Getting personal with the 66AK2Gx SoC

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Introduction

We live in a world driven by data: financial data, medical data and entertainment data. Moreover this data, be it audio, video or the written word, are tailored specifically for us and our interests. So what type of processor powers this always “connected” yet personalized experienced?

Digital Signal Processors (DSPs) deal with real world signals that you can interact with. You speak with your voice, you listen to other people’s voices, you listen to music and you see the world around you. These analog signals are digitized and represented by numerical values. These values can represent the pitch or frequency of our voices and the amplitude or how loudly we are speaking.

DSPs work in real time. They receive data and process it before the next data point arrives. Unlike other processors, DSPs do not gather data and work off-line to produce results. In the world we live in there is no time to wait and no time to waste. DSPs are decisive; processing the data leads to immediate action.

Texas Instruments (TI) first used signal processing to look for oil deposits when it was a geophysical company. The **Speak and Spell educational toy** used voice synthesis technology to provide parents/educators with a new tool to use to teach children. Over the past 30+ years TI has worked with customers who have developed DSP applications that impact our daily lives that solve either simple tasks or provide solutions to the most complicated problems.

Manipulating real-world data means a lot of multiplying, adding and subtracting to get the information we need. The TMS320™ family of DSPs is designed with hardware multipliers to do a lot of math quickly, in fact in a single clock cycle. Other processors do multiple adds to do a multiply but this does not happen in one clock cycle. With devices using the TMS320C66x (“C66x”) DSP core which can run at a clock rate of up to 1.2 GHz, the DSP can represent data in floating-point as well as fixed-point format. Floating point lets you represent signals with a wide dynamic range and with greater precision than in fixed point representation.

The C66x DSP has multiple data buses and plentiful on-chip memory to keep data flowing into and out of the processing engine. Even in a single-core configuration, the C66x DSP is the ultimate multi-tasker. Its inherent parallelism allows you to do more things at the same time, i.e., more math calculations, more data comparisons. It also uses pipelining to break up problems into smaller tasks to speed their completion. This programmable processor is a good “C” engine. The C6000™ compiler does the allocation of hardware resources at compile time; no assembly language is required to achieve high performance.

So how do we build upon our C66x DSP foundation? We craft a System on Chip (SoC) adding a powerful ARM® processor and several high-speed connectivity options like Gigabit Ethernet and Peripheral Component Interconnect Express (PCIe). The addition of an ARM like the Cortex®-A15 allows customers to run High Level OS (HLOS) like Linux® on the ARM while allowing the DSP to continue processing the real-time data. The ARM can also manage the less time critical data traffic that comes through network interfaces like Ethernet, Universal Serial Bus (USB) or Controller Automated Network (CAN). As shown in **Figure 1**, we have created the 66AK2Gx SoC.

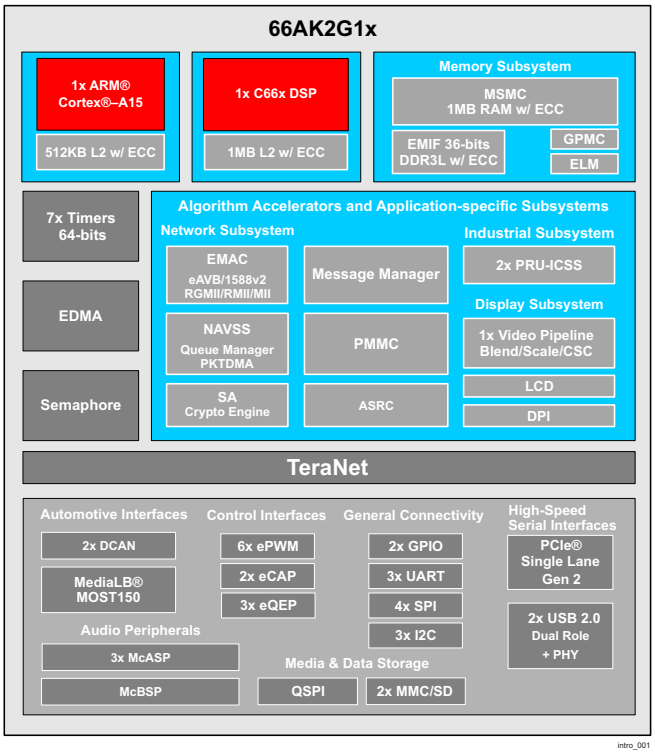

Figure 1. *66AK2Gx SoC functional block diagram.*

So now we have a processing SoC that is highly connected but how does that relate to personalization?

Audio in the car and home

Audio devices based on DSP technology were the first to be personalized allowing us to create our own playlists and take them with us when we are on the go. But what if I want to enhance my audio experience and surround myself with sound whether I am in the car or at home?

The automotive amplifier creates the audio environment within the car. These are the amplifiers behind the speakers that you find on your car doors and in your dashboard. The car is a difficult environment for creating a concert hall experience. It is a noisy environment and as cars become lighter to get better mileage, the noise problem only increases. So how does the 66AK2Gx SoC address this? The 1 GHz C66x DSP is responsible for the audio processing (equalization, mixing, compression, delay compensation, etc.) and noise cancellation. The ARM Cortex-A15 provides system control of the network interfaces. The possible network communication interfaces in a car may include CAN and either Media Local Bus (MLB) or Ethernet depending on the specific car model.

The 66AK2Gx SoC, as shown in **Figure 2** on the following page, is a great solution for automotive amplifier manufacturers who want to reduce their current cost and footprint by having an SoC that integrates a high-performance DSP and ARM and an abundant amount of on-chip memory—more than 2.5 MB. With QSPI memory to boot from and 2.5 MB of on-chip memory, it may be possible to eliminate external double data rate (DDR) memory to lower power consumption as well as reducing cost and size of the total system. The 66AK2Gx SoC also allows for multiple automotive bus communication protocols (Ethernet and MLB) in a single scalable platform design.

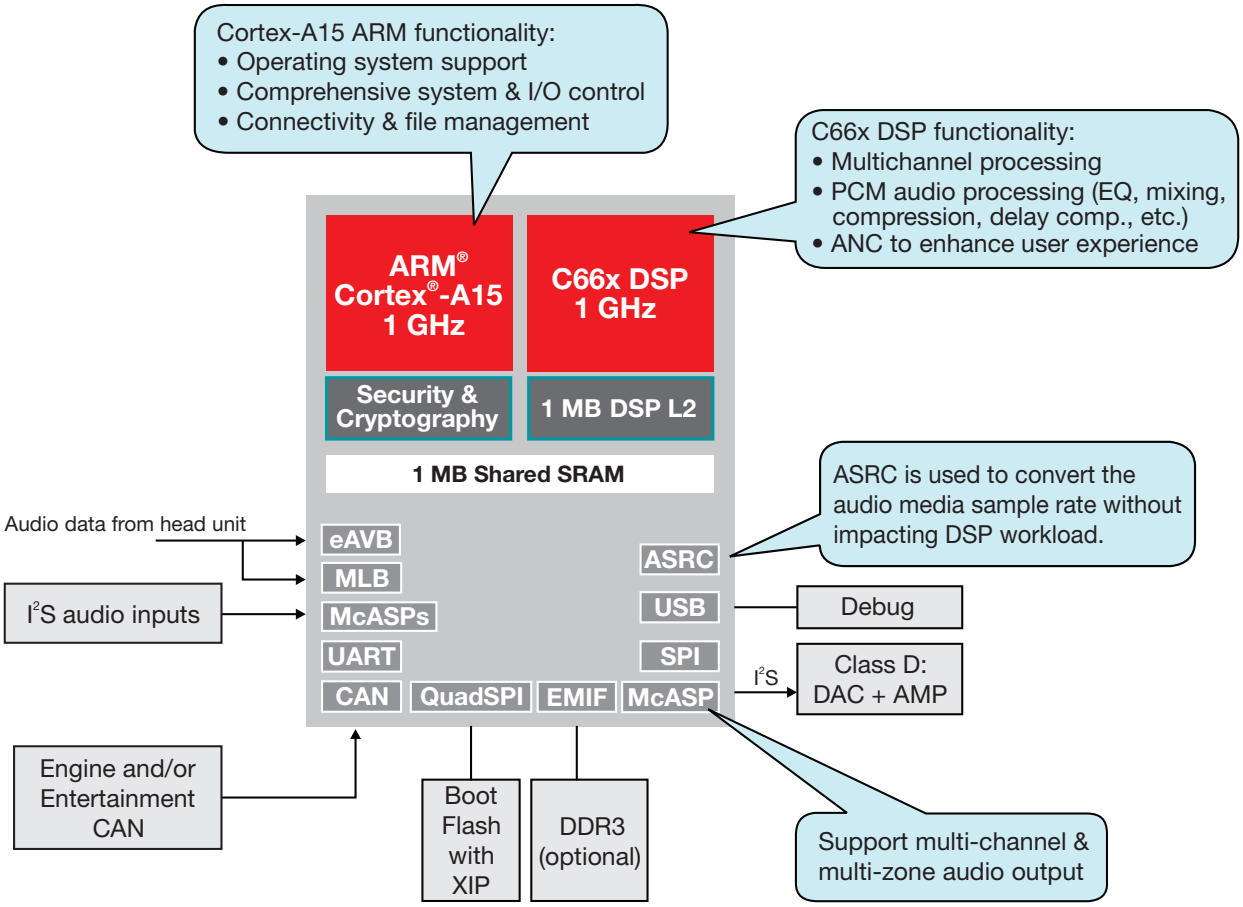

Figure 2. *The 66AK2Gx SoC within an automotive amplifier design.*

The Ethernet requirements for car audio include time sync, audio video bridge (AVB) transport, quality of service (QoS) and streaming media encapsulation, which are defined by IEEE standards. These are all defined by IEEE standards that are beyond the scope of this white paper.

The audio stream received via the automotive network may arrive at a sample rate that is not well suited to the rest of the automotive amplifier system. The media rate could be at 48 KHz which is common in an MLB system but the desired rate to go out the amplifier is 44.1 KHz. The Asynchronous Sample Rate Converter (ASRC) accelerator block found in the 66AK2G12 device can be utilized to convert the sample rate without impacting the work load of the C66x DSP.

The ASRC has 8 sample rate converters that can support up to 16 channels. This allows the C66x DSP to do more audio processing.

So in short, the 66AK2Gx SoC creates the right audio environment based on the current conditions the car is experiencing. And since this an automotive application, the 66AK2Gx SoC needs to and does meet the requirements for reduced defects and low Failure in Time (FIT) rates. Further the time is coming where higher end vehicles will try to provide more channels of audio and customization for a per passenger audio experience.

In the home, new audio applications drive the need for increased DSP performance over existing solutions. Internet audio streaming and local media streaming

(Wi-Fi®, hard disk drive, MP3 files) require increased ARM performance. The 66AK2Gx SoC has three multichannel audio serial ports or McASPs. The McASPs function as a general-purpose audio serial port optimized for the needs of multichannel audio applications. The McASPs can support many different data formats such as time-division multiplexed (TDM) streams, Inter-Integrated Sound (I^2S) protocols, and intercomponent digital audio interface transmission (DIT). Other key features include flexible clock and frame sync generation and up to 16 transmit or receive data pins and serializers. And all three can be used simultaneously with two clock zones each.

Reliability and security on the factory floor

Audio is not the only application that can benefit from the features of the 66AK2Gx SoC. Industrial markets can also be enhanced with high-performance processing, large on-chip memory and provisions for error correction and detection.

A Programmable Logic Controller (PLC) provides the main controlling function in an automation system. It controls different local and remote I/O nodes—sensors, actuators and drives. The PLC manages the I/O communication as well as coordinates decision making for the connected remote nodes in the field. PLCs are used in factories, buildings, mobility/transportation, processes and energy automation.

The primary purpose of the CPU in the PLC is to process messages or data packets that are transmitted and received from I/O device nodes or from the neighboring PLCs. It is critical that both the transfer of data to /from the interface and the processing of the data be deterministic with low variability.

On a 66AK2Gx SoC, the Cortex-A15 does the processing using the internal memories as much as possible to reduce delays (latency), as shown in **Figure 3**. In addition, to ensure high reliability, error correction and detection is required on all memories in the system. Specifically, single-bit error correct and dual-bit error detect (SECDED) is supported for program and data accesses from the Cortex-A15. To learn more about ECC and its importance to decrease Failure in Time rates please see the white paper, "**Designing embedded systems for high reliability with the 66AK2Gx DSP + ARM® processor**".

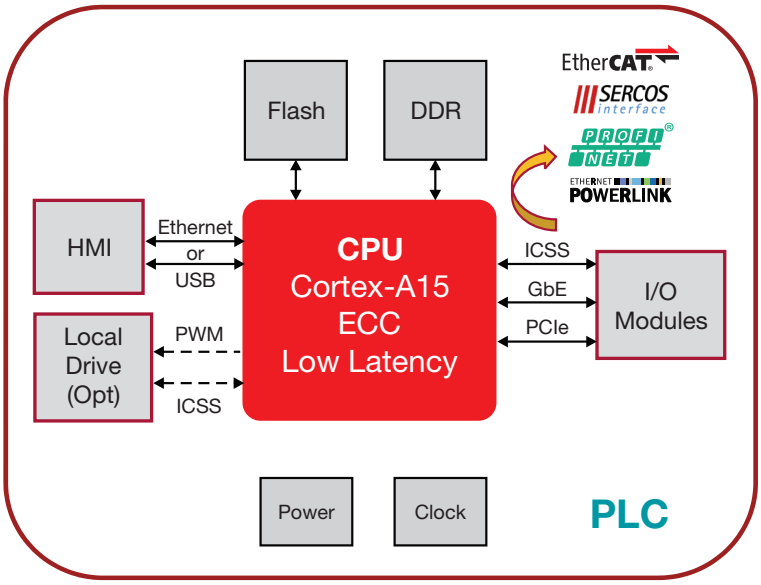

Figure 3. *The 66AK2Gx SoC used in a Programmable Logic Controller.*

In addition to the Cortex-A15, two dual-redundant fast industrial Ethernet rings must be supported. This can be achieved with the two Industrial Control Sub-Systems (ICSS) found in the 66AK2Gx SoC. Each ICSS can support Industrial Ethernet Protocols such as PROFINET®, EtherCAT® and EtherNet/IP™. Communication can be augmented via an additional Gigabit Ethernet connection.

An increasingly important requirement of the PLC CPU is to provide secure boot and secure processing. PLC manufacturers are starting to get concerned about the privacy of their network traffic but the higher priority is currently the authenticity of the communication. They want to make sure that the message that they receive is from a real endpoint in the automation network. The 66AK2Gx SoC is capable of supporting standard secure boot with customer programmable keys that are stored in One Time Programmable (OTP) memory. A security accelerator supporting encryption standards such as several Security Hash Algorithms (SHAs), Triple Data Encryption Algorithm (3DES) and Advanced Encryption Standard (AES) is also part of the 66AK2Gx SoC.

Programmable, scalable and affordable

The power of the SoC is in the designers' ability to leverage the resources they need to meet their application requirements. The Processor Software Development Kit (SDK) was designed from the ground up to provide a starting point for embedded applications.

When developers implement application software for an automotive audio application or an industrial PLC, they often need that application to be portable from one product to another to maximize reuse and engineering efficiency. Designers need to focus on what they do best so they need a software development environment that abstracts the SoC for them. Lower levels of software can effectively provide this abstraction and these are included in the Processor SDK.

Processor SDK 4.00 includes support for both Linux® and TI-Real Time Operating Systems (RTOS). On the 66AK2Gx SoC either Linux or TI-RTOS can run on the Cortex-A15. The C66x DSP can run a TI-RTOS specifically optimized for it, or run no OS at all.

The Linux SDK provides Long-Term Stable (LTS) Mainline Linux kernel support. Version 4.9.28 is supported in Processor SDK 4.00. There is also U-Boot bootloader support; the 66AK2Gx SoC can be boot-loaded from a variety of sources. The SDK also includes Linaro GNU compiler collection (GCC) tool chains and Yocto Project™ OE Core-compatible file systems.

The RTOS SDK provides TI-RTOS kernel which is a light-weight real-time embedded operating system for TI devices. Chip support libraries, drivers, basic board-support utilities and diagnostics are also provided. The SDK also supports inter-processor communication (IPC) between the C66x DSP and the Cortex-A15. Other elements include optimized C66x DSP algorithm libraries, basic networking stack and protocols and secondary bootloaders and boot utilities. Linaro GCC tool chains, C6000 DSP Code Generation tools and PRU compilers for ICSS are included in the Code Composer Studio™ v6.x IDE environment used to develop code with RTOS SDK.

All basic Processor SDK software is provided at no cost to the developer, and because of the use of open source, there are no royalties associated with its use. There are a large number of TI embedded processors that are all supported within the Processor SDK. This not only provides a common look and feel across devices but it also allows easier porting from one device to another.

Get started today

We have introduced the 66AK2Gx SoC and how the real-time C66x DSP and powerful Cortex-A15 and many connectivity options make it ideal for embedded systems like automotive/home audio and industrial PLC applications. We see that the 66AK2Gx SoC also offers high reliability by offering ECC on all internal and external memories. We have covered the Processor SDK and how it can be used in software development.

Want to learn more about how the 66AK2Gx SoC can be used in your embedded application?

We have a **data sheet and technical reference manual** available for download today. We also have an Evaluation Board (EVM), the **EVMK2G** available for purchase which provides actual hardware with the 66AK2Gx SoC and Processor SDK to begin your software evaluation.

Personalization will still be a driving force as we move ahead. Presenting data that is not only targeted but also timely will continue to make life easier at home, at work, in the car or at the concert hall. The 66AK2Gx SoC can help create that future.

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