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SD card Interfaced Audio Player

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Abstract

Secure Digital (SD) card is now widely used in digital cameras, mobile phones, and media players. In this project we interfaced an SD card for wav file playback. WAV file can be read in SPI (serial peripheral interface) mode from SD card, which can be fed to the DAC (digital-to-analog converter) which can run speaker after amplification. When the device is turned on, a wav file name appears on LCD screen. There are two interfaced keys to read/select the file from the SD card and the same keys are functioned as stop, play and pause. In this report we have presented the project design details, interfacing of various devices and, FAT system and SD card initialization.

Contents

1. Introduction

SD card is a non-volatile memory card format developed by Panasonic, Sandisk and Toshiba for use in portable device. It is available in different capacities. For this project we have used an SD card having a capacity of 128MB. Since our aim is to play a wave file, this capacity is sufficient. There are 3 different transfer modes for data transfer. They are One-bit SD mode, Four-bit SD mode and SPI mode. SPI mode is a simpler subset of the SD protocol for use with microcontrollers. It is a synchronous serial communication protocol. Data rate achievable from SD card with SPI mode is sufficient for playback of music files.

In this project WAV format of audio file is used to play songs. Waveform Audio File Format (WAVE or more commonly known as WAV) is a Microsoft and IBM audio file format standard for storing an audio bitstream on PCs. WAV file can hold compressed audio; the most common WAV format contains uncompressed audio in the linear pulse code modulation (LPCM) format. We have used uncompressed format since WAV audio can be edited and manipulated with relative ease using software.

WAV file read from SD card by implementing FAT (File Allocation Table). FAT is file system architecture now widely used on many computer systems and most memory cards, such as those used with digital cameras. FAT file systems are commonly found on floppy disks, flash memory cards, digital cameras, and many other portable devices because of their relative simplicity. Using microcontroller WAV stream is fed to a DAC (Digital-to-Analog converter). DAC is a device that converts a digital (usually binary) code to an analog signal, which is fast enough to convert the data between two samples. Before giving the data to speaker Current to voltage conversion is done which is then amplified and signal is fed to speaker.

LCD and keys are interfaced to provide access to the user. The name of WAV file is displayed in the LCD, which can be scrolled down using one of the two interfaced keys and the same key is used to stop the currently playing song. Another key is used to play currently display song in the LCD and the same key is used to as pause the currently playing song.

This report is organized as follows. Section 2 describes the problem statement. Section 3 describes design approach. Section 4 describes interfacing of various hardware. Section 5 describes the details of hardware used. Section 6 describes about the software details.

2. Problem Statement

a) WAV file should be read from SD card.
b) File name must appear on LCD screen.
c) User should be able to scroll down the file list from SD card.
d) There should be provision of playing currently selected or display WAV file.
e) There should be provision of stopping and pausing currently playing song.
f) Audio WAV file must be amplified before feeding it to speaker.

3. Design Approach

Microcontroller can be used to process data. File from SD card can be read using microcontroller by implementing FAT32. LCD can be used to display the file name. File selection and Play/Pause/Stop for audio file can be done by interfacing of the keys.

As shown in fig. 1, the digital output from SD card is fed to DAC0808 (which gives analog output in the form of current) followed by I-to-V converter then after audio amplification it is fed to speaker.

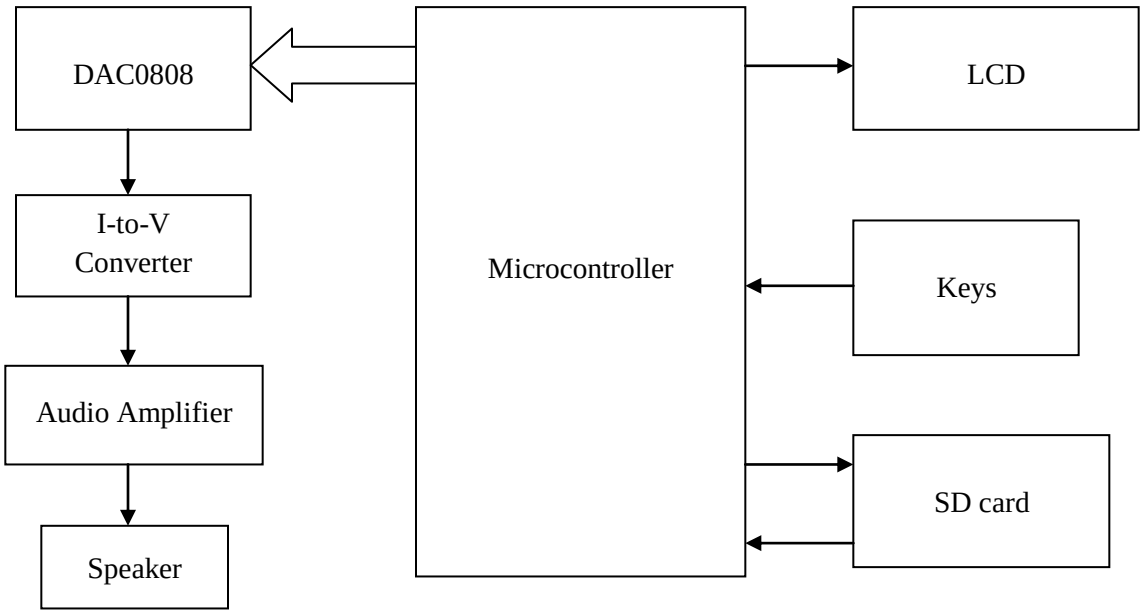


Fig. 1. Block diagram of the design approach

The following points are considered in design approach are:

a) Upon power on, a menu display on LCD which shows WAV file name (or the files from the SD card) in the first line and string “Playlist” in the second line.
b) While displaying the content file, file format of each file can be display for identifying WAV file format. This can be achieved by checking the file attributes of each file.
c) Two keys K1 and K2. K1 can be used to play song and string “Playing” should display in second line and the same key can be used to pause to the currently playing song and string “Paused” should display in second line. K2 can be used to stop the song then string “Playlist” should display in the second line and same key can be used to scroll the file list and the name appear on first line in LCD.
d) For playing WAV file the data need to send at rate equals to sampling rate of WAV file to the DAC0808.

3.1 Design Details

It consists of the following elements:

a) Atmega32L microcontroller.
b) SD card (Transcend, 128 MB).
c) Digital to analog converter, DAC0808.
d) LCD
e) Keys
f) I-to-V converter (LF351)
g) Audio Amplifier (LM386)
h) Speaker

Total I/O requirements are calculated which is shown below in Table-1

Table-1:

Serial No	Interface	I/O required
1.	SD card	4
2.	LCD interfacing	10
3.	DAC interfacing	8
4.	Key pad interfacing	2
Total		24

4. Interfacing

4.1 SD card interfacing

Interfacing to SD card is done through the transfer mode Serial Peripheral Interface Bus. There are 4 pins used for interfacing SD card with microcontroller. Here microcontroller Atmega32 is acting as the master and SD card is acting as the slave. The connection between master and slave is shown in fig. 2.

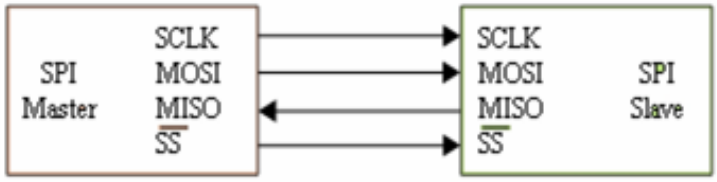


Fig. 2. SPI bus: Single master and single slave

The connection to SD card should be given based on the fig. 3. This SD card is connected to SD card connector (Connector J1 as shown in fig. 4 connections are according to pin numbers).

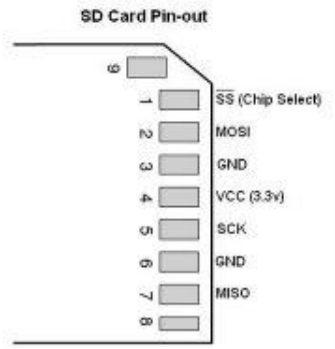


Fig. 3. SD card pin out

4.2 DAC interfacing

DAC0808 is widely available DAC with 125 ns conversion speed. It is 8 bit DAC suitable for 8 bit wav format. It sinks current according to input applied. The current sinks in unipolar direction. The current output has to be connected to I-to-V converter for voltage output. The connection to microcontroller is given in fig. 4.

4.3 LCD interfacing

LCD used is 2x16 alphanumeric displays. The connections to microcontroller are shown in fig. 4.

4.4 Key Interfacing

Two keys are interfaced to enable Play/Pause/Stop facility. Its connections are shown in fig. 4.

4.5 I-to-V Converter

The DAC0808 sinks 1 mA for maximum input and no current for minimum input. IC LF351 is used to convert current to voltage. The circuit diagram is shown in fig. 4.

4.6 Audio Amplifier

LM386 is used as audio power amplifier. The LM386 is a power amplifier designed for use in low voltage consumer applications. The gain is internally set to 20 to keep external part count low, but the addition of an external resistor and capacitor between pins 1 and 8 will increase the gain to any value from 20 to 200. The circuit diagram is shown in fig. 4.

5. Hardware Details

The hardware schematics are shown in fig. 4. Voltage regulator IC 7805 and LM317L is used to generate necessary power supply, to fulfil the power requirement of various hardware. Power supply Vcc1 is 12 volts is given as input to LF351 and LM386 and to 7805 to generate 5 volt power supply which is Vcc2. Vcc2 is necessary for DAC0808 and LCD and given as input to LM317L to generate 3.4 volt which is Vcc3. Vcc3 is required for microcontroller and SD card.

To interface LCD J4 of LCD is connected to J3 (from 1-10). SD card is connected to J1 i.e. SD card connecter. To interface DAC0808 J5 need to connect to J2 (from 1-8). The output of DAC is current is fed to LF351 which is I-to-V converter. The output of I-to-V converter is not capable of running speaker; therefore it is fed to audio amplifier LM386.

Some pins of PortC (pin 24-27) were used for JTAG Programming. The JTAG programmer is a device allowing you to program and debug JTAG enabled. Once the physical integrity of the circuit has been verified and devices appropriately programmed, functionality can also be tested. Some JTAG-compliant devices are designed to incorporate a Built-In Self Test (BIST) to test their internal logic. Applying the correct set of signals to the JTAG controller will cause these tests to be executed.

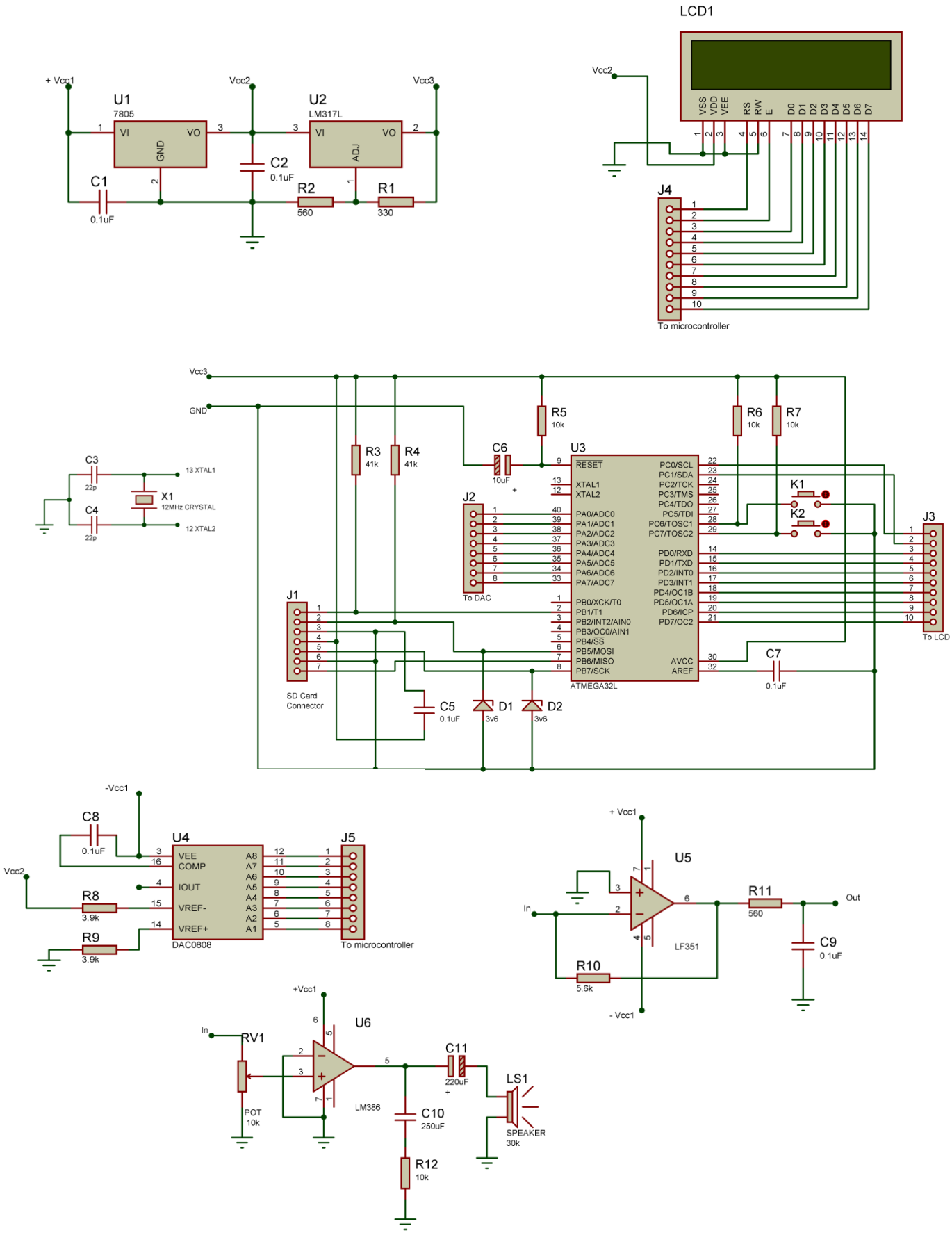


Fig. 4 Hardware Schematic

5.1 Selection of Components

The main criteria for selecting different components are as follows:

a) Atmega32L microcontroller
   1) General purpose widely used easily available microcontroller.
   2) Development tools were available.
   3) Sufficient to meet the requirements like i2c, SPI interface.
   4) Low power requirement.

b) Digital to analog converter (DAC0808)
   1) DAC0808 is widely available DAC with 125 ns conversion speed. It is 8 bit DAC suitable for 8 bit wav format.
   2) The power supply current of the DAC0808 is independent of bit codes, and exhibits essentially constant device characteristics over the entire supply voltage range.

c) I-to-V Converter (LF351)
   1) The LF351 is a low cost high speed JFET input operational amplifier.
   2) The device requires a low supply current and yet maintains a large gain bandwidth product and a fast slew rate.
   3) The LF351 may be used in applications such as high speed integrators, fast D/A converters, sample-and-hold circuits and many other circuits requiring low input offset voltage.

d) Audio amplifier (LM386)
   1) The LM386 is a power amplifier designed for use in low voltage consumer applications.
   2) It has wide range of application such as AM-FM radio amplifiers, Portable tape player amplifiers, Intercoms, TV sound systems, Line drivers etc.

6. Software Details

6.1 FAT file system

We have used Petit FatFs module which is free software and is opened for education, research and development.

Petit FatFs is a sub-set of FatFs module for tiny 8-bit microcontrollers. It is written in compliance with ANSI C and completely separated from the disk I/O layer. It can be incorporated into the tiny microcontrollers with a small memory even if the RAM size is less than sector size.

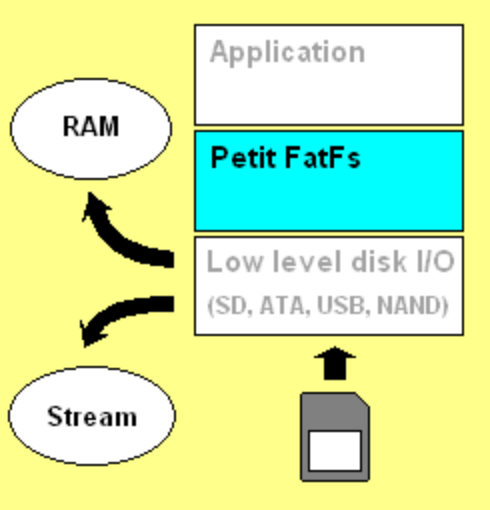


Fig. 5 Petit FatFs

Features:

1) Very small RAM consumption (44 bytes work area + certain stack).
2) Very small code size (2K-4K bytes).
3) Supports FAT32
4) Single volume and single file.
5) File write function with some restrictions.

6.2 SD card initialization

Very small RAM consumption (44 bytes work area + certain stack). The flowchart of SD card initialization is shown in fig. 7.

6.3 SPI Details

SPI (Serial Peripheral Interface) is one of the on-board inter-IC communication interfaces.

SPI structure

The basic structure of the SPI is shown in fig. 6. The master IC and the slave IC are tied with three signal lines, *SCLK* (Serial Clock), *MISO* (Master-In Slave-Out) and *MOSI* (Master-Out Slave-In), and contents of both 8-bit shift registers are exchanged with the shift clock driven by master IC. Additionally an *SS* (Slave Select) signal other than above three is used to synchronize start of packet or byte boundary, and for realize multi-slave configuration simultaneously. Most slave ICs assign different pin names, such as DI, DO and CS, to the SPI interface. For one-way

transfer device, such as DAC and single channel ADC, either of data lines may be omitted. The data bits are shifted in *MSB first*.

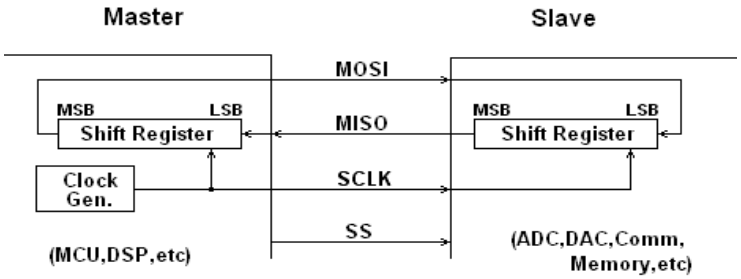


Fig. 6 SPI Structure

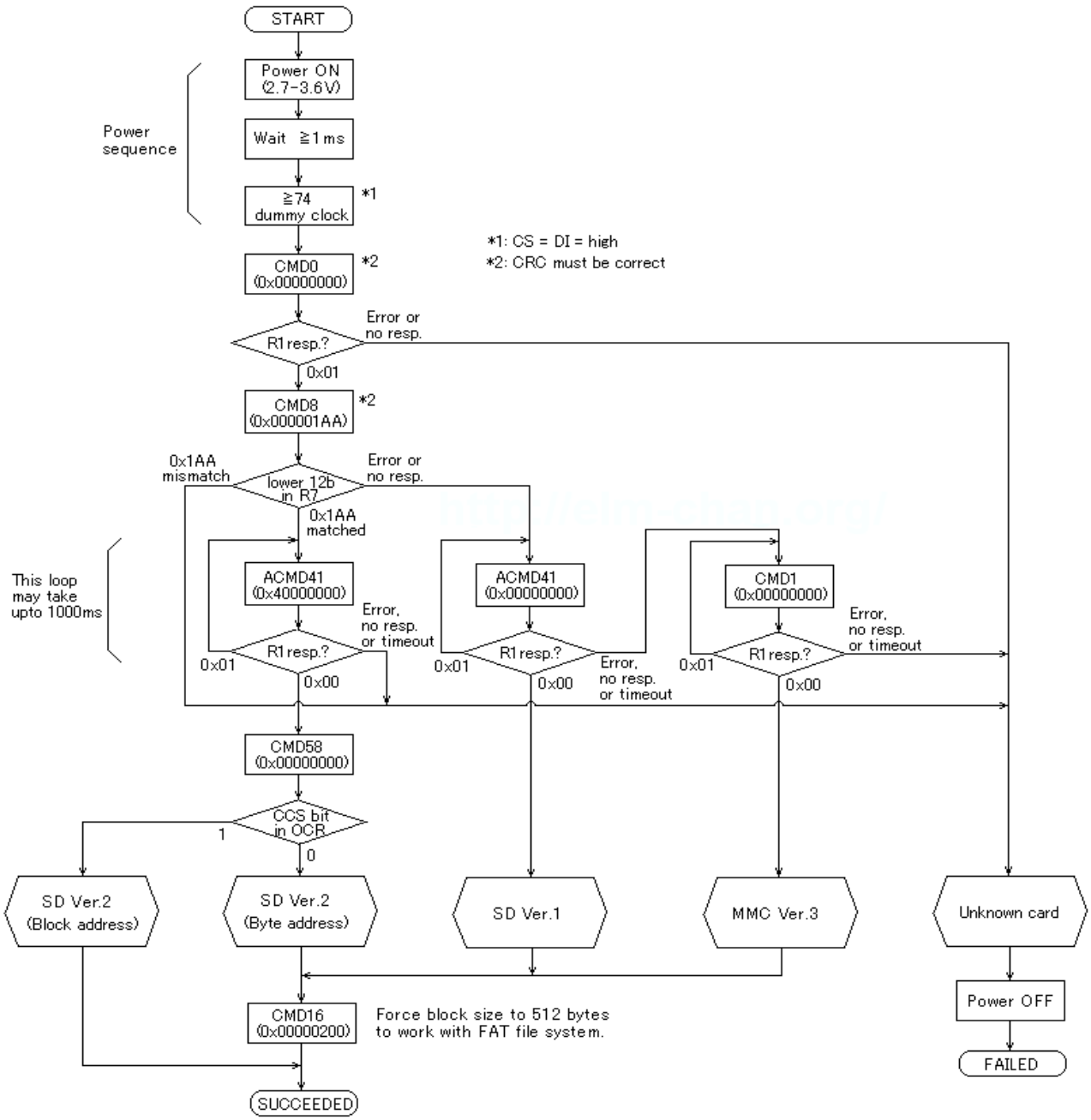
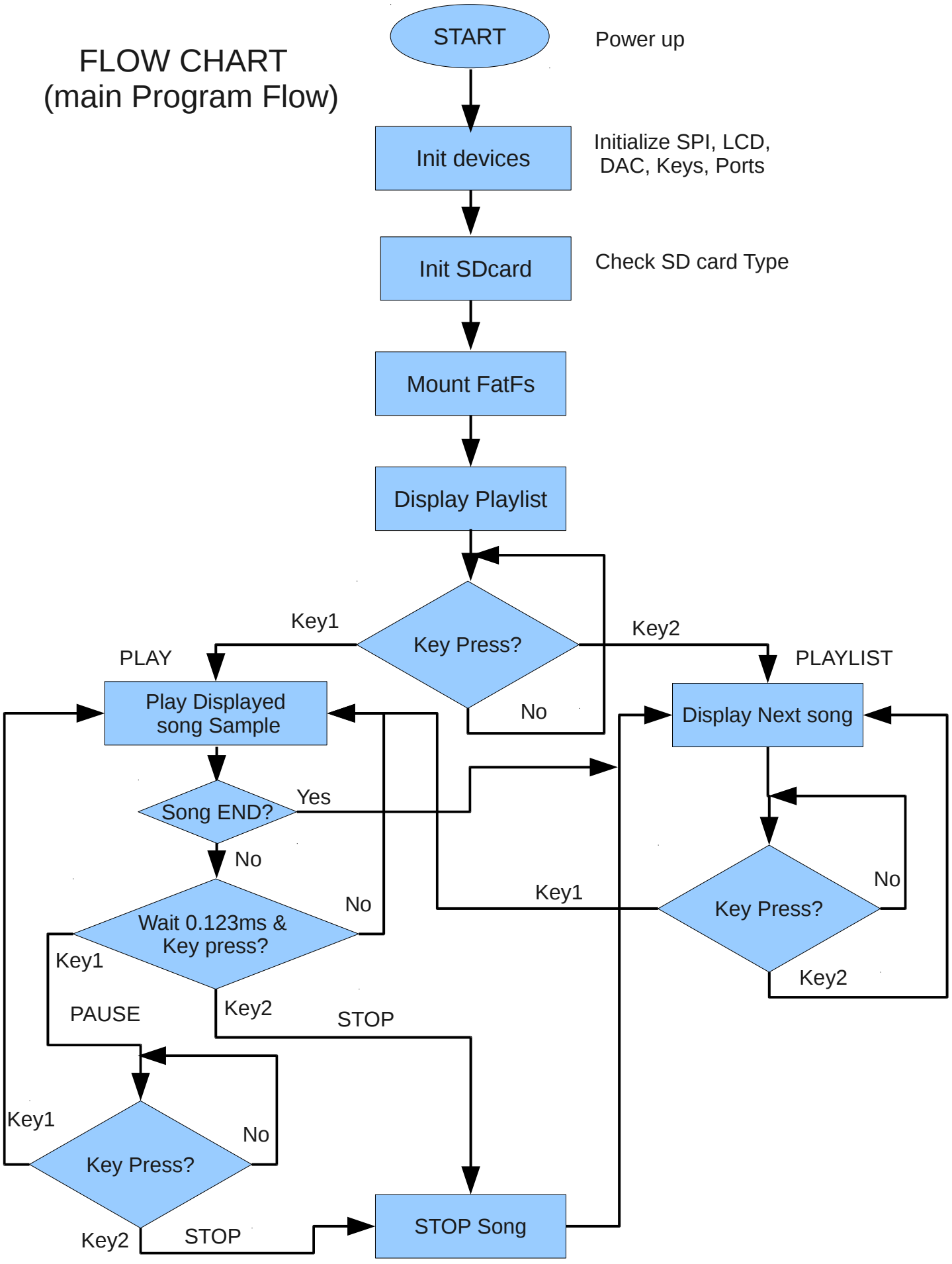


Fig. 7 Flowchart of SD card initialization

FLOW CHART
(main Program Flow)



Conclusion and Suggestions

SD card is successfully interfaced by implementing FAT32. The provision of Play/Pause and Stop music are successfully implemented and tested. However, there is further scope of improvement which has not been done in this project because of lack of time and lack of resource. External DAC0808 which uses +5 and -15 volt power supply can be removed by a replacing a microcontroller with no internal DAC eg. ATMega32L, with microcontroller with built-in internal DAC eg. ATMega128.

It can be further expanded by recording of music from a mike and the file can be saved into SD card as a WAV file format.

References

1) ATMega32L:
   i. http://www.atmel.com/dyn/resources/prod_documents/doc2503.pdf
2) SD card specification:
   i. http://www.sdcard.org/developers/tech/sdcard/pls/simplified_specs/
   ii. http://elm-chan.org/docs/mmc/mmc_e.html
   iii. "SanDisk Secure Digital Card, Product Manual , Version 1.9, Document No. 80-13-00169,December 2003"
3) Embedded FAT file System:
   i. http://elm-chan.org/fsw/ff/00index_p.html