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Music Synthesizer with FPAAs

Low-Power Systems for Music Synthesis with FPAAs

Introduction

With the growing number of hand-carried electronics, the low-power embedded system-on-chip (SoC) has become the center of interest. For the SoCs to provide wide range of operations and functionality, the overall power consumption of the system is a basic, but necessary, indicator of processor performance. This technical review paper summarizes some of the commercially available SoC applications, how and why the technology works, and what is necessary for implementing the technology.

Commercial Applications

The main application of SoC design is portable devices; ranging from smartphones to media devices, the portable embedded systems require both the high processing speed and the low power consumption. The electronics nowadays are designed to serve multiple purposes within a single battery-life. The physical limitations of a battery lifetime impose a design and performance constraint on the overall system. Power utilization can not only cope with the performance limitations but also aid in packaging or the cooling aspect of the system [1]. Flexible Hybrid Electronics (FHE) system is another application of low-power SoCs. Possible areas of application of the flexible technology include wearables, soft robotics, and medical health monitoring [2]. Similar to cell phones and multimedia devices, the flexible electronics run on battery-life and are subject to design limitations. On a larger scale, another use of the system-on-chip technology is the precision-time-protocol (PTP). PTP functions to connect substation communication networks, enabling synchronization accuracies in the nanoseconds. Such high synchronization within the network is desired because a time error of one microsecond would result in a location error of 300 meters [3].

Rising investments in smart cities to IoT devices drive the system-on-chip market. The global SoC market is highly competitive with major vendors competing based on not only price but also quality and service. Apple Inc. offers Apple A12X Bionic, an ARM-based SoC. Huawei Technologies Co., Ltd offers Kirin 980, an ARM-based SoC. MediaTek Inc. offers MT2523, designed for wearable applications. Qualcomm Technologies, Inc. offers Qualcomm QC605, incorporating an ARM IoT microprocessor, designed for IoT applications. SAMSUNG ELECTRONICS CO., LTD. offers Exynos, an ARM processor with fast data sharing and streaming, delivering high performances [4].

Technology

The low-power consumption can be analyzed from different levels of the design. One area of power consumption is the dynamic power consumption. This is due to the input signal, charging and discharging process, and the short-circuit current. On a system level, the dynamic power consumption can be lowered by making the system-on-chip stay in the sleeping state without performing any operations. On a resistor-transfer level of design, the addition of a Gating clock circuit successfully reduced the dynamic power of clock network [5].

A typical mobile audio system is mainly centered on an audio digital signal processing (DSP) core with other audio peripherals such as the speakers and microphones attached to the DSP via a digital bus interface. The audio core can be integrated into the SoC with access to the SoC's main memory system. If the core subsystem is not integrated, there should be a bus interface to connect the DSP to the SoC. The data processing speed can be improved by adapting a DSP tunneled model, where the audio data processing is localized to the DSP with dedicated local memory to bring the system to a much lower frequency and to reduce the power consumption of the system [6].

The specific hardware technology of interest is the integrated ultralow-power system-on-chip (SoC) field-programmable analog array (FPAA) IC. The addition of the routing fabric, low-power programmable and configurable, enables the rapid reconfigurability. Such modification reduces the number of intermediate data storage required for computations, which is often the largest power and cost consumption of the system [7].

Implementation

Field-programmable analog array (FPAA) was designed in the past with modifications to reduce the overall power consumption. However, at a student design level, it is not possible to fabricate an integrated FG programming system for system-level ICs. Most of the power management should be performed at a programming level to control the components of design. For example, one of the main components of this project is the input sensor, such as a microphone. The computation of sensor data with lower starting precision point should be considered for a higher performance of the device [8]; however, this would lead to a trade-off between power consumption and performance.

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