2． 項目簡介

(*項目所屬科學技術領域、主要技術內容、授權專利情況、技術經濟指標、應用推廣、人才培養及對澳門科技進步的推動作用等*)

Audio processing is essential to consumer electronic applications such as mobile smart phones, MP3 players, tablet computers, DTV/3DTV and set-top boxes and a host of other high-volume products. Since different applications have different multitude of requirements, determining the functions' lineup that optimally serves a particular target application and the market demands high-quality high fidelity (Hi-Fi) audio capabilities, while keeping silicon area and power consumption to an absolute minimum, is a challenge commonly faced by both System-on-Chip (SoC) integrators and IP providers. Integrating audio IP that has been silicon-proven and optimized for specific audio functions helps reduce system power, area, and cost in today's multimedia SoCs.

The core of an audio CODEC is composed of standard stereo or multi-channel (e.g. 5.1 audio) record and playback channels with analog and digital portion. At analog side, the record channel includes amplifiers with volume controls to bring both the weak microphone levels and the large interconnect line levels to the input range of the analog-to-digital converter (ADC). The playback channel includes a digital-to-analog converter (DAC) and several output drivers able to directly connect to earphones or to loudspeakers, each with its respective volume controls. Audio drivers must be able to efficiently address a wide variety of different loading conditions such as line loads (analog audio connectivity), earphone and headset loads, passive loudspeaker loads and many more. When determining the trade-offs between application requirements versus area and power, designing the right audio CODEC has become one of the most critical decisions for SoC designers.

The digital side mainly includes digital audio filters, digital volume and advanced audio signal processing. With a modern mobile multimedia system, there are likely to be a number of digital hosts, all operating on their own clock domains. It is very challenging to ensure that all multi-rate blocks are synchronized with each other and supports the required sampling rate combinations, e.g. baseband processor manages cellular radio communication, application processor manages media files from the flash memory, and Bluetooth IC connects to any number of Bluetooth-enabled peripherals. Each of these digital hosts is operating on separate, and asynchronous, clock rates. Therefore, an audio CODEC in such a system is not only bridging the digital to analog domain, but it is also interfacing among different clock domains in a digital ecosystem.

For higher competitiveness, different fabless chip producers target for their preferred foundry technology from cost, time-to-market, and IP maturity considerations, e.g. China companies prefer more SMIC, tier-one chip producers prefer to employ TSMC at 1st product release and later switch to SMIC for lower cost; Some Japan companies select local foundry Fujitsu; Korean one uses Samsung or Global Foundry, etc. Also the process nodes are one of the key factors of the chip cost, different or same chip producers at different phase have different process nodes requirement. Therefore, to minimize development cost and maximize the design technology coverage with silicon right performance for all different foundries at different process nodes are one of most challenging tasks for IP developers.

As designs migrate to 28nm process, the challenge of integrating audio functionality becomes more complicated, as digital circuits follow Moore's Law, higher wafer costs can be justified through improved performance and higher gate density. Analog circuits such as audio make extensive use of I/O devices and do not scale with process node in the same way as digital circuits that use primarily core devices. However, wafer cost of 28nm is significantly higher than in 65nm or 40nm. Without inherent performance or area improvements to offset the increased wafer cost, analog circuits must evolve and develop new architectures to reduce the overall area, e.g. a 2mm2 audio IP in a 65nm would need to decrease to 1.5mm2 in 28nm to keep the silicon cost the same. This 25% area reduction requirement is the key challenge for integrated audio in advanced nodes.

This applied R&D project has overcome the multi-dimension challenges facing at Audio CODEC in nano CMOS and lead to the state-of-the-art Audio CODEC IP platforms developed in multiple generations with respect to the ~15 key innovations at both architectural and circuit-level perspectives:

1) Architecture-level Innovations, e.g. Multi-Technology Compatible Development Approach for consistent design quality ; Tailor-Made-Product Configuration Enabling Architecture for shorter Time-To-Market with most optimum performance; Advanced Audio Volume Soft ramping Control to achieve a compact design to change the volume regardless of the signal level; Advanced Asynchronous Sample Rate Converters to support a wide range of audio-video applications. PLL-less technique for lower cost and complexity; Advanced Digital Feature like Automatic Level Control, Hybrid volume Control and Inputs/Outputs multiplexing with programmable source attenuators etc.; Adaptive Interface Prototyping & Application Evaluating System to enable either FPGA-based or SoC-based application-level validation, thus allowing early phase digital software and later phase full hardware integrated design to match end-user system development needs.

2) Circuit-level Innovations: e.g. Area-Effective Passive Mic Boost Circuit Embedded into PGA which is 50% area reduced compared to traditional design; A Wide Tuning Gain Range (-18dB-47dB, 1dB/step) Programmable Gain Amplifier with embedded 2nd-order filtering; 3-input mixing fully-feedforward sigma-delta ADC with low-frequency flicker noise and aliasing noise rejection techniques which adopted well the rapid technology scale-down challenge; High-Resolution multi-level Switched-Capacitor Audio DAC with Embedded Reconstruction Filtering and effective power consumption and area; Multi-Input and Dual-Output Driver with Independent Mute Circuit; industry 1st released All-in-One driver with wide-loading range driving capability to support versatile customer application; Novel Pop Noise suppression technique with optimum and fully programmable Pop Noise level during power-on and power-down period.

From this applied R&D project, the developed advanced innovations have been well deployed for the Audio CODEC IP Platforms from two product generations: Advanced Generation (AG) for 65nm, 55nm and 40nm and Premium Generation (PG) in 28nm or below where the PG platform development has also enabled the 1st Audio CODEC IP in 28nm available in IP market, which bring great opportunity for future SoC solution in new consumer electronics application.

Such IP platform development enables directly around 8.9 Million USD IP sales value (71 Million MOP) for > 25 applying units which are all world leading electronics companies from USA, Europe, Japan, mainland China and Taiwan. Most of their products are in mass production and employed in market well-known consumer electronic devices, just to name a few, Zik Bluetooth Headphone, Hisense STB, Nikon, Fujifilm, Samsung digital camera, TCL DTV, and also other brand-named Tablet, smart phone, media players and IP conferencing phone and so on. The very conservative estimation of mass production chip volume is > 23 Million and the corresponding market value > 350 Million USD (> 2.8 Billion MOP).

Such applied R&D has strategic value and creates solid foundation for Macau company to further accelerate the aggressive IP roadmap and healthy local company development plan, which opens great job opportunities for Macau's young generation to devote their careers in the Hi-tech development, thus also stimulating the momentum of Macau higher-education with also high-level academic R&D.

The adoption and production of the advanced IP technology developed by Macau team by rich national/international brand-named customer bases at such a cutting edge semiconductor industry definitely have also created highest promotion and indeed elevated worldwidely Macau science & high-technology development position, thus contributing ultimately to multi-diversifications of Macau industry.