AUDIO CODEC INTEGRATED CIRCUITS

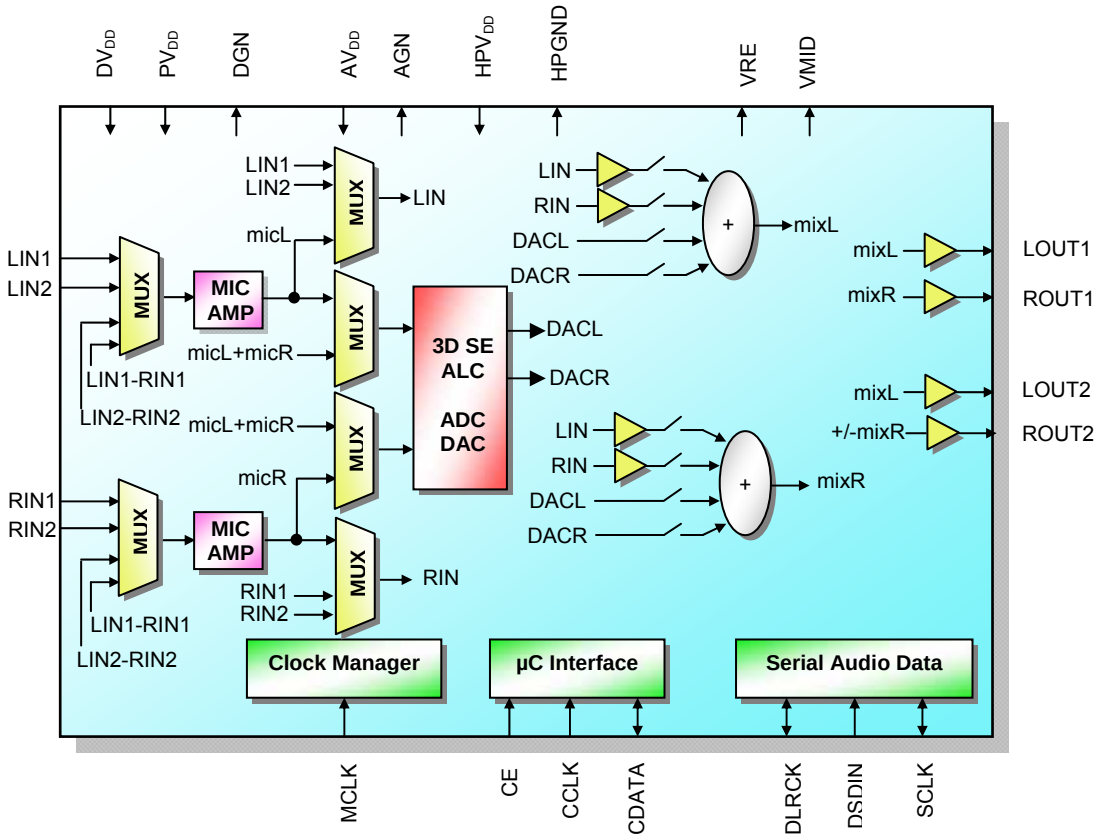

Figure1. Block diagram of PA5388 Stereo Audio CODEC

Audio CODEC IC's are at the heart of many different portable devices that feature both record and playback capabilities. While the basic product selection of input and output channels with their respective performance may be simple, today's devices offer many integrated features that can affect audio quality, as well as system cost, power requirements and design complexity. Understanding what these features bring to a portable application is needed to make the best choice.

System architecture

The audio system in a portable record and play appliance includes more than the basic converters. These devices almost always include a stereo DAC, a mono or stereo ADC, a microphone amplifier, and outputs that may include a headphone and/or a speaker amplifier, and a line level output. Additional features can include a programmable gain amplifier (PGA), input and output automatic level controls (ALC), a PLL, and an analog mixer. CODEC's are available that address the most basic system through the most complex. Once the full list of desired features has been determined, there are secondary considerations, including the control interface, amplifier interface, and clocking requirements.

Microphone inputs and the ADC

Placement of the microphone and routing of its signal can be a critical factor. The microphone is mounted near the user's mouth, but this is often far away from the CODEC. Most applications employ single-ended microphones, but when the signal is routed over a long distance, it is prone to noise interference. Considering that the fixed-gain for the microphone is 20dB to 30dB, that level of noise can be very strong. By using a differential signal path, the noise is cancelled through common mode rejection, and the signal is boosted by 6dB. Most CODEC's provide power for electret microphones, but an important feature to look for is a buffered output. A buffer prevents power supply noise from coupling into the microphone. There is usually a fixed gain block, offering gain from 15dB to 40dB. It may also be useful to have a programmable gain amplifier, enabling fine-tuning for a particular microphone source or environmental condition. Microphone gain should be done in the analog domain. If the gain is realized in the digital domain after

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the ADC, the constant quantization noise of the ADC is gained up during quiet input passages. It is generally not important to have a high-quality ADC, since the microphone element is usually the limiting factor for signal-to-noise performance. For most consumer devices, anything over 80dB should be adequate.

Automatic level Control and input filtering

ALC is applicable to both input and output signals. For the input, ALC is used to maintain a constant recording level, as the user's voice level changes either through inflection or distance. ALC can be realized in either the analog or digital domain. For portable applications, digital ALC is often used, saving cost and providing more flexibility in determining ALC parameters such as attack, threshold, and release.
Output ALC is used to normalize the output volume, as well as provide some pre-amplification to the signal. When a user creates a mix of songs from multiple sources, the recording levels can vary widely. A typical level may be at -12dB. If this signal is sent through the DAC with no normalization, the power amp must provide extra amplification, burning excess power. By normalizing the signal in the digital domain, the power amp is much more efficient, producing more sound level for less power.
Some specific applications can benefit from special digital filtering. For camera and phone applications where the user may be in a windy area, a high pass filter can be employed to remove the wind noise. Notch filters may be used to eliminate motor noise in camera applications, or GSM noise in mobile phone applications.

Audio and control interface

Most portable audio CODEC's operate with I2S audio data, and either an SPI or I2C control interface. The speed of the control interface is not critical, since no audio sample data is passed over the control bus. For the digital audio interface, I2S is the most common format, and most CODEC's will support MSB- or LSB justified as well. If I2S is selected, virtually every CODEC will support it. For resolution, the majority of CODEC's support 16-bits, although there are some higher resolution parts, up to 24-bits. In reality, there is no need to go beyond 16-bits, since the audio performance will not need to be better than 90dB.

Clocking

A standard digital audio clock interface includes a master clock (controls the modulator), a bit clock, a left-right (frame or word) clock and a data in/out line. Providing high-accuracy low-jitter clocks may be difficult, so consider a CODEC with an integrated PLL. High-performance analog PLL's are available that operate off of a wide variety of clock sources, including audio, video, USB, and DSP clocks. A CODEC with an integrated PLL eliminates concerns about accuracy and coupling from high-speed clocks.

DAC performance and features

As previously mentioned, it is a waste to use high-performance DAC's for portable applications. Audio sources such as MP-3 have limited dynamic range depending upon the compression ratio, so a rule of thumb for the DAC performance is 90dB. Some CODEC's include audio enhancement algorithms, such as 3-D stereo enhancement, bass boost, EQ, and ALC. The 3D stereo enhancement algorithms are usually simple sum-and-difference types, which creates a wider (stereo image) sound field. A bass-boost filter can be utilized to boost low frequencies, either programmable or with a pre-determined response. The signal amplitude provided to these digital filters is always below full scale (FFFFh), since it is not possible to boost digital signals beyond full-scale.
A typical bass-boost filter can provide +15dB of gain for frequencies below 80Hz, rolling off to zero boost around 1kHz. The bass boost filter also compensates for the high-pass characteristic of the output AC-coupling cap, allowing for a smaller DC-blocking capacitor. After the bass boost and EQ filters, the signal may be normalized with an ALC algorithm. All of these filter features are important to enhance playback quality for the user experience.

Playing the music

Most portable appliances offer several types of output: line level, headphones, and speakers. The line output is usually designed to drive a high-impedance load (~10kΩ) through an AC-coupling capacitor. The headphone driver can also be configured for the line output. For the headphone amplifier, the output power runs anywhere from 15mW to 50mW, although 30mW is usually more than adequate for driving the most inexpensive headphones. The important parameter is speaker power level (SPL), not necessarily the raw

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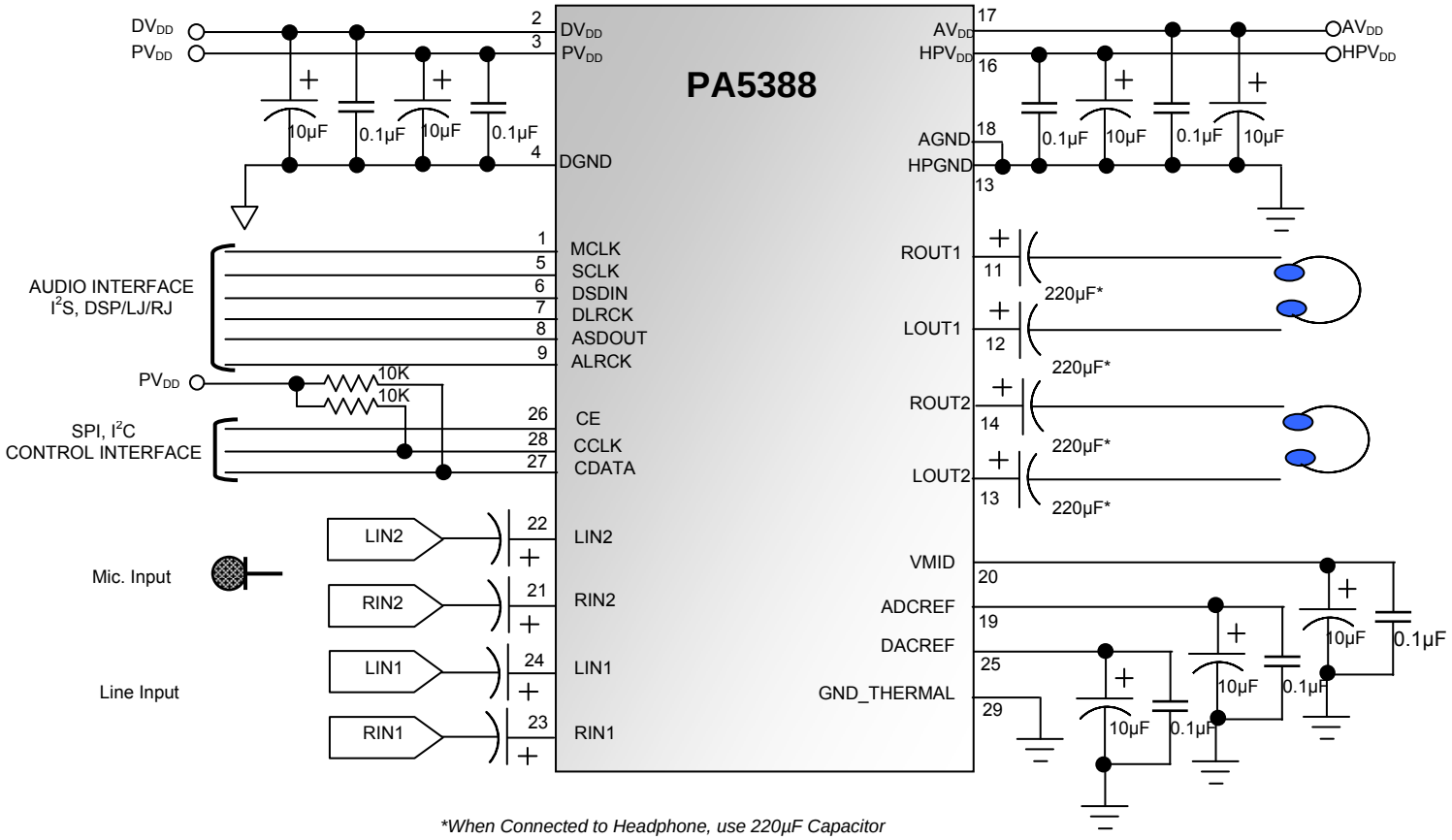
output power. These outputs have been typically AC-coupled, although the trend towards very small appliances is driving cap-less outputs to eliminate large and expensive DC-blocking capacitors. This kind of output can be accomplished by having differential BTL drive, a charge pump that generates a negative rail with a ground reference, or by creating a virtual ground at Vcc/2. The virtual ground method can work for a closed-loop system (operating under battery power only), but when connected to an AC supply (as in a docking station), ground must be ground, not biased up, or the device may have catastrophic failure. Also, biasing up the headphone ground prevents the wire from being used as an FM antenna, if a radio is included in the appliance.

Conclusion

An audio CODEC for portable appliances does far more than convert digital audio. It can provide features that enrich the user experience for both recording and playback, as well as integration that simplifies system design. The most important considerations in choosing an audio CODEC are features, cost, power, and finally performance. While these devices are not intended for audiophile listening, the audio experience can be substantially improved with a few basic considerations.

Typical Application Schematic



*When Connected to Headphone, use 220µF Capacitor
*When Connected to Line Out, use 1 or 10µF Capacitor

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