Using the Bluetooth Audio Signal Processor (BTASP) for High-Quality Audio Performance

Application Note

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Abstract and Contents

A key component of Motorola's approach to delivering high quality audio over Bluetooth is the Bluetooth Audio Signal Processor (BTASP) that has been designed into the MC71000 Protocol Controller. The MC71000 engineering team drew upon a strong Motorola heritage of voice and data radio systems to ensure that robust and quality audio is delivered using Motorola's system solution.

The Bluetooth Audio Signal Processor (BTASP) is a dedicated module that handles all computation-intensive audio functionality in a Bluetooth system. Bluetooth supports voice links compressed with either log-PCM (A-law or μ-law) or CVSD. A voice link is duplex and the data rate is fixed at 64 kbit/s.

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1 Bluetooth Audio Signal Processor (BTASP)

A key feature of Bluetooth is its native quality-of-service supporting audio at both the link and application levels. The Bluetooth system solution from Motorola builds upon Bluetooth's native audio capability to deliver the highest quality audio possible.

A key component of Motorola's approach to delivering high quality audio over Bluetooth is the Bluetooth Audio Signal Processor (BTASP) that has been designed into the MC71000 Protocol Controller. The MC71000 engineering team drew upon a strong Motorola heritage of voice and data radio systems to ensure that robust and quality audio is delivered using Motorola's system solution.

The Bluetooth Audio Signal Processor (BTASP) is a dedicated module that handles all computation-intensive audio functionality in a Bluetooth system. Bluetooth supports voice links compressed with either log-PCM (A-law or μ-law) or CVSD. A voice link is duplex and the data rate is fixed at 64 kbit/s.

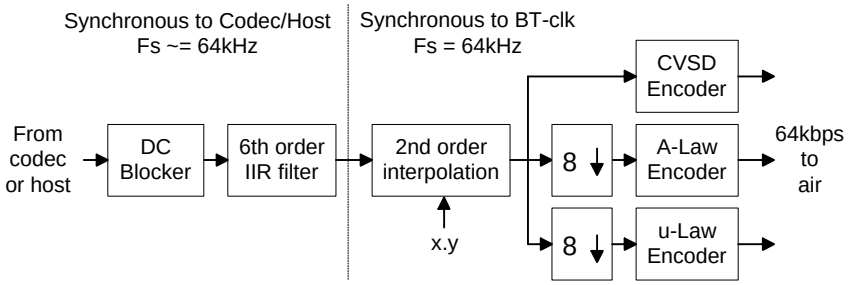
Four different packet types are defined: HV1, HV2, HV3 packets with 10, 20, or 30 bytes of encoded audio, and DV packets with 10 bytes of encoded audio and up to 9 bytes of ACL data. SCO packets are single-slot packets sent at fixed intervals. Multiple simultaneous SCO links are possible if HV2 or HV3 packets are used.

The Bluetooth clock and the CODEC sample clock are not synchronous and may drift. Therefore, it is necessary to synchronize data to/from a CODEC with the Bluetooth clock.

The BTASP implements all signal processing needed to support a maximum of three simultaneous audio links using all the defined compression/decompression standards. The BTASP will also handle Bluetooth/CODEC synchronization.

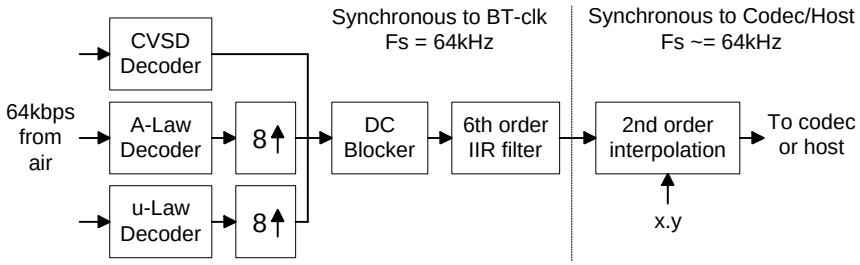
2 BTASP Overview

The BTASP is a simple but powerful module. The uplink processing (CODEC to air) is shown in the figure below.



The DC blocker will remove any potential DC-offset from the signal. The IIR filter will band limit the signal according to the Bluetooth requirements and the interpolator will handle the synchronization issues. The three encoders handle the actual audio compression.

The downlink processing (air to CODEC) is shown in the figure below. The data flow is reversed.



3 Using the BTASP

The BTASP is simple to use. Audio handling is based on processing entire SCO frames. The following steps show how to use the BTASP:

1. The BTASP is initialized by writing to a number of dedicated registers, initializing the filter delay line is a good example of the setup needed.
2. A command is written to the BTASP (frame encode or frame decode).
   - Encode: The host processor writes PCM samples to the BTASP. The BTASP encodes these samples on the fly. The host processor will read the encoded bits in chunks of 32 bits. This process is continued until an entire SCO frame is ready.
   - Decode: The host processor writes encoded data to the BTASP. The BTASP decodes these samples on the fly. These samples are then read by the host processor. This process is continued until an entire SCO frame is processed.
3. The BTASP state is stored by reading a number of dedicated registers, saving the current filter delay line is a good example of the backup needed.

The BTASP is used by accessing a number of dedicated registers. The host processor handles all I/O (no DMA).

Missing frames (for example, packet loss) are not handled by the BTASP in order to let the host processor implement dedicated packet loss handling algorithms such as fade-out or repeat.

4 BTASP Key Features

The following lists some of the key features of the BTASP:

- The first order DC-blocker filter is a configurable feature (enabled or disabled) which is used to remove any DC offset from badly behaving CODECS.
- The 6th order fully configurable IIR filter provides a highly flexible solution for band limiting and gain control. 60dB stop band attenuation is easily achieved. This is important to avoid imaging and aliasing in the up/down-sampling. The audio quality is significantly better when compared to a 4th order IIR filter. The IIR filter also provides extremely low audio latency that is essential in many applications. In duplex applications, such as a headset, a too high latency may necessitate the use of echo cancelers. The filter noise floor is close to -100dB, and will not degrade the quality possible within the Bluetooth audio specification

- The BTASP operates at 64 kHz but is able to handle a wide range of CODEC frequencies from below 8 kHz to above 64 kHz. The second order interpolation algorithm used and the superior filter have a key role in providing superior audio quality no matter the choice of CODEC. The interpolator provides a way to stretch or compress the number of available samples to what is needed, providing a quality far superior to simpler synchronization schemes such as repeating or discarding samples. The setup and control of the interpolator is handled by software so the synchronization and choice of CODEC is highly flexible.
- The frame-based audio processing is fast, only 6 clock cycles/sample are used. At 24 MHz clock frequency, this implies that an HV1 frame can be processed in approximately 20 μs (an HV3 packet requires approximately 60 μs). Clock frequencies down to at least 12 MHz are supported (that is, frame processing speed is still far below the Bluetooth slot frequency). It is possible to use the BTASP even at the lowest system frequency.
- Three simultaneous SCO channels are supported.
- Three encoding/decoding schemes supported (A-law, μ-law, or CVSD). It is possible to bypass the DC blocker, the filter, and the interpolator, thus providing pure encode/decode functionality.