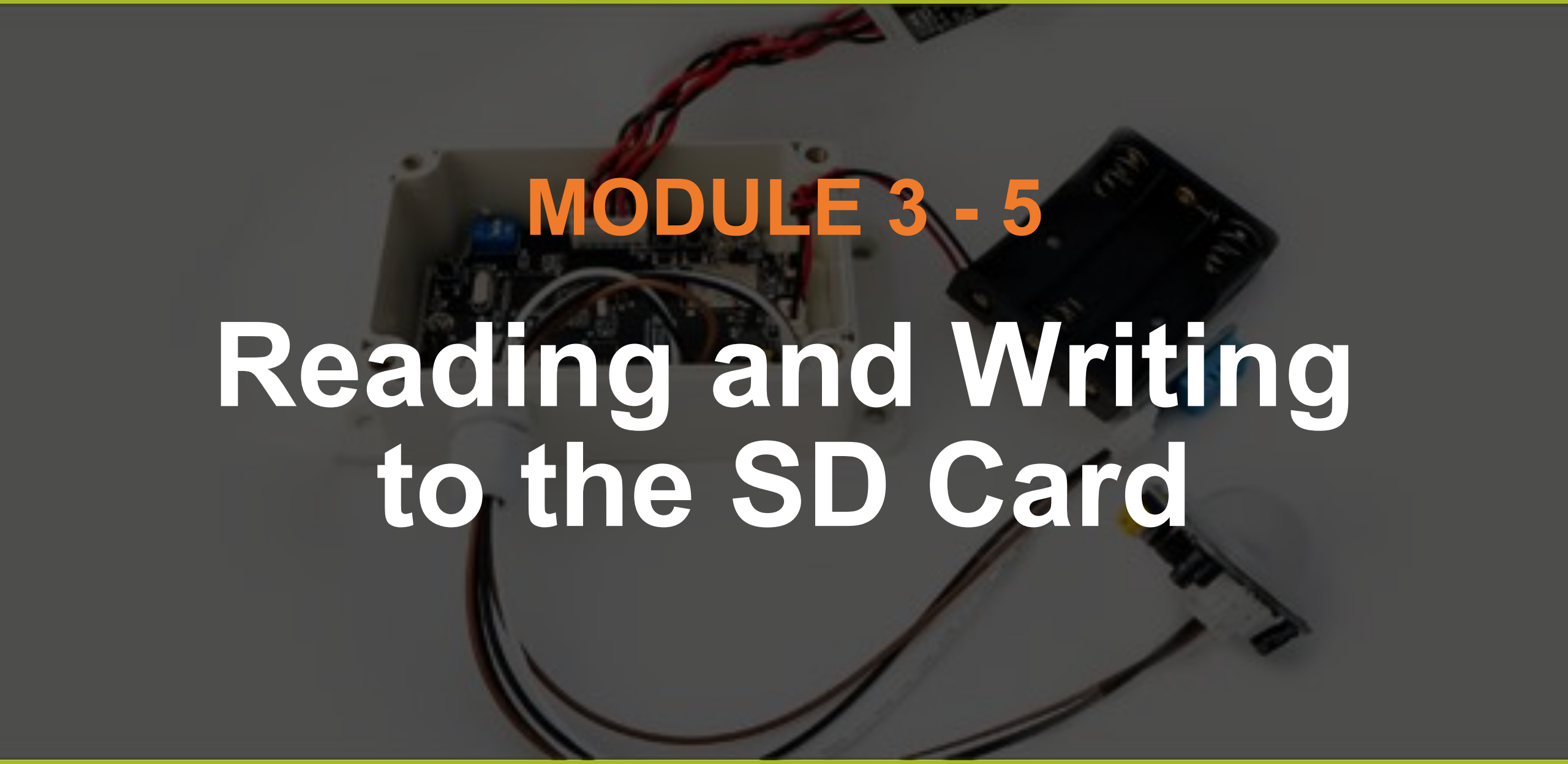
VIRTUAL COURSE

BUILD YOUR OWN DATA LOGGER

WILDLABS.NET

[The conservation technology network]

FREAKLABS



MODULE 3 - 5

Reading and Writing to the SD Card

Memory Cards

- A type of flash memory storage device used to save media and data files.

- Used in small portable devices eg. cameras, phones, mp3 players, camera traps, data loggers etc

- Contains either NAND or NOR Flash Memory
  - NAND = more common, cheaper, less efficient r/w/e,
  - NOR = less common, more expensive, harder to manufacture, more efficient r/w/e,

- Different types (eg MMC, Compact Flash) with different dimensions, r/w speeds, storage capacity, device compatibility

- Different levels of quality, cost, reliability, endurance (or how many r/w/e it can do before it becomes un-usable)

Common Types of Memory Cards

Secure Digital (SD) cards

- Common – what we're using with WildLogger
- Based on MMC format
- NAND Flash
- Different kinds (microSD, SDHC, microSDHC, SDXC, microSDXC)

MultiMediaCard (MMC)

- Early memory card format, precursor to SD
- NAND Flash
- Different kinds (MMCmicro, SecureMMC, eMMC, RS-MMC (reduce size), DV-MMC (dual voltage), MMCplus, MMCmobile

CompactFlash (CF)

- Early memory card format
- NAND Flash
- Often used in DSRL cameras / camcorders (eg. Canon, Nikon)
- Different kinds (CFI, CFII, CFast, CFExpress)

Selecting a Memory Card

Application Requirements

- Type of data *(text, video – HD?, images)?*
- How often logging? *(hourly, daily, triggered)?*
- How critical is the data?

Deployment Conditions

- What type of deployment conditions? *(temperature range, humidity?)*
- How long deployed before swapped out?

Card Features

- Physical dimensions and compatibility with device
- Storage capacity
- Read / write speed
- Power consumption *(important - affects battery life of device)*
- Endurance *(or number of program (write) / erase cycles eg - how many times card can write / erase before being unusable)*

PLUS BUDGET!

SD Cards

Read Speed

Lock / Unlock

Storage Capacity

SD Card Type

Video Speed Class

UHS Bus Speed

Speed Class

UHS speed class

SD Card

Lock / Unlock

When locked, you can't read/write to the card.

Storage Capacity

Storage space.
Nb. the usable storage space will be a bit less than the capacity indicated on the card.

SD Card Type

There are four types

- **SD** (Secure Digital): storage capacity 128 MB - 2GB
- **SDHC** (Secure Digital High Capacity): storage capacity 4GB to 32GB
- **SDXC** (Secure Digital Extra Capacity): storage capacity 64GB - 2TB
- **SDUC** (Secure Digital Ultra Capacity): storage capacity up to 128TB

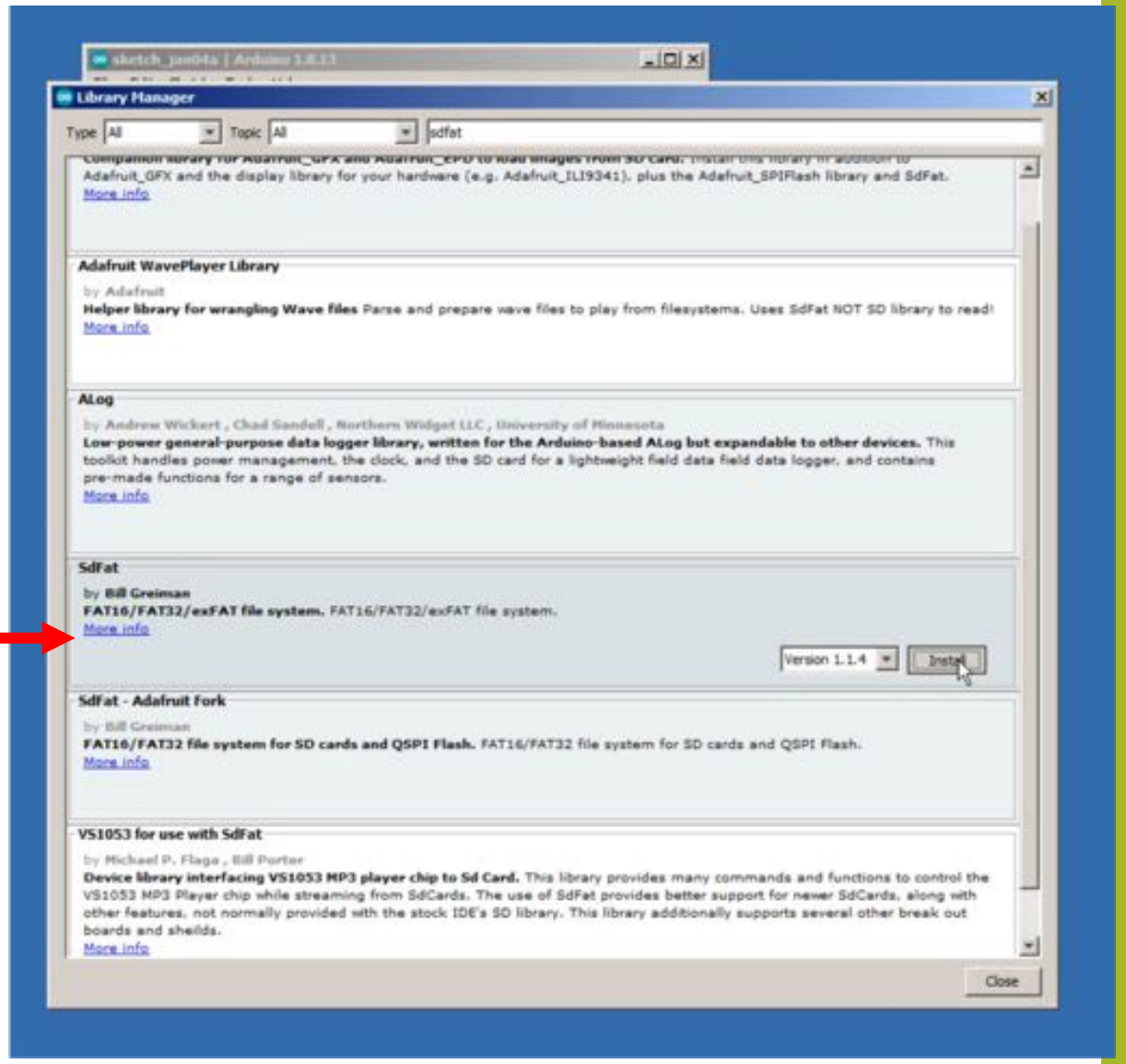
SD Card Comparison

	SD Standard	SDHC Standard	SDXC Standard
Capacity	up to 2GB	more than 2GB up to 32GB	more than 32GB up to 2TB
File System	FAT 12, 16	FAT 32	exFAT
SD Memory Cards			

SdFat Library

We're using **SdFat library v 1.1.4** by Bill Greiman

We haven't field tested exFAT in this library yet



SD versus microSD

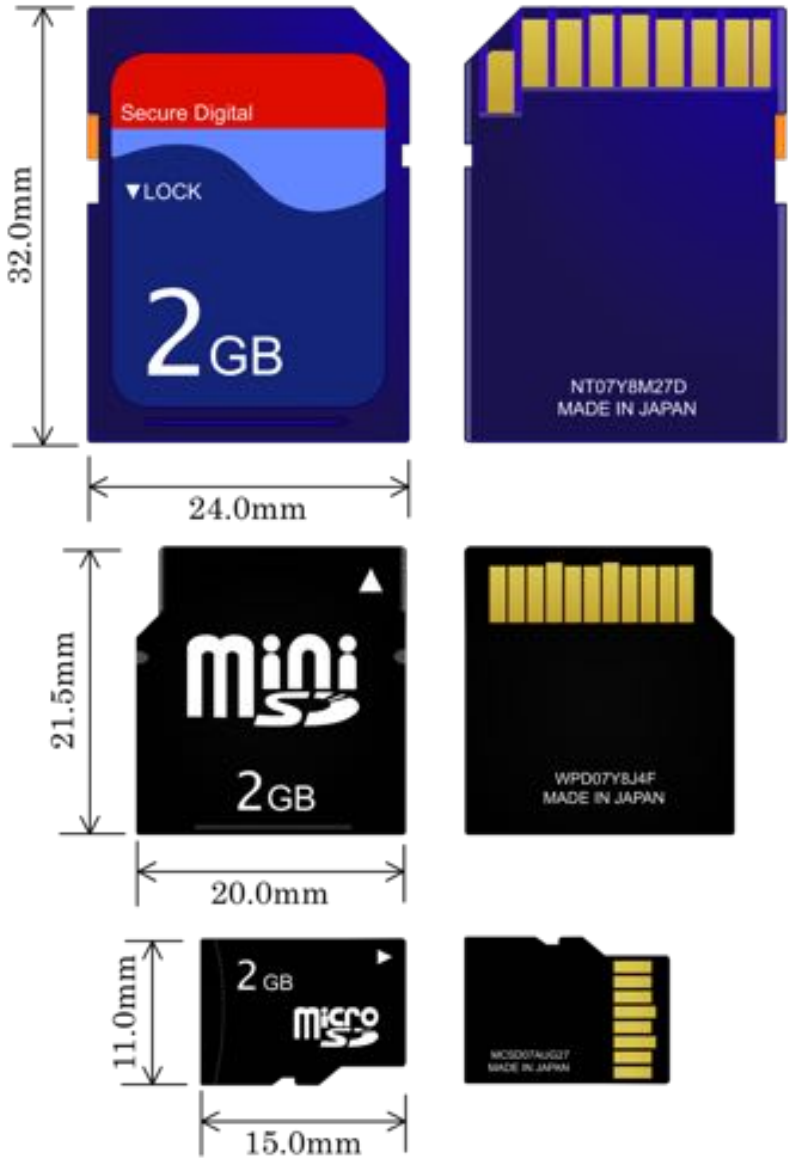
	Full SD	miniSD	microSD	SD Card Capacity
SD				up to 2GB
SDHC				High Capacity 4GB to 32GB
SDXC				Extended Capacity Over 32GB up to 2TB

SD Cards

SD Card

miniSD

microSD



SD Cards

Read Speed

How quickly information can be *read* from the card;

Usually slightly faster than write speed

Ultra High Speed (UHS) class

UHS Speed Class 1: min write speed of 10MB/s

UHS Speed Class 3: min write speed of 30MB/s

Video Speed Class

V6, V10, V30, V60, V90.
min. sustained write speed in MB/s.
V30 = min. sustained write speed of 30MB/s

UHS Bus Speed

How fast the bus interface can transfer data.

UHS-I =
max. bus speed of 104MB/s

UHS-II =
max. bus speed of 312MB/s

UHS-III
= max. bus speed of 624MB/s

Speed Class

2, 4, 6, or 10
min. sustained write speed of the card in MB/s
10 = min. sustained write speed of 10 MB/s

SD Card Write Speed Specs

Minimum Sequential Write Speed	Speed Class	UHS Speed Class	Video Speed Class
2 MB/sec	Class 2 (C2)		
4 MB/sec	Class 4 (C4)		
6 MB/sec	Class 6 (C6)		Class 6 (V6)
10 MB/sec	Class 10 (C10)	Class 1 (U1)	Class 10 (V10)
30 MB/sec		Class 3 (U3)	Class 30 (V30)
60 MB/sec			Class 60 (V60)
90 MB/sec			Class 90 (V90)

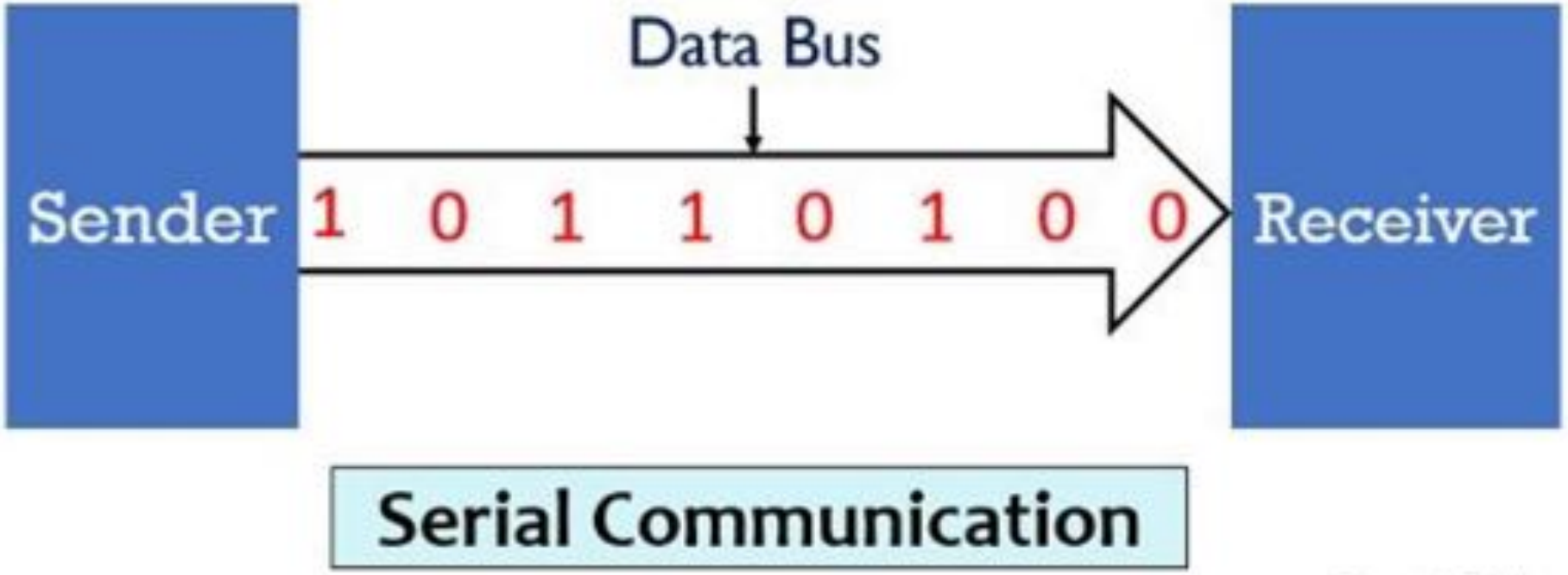
Video - Speed Class, UHS Class, Video Class

MIN. WRITE SPEED	SPEED CLASS	UHS CLASS	VS CLASS	SUITABLE FOR
2 MB/S	2			STANDARD VIDEO
4 MB/S	4			STANDARD VIDEO
6 MB/S	6		V6	STANDARD VIDEO, HD / FULL HD
10 MB/S	10	1	V10	STANDARD VIDEO, HD / FULL HD, 4K / UHD
30 MB/S		3	V30	STANDARD VIDEO, HD / FULL HD, 4K / UHD, 4K +
60 MB/S			V60	4K +
90 MB/S			V90	4K +

Speed Class - Images

PICKING THE **RIGHT** SPEED SD CARD			
U3	4K	HD & UHD Video	1080p
U1 / C10	Hi Res RAW	Hi Res JPG	HD Video 720p & 1080p
C6 / C4	JPG	Low Res RAW	HD Video 720p & 1080i
C2	JPG	Audio	SD Video

Bus Speed


Data Bus
Sender
1 0 1 1 0 1 0 0
Receiver
Serial Communication
Circuit Globe

Other Useful Specs

- Endurance (number of Program/ Erase or P/E cycles)
- Power consumption

Program / Erase Cycles (P/E Cycles)

Program / Erase cycle

1. **Program** (write) data to ‘blocks’ in the flash memory cell. Once full,
2. **Erase** old data so new data can be written to the same block.

- Each P/E cycle causes a physical degradation or ‘wear and tear’ on the materials that make up the flash memory.
- Finite number of program / erase (P/E) cycles.
- Use ‘Wear Levelling’ hardware / software to manage process, minimise the p/e cycles and ensure there’s even degradation.

P/E Cycles

NAND Flash Type

- Single Level Cell (SLC)
- Multi Level Cell (MLC)
- Triple Level Cell (MLC)

Determines how many P/E cycles there are

	Industrial microSD	Utility microSD	COEM
Series Available	U300		
	U331A		
	U331B		
Capacities Available	128MB – 8GB	4GB – 128GB	16GB & 32GB
Flash Type	Single Level Cell (SLC)	Multi Level Cell (MLC)/ Industrial 3D	3D
Speed Rating	SD 3.0, Class 10, UHS-I	SD 3.0, Class 10, UHS-I	SD 6.0, Class 10, UHS-I
Operating Temp	-40 to 85 ° C	Utility -25 to 85 ° C	-25 to 85 ° C
		Utility+ -40 to 85 ° C	
Read Speed	24MB/s	95MB/s	95 MB/s
Write Speed	20MB/s	90MB/s	30 MB/s
Data Retention	10 years when up to 10% of P/E cycles consumed	5 years when up to 10% of P/E cycles consumed	5 years when up to 10% of P/E cycles consumed
	1 year when 100% of P/E cycles consumed	1 year when 100% of P/E cycles consumed	1 year when 100% of P/E cycles consumed
MTBF (hours)	>3 million hours	>3 million hours	> 1 million hours
SMART Feature	yes	yes	no

P/E Cycles

3 types of NAND storage: Single Level Cell, Multi Level Cell, Triple Level Cell

	SLC	MLC	TLC
Bits per cell	1	2	3
P/E Cycles	100,000	3,000	1,000
Read Time	25 µs	50 µs	~75 µs
Program Time	200-300 µs	600-900 µs	~900-1350 µs
Erase Time	1.5-2 ms	3 ms	4.5 ms

By density we basically mean storage

Source: http://www.anandtech.com/show/6337/samsung-ssd-840-250gb-review/2

P/E Cycles

SLC - High Grade

- highest endurance, most robust, most expensive, less storage, slower r/w/e speeds
- Suitable for applications requiring low density / storage (roughly 16GB or less), store of mission critical data in a harsh / industrial environment.

MLC - Middle Grade

- Mid level endurance and reliability at a more moderate cost.
- Suitable if higher densities needed, data less critical, semi-harsh environment (eg. need a wide temperature range the SD card can operate in)

TLC - Lower Grade

- lowest endurance, least expensive, requires most power, higher capacity, faster r/w/e speeds.
- Commonly used for consumer applications, where endurance is not critical, and in larger form factors allows for very high density mass storage.

Specs

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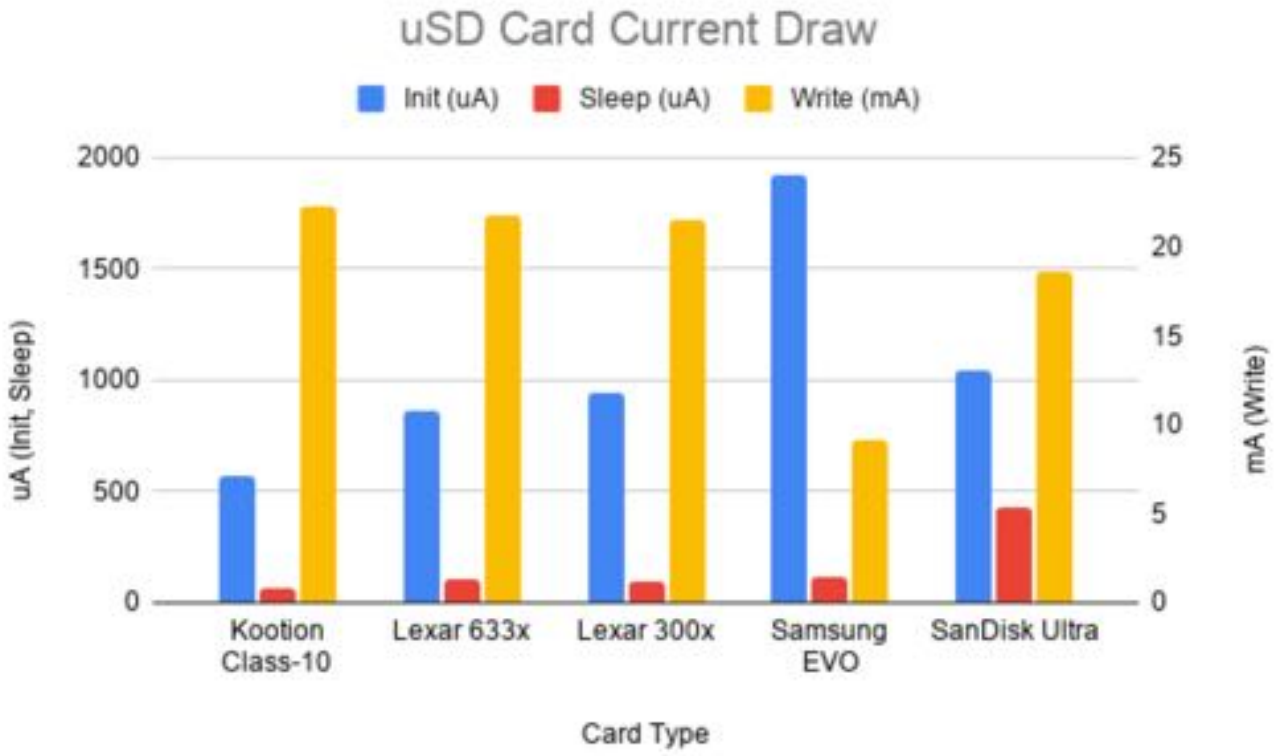
	1 year when 100% of P/E cycles consumed	1 year when 100% of P/E cycles consumed	1 year when 100% of P/E cycles consumed
MTBF (hours)	>3 million hours	>3 million hours	> 1 million hours
SMART Feature	yes	yes	no

Power Consumption

- SD cards consume lots of power (in embedded devices)
- Want to minimise the time it’s awake and not reading/writing/erase
- Can use RTC for this
- Power consumption varies based on speed mode, manufacturer and model
- Some cards have a low power mode

Power Consumption

Useful Reference:
https://gaidi.ca/weblog/low-power-showdown-usd-card-sleep-and-write-current-draw



Consumer versus Industrial

Retail

Choose a reputable brand / provider

Beware fakes!

Industrial

- Generally cheaper
- Usually MLC or TLC NAND Flash
- Mid (3000) - Low (1000) Endurance (P/E Cycles)
- Operate between -25 to +85 degrees Celsius
- May not have low power mode enabled
- Probably no wear levelling software / hardware

- More expensive
- Usually SLC or MLC NAND Flash
- High (100,000) – Mid (3000) Endurance (P/E Cycles)
- Low power mode on (check tho!)
- Operating temp range -40 to +85 degrees Celsius
- Protective casing, waterproof
- Power failure protection
- Wear levelling software / hardware

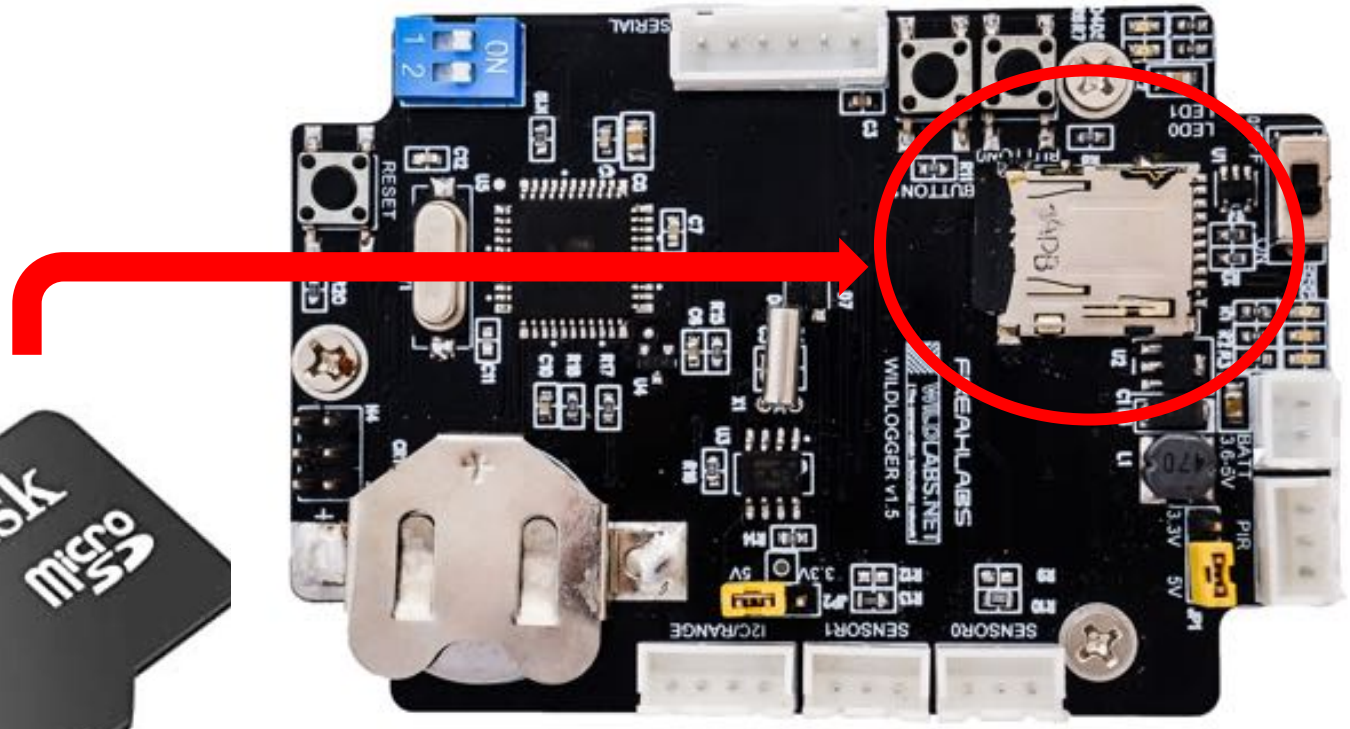
microSD card – On the WildLogger

You'll need a microSD card with 32 GB or less..

32 GB or less cards come preformatted with FAT32.

MicroSD cards over 32 GB usually come preformatted with exFat

You'll need to reformat it with FAT32 .



COMING UP: MODULE 3 - 5

Lab 5A:
The FAT File System and Reading / Writing our First Files