Embedded EMAT System Based on DSP and ARM

Zhiyu Li, Peng Chen, Shuai Wang
Ordnance Engineering College of PLA, Shi Jiazhuang, China
e-mail bryantzhi@126.com

Abstract: Design of the embedded system uses the system architecture of double CPU (ARM+DSP), making full use of the control capability of ARM and the processing capability of DSP. The architecture makes the work separated more clearly and the function more strong in the system. By transplanting excellent Real Time Operating System, Linux, the equipments are provided with an effective, perfect, stable, reliable software platform, using QT which is the most popular graphics designing tool in Linux operating system to design an intelligentized man-machine interface. An embedded EMAT system based on ARM and DSP is designed successfully. The Electro-magnetic Acoustic Transducer (EMAT) system adopts advanced and reasonable hardware framework of superstratum plus substrate computers, embeds Linux operating system and an intelligentized man-machine interface.

Keywords: ARM; DSP; EMAT; embedded; man-machine interface

1 Introduction

EMAT is short for Electro-magnetic Acoustic Transducer. It's a new device for acoustic emission and receiving. It has been a main means of testing ferromagnetic material surface and near surface defect. For the defect of inside the ferromagnetic material, precise testing and analyzing are very important. From this way, it can be analyzed and judged correctly what the reasons of effecting are for the quality of material, and provides foundations for improving the quality. EMAT system is the terminal of composite testing and supervising quality of material. It's used to realize that the data of testing quality is collected and transported with computer system. This system can deal with numerous tasks, including: data collection, various kinds of calculation, information transportation and Human-Machine interaction, and so on. And it must ensure the quality of Real-Time. In this situation, it required the equipment must have not only high speed and great ability of processing, but also controlling Real-Time tasks. In the end, it has to calculate the costs [1], [2], [3].

Sum up all the reasons, the way of both DSP and ARM is advanced. The advantages of microprocessor ARM are including speedy and highly functional and chip integrated, low power loss and plenty peripherals interface. Now, the cost of chip ARM is a little more than single chip. The chip ARM can be transplanted by the type of embedded Real-Time operation system. It's easy to attemper multitask. Also, it predigests exploitation of function of LCD, storing of hard disk, communications of network. It greatly reduces the cycle of exploiting production. At the same time, using high speed operation of DSP and character of multichip peripherals, it can achieve catching, sampling and transforming input signals and communicating with ARM. It gives attention to Real-Time performance of system and special requests of supporting complex algorithm. In addition, an intellectualized Human-Machine interface is designed so that operators can inquire results quickly and exactly. Then they can take action to eliminate defaults, to ensure the reliability of EMAT [4], [5].

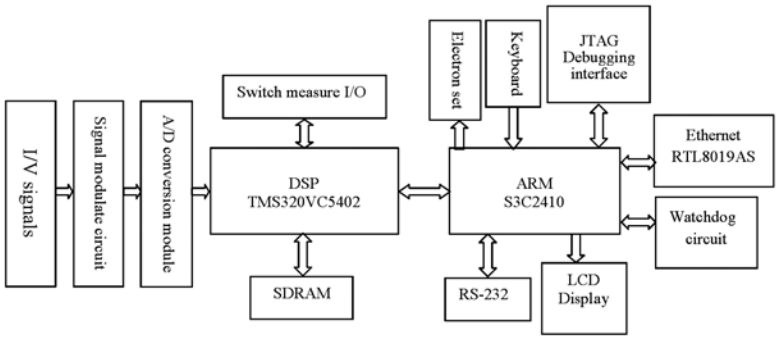

Figure 1. Embedded EMAT system hardware structure chart

978-1-935068-01-3

2 Collective Designing for Embed ded EMAT System

The system adopts principal and subordinate disposing system of ARM plus DSP. It collects Human-Machine interaction and data messages to subsystem of ARM. The mainframe completes peripherals control. While the input signals are taken, sampled, transformed by DSP chip. Realize disposal arithmetic for multi-signal. Then it transmitted the DS which has been done to ARM. The ARM transmitted the data to net through Ethernet control, and then it achieves long-distance control survey [4].

TMS320VC5402 type of DSP chip is selected. The chip is fixed point DSP designed by TI co. especially for low energy consuming and high capability. It gives McBSP (Multi-Channels Buffer Serial-Port); DMA controller of 6 channels; 8 bits enhanced HPI (mainframe interface); the bus inside uses Harvard structure to improve speed of calculation greatly. The ARM chip is series chips of ARM9 made by Samsung co. named S3C2410. The core processor and peripherals constitute a whole ARM system. It has many advantages including small volume, low power consuming, high disposing capability. It can load and run embedded Linux operation system [6].

2.1 Data Collection Module

The data collection module of the system is THS10064 made by TI co. It uses CMOS structure,10 bits precision,6 MIPS Sampling Rate. It can sample 4 channels signals or 2 groups' difference signals at the same time. The clock of A/D chip is provided by BCLKX0T. Its clock output of MS320VC5402 multicentre buffer serial ports McBSP. And its clock frequency can be set by software program. When A/D is working at 6MHz, DSP is still working at 100MHz or more. It doesn't affect dealing with collecting data. Otherwise, because of the FIFO of 16 bytes in A/D, through controlling register inside of A/D, decreasing times of communication between DSP and A/D, DSP working at high speed can still communicates with A/D, and won't affect DSP.

2.2 Interface Design of ARM and DSP

HPI (Host-Port Interface) is an interface part inside of TMS320VC54x series fixed point. It's mainly used to communicate between DSP and other bus or CPU. Figure 2 is interface diagram of DSP and ARM. Two address lines of S3C2410, ADDR2 and ADDR3, linking selecting signal footprint, HCNTL0, HCNTL1, of DSP register to finish selecting different registers. HBIL signal of DSP is used to indicate that the upper 8 bits or lower 8 bits transmitting in HD [0…7]. Address lines ADDR1 of S3C2410 connect with it. Because S3C2410 lacks $HR/\overline{W}$ signal, ADDR4 connects with $HR/\overline{W}$ of HPI interface instead of the signal. High Level or low of ADDR4 decides reading state or writing of HPI separately. nGCS2, signal for selecting chips of BANK2 which is space of exterior storage S3C2410, connects with $\overline{HCS}$, signal for selecting chips of HPI. $\overline{HDS1}$ and $\overline{HDS2}$ of HPI are data selecting signal, and they connect with nOE and nWE which are R/W signal of S3C2410. $\overline{HINT}$ is interrupt signal of HPI, so it can be generated by DSP to interrupt ARM, or by ARM to interrupt DSP. The interrupt signal connects with EINT8 which is exterior interrupt footprint of S3C2410. In this way, EINT8 can generate signal to interrupt DSP, also can intercept interrupt signal from DSP.

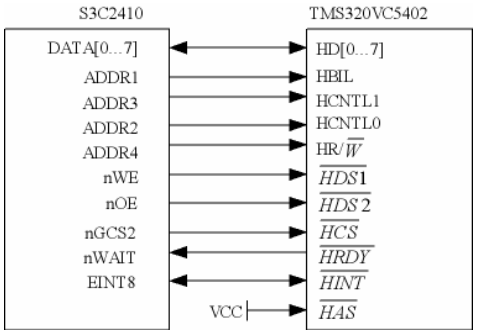

Figure 2. Interface circuit of ARM and DSP

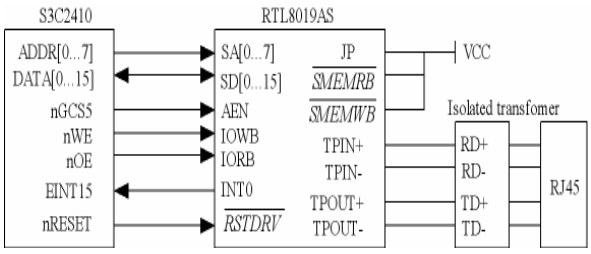

Figure 3. Interface circuit of RLT8019AS and S3C2410

2.3 Design for Communicating Interface Between ARM and Ethernet

The communication function of Ethernet is realized by one RTL8019AS chip. It hasn't special request for em-

bedded processor, and it is very universal. The design uses default config of RTL8019AS and some interfaces as initial methods network card. In this way, it can save config storage, minish volume of embedded hardware platform. Interface circuit of RTL8019AS and S3C2410 are showed in Figure 3 [7].

3 Design for Embedded EMAT System Software

The software of system is including software of DSP, ARM and communication software between double CPU, software of Human-Machine interaction and computer system software. The DSP is mainly used for collecting data, calculating on Real-Time responding controlling commands of ARM, and sending the data and calculation results back to ARM. The main program of DSP is shown in Figure 5. The ARM performs to supervise and control the whole system. It sends commands to DSP and requests to return different kinds of data and information based on different situation. The key in the embedded system based on double CPU structure is to make data supervision on Real-Time. A part of Human-Machine interaction is used for realizing Human-Machine interface which is intellectualized menu style. It's convenient for people to inquire about data and find faults. Computer software is mainly used for analyzing and dealing with uploaded data by ARM again.

Communication protocols between DSP and ARM are as follows: At first, ARM sends a command (such as data acquisition) and interrupts DSP through HPI to make DSP perform relevant functional subprogram. At the same time, DSP stores the acquisition data and the processed data into two buffers. The length is 256 bytes (one frame). When ARM requests data from DSP, ARM sends a frame synchronization command, and interrupts DSP. After that, DSP stores data which has been deal with to RAM of HPI. After storing one frame, DSP sends an interrupt to ARM. When ARM responds, first of all, it eliminates the interruption and takes data out from RAM of HPI. It is necessary to point out that after the system resets every time, DSP makes the level of $\overline{HINT}$ low. So when HPI is initialized, ARM cleans the interruption up through HPI firstly, and then performs relevant interruption. The flow chart of communication program between DSP and ARM is shown in Figure 4.

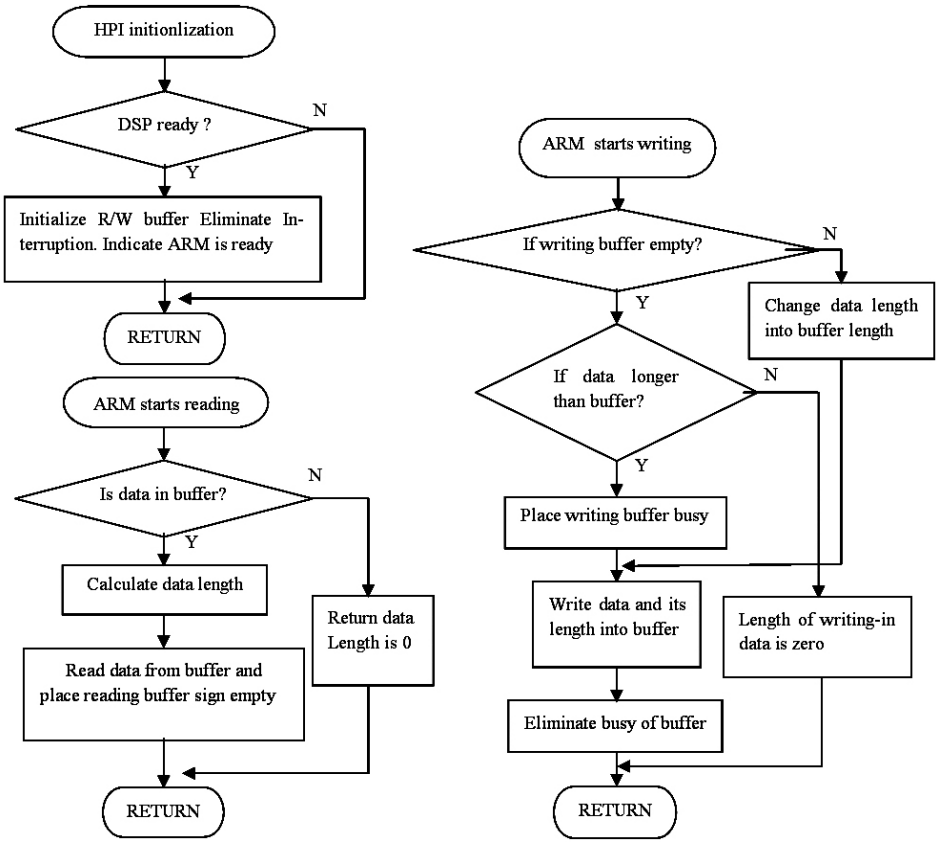

Figure 4. Flow chart communicated program between ARM and DSP

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The design of the interface of Human-Machine interaction uses menu style design. It can display the commands directly. The operators needn't remember the commands. So it provides easy and flexible operations, and reduces the complexity. It makes the operators operate the system on Real-Time and knows monitoring information and running state of EMAT. The system uses the best tools of figure exploiture in Linux system—QT to design Human-Machine interface. QT is a cross-platform application program frame of graphical user interface based on C++. It is a production of Trolltech Company. It provides application program developers all functions which are needed to build art graphical user interface, and plenty of Windows parts assembly. It has many characteristics such as object-oriented; it's easy to be extended and unalloyed program. So far, KDE which is the most popular desktop environment is built on the basis of QT base. The intellectualized menu style Human-Machine interface designed in the system is shown in Figure 6.

4 Conclusions

Nowadays, EMAT is developing to be continuously inspirited, reduce power consumption, analyze on Real-Time and change to network. In this way, more and more intelligential functions are requested in the EMAT system. Except for functions of calculation and display, it also needs functions of judgment, analysis, decision-making and so on. And it will be capable of realizing remote communication and transporting automation and intelligence of data transportation. This system uses the structure of principal and subordinate type double CPU of ARM and DSP to perfect the hardware platform of the system. It perfects software platform through transplanting mature and steady embedded Real-Time operation system—Linux. It designs intelligent Human-Machine interface to realize faster and more perfect function of EMAT [8], [9].

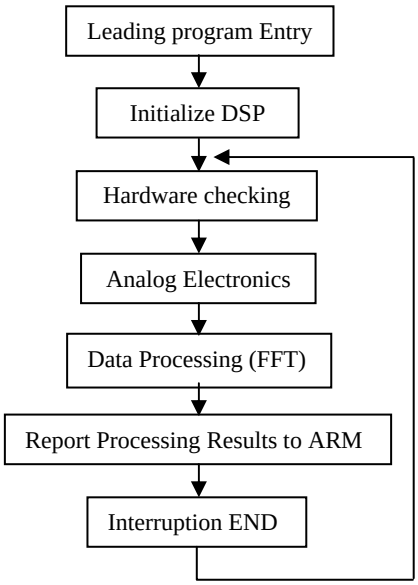
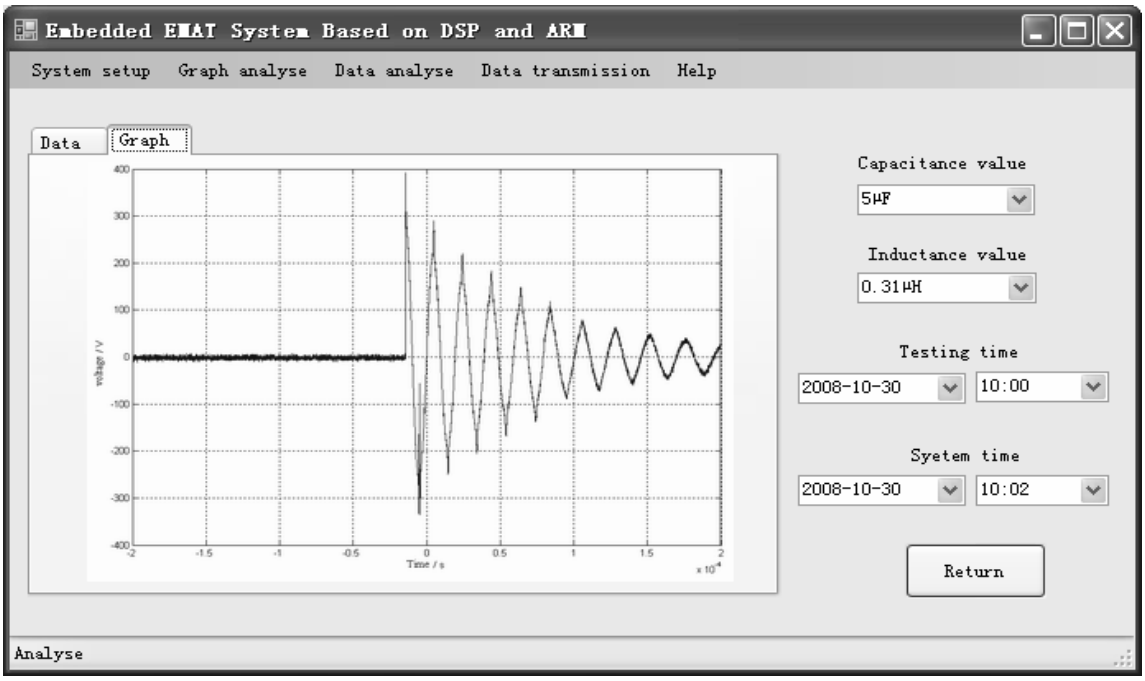


Figure 5. Main program flow chart of DSP



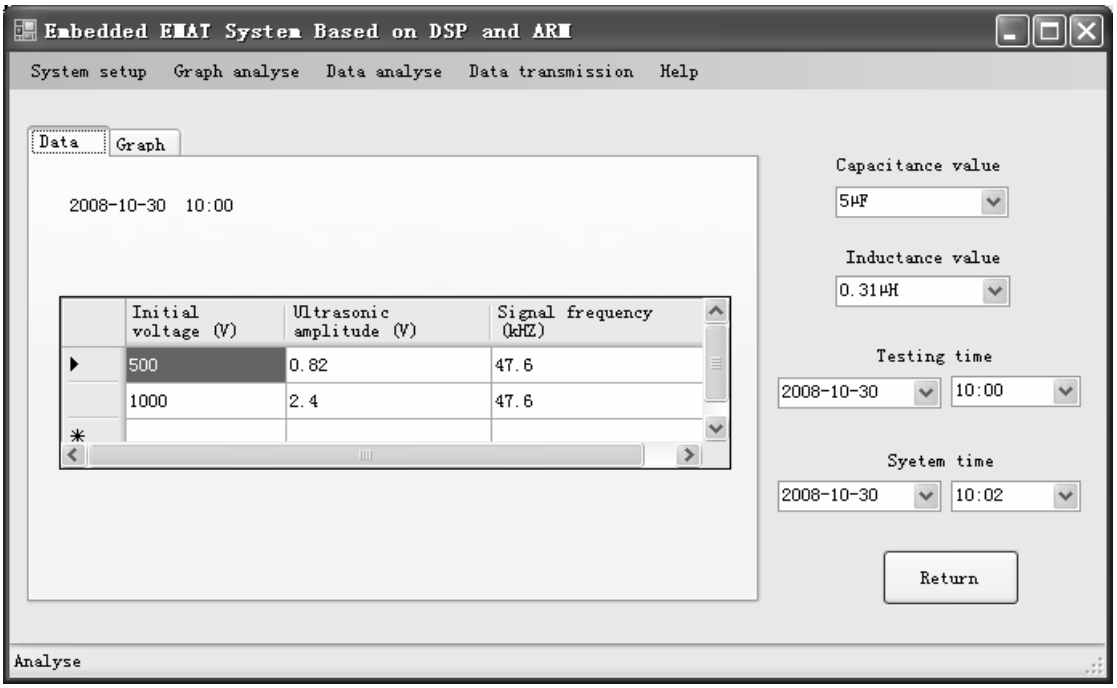


Figure 6. Human-Machine interface of embedded EMAT

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