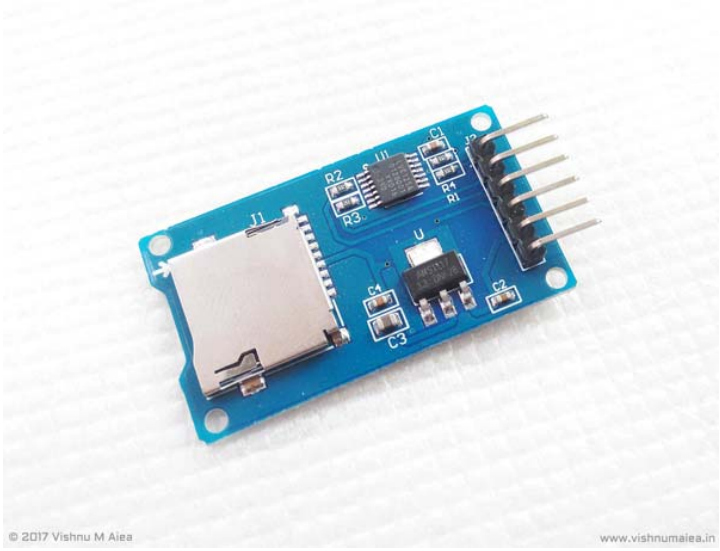
Interfacing Catalex Micro SD Card Module with Arduino

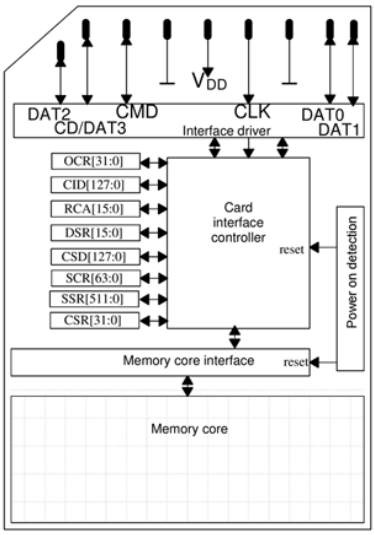


There'll be times when you have to store large amount of log data and other information for your Arduino project, for example a GPS logger. The EEPROM memory of all available microcontrollers are limited in size. The solution is to use a NAND Flash memory. The portable version of a NAND Flash memory is available as SD cards, in many storage sizes and form factors. SD cards and USB flash drives have become an indispensable things in our everyday life.

Though you could insert an SD card in your phone or computer easily and browse all your files, hardware interfacing an SD card of any type with Arduino or similar development boards isn't that easy. You could understand it just by reading the SD card spec sheet. The Secure Digital (SD) standard is maintained by the SD Card Association. They standardize and publish all the related specifications to manufacture and implement SD cards. Most of the documents are confidential and are only available to manufacturers and software companies. A simplified version (it isn't that simple) of the SD card specification is available for the public in the SD Card Association's website.

What we're going to do here is to interface a microSD card with an Arduino Uno using the SdFdat library developed by William Greiman and is based on the Simplified SD Card Specification. Before we delve into the interfacing, let's have a basic understanding of what an SD card is, how it is organized, different forms and pinouts of it.

SD Card Architecture



SD Card Architecture

The microSD card is a type of removable **NAND**-type small Flash memory card format which was introduced in 2003. microSD measures 11mm x 15mm and is 1mm thick. Internally the card is organized as interface driver, card interface controller and memory core.

The interface driver connects to the external interface pins. This sets the pins to appropriate modes and select and monitor the operating voltage and other parameters required for physical interfacing. The card interface controller is the section that processes user commands and read from or write to the actual memory core. It has many registers associated with it. The memory core is where data is stored. It is typically a NAND Flash memory.

Formatting

The SdFat library requires a properly formatted card to work exactly as we want. The library supports **FAT16** and **FAT32** file systems, though it is recommended to format to FAT16 when possible. You need a card reader and a PC to format the card. If you're on Windows 7, right click the card volume icon and select the "Format" option. Now a window will open on which you have to select FAT or FAT16 from the drop-down list for file system and then click "Start Format".

Micro SD Card Pinout

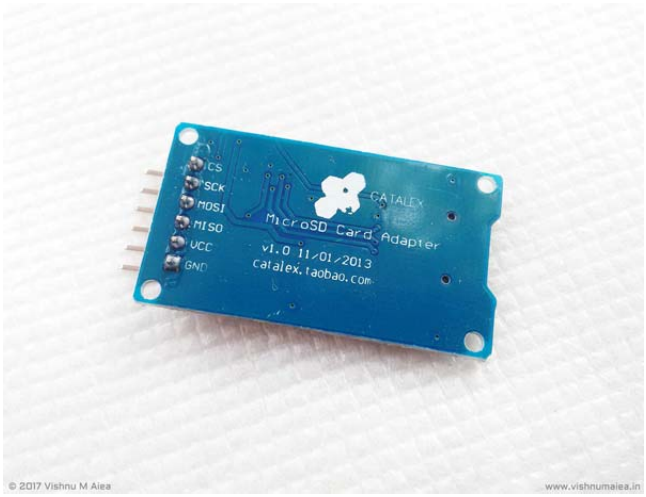
There are 8 pins on the microSD card which you should avoid touching as you may damage the card, even though it's protected against ESD. There are two ways a microSD can be interfaced with a microcontroller - **SPI mode** and **SD mode**. The pin assignments for these modes are different. The SD mode is the fastest and is used in mobile phones, digital cameras etc. The Serial Peripheral Interface (SPI) mode is slow but requires less overhead compared to SD mode and is compatible with any microcontroller with built-in SPI. So we'll be using the SPI mode and its pin assignments.

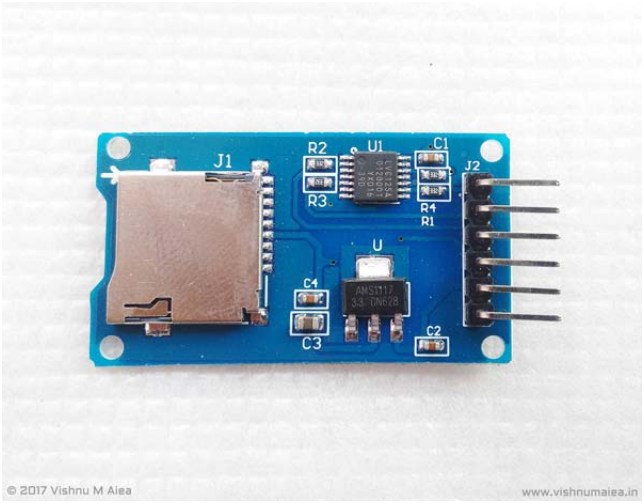
Pin	Pin Name	Function
1	NC	Not used
2	CS	Chip Select
3	MOSI	Master-out, Slave-in
4	VDD	Positive Supply
5	CLOCK	Serial Clock
6	GND	Ground
7	MISO	Master-in, Slave-out
8	NC	Not used

microSD Card pinout for SPI mode

Schematic of Catalex SD Card Adapter

I had bought a couple of **Catalex Micro SD Card Adaptors** from inkocean for Rs.70. What is "Catalex" you may ask. I don't know; it's just printed on the back of the PCB with a dead link that redirects to a Chinese site. I couldn't find any datasheet or schematic for the module. So I had to design one myself.





The microSD card works with 3.3V. So we can't connect it directly to circuits that use 5V logic. In fact, any voltages exceeding 3.6V will damage the SD card permanently. That's why there's 74LVC125A on the PCB. The 74125 is a quadruple 3-state buffer. It can translate the 3.3V logic signals from the card to and from our 5V Arduino if we provide 3.3 - 3.6V as supply voltage for the buffer. This is called logic level shifting. Three of the pins, MOSI, SCK and CS carry signals from the Arduino to the card and the MISO carries signals from the card to Arduino. Therefore one of the buffer is connected in reverse order. All the four buffers have 3.3K resistors in series for protection.

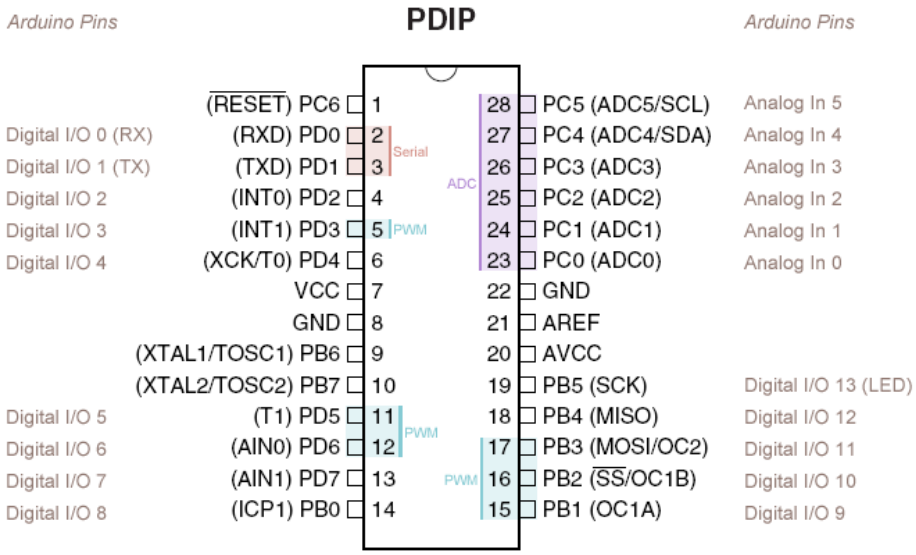
But there's another problem; as the ENABLE pin 13 of the MISO buffer is always tied to ground, other slaves, if using multiple slaves, on the same SPI bus cannot communicate with the master as the signals will interfere each other. Slaves actually need to activate high impedance state on the MSIO pin when not selected on a common SPI bus. So to use other slave devices along with this module, you need to make some small changes. First disconnect the pin 13 of the buffer from ground and then tie it to the respective SS pins of the master, probably with a pull-up. This way, the MISO of the module will be brought to high Z state when it's not selected. Thanks to Christian Charlot to pointing out this issue. Below is a modified schematic to allow multiple slaves on the common SPI bus.

Wiring with Arduino Uno

Even though the microSD card has 8 pins, we need only 6 pins to interface it using SPI and thus has 6 header pins soldered on it. There are two supply pins - **VCC** and **GND**. VCC is connected to 5V and the on-board low drop regulator AMS1117 will provide 3.3V to the card and the buffer IC 74LVC125. The **MISO** (Master Input Slave Output), **MOSI** (Master Output Slave Input) and **SCK** (Serial Clock) are connected to the respective pins of the microcontroller. The **CS** (Chip Select) is connected to the Slave Select (**SS**) of the microcontroller. In fact, you can use any digital pins to connect to the module and bit-bang the SPI protocol using any library. But it'd be better to use the hardware SPI for some reasons. I've provided a wiring schematic below and to make it easy for you, the wiring procedure in steps too. If you're using another Arduino model, just use the respective pins. Connect,

1. VCC of module to 5V of Arduino.
2. GND of module to GND of Arduino.
3. CS to digital pin 10 of Uno.
4. MOSI to digital pin 11 of Uno.
5. MISO to digital pin 12.
6. SCK to digital pin 13.

In Arduino Uno, the digital pin 10 (pin 16 of ATmega328P) is the dedicated Slave Select (SS) pin. But you could connect the CS of the module to any digital pin of the Uno by initiating the card with *SD.begin(pin)*. The SdFat library we'll be using needs the digital pin 10 (SS pin on Arduino) to set as output, because the SS will be still manipulated when hardware SPI is used. So changing its state might disable the SPI. There will be usually a Chip Detect (**CD**) pin from the SD card slot. But unfortunately this Catalex module doesn't have a CD output. So that's all about the wiring. Here's a pinout of an ATmega8/168/328 if you have any confusion.



For using the module with 3.3V devices, all you need to do is to bypass the on-board 3.3V regulator and connect your 3.3V supply to the output pin of the regulator (or you can remove the regulator too). The 74LVC125 will work fine with 3.3V supply.

Code

If you've connected the module with Arduino, now we can upload the code to read the card information. The program is available from the example library in the Arduino IDE. Go to *File > Examples > SD > CardInfo*. Now the program will be opened in a new window. On the 36th line, change the value of *chipSelect* from 4 to 10, if you had connected the module as we said earlier. Otherwise set it to the pin you chose. Then compile and upload. If everything was done correctly, you can see the card information printed when you open the serial monitor.

If nothing shows up, chances are you did the wiring wrong. Go back and check if everything's done right. If wiring is right and the card you inserted is faulty, then an "inititialization failed" message will be printed along with some troubleshooting tips.

If the wiring is right and the card is well formatted to FAT16 or FAT32, then the program will print the card details and list of files present in it. If the SD card is not properly formatted, the following message will show up.

As I mentioned earlier, we'll be using the SdFat library for which we should thank William Greiman. The Arduino IDE comes with the SD library. So all you have to do to use the library is to include the *SD.h* file in your code. The SD library is well documented in the reference section of Arduino website. Head over to there and read about the available classes, functions and their return types. The CardInfo.ino program uses some utility functions that are not documented in there. You can find those information and more in the GitHub page of the SdFat library. The repository contains an HTML documentation.

I've written some code to initialize, write to and read from the SD card through simple commands. This would help you to be conscious of what happening rather than opening the serial monitor and seeing everything printed automatically. The following code initializes the card when you type and send the command "**i**".

GitHub Link

```
//--------------------------------------------------
//
//  Micro SD Card initialization code.
//  Type "i" or "I" in the serial terminal to
//  initialize the card.
//
//  Author : Vishnu M Aiea
//  Web : www.vishnumaiea.in
//  IST 4:04 PM 28-02-2017, Tuesday
//
//--------------------------------------------------


#include <SPI.h>
#include <SD.h> //include the SD library

byte inByte;
bool sdInitSuccess = false; //card init status

void setup() {
  Serial.begin(9600);
  while (!Serial) {
    ; //wait for the serial port to connect.
  }
}

void loop() {
  if (Serial.available() > 0) {
  inByte = Serial.read();

    if (inByte == 'i' || inByte == 'I')
    {
      if (sdInitSuccess) {
        Serial.println("Already initialized.");
        Serial.println();
      }
      else if (!sdInitSuccess) { //if not already initialized
        Serial.println("Initializing SD Card..");
        if (!SD.begin(10)) { //using pin 10 (SS)
          Serial.println("Initialization failed!");
          Serial.println();
          sdInitSuccess = false;
          return;
        }
        else {
          Serial.println("Intitialization success.");
          Serial.println();
          sdInitSuccess = true;
        }
      }
    }
  }
}
```

The code is self-explanatory. It first establishes serial communication link with a baud rate of 9600 when the uC turns on. The card gets initialized when you type and send "**i**" or "**I**" from the serial monitor. Then it'll print

whether the initialization was success or failure. You can not initialize a card that is already initialized. You have to break the serial comm link to do that.

Below is a code that'll initialize the card, open a text file called "TEST.txt", create if there isn't one, write a piece of text to the file, read and print from the file. Type "**i**" to initialize, "**n**" to open/create a text file and "**r**" to read and print from the file via serial monitor. There's one thing to be aware of : file naming convention. You can not have files named like "I Have Some File Here.txt". Because the SD Card library only supports the 8.3 or Short File Name convention. As per SFN scheme, the file name must be of maximum 8 characters + a period + three character extension (thus the 8.3) and the name is not case sensitive.

GitHub Link

```
//---------------------------------------------------------------//

//    Writing to and reading from a micro SD card.
//
//    Type "i" or "I" in the serial terminal to
//    initialize the card.
//
//    Type "n" to open/create a new file and
//    write to it.
//
//    Type "r" to read some text until a \n is found.
//
//    Author : Vishnu M Aiea
//    Web : www.vishnumaiea.in
//    IST 7:22 PM 28-02-2017, Tuesday

//---------------------------------------------------------------//

#include <SPI.h>
#include <SD.h> //include the SD library

byte inByte; //byte read from terminal
bool sdInitSuccess = false; //card init status
File myFile;
String readText; //text read from file
char readCharArray[128]; //buffer for reading from file
unsigned long fileSize; //size of opened file
unsigned long filePos = 0;

//---------------------------------------------------------------

void setup() {
  Serial.begin(9600);
  while (!Serial) {
    ; //wait for the serial port to connect.
  }
}

//---------------------------------------------------------------

void loop() {
  if (Serial.available() > 0) {
    inByte = Serial.read();

    if (inByte == 'i' || inByte == 'I')
    {
      if (sdInitSuccess) { //check if card is initialized already
        Serial.println("Already initialized.\n");
      }
      else if (!sdInitSuccess) { //if not already initialized
        Serial.println("Initializing SD Card..");
        if (!SD.begin(10)) { //using pin 10 (SS)
          Serial.println("Initialization failed!\n");
```

```
        sdInitSuccess = false; //failure
        return;
      }
      else {
        Serial.println("Intitialization success.");
        Serial.println();
        sdInitSuccess = true;
      }
    }
  }

  else if (inByte == 'n' || inByte == 'N') {
    if (sdInitSuccess) { //proceed only if card is initialized
      myFile = SD.open("TEST.txt", FILE_WRITE);

      if (myFile) {
        Serial.println("File opened successfully.");
        Serial.println("Writing to TEST.text");
        myFile.println("Some Text");
        myFile.close(); //this writes to the card
        Serial.println("Done");
        Serial.println();
      }
      else { //else show error
        Serial.println("Error opeing file.\n");
      }
    }

    else {
      Serial.println("SD Card not initialized.");
      Serial.println("Type \"i\" to initialize.\n");
    }
  }

  else if (inByte == 'r' || inByte == 'R') {
    if (sdInitSuccess) { //proceed only if card is initialized
      myFile = SD.open("TEST.txt");

      if (myFile) {
        Serial.println("File opened successfully.");
        Serial.println("Reading from TEST.text");
        readText = (String) readUntil(myFile, 10); //read until newline (DEC = 10)
        Serial.print(readText);
        Serial.print(", ");
        Serial.println(filePos); //print current file position
        Serial.println();
        myFile.close();
      }
      else {
        Serial.println("Error opening file.\n");
      }
    }

    else {
      Serial.println("SD Card not initialized.");
      Serial.println("Type \"i\" to initialize.\n");
    }
  }

  else {
    Serial.println("Not recognized.\n"); //unknown cmd
  }
 }
}

//-------------------------------------------------------------

String readUntil(File &myFile, char n) { //read until n
  int i = 0;
  myFile.seek(filePos); //read from current filepos
```

```
  do {
    if (myFile.peek() != -1) { //check if file is empty
      readCharArray[i++] = myFile.read(); //read otherwise
      filePos++; //advance the filepos
    }
  } while ((myFile.peek() != -1) && (readCharArray[i - 1] != n)); //if not eof | \n

  if (myFile.peek() == -1) { //if eof reached
    filePos = 0; //if eof, reset to start pos
  }
  readCharArray[i - 1] = '\0'; //remove the extra \n
  return readCharArray;
}

//-----------------------------------------------------------------
```

I've thoroughly commented the code. So I hope you wouldn't find it hard to understand. The card is initialized just like we saw in the previous program. The boolean variable *sdInitStatus* keeps track of the card initialization status. The file is opened with write mode when you enter "**n**" and if there is no file with that name, the write mode will cause a file to be created and then opens it; just like in the C/C++ file handling programs. An object of type SD is used in conjunction with the *println( )* function to write to the file. Note that data is written to the file only when the functions *close( )* or *flush( )* is invoked. Make sure to do that right when you write a program for any application.

The "**r**" command will open the file we just created with read mode which is the default one. You can use the *read( )* function to read a single byte from the file. The read function will return -1 if the file is empty or the **EOF** (End of File) is reached. The current position within the file is incremented by one when you read a byte using the *read( )* function. We keep track of the file position using the variable *filePos*. The file position can be obtained using the *position( )* function. The maximum value of file position will be the size of the file which can be obtained by calling *size( )*.

Here we're using a separate function to read any text from the file until a newline character (\n whose DEC equivalent is 10) is found or the EOF reached. The function uses *peek( )* to determine the end of file which returns a -1 at EOF. Unlike *read( )*, the *peek( )* doesn't increment the actual file position after execution. The *seek( )* function sets the file position to desired point in file. We have used this to relocate the file position to the start of the file when EOF is found so that we can read the file again.

Text is read to a char array *readCharArray[ ]* and then converted to String type using type casting.

Now you know how to include a microSD card in your next Arduino project and learned what the SD library can and can't do. I hope you enjoyed reading this tutorial and learned something new. If you found any error with the descriptions, code or missed something important, however small it is, please feel free to inform me. Thanks **:)**