

## AN004b - Comparison of M3i, M2i cards and MC/MX cards

This application note should give you an overview on the differences between the cards of the MC and MX series, the M2i series and the cards of the M3i series. It will show all differences between the two card families for different aspects of the hardware. However, before relaying on this application note please have a look at the latest manual version of the respective card series to see the current details there.

This application note is focused on experienced users of the Spectrum cards who wish to have some more information on the differences between the modular cards of the first generation (MC and MX), the cards of the second generation (M2i and M2i-exp) and the third generation series (M3i and M3i-exp) and who want to see the fundamental differences that they have to expect when changing from one series to the other.

## Hardware

All hardware details of the M3i and M2i series are based on the first series version 1.x. All hardware details of the MC and MX series are based on the version that was available when this application note was made. This is version 15.x (Hardware version 1.4).

Base card	M3i and M2i card series	MC and MX card series
Size of the base card	M2i: full size PCI length M2i-exp: full size PCI Express x1 card	MC: Compact PCI 6 U form factor MX: Compact PCI 3 U form factor with PXI extension
Interface	M2i: PCI-X interface capable of running with 33 MHz or 66 MHz PCI bus speed. Fits into any 32 or 64 bit PCI/PCI-X slot  M2i-exp: PCI Express x1 card edge connector. Fits into any PCI Express slot (1x, 4x, 8x, 16x)	PCI interface running with 33 MHz PCI bus speed.
Maximum theoretical PCI bus transfer speed	M2i: 264 MB/s M2i-exp: 250 MB/s	132 MB/s
Reached maximum transfer speed on 33 MHz PCI	115 MB/s	105 MB/s
Reached maximum transfer speed on 66 MHz PCI-X	220 MB/s (> 240 MB/s using continuous memory)	105 MB/s
Reached maximum transfer speed on PCI Express slot	130 MB/s (> 160 MB/s using continuous memory)	not available

Memory	M3i card series	M2i card series	MC and MX card series
Memory options	256 MB (default) , 512 MB, 1 GB, 2GB		MC: 16 MB, 32 MB, 64 MB, 128 MB, 256 MB, 512 MB MX: 16 MB, 32 MB, 64 MB, 128 MB
FIFO buffer usage	Uses the complete on-board memory as FIFO buffer		Uses the on-board memory for a double buffering. Used buffer size is programmed. One of the double buffers is transferred completely if it's full
Granularity of programmable memory size	Minimum 8 samples up to installed memory in steps of 8 samples independent of the number of activated 8 or 16 bit channels.	Minimum 8 samples up to installed memory in steps of 4 samples independent of the number of activated 8 or 16 bit channels.	Minimum and stepsize depend on number of activated channels: 64 / channels / bytes per sample. Memsize can be up to the installed memory.
Granularity of programmable posttrigger	Up to 8 GSample in steps of 8 samples	Up to 8 GSample in steps of 4 samples	Stepsize depends on number of activated channels: 64 / channels / bytes per sample. Maximum depends on the number of activated channels: 256 MSamples / channels / bytes per sample
Later memory update	Possible without extra charge		Possible but including an extra charge as parts are soldered to the PCB
Data ordering in memory	Depends on the number of activated module(s) only		Depends on the number of activated modules, the number of bytes per sample and the used mode (standard or FIFO)
FIFO mode sampling speed limitations	No limitations, all sampling rates, all modes available within FIFO mode		FIFO mode is limited to a maximum of 250 MB/s sum transfer from module(s) to on-board memory. This limit is even valid for Multiple Recording and Gated Sampling
DMA mode of data transfer	Busmaster Scatter-Gather DMA with hardware demand mode (more robust against system background jobs and other tasks)		Busmaster Scatter-Gather DMA handled by the kernel driver
Data transfer for timestamps (and ABA)	Second busmaster Scatter-Gather DMA engine with hardware demand mode		Kernel driver base PIO mode for timestamps. ABA mode not available.

Channel Selection	M3i card series	M2i card series	MC and MX card series
1 channel mode	Any channel on the card can be used	Any channel on the card can be used (if not using interlace mode), even one channel located on module B	Only channel 0 can be activated
2 channel mode	The two channels on the card can be used	Any two channels on the card can be used (if not using interlace), even two channels located on module B	Only channel 0 + channel 1 or channel 0 + first channel on module B can be activated
4 channel mode	not available	Nearly any channels on the card can be used as long as either all channels are on one module or both modules have the same number (not positions) of channels activated	Only channel 0 to channel 3 or the both first channels on both modules can be activated
8 channel mode	not available		Only channel 0 to channel 7 or the four first channels on both modules can be activated

Clock	M3i card series	M2i card series	MC and MX card series
Available clock modes	Internal PLL with standard reference, custom internal reference (option), external reference	PLL, Quartz1, Custom Quartz (option), External, External reference	PLL, Quartz, External, External reference
Additional clock divider resolution	not available	2 to 8190 in steps of 2	16 fixed divider values
Internal PLL reference clock	programmable reference, 32 ppm clock	10 MHz 20 ppm clock	40 MHz, 50 ppm clock
PLL settings granularity	internal programmable reference: 1 Hz internal custom reference: 1 kHz external reference: 1 kHz	Improved granularity independent of the number of activated channels and the used mode	limited granularity depending on the number of activated channels and the used mode
External clock ranges	no direct external clocking	Maximum 2 ranges, lowest range going from DC to 50 MHz / channels per module	Maximum 5 ranges, lowest range going from DC to 5 MHz / channels per module

Trigger	M3i card series	M2i card series	MC and MX card series
Trigger conjunction	AND and OR conjunction of any trigger source including the mixture of external and channel triggers		OR conjunction of channel triggers
External triggers	1 analog window trigger and 2 additional TTL lines with multi-purpose inputs	1 TTL trigger as standard and 2 additional TTL lines with option BaseXIO	1 external TTL trigger
Pulse width counter width	not available at the moment	16 bit wide	8 bit wide
Delay trigger	0 to 32 GSamples in steps of 8	0 to 64 kSamples programmable in steps of 1	not available
Enable / disable trigger by command during runtime	available		not available

Option overview	M3i card series	M2i card series	MC and MX card series
Memory upgrades	up to 2 GByte as specified in the memory section		up to 512 MByte as specified in the memory section
Multiple Recording	available as firmware option		available as firmware option (except for MC.47xx cards)
Gated Sampling	not available	available as firmware option	available as firmware option (except for MC.47xx cards)
Timestamp	available as firmware option		available as extension module (not available for MX cards)
ABA mode	available as firmware option		not available
Cascading synchronization	not available	not available	available as hardware option
Star-Hub (no external slot needed)	for 4 cards available as extension module	for 5 cards available as extension module	not available
Star-Hub (external slot needed)	for 8 cards available as extension module	for 16 cards available as extension module	for 16 cards available as extension module (not available for MX cards)
Later synchronization of already fielded cards	No update needed, all cards are prepared for synchronization, one card need to be equipped with star-hub 4 or star-hub 8	No update needed, all cards are prepared for synchronization, one card need to be equipped with star-hub 5 or star-hub 16	cards need to be sent back to Spectrum and synchronization need to be soldered depending on the mode. If using cascading all cascaded cards have to be synchronized
Extra I/O	BaseXIO option: adds 8 digital I/O lines on the base card. I/O lines can be used for timestamp as well	BaseXIO option: adds 8 digital I/O lines on the base card. I/O lines can be used for extended trigger and timestamp as well	available as extension module offering 24 digital I/O lines and 4 analog outputs (not available for MX cards)

Synchronization option	M3i card series	M2i card series	MC and MX card series
Available options	star-hub 4 and star-hub 8	star-hub 5 and star-hub 16	MC: cascading and star-hub 16 (smod) MX: PXI synchronisation bus support
Needed size	star-hub 4: only one slot star-hub 8: two slots	star-hub 5: only one slot star-hub 16: two slots	cascading: only one slot smod: two slots
Phase delay	star-hub 4: no phase delay star-hub 8: no phase delay	star-hub 5: no phase delay star-hub 16: no phase delay	cascading: ca. 500 ps between adjacent cards smod: no phase delay
Card trigger connection abilities	star-hub 4: OR trigger for all cards star-hub 8: OR trigger for all cards	star-hub 5: AND and OR trigger for all cards and channels star-hub 16: AND and OR trigger for all cards and channels	cascading: one card is trigger source, no trigger connections smod: OR trigger for all cards and channels

Synchronization option	M3i card series	M2i card series	MC and MX card series
Card clock connection abilities	starhub carrier card is clock master, all synchronized cards must use the same sampling rate	any of the fastest sampling cards can be clock master, cards can run with different clock rates (slave dividers)	any of the cards with the highest sum sampling rate can be set to clock master, cards can run with different clock rates (slave dividers)
Pretrigger area synchronization, enabling of trigger machines from all cards when using different memory sizes or sampling rates	Fully implemented in hardware, all combinations of pretrigger, posttrigger, memory size are automatically synchronized through the cards, trigger machine is enabled as soon as all cards are prepared to accept trigger	Fully implemented in hardware, all combinations of pretrigger, posttrigger, memory size and clock rates are automatically synchronized through the cards, trigger machine is enabled as soon as all cards are prepared to accept trigger	No hardware synchronization, memory size and sampling clock must match. Start need to be delayed in software to allow different pretrigger areas.

Multiple Recording option	M3i card series	M2i card series	MC and MX card series
Programmable segment size	Minimum 8 samples up to installed memory in steps of 8 samples	Minimum 8 samples up to 8 GSample / installed memory in steps of 4 samples	Minimum and stepsize depend on number of activated channels: 64 / channels / bytes per sample. Maximum depends on the number of activated channels: 256 MSamples / channels / bytes per sample
Programmable pretrigger	Up to (32 kByte / channels / bytes per sample)	Up to ((32 kByte - 32) / channels / bytes per sample)	not available
Delay of trigger edge to first sample	no delay as pre- and posttrigger are freely programmable	no delay as pre- and posttrigger are freely programmable	fixed delay depending on card type, mode, activated channels, activated synchronization and used trigger mode
Programmable delay trigger	from 0 to 32 GSamples in steps of 8	from 0 to 64 kSamples in steps of 1	not available
Programmable number of segments in FIFO mode	Available in hardware with 100% defined stop at end of last segment	Available in hardware with 100% defined stop at end of last segment	Programmable in software, counting the number of transferred buffers, some more data is acquired or generated as stop is done by software command

Gated Sampling option	M3i card series	M2i card series	MC and MX card series
Programmable pretrigger	not available	Up to ((32 kByte - 32) / channels / bytes per sample)	not available
Programmable posttrigger		Fully programmable	not available
Gate stop alignment		Stops are aligned on 4 byte positions (4 sum samples on 8 bit cards, 2 sum samples on 12/14/16 bit cards)	Stops are aligned on 16 byte positions (16 sum samples on 8 bit cards, 8 sum samples on 12/14/16 bit cards)
Delay of trigger edge to first sample		no delay as pre- and posttrigger are freely programmable	fixed delay depending on card type, mode, activated channels, activated synchronization and used trigger mode
Programmable delay trigger		from 0 to 64 kSamples in steps of 1	not available
Programmable number of gate segments in FIFO mode		Available in hardware with 100% defined stop at end of last gate segment	not available

Timestamp option	M2i card series	M2i card series	MC card series
Shape of option	Firmware option, no additional hardware needed		Extension module
Counter width	56 bit		56 bit
Available timestamp modes	Standard, Start-Reset, RefClock mode		Standard, Start-Reset, Refclock mode
Additional modes	Synchronous acquisition of 8 bit digital information with each trigger event. (Option BaseXIO needed)		not available
Fed in of RefClock signal	Included in option BaseXIO, no additional slot occupied		As an extra option on demand, additional connector is soldered on the back of the extension module, occupying the neighbour slot
Timestamp memory	4 kByte FIFO with its own DMA engine running in busmaster scatter-gather demand mode. Capable of transferring up to 100 MB/s of sustained data		512 kByte FIFO with PIO access by kernel driver

## Software

The comparison of the software features is based on the driver versions that have been available when adding the M3i series to this application note. Any changes to the drivers after May 2009 are not mentioned in this comparison list.

Basic Driver Interface	M3i card series	M2i card series	MC and MX card series
Driver Type	Software register based easy to use driver interface		Software register based easy to use driver interface
Available driver functions	9 functions (+ additional 5 sub-functions)		5 functions
Open/Close	Handle based open and close routines that allow access to different cards from different application programs		One initialization routine that gains exclusive access to all Spectrum cards for one application program
Software register access	SetParam, GetParam with different call types to allow access to 64 bit registers		SetParam, GetParam
Data transfer	Four functions: Two for standard transfer buffer definition and invalidation and two functions for continuous kernel memory buffers		Two functions for read and write data transfer
Error handling	Separate error handling function generating a printable error message		Error handling via software registers
Windows driver	Using standard library interface		Using standard library interface

Basic Driver Interface	M3i card series	M2i card series	MC and MX card series
Linux driver	Using standard library interface, identical to windows driver interface		Using direct kernel driver access with a slightly modified driver interface compared to windows driver interface
Linux driver files	Divided into library and kernel module		One kernel module including kernel and library

Commands	M3i card series	M2i card series	MC and MX card series
Start command + status polling	available		available
Start command + waiting for ready interrupt	available		available
Waiting for ready interrupt with timeout	available		not available
Waiting for pretrigger ready	available		not available
Waiting for trigger received	available		not available
Poll for trigger received	available		available
Start command + later waiting for ready interrupt	available		not available
Force trigger command	available		available
Enable / disable trigger command	available		not available
Wait for FIFO buffer ready interrupt	available		available
Poll for FIFO buffer ready	available		not available
Wait for FIFO buffer ready interrupt with timeout	available		not available

Software updates	M3i card series	M2i card series	MC and MX card series
Firmware update	available per integrated software (Spectrum control center)		available using third-party software and special programming cable.
Later feature update	available per integrated software using an update code		available per individually compiled update software

Data transfer	M3i card series	M2i card series	MC and MX card series
Transfer of data chunks defined by offset and length	available		available
Timeout for data transfer	available		not available
Non-blocking wait for end of data transfer	Yes		No, function returns after complete transfer has finished
Splitted start of transfer and wait for end	Yes		No
FIFO application data buffer organization	One buffer with any size that fits into the memory, notification of new data can be programmed with stepsize of 4k		Up to 256 buffers of the same length like hardware double buffer. Notification of new data is stuck to the buffer length
Polling data transfer status	available		not available
DMA mode of data transfer	Busmaster Scatter-Gather DMA with hardware demand mode (more robust against system background jobs and other tasks)		Busmaster Scatter-Gather DMA handled by the kernel driver
Data transfer for timestamps (and ABA)	Second busmaster Scatter-Gather DMA engine with hardware demand mode		Kernel driver base PIO mode
Start of data transfer in all acquisition single modes	Data transfer can start as soon as first trigger is received and runs while acquisition is still running		Data transfer can earliest start if all data has been recorded