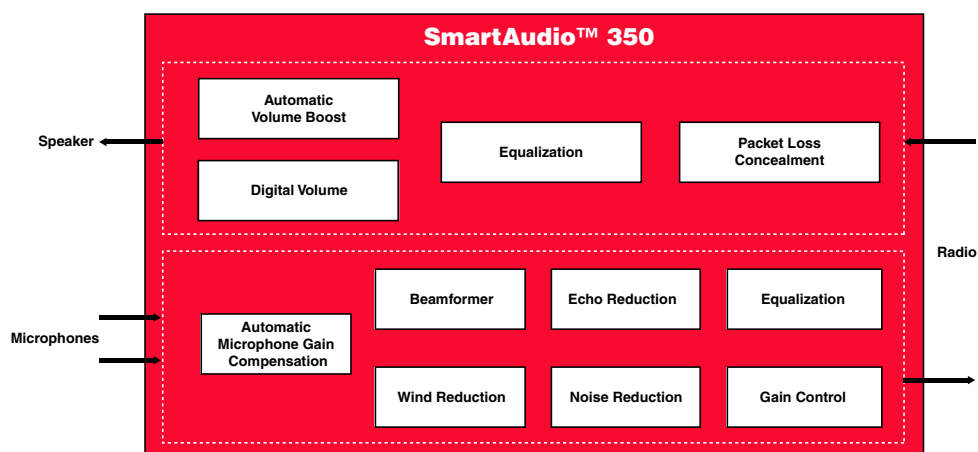




# SmartAudio™ 350

Innovative Sound and Voice Enhancement Technology

## TECHNICAL BRIEF



SmartAudio™ 350 Block Diagram

### FEATURES AND BENEFITS

#### Send Path

- Automatic Microphone Gain compensation ensures that the sensitivity between the two microphones remains matched through the device life.
- Wind Noise Suppression eliminates the wind noise from the microphone signals. Typical operating range is 30 dB of wind noise suppression.
- Sub-band Noise Reduction consists of a Sub-band Beamformer followed by a Sub-band noise reduction module. These algorithms reduce the effect of background noise on headset user's speech and improve 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 Reduction eliminates the echo, which occurs from coupling between the speaker and microphones.
- Sub-band Send Equalization equalizes the overall send path frequency response.
- Digital Send Gain Control

### INTRODUCTION

The BCM2047 is a monolithic 0.13- $\mu$ m single-chip Bluetooth® wireless audio solution. SmartAudio™ 350 (SA350) is a dual-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 350 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 350. Blocks on the send (microphone) path enhance the speech quality perceived by the remote talker. Similarly, each block on receive (speaker) path improves the remote talker speech as perceived by the headset user.

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### Receive Path

- High-Performance Packet Loss Concealment (PLC), optimized specifically for Bluetooth voice communication.
- Automatic Volume Control (AVC) increases the speaker volume as the noise in the environment increases.
- Receive Path Equalization equalizes the speaker frequency response.
- Digital Receive Volume Control
- Sidetone enables a more natural sounding headset, and prevents “yelling” over background noise.

### APPLICATIONS

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

### DESCRIPTION

#### Microphone Automatic Gain Compensation

The sensitivity of microphones is typically specified within an operating range. In a dual-microphone headset, gain mismatch between the two microphones is a common phenomenon. In addition, the gain characteristics of the microphones may vary during the lifetime of a device. To optimize the performance of the SmartAudio algorithms, it is desirable to minimize or eliminate this gain mismatch. SA350 Automatic Microphone Gain compensation tracks the gain mismatch between the two microphones and compensates one channel to match the other.

#### Dual-Microphone Sub-Band Wind Noise Suppression

SA350 dual-microphone Wind Noise Suppression relies on the state-of-the-art technology that can reliably and rapidly distinguish between wind and speech, without introducing any processing delay. The Wind Noise Suppression algorithm operates independently in different sub-bands. Hence, it

allows wind in the contaminated bands to be suppressed while keeping speech intact in clean sub-bands. SA350 dual-microphone Wind Noise Suppression achieves up to a 30 dB reduction in wind noise.

#### Dual Microphone Sub-Band Beamforming

Beamforming is a spatial filtering technique that reduces the undesired noise signal in the headset environment. The SA350 dual-microphone sub-band Beamforming algorithm can steer a null in the direction of dominant noise source. The algorithm operates independently in different sub-bands. For diffuse noise, the Beamformer achieves suppression of up to 5 dB (close to the theoretical limit of 6 dB). For a localized noise source (not facing the headset user), suppression of up to 15 dB can be achieved.

#### Sub-Band Echo Reduction 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 acoustic environment. The SA350 Sub-band Echo Reduction algorithm relies on a Broadcom® proprietary technology deployed across several product lines in telephony and VoIP markets. The core technology was adopted for the Bluetooth framework and is fully integrated with the Beamforming algorithm, the Wind Noise Suppression, and the Acoustic Noise Suppression blocks. SA350 Sub-band Echo Reduction closely monitors the amount of echo per sub-band in the microphone signal and then determines the best echo reduction strategy in order to maintain full-duplex communication. In the absence of headset user speech (and when headset user's background noise is well-

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estimated), the microphone signal is replaced by comfort noise in the sub-bands where echo is perceivable. SA350 Sub-band Echo Reduction parameters are adjusted in the configuration file.

### Sub-Band Noise Reduction

There can be various sources of noise 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 street noise, a restaurant, a pub, or an office environment. The SA350 Sub-band Noise Suppression reduces the acoustic noise beyond what is accomplished by the beamformer and Wind Noise Suppression logic. The SA350 Sub-band Noise Suppression monitors the level of speech and background noise in different sub-bands relative to a target signal-to-noise ratio (SNR). Noise reduction is carried out in manner that provides the best overall voice quality. The adverse effects on the naturalness and clarity of user's speech are, therefore, avoided or minimized. Noise suppression parameters are specified in the configuration file. The typical operating range is 18 dB for stationary noise and 14 dB for non-stationary noise.

### Send/Receive Path Equalization

The role of the equalizer is to compensate for any undesirable frequency shaping introduced by the frequency response of the microphones and speaker. On the receive path, the equalizer models the inverse response of the speaker. On the send path, the equalizer compensates for the frequency response of the microphones. Both equalizers are programmable via the configuration file. The headset manufacturer can adjust the parameters of the equalizers based on the type and the placement of the transducers, the mechanical design, and the desired send and receive frequency response.

### Packet Loss Concealment

Interference can result in corruption or loss of audio data. This can lead to significant audio quality degradation. The Packet Loss Concealment (PLC) algorithm reconstructs the lost speech samples and significantly improves the voice communication quality. The SA350 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 information in speech to substitute the missing data with an approximate version of the missing speech. By doing so, it eliminates the unpleasant, audible effect of interference.

### Automatic Volume Control

Automatic Volume Control (AVC) adjusts the speaker volume based on the amount of noise in the headset environment. AVC constantly monitors the amount of background noise and the volume settings. When the ambient noise exceeds some threshold, AVC gradually increases the volume, and in doing so it eliminates the need for manual volume adjustment. The net result is a more pleasant listening experience and better intelligibility of the remote talker speech. All AVC parameters are tuned via the configuration file.

### Sidetone

SA350 includes a sidetone algorithm that provides feedback on the perceived speech received by the far end. This prevents the user from "yelling" over background noise when that noise is effectively being suppressed by other SA350 algorithms. In addition, sidetone provides a more natural sound when using a headset with an ear seal and also acts as an effective wind noise detector.

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### SUMMARY

Broadcom's SmartAudio 350 dual-microphone mono-headset voice processing engine offers a rich set of speech enhancement algorithms on the BCM2047 platform, allowing for a clear and pleasant headset audio experience.

For more detailed information, refer to the BCM2047 technical documentation available on the Broadcom Corporation Customer Support Portal, or contact your Broadcom Corporation sales representative for assistance.

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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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### BROADCOM CORPORATION

5300 California Avenue  
Irvine, California 92617  
Phone: 949-926-5000  
Fax: 949-926-5203

E-mail: [info@broadcom.com](mailto:info@broadcom.com)

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