The use of removable storage media

White Paper

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imc measurement devices make it possible to save measurement data with various removable media, autarkic in the device. This white paper is intended to provide guidance on the use of the most frequently used storage media at imc. Particular attention will be paid to the central performance characteristic value of the writing speed. The writing speed is the maximum data rate and the number of channels that can be stored continuously. The memory process must be able to follow the data collection without the risk of data overflow or loss of data.

Today, a storage medium is a complex product in which many parameters play a role, all of which must be observed in order to make a statement about the overall system. It is, however, as always with flash media that the writing performance is not simply based on its "speed - degree". However, it depends very much on the buit-in media controllers and operating conditions, in particular the number of channels (i.e., the files to be processed in parallel) and the measurement configuration (imc Online FAMOS, transfer over the network and the PC, triggers, etc.). Therefore, it is strongly recommended to use only the storage media explicitly recommended by imc that has been tested under a variety of different operating configurations!

There are basically five different memory card types that are supported by imc (see the table labeled "Overview of relevant flash media", p.2). The card most commonly used is the Compact Flash (CF) card. Older units sometimes come equipped with a PCMCIA slot, which is, however, operated by a mechanical adapter, usually in conjunction with a CF card. There are ExpressCards, the recently available CFast cards and USB flash drives.

CF card:

The CF card is the card most frequently used in imc devices. The interface of a CF is parallel to IDE-ATA.

PCMCIA slot:

Older devices sometimes come equipped with a PCMCIA slot, which is, however, operated by a mechanical adapter, usually in conjunction with a CF card.

Express card:

These cards are rarely available. There is a possibility to adapt an Express card to an SD card. In this case, the write speed can be restricted. imc has not found any combination with these adapted SD cards, in order to save 2MSample continuously. imc has the Express card, but only installed in the imc CRONOS*flex* (CRFX-2000), and it also gives an alternative possibility for this device to save the data to USB. The CRFX 2000 has since been replaced by CRFX-2000G and is equipped with a CFast slot.

CFast card:

A key advantage of the new CFast card is the increased transfer or writing speed, which should alleviate existing bottlenecks significantly. CFast is not compatible with CF (Compact Flash)! Although the format is similar mechanically, electrically, however, the format is not compatible.

CFast is based electrically on the serial SATA standard and therefore provides significantly higher transfer speeds. Although CFast has not (yet) been implemented on the camera and consumer market, the "industrial" and "embedded" area, however, is different: Here is the format of the future!

From imc, CFast USB readers are available as an option by which you can connect CFast media directly to a PC. These PCs usually don’t have an adequate internal card reader abilility for this format. This is especially helpful when memory cards are collected and exchanged by service personnel and can not be read directly from the device on site.

USB:

The USB host port is an attractive interface for connecting storage devices, alternative to the Flash card slot. It allows the connection of USB sticks or portable USB hard drives. USB drives are now available in tiny “nano-versions” that practically no longer protrude from the front and , thus, don’t need to be protected. However, it must be noted that these “nano versions” have less complex controllers and are therefore usually slower. Experience shows that the aggregate writing speed with USB Nano Flash Drives is less that 3 MB/s. “Conventional” USB memory sticks are known to achieve speeds up to 5 MB/s.

Overview of relevant flash media

	imc C-SERIES imc CRSONOS-PL imc CRONOS-SL	imc SPARTAN imc BUSDAQ	imc SPARTAN-R imc CRONOS-SL-N imc C-SERIES-N imc CRONOS*compact* CRC-400 imc **CRONOS*flex*** CRFX-400	imc CRONOS*compact* CRC-2000E imc **CRONOS*flex*** CRFX-2000	imc CRONOScompact CRC-2000G imc CRONOSflex CRFX-2000G
Administration					
Device Group	1, 2, 3	4	5	6	7
Serial Number Range	SN12xxxx	SN13xxxx	SN14xxxx	SN16xxxx	SN19xxxx
Data Storage					
PCMCIA-Slot	●				
CF card slot (Compact Flash)	(●)(1)	●	●		
CFast card slot					●
Express Card slot				●	
USB 2.0 host port (external removable storage)				●	●
storage on network drive		●	●	●	●

(1) via PCMCIA Adapter

If you buy the card from a supplier other than imc, we can not guarantee the quality, in particular, whether the acquired card has the same components installed, under which we have tested the card. Straight from the card vendor, little information can be revealed as to the controller, as this is the "know-how" for manufacturers and they understandably do not want to make it readily available. Although, the manufacturers usually give notice if anything has changed on the controller, but what, or in what form, remains unclear. Once changes to the controller are made, the corresponding memory types are again checked by imc, as soon as possible.

Hardware:

In priciple, a memory card’s flash components are constructed out of a controller. One of the key differences for the flash is whether it is a single-level or multi-level cell. The multi-level cells are not usually suitable for extended temperature ranges and have a much shorter life span.

Software:

There are different file systems that are exclusively used by imc for removable storage media that have only the correct sized FAT (File Allocation Table). The cluster size is the critical parameter that affect the writing speed and the utilization of the available memory.

Cluster:

By formatting fixed block sizes, the smallest possible processing blocks are produced.

Data block sizes (chunk):

Actually, with writing on the processing blocks used by the device firmware, i.e., data packets, each ”piece” is processed without interruption.

Data rate, channel number, formatting:

Each storage medium has a maximum data rate that continuous data can be written to the medium. Manufacturers like to cite maximum values, but these appear only under certain operating conditions. In general, these specifications are applications such as cameras based on typical consumer usage, where a single, huge file is created. The typical use when it comes to the use of an imc measurement device deviates from this greatly. When only a few data channels with high data rates are written, large units (clusters) on the disk are beneficial. When formatting, the cluster size is adjusted. The format depends on the file system, the disk size and the operating system. For example, when FAT32 and plate sizes <8 GB when formatting Windows, a cluster size of 4 KB is selected. This causes an unfavorably small size, leads to a corresponding number of clusters and a reduction in performance. This means, that in a particular circumstance,the writing speed can be significantly be reduced, which can result in data overflow in extreme cases at the aggregate sampling rate. The formatting should therefore take place on the imc-device (Linux operating system), because, unlike the PC under Windows, the cluster size is optimized for maximum writing rate. In the case of data collection, the data are first written to the global FIFO buffer RAM within the imc device. This serves as a buffer between the different real-time processes:

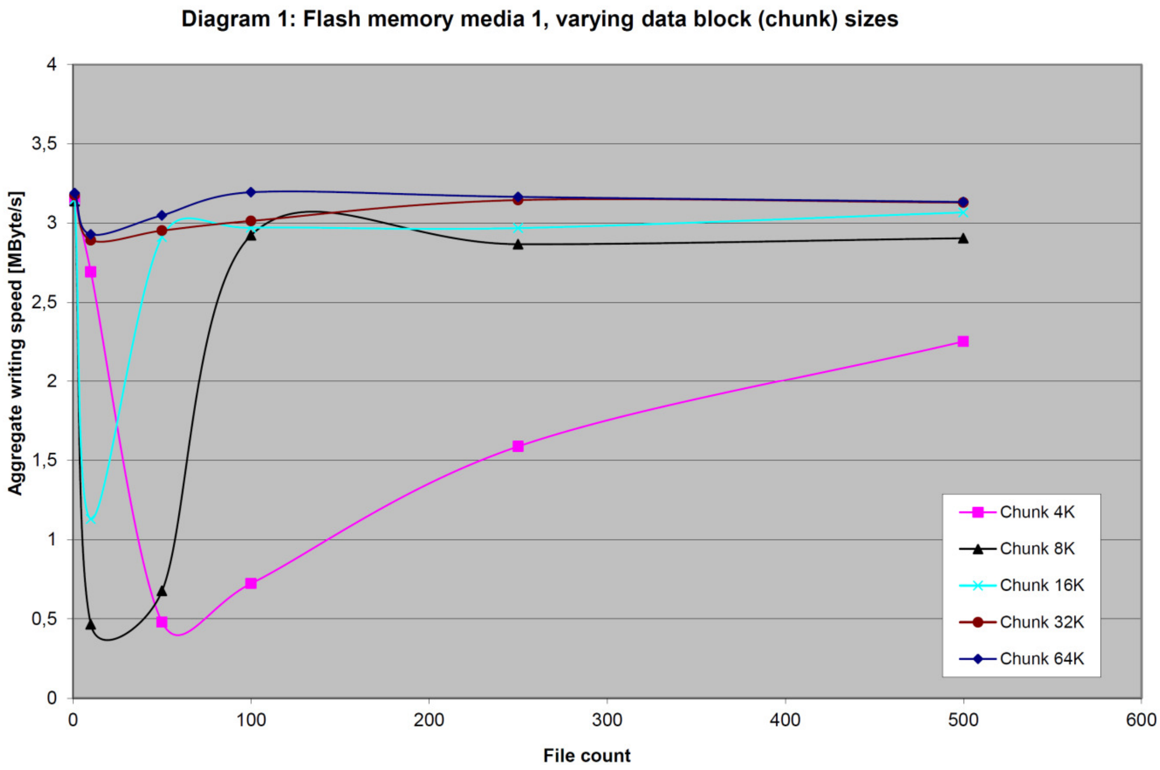
The device's processor must, depending on the application, use all of these processes. The FIFO RAM must be cyclically read per channel and proportionate to the data instances mentioned above . Depending on the number and extent of concrete tasks to be executed, the processor has relatively little time to dwell on one channel. It can be processed "on track", thus allowing only small data blocks (chunks) to be processed before the processor continues with the next channel (because it must use all channels on average).

Basically, the device software always tries to process the largest possible data packets per channel in order to minimize the administrative burden. However, this can not always be guaranteed, as the above-described parallel competing processes affect the size of the actual processed data packets (chunks). There is also the possibility of additional factors and difficulties, such as a temporary bad network connection. It is not easy to predict how much the system will ultimately be "stressed".

As part of testing, you now want to find out how the aggregate writing speed of each channel number and the actual operation of each "piece" of processed data block sizes (chunks) are influenced.

In the following three diagrams, three different memory cards are displayed. The aggregate writing speed is always plotted against the number of channels or files stored, wherein for each channel an individual file is always created. In the sets of curves in each diagram, a selected memory card is represented in which the data block size (chunk) was varied. Each curve represents a different curve set – a "simulated" use case, in which the system was to a different extent "stressed".

For this test, a modified firmware has been used, each with different, solid chunk sizes. This can systematically simulate different "demanding" applications. In reality, the default firmware would be required to dynamically vary the chunk size.



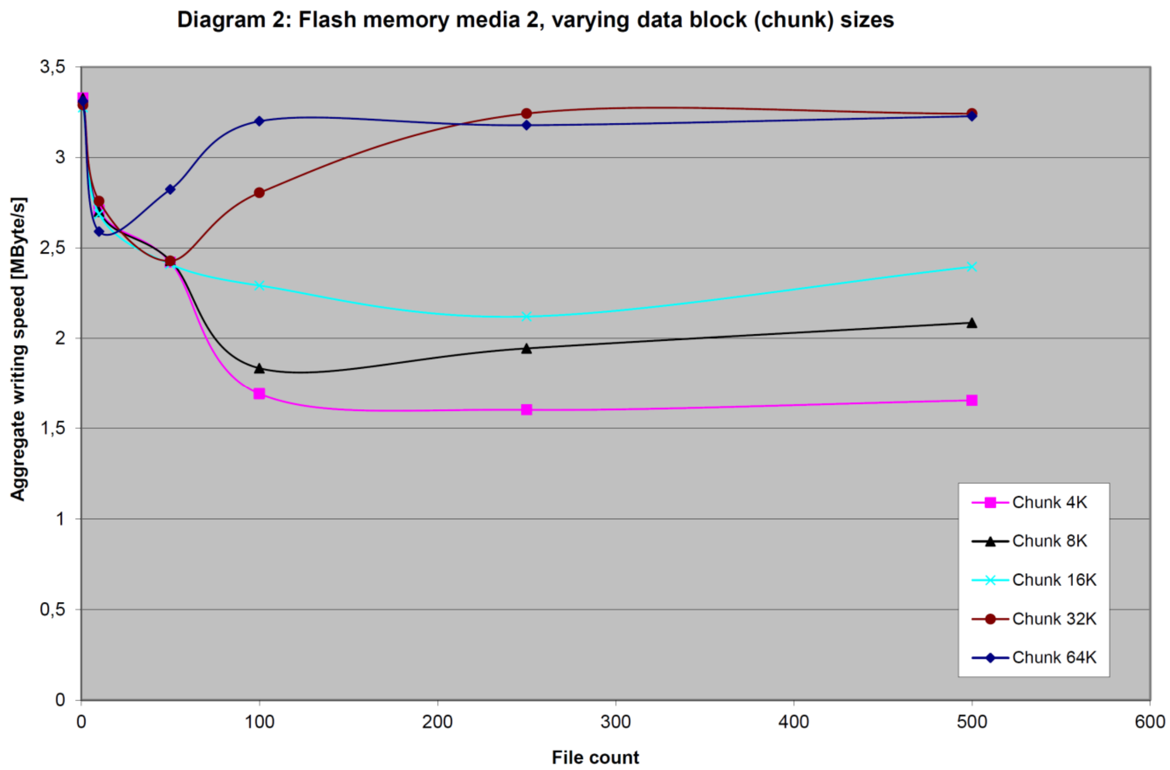
In Diagram 1, you can see, first, that the writing performance is unexpectedly drastic and not proportionately dependant on the channel number (files). In fact, there are relatively "small" areas or channel numbers when the performance strongly collapses for higher channel counts, but then significantly improves again. This shows that very extensive tests are necessary with a variety of configurations (number of active channels) in order to detect any possible weaknesses: If you had conducted the above case tests with only a few test cases , each with around 100 channels (files), this behavior wouldn't stand out!

So here we see that the aggregate writing speed for those curves with 4K, 8K and 16K chunk operating cases in the range between 0 and 100 channels partially breaks down by more than 80% percent.

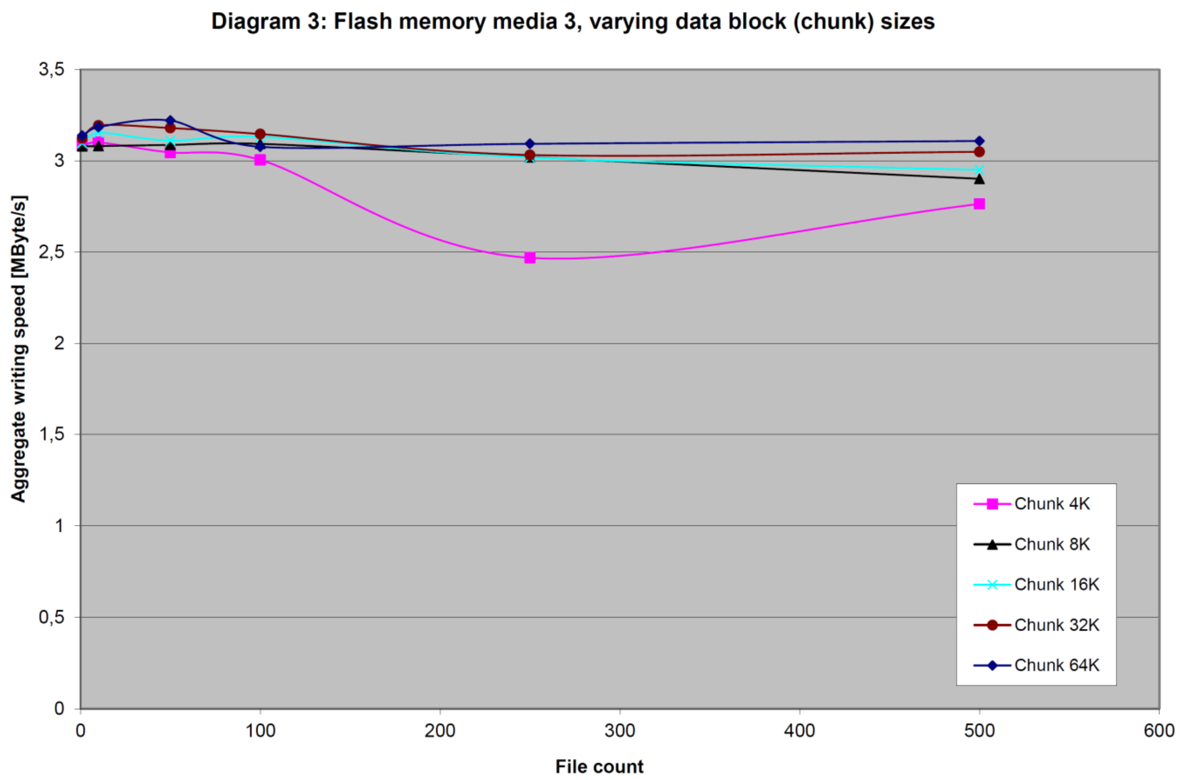
All three diagrams confirm, with their curves, that the writing performance decreases with decreasing chunk sizes. This corresponds to the actual operation, when the system is exposed to further data storage "stresses" through additional parallel-issues, as functions of the system configuration (imc STUDIO; data transfer to PC, etc.). This result tends to occur more frequently and interruptions of the data memory tasks result in smaller processing units.

These extensive tests are mainly to clarify through specific memory models how sensitive they are and to discover in which channel numbers characteristic-colapses occur and how strong they are. This determines the worst-case performance among representative and reproducible "stress configurations" simulations by solid chunk sizes.

This shows that the memory card shown in the first diagram is unsuitable for measurement using an imc device.



In the Diagram 2, you can see that the aggregate writing speed varies quite strongly with the number of channels (files). While you can see the curves 4K, 8K, and 16K, the aggregate writing speed decreases steadily with the number of recorded files. In curves 32K and 64K, is is displayed that the aggregate writing speed decreases at first, but again, for very large numbers of channels, "recovers" and then merges into a saturation region. The characteristic performance degradation for this card is not nearly as dramatic as that shown in the first diagram: The aggregate writing speed is never less than 1.6 Mbytes/s. For an imc device with an aggregate sampling rate of 400 kHz, this card is thoroughly recommended.



For the card shown in Diagram 3, the variations in the writing speeds are relatively low, i.e., the aggregate writing speed ultimately doesn't so much depend upon how large the data block size being used by the firmware is. Also, there is hardly any significant dependence on the number of channels. Since an aggregate writing speed of 2.4 MB/s is not exceeded, this is an example of a very well-suited and "robust" card, depending on the operating configurations.

Note: imc does not influence the quality of the removable storage media from different manufacturers. Disks that come with new devices are checked for quality assurance and have undergone appropriate tests. We expressly point out that the use of removable storage media is to be used at your own risk. imc and its resellers are liable under the warranty and only to the extent of replacement. imc expressly disclaims any liability for damages that may result from any loss of data.

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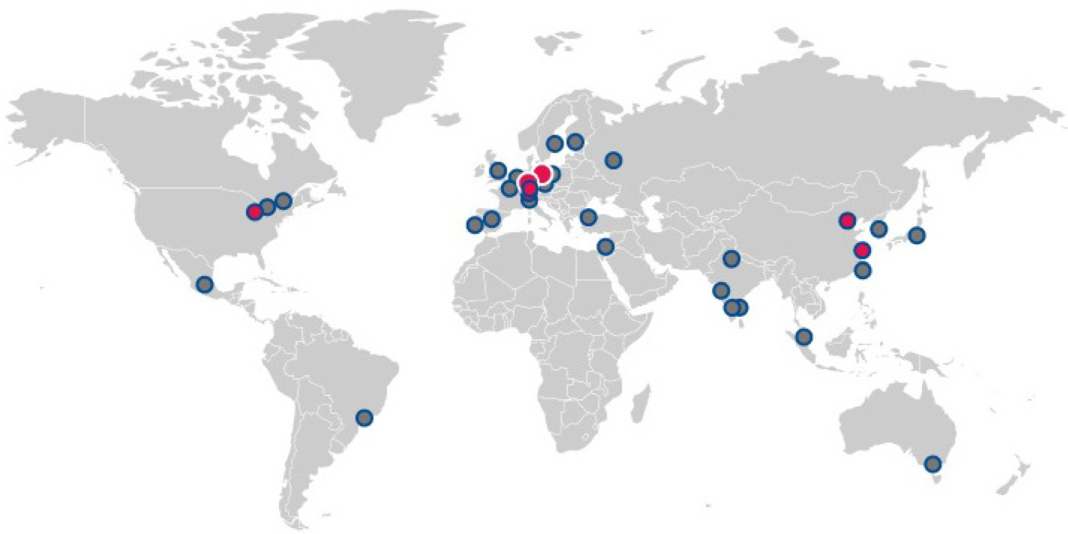

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