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Design of a Multi-parameter Measurement System

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Abstract

This paper introduces a multi-parameter measurement system, which is used for recording the temperature and humidity, atmospheric pressure, rotation speed and acceleration, etc. The system uses a 32-bit RISC microprocessor of STM32F103ZET6 based on the core of ARM Coretex-M3 as master chip. Meanwhile, it writes the data recorded to NAND FLASH. After it is over, it copies the data to host-computer through SD card.

Keywords: *multi-parameter measurement system, STM32F103ZET6, NAND FLASH, SD card*

1. Introduction

Measurement of attitude and meteorology during flight of high speed is always a puzzle. Nowadays, quite a lot of methods are used to measure the flight attitude and meteorology, such as optical test method, radar test method, high-speed photography method and accelerometer method, etc. These methods have their own limitations. Optical test method is climate-sensitive and has a short efficient distance; radar test method is susceptible to be interfered and poor in accuracy when working at long-distance; high-speed photography method has a short test time and efficient distance; accelerometer method must combine a lot of accelerometers, and has a high requirement of installation precision [1], meanwhile its attitude algorithm is complex. Because of the limitations of the common test methods, this paper uses dynamic memory recorders, accelerometer and gyroscope as sensitive element to measure the flight attitude and meteorology [2].

2. System Function

The system has five function modules, including STM32 core module, sensor module, ADC module, storage module and data-transmission module. STM32 core module is the most important module, which is responsible for data processing. Sensor module records environment parameters, some of which are analogy signals. ADC module transforms the analogy signals to digital signals for STM32 core module. Storage module consists of a NAND FLASH, and stores data temporarily. Data-transmission module is used to transmit data to host-computer. As is shown in Figure 1, five function modules make up the whole parameter measurement system.

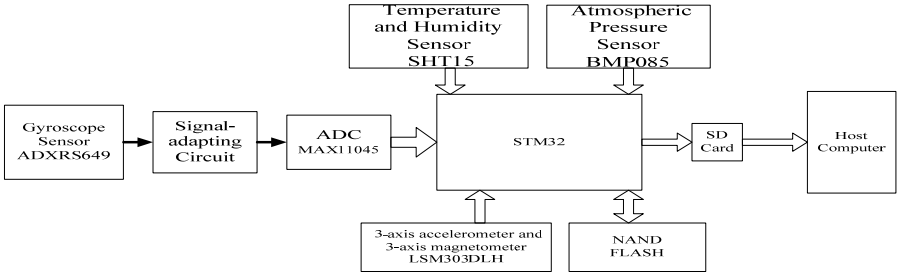

Fig 1. System Description

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3. Design and Implementation of Hardware System

3.1. STM32 Core Module

STM32 is the core of the whole system, which consists of ADC block, SD card transmission block, NAND FLASH block and PLL frequency multiplication (DCM) block. The principle diagram is shown in Figure 2.

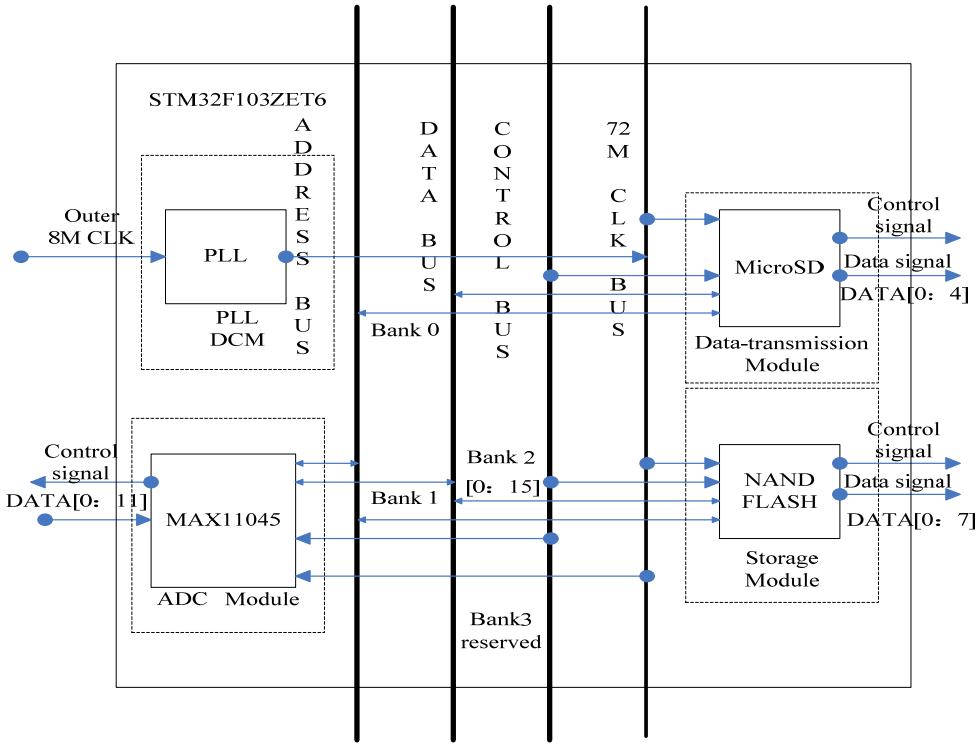

Figure 2. STM32 Core Module Diagram

STM32 integrates an inner 8M high-speed RC oscillator, but the precision of this RC oscillator is not high. So in the system, an active crystal of 8MHz is chosen for STM32, which will be multiplied to 72MHz as system CLK.

3.2. Sensor and ADC Module

Sensor module has four sensors to record environment parameters, including temperature and humidity sensor SHT15 from Sensirion Inc., atmospheric pressure sensor BMP085 from BOSCH Inc., 3-axis accelerometer and 3-axis magnetometer LSM303DLH from SGS-THOMS Inc. and gyroscope sensor ADXRS649 from ADI Inc.[3]. Among them, SHT15 woks on low- power mode, and the resolution of temperature is 12 bits, while the resolution of humidity is 8 bits[4]; BMP085 has an EEPROM ,which supplies 176 bits standard data to compensate the voltage measured; LSM303DLH consists of accelerometer module and magnetometer module, which have different power-in pins[5] and the accelerometer uses +3.3V power supply, while the magnetometer uses +1.8V power supply; ADXRS649 should have a reference voltage of +5V, which is produced by low dropout linear regulator ADR125.

ADC module uses MAX11045 chip from MAXIM Inc. to convert the analog output of ADXRS649 to digital signal. MAX11045 has 6 A/D channels, two of which have been used in this system. The principle diagram is shown in Figure 3.

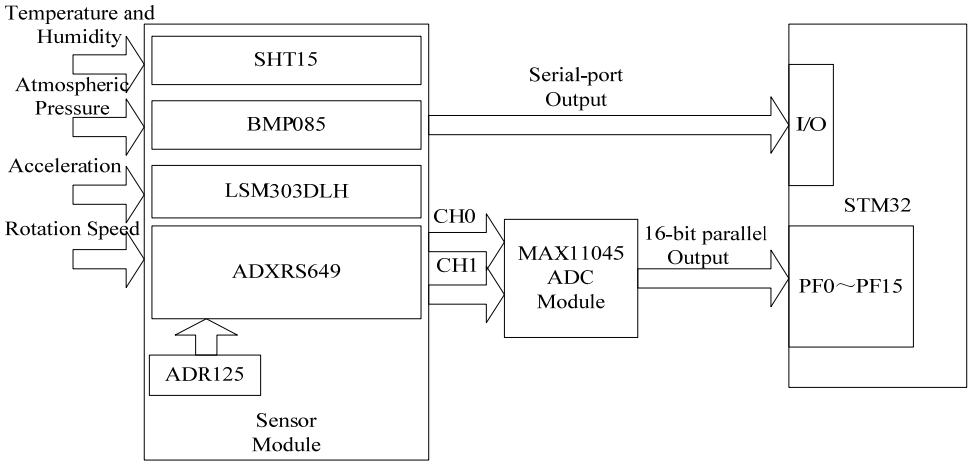

Figure 3. Sensor Module and ADC Module Diagram

3.3. Storage Module

The MCU of STM32F103ZET6 can be connected to all kinds of asynchronous and synchronous memory through FSMC. NAND FLASH MT29F2G08 from Micron Inc. based on SLC (Single-level cell) is chosen to record data in real-time, which is connected to BANK2 of MCU, while BANK3 is reserved [6]. The principle diagram is shown in Figure 4.

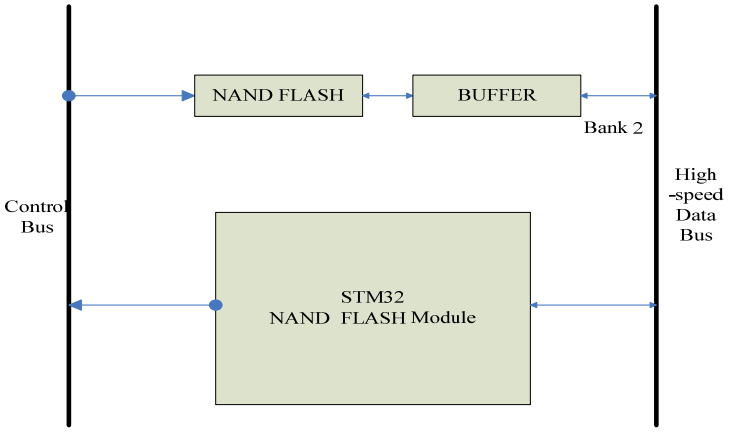

Figure 4. Storage Module Diagram

3.4. Data-Transmission Module

The system uses SD card to copy data from NAND FLASH MT29F2G08 to host computer. SD card supplies two communication styles, called SDIO and SPI. When SDIO style is used, the main controller requires CLK, CMD, and 4-bit data signal to communicate with SD card. SDIO style supports R/W, and has error correction function on transmitted data [7]. The principle diagram is shown in Figure 5.

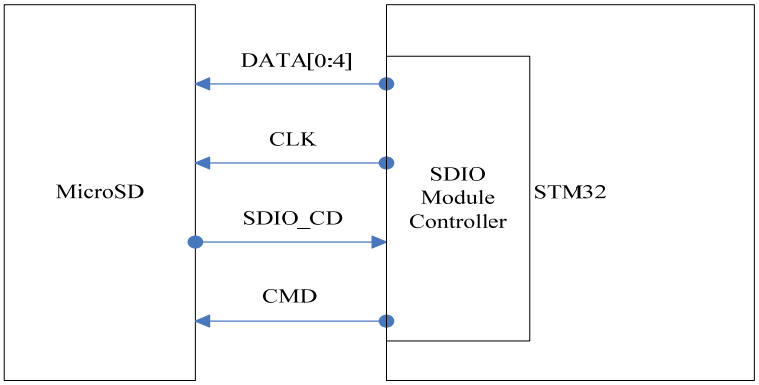

Figure 5. Data-Transmission Module Diagram

4. Design of Software System

The integrated development environment of RealView MDK from ARM Inc. is adopted to design the system software based on the firmware library program supplied by SGS-THOMS Inc.

Software system includes two functions, system-measurement and data-copy, which can be chosen through an I/O port with 1 or 0. In the function of system-measurement, two data buffers of 20kB are created in the RAM of chip. After then, it measures the parameters data through sensors in the interrupt program of timer, and writes them to the data buffer. Meanwhile, the data in buffer are written to NAND FLASH in the main loop. Because there are two data buffers, ping pong operation is chosen to realize data Reading and Writing, which ensures data writing from A/D to buffer and buffer to NAND FLASH independently[8]. In the function of data-copy, SD card would be sticked in firstly. After SD card detected, it reads a page of data of 2048 bits from NAND FLASH and writes them to SD card, and this process lasts until data-copy is over. The principle diagram is shown in Figure 6.

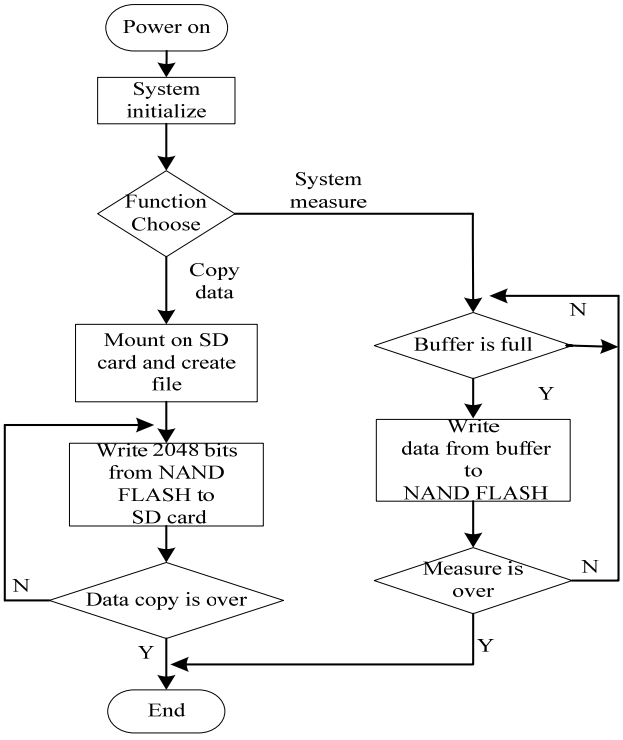

Figure 6. Software System Diagram

The design of system-measurement function includes sensor (LSM303DLH、BMP085) program design and ADC program design, while the design of data-copy function is SD card program design.

4.1. LSM303DLH Program

It configures the I/O after powering on the LSM303DLH, then initializes the accelerometer and magnetometer[9]. The format of output data is 16 bits, and the output rate is 50Hz. The data of X,Y and Z axis of accelerometer are saved in 6 registers whose address is 28h~2dh, and the magnetometer's is 03h~08h. The process is shown in Figure 7.

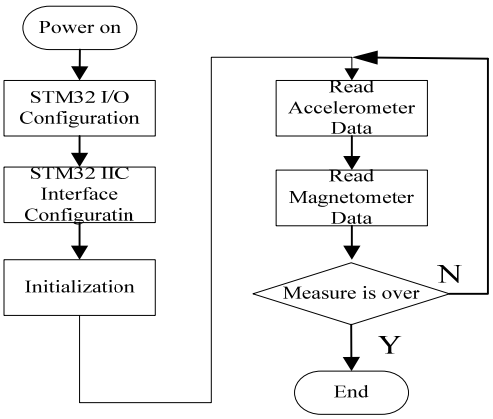

Figure 7. LSM303DLH Program Diagram

4.2. BMP085 Program

Atmospheric pressure sensor BMP085 communicates with STM32 through I^2C interface. The temperature data and atmosphere data from BMP085 are with a low precision. In order to get the precious temperature and atmosphere data, measured data would be compensated with the standard data in EEPROM according to the formula in the datasheet. The process is shown in Figure 8.

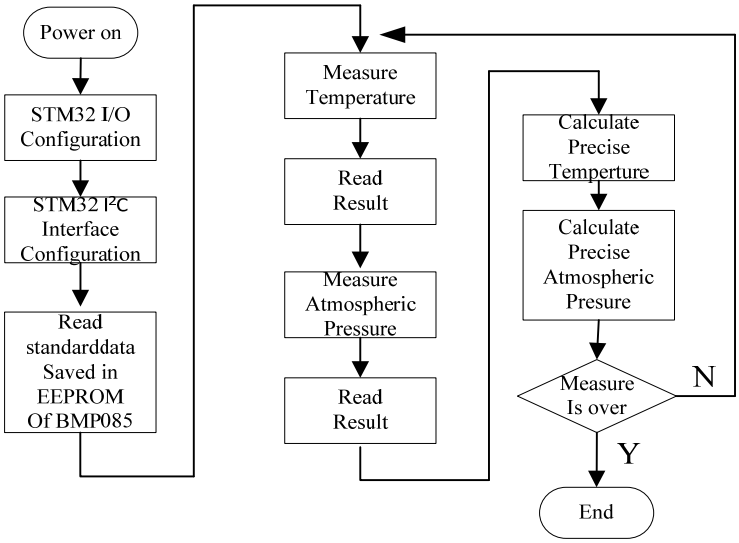

Figure 8. BMP085 Program Diagram

4.3. ADC Program

After the system is powered on, STM32 and MAX11045 are initialized. When CONVEST pin is reset, the A/D conversion on Channel 1 begins. The results would be transmitted to DB0~DB15 data bus. Upon the next falling edge of RD, the AD conversion on Channel 2 begins. The process lasts until measurement is over. The principle diagram is shown in Figure 9.

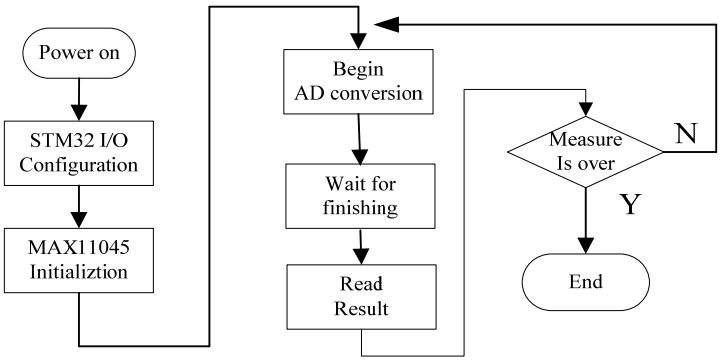

Figure 9. ADC Program Diagram

4.4. SD Card Program

In the system, SD card is operated in the general file system module of FatFS, including creating file, deleting file, writing data, reading data and creating folders [10]. The operation process of SD card based on FatFS is shown in Figure 10. Firstly, a work space is created and a new file is defined on SD card, and then, data are written to this file in loop until data-copy is over.

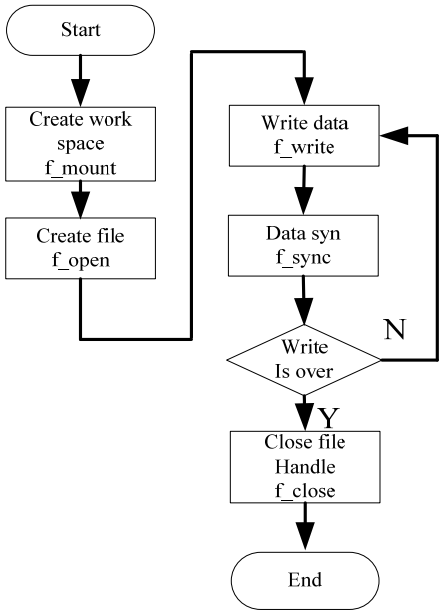

Fig.10 SD card Program Diagram

5. Experiment Results

The parameter measurement system is manufactured in PCB of 2 layers. It is not appropriate to make it too big, and the actual size of disc is nearly 8.5cm of diameter. The physical object is shown in Figure 11.

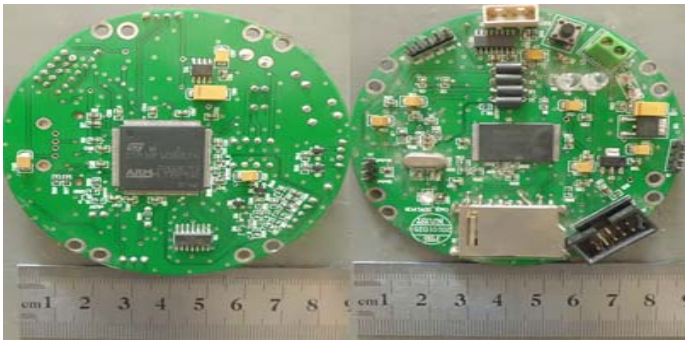

Figure 11. Physical Object

The data of accelerometer and magnetometer is shown in Figure 12 and Figure 13, respectively. The data of temperature and humidity, and atmospheric pressure is shown in Figure 14 and Figure 15, respectively.

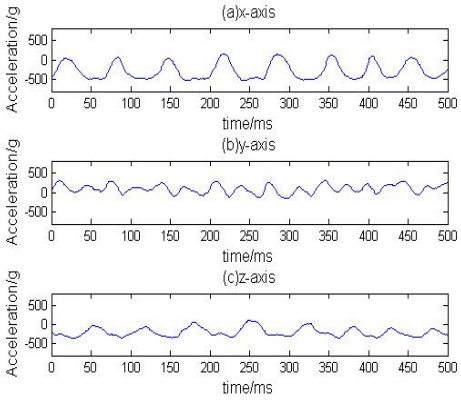

Figure 12. 3-axis Accelerometer Wave

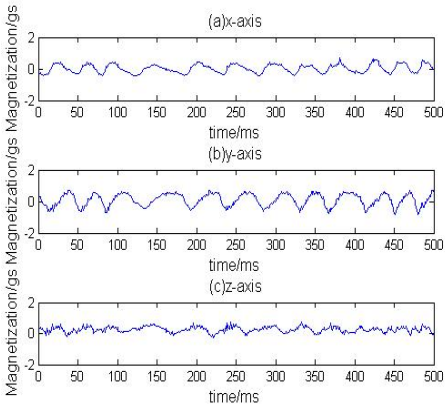

Figure 13. 3-axis Magnetometer Wave

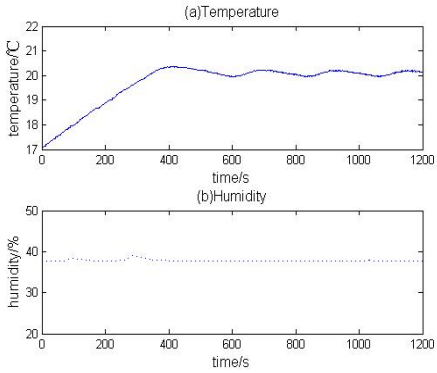

Figure 14. Temperature and Humidity Wave

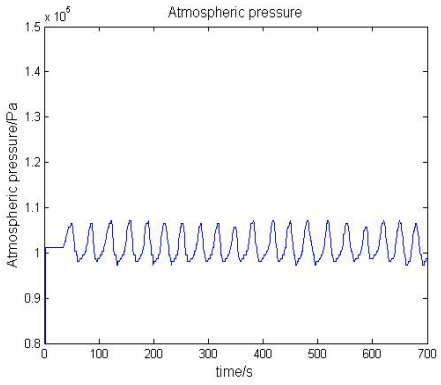

Figure 15. Atmospheric Pressure Wave

Acknowledgements

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