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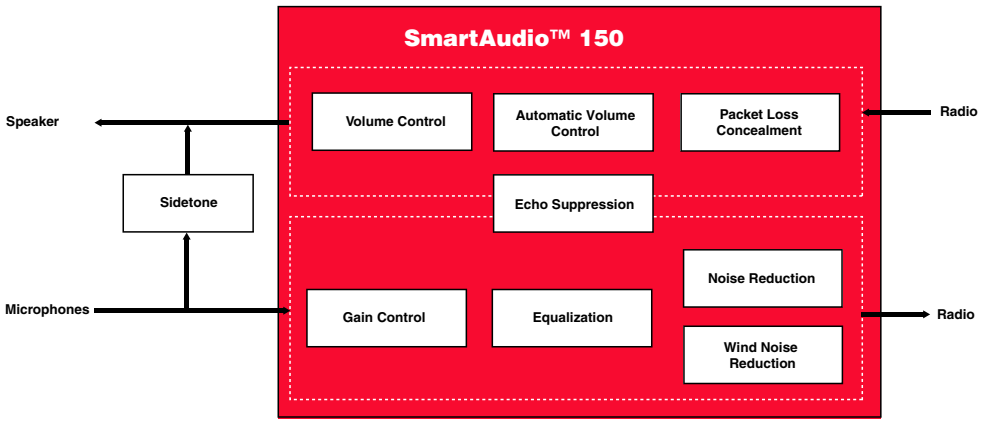
SmartAudio™ 150

Innovative Sound and Voice Enhancement Technology

TECHNICAL BRIEF



SmartAudio™ 150 Block Diagram

INTRODUCTION

The BCM2044S is a monolithic 0.13-µm single-chip Bluetooth® wireless audio solution. SmartAudio™ 150 (SA150) is a single-microphone mono-headset voice processing engine that provides a variety of audio enhancement features for both headset user and the remote talker. Each component of SmartAudio 150 is configurable and can be tuned to meet the performance and the design requirements of headset manufacturers.

The figure above illustrates the high-level block diagram of SmartAudio 150. Blocks on the send (microphone) path enhance the speech quality perceived by the remote listener. Similarly, each block on receive (speaker) path improves the remote talker's speech as perceived by the headset user.

FEATURES AND BENEFITS

Send Path

- Sub-band Wind Noise Reduction eliminates turbulent input due to wind from the microphone signals. Typical operating range is up to 14 dB of wind noise reduction.
- Sub-band Noise Reduction consists of a sub-band noise reducing module. This algorithm reduces the effect of background noise on the headset user's speech and improves the quality and intelligibility for the remote listener in noisy environments. The amount of noise reduction is configurable. The typical operating range is up to 18 dB for stationary and 14 dB for non-stationary noise.
- Sub-band Echo Suppression eliminates the echo that occurs from coupling between the speaker and microphones.
- Sub-band Send Equalization equalizes the overall send path frequency response.
- Digital Send Gain Control can boost the gain without affecting the Send equalizer and Echo suppression parameters, programmable via a configuration file.

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Receive Path

- Packet Loss Concealment (PLC) repairs damaged or lost packets for dramatic intelligibility improvements.
- Automatic Volume Control (AVC) not only increases the speaker volume as the noise in the environment increases, but also adjusts or normalizes the speaker volume based on receive speech level.
- Sidetone enables a more natural sounding headset and eliminates the perceived need to yell over background noise.
- Receive Volume Control controls the volume control on the headset and is programmable via a configuration file. The volume table in the configuration file allows up to 16 volume steps, and can range from –40 dB (silent) to 8 dB receive gain.

APPLICATIONS

- Mono headset connected to a cell phone.
- Mono headset connected to a PC for VoIP applications.

DESCRIPTION

Wind Noise Reduction

The SA150 Wind Noise Reduction algorithm reduces the acoustic noise caused by wind deflection of the microphone membrane. It leads to improved speech intelligibility in moderate wind situations and a reduction in the perceived noise level. Wind noise is often annoying and leads to listener fatigue; it is impulsive, with a high amplitude that may exceed the nominal speech amplitude. The noise is caused by turbulent airflow over the microphone. It has signifcant bursts and gusts lasting from a few milliseconds to a few seconds.

The algorithm detects windy sections of a call by monitoring a number of signal attributes in the time and frequency domains. In sections containing wind noise, various degrees of attenuation are applied to the appropriate sections of the spectrum, proportional to the level of wind noise detected. The effect of wind noise reduction is noticeable when listening for a few minutes on a call in a windy environment, as the listener experiences less overall fatigue from the otherwise high amplitude of the impulsive wind noise. The algorithm becomes transparent when no wind is present, and also gradually disengages (i.e., provides minimum attenuation) in severe wind conditions. This mitigates against the speech distortion that would occur as a result of aggressive attenuation in these cases.

Sub-Band Noise Reduction

There can be various noise sources in the environment where the headset operates. The noise can vary in level and can change in nature. Examples of noise sources are car engines, background noise on a street, a restaurant or a pub, or an office environment. The SA150 Sub-band Noise Reduction algorithm further reduces the acoustic noise beyond that accomplished by the Wind Noise Reduction logic.

SA150 Sub-band Noise Reduction monitors the level of speech and background noise in different sub-bands and calculates a target desired Signal-to-Noise Ratio (SNR). Noise reduction is carried out in a manner that provides the best overall voice quality. The adverse effects on the naturalness and clarity of the user's speech are, therefore, avoided or minimized.

The noise reduction parameters are specified in the configuration file. The typical operating range is 18 dB for stationary noise and 14 dB for non-stationary noise.

Sub-Band Echo Suppression and Comfort Noise Generation

Echo refers to the speaker signal that is coupled or leaked in the microphone path. Echo can be a major source of audio distortion and can impair mobile communication. The amount of echo can depend on the type of transducers, headset design, and the acoustic environment. The SA150 Sub-band Echo Suppression algorithm

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relies on a Broadcom® proprietary technology deployed across several product lines in telephony and VoIP markets. This core technology was adopted for the Bluetooth framework and is fully integrated with the Wind Noise Reduction and the Acoustic Noise Reduction blocks.

SA150 Sub-band Echo Suppression closely monitors the amount of echo per sub-band in the microphone signal and then determines the best echo suppression parameters in order to maintain full-duplex communication. Where echo is perceivable in the absence of headset user speech (and when headset user's background noise is well-estimated), the microphone signal is replaced by comfort noise in the sub-bands. The SA150 Sub-band Echo Suppression parameters are adjusted in the configuration file.

Send Path Equalization

The role of the equalizer is to compensate for any frequency shaping introduced by the microphone. The equalizer is programmable via the configuration file and adjusts the response in 29 different sub-bands. The headset manufacturer can adjust the parameters of the equalizer based on the type and the placement of the transducers, the mechanical design, and the desired send frequency response.

Packet Loss Concealment

Radio interference can result in corruption or loss of audio data. This can lead to significant audio quality degradation. The Packet Loss Concealment algorithm reconstructs lost speech samples and significantly improves voice communication quality. The SA150 PLC algorithm is based on ITU-T G.722 Appendix III, a worldwide standard developed at Broadcom. This state-of-the-art technology has been adapted to address the unique challenges of audio communications over a Bluetooth link. PLC uses the past speech information to substitute missing data with an approximate version of the missing speech. By doing so, it eliminates the unpleasant, audible effect of radio interference.

Automatic Volume Control

Automatic Volume Control (AVC) adjusts the speaker volume based on the amount of noise in the headset environment as well as the receive speech level. AVC constantly monitors background noise and volume settings. When the ambient noise exceeds a threshold, AVC gradually increases the volume, and when the background noise level drops below the threshold, the volume level will go back to the normal level. This eliminates the need for manual volume control adjustment during noise environment changes. The AVC also monitors the receive speech levels and normalizes the speech based on the speech level, meanwhile providing protection against clipping and false gain increases on background noise. The net result is a more pleasant listening experience and better intelligibility of the remote talker's speech. All AVC parameters are tuned via the configuration file.

Sidetone

The SA150 includes a sidetone algorithm that provides a low-volume version of the user's speech at the headset speaker. Allowing the user to hear his own voice prevents the user from yelling over background noise that is already suppressed by other SA150 algorithms. In addition, the sidetone algorithm provides a more natural sound when using a headset with an ear seal. Finally, the sidetone algorithm provides an effective wind noise detector for the user by passing any wind noise generated at the microphone back to the user's ear.

SUMMARY

Broadcom's SmartAudio 150 single-microphone mono-headset voice processing engine offers a rich set of speech enhancement algorithms on the BCM2044S platform, allowing for a clear and pleasant headset audio experience.

For more detailed information, refer to the BCM2044S technical documentation available on the Broadcom Corporation Customer Support Portal, or contact your Broadcom Corporation sales representative for assistance.

To achieve this breakthrough in audio clarity and quality, we've leveraged unique technologies from our deep communications portfolio, which, coupled with our considerable expertise in Bluetooth, has resulted in a powerful new platform that addresses existing audio headset deficiencies

---- Craig Ochikubo, Vice President, General Manager of WPAN/Bluetooth

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