Really Fun Peripherals

Overview

Interfacing Methods

Liquid Crystal Display (LCD)

Touchscreen

Sensors

Mass Storage

Use google and wikipedia to get more information

Interfacing Methods

Analog – use ADC or comparator

Digital

- Pulse width modulation
  - Measure width of pulse with timer or interrupts
- RS232
  - Use UART
  - Bit-bang with GPIO if not available
- synchronous (clocked) serial
  - Use UART in clocked serial mode
  - Bit-bang with GPIO if not available
- parallel
  - Use GPIO port

Clocked (Synchronous) Serial Interfacing

Basic ideas

- Send data serially between chips to reduce pin count and PCB complexity
- Provide *a clock* with the serial data to make interfacing easy

Example protocols

- SPI – serial peripheral interconnect.
- I^2C^{TM} – inter-integrated circuit bus.

SPI – Serial Peripheral Interface

Based on shift registers

Example: AD7877

Signals to get bytes in and out

- DCLK – Data clock
- DIN – Data into peripheral device
  - Is read at rising edge of DCLK (Must be ready 12 ns before)
  - Also called MOSI: master out, slave in
- DOUT – Data out of peripheral device.
  - Is valid 16 ns after falling edge of DCLK
  - Also called MISO: master in, slave out
- Need to provide individual chip-selects if multiple SPI devices share DCLK/DIN/DOUT

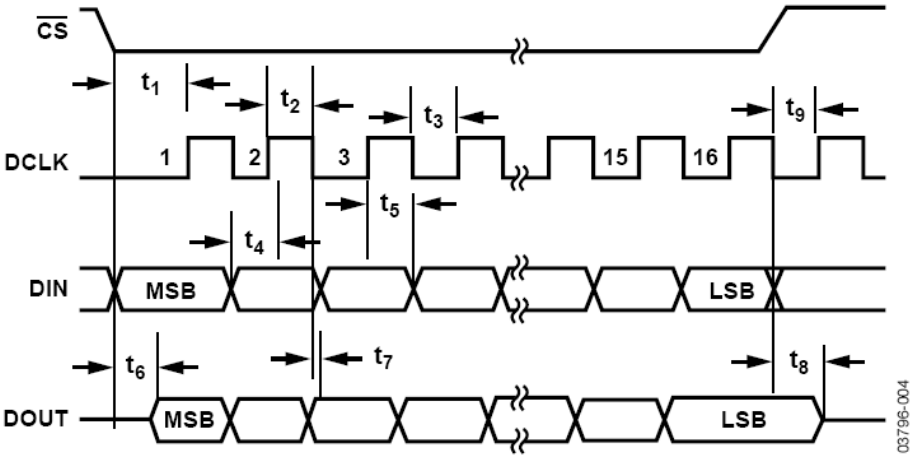


Figure 2. Detailed Timing Diagram

What do those bytes mean?

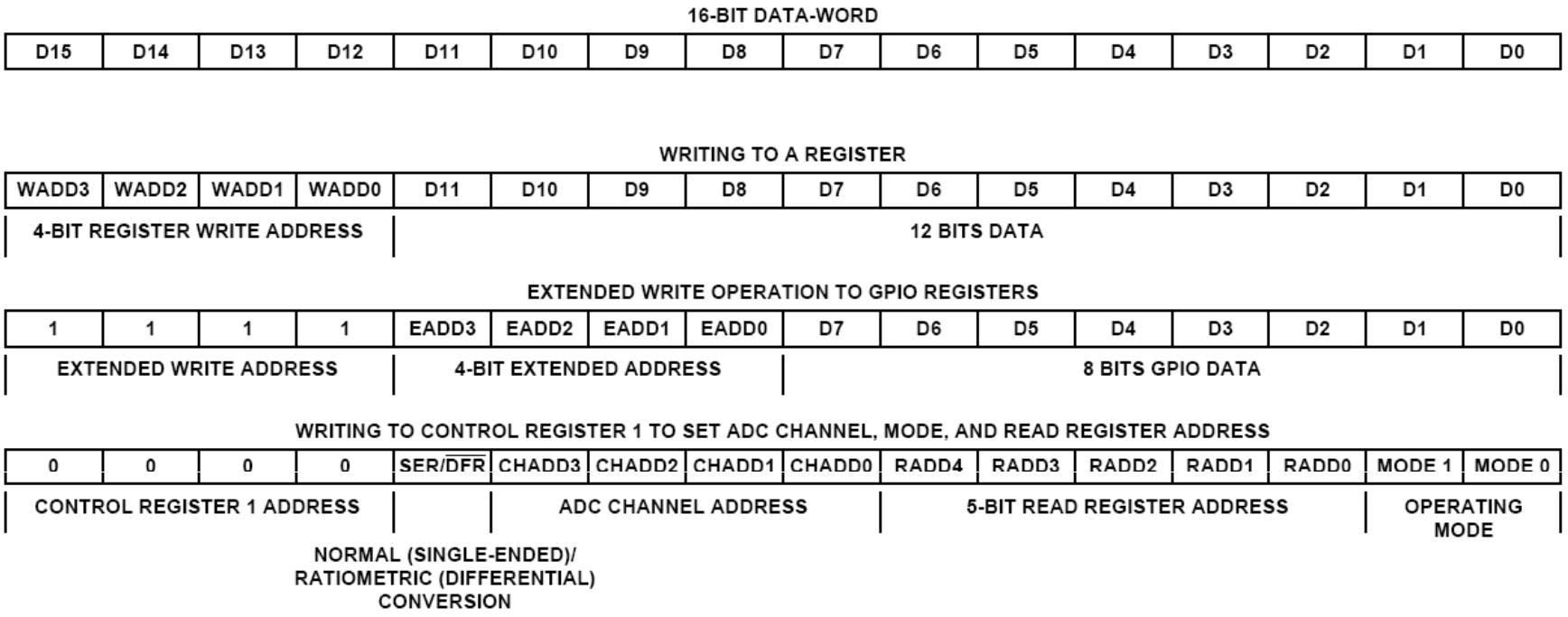


Figure 46. Designation of Data-Word Bits in AD7877 Write Operations

What do those registers mean?

Table 13. Write Register Map

Register Address					Register Name	Description
Binary						
WADD3	WADD2	WADD1	WADD0	HEX		
0	0	0	0	0	None	Unused; writing to this address has no effect
0	0	0	1	1	Control Register 1	Contains ADC channel address, register read address, and ADC mode
0	0	1	0	2	Control Register 2	Contains ADC averaging, acquisition time, power management, first conversion delay, STOPACQ polarity, and reference and timer settings
0	0	1	1	3	Alert status/enable register	Contains status of high/low limit comparisons for TEMP1, BAT1, BAT2, and AUX1, and enable bits to allow these channels to become interrupt sources
0	1	0	0	4	AUX1 high limit	User-programmable AUX1 upper limit
0	1	0	1	5	AUX1 low limit	User-programmable AUX1 lower limit
0	1	1	0	6	BAT1 high limit	User-programmable BAT1 upper limit
0	1	1	1	7	BAT1 low limit	User-programmable BAT1 lower limit
1	0	0	0	8	BAT2 high limit	User-programmable BAT2 upper limit
1	0	0	1	9	BAT2 low limit	User-programmable BAT2 lower limit
1	0	1	0	A	TEMP1 low limit	User-programmable TEMP1 lower limit
1	0	1	1	B	TEMP1 high limit	User-programmable TEMP1 upper limit
1	1	0	0	C	Sequencer Register 0	Contains channel selection data for slave mode (software) sequencing
1	1	0	1	D	Sequencer Register 1	Contains channel selection data for master mode (hardware) sequencing
1	1	1	0	E	DAC register	Contains DAC data and setup information
1	1	1	1	F	Extended write	Not a physical register; enables writing to extended writing map

Other Comments

Other SPI-based devices will have different protocol details

- Command length
- Register address length
- Register addresses

I²C™ – inter-integrated circuit bus.

Full-fledged protocol created by Philips (now NXP Semiconductor, see document UM10204 for details)

TWI – two wire interface – generic name for I²C™

Signals 100-400 kbps

- SCK – serial clock
- SDA – serial data – bidirectional

Foundation for other protocols (SMBus and PMBus)

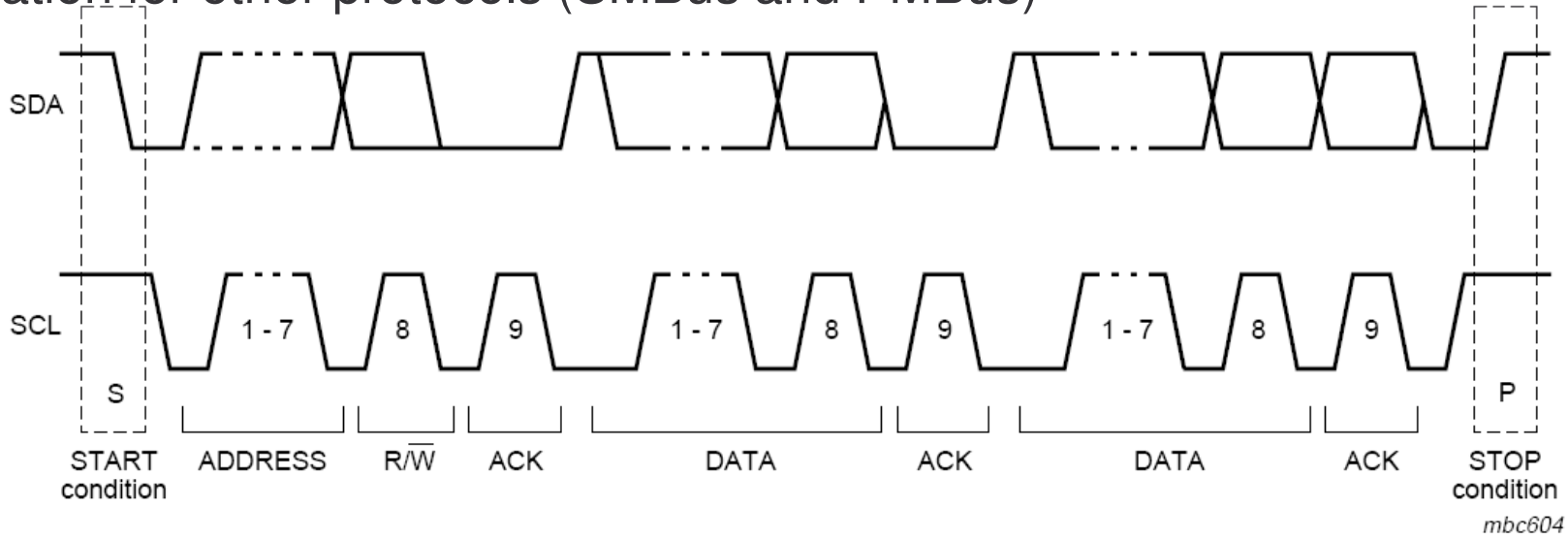


Fig 9. A complete data transfer

LCD

Basics

- Sandwich of polarizer, glass, electrode, liquid crystal, electrode, glass, polarizer (90 deg. from first)
- Liquid crystal is twisted to change polarization of light passing through, so it makes it through both polarizers (light/clear)
- Apply voltage to electrodes to reduce twist, reducing polarization and hence darkening the display element (dark/opaque)

Backlighting

- LED – low voltage (e.g. 1.5 – 4 V)
- CCFL (cold-cathode flourescent) – high voltage (e.g. 100V)

Arranging the Dots

Segmented (e.g. 7-segment, 16-segment)

Dot matrix

- Text only
- Text and graphics

Passive vs. Active

Becomes an issue when you have a multiplexed display (don't have a wire per pixel or segment)

Passive – Rely on LC to stay in same state of twistiness before it is refreshed next. Slow response time, limited contrast

Active – Build transistors onto the display right next to the electrode to retain the state between refreshes

Driving the LCD

- Direct
  - Dedicated wire per segment. Just apply a voltage.
  - Lots of wires and pins
- Multiplexing options
  - Need to turn on and off pixels frequently enough to keep them from fading
  - Multiplexed segments (e.g. QSK's display)
    - Connections
      - Segment 1-40 (5x8 segments per character location)
      - Common 1-16 (8x2 = 16 character locations
    - Select the character with the Common line, then turn on the appropriate segments
    - Use a controller chip (e.g. HD44780, KS0066)
    - Could also use MCU to do it in software or with DMA (see Renesas DirectDrive)

More Multiplexing

Rectangular matrix of rows and columns

- Select the row, then turn on the appropriate pixels (columns)
- Shift registers are used to simplify interface, so timing evolved from raster scanning of CRTs
  - For each frame, VSync signal resets vertical counter
    - For each row, HSync signal resets horizontal shift register and advances vertical counter
      - » For each pixel, Clock signal shifts some data into horizontal (column driver) shift register. E.g. 1 pixel's worth (18 or 24 bits)
- Use a controller chip (e.g. T6963, SED1335)

Could also use MCU to do it in software or with DMA (see Renesas DirectDrive)

Example of Text LCD Module

ACM0802C module

Used on QSK62P

See ACM0802C datasheet

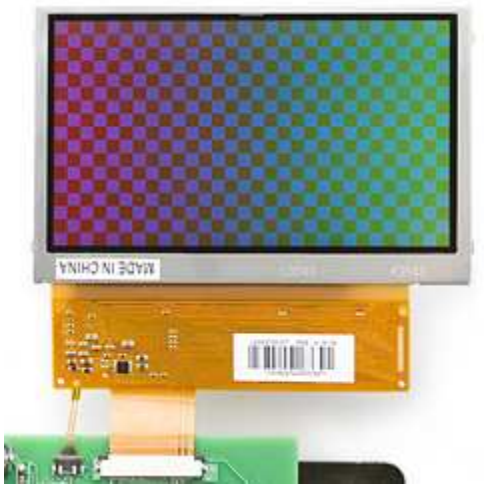
Uses KS0066 controller, compatible with HD44780

Example of Graphic LCD Panel without Controller

Sony Playstation Portable display

Sharp LQ043T3DX02

- TFT (active matrix)
- 480 x 272 pixels
- 4.3” diagonal
- LED backlight



See data sheet

- Signals – p.7
  - Data - 8 bits per pixel (24 bit data interface)
  - Data clock
  - HSync
  - VSync
  - Display on/off
- Signal timing – p.14

Talking to a Text LCD Controller

- See HD44780 data sheet
  - Overview – p.3
  - Signals – p.8
    - RS – register select
    - R/~W – read/~write
    - E – enable read or write
    - DB0-7 – four or eight data bus bits
  - Command Timing – p.22
  - Command Set – pp.23-31
  - Character set – p.18
- User can define eight custom characters
  - See Myke Predko's page
  - See enhanced QSK_LCD.C/H files for functions which provide fake bit-mapped graphics for half of the display

Talking to a Graphic LCD Controller

See SED1330/1335/1336 data sheet

- Overview – p.13
- Signals – pp.21-22
- Command Timing – pp.55-56
- Commands – pp.27-47
- Display control – pp.79-93

Resistive Touchscreen

Other technologies available too (capacitive, acoustic, optical)

Sandwich

- Conductive flexible membrane (has an electrode if 5-wire)
- Spacers
- Substrate (has 4 electrodes (X+, X-, Y+, Y-) along edges)
- Display

Using it

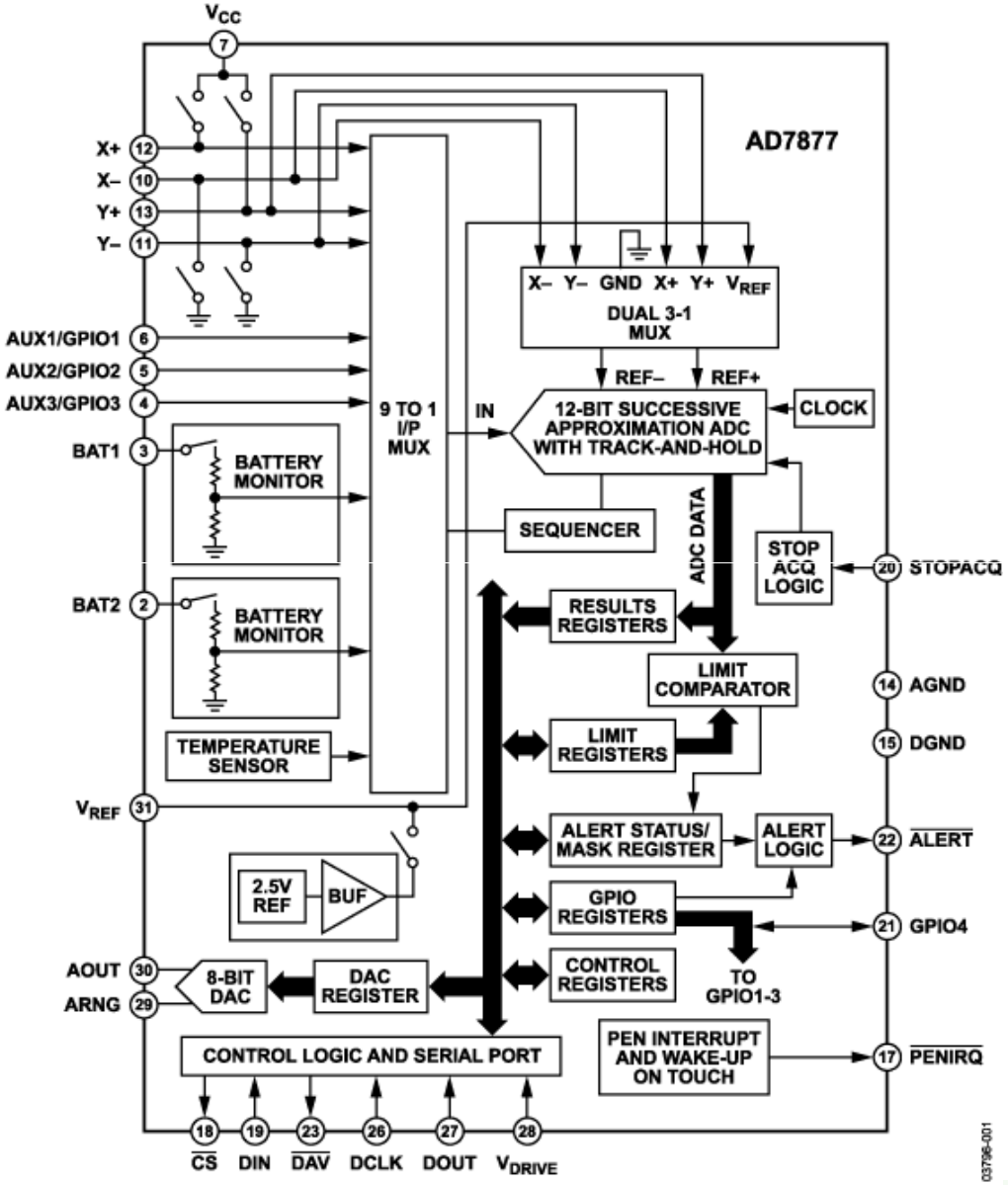
- Determine X position
  - Apply V+ to X+, V- to X-
  - Measure analog voltage at electrode (5-wire) or at Y+ and Y-
- Determine Y position
  - Apply V+ to Y+, V- to Y-
  - Measure analog voltage at electrode (5-wire) or at X+ and X-
- Linearize X and Y based on calibration

More Information

- http://www.edn.com/archives/1995/110995/23dfcov.htm

Example Driver IC for Touchscreen

- Analog Devices AD7877
- Includes 12-bit ADC, 8-bit DAC
- Automatically sequences through sampling steps
- Averages samples for noise reduction
- Measures touch pressure
- Includes battery monitors
- Clocked serial interface

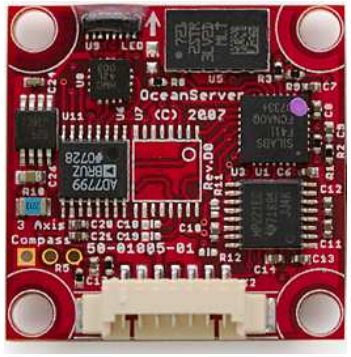


Sensors, and Applications

- Temperature
  - Thermometer (do you have a fever?)
  - Thermostat for building, fridge, freezer
  - Car engine controller
  - Chemical reaction monitor
  - Safety (e.g. microprocessor processor thermal management)
- Light (or infrared or ultraviolet) intensity
  - Digital camera
  - IR remote control receiver
  - Tanning bed
  - UV monitor
- Rotary position
  - Wind gauge
  - Knobs
  - Compass
- Humidity
- Proximity
- Pressure
  - Blood pressure monitor
  - Altimeter
  - Car engine controller
  - Scuba dive computer
  - Tsunami detector
- Acceleration
  - Air bag controller
  - Vehicle stability
  - Video game remote
- Mechanical strain
- Pressure
- Capacitive (touch)
- Other
  - Touch screen controller
  - EKG, EEG
  - Breathalyzer

Example Sensors

Compass
- RS232 interface
- 1 degree accuracy
- Tilt-compensated
- Model rocket, robot, etc.



Accelerometer
- Analog or PWM output
- 2-10 G ranges available
- Model rocket, tilt, etc.

Ultrasonic rangefinder
- RS232, PWM and analog outputs
- 0-255 inch range, 1 inch resolution
- 20Hz update rate

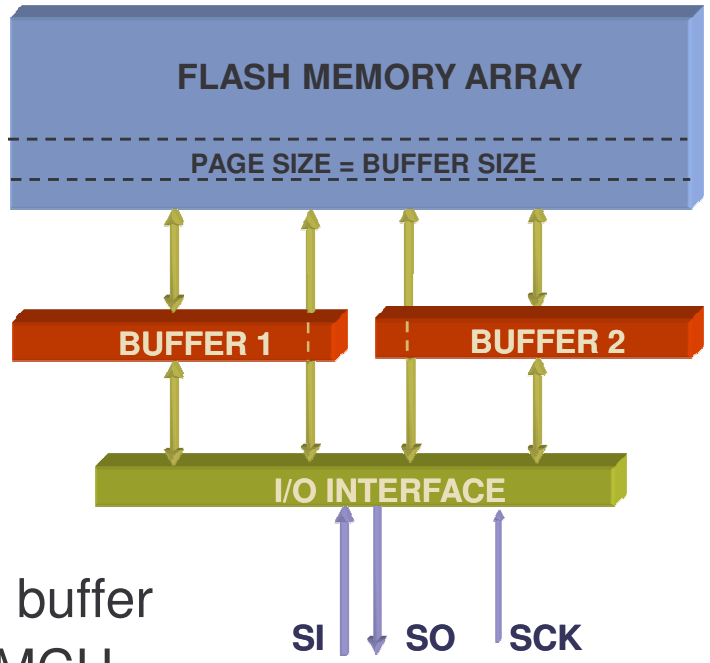
Inertia Measurement System
- Acceleration in X,Y,Z directions
- Rotation around X,Y,Z axes (gyros)
- Temperature
- Federal funds discount rate ;-)
- Logic-level RS232 serial interface

Images courtesy SparkFun Electronics

Fixed Mass Storage of Non-Volatile Data

Use MCU's flash program memory. 384KB!

- See REU04B0058-2_Simple_Flash_API.pdf application note
- C:\Renesas\QSK62P\Sample_Code\FlashAPI
- Programming interface
  - Write these bytes starting at this addr
  - Read from address in MCU memory



Add external flash memory chips to circuit board

- Atmel DataFlash chips
- SPI-based interface
- Programming interface
  - Read page N from flash into an SRAM buffer
  - Transfer SRAM buffer contents to the MCU
  - Load the SRAM buffer (or part) with these bytes
  - Write SRAM buffer to Flash page N

A Brief Digression – File Systems

What's there

- Lots of bytes, each individually addressable

What we want

- Individual files of different lengths
  - Ability to create, delete, append, overwrite these files
- Perhaps even a hierarchical collection of folders/directories

File system

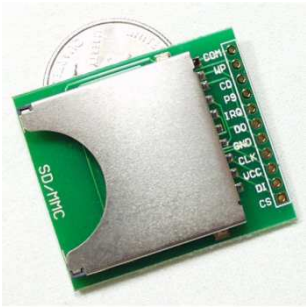
- Provides abstractions to give us the above
- Index (directory table) in each directory tells about each item (file or directory)
  - Name, starting address, length, access date, etc.

Examples

- FAT12, FAT32, NTFS

Removable Mass Storage 1

Secure Digital card



- Based on MMC (multimedia card) – Toshiba added encryption hardware to make it Secure
- SD cards support MMC's SPI interface mode
  - How to use MMC/SDC: http://elm-chan.org/docs/mmc/mmc_e.html
  - Also Maxim application note AN3969.pdf
- Interface is low-level
  - Read, write block (e.g. 512 bytes)
  - Doesn't directly support a file system
    - User must provide this (e.g. ChaN, FatFs, TinyFatFs)
    - Or else use your own scheme for tracking used/free blocks

- Interesting…
  - Spark Fun BOB-00204 – breakout board for SD-MMC cards
  - Article "SD Card Display Controller" by Sylvain Davaine in December 2007 Circuit Cellar

Removable Mass Storage 2

USB Mass storage device (flash drive)

- Use an interface module to avoid having to hack USB support
- Vinculum VDIP1 and VDIP2 modules
  - http://www.vinculum.com/prd_vdip1.html
  - USB peripheral device (e.g. mass storage
  - MCU interface: UART, SPI or FIFO (paral
- Interface includes high-level features:
  - Has built in-support for FAT file systems
    - Open, close, delete files,
    - List files in directory, get sizes
  - Append data, read data, seek offset
  - Lots of other features