shimmer
DISCOVERY IN MOTION

Shimmer3

MicroSD Media Guide

Revision 1.1

Legal Notices and Disclaimer

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1. Introduction

Shimmer allows sensed data to be logged to an on-board microSD card. Stock firmware (FW) solutions leveraging this functionality include both *SDLog* and *LogAndStream*, which are freely available to all customers. For *Shimmer3* compatibility, the microSD card must implement 1-bit SPI mode.

The purpose of this document is to provide comparative data regarding the performance of microSD cards of varying sizes and types, and from different manufacturers. The investigation is intended as a guideline and is based on experimental findings from a finite number of sample cards. It should be noted that optimisation of the FW has not been carried out for any of the tested cards. It should further be noted that Shimmer has no connection with any of the microSD card manufacturers whose devices were tested, nor was any manufacturer or vendor involved in the design or implementation of the experiments.

2. Background

The operation of writing data to the SD card on-board the *Shimmer3* is blocking, so no other operations, like sampling data from the sensors, can be carried out during the write operation.

Ideally, the write operation should be completed during the period between two adjacent sampling operations. If the writing to SD card exceeds the sampling period, the next one or more sampling operations will be blocked, causing samples to be skipped in the logged data files. Comparing the timestamps of the logged samples allows the number of samples skipped during the logging period to be calculated. In this study, the number of samples skipped is used as a parameter to represent the logging performance of the SD cards.

Normal write operations are fast enough to finish during the sampling period even for high sampling rates (e.g. 500 Hz). However, when a single write operation must write data across multiple memory allocation units, additional operations such as bounds checks must be performed on the microSD card. It can be seen in the 'Format' options (in Windows OS) that the allocation unit size of SD cards varies from 512 to 16k bytes, and the typical value (factory default for most cards) is 4096 bytes. Depending on the number of sensing channels enabled and the sampling rate on the Shimmer, the number of bytes written in each packet and, hence, the frequency of write operations crossing allocation units will vary.

Closing, opening and creating files are also time-consuming SD card operations. In *SDLog* and *LogAndStream* FW, these operations occur approximately once per hour, so their effect on the number of skipped samples is assumed to be insignificant.

3. Test specifications

Fifteen microSD cards were tested, including a variety of size, type and manufacturer, as outlined in Table 3-1.

Card brand	Card type	Size (GB)	Number of cards tested
SanDisk	SDHC4	**8**	2
Kingston	SDHC4	**8**	2
Transcend	SDHC10	**8**	2
Transcend	SDHC4	**8**	2
ADATA	SDHC10 u1	**16**	1
SanDisk	SDHC u1	**32**	2
SanDisk	SD	**2**	2
SanDisk	SDXC u1	**64**	1

Table 3-1 Cards tested

Table 3-2 outlines the conditions under which the target SD cards were tested:

Test specifications	
Firmware	*SDLog* v0.6.4 (release candidate)
Enabled sensor channels	Timestamp; Analog Accel (X, Y, Z); Digital Accel (X, Y, Z)
Data packet size per sample	14 bytes
SD card power cycle time	120 ms

Table 3-2 SD card logging experiment specifications

Two experiments were defined and both were carried out for each SD card under test. The important characteristics for each experiment are outlined in Table 3-3.

Experiment id	Experiment1	Experiment2
Experiment length (hours)	7	15
Sampling rate (Hz)	49.95	496.48
Sampling period (ms)	20	2

Table 3-3 SD card logging experiment specifications

Experiment1 represents a typical use case of logging 3 channels of analog sensor data and 3 channels of digital sensor data at the 'standard' sampling rate of approximately 50 Hz.

Experiment2 represents a "stress test". The sampling rate is approximately ten times faster than that for Experiment1, resulting in a shorter period between write operations, and the test length is doubled, meaning that the amount of data on the SD card is significantly greater.

4. Test results

The metrics of interest for the comparison of SD card performance were the following:

1. Percentage of samples skipped:
    - Percentage of total samples for the logging duration that were not written to the SD card.
2. Cross Unit Write Time (CUWT):
    - Typical duration of the write operation when the data packet is written across multiple memory units.
    - Reported value is the mode of all measured durations for writing across memory units.

Card ID	Size (GB)	Card brand	Card type	% samples skipped (Experiment1)	% samples skipped (Experiment2)	CUWT (ms)
sd1	8	SanDisk	SDHC4	0.023%	0.080%	28
sd2	8	SanDisk	SDHC4	0.023%	0.080%	28
sd3	8	Kingston	SDHC4	0.530%	1.000%	308
sd4	8	Kingston	SDHC4	0.510%	0.950%	304
sd5	8	Transcend	SDHC10	0.034%	0.058%	28
sd6	8	Transcend	SDHC10	0.046%	0.056%	28
sd7	8	Transcend	SDHC4	0.001%	0.057%	26
sd8	8	Transcend	SDHC4	0.001%	0.050%	22
sd9	16	ADATA	SDHC10 u1	0.035%	0.065%	30
sd10	16	G.Skill[1]	SDHC10 u1	n/a	n/a	n/a
sd11	32	SanDisk	SDHC u1	0.007%	0.300%	136
sd12	32	SanDisk	SDHC u1	0.013%	0.360%	138
sd13	2	SanDisk[2]	SD	0.014%	0.068%	14
sd14	2	SanDisk[3]	SD	0.012%	0.041%	12
sd15	64	SanDisk[4]	SDXC u1	n/a	n/a	n/a

Table 4-1 Results

Table 4-1 details the specifications of the target SD cards, along with the performance of each card in the two experiments, in terms of % skipped samples and the typical CUWT.

Two of the cards were found to be incompatible with *Shimmer3*.

For each pair of the same type and brand of microSD card, the cross unit writing time was found to be similar for the two devices.

[1] Not compatible.
[2] Old 2GB card with >1 year of use.
[3] Old 2GB card with >1 year of use.
[4] Not compabitle.

As expected, a higher sampling frequency leads to a higher percentage of skipped samples, due to the reduced sampling period.

Both sd3 and sd4 were found to have a very high CUWT and a large percentage of skipped samples in both experiments.

The 32GB SDHC u1 cards, sd11 and sd12, were both seen to have a relatively high CUWT and a high percentage of skipped samples in Experiment2 (high sampling frequency), whilst the performance in Experiment1 (low sampling frequency) was good.

5. Conclusions

Shimmer3 devices, programmed with *SDLog* FW v0.7.0 or later, support most microSD cards of type SDHC and with sizes up to 32GB. The performance, in terms of write speed and, hence, skipped samples, varies depending on the size, type and brand of the card.

If a particular microSD card is found not to work with *Shimmer3* or if a high level of sample loss is found to occur, replacing the card with one from an alternative manufacturer or with a different size or type is recommended.

Heavy use can also cause degradation of microSD card performance. It is advised to replace cards periodically, in particular, if an increase in skipped samples is observed.

It should be noted that SDXC (64 GB) cards are not compatible with *Shimmer3*.

6. Appendices

6.1. Timestamp analysis examples

Figure 6-1 and Figure 6-2 below illustrate two examples of the number of and frequency of skipped samples, calculated according to timestamp difference between adjacent sample packets.

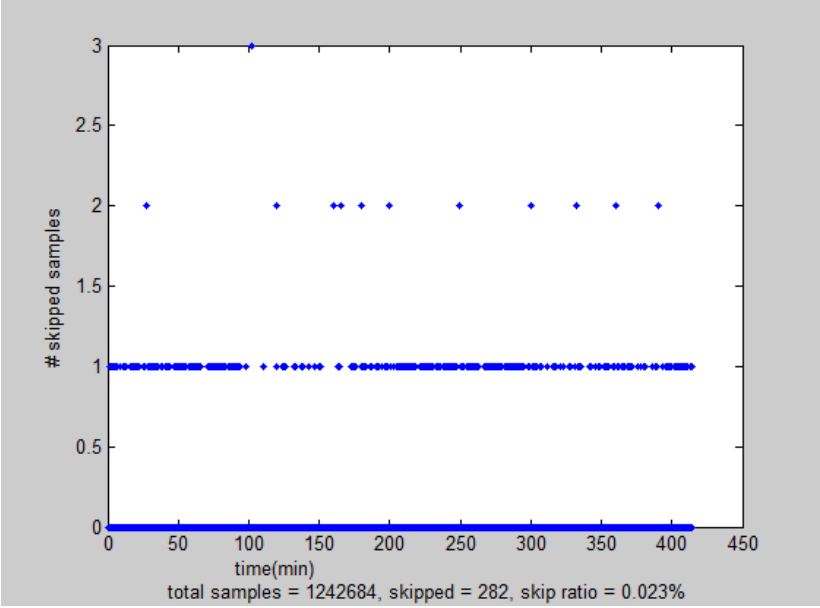


Figure 6-1 # samples skipped, sd1, Experiment1

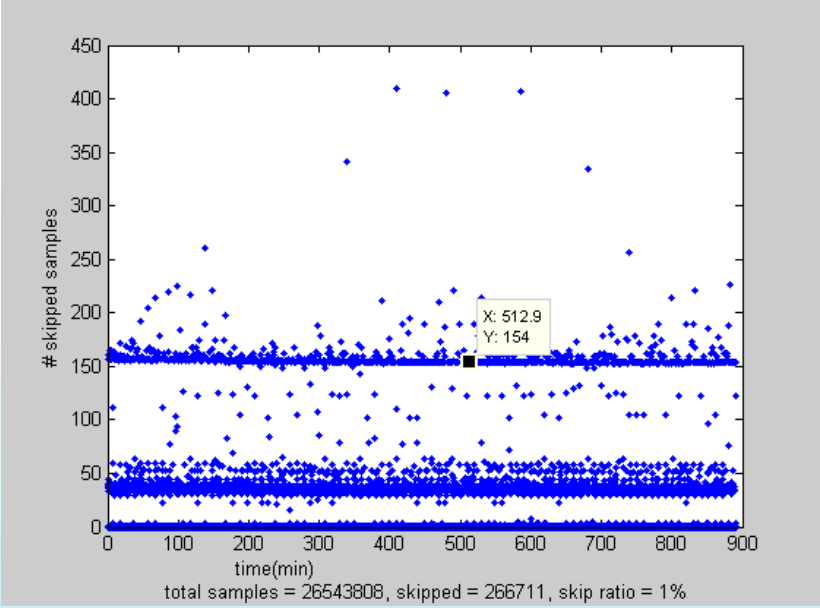


Figure 6-2 # samples skipped, sd3, Experiment2

6.2. Card Information

Table 6-1 contains images of the front and back of each microSD card used in testing, showing the card manufacturer's markings.

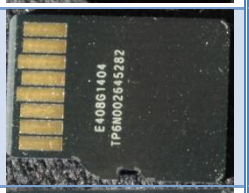
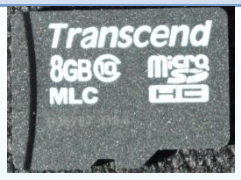
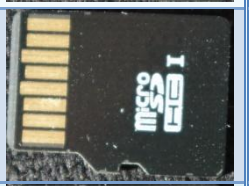
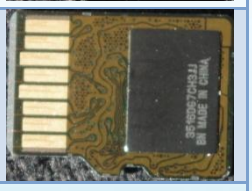
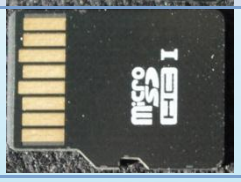
Card ID	Image of Front	Image of Back	Card ID	Image of Front	Image of Back
sd1			sd9		
sd2			sd10		
sd3			sd11		
sd4			sd12		
sd5			sd13		
sd6			sd14		
sd7			sd15		
sd8					

Table 6-1 Card Images

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