Design and implementation of acoustic target recognition system based on TMS320F2812

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Abstract

In this paper, TMS320F2812 is adopted as the core component and the hardware circuit system is designed for acoustic target recognition, which includes signal conditioning circuit, A/D acquisition circuit, memory expanding circuit, power management circuit and data communication circuit, etc. The recognition algorithm was transplanted to the acoustic recognition system based on DSP, which enhanced the running rate in DSP. This system can accomplish acoustic signal sampling, pretreatment, feature extraction and recognition. On the basis of the simulation and real tests, it is proved that the acoustic target recognition system proposed in this paper is stable and reliable, which can satisfy the practical requirements.

Keywords: DSP, TMS320F2812, algorithm, acoustic target recognition

1 Introduction

Acoustic target recognition (ATR) is the key technology in battlefield detection system, which attracted people's great concern at home and abroad in recent decades [1-4]. Chinese research institutes and universities have conducted research on acoustic target recognition technology sequentially; the in-depth theoretical research was carried in acoustic sensor technology, acoustic feature analysis of the target signal, signal processing, artificial intelligence and other aspects, and a series of achievements also be made by scientific research. However, due to the lacking research on feature extraction of non-stationary target signal, target recognition method and system synthesis with non-determinacy characteristics, identify systems fusion, etc., there are many theoretical and technical issues need to be addressed in acoustic target recognition technology in china. Especially there are many problems in recognition accuracy, real-time, miniaturization, and other aspects. Therefore, ATR technology is still far from reaching maturity [5, 6].

Generally speaking, the design of target recognition system mainly includes the following three aspects:

1) Self-perception. Perceiving external information by acoustic, magnetic, vibration, infrared sensors;

2) Real-time data processing and transmission. Processing perceived information timely, so that each attack department or combat unit will quickly react and make decision;

3) Microminiaturization. Small size can be distributed more conveniently or concealed easily [4, 7, 8].

Acoustic detection and recognition technology has a long history [9, 10]. Early in World War II, it had been applied in the battlefield for detecting, identifying and localizing the enemy military facilities and armed personnel, so ART played an important role at that time. Compared with other methods, acoustic detection technology has the following advantages:

1) Passive working style is difficult to be detected or located by enemy surveillance equipment;

2) Unrestricted by visual field or obstacles;

3) The acoustic detection equipment has relatively simple structure, low cost, small size, light weight, high mobility, and unrestricted from climate and other natural conditions, so it can work all-weather;

4) Pre-warning network can be composed based on acoustic detection technology, which will improving detection accuracy and reducing false alarm rate [3, 11, 12].

2 Hardware circuit design

2.1 SYSTEM STRUCTURE

The hardware circuit of the acoustic target recognition system proposed in this paper includes: signal conditioning circuit, analogue to digital (A/D) acquisition circuit, memory expansion circuit, power management circuit, data communications circuit and other interface circuit. The overall diagram of system structure is shown in Figure 1.

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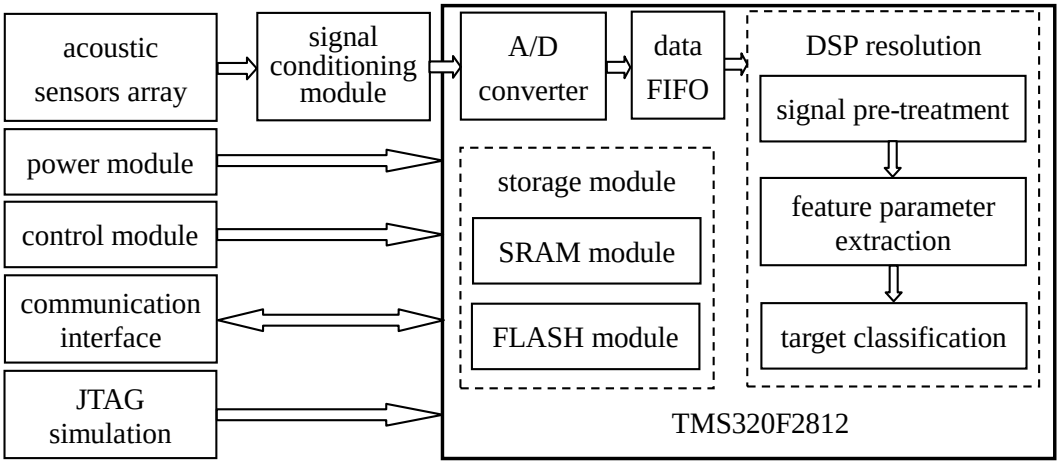

FIGURE 1 The overall diagram of system structure

2.2 TMS320F2812 DSP

ATR system requires "high real-time processing" capability, which is: the system must complete all operations and processing for current data before the next sampling time, otherwise it will affect the subsequent processing of sampling data. When data sampling rate is high or the amount of computation is large, the general processor is difficult to achieve "real-time processing" requirement. Digital signal processing (DSP) chip was developed rapidly in recent decades. DSP has a series of advantages, so it can be used in the high-speed real-time processing system [13]. TMS320F2812 is developed by Texas Instruments (U.S.A.), which is a low-power, 32-bit fixed-point DSP. TMS320F2812 has a micro-controller structure, firmware and tool equipment, reduced instruction set (RIS) feature, rich instruction set, multi-pipeline operation, large storage space and faster computing speed [1, 13, 14].

2.3 ACOUSTIC SENSOR

Acoustic sensor is also named as "microphone", and there are several types, such as: piezoelectric type, moving-coil type, capacity type, electrets type, and so on. Among them, because of the poor frequency response and stability, the moving-coil and piezoelectric types had been rarely used. Generally, electrets microphone is most suitable for acoustic target recognition system. According to practical demand, PF0-T6027 is used in this paper, which is a omni-directional electrets microphone.

2.4 SIGNAL ACQUISITION & CONDITIONING CIRCUIT

Acoustic signal acquisition is the first link in target recognition system. An A/D converter (12-bit) in TMS320F2812 is adopted, which is simple and flexible, and the hardware design can be simplified to some extent. Because of the internal A/D converter module in DSP, it has high anti-interference ability, and the performance was significantly better than other external A/D chip.

During the sampling, quantization, due to the frequency aliasing, the sampling signal may be distorted owing to systematic errors and random errors. In order to ensuring the sampling accuracy, the analogue signal must be properly conditioned before sampling. Generally, the analogue signal is usually filtered and amplified firstly, so as to fully utilize the dynamic range of A/D converter module. Furthermore, the input voltage range of internal A/D is 0~3V, therefore the sampling signal of the microphone must also be limited. Signal conditioning circuit is shown in Figure 2.

Mentioned above, amplitude range of conditioned acoustic signal is 0 ~ 3V, which is connected to the A/D input channel ADCH in TMS320F2812. A/D module is comprised by: front-end analogue multiplexer switches, a sampling and holding circuit, a conversion circuit, a voltage stabilizing circuit, and so on. The digital circuit includes: programmable conversion sequence generation circuit, result registers, analogue power connector, other peripheral interface circuit, and other module interface circuit.

Two 8-channel modules can choose any input from the eight input channels. In the cascade operation mode, the automatic sorting will become a single 16-channel sequencer. In each sequencer, once the conversion is complete, the conversion result will be stored in the corresponding ADCRESULT register. The automatic sorting allows system converts the same channel multiple times in order to achieve over-sampling. Compared with the traditional single-sampling mode, this conversion mode is in favour of improving the data sampling resolution.

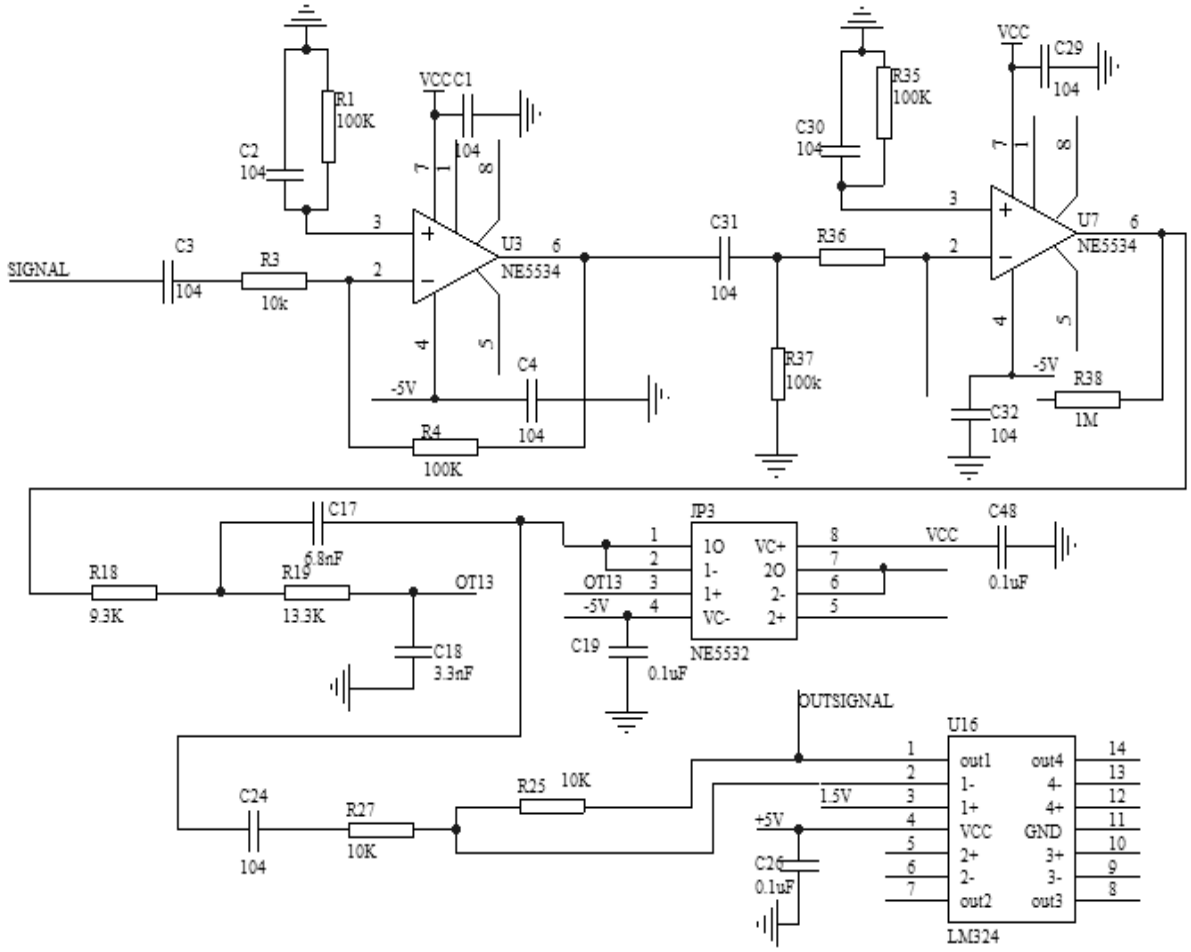

FIGURE 2 Signal conditioning circuit

2.5 SERIAL COMMUNICATION CIRCUIT

UART is a standard universal asynchronous receiver/transmitter. The acquisition data can be outputted via UART, and the data communication between DSP and PC will be achieved. Subsequently, the data can be processed by the data analysis software in PC. As a UART interface circuit between DSP and PC, the transmission and receiving of serial data between DSP and PC can be completed only need a few instructions in the program, as well as the rest of the work will be done in UART automatically. All pins' output is TTL level in TMS320F2812, while the PC's serial port follows RS232 standard. As a result, it requires a level conversion interface between PC's serial port and the DSP [1]. In this paper, MAX3160 transceiver (Maxim Company) is selected, which is a programmable multi-protocol transceiver following RS-232, RS-422, RS-485 and other data transmission mode. In addition, +3 ~ +5.5 V power supply will satisfy the RS-232 and RS-485/422 protocol standards. Communication interface circuit between PC and TMS320F2812 is shown in Figure 3.

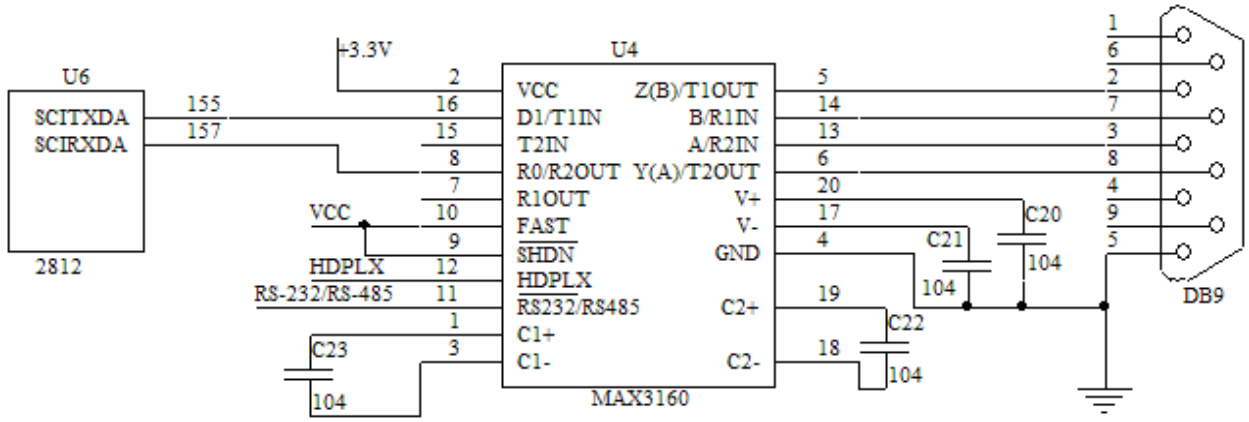

FIGURE 3 Communication interface circuit between PC and TMS320F2812

3 Embedded system software design

There are some specific requirements when the application program runs in TMS320F2812's internal Flash. Some problem may be concealed when the application program is debugged in RAM by means of CCS simulation software, but the actual use of DSP requires paying more attention to these issues. The following text will discuss how to configure the application software so that it can run properly in Flash [1, 13].

3.1 LINKING PROGRAM BLOCK

TMS320F2812 can be used in embedded systems independently, its on-chip Flash can be saved using an external non-volatile memory, and unnecessary initialization data can be stored in other resources such as SRAM. When the program block is being linked, a user link command file is must be created. In this file, a number of memory cells are defined, and the location area of the block is specified. The format of this file is similar mostly with the ".cmd" file running in RAM, while the main difference between them is where the program block is linked to.

3.2 COPY THE FUNCTION PROGRAM BLOCK FROM FLASH TO RAM

PIE module is used for managing the interrupt requests in TMS320F2812. When system is powered on, all interrupt vectors must have been stored in non-volatile memory Flash in advance. Meanwhile, in the initialization code, the interrupt vectors must be copied to the PIE RAM. PIE RAM is to be located at special RAM area in data space, and the starting address is 0X000D00. Copying PIE vector table needs to be accomplished in a file called as "DSP28_PieVect.c".

3.3 INITIALIZATION THE CONTROL REGISTERS

The control registers in Flash include: FOPT, FPWR, FSTDBYWAIT, FACTIVEWAIT, FBANKWAIT, FOTPWAIT, and so on. Initialization of these registers cannot be completed in Flash, so they must be copied form Flash to RAM and then executed initialization.

Since the Flash control registers are protected by Code Security Module (CSM), if DSP is safe, the Flash register initialization code is must be executed in secured RAM (usually is L0 or L1 RAM). Otherwise the initialization function InitFlash() will not be able to access the Flash register.

3.4 EXECUTE TARGET RECOGNITION ALGORITHM FUNCTION

In this paper Target recognition algorithm has been designed and simulated in PC, the main functions include: acoustic signal pre-treatment, feature extraction and classification. In this system, the corresponding algorithm needs to be transplanted to the DSP in order to achieve the classification and recognition capabilities.

The clock frequency in TMS320F2812 is 150MHz, and the Flash memory in which can only provide about 120MIPS (Millions of Instruction per Second) of processing speed. As for the on-chip RAM, its performance can reach 150MIPS. So in some cases, some time-sensitive or large computational subprogram should execute in RAM. However, in a separate embedded system, all code must be stored in the non-volatile memory. As a result, the function executed in RAM must be set load and run address. In addition, the copy process from Flash to RAM must be carried out after power on.

3.5 EXECUTE CODE IN FLASH

TMS320F2812 contains a ROM guide loader, which can transfer the code to Flash and execute it after DSP is reset. When the guide mode configures the pin as "Skip to Flash", ROM guide loader will execute the instruction at the specified location. So the user must set up a jump instruction here, which will point to the start address of the user code.

Generally speaking, the jump instruction will jump to the start position of initialization subroutine in "rts2800_ml.lib" supported by C compiler. The entry symbol of this subroutine is "_c_init00", and only after running the routine, the remaining code can be executed.

4 Simulation experiments

4.1 SIMULATION EXPERIMENTS IN CCS

In the simulation experiments, the target recognition system board and DSP hardware emulator is connected together firstly. Secondly, the program is downloaded to the TMS320F2812 chip through CCS development tools. Finally, the pre-treatment, classification and recognition of collected acoustic signals are simulated. The recognition result is displayed on the lower screen of CCS interface, which is shown in Figure 4.

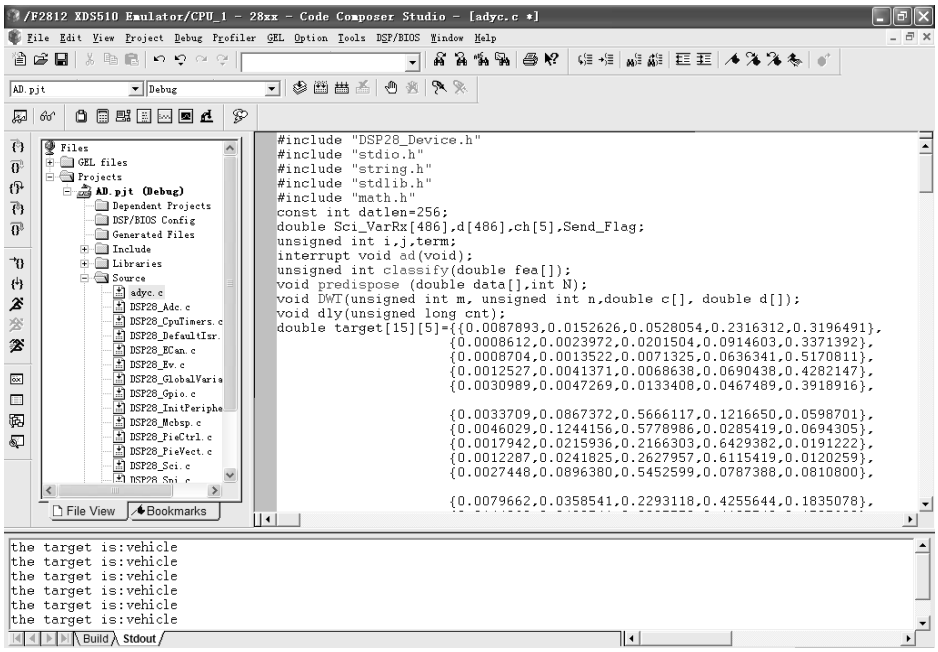

FIGURE 4 Online simulation interface and results in CCS

4.2 SIMULATION EXPERIMENTS RESULTS

In the online simulation in CCS, the nearest neighbour classifying method is applied for target classification and recognition, and the results are shown in Table 1. It is clear that the personnel's acoustic and the vehicles' acoustic can be distinguished effectively in the using of the acoustic target recognition system proposed in this paper, and the average recognition rate is over 90%.

TABLE 1 Simulation experiments results

Category	Personnel		Vehicle	
Sample sum	400		400	
Recognition Results	Correct	Fail	Correct	Fail
	363	37	381	19
Recognition Rate (%)	90.75		95.25	
Average recognition Rate (%)	93			

5 Conclusions

In recent decades DSP technology has been widely applied in various fields, such as: military, industrial inspection and control, smart instrumentation, communications, and medical treatment, etc. TMS320F2812 chip is specially designed for industrial applications, new-generation 32-bit fixed-point DSP processor, which has high integration, high speed, high precision and low cost advantages, also has a lot of peripherals, interfaces and modules [1, 13, 14]. In this paper, the hardware circuit based on TMS320F2812 is designed; the algorithm of acquisition, processing, feature extraction and recognition is accomplished and simulated; algorithms in each module are transplanted to DSP; part of the algorithms are optimized, and which improved the execution speed in the DSP. A higher recognition rate is achieved in the distinguishing between personnel's acoustic signals and vehicles' acoustic signals. In addition, the system is also be used in numerous practical applications and made several good recognition results.

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