WS6318 Acoustic Echo Cancellation

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APN Content Level	BASIC		INTERMEDIATE	✓	ADVANCED		Confidentiality	Public	✓	Private	

Hardware Compatibility	Product Line	AirPrime	Series	WS6318	

Software Compatibility	ALL

1 Version

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2 Introduction

This APN (Application Note) is provided to Sierra Wireless distributors and clients to aid more rapid development of embedded applications using the Sierra Wireless portfolio of cellular solutions. To request a new application note, contact your regional Sierra Wireless Product Marketing Manager.

3 Application Note Description

This Application Note describes the hands-free solution available on AirPrime WS6318 module.

A brief explanation of the hands-free solution is followed by a detailed presentation covering:

- Overview, block schematic
- Parameters explanation
- Tuning guidelines & default parameters.

4 Glossary

Terms	Description
Acoustic Echo	Echo resulting from the acoustic coupling between the application loudspeaker and the application microphone.
AEC	Acoustic Echo Cancellation
Comfort noise	Process of inserting synthesized noise in the transmitted audio to overcome shifts in the background noise transmission level due to imperfect full duplex ability of the echo suppression. It also helps masking the residual echo.
CPU	Central Processing Unit
Double talk situation	Belongs to the echo cancellation terminology, and refers to situations where both near end speech and far end speech are present (full duplex).
DSP	Digital Signal Processor
Echo cancellation	Process of canceling the echo signal without altering the near end speech transmission quality, thus preserving full duplex quality.
Echo suppression	Process of suppressing the echo signal in a non-linear way, thus decreasing the full duplex quality.
FAP	Fast Affine Projection
FIR	Finite Impulse Response
Full duplex	Transmission of speech in both directions simultaneously
Half duplex	Transmission of speech in one direction at a time
Near end speech	Speech locally generated by the local user.
NR	Noise Reduction
Residual Echo	Echo that isn't cancelled completely by the echo canceller

Terms	Description
Rx	Receive
Single talk situation	Belongs to the echo cancellation terminology, and refers to situations where only far end speech is present.
Switch attenuation	Basic echo suppression process consisting in attenuating the transmit gain whenever far end speech or echo is detected, thus altering the full duplex quality.
Tx	Transmit

5 Overview

5.1 Purpose

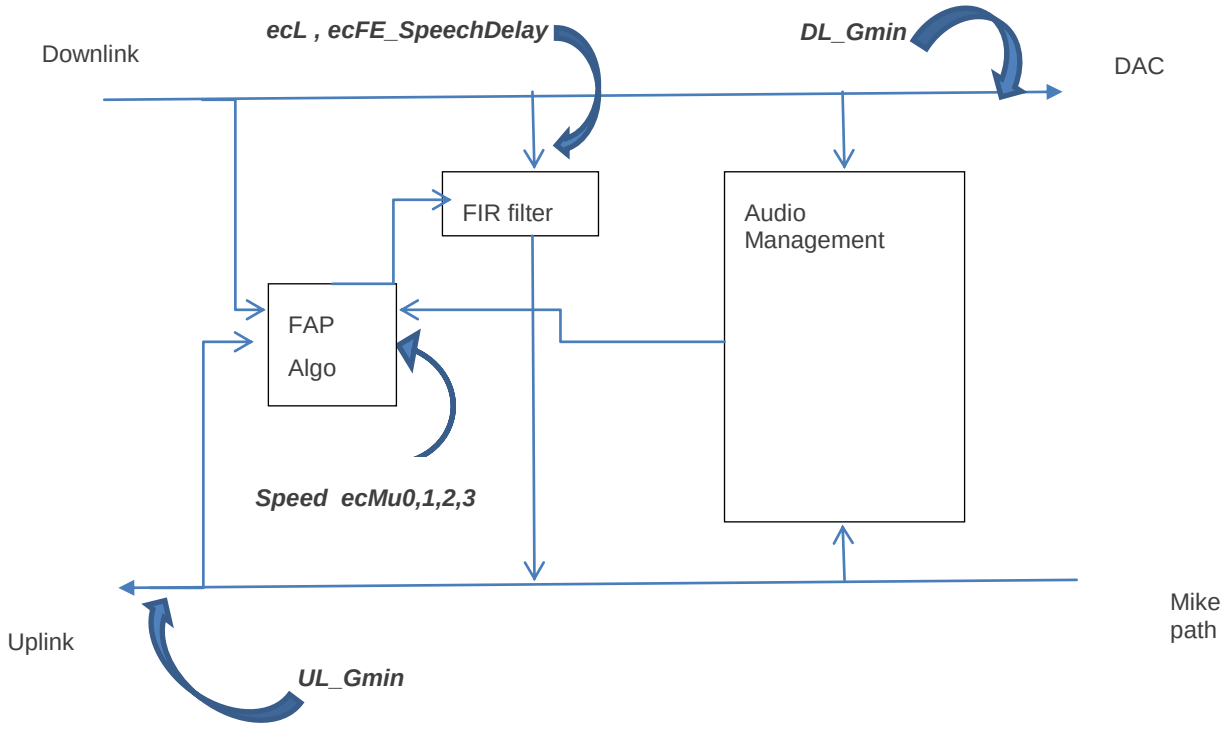
Acoustic echo cancellation is needed for hands-free operation (hands-free car-kit or handset with high loudspeaker volume) and is also useful in normal operation when the acoustic coupling between the microphone and the loudspeaker is high.

The purpose of the hands-free solution is to cancel the echoes without altering the near end speech, and to reduce the background noise picked up by the microphone.

Note that the echoes are generated on the application side but they are perceived by the distant speaker only, and they are only present when the distant speaker is talking. Echoes perceived by the near-end speaker come from the far-end side (or from the line) and the echo canceller cannot process them.

5.2 Block Schematic

The building blocks are shown in the figure below.



6 Parameter Set

6.1 Parameter Set Overview

The hands-free solution is controlled via 8 parameters. This parameter set makes the solution very flexible, so that it can be efficient in all situations, and it enables the user to customize the hands-free to their own specific needs and tastes.

The parameters are set through the “AT+WMECHO” command. The syntax for this command is detailed in the AT Command and Parameter Map section.

Default parameters set for the most common situations are provided in the section on Tuning guidelines.

6.2 Parameter Description

6.2.1 DL_Gmin: DL Echo Suppressor Attenuation

The echo suppressor is basically used to reduce the downlink path level during double talk operations.

During double talk, the DL echo suppressor applies a programmable attenuation.

Echo suppression in the downlink path should only be used if all other echo control functions fail to provide adequate performance.

6.2.2 UL_Gmin: UL Echo Suppressor Attenuation

The uplink path includes an echo suppressor. Its goal is to reduce the mike path gain in case of potential echo,mainly when the downlink path is active.

When the downlink path is inactive, the echo suppressor has unity gain. When the downlink path is active the uplink path gain is set to a configurable value.

6.2.3 ecL Filter Length

One of the main components of the EC is the FIR filter (see the figure above).

The main parameter of the FIR filter is its length. The longer the length, the better the precision of the low frequency model of the external transfer function.

Furthermore, the echo canceller can compensate for long delays between loudspeaker and mike (e.g., compensate for some large room wall sound reflection).

On the other hand, a large number of coefficients increase the risk of wrong adaptation, especially for the longer delaytaps.

So the FIR filter length has to be tuned following the real mode of operation of acoustic devices. A basic length is 256 but shorter lengths (down to 50~70 for example) could give very good results (stable and precise) if the echo transfer function has relatively short delay and emphasizes higher frequencies.

The tuning parameter is: ecL Filter length

6.2.4 ecFE_SpeechDelay

After the point where the EC is picking up the downlink voice, the signal is passing through different buffers. This adds an inherent delay between the EC image of downlink signal and the speaker one.

This delay is determinist and has to be compensated in order to minimize the FIR filter length and to reach an optimal functioning of the different meters.

The echo canceller includes then a delay line at the point it senses the downlink signal. When well tuned, this delay line would realign perfectly the downlink signal used by the EC algorithm with the mike signal. By default the delay is 125samples when a 32 taps FIR filter is enabled. It has to be recomputed if the uplink path filtering is changed (no more FIR filter for example).

The tuning parameter is: ecFE_SpeechDelay

6.2.5 ecMu Parameters

The modified FAP (Fast Affine Projection) is an efficient algorithm to accelerate convergence of the predictor filter.

The modified FAP algorithm updates the FIR filter coefficients at a tunable speed.

The faster the speed the quicker the echo canceller can converge. On the other hand, a faster speed places the EC is a less stable state permitting more rapid divergence if the EC is tuned during double-talk, etc.

The main full speed of FAP algorithm can be adjusted using: ecMu: FAP full speed

6.2.5.1 ecMu0, ecMu1, ecMu2, ecMu3

The echo canceller provide a multiple offering of convergence speed following the certainty ofdouble talk activity. 5 speeds are automatically selected:

1. Fast convergence speed: the double talk probability is very low, the FAP algorithm is set to full speed: full speed (set by ecMu0)
2. Med-high convergence speed: the double talk probability is low but false detection is possible: full speed * ecMu1
3. Med-slow convergence speed: double talk is probable but maybe it is false detection: full speed * ecMu2
4. Slow convergence speed: double talk is certain: full speed * ecMu3
5. Null speed: no downlink activity, adaptation is stopped:0.

7 Standard AT Commands

A command is issues for enabling or disabling the RX and TX Acoustic Echo Cancellation (AEC), and Noise Reduction (NR). It can also configure the TX Echo Cancellation and Suppression values. For a detailed presentation of this command, refer to the AT commands Interface Guide [1].

The following tables present an overview of this command and the correspondence between the command's arguments and the hands-free algorithm's parameters.

AT Command Syntax		
AT+WMECHO=<eState>,<nState>[,<speaker_id>[,<ecL>[,<ecMu0>[,<ecMu1>[,<ecMu2>[,<ecMu3>[,<ecFE_SpeechDelay>[,<esUL_Gmin>[,<esDL_Gmin>]]]]]]]]		
Parameter	**Values**	**Description**
< eState >	0,1	enabling or disabling the RX and TX Acoustic Echo Cancellation (AEC) 0: AEC is off 1: AEC is on
< nState >	0,1	enabling or disabling the RX and TX Noise Reduction (NR). 0: NR is off 1: NR is on
< speaker_id >	1,2,3	1: Speaker 1 2: Speaker2 3: PCM

The other parameters configure the echo cancellation as follows.

+ECHO parameter	**Parameter**	**Allowed range**	
		min	**max**
< ecL >	Filter length in number of coefficients	0	382
< ecMu0>	Speed for FAP algorithm (Fast convergence speed)	0x0000	0xFFFF
< ecMu1>	Reduction coefficient of FAP speed (medium-high convergence speed)	0x0000	0xFFFF
< ecMu2>	Reduction coefficient of FAP speed (medium-slow convergence speed)	0x0000	0xFFFF
< ecMu3>	Reduction coefficient of FAP speed (slow convergence speed)	0x0000	0xFFFF
< ecFE_SpeechDelay >	Number of sample	80	200
< UL_Gmin >	UL attenuation of echo suppression	0x0000	0xFFFF
< DL_Gmin >	DL attenuation of echo suppression	0x0000	0xFFFF

8 Tuning Guidelines

For proper operations (efficient echo cancellation with preserved speech quality), it is necessary to customize the algorithm to the application that will embed AirPrime Embedded Intelligent Modules.

Two typical situations are described (handset and hands-free), and a default parameter set is given for each of them. These parameter sets can be used in almost all situations, giving satisfying results.

If needed, the most relevant parameters are also highlighted to help improving the performances. For further tuning, the parameter set corresponding to the application should be used as a starting point.

8.1 Handset

This use case concerns applications with a handset (that is application with low loudspeaker volume, where the handset is held near the ear). In these kinds of applications, the acoustic echo path is rather short.

8.1.1 Default Parameter Set

Parameter	Value
< ecL >	100
< ecMu0>	3E80
< ecMu1>	3E6F
< ecMu2>	12BB
< ecMu3>	0320
< ecFE_SpeechDelay >	150
< UL_Gmin >	5A9D
< DL_Gmin >	0148

8.2 Hands-Free and Car-Kit

This use case concerns hands-free applications (that is application with high loudspeaker volume, where the loudspeaker is not held near the ear). It includes car-kit applications. In these kinds of applications, the acoustic echo path is rather long, and the background noise can be high.

8.2.1 Default Parameter Set

Parameter	Value
< ecL >	180
< ecMu0 >	3E80
< ecMu1 >	3E6F
< ecMu2 >	12BB
< ecMu3 >	0320
< ecFE_SpeechDelay >	180
< UL_Gmin >	2879
< DL_Gmin >	0148

9 Reference Hardware

None

10 Software Compatibility Matrix

List all current software configurations and compatibility with this application note.

Firmware	Sierra Wireless Software	Plug-Ins
L3x	N/A	N/A

11 Support

For direct clients: contact your Sierra Wireless FAE

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12 Document History

Revision	Date	Document History
1.0	August 1, 2013	Creation

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