In-vehicle Information Terminal System LSI

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Some remarkable high performance and highly sophisticated car navigation systems have been produced in recent years. They are equipped not only with navigation functions but they also incorporate a television receiver, DVD player and audio player functions. So many functions are available with these systems and a connection with a mobile phone completes the in-vehicle information terminal.

This paper describes the ML673500, which is an in-vehicle information terminal system LSI we developed for the purpose of realizing audio, visual, navigation and communication functions as an in-vehicle information terminal with the car navigation system as the main feature. The ML673500 is a system LSI created with the intention of balancing a high performance with sophistication.

Targeted Systems

Targeted systems for the implementation of the ML673500 will be described first. Careful consideration was given to the specifications of the ML673500 in order to create a system LSI that can support various modes of applications. An application example of an integrated system comprised of audio, visual, navigation and communication components, is shown in **Figure 1**. In-vehicle information terminals are generally composed of components, such as a hard disk drive (HDD), global positioning system (GPS), gyroscope, DVD player, tuner, LCD display, with memory, an interface for mobile phones and an in-vehicle bus interface. The ML673500 is intended to control all such peripheral devices and implementation is targeted for systems that integrate audio, visual, navigation and communication components.

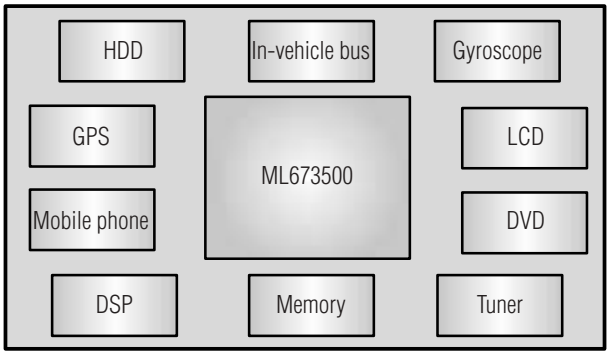

Fig. 1 An example of an application for audio visual navigation and communication integrated system.

As mentioned above, the ML673500 incorporates numerous functions that can respond to various modes of in-vehicle information terminals, while at the same time able to meet the demands as a low cost product.

Function Summary

The following targets were established for the purpose of determining specifications for the ML673500, which is designated as an LSI for in-vehicle information terminals.

- A CPU offering adequate performance for controlling in-vehicle information terminals must be built in.
- An interface function for external devices, which is essential for general-purpose microcomputers, must be available.
- As many of the functions previously realized for in-vehicle information terminals, which were added as individual separate components, are to be incorporated.
- The product must be available for a low cost.

Specifications of the ML673500 are provided in **Table 1**, while a configuration diagram is shown in **Figure 2**.

One of the µPLAT® series of products we developed, the µPLAT-946, has been loaded into the CPU platform. The ARM946E-S*[*1)], featuring low power consumption and high performance, has been loaded into the CPU core. The µPLAT® is a CPU platform designed to improve design productivity, shorten design times and increase the levels of software asset inheritance for system LSIs, which continue to grow in scale. Minimal peripheral functions necessary for the operation of a real-time operating system are built into the µPLAT®.

The ML673500 is equipped with functions that are generally required for microcomputers, such as an analog-digital converter (ADC), general purpose input/output (GPIO), watchdog timer (WDT) and flexible timer (FTM). Furthermore, it is also equipped with interfaces for external devices, such as a universal serial bus (USB) 1.1HOST, controller area network (CAN), pulse width

*1) ARM946E-STM is a trademark of ARM Ltd.

Table 1 Specifications of ML673500

Platform	µPLAT946.
CPU core	ARM946E-S.
Internal operating frequency	120MHz.
Cache memory	•8KB instruction cache. •8KB data cache.
Internal RAM capacity (byte)	16KB.
External bus	•ROM space of 32MB. •SRAM space of 32MB. •SDRAM space of 128MB. •I/O space of three banks. •8,16,32-bit device connection.
I/O port	•I/O settings. •Interrupt input settings.
CAN	Complies with CAN V2.0 Part B/Active.
FTM	16-bit auto reload timer.
FM multiplex decoder	Data radio channel (DARC)-type multiplex receiver function.

USB	•USB 1.1 HOST •Internal transceiver.
PWM	•16-bit •I/O function.
WDT	16-bit
ADC	10-bit
RTC	Real-time clock that has seconds, days of the week and years.
Display controller	•Digital/analog RGB. •Maximum three layers as well as a cursor. •Display size: Max. 800 x 480 picture elements. •α-blend function.
Graphic processor	Bit built function.
Universal serial	Synchronous/asynchronous.
DMAC	10 channels.
Power saving function	•Standby mode. •Stop mode.
Operating temperature	-40˚C to 85˚C
Power supply voltage	1.5/3.3V

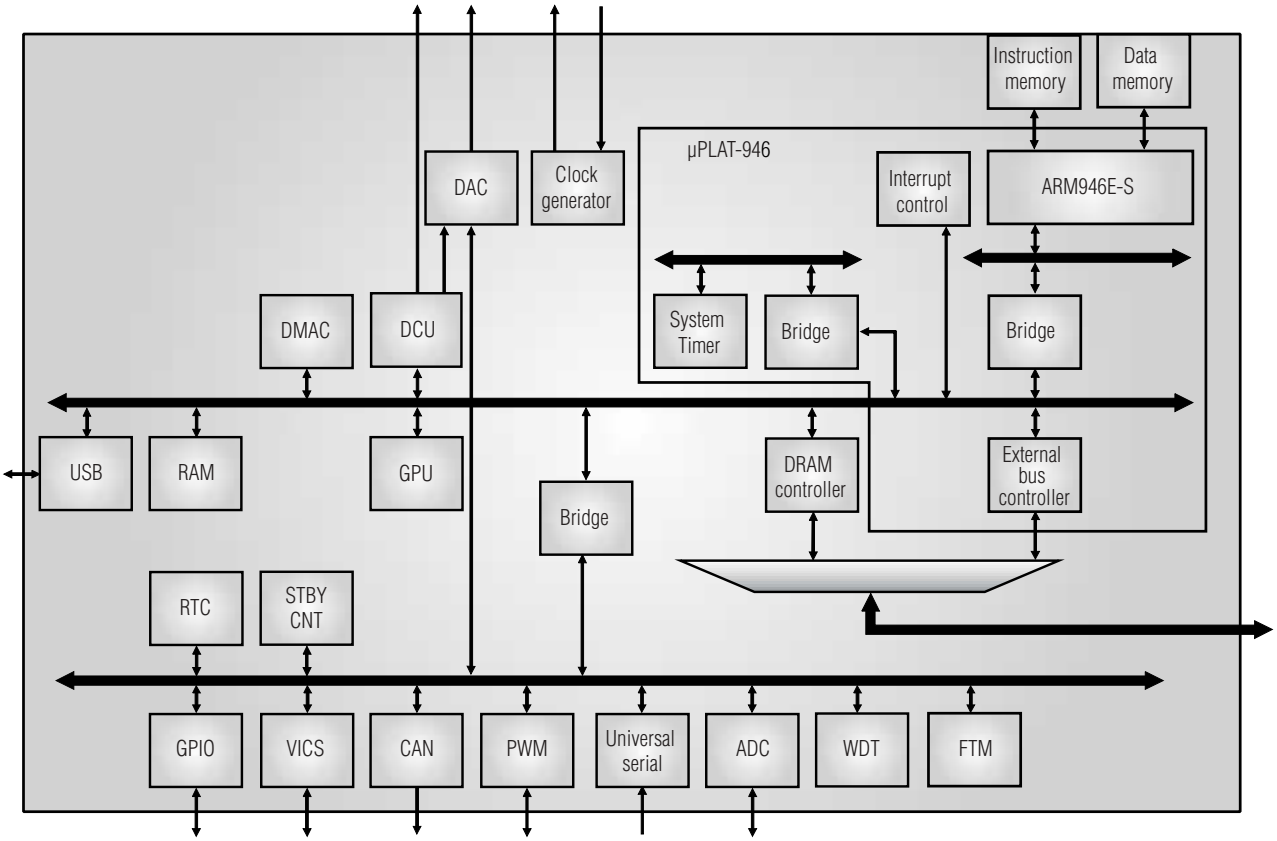

Fig. 2 Configuration diagram of the ML673500

modulator (PWM) and synchronous/asynchronous universal serial interface, making it compatible to connect to a variety of devices. The external memory interface can be connected to a flash ROM, ROM, SRAM and SDRAM. It is also possible to connect it as a universal input/output device with advanced technology attachment (ATA) devices.

The vehicle information and communication system

(VICS) function, which was previously realized as an individual component, is also realized with the ML673500 through the adoption of an FM multiplexing decoder. Furthermore, image processing functions, such as the display controller (display control unit, DSU) that outputs image data to the external LCD and the graphic processor (graphic processing unit, GPU), essential for car navigation systems, are also supported.

In order to inhibit the flow of electric current while the ML673500 is in a standby condition, the sections with the internal power supply turned on at all times are separated from the rest of the sections. Furthermore, the supply of power that comes from a power source can be controlled from an external regulator. Through these types of mechanisms, it is possible to inhibit the amount of electric current to an extremely small value when devices, such as car navigation systems, have the power turned off, even if the data of necessary information is retained and clock operations are ongoing (standby mode).

Features

A detailed description is provided for the display control function, graphic function, accelerated data transmission rates and the standby function, which are all features of the ML673500.

(1) Display control function

The product is loaded with a display controller that controls the display of images on the external LCD. The display controller is capable of controlling both the display layers and cursor layer. The α-blend function is concurrently in operation while individual layers are superimposed on top of each other, making it possible to readily realize various types of display modes, such as superimposing a menu on to a map. The progressive display and interlaced display are both supported as display methods. Furthermore, the product is also compatible with a synchronous function for external synchronous signals. Images fed from external cameras or from DVDs can now also be displayed on the same display as the one on which the car navigation system is being displayed. It is necessary to ensure that the display data is output without delay, in order to prevent the occurrence of a partial omission of display images (such as disturbed screen displays). For this reason the bus master is directly connected to the bus interface and data is acquired from the external SDRAM directly without any intervention by the CPU, while the size of the image data buffer inside the display controller is optimized. A block diagram of the display controller is shown in **Figure 3**, while an example of the display screen is shown in **Figure 4**.

(2) Graphic function

We loaded a graphic processor that performs the imaging and copying of images to the frame memory in the product. It is possible to depict dots, lines and rectangles using one color on the frame memory and to image dots, lines and rectangles with particular source

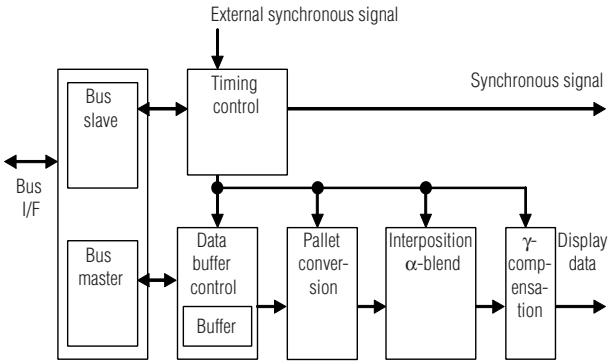

Fig. 2 Block diagram of display controller

Fig. 3 Display screen example

patterns. Since the product is equipped with magnifying and reducing functions, it is also possible to depict maps, menu boxes, buttons and icons at high speeds. In order to reduce the load on the CPU as much as possible imaging sequences composed of multiple groups of imaging commands are stored in the external memory in advance so that such command lines can be referenced by the CPU as needed, thereby making it possible to sequentially perform imaging processes without any intervention by the CPU. The graphic processor automatically determines the optimum burst transmission size for the data transmission of data to the frame memory in order to perform the imaging efficiently. An example of the rendering function is shown in **Figure 5**.

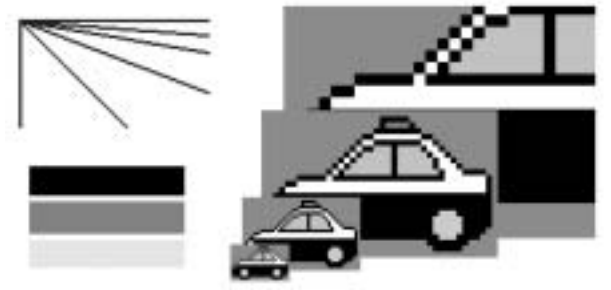

Fig. 4 Graphic function example
Left top : Imaging straight lines.
Left bottom : Fills.
Right : Magnification and reduction.

(3) Accelerated data transmission rates

Design of the bus was made with consideration for applications used by in-vehicle information terminals when developing the ML673500. A multiple layer bus configuration was selected for the bus of the ML673500, with optimum layer arrangements for the display controller, graphic processor, direct memory access controller (DMAC) and CPU with the following priorities:

① Disturbance to the display or sound must not exist.
② The necessary operating performance must be secured for components related to display and sound processes, such as the CPU, even under heavy loads.

Furthermore, prioritizing sequences between and inside bus layers, as well as arbitration methods, were optimized as well, resulting in the realization of a well balanced performance for the applications of in-vehicle information terminals.

(4) Standby function

In order to reduce the amount of electric current consumed by the ML673500 during standby conditions, such as when the engine of the car is turned off, the power source distribution zones inside the LSI were separated into the following two sections:

- A section essential for continuous operations, such as clock display: Standby section.
- A section necessary for operating only when an application is executed, such as the CPU: Core section.

The mechanism stops the supply of power to the core section when applications are not being executed and limits the power supply only to the standby section by restricting the amount of electric current expended during the standby mode to a low level.

Future developments

As mentioned above, the ML673500 realizes the functions necessary as an LSI for in-vehicle information terminals.

In the future, in order to provide products that can respond to the needs of in-vehicle information terminals with progressively higher performance levels and more sophisticated functions, we plan to improve the basic functions of our product through the improvement of operating frequencies by substantiating multimedia functions including MP3 or MPEG4 functions, while providing support to ETC as well as responding to the needs for a high-speed bus for in-vehicle systems, such as media oriented systems transport (MOST).

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