System LSI for Silicon Audio Player

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There are clear signs that the expansion of broadband Internet connections is stimulating growth in the music distribution market. One indication is the increasing popularity of silicon audio players which allow the user to store downloaded music data onto a semiconductor memory and then reproduce wherever and whenever they want.

Photo 1 Example of the MP3 player incorporating Oki LSIs

The music data is compressed by sound compression technology, the de facto standards for the compression format being MP3 (MPEG-1 audio layer 3), and the emerging WMA (Windows Media Audio®) *1) format.

The silicon audio players of the future will be required to provide multi-format compatibility and copyright protection facilities for the downloaded music, alongside the established criteria of compactness and low power consumption.

Since the release of the first MP3 player in 1999, Oki has been supplying the system control microcomputer MSM66573L, and more recently, the ML66525 which incorporates USB (Universal Serial Bus) device and flash memory controllers [1] (see Photo 1).

At present, we are developing a system LSI, the ML67Q5200, based on our SPA (Silicon Platform Architecture) concept, to enable control of music data signal processing (decoding) and copyright protection management, as well as system control, on a single chip.[2] By using this LSI, it is possible to develop a high-performance silicon audio player in a short time frame. This essay describes the features of the ML67Q5200.

System overview

Amongst other functions, a silicon audio player is required to reproduce music data, provide copyright protection, and perform download and display operations. In order to achieve these functions, our LSI has a base containing a DSP (Digital Signal Processor) with a 16-bit DSP core TEAK®*2), and a CPU section formed around a 32-bit RISC core, the ARM7TDMI®*3), as well as various built-in functions, such as a USB device controller. Table 1 lists the specifications of the system, which is illustrated in Fig. 1.

Table 1 System specifications

Model	ML67Q5200
Operating voltage	Internal = 1.8V; I/O section = 3V
Operating frequency	CPU section : 30 MHz (clock gear function, HALT mode)
	DSP section : 60 MHz
Program ROM	256kB (flash ROM) / 1024 kB (external max.)
Data RAM	32 kB
Music decoder	MP3 / WMA
Sound recording	OKI ADPCM
Copyright protection	Yes
I/O board	80 I/O pins, 4 Input pins
Timer	16-bit auto-reload timer ¥ 2ch 16-bit auto-reload timer (shared with serial transfer baud rate generator) X 2 ch TBC X 1 ch WDT X 1 ch 16-bit PWM X 1ch
Serial board	Clock sync X 2 ch UART X 1 ch I2C X 1 ch Serial Audio-out X 1 ch, Serial Audio-in X 1 ch
USB device controller	USB ver. 1.1 compliant (12 Mbps) built-in transceiver, Vbus detection circuit, bus-powered, 6 End Points
Data transfer RAM	512 kB X 4 buffer
Flash memory controller	High-speed data read/write sequencer, ECC circuit
DMA controller	4 ch
External bus interface	SRAM / ROM / DRAM (SDRAM) / IO
Other	External interrupt X 4 ch, PLL function, 8-bit A/D converter X 4 ch
Package	LFBGA144 / LQFP208 (evaluation chip)

*1) Windows® and Windows Media Audio® are trademarks of Microsoft Corporation in the U.S.A. and other countries.
*2) TEAK® is a registered trademark of DSP Group Limited. *3) ARM7TDMI® is a registered trademark of ARM Ltd.

The DSP section controls data decoding during reproduction of the music data, as well as the data output and equalizer/volume functions. The CPU section, program flash ROM, data RAM, and so on, administer the music data copyright management, display of track titles, etc., and also provide overall system control. Music data is downloaded by means of the USB device controller, data transfer RAM, DMA (Direct Memory Access) controller, flash memory controller, and the like.

System features

This LSI provides the following features suitable for a silicon audio player.
(1) Low-power consumption
(2) Accelerated data download speed
(3) Diversification of functions and specifications
(compatibility with multiple formats, copyright protection, etc.)
(4) Simplification of program development environment (product development in short TAT).

Below, we will look at how each of these features is achieved.

(1) Reducing power consumption

In order to manage and control copyright protection and sound data, the CPU operates at a frequency of 30 MHz (fast), but when controlling other operations, it is necessary to cut power consumption by reducing the operating frequency.

Therefore, a clock gear function is used to set the CPU section operating frequency to a low speed of 15 MHz (1/2), 7.5 MHz (1/4), 3.75 MHz (1/8), and a HALT mode enables the clock to be stopped. Although the system is built in with a DSP section, DMA controller, data transfer RAM, flash memory controller, and so on, not all of the these functions have to be operated

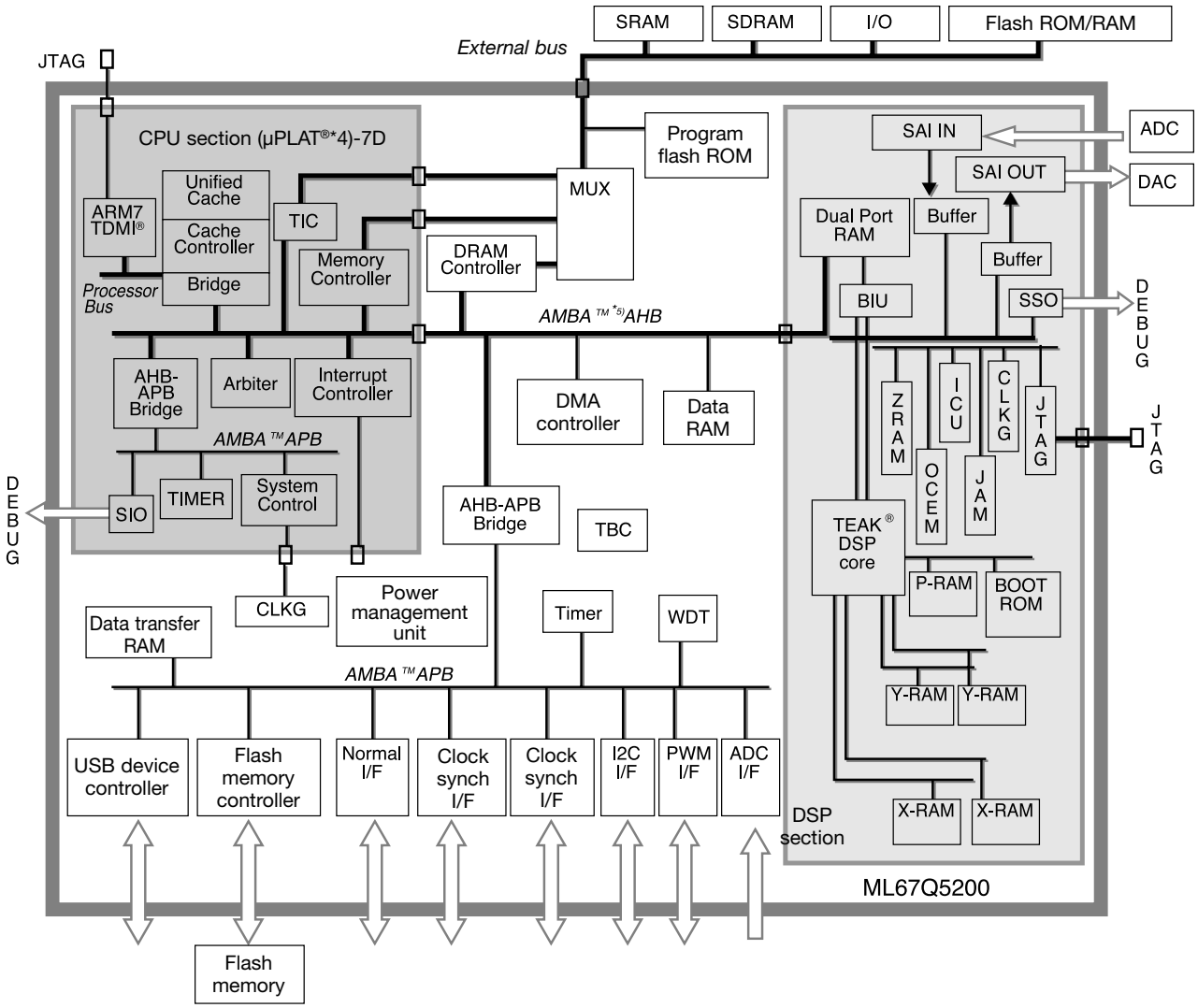

Fig. 1 System structure

*4) μPLAT® is a registered trademark of OKI®. *5) AMBA™ is a registered trademark of ARM Ltd.

all of the time. To save power use, the functions can be switched on and off according to requirements, by means of the power management unit.

(2) Increasing data download speed

The USB function is used to download music data from a PC. There are two steps in the download operation: (1) When data is received from an external source, it is written from the USB device controller to the data transfer RAM, under the supervision of the DMA controller; (2) When a specific amount of data has been written, the DMA controller transfers this data from the data transfer RAM to the flash memory, via the flash memory controller. Steps (1) and (2) are performed repeatedly, and high-speed download can be achieved by performing (1) and (2) simultaneously. The data transfer RAM therefore comprises four buffers, two of which are used to store data from the USB, whilst the other two read the data to the flash memory. Simultaneous implementation of steps (1) and (2) is achieved by switching alternately between these buffers. Additionally, the flash memory controller contains an ECC (Error Correcting Code) circuit, which is able to make ECC calculations during data transfer. In this way, the data transfer speed can be accelerated

(3) Diversifying functionality and specifications

Future audio players will have to permit strengthening of security for copyright protection, as well as addition of different music data formats, and new or modified functions. Therefore, we have provided a facility for updating system programs from an external source, via the USB device controller, for instance.

Depending on the model, the player might also combine FM radio and clock display functions, or the like, and external LSI control will be required to perform these functions. Therefore, built-in interfaces for an external bus, clock sync serial board (2ch), and I2C bus are provided.

(4) Simplifying the program development environment

Alongside the debug JTAG (Joint Test Access Group) in the CPU/DSP section, an RS232C serial input/output port (SIO) is provided in the CPU section, and a special serial output port (SSO) in the DSP section, for use in program debugging. In addition to debug based on the actual devices of the flash ROM product, a software development kit (SDK) is also provided. The SDK comprises software and an evaluation board.

The evaluation board is mounted with an ML67Q5200 eva chip (LQFP208 package), program flash ROM, SRAM for storing debug information, flash memory, DAC (Digital to Analog Converter), ADC (Analog to Digital Converter), USB connector, and the like, and is able to function as a basic audio player. This can be used as a simplified ICE (In Circuit Emulator), by using a JTAG/RS232C to connect to the PC and a special connector to connect to the customer target board.

The software consists of firmware for controlling the host-side debugging tools and evaluation system, and is able to operate as a player on the evaluation board.

Fig. 2 shows the composition of this software.

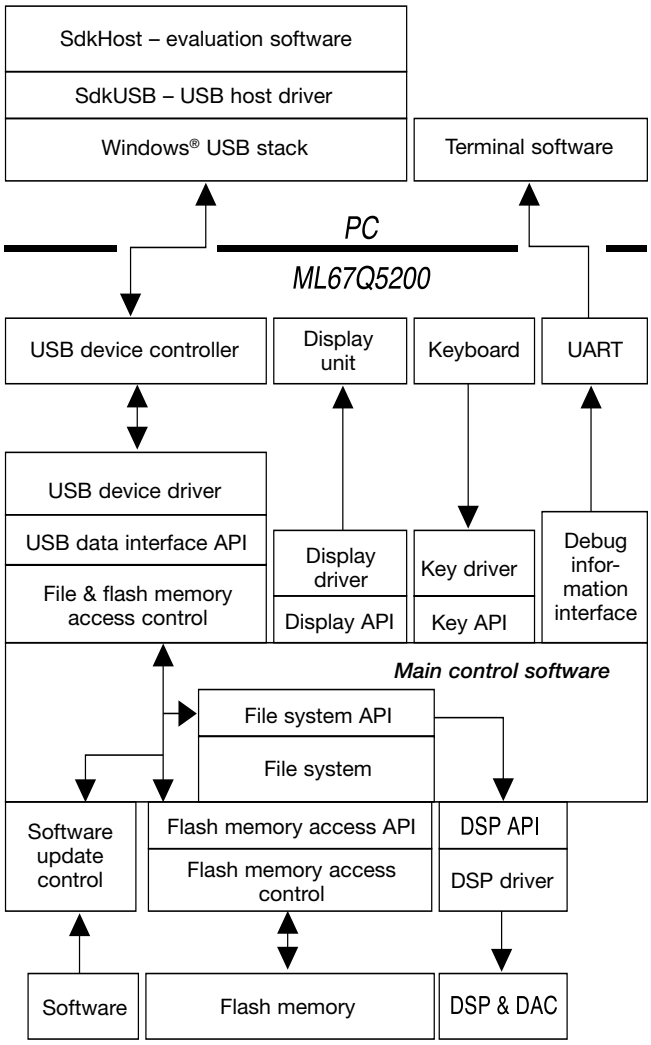

Fig. 2 Software structure

Drivers converted entirely to APIs(Application Program Interface) can be used for controlling the functions required for the silicon audio player in this LSI, which means that the developer is able to concentrate on development of the upper application layers. In other words, by using the host tools, system control firmware and evaluation board provided by Oki, customers can greatly reduce their work loads in the initial stages of product development.

Design procedure

The ML67Q5200 has been developed in a system LSI design environment based on our SPA concept. By incorporating development tools which have been optimized for system LSIs incorporating a large number of IPs, such as mega macros for the ARM (CPU) core, DSP core, USB device controller, and so on, we have completed a highly efficient design in a short timeframe.

The development procedure involves creating LSI development specifications on the basis of requirement specifications, and then determining the detailed specifications for each functional block. In this, we make use of existing IPs, wherever possible, to shorten the design period and improve quality. Whilst designing new blocks and modifying and analyzing existing IPs, we also start on chip level design and analysis. By using separate designers for the chip level design and analysis and the block design, we are able to prevent errors caused by preconceived ideas, and shorten development time.

By adopting this procedure, designers are able to free up a lot of time through the use of power use reduction measures, enabling them to develop highly competitive products.

Conclusion

The ML67Q5200 has been designed to provide rapid adaptability to changes in the audio market, by incorporating a software-rewriteable flash ROM, and measures for controlling the clock supply to each block in order to reduce power consumption.

The ML67Q5200 provides a fully functioning system LSI with preinstalled software. It can also form a platform for realizing different functions if the software is changed.

From here on, rather than concentrating on silicon players alone, we will looking at the whole spectrum of digital audio products, from CD players, to hard disk music servers, and so on, and aiming to develop high-performance system LSIs, along with well researched software products, for these applications.

References

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