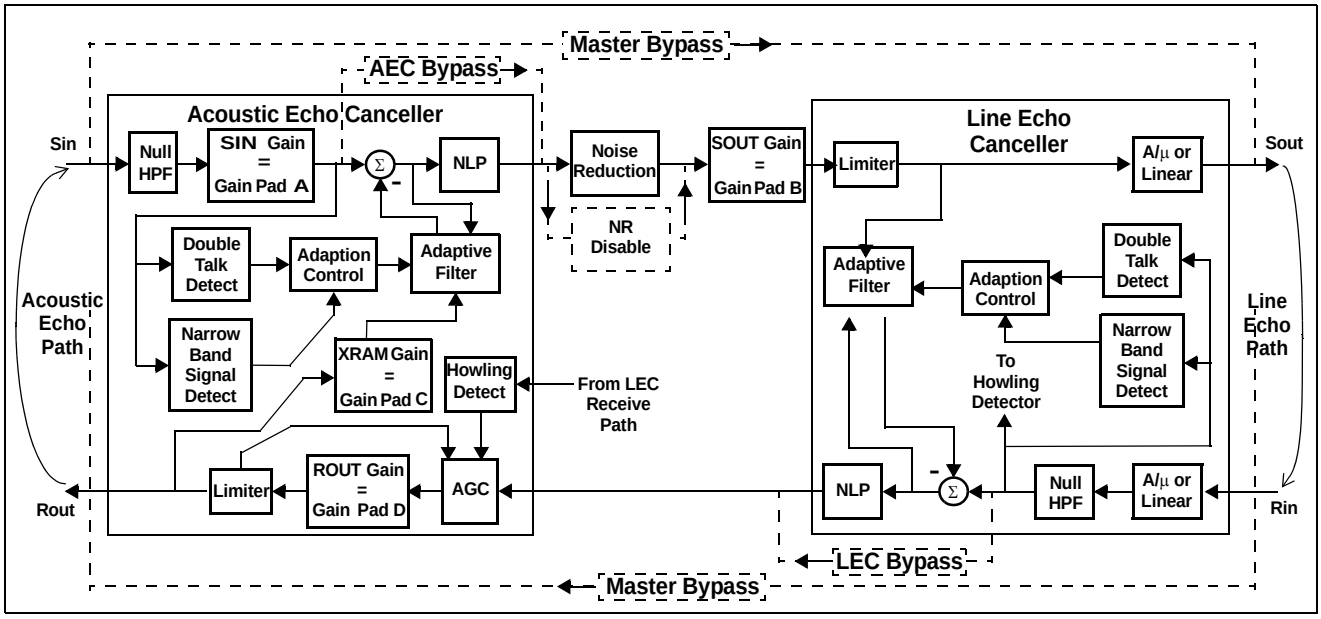

Figure 1 - Firmware Block Diagram

1.0 Functional Description

ZLS38501 is firmware that runs on the ZL38005 (Advanced Acoustic Echo Canceller with Noise Reduction) hardware platform to realize audio applications requiring acoustic echo cancellation and noise reduction.

2.0 Firmware Algorithm Description

The ZLS38501 application firmware contains two echo cancellers which can be configured to provide one channel of echo cancellation in back to back mode. One for echo canceller to cancel Acoustic echo and the other to cancel line echo, providing full-duplex echo cancellation.

The echo canceller used on acoustic path is called acoustic echo canceller (AEC) and the one used on line echo path is called line echo canceller (LEC).

Each block can be bypassed allowing a AEC or LEC mode only. The intended platform (ZL38005) has a 256 ms filter that can be divided up between the AEC and the LEC. If the firmware is configured in AEC only mode then the AEC can cancel echo tails up to 256 ms. If the firmware is configured with both AEC and LEC active (in a back to back configuration) then the 256 ms must be shared between the AEC and LEC (i.e., 192 ms for AEC and 64 ms for LEC). The echo tail lengths are programmable in 8 ms blocks.

The ZLS38501 application firmware contains the following sub-functions:

- **Offset Nulling filter**: removes DC signal from either RIN or SIN input signal
- **Gain pad**: used to adjust signal levels at SIN, SOUT and ROUT
- **Limiter**: used to limit ROUT and SOUT signals to certain maximum values
- **Adaptive Filter**: learns echo path adoptively and cancels the echo in acoustic side or line side
- **Non Linear Processor (NLP)**: Non-linear processor for reducing echo residual to a negligible level
- **Narrowband Detector**: detects narrowband signal coming from either send path or receive path. The presence of narrowband signal will affect adaptive filter operations
- **Double Talk Detector**: detects double-talk situation. It will affect NLP and adaptive filter operations
- **Adaptation Control**: control adaptation speed of adaptive filter based on DT and NB conditions
- **User Gain**: adjusts speaker volume
- **Automatic Gain Control (AGC)**: Automatic gain control at speaker side to prevent clipping and howling
- **Howling detector**: detects howling caused by positive feedback in the loop. When howling is detected, the AGC gain is reduced to eliminate the howling
- **U/Alaw-Linear**: converts PCM (mu-law or a-law) data to linear data
- **Linear-U/Alaw:** converts linear data to PCM (mu-law or a-law) data

2.1 Acoustic Echo Canceller (AEC) Description

The AEC provides high performance full-duplex operation similar to network echo cancellers. That is, the AEC will provide clear speech and uninterrupted background signals that occur during normal conversations, without the sound quality problems associated with “noise gating” or “noise contrasting”. The AEC does not use variable attenuators during double-talk or single-talk periods of speech, as do many other speakerphone acoustic echo cancellers. This guarantees clear signal transmission in both transmit and receive audio paths even in the presence of low level signals.

The AEC uses an advanced adaptive filter algorithm that is double-talk stable - allows convergence even when both parties are talking. This algorithm continuously tracks changes in the echo path, regardless of double-talk, as long as a reference signal is present.

2.2 Line Echo Canceller (LEC) Description

The LEC filter adapts to the echo path and generates an estimate of the echo signal. This echo estimate is then subtracted from the echo path. The echo tail length of the LEC is programmable up to 256 ms in 8 ms steps.The LEC meets the ITU-T G.168 recommendations. The convergence time in most test cases is less than 100 ms.

2.3 Adaptive Filter

The adaptive filter adapts to the echo path and generates estimate of the echo path. This replica is subtracted from the return signal. The resulting echo cancellation is monitored and the estimated echo updated.

2.4 Non-Linear Processor (NLP)

When the AEC/LEC functions have converged and a single talk (i.e., Rin to Rout incident audio signal; no return Sin to Sout audio, or Sin to Sout incident audio signal; no return Rin to Rout audio) condition exists there will be low level echo on the return path due to ADC and DAC quantization errors. The AEC/LEC echo cancellation algorithms cannot predict quantization errors; therefore, this small amount of echo (i.e., residual echo) will not be cancelled. The NLP algorithm, illustrated in Figure 2, replaces this residual echo signal with a background noise signal that diminishes to zero with time. This background noise has the same signal strength and same spectral characteristics as the original signal.

During normal operation when the input signal level of the NLP is below the background noise level, the filter of Figure 2 will learn the background noise level through switch SW1. When the input signal level is above the background noise level and the signal is residual echo, the Filter input will be zero through SW1 and the filter output signal will pass through SW2 to Sout. When the input signal level is above the background noise level and the signal is no dominated by residual echo SW2 will bypass the NLP and the filter input will be connected to zero.

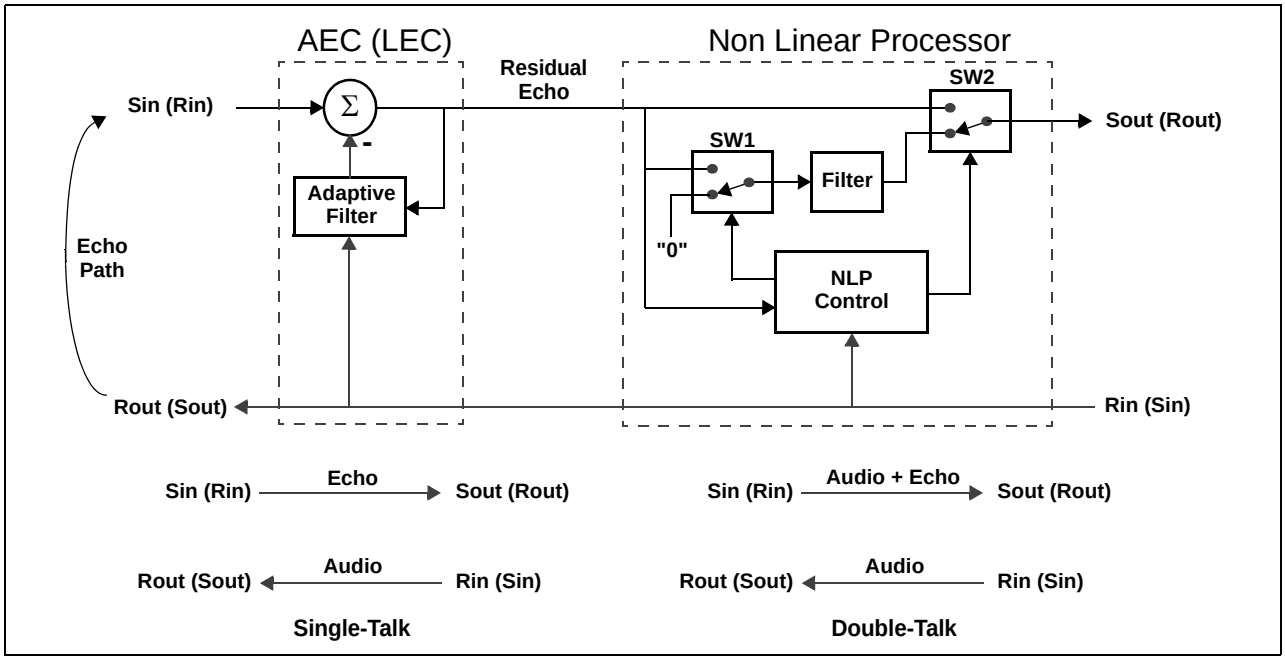

Figure 2 - NLP Block Diagram

2.5 Narrow Band Signal Detector (NBSD)

Narrow band signals such as single or multi-frequency tones (e.g,. DTMF, or signalling tones) present in the reference input of an echo canceller for a prolonged period of time may cause the adaptive filter to diverge. The Narrow Band Signal Detector (NBSD) is designed to prevent this divergence by detecting single or multi-tones of arbitrary frequency, phase, and amplitude. When narrow band signals are detected, the filter adaptation process is stopped but the echo canceller continues to cancel echo.

2.6 Howling Detector (HWLD)

The Howling detector is part of an Anti-Howling control algorithm that prevents oscillation as a result of positive feedback on the audio paths. When howling is initially detected the AGC at Rout will reduce the signal level by 6 dB. If howling persists then the AGC will decrease the signal level by an additional 6 dB. This continues until the howling stops. At this point the AGC will increase the its gain to determine if the howling begins again. If it does then the AGC gain is reduced again. If the howling condition does not exist then the AGC will increase its gain in 6 dB steps until the user defined signal level (without howling) is reached.

2.7 Programmable High Pass Filter (Offset Nulling Filter)

Programmable high pass filters are placed at the Sin and Rin ports, Figure 1. These filters have two functions: first, to remove any DC offset that may be present on either the Rin or the Sin ports; and second, to filter low frequency (below 400 Hz) noise such as road noise.

2.8 Limiters

The limiters on the send and receive paths prevent the Rout and Sout output signal levels from exceeding a preset limit.

2.9 User Gain

The User Gain function is used to adjust the speaker volume outside the echo path. This gain is optimally placed outside the echo path so re-convergence is not necessary after gain changes. It is important to use ONLY this gain pad to adjust the speaker volume during normal operation. This gain is adjustable from -24 to +21 dB in 3 dB steps.

2.10 Automatic Gain Control (AGC)

The Automatic Gain Control (AGC) is used to automatically adjust the input speech level of the audio signal to a predetermined output value. The AGC automatically decrease the speaker path gain during the following conditions:

- when clipping of the receive signal occurs at Rout,
- when initial convergence of the acoustic echo canceller detects unusually large echo return, and
- when howling is detected

2.11 Programmable Gain Pad

The AEC has gain pads associated with Sin (Gain Pad A), Sout (Gain Pad B) and the AEC adaptive filter (Gain Pad C). These gain pads are intended to be set once during initialization and not adjusted during normal operation. Their purpose is to help fine tune the performance of the acoustic echo canceller for a particular application.

2.12 Mute Function

Mute functions are provided for independent control of the Receive (Rin to Rout) and Send (Sin to Sout) audio paths. Setting the MUTE_R or MUTE_S bits causes quiet code to be transmitted on the Rout or Sout ports respectively.

LINEAR 16 bits 2's complement	SIGN/ MAGNITUDE μ/A-Law	CCITT (G.711)	
		μ-Law	A-Law
0x0000	0x80	0xFF	0xD5

2.13 Master Bypass

When the Master Bypass function is active, PCM data passes transparently from Rin to Rout and from Sin to Sout, with bit-wise integrity preserved. When then this mode of operation is selected, most internal functions are automatically powered down to reduce power consumption.

2.14 AEC Bypass

The AEC bypass function allows send and receive PCM data to pass around the AEC function with bit-wise integrity preserved (i.e., the echo estimate from the AEC adaptive filter is not subtracted from the Send path). This mode of operation does not affect the normal operation of other functions.

2.15 LEC Bypass

The LEC bypass function allows send and receive PCM data to pass around the LEC function with bit-wise integrity preserved (i.e., the echo estimate from the LEC adaptive filter is not subtracted from the Send path). This mode of operation does not affect the normal operation of other functions.

2.16 Adaptation Control

The adaptation control block regulates the convergence speed of the adaptive filter. When adaptation is disabled by the user the current echo profile is frozen and used to continue cancelling echo. In this state changes in the echo path are not tracked. Additionally, the Adaptation Control block supports the following:

- Freeze filter adaptation when narrow band signal is detected
- Freeze filter adaptation when no active far-end speech appears
- Increase convergence speed when active near-end speech is absent
- Decrease convergence speed when low level double talk is present
- Decrease convergence speed further (or freeze adaptation) when high-level double talk is detected

For more information about all Zarlink products visit our Web Site at

www.zarlink.com